USING SPECTRUM TO ADVANCE PUBLIC SAFETY, PROMOTE BROADBAND, CREATE JOBS, AND REDUCE THE DEFICIT

HEARING

BEFORE THE

SUBCOMMITTEE ON COMMUNICATIONS AND TECHNOLOGY

OF THE

COMMITTEE ON ENERGY AND COMMERCE

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

APRIL 12, 2011

Serial No. 112–36

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SUBMITTED MATERIAL

USING SPECTRUM TO ADVANCE PUBLIC SAFETY, PROMOTE BROADBAND, CREATE JOBS, AND REDUCE THE DEFICIT

TUESDAY, APRIL 12, 2011

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON COMMUNICATIONS AND TECHNOLOGY,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to notice, at 1:30 p.m., in room 2123, Rayburn House Office Building, Hon. Greg Walden (chairman of the subcommittee) presiding.

Present: Representatives Walden, Terry, Shimkus, Blackburn, Bilbray, Bass, Gingrey, Scalise, Latta, Guthrie, Kinzinger, Upton (ex officio), Markey, Matsui, Barrow, Dingell (ex officio), and Waxman (ex officio).

Staff Present: Ray Baum, Senior Policy Advisor/Director of Coalitions; Michael Beckerman, Deputy Staff Director; Andy Duberstein, Special Assistant to Chairman Upton; Neil Fried, Chief Counsel, C&T; Debbee Keller, Press Secretary; Carly McWilliams, Legislative Clerk; Jeff Mortier, Professional Staff Member; David Redl, Counsel, Telecom; Roger Sherman, Minority Chief Counsel; Shawn Chang, Minority Counsel; Jeff Cohen, Minority Counsel; Sarah Fisher, Minority Policy Analyst; and Pat Delgado, Chief of Staff for Mr. Waxman.

OPENING STATEMENT OF HON. GREG WALDEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Mr. WALDEN. We are going to call to order the Subcommittee on Communications and Technology and open our hearing on "Spectrum to Advance Public Safety, Promote Broadband, Create Jobs, and Reduce the Deficit."

We are here this afternoon for a broad overview on how spectrum can help expand broadband availability, advance public safety, help broadcasters further innovate, create jobs, and reduce the deficit. Spectrum is a critical input for broadcast television, wireless voice and broadband services, and public-safety communications. As a former radio broadcaster and licensed ham radio operator, spectrum is a medium with which I am somewhat familiar. These critical uses of spectrum have shaped the way Americans live, work, and stay connected to their families and the world.

None of the services we enjoy today would be possible without the hard work of the FCC and the NTIA, who manage the commercial and governmental spectrum assets of the American people. The

FCC's commercial-licensing process has evolved over time from lotteries—literally ping-pong balls in a machine like a Mega Millions drawing—to the so-called "beauty contests" of competitive hearings. The FCC has used a number of tools over the years to determine who would receive licenses and for what purposes.

But, in 1993, Congress found a way that not only put spectrum to better use but raises money for taxpayers in the process. Spurred in part by Nobel Prize-winning work of Dr. Ronald Coase and "A Beautiful Mind"'s Dr. John Nash, the Congress to the bold step of reducing the government's role and letting the market decide through government auctions how spectrum should be allocated for commercial wireless services.

Since the FCC began auctions of spectrum for commercial mobile radio services, they have been a resounding success, producing a vibrantly competitive and innovative wireless industry and generating more than $50 billion for the Treasury.

In the last major spectrum auction, which covered the spectrum vacated as part of the DTV transition, Congress allocated 24 megahertz of spectrum for public safety, provided $1 billion for public-safety equipment, and raised nearly $20 billion through auction of spectrum for commercial wireless services. That auction is largely responsible for the 4G wireless broadband services coming on line today.

Today, we will begin discussing how we will get the next wave of spectrum deployed. There is growing consensus we need between an additional 100 megahertz and 300 megahertz in the short term, say, 5 to 10 years, to meet the exploding consumer and economic demand for wireless broadband. Given the staggering growth in smartphone sales, App Store sales, and demand for streaming video content, it is no surprise that the FCC's National Broadband Plan and the President of the United States are calling for an additional 500 megahertz of spectrum to be allocated for wireless broadband use in the next 5 years.

There are a variety of options that could be used in combination to start addressing this need. There are bands of spectrum that are already close to ripe for auction. For example, spectrum in the Advanced Wireless Services band is currently clear. If paired with other spectrums, such as some currently held by government users, that spectrum could be auctioned in the near future.

This raises a related issue. The Federal Government is a major tenant on Federal spectrum. There may be opportunities to make government use more efficient, clear some spectrum for commercial purposes, and use some of the auction proceeds to pay for the cost of relocating the government and improving agency communications facilities. The Commercial Spectrum Enhancement Act is designed to do some of that, but that act could potentially, itself, use some enhancing to make the government clearing process smoother.

There is also the 700 megahertz D block, 10 megahertz of spectrum that was designated for commercial use in the DTV transition. This spectrum is separate from the 24 megahertz already cleared for public safety in the DTV legislation based on recommendations of the 9/11 Commission.

Some advocate allocating the D block to public safety, as well. Others say it should be auctioned to meet our growing commercial wireless needs and that funding, not spectrum, is the key to creating the nationwide interoperable public-safety broadband network that we all seek. Indeed, the auction approach was the central plank of the FCC's National Broadband Plan. That approach enjoyed bipartisan support last Congress in this committee, and I look forward to examining this issue again.

While we are on the topic of D block, I want to thank Senator Gorton and Deputy Chief Dowd for being here today. I think I can speak for all of us when I say we thank you for your commitment to public safety and look forward to a vibrant discussion of the communications needs of America's first responders.

Another potential tool is incentive auctions, in which current FCC licensees can volunteer to relinquish some or all of their spectrum in exchange for a portion of auction proceeds. This can present a win-win-win situation for participating licensees, auction bidders, and the U.S. Treasury.

While broadcast television spectrum holds great potential as a candidate for voluntary incentive auctions, it is by no means the only option. There are many other spectrum licensees who may be willing to participate in incentive auctions. So I look forward to a robust discussion of how incentive auctions could be applied to licensees of all sorts as an economic tool to maximize the value of spectrum to existing licensees, potential bidders, and the Treasury.

While there have been a lot of discussions about innovation in the wireless communications space, innovation is not limited to that industry alone. America's broadcasters continue to work to bring innovative services to over-the-air television viewers. But the broadcasting rules in Title III of the Communications Act are a relic to an era that could not have imagined the technological changes that we have seen in the communications sector.

Could incentive auction legislation help provide capital for broadcasters to explore new-generation services such as mobile DTV and broadband-like broadcast services? Could that legislation help strip regulatory obstacles that are hindering broadcasters' continuing efforts to innovate and bring novel services to the U.S. TV airwaves? Innovation should be encouraged to flourish in every part of the spectrum marketplace.

So I thank all of our witnesses for their participation today, and I look forward to their testimony.

[The prepared statement of Mr. Walden follows:]

Prepared statement of Hon. Greg Walden

We're here today for a broad overview on how spectrum can help expand broadband availability, advance public safety, help broadcasters further innovate, create jobs, and reduce the deficit. Spectrum is a critical input for broadcast television, wireless voice and broadband services, and public safety communications. As a former radio broadcaster and licensed HAM radio operator, spectrum is a medium with which I am somewhat familiar. These critical uses of spectrum have shaped the way Americans live, work, and stay connected to their families and the world.

None of the services we enjoy today would be possible without the hard work of the FCC and the NTIA to manage the commercial and government spectrum assets of the American people. The FCC's commercial licensing process has evolved over time. From lotteries—literally ping pong balls in a machine like a Mega Millions drawing—to the so-called "beauty contests" of comparative hearings, the FCC has used a number of tools over the years to determine who would receive licenses and for what purposes. But in 1993, Congress found a way that not only puts spectrum to better use but raises money for taxpayers in the process. Spurred in part by Nobel prize-winning work of Dr. Ronald Coase and "A Beautiful Mind's" Dr. John Nash, the Congress took the bold step of reducing the government's role and letting the market decide through government auctions how spectrum should be allocated for commercial wireless services.

Since the FCC began auctions of spectrum for commercial mobile radio services they have been a resounding success, producing a vibrantly competitive and innovative wireless industry and generating more than $50 billion dollars for the Treasury. In the last major spectrum auction—which covered the spectrum vacated as part of the DTV transition—Congress allocated 24 MHz of spectrum for public safety, provided $1 billion for public safety equipment, and raised nearly $20 billion dollars through auction of spectrum for commercial wireless services. That auction is largely responsible for the 4G wireless broadband services coming online today.

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This raises a related issue. The federal government is a major tenant on federal spectrum. There may be opportunities to make government use more efficient, clear some spectrum for commercial purposes, and use some of the auction proceeds to pay the cost of relocating the government and improving agency communications facilities. The Commercial Spectrum Enhancement Act is designed to do some of that, but the Act could potentially itself use some enhancing to make the government clearing process smoother.

There is also the 700 MHz D block: 10 MHz of spectrum that was designated for commercial use in the DTV transition. This spectrum is separate from the 24 MHz already cleared for public safety in the DTV legislation, based on recommendations of the 9/11 Commission. Some advocate allocating the D Block to public safety, as well. Others say it should be auctioned to meet our growing commercial wireless needs, and that funding-not spectrum-is the key to creating the nationwide, interoperable public safety broadband network we all seek. Indeed, the auction approach was a central plank of the FCC's national broadband plan. That approach enjoyed bipartisan support last Congress in this Committee. I look forward to examining this issue again.

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Another potential tool is "incentive auctions," in which current FCC licensees can volunteer to relinquish some or all of their spectrum in exchange for a portion of auction proceeds. This can present a win-win-win situation for participating licensees, auction bidders, and the U.S. Treasury. While broadcast television spectrum holds great potential as a candidate for voluntary incentive auctions, it is by no means the only option. There are many other spectrum licensees who may be willing to participate in incentive auctions. I look forward to a robust discussion of how incentive auctions could be applied to licensees of all sorts as an economic tool to maximize the value of spectrum to existing licensees, potential bidders, and the Treasury.

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I thank the witnesses for their participation today, and look forward to their testimony.

# # #

Mr. WALDEN.

With that, I would now recognize the ranking member of the full committee, Mr. Waxman, for an opening statement.

OPENING STATEMENT OF HON. HENRY A. WAXMAN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. WAXMAN. Thank you very much, Mr. Chairman.

From the start of this Congress, we have had a contentious, partisan divide over efforts to overturn the FCC's open Internet order. This kind of partisanship is unusual for this subcommittee, so I look forward to returning to bipartisan efforts to address the numerous communications and technology issues that require our urgent attention.

Spectrum policy is a good place to start. Smart spectrum policy can help improve public safety, promote broadband, create jobs, and reduce the deficit. These aren't easy goals to achieve because the spectrum policy issues are complicated, but if we work together, I believe we can succeed.

One essential task is to provide public safety with a nationwide interoperable broadband network. There are different views on the best way forward. Some want the FCC to auction the D block to a wireless provider and encourage collaboration between the winning bidder and public safety. The FCC's broadband plan recommended this approach, and in the last Congress, bipartisan staff circulated a discussion draft that proposed to implement a number of the FCC's recommendations.

Others want Congress to reallocate the D block to public safety. This approach is favored by public-safety leaders and President Obama and has bipartisan support in the House and the Senate. Both approaches have promise.

With the 10th anniversary of 9/11 fast approaching, we need to settle on a path forward and work cooperatively together to ensure that public safety has what it needs to deploy an interoperable broadband network nationally. And I will work with my colleagues in the House and in the Senate to find the best solution.

Second, we need to determine the best way to implement incentive auctions. I believe incentive auctions are an innovative proposal for using underutilized spectrum to advance public safety, promote broadband, and create jobs.

As noted by 112 economists who wrote to the President in support of incentive auctions last week, quote, "Incentive auctions can facilitate the repurposing of spectrum from inefficient uses to more valuable uses while minimizing transaction costs incurred. Giving the FCC the authority to implement incentive auctions, with flexibility to design appropriate rules, would increase social welfare," end quote.

I recognize some are concerned about whether we can ensure that voluntary actually means voluntary. I am confident we can find a way to avoid unfairly disadvantaging broadcasters in this process, and I appreciate the broadcasters' willingness to work with us to figure this out.

And, finally, we need to examine Federal uses of spectrum resources. The administration deserves credit for directing NTIA and FCC to identify and make available 500 megahertz of spectrum over the next 10 years.

I am glad we are having this important hearing so we can begin our work on these important issues. I look forward to what our witnesses will have to say.

And I want to yield the balance of my time to Mr. Barrow.

Mr. BARROW. I thank the gentleman for yielding.

Today, we begin the important conversation of how best to use spectrum to serve our national interests. Wireless technologies relying on spectrum have become essential to economic growth. And because of the growth in demand for spectrum, we face a spectrum crunch in the next decade. We have to find ways to free up spectrum to meet that demand.

I look forward to discussing incentive auctions with today's panel and how these auctions can be used to free up spectrum and reduce our national debt.

I have introduced a bill, H.R. 911, that authorizes a comprehensive spectrum inventory on how spectrum is being used and gives financial incentives for licensees who relinquish spectrum they are not making good use of.

I understand the FCC is making progress on a spectrum inventory, and I commend them for their efforts.

I look forward to working with my colleagues on this committee to address our spectrum goals.

And I thank the ranking member for yielding me time.

With that, I yield back to Mr. Waxman the balance of my time.

Mr. WAXMAN. I yield back my time.

Mr. WALDEN. The gentleman yields back his time.

Now I would recognize the chairman of the full committee, the gentleman from Michigan, Mr. Upton.

OPENING STATEMENT OF HON. FRED UPTON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Mr. UPTON. Thank you, Mr. Chairman.

As the title of this hearing indicates, spectrum policy can help meet several of our committee's goals: promoting broadband, advancing the communications needs of our public-safety officials, creating jobs, and also reducing the Federal deficit. Today, we begin that discussion to maximize our spectrum resources.

One thing that we will consider is the spectrum allocated in the Federal Government and whether those spectrum bands can be better allocated at both the government and commercial sectors. There is already legislation designed to help relocate government users and provide them with better communications resources to be paid for with auction proceeds from spectrum that they clear. And there may also be ways to make that legislation work better.

There is the 700 megahertz D block, 10 megahertz of spectrum that Congress specifically allocated for commercial use in the DTV legislation. That legislation also gave the public safety a completely separate 24 megahertz block of spectrum to create an interoperable broadband network. And an amendment that I offered added a billion dollars for the purchase of interoperable equipment. For a number of reasons, the D block remains unauctioned and unused today.

The question now is how best to create the interoperable broadband communications network recommended by the 9/11 Commission. Today, we will discuss auctioning the D block as required by current law and as this committee and the FCC favored last Congress, on a bipartisan basis, as compared to recent proposals for reallocating the spectrum to public safety. I look forward to that discussion.

We are also going to discuss incentive auctions as a way to present a win-win-win for existing licensees, potential licensees, and the U.S. Treasury. Such auctions would allow the FCC to share the proceeds from the auction of spectrum that current licensees voluntarily return.

The work we begin today on spectrum issues can help us extend the reach of broadband, meet the needs of public safety, create jobs, reduce the deficit, and allow the economics of the spectrum market to permit innovation to flourish across all spectrum-based services.

I thank our witnesses, the members of this committee, and, particularly, my good old friend, Slade Gorton. I know we had lots of battles in years past in his days in the Senate.

I yield to the vice chair of the subcommittee, Lee Terry.

[The prepared statement of Mr. Upton follows:]

Prepared statement of Hon. Fred Upton

As the title of this hearing indicates, spectrum policy can help meet several of our committee's goals: promoting broadband, advancing the communications needs of public safety officials, creating jobs, and reducing the federal deficit. Today we begin a discussion of ways to maximize our spectrum resources.

One thing we will consider is the spectrum allocated to the federal government and whether those spectrum bands can be better allocated to both the government and commercial sectors. There is already legislation designed to help relocate government users and provide them with better communications resources, to be paid for with auction proceeds from spectrum they clear. And, there may be ways to make that legislation work even better.

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# # #

Mr. TERRY. Thank you, Full Committee Chair and Mr. Walden.

I welcome our witnesses and thank you for testifying and your answers later. It will help us develop a well-balanced spectrum policy.

Any spectrum policy that this committee establishes will play a critical role in bringing interoperable broadband communications to public safety, advancing our exponentially growing appetite for wireless broadband, and, most importantly, reducing our deficit.

I look forward to hearing our witnesses flesh out what the true definition of "voluntary" means. I also look forward to learning more about repacking and some of the concerns associated with relocation.

I also welcome testimony from our witnesses today on the details pertaining to an interoperable public-safety network. Is more spectrum really needed or are efficiencies needed? Should proceeds from an auction be used to help construct a nationwide network or does public safety currently have what it needs to go interoperable?

Those are many questions. I look forward to receiving answers.

I thank the distinguished chairman and yield back my time.

Mr. WALDEN. The gentleman yields back his time.

I now recognize the gentleman from Massachusetts, Mr. Markey, for 5 minutes.

Mr. MARKEY. I thank the chairman.

I ask unanimous consent to enter into the record a letter from 112 economists in support of the incentives auction authority for the FCC.

Mr. WALDEN. Without objection.

[The information appears at the conclusion of the hearing.]

OPENING STATEMENT OF HON. EDWARD J. MARKEY, A REPRESENTATIVE IN CONGRESS FROM THE COMMONWEALTH OF MASSACHUSETTS

Mr. MARKEY. I thank you.

We have moved very quickly from the day when the chairman of AT&T, in 1981, thought 1 million people would have cell phones by the year 2000 to the day where we have spectrum being at the core of the debate that we have in our country for economic growth and for public safety.

In 1993, I was the chair of the subcommittee. We were able to move over 200 megahertz of spectrum, which created the third, fourth, fifth, and sixth cell phone licenses. The first two were analog and charged 50 cents a minute. If you had a brick that you were carrying around, something the size of a brick, you were using it. But, by 1996, we all had a cell phone in our pocket because the four new companies all went digital, dropped their prices to under 10 cents a minute, and that is the year you all put cell phones in your pocket for the first time.

And we are very proud of that on this committee, and it just changed everything. Although, let me be honest with you: The two incumbents, whose names are well-known, weren't happy with that decision.

We have the same kind of choices that we have to make today. And I think the Obama administration's national wireless initiative to make available high-speed wireless services to at least 98 percent of Americans is a tremendously important undertaking. It will spur innovation, create nationwide interoperable wireless services for public safety, while reducing the national deficit by approximately $10 billion.

Spectrum is the oxygen of the wireless ecosystem, so we have to find more spectrum. We have to manage that which we have better, but we also have to find more because of all of the tremendous opportunities which it presents.

And we have to free up TV white space spectrum to enable new technologies like Super Wi-Fi and make new innovative Super Wi-Fi devices available soon. But the broadcasters should do that on a voluntary basis. We have to have a formula here which ensures that that happens.

But at the end of the day, public safety has to be at the core of this. There were two planes that were hijacked in Boston with 150 people from my district and the surrounding districts that flew into the World Trade Center. There was a communications failure on that day. We have to make sure that our public-safety first responders never face another day like they did on 9/11. We have to make sure they have the spectrum they need in order to respond.

I served on the Homeland Security Committee for 6 years working on this issue because I saw what happened and I saw what the casualties were in my own life and in the lives of tens of thousands, millions of others. So we have to be able to accomplish this, to take care of public safety while ensuring that we see the economic growth that we want.

And for the remaining 2 minutes, I yield to the gentlelady from California, Ms. Matsui.

Ms. MATSUI. Thank you, Mr. Markey, for yielding to me.

I would also like to thank the witnesses for joining us today.

There are approximately 270 million wireless subscribers in the United States, and that number is growing. President Obama recently identified the need for increased spectrum in the market. The FCC has said our Nation will soon face a spectrum crisis. There are some estimates that, by 2014, the demand for spectrum will exceed supply.

It is our job to remain focused on getting the spectrum out there, and we should move as quickly as possible. The FCC should have the flexibility to structure and conduct incentive auctions that will truly maximize the economic and social value of the spectrum.

On the issue of public safety, we must provide public safety with interoperable capabilities they need and deserve to protect our Nation during challenging times. As we approach the 10th anniversary of the tragic events of September 11th, it is not acceptable that our Nation does not have a public-safety communications system with a nationwide level of interoperability in place.

While we will debate the merits of how to fund and construct a nationwide public-safety system, we can all agree that we must find a path that provides the funding required to build an interoperable system that fulfills the needs and security of our public-safety goals. We must also do so in a fiscally responsible manner. It will not be easy, but we must get there.

I also believe that spectrum should be preserved for the advancement of technologies, including smart grid and health IT capabilities.

I thank you very much for being here.

And I yield back the balance of my time to Mr. Markey, who may want to use 12 seconds.

Mr. MARKEY. And that would just be to say that we welcome you, Senator Gorton.

As you all know, he wound up on the west coast, but Gorton's of Gloucester is where it originated. So we still have, I think, a lot of things in common that we can work on. And thank you for your service to our country.

Mr. WALDEN. And, with that, I welcome Senator Gorton and your testimony. Thank you for coming today. We appreciate your service on the 9/11 Commission and in the United States Senate, and we look forward to your counsel. Please go ahead.

STATEMENTS OF THE HON. SLADE GORTON, FORMER U.S. SENATOR, MEMBER OF THE 9/11 COMMISSION; DEPUTY CHIEF CHARLES DOWD, COMMANDING OFFICER, COMMUNICATIONS DIVISION, NEW YORK POLICE DEPARTMENT; COLEMAN D. BAZELON, PRINCIPAL, THE BRATTLE GROUP; MARY N. DILLON, PRESIDENT AND CHIEF EXECUTIVE OFFICER, U.S. CELLULAR; ROBERT GOOD, CHIEF ENGINEER, WGAL–TV; JULIAS P. KNAPP, CHIEF, OFFICE OF ENGINEERING AND TECHNOLOGY, FEDERAL COMMUNICATIONS COMMISSION; PETER PITSCH, EXECUTIVE DIRECTOR OF COMMUNICATIONS POLICY AND ASSOCIATE GENERAL COUNSEL, INTEL CORPORATION

STATEMENT OF SLADE GORTON

Mr. GORTON. Mr. Chairman, one minor annoyance of being on your side of the dais for some 18 years was to listen to people read testimony that I had already read and that added very little to the debate. So I will spare you that and hope that you have or will read my written testimony and simply make a handful of points.

And the first of those points is that the nature of this debate has changed profoundly, I believe, just in the course of the last few months. You all are more aware than I am—and I am plenty aware—of the debates that have taken place in this House and the Senate over the course of the last 3 or 4 weeks and continue, and the blood, sweat, and tears that has gone into a continuing appropriation designed to save some $38 billion.

Well, Mr. Chairman, the demand that the D block be turned over for free to public safety would automatically reduce that saving by roughly 10 percent, just the gift of the spectrum itself. To provide the amount of money that local governments think that they need actually to exploit that would very likely take that whole $38 billion and would require a continuing subsidy.

Mr. Chairman, I submit to you, even from this side of the table, that is not going to happen. You are not in this Congress, or I think for several Congresses to come, going to start a major new Federal program of subsidization for this particular purpose. I just don't believe that that is in the cards. That is the first point I want to make.

The second is that the auction of the D block itself will not only bring money into the Treasury, which you can use for one or two things—as I looked through the testimony here, some talk about reducing the deficit, some talk about using that money to help subsidize the public-safety mission. Obviously, it can't be used for both. But the overall economic impacts of that auction will be far greater in the investment that the private sector will make in using the D block spectrum itself. That will be a major investment in better communications in the country. It will meet at least some of the demand, which is huge.

Congressman Markey, I think, talked about that, thousand cell phones. Even 2 or 3 years ago, we could not have imagined the demand for private spectrum that exists in the country today. It will provide better communications for the people of the United States. It will provide jobs. It will provide tax receipts, of course. And the money almost certainly will be better used than it would be if it went through various government agencies for technologies that are often outmoded by the time the governmental process gets them contracted for.

But that does bring us to the other very real need, and that is the need for public-safety agencies and entities. Several of you have mentioned the fact that the 9/11 Commission, on which I served, as one of its recommendations recommended additional spectrum for public-safety entities. That is true.

And a year after the 9/11 Commission was formally dissolved, we got back together again and had the gall, I guess, to give the Congress a report card on how well it had done. I may say that Congress probably adopted more of our commission's recommendations than any other such commission in my lifetime. Nevertheless, at that point, after the first round in 2004, Congress got an F on that score, on new spectrum. But on the second round of 9/11 legislation, that grade went up to a C. Now, that may not be a great grade by any stretch of the imagination, but we were hard graders, and there weren't many elements that got C grades from us at all.

So the recommendation that the 9/11 Commission made for additional spectrum has essentially been carried out by Congress. That doesn't settle the question completely by any stretch of the imagination, but it allows me to be here testifying, as I am, for a much more dynamic solution. And that solution is to go forward with those auctions and allow it primarily, but not exclusively, to the Federal Communications Commission to see to it that that auction and those private sales benefit our public-safety agencies as well.

And on that score, without going into the technicalities, I am convinced that they not only can do it but that it will provide additional spectrum and additional equipment for public-safety entities across the country much more rapidly than will the dead-end street of a huge new Federal program, which, very bluntly, Congress is not going to fund in any event.

[The prepared statement of Mr. Gorton follows:]

TESTIMONY OF HON. SLADE GORTON

on

USING SPECTRUM TO ADVANCE PUBLIC SAFETY, PROMOTE BROADBAND, CREATE JOBS, AND REDUCE THE DEFICIT

before the

SUBCOMMITTEE ON COMMUNICATIONS AND TECHNOLOGY

of the

HOUSE COMMITTEE ON ENERGY AND COMMERCE

APRIL 12, 2011

TESTIMONY OF HON. SLADE GORTON

Good afternoon Chairman Walden, Ranking Member Eshoo and members of the Subcommittee. Thank you very much for this opportunity to appear today to discuss critical issues in spectrum policy. My name is Slade Gorton and I spent 18 years representing Washington State in the United States Senate. During that time, I served, among other positions, on the Commerce Science and Transportation Committee and as the chairman of its Aviation Subcommittee. I also served on the National Commission on Terrorist Attacks Upon the United States, or the "9/11 Commission." The Commission was chartered to prepare a full and complete account of the circumstances surrounding the September 11, 2001 terrorist attacks, including preparedness for and the immediate response to the attacks and was mandated to provide recommendations designed to guard against future attacks. I am testifying today on behalf of the Connect Public Safety Now Coalition.

Federal law requires ten megahertz of valuable spectrum, called the 700 MHz D Block, to be sold to the private sector by auction to provide advanced wireless broadband services for consumers. Our Nation's increasing use of wireless technologies is well documented. As more applications for bandwidth-intensive personal and business use of wireless devices are developed, commercial wireless providers will struggle to keep up with demand. For these reasons, experts estimate that auction of the 700 MHz D Block spectrum is estimated to raise some $3.2 Billion for the federal government.

The Federal Communications Commission, the expert agency on spectrum matters, after careful study, recommended in its *National Broadband Plan* that, consistent with current law, the auction of the D Block for commercial wireless systems. Under the FCC's plan, the 700 MHz D Block spectrum would be used in a public-private partnership, with first responders having access to this commercial spectrum when required. Public safety entities could take advantage of the commercial system, for example, by sharing tower sites when possible and otherwise working with commercial providers. Virtually all non-Bell wireless carriers have urged the FCC to pursue the approach endorsed by the *National Broadband Plan* and expeditiously auction the D Block spectrum.

A coalition of law enforcement and emergency responder agencies proposes that the entire D Block be reallocated for their use and that the federal government furnish, in large part, both the capital investment necessary to implement that reallocation and its long term operation. Substantial additional matching contributions to this funding would be expected from state and local governments. The proposed reallocation of the D Block would be on top of the 700 MHz spectrum that public safety already holds and on top of the spectrum that public safety holds in other spectrum bands.

This is the issue before you.

There can be little doubt that our first responders must have the spectrum resources they need. On September 11, paramedics, police and firefighters rushed into the World Trade Center's twin towers without the technology they needed to communicate with each other and navigate the horrific conditions they confronted. Our nation's inability to provide first responders with the tools necessary to communicate during that crisis was inexcusable, and it was part of the impetus for the formation of the 9/11 Commission.

Giving public safety the D Block, however, will provide no additional service unless it is accompanied by what first responders really need -- funding -- to build and operate a new public safety network. When the public safety community first voiced its desires for the D Block, it was at least conceivable that the federal government might not only reallocate the spectrum as requested, but that it would defray a substantial portion of the capital cost of its development, and perhaps of its continuing operation.

I put it to you that at the present time, and for probably for at least the next decade, there is not the slightest chance of such a large new federal program being funded, and that state and local governments, almost all of which are equally constrained, will be unable to make such investments on their own or even provide matching funds for a non-existent federal grant program. The FCC estimates that it would take between $34 billion and $47 billion to build and operate a ten megahertz nationwide public safety network over the next ten years. As a consequence, such a reallocation is likely to leave the spectrum in question largely unused for an extended period of time.

The FCC's plan to auction the D Block is a better approach both for public safety and for American public generally. The funds received from an auction of the D Block could be used to begin to pay for the build out of the spectrum that first responders have already been allocated if Congress were to determine that to be a higher priority than reducing the deficit. In any event, in a public-private partnership, public safety can take advantage of the extensive infrastructure that will be built by a commercial system. As a recent study submitted to the FCC by the former Chief Technical Officer of Motorola showed, the technology is available today to assure that public safety communications can have priority access on a commercial 700 MHz network customized to meet local public safety command, control and coordination requirements. A public-private partnership will also foster the development of a more robust market for public safety handsets, which are now more expensive and less technologically advanced than the wireless handsets that you and I use. A public-private partnership will also result in public safety having access to 700 MHz spectrum *now*. On the other hand, a public safety-only network would take years to develop even if the massive desired public subsidies were available.

The American public will benefit from a sale of the D Block because it will help our economy in at least four ways. *First,* the auction revenues will help reduce our soaring deficits. *Second,* the use of this spectrum for commercial systems will result in a large private sector investment in the spectrum, providing both American jobs and a higher quality of personal and business communication. The wireless industry already provides 2.4 million American jobs and making additional spectrum available will create even more jobs. Those jobs will appear in many sectors of our economy – sales and service, technology development, system design, operation and maintenance, just to name a few. *Third,* the public private partnership will eliminate at least some of the need for public funding to build a public safety network. *Fourth,* the commercial use of the D Block will support the continued growth of entire industries – e-commerce, for example – that rely on communications capacity in general and increasingly on wireless communications capacity in particular. Private sector investment in the D Block, and the attendant competition among communications companies that it will engender, will also allow new, better and less expensive services to be provided to more people and companies, obviously including public safety entities.

In sum, the FCC's own preferred alternative, the auction of the D Block to the private sector, will reduce the deficit, empower huge investments in new technology and job creation, and will meet the very real needs of our vital public safety sector.

Thank you again for the opportunity to testify. I appreciate your interest and focus on these important and timely issues. I would be happy to answer any questions.

Mr. WALDEN. Senator, thank you very much for your testimony, both prepared and your oral. Thank you very much.

We are going to go now to Deputy Chief Charles Dowd, Commanding Officer, Communications Division, New York Police Department.

Deputy Chief Dowd, thank you for being with us. Thanks for your service to the people of New York and to America. And on 9/11, we were all New Yorkers. And I welcome your testimony today.

STATEMENT OF CHARLES DOWD

Mr. DOWD. Thank you, Mr. Chairman, Congressman Markey. It is a pleasure to be here again.

Unlike the Senator, who is far more experienced at this, I am going to read my testimony.

Again, thank you for the opportunity to testify today. Let me begin by expressing gratitude to Representatives Peter King and Bennie Thompson for their bipartisan effort that has resulted in the introduction of H.R. 607, the "Broadband for First Responders Act of 2011," and, as well, to Senator Jay Rockefeller introducing Senate bill, S. 28, the "Public Safety and Wireless Innovation Act."

Due to their efforts and the cosponsors on both bills, we are closer than ever to providing our Nation's first responders with a tool they desperately need: a nationwide, mission-critical broadband network dedicated to public safety. We are also grateful for the President's support on this vital issue. However, we are missing one essential element to accomplishing this goal. We need the support of the members of this subcommittee to get this legislation passed.

I come to Washington today not only on behalf of the New York City Police Department but as the representative of every public-safety organization and agency in the country and the over 32,000 law enforcement, fire, and emergency medical chiefs whose agencies and lifesaving operations will benefit enormously from this technology. We consider it essential to the future of our mission. The need to reallocate the D block spectrum to public safety is a view shared by agencies large and small, urban and rural, across the country.

Like virtually all public-safety organizations, the New York City Police Department relies principally on two-way voice radios to communicate. This technology is extremely limited. It cannot exchange electronic data or video. We have made some progress in radio interoperability since the 9/11 attacks, but disparate spectrum and aging technologies prevent first responders from attaining truly nationwide, seamless, interoperable communications. Broadband on 700 band spectrum would allow us to be seamlessly interoperable on all levels: local, State, and, very importantly to this issue, Federal.

Police Commissioner Ray Kelly recently testified that a 16-year-old teenager has more communications capability on a smartphone than a police officer or firefighter with their portable radio. I hope the members of this subcommittee consider that fact and agree that this situation cannot continue. Inaction on D block's reallocation risks not only the public's safety but also the lives of those whose job it is to protect them.

Two weeks ago, the co-chairs of the President's 9/11 Commission, Governor Tom Kean and Congressman Lee Hamilton, testified before Congress about first-responder needs. Their testimony in part was, and I quote, "The inability of first responders to communicate with each other was a critical failure on 9/11 that led to needless loss of life. We support the immediate reallocation of the D block spectrum to public safety. We must not approach these urgent matters at a leisurely pace. We don't know when the next attack or disaster will strike. Further delay is intolerable."

A number of recent studies, some of which I would like to submit for the record—there are four of them—have proven the need for public safety to have a 20 megahertz block of spectrum for a broadband network. New York City issued a white paper based on throughput analysis of its current NYCWiN network that identified the need for more than 10 megahertz. A report commissioned by the Government of Canada for public safety indicated spectrum need would exceed 20 megahertz in the long term. A study by the Phoenix Center in Washington found that assigning the D block to public safety provides at least $3.4 billion more in social benefits as opposed to an auction. And, lastly, several papers by Mr. Andrew Seybold, a nationally recognized expert, concluded that 10 megahertz is not enough.

[The information appears immediately following Mr. Dowd's prepared statement.]

Mr. DOWD. For some time now, we in public safety have stated we want to be as spectrally efficient as possible. We know that the flexibility of broadband technology allows for potential use of the network by other governmental agencies, public utilities, as well as public-private partnerships that could bring broadband technology to the public in underserved rural areas.

The efficiencies of such a network would dramatically reduce operating costs for local and State governments, while maintaining the public-safety mission-critical nature of the network. We have agreed to use commercial technology that will allow us to take advantage of the economies of scale.

We are also prepared to work with the FCC to study the feasibility of returning currently held public-safety spectrum if sufficient broadband spectrum is allocated to us. We understand the current fiscal realities, but the need for the network, coupled with the cost savings, means we simply cannot afford not to build it.

Some have made the argument that reallocation is not necessary because public-safety communications can use commercial networks. You should know that every major public-safety organization in the country has explicitly rejected this option as unworkable. Our experience with commercial networks and especially the failures that sometimes occur, like on 9/11 and during Hurricane Katrina, tell us these networks are definitely not interchangeable with dedicated public-safety networks. There are fundamental differences in the architecture that go to the heart of public-safety communications. Simply put, commercial networks are not designed for the crisis demand that first responders will inevitably put on them.

A dedicated public-safety network would enable the NYPD to fully leverage the powerful technology that we use in the NYPD's

Real Time Crime Center. This state-of-the-art facility is a massive database containing billions of public and classified records. We have made these databases searchable with the latest smartware. Twenty-four hours a day, detectives call from investigations in the field, looking to follow up on various leads they have obtained: a partial license plate, a seemingly untraceable cell number, a nickname, or even a tattoo. They conduct instant searches, sometimes that would previously take us days.

Now we are looking to put this technology in the hands of thousands of officers on patrol. An officer operating in this network could be sent highly detailed information about a location to which he or she is responding, even before those officers arrive. They will be able to know who resides there, whether or not the police have been there before and why, if any of the occupants has an outstanding warrant, prior arrest, an order of protection, or a firearms license. They will be able to take electronic fingerprints at the scene and compare those records instantaneously with State and city records.

There are other examples here, but, in the interest of time, I am going to skip ahead and just say, right now these capabilities simply don't exist, and they don't exist because we need Congress to reallocate the D block and provide the necessary funding to public safety to build this hardened mission-critical network.

With the 10th anniversary of 9/11 rapidly approaching, we urge the Congress in the strongest possible terms to pass the above legislation and send it expeditiously to the President for his signature. The City of New York Police Department looks forward to the day when public-safety users can share a nationwide network that supports voice, video, and data on an integrated wireless network. For the sake of the security of cities and towns all across the country, we sincerely hope we see that day before a new attack or disaster.

Thank you for the opportunity. I will answer any questions that you may have.

[The prepared statement of Mr. Dowd follows:]

DEPUTY CHIEF CHARLES DOWD
COMMANDING OFFICER, COMMUNICATIONS DIVISION
NEW YORK CITY POLICE DEPARTMENT

TESTIMONY ON USING SPECTRUM TO ADVANCE PUBLIC SAFETY, PROMOTE BROADBAND, CREATE JOBS, AND REDUCE THE DEFICIT

BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON ENERGY AND COMMERCE
SUBCOMMITTEE ON COMMUNICATIONS AND TECHNOLOGY

TUESDAY, APRIL 12, 2011

Chairman Walden, Congresswoman Eshoo, members of the Committee. Thank you for this opportunity to testify.

Let me begin by expressing our gratitude to Representatives Peter King and Bennie Thompson for their bipartisan effort that has resulted in the introduction of House Bill H.R.607, the "Broadband for First Responders Act of 2011," and to Senator Jay Rockefeller for introducing Senate Bill S.28, the "Public Safety & Wireless Innovation Act." Due to their efforts and the co-sponsors on both Bills, we are closer than ever to providing our nation's first responders with a tool they desperately need: a nationwide mission-critical broadband network dedicated to public safety. We are also very grateful for President Obama's support for this vital issue. However, we are missing an essential element in accomplishing this goal -- we need the support of the members of this Subcommittee to get this legislation passed.

I come to Washington today not only on behalf of the NYPD, but as the representative of every public safety organization and agency in the Country, and the over 32,000 law enforcement, fire, and emergency medical chiefs, whose agencies and life-saving operations will benefit enormously from this technology. We consider it essential to the future of our mission. The need to reallocate the D block spectrum to public safety is a view shared by agencies large and small, urban and rural, across this country.

Like virtually all other public safety organizations, the New York City Police Department relies principally on two-way voice radios to communicate. This technology is extremely limited. It cannot exchange electronic data or video. We have made some progress on radio interoperability since the 9/11 attacks, but disparate spectrum and aging technologies prevent first responders from attaining truly nationwide seamless interoperable communications. Broadband on 700 band spectrum would allow us to be seamlessly interoperable on all levels, local, state, and federal.

Police Commissioner Raymond Kelly recently testified that a 16 year old teenager has more communications capability on a smartphone than a police officer or firefighter. I hope that Members of this Subcommittee consider this fact and agree that this situation cannot continue. Inaction on D Block reallocation risks not only the public's safety but also the lives of those whose job it is to protect them.

Two weeks ago, the Chairmen of the President's 9/11 Commission, Governor Thomas Kean and Congressman Lee Hamilton, testified before Congress about first responder needs. Their testimony was in part, and I quote:

> The inability of first responders to communicate with each other was a critical failure on 9/11 [that] led to needless loss of life . . . . We support the immediate allocation of the D-block spectrum to public safety. We must not approach these urgent matters at a leisurely pace. We don't know when the next attack or disaster will strike. Further delay is intolerable.

A number of recent studies have clearly proven the need for public safety to have a 20 mhz block of spectrum for a broadband network: the City of New York issued a white paper based on throughput analysis of the City's NYCWiN network that identified the need for more than 10 mhz; a report commissioned by the Government of Canada for public safety indicated that the spectrum need would exceed 20 mhz in the long-term; a study by Phoenix Center in Washington, D.C. found that assigning the D block to public safety provides at least $3.4 billion more in social benefits as opposed to an auction; and lastly, several papers by Mr. Andrew Seybold, a nationally recognized expert in the field, concluded that 10 mhz of spectrum is simply not enough.

For some time now we in public safety have stated that we want to be as spectrally efficient as possible. We know that the flexibility of broadband technology allows for the potential of network use by other governmental agencies, public utilities, as well as public/private partnerships that could bring broadband technology to the public in underserved rural areas. The efficiencies of such a network would dramatically reduce operating costs for local and state governments while maintaining the public safety mission-critical nature of such a network. We have agreed to use commercial technology that will allow us to take advantage of the economies of scale. We are also prepared to work with the FCC to study the feasibility of returning currently-held spectrum if sufficient broadband spectrum is allocated to us. We understand the current fiscal realities, but the need for the network coupled with the cost savings means we simply can't afford not to build it.

Some have made the argument that reallocation is not necessary because public safety communications can use commercial networks. You should know that every major public safety organization in the country has explicitly rejected this option as unworkable. Our experience with commercial networks, and especially the failures that sometimes occur, like during 9/11 or Hurricane Katrina, tells us these networks are definitely not interchangeable with dedicated public safety networks. There are fundamental differences in the architecture that go to the heart of public safety communications. Simply put, commercial networks are not designed for the crisis demands that first responders inevitably will put on them.

A dedicated public safety network would enable the NYPD to fully leverage the powerful technology that we use in our Real Time Crime Center. This state-of-the art facility is a massive database containing billions of public and classified records. We've made this database searchable with the latest smartware. Twenty-four hours a day, crime center detectives take calls from investigators in the field, looking to follow up on various leads they've obtained: a partial license plate, a seemingly untraceable cell phone number, a nickname, or even a tattoo. They conduct instant, on the spot searches, something that previously could take days.

Now, we are looking to put this technology in the hands of thousands of officers on patrol. An officer operating on this network could be sent highly detailed information about a location to which he or she is responding. Even before those officers arrive, they will be able to know who resides there;

whether or not the police have been there before and why; if any of the occupants has an outstanding warrant, prior arrests, an order of protection, or a firearms license. They will be able to take electronic fingerprints at the scene and compare these instantaneously with city and state records.

To give you one example, as part of our response to the attempted car bombing in Times Square last May, we deployed a robot to inspect the vehicle. As is the case with all of our robots, it was controlled by its operator through a thin, fiber-optic cable. Our need to maneuver around fire hoses and other obstacles on the street increased the risk that the cable would be run over and severed. If that had happened, we would have lost control of the robot. With a dedicated broadband network, we could operate multiple robots simultaneously and share video and data with other local, state, and federal law enforcement.

Right now, these capabilities do not exist. But they will if Congress reallocates the D block and provides the necessary funding to build this hardened, mission critical network.

With the tenth anniversary of the 9/11 attacks rapidly approaching, we urge the Congress in the strongest possible terms to pass the above legislation and send it expeditiously to the President for his signature. The New York City Police Department looks forward to the day when public safety users can share a nationwide network that supports voice, video, and data on an integrated wireless network. For the sake of the security of cities and towns all across this country, we sincerely hope we see that day before a new attack or disaster.

Thank you again for this chance to testify. I would be pleased to answer any of your questions.

Report for the TETRA Association

Public safety mobile broadband and spectrum needs

Final report

8 March 2010

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1 Executive summary

This is the final report of a study conducted by Analysys Mason Limited ('Analysys Mason') for the TETRA Association, to undertake a review of future mobile broadband needs for public safety mobile communications, and how these needs might be addressed.

For the purposes of this report, the term 'public safety' is assumed to comprise primarily police, fire and ambulance services, although the requirements are also considered to be applicable in a wider Public Protection and Disaster Relief (PPDR) context.

The majority of public safety users in Europe currently use dedicated radio networks for their mobile communications that have been designed specifically to meet their needs, typically using digital mobile communications technologies such as TETRA or TETRAPOL and operating in spectrum in the 380–400 MHz band. These networks offer a range of low rate data services, but the speed and capacity that is available within those networks limits more widespread use of higher-speed data applications.

In line with societal trends for access to information on the move, public safety operations are becoming increasingly information-driven, requiring access to a wider range of wideband and broadband applications. These range from high-quality imaging to uploading and downloading of large data files, and real-time video.

Given the limitations in capacity of existing dedicated networks to deliver mobile broadband services, it is considered likely that a new generation of solution will be required across Europe in the next five to ten years, to meet future public safety user demands. This new solution, if delivered using new dedicated mobile broadband networks that are designed to meet public safety requirements, will require additional spectrum to deliver the services required.

In order to define the benefits of the development of a new generation of dedicated mobile broadband networks for public safety, and to support the identification of additional spectrum to meet future needs, the TETRA Association has commissioned Analysys Mason to undertake this study to gather information on future public safety user requirements, based on a review of existing documents and reports that have been published in Europe over the past few years and are available in the public domain.

We have reviewed each of the documents (listed in Annex B), with a view to determining:

- the future mobile data and multimedia applications that are envisaged to be in widespread use within the public safety sector over the short and medium term
- the network requirements that are associated with these applications, i.e. the operational requirements of mobile communications networks that will meet public safety user requirements

- the benefits to the public safety sector of the development of a next-generation of dedicated mobile data networks (requiring additional, dedicated spectrum to deliver), compared to the alternative options such as re-engineering of existing or planned commercial networks in Europe.

The authors of this report would like to thank the TETRA Association for their inputs to this study and identification of the relevant documents and reports that have formed the basis of the study's recommendations.

1.1 Summary of applications and user requirements

Current and future public safety mobile data and multimedia applications identified in the various reviewed documents cover a range of needs, including:

- mobile office
- transfer of images
- biometric data
- automatic number plate recognition
- digital mapping and location services
- remote database access
- personnel monitoring
- sensor devices/networks
- remotely controlled devices
- non-real-time video
- real-time video.

Summary of operational requirements essential to public safety mobile communications

The reviewed documents make reference to a number of specific operational requirements that are essential for public safety mobile communications, in order to ensure the availability, reliability and integrity of networks. These include:

- high levels of network availability
- high degree of network control, including the ability to implement prioritised access for specific user groups or individuals, and to reserve capacity where required
- near nationwide geographic coverage, including the ability to communicate in remote areas
- security
- low latency, specifically end-to-end voice delay of no more than 200 milliseconds
- interoperability between different public safety authorities and across borders
- highly resilient networks, including various layers of redundancy
- ability to support mixed traffic.

1.2 Summary of evolution of applications in the public safety sector

There are number of key trends apparent within the daily routines of public safety users, as well as in improved responsiveness at major planned and unplanned events, which are affecting the public safety sector's future mobile data requirements:

- ways of working are changing
- data is being used to enhance voice
- command and control is moving from command centres to the field
- there is greater awareness and use of multimedia.

These trends have been used to develop four alternative evolution paths to illustrate how future use of mobile data and multimedia applications might develop within the public safety sector, as summarised below in Figure 1.1.

Evolution path	*Description*
Steady growth	Working methods change slowly, and voice remains the dominant method of mission critical communication. Existing data applications continue to be used alongside this, with a gradual increase in use.
Data enhances voice	Incident response increasingly relies on situational awareness provided through a range of data applications on the move, and access to a range of faster data applications that can be used in a similar net-centric fashion to that of group-based voice calls (i.e. group sharing and exchange of data).
Information driven	A common operating picture is established at incident scenes through use of mobile command centres alongside central command units, and sharing of information (including voice, text, images, data and video) between the two. This drives requirements for real-time uploading and downloading of information (images, data) between field and control rooms, including use of video conferencing and other on-demand video services to aid communications and incident response.
Full multimedia reliance	A diverse range of mobile broadband applications, including high-quality imaging and real-time video applications take off, with widespread use across the public safety sector. Widespread information sharing improves the establishment of common operating pictures at incidents, facilitates real-time decisions at incidents, and enables the introduction of new video services such as remote medical applications, and personal characteristics recognition.

Figure 1.1: Evolution paths to illustrate alternative views of how future usage might evolve [Source: Analysys Mason]

Our assessment of the implications arising from each of the evolution paths in terms of future network requirements is summarised in Figure 1.2 below.

Evolutionary path	*Outcome*	*Implications*
Steady growth	Minimal changes to existing operational practices, and limited scope to achieve greater efficiencies and responsiveness through new ways of working.	Public safety users will require longer-term retention of existing dedicated networks to meet voice, narrowband and wideband data functionally, however these will be insufficient to meet future mobile broadband needs. This will constrain the development of new working methods and use of a wider range of data and multimedia applications. Limited additional sector-wide benefits are gained through migration to better, faster and more responsive ways of working, but overall growth in data usage is limited by network constraints.
Data enhances voice	Public safety users benefit from significantly greater situational awareness at incident scenes, through sharing and exchange of a range of data and images. Security of data transfer becomes increasingly significant, which limits the usefulness of commercial networks to carry sensitive data traffic.	Existing dedicated narrowband and wideband networks will be insufficient to accommodate the volumes of data traffic that will occur in everyday use. Commercial networks are not deployed to meet the operational requirements for mission-critical data applications, such as secure data transfer, nationwide coverage, guaranteed availability and control. This supports the need for a new generation of dedicated mobile broadband network designed to meet the operational needs of mission critical data.
Information driven	Mobile officers and those in command centres have access to a common picture of incident operations, facilitated by sharing of data, images and other information. This improves decision making, responsiveness and the ability of public safety officers to work in crisis situations, as well as to respond to everyday incidents. Applications such as fingerprint recognition, licence plate recognition, and access to criminal records can all be conducted remotely, in real time.	The need for data applications to be delivered over networks that ensure high availability, resilience and secure communication, and are as reliable as existing TETRA/TETRAPOL voice networks, is increased as a result of the need to access a wider range of applications from anywhere, at any time. Networks must be capable of mobile broadband information upload and download. The need for a more extensive range of mobile applications therefore requires capacity enhancement, similar to the "data enhances voice" path, which will be beyond the capability of existing dedicated networks.
Full multimedia reliance	New ways of working are implemented across the public safety community. A new generation of situational awareness applications are used in daily response as well as for major incidents. Public safety users are able to operate more efficiently, making better use of resources and reducing unnecessary travel. Real-time video is widely used – for example, video calls between mobile command and central command units, real time CCTV image transfer, and remote medicine applications.	With the evolution in data and multimedia applications, and the requirement for those applications to be available over a very wide area (to make applications such as remote telemedicine feasible), existing narrowband and wideband networks will have insufficient capacity and functionality to meet the requirements of this evolutionary path. Similarly, there are limitations in use of commercial networks due to a lack of full geographic coverage, capacity and ability to carry secure data. This evolutionary path therefore requires the development of a new generation of dedicated mobile broadband networks to deliver more network capacity, higher bitrates and a wider range of applications.

Figure 1.2: *Impact of different paths on future network requirements [Source: Analysys Mason]*

1.3 Summary of options to meet public safety's evolving requirements

It appears that the capabilities of existing narrowband and wideband dedicated mobile networks currently used by the public safety sector will not be sufficient to meet future requirements under three of these four evolution paths. The only evolution path that could be accommodated by existing networks is the "steady growth" path. However, this is not sustainable in the longer term since there is already growing evidence of changes in working methods and trends within the public safety sector that suggest that this path will not match future demands.

A summary of the four alternative evolution paths and their impact on network requirements is provided in Figure 1.3 below.

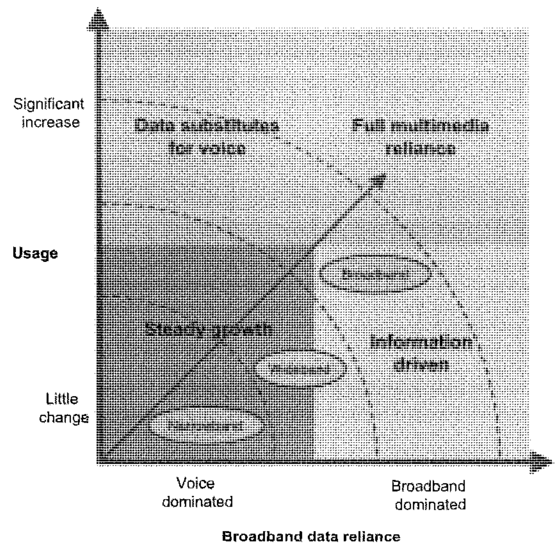

Figure 1.3: The four alternative evolution paths and their impact on network requirements [Source: Analysys Mason]

The four evolutionary paths indicate that a new generation of mobile broadband service is required to accommodate the range of future data, image and multimedia applications that public safety users will demand. The options for delivering this new generation of services are to make use of upgraded commercial networks (e.g. using HSPA+/LTE technology, with network deployment modified to meet the specific operational requirements of the public safety sector), or to develop a new generation of dedicated mobile broadband networks for exclusive public safety use.

While the new generation of data service could theoretically be delivered through upgrading and re-engineering commercial networks, the reviewed documents suggest that this might not be achievable in practice, based on a number of reasons, which range from technical limitations through to cost and commercial considerations.

In particular, there are a number of reasons why commercial operators might be unwilling to make the necessary network changes to support public safety operational needs:

- the public safety sector requires very extensive geographic coverage as well as in-depth coverage penetration inside buildings, irrespective of location, which does not match the typical roll-out requirements of a commercial network
- it is likely to be very expensive to re-engineer commercial networks to achieve all of the public safety sector's operational requirements, and there are questions about whether sufficient incentives exist for commercial operators to do this. For example, typically requirements include the need for battery back-up to be available at thousands of base station sites across the network, and for networks to be designed to ensure that they are highly resilient (including overlapping coverage, standby power supplies and fallback sites) and that no single 'point of failure' exists either in access or core networks
- there are questions about whether some of the public safety requirements are actually achievable
- there is a question about whether the required Grade of Service for public safety use can be guaranteed within a network shared with commercial users, particularly in times of very high traffic loading
- there are conflicting views on whether signalling could be encrypted over the air interface in 3G/LTE
- ensuring the specific requirements for carriage of 'restricted' or 'confidential' documents requires careful network planning and approvals, which is complex and costly to achieve
- it is not clear that networks can be dimensioned to achieve the required immediacy and guaranteed access that public safety requires.

In addition, the reviewed documents presented a further range of reasons why public safety users have been reluctant to make more widespread use of existing commercial networks, and have favoured the development of their own dedicated networks. These include the following.

Coverage	Commercial operators typically invest in coverage where populations exist, and capacity is designed to maximise revenue generation in those areas, with little incentive to invest in areas of low-density population. Public safety, by contrast, requires ubiquitous coverage across a country's geography for everyday use, irrespective of population densities.
Network design	Re-engineering of commercial networks to meet public safety's requirements might be feasible in theory, but in practice would result in large parts of the commercial network being heavily over-engineered. This is likely to be more costly for the public sector to fund than a dedicated network provisioned to meet the specific coverage and capacity needs of the public safety user based, without having to provision for additional commercial traffic.
Sabotage	There is a view that commercial networks might be more vulnerable to sabotage by criminals that dedicated networks are, if the network is known to be used for public safety communications. Dedicated public safety networks are typically more guarded against sabotage through a range of specific measures (e.g. vetted staff, secure fencing at sites, and networks designed to ensure no single point of failure in the event of sabotage, etc.).
Rollout schedules	There are precise requirements for the roll-out of public safety networks (e.g. the need to align with police/fire/ambulance area boundaries), which do not match typical commercial roll-out strategies.
Risks of shared use	There are risks such as information security, quality of service and control of service level agreements if public safety users share networks with commercial users, which previous experience suggests can be avoided through use of dedicated networks under government control and supervision.
Reliance on commercial operators	There is a reluctance for public bodies to be reliant on a fully commercial operator, in view of the potential lack of control upon future network investment, business plans and financing[1].

1.4 Conclusions

The study has found that, in line with societal trends evident within today's Information Society, a diverse range of data, imaging and multimedia applications are in demand within the public safety sector. Demand for access to a wider range of information is being driven by changes in working practices, which is creating requirements for access to a far wider range of data sources (textual, images and video) that is typical in commercial mobile networks. Sharing of various data types (textual, images, video, etc.) is being used in order to establish and maintain a common operational picture between agencies and between field and central command staff. This is being used to improve responsiveness, aid the deployment of resources, and improve timeliness and decision making in daily public safety operations and when responding to major planned or unplanned events.

Three of the four evolutionary paths developed for this study illustrate the public safety sector's need for a next generation of mobile broadband network to deliver the range of applications that are envisaged in the future. As there is a limit to the range and volume of data and multimedia applications that existing dedicated narrowband and wideband networks, and existing commercial

[1] This is referenced, for example, in ETSI TR 102 628 (SRD on additional spectrum requirements for future PSS wireless communication systems in the UHF frequency range, which refers to specific conditions in place in a number of European countries

networks, can provide, if a new generation of mobile broadband network is not made available, some new applications cannot be delivered. Ultimately, this will affect how already emerging changes to ways of working within the public safety might evolve, and, in the longer term, constrain the further development of the sector.

A new generation of services could in theory be delivered using an upgraded commercial network, with the deployment of the network engineered to meet specific public safety requirements. However, as explained in Section 6.2, this option does not appear to be achievable in practice. The only other option is to encourage industry to develop a new generation of mobile broadband networks for dedicated public safety use. To enable the industry to devote the necessary investment to develop new dedicated networks, there is a need for additional spectrum to be identified, since existing bands are already fully utilised by existing dedicated public safety systems. It should be noted that identifying suitable spectrum is on the "critical path" to support development of a new generation of dedicated mission critical mobile broadband solution, because of the timescales associated with identifying suitable spectrum.

This additional spectrum demand is based upon the combination of the various factors identified throughout this report, specifically:

- trends in the range of data and multimedia applications in demand within the public safety sector
- potential increase in user densities and intensity of use for data applications
- specific traffic characteristics of public safety operations (e.g. network-centric ways of working)
- the infrastructure and technical requirements to meet the operational requirements of the public safety community (e.g. availability, security, reliability, latency), and limitations in use of commercial networks to deliver these.

Given the cost of deploying new networks, access to spectrum in bands below 1GHz will ensure maximum commonality with existing dedicated networks deployed in the 380–385/390–395MHz bands, facilitate re-use of assets where possible (e.g. radio sites). Use of spectrum above 1GHz (e.g. bands around 2 GHz) might be feasible but would incur significantly higher roll-out costs compared to that below 1GHz, raising questions at national government level as to whether and how the additional costs can be funded.

Based on the reviewed documents, the European dimension to the public safety spectrum requirement is important for a number of reasons:

- the public safety sector is a niche market and therefore benefits from the identification of harmonised spectrum even more than commercial mobile systems (e.g. GSM or UMTS), because of the smaller user base and resulting lower volumes of equipment and terminals

- even if commercial solutions are adapted to meet specific requirements of a niche sector such as public safety, there are still costs involved in the necessary modifications, and therefore harmonised spectrum availability is key to ensure that manufacturers are able to develop products for a European market. An example of the re-engineering of existing commercial standards to meet niche requirements is that of GSM-R (the railways version of GSM) – although the GSM standard is supported by all major vendors around the world, GSM-R equipment is supplied by relatively few and the availability of harmonised spectrum for the product has therefore been important to reduce costs

- interoperability is an increasingly important requirement within the public safety sector, both to communicate between different public safety authorities within a country, and to communicate across borders. This is evidenced by a number of the documents reviewed for this study.

The lack of available spectrum is therefore a significant barrier to the further development of mobile communications capabilities tailored to meet public safety requirements, until such time as a new, harmonised band can be identified at a European level.

2 Introduction

This report has been prepared by Analysys Mason Limited ('Analysys Mason') on behalf of the TETRA Association, to present the results of a study to review the future needs and requirements for mobile data and multimedia applications within tbe public safety sector.

For the purposes of this report, the term 'public safety' is assumed to comprise primarily police, fire and ambulance services, although the requirements are also considered to be applicable in a wider Public Protection and Disaster Relief (PPDR) context.

The public safety sector uses a variety of communications networks at present, including a range of fixed voice and data systems within headquarters (HQ), and digital mobile networks while on the move. The majority of public safety users in Europe use dedicated radio networks for their mobile communications that have been designed specifically to meet their needs, typically using TETRA or TETRAPOL digital mobile communications technologies and operating in spectrum in the 380–400 MHz band.[2] This is the frequency band identified at a European level for digital public safety communications as a result of ERC/DEC/(96)01 and subsequent decisions.

While the public safety sector has traditionally relied on voice communication as its primary means of communication at incidents, making particular use of group calls, as well as Direct Mode Operation (DMO) and air to ground voice communications, the requirements for access to a range of mobile data applications have evolved over recent years and are now considered to be an essential part of the public safety sector's mobile communications. This is evidenced, for example, by the dependency on applications such as automatic number plate recognition (ANPR) and access to various databases by police while on the move.

The public safety sector currently has two options to address the use of a wider range of data applications:

- to upgrade existing narrowband networks to provide a wideband overlay (e.g. TEDS), providing wideband data capability
- to continue to make use of existing dedicated networks for mission critical voice and low speed data, and use commercial networks to deliver higher bandwidth, non-mission-critical[3] data.

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2 In many countries in Europe, public safety users also make use of existing commercial networks (e.g. GPRS or 3G) in addition to dedicated TETRA/TETRAPOL networks. Commercial networks are often used for the provision of additional vehicle and handheld data services, typically of a non-mission critical nature. This is because commercial networks are not designed to meet the specific functional requirements for mission-critical public safety communications, which requires very high levels of network availability, low latency, very wide area coverage and various levels of security and encryption.

3 "Mission-critical" refers to a service or information for which failure to deliver, disruption or delay is not tolerable in view of its impact on public safety operations.

However, neither of these options is envisaged to meet public safety requirements in the future, since there is a need for a mobile broadband solution that can deliver mission critical high speed data, requiring a network that is designed to meet the specific operational requirements of the public safety sector. Underpinning support for the development of a next-generation of mission critical mobile broadband solution is the identification of suitable spectrum to deploy future systems. This is required because the existing spectrum available for public safety mobile communications is already fully deployed to accommodate today's narrowband and wideband networks.

The TETRA Association has therefore commissioned this study to provide an assessment of future public safety user needs, which will determine future spectrum requirements. Since much of the required information on future public safety needs exists in a range of documents and reports that have been published in Europe over the past few years, the scope of this study has not been to conduct new research into potential future user requirements, but rather to summarise the requirements that are already known to exist through a review of the existing documents.

The remainder of this document is laid out as follows:

- Section 3 describes our overall approach to the study.
- Section 4 reviews the current and future requirements and needs of the public safety sector
- Section 5 considers alternative trends of how public safety needs might evolve
- Section 6 presents the results of our analysis, in terms of options to meet future public safety requirements
- Section 7 presents our conclusions from the study.

The report includes a number of annexes containing supplementary material:

- Annex A provides a list of the acronyms used in this document
- Annex B provides the list of documents that have been reviewed as part of this study
- Annex C includes a summary of our review of each document.

3 Approach to the study

The overall approach to the study is summarised in Figure 3.1 and a brief description of each task is provided below.

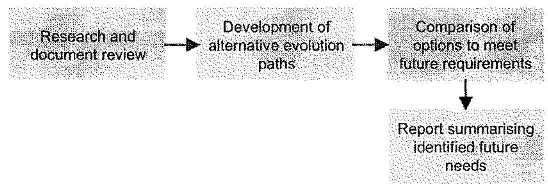

Figure 3.1: Approach to study [Source: Analysys Mason]

Research and document review

In this task, a wide selection of documents from a range of public-domain sources (listed in Annex B) were reviewed and used to provide an overall assessment of public safety user needs, and the associated benefits from use of dedicated mobile broadband networks to meet those needs. A summary of the findings from this document review is provided in Annex C.

An objective of this task was to review the forecast demand for data and multimedia applications as presented in the range of existing documents recommended by the TETRA Association for inclusion in this study, including assumptions on requirements for dedicated networks and the benefits of using dedicated networks compared to a shared network.

Development of alternative evolution paths

The first aim of this task was to identify which applications are considered to be driving demand for a new generation of mobile broadband networks for public safety use. This was achieved by summarising the range of applications that were presented in the reviewed documents and grouping them into similar application types.

The second aim of this task was to develop a series of alternative trends for the development of public safety user needs, illustrating how usage might evolve under different alternative views of the future. Four alternative evolution paths were developed, ranging from a steady-growth base case (i.e. continued and slightly increased use of existing applications) to a much greater reliance on a range of traffic types (voice, data and media) within mission-critical environments.

Comparison of options to meet future requirements

In this task, the options available to the public safety sector for providing mobile broadband services were summarised. In addition, the limitations of existing dedicated networks and existing commercial networks to deliver the range of requirements illustrated by the alternative evolution paths were identified, and the public safety user requirements that a new generation of mobile broadband network need to meet were considered.

Report summarising identified future needs

The results of the analysis are contained in the remainder of this report, which forms the main deliverable from the study.

4 Summary of applications and user requirements

4.1 Current and envisaged future mobile applications

Based on an assessment of the currently used applications within the public safety sector, along with those envisaged to be used in the future, it is apparent that public safety mobile communications have traditionally been voice-based, but there is a trend towards using a range of data applications alongside traditional voice applications to enhance communications.

Traditional voice services are widely used for mission-critical mobile communications, and often used in a 'network-centric' fashion[4], evidenced by the widespread use of group calls. Various documents[5] indicate that the requirement for these services will likely continue to exist. The range of voice services that public safety users rely on includes:

- group calls
- encrypted individual and group calls, with authentication
- individual calls to command centre PABX and/or public telephone networks
- direct mode operation between terminals (i.e. terminal-to-terminal communication, without a network)
- emergency calls
- air-to-ground communications.

It is now apparent that a range of data, image and video applications are emerging alongside these traditional voice services, and there is an increasing demand for these data-based applications to be used alongside voice for mission-critical communications, in many cases in a similar 'network-centric' manner to voice.[6]

Examples of emerging applications are described in Figure 4.1 below.

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4 "Network-centric" refers to sharing of information between people and devices in a many-to-many (group) configuration, as is often used within the public safety sector.

5 For example, as referred to in results of TETRA Association TEDS workshop, 2007.

6 For example, personalised data is being shared amongst different users at an incident scene, which can offer benefits such as improving the situational awareness of officers at a scene. There is also a trend towards mobile offices, and mobile command and control.

Application	*Description*
Mobile office	Access to mail and intranets, transmission of incident reports from an incident scene or remote location, etc.
Transfer of images	A very wide range of image requirements, including high quality images of damage within buildings, detailed buildings plans, photographs of potential criminals, personal recognition systems (e.g. facial, iris), images of lost children, injuries at incident scenes and other incident-related images required for subsequent evidential purposes.
Biometric data	A greater range of personal recognition systems including fingerprint, facial and iris recognition of potential criminals by officers on patrolling duty, and transfer of this information in real time to HQ/command centres to be checked against biometric records. This improves the efficiency of the potential identification of criminals.
Automatic number plate recognition	A camera captures licence plate details and transmits the image back to HQ/ control centre. This is an application that has emerged in widespread use in a number of countries over the past few years, and its use is expected to continue. Transferring the image back to HQ/command centre enables officers to verify whether the vehicle is stolen, or involved in a crime or other offences. In future, this application could be extended so that image capture and checking against information contained within police databases could be conducted entirely by officers while on patrolling duties, in real time.
Digital mapping and location services	Tracking of vehicles or people, precise geographic positioning (e.g. similar to applications that are provided on commercial mobile handsets to enable navigation and identification of nearest location of interest).
Remote database access	Remote database checks of various types, used increasingly within the public safety sector to retrieve information from databases stored in HQ/command centres by offices on patrol or at incidents. Other databases that could be accessed in real time to support incident response include the Fire Service 'Gazetteer'.
Personnel monitoring	Monitoring of public safety officers in real-time to monitor health conditions while responding to incidents (e.g. fire fighters within a building, or officers involves in search and rescue operations). Other applications might include perimeter monitoring (e.g. of people entering/leaving an incident scene), vehicle or personal alarms, or tracking the location of an assigned individual for general personnel management purposes as well as in the event of an emergency.
Sensor devices/networks	Sensor networks deployed in specific incident areas, used to collect data or images within the area for onward transmission back to HQ/command centres (e.g. collection of thermal imaging from inside buildings reporting on the state of fire or other damage). Fixed or mobile sensors used to record data and images in real time (including images in a video-streaming format), which could then be distributed to other officers at the same incident (e.g. via a sensor network at the incident scene), or back to HQ/command centres. This enables officers in the command centre to have access to the same images as the officers at the incident, enabling real-time decision-making.
Remotely controlled devices	Robotics devices, used to record images within badly damaged buildings that are too unstable for officers to enter, or to operate within explosive areas or in underwater searches. Other applications include remotely turning on or off surveillance microphones or surveillance cameras (including remotely aiming or pointing the camera), and activating and de-activating alarms. Various telemetry systems also in use or envisaged within a range of public safety usage scenarios include control of moving fixed assets (e.g. vehicles, equipment in hospitals, etc.).

Non-real-time video	Capture of video streams at the scene of an incident, which are then stored (e.g. in a vehicle) and downloaded when the vehicle returns to HQ. Could also refer to slow-scan video used to gauge activity at an incident scene, but which is not of sufficient quality to be used as evidence or to support real-time decision-making.
Real-time video	Real-time video surveillance from fixed cameras permanently located along streets and in buildings or from portable cameras mounted on vehicles. Other applications include transmission of video from field officers to command centres, and vice versa, and uses within the health sector, such as remote medical services (e.g. treating patients in rural areas using video calls between the patient's home and the health centre) or treatment of casualties at an incident using real-time transfer of images between responders at the incident area and doctors in hospitals who are able to provide guidance on remote treatment at the incident scene or while the patient is in an ambulance being transported to hospital.

Figure 4.1: Summary of the range of current and future public safety mobile data and multimedia applications [Source: Analysys Mason]

The increase in data, image and video applications is driving, and will continue to drive, demand for greater bandwidth and increased functionality from public safety mobile networks.

A summary of the range of applications that are in current use within the public safety sector, along with their approximate intensity of use (on a scale of high to low use), is provided in the ERO summary of responses to its questionnaire on public safety and disaster relief produced for CEPT FM PT38, as reproduced in Figure 4.2 below.

Intensity of use	*Application*
High	Geo-location identification (of vehicles and people)
	Database query/access
	Short data/messaging
	Direct mode communication
	Image/video/map/plan/photo transfer
Medium	Group calls
	PSTN calls
	Air-to-ground communications
	Command and control (dispatch)
	Data from ambulance to hospital
	Emergency call
Low	WAP queries
	Email and mobile office
	Calls to/from PSTN and office PABX
	Tracking (e.g. RFID)
	Priority call/access
	Trunked operations
	Fire applications
	Video calls
	Radio paging

Figure 4.2: Summary of applications in CEPT WG FM38 survey response [Source: ERO]

A similar range of applications is identified in other documents, such as the ETSI Technical Specification (TS) on requirements for communications between authorities/organizations during emergencies (ETSI TS 102 181). This document also includes a different range of applications, which have been defined in terms of their impact on network throughput, timeliness (i.e. latency) and robustness. This is reproduced in Figure 4.3 below.

Service	*Throughput*	*Timeliness*	*Robustness*
Email	Medium	Low	Low
Imaging	High	Low	Variable
Digital mapping/GIS	High	Variable	Variable
Location services	Low	High	High
Video (real time)	High	High	Low
Video (slow scan)	Medium	Low	Low
Remote database access	Variable	Variable	High
Database replication	High	Low	High
Personnel monitoring	Low	High	High

Figure 4.3: Data services table from ETSI TS 102 181 [Source: ETSI]

Usage scenarios

Various documents[7] include a number of detailed usage scenarios within the public safety sector, which illustrate the range of applications that might be used within daily operations, or to respond to specific incident types. A summary of usage scenarios contained within the reviewed documents is provided in Figure 4.4 below.

7 Operational scenarios are described in a range of documents including references 9 (Mesa), 11 (WIK), 13 (Euler) and 17 (Safecom) – see Annex B.

Figure 4.4: Examples of usage scenarios within public safety [Source: Analysys Mason]

Usage scenario (source)	*Summary of applications used*
Patient services for a car crash (US Department of Homeland Security)	• Video conference call set up between the ambulance and the hospital • Ambulance's geo-location, along with vital measurements and treatments of the patient, recorded from the ambulance and transmitted wirelessly to the hospital
Major explosion/bomb (MESA/TS 70.001 v3.3.1)	• GIS used by police to establish the perimeters for the incident scene • Initial casualties information forwarded to hospitals, including images of injuries taken at the incident scene • Real-time video feeds relayed to the control room of the incident area • Fire fighters enter damaged buildings using bio-telemetry devices to monitor people and conditions within the building • Robotic devices used to confirm that no other explosives are present • Crime scene diagrams constructed using portable laptops at scene of incident • Images recorded as evidence by investigators at the scene
Traffic stop (US Department of Homeland Security)	• Situation message, police vehicle's ID and geo-location transmitted from police car at the scene of incident to other offices and to command centre • Suspect's licence plate read and sent to command centre, and queried against several databases located at HQ • Results from database query send back to police car • Video stream of the action at the incident transmitted and stored in central database, and made available on demand to dispatch/command centre. Onward message sent to other offices, along with video footage, to arrest the suspect • Arresting officer's ID loaded onto RFID handcuffs • Suspect's biometric data taken at incident scene, stored and forwarded to command centre • Case report sent electronically from arresting officer's car
Large earthquake in urban area, with many damaged buildings (MESA)	• Virtual treatment centre set up at incident scene; buildings surveyed for damage and identification of locations of further casualties • Handheld computers used to sketch building structures, entrances, etc. • Mobile command centre set up • Hazardous zones identified in buildings; fire fighters equipped with personal monitors and location tracking devices to enter hazardous areas

Large international finance summit (scenario developed by a UK agency)	• Mobile command centre established at venue, for in-building communications and to establish perimeter control, linking to central command units of police, fire and ambulance authorities • Establishment of a common operating picture using a range of data types (images, text, voice, video) • A range of mobile broadband at-venue applications available including o Enhanced personal recognition systems (iris, facial) o Ability for ambulance service to send high-quality video streams from the venue and from vehicles to hospitals, if required o Ability for fire service to send high-quality video streams from venue to command centre (e.g. in-building plans, structural plans, etc.) o CCTV camera images captured from the venue and distributed to central command centres in real time o Ability to track people and objects within the venue
Large fire in a high rise building (TR 102 485 : Technical characteristics for Broadband Disaster Relief applications (BB-DR) for emergency services in disaster situations)	• A scenario involving fire and rescue and police rapid response – within a concentrated area of 1km^2 • Personnel protection and surveillance using sensors with panic alarms • Thermal image video capture and transmission • Asset tracking within the incident area • Video surveillance across the incident area • Perimeter zone control to track all cars going in and out of a fixed location • Data capture and control devices to capture or deliver data to the point of decision within the incident area • Back office applications enabling a range of business functions within the area

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All of the above examples suggest that future public safety operations will rely on the availability of multiple data, imaging and video applications as well as voice, and demonstrate the necessity for applications to be supported within a single network, to ensure interoperability between different public safety authorities/organisations involved in the response of a specific incident.

4.2 Operational requirements essential to public safety mobile communications

Public safety networks have features that are distinct from those of commercial networks, as they need to be able to support mission-critical applications that have unique technical and operational requirements such as extensive coverage, capacity, reliability, immediacy of communications, security, redundancy and resilience. Other requirements also include the ability to support non-voice applications (in real time and non real time), interoperability within the organisation, as well as other emergency services, and cross-border communications.

The documents and reports that were reviewed make reference to a number of these operational requirements, as summarised in Figure 4.5 below.

Requirement	*Summary*
Availability	Availability in time is specified as three or four 'nines of availability' (e.g. 99.98% or better at all times) for some users. Others specify different requirements for different times, such as 99.9% per year, 99.7% per month and 99% per 24 hours (e.g. as referenced in CEPT FM38 questionnaire response on PPDR from the Denmark administration). This high degree of availability includes access to networks in all areas at all times (including under very high traffic loading conditions during which it may be necessary to reserve capacity for specific incident responders).
Control	A high degree of network control is required (e.g. to enable prioritised access or reserved capacity to be guaranteed when required)[8]. Control requirements also include the ability to queue traffic, and to manage queuing conditions and update these in real time.
Coverage	Public safety network coverage requirements differ from those of commercial networks, which are typically designed to cover areas where populations live (and therefore may provide near-100% population coverage, but do not provide the same level of geographic coverage). The public safety sector, by contrast, requires much wider geographic coverage, and the availability of the same set of applications across all geographies. Coverage must also be consistent with typical organisational boundaries within the various public safety services. Coverage requirements are specified as, for example, 99.5% (outdoor mobile), 65% or better (indoor mobile), 99.9% (air to ground).[7] Another document from a UK agency refers to at least 99% of the landmass of Great Britain needing to be covered (including offshore islands).[7]
Security	Security requirements are guided by national security and accreditation requirements, which vary in different countries. TETRA provides different layers of encryption including over-the-air and end-to-end (better than 80-bit encryption is referred to in documents we have reviewed). Other security features include two-way authentication.
Low latency	There are requirements for very short call set-up times and for limited end-to-end voice / data transmission delay (for mission-critical applications). One document refers to end-to-end voice delay being no more than 200 milliseconds.[9]

8 E.g. referenced in various replies to the ERO questionnaire on PPDR on behalf of CEPT WGFM PT38 and in ETSI TR 102 628

9 For example, as referred to in various replies to ERO questionnaire on PPDR of CEPT WGFM PT38.

Interoperability	There is an established need for different units within the public safety sector to interoperate (e.g. police, fire and ambulance, and associated services), requiring each to use the same technology. In addition, there is a growing awareness of the benefits of cross-border interoperability between different public safety units operating in different European countries.
Resilience	Networks must be highly resilient and include various layers of redundancy. Central network switching must be fully redundant, with geographically distributed switching. Interconnection between base stations must also be fully resilient and include back-up lines between key base stations. Back-up power supplies are required at different levels – for some key sites, there is requirement for up to seven-day back-up in some instances. Key base stations sites (i.e. a selected number of sites from within the overall network) need to have fallback sites available in the event of failure of the primary site.
Ability to support mixed traffic (i.e. voice and data)	An integrated network solution providing support for transmission of mixed traffic types (e.g. voice, data, images) is a requirement for public safety, in order to be able to use the same technology in all environments (e.g. ranging from day-to-day emergency response to major planned incidents and major disasters/unplanned incidents).

Figure 4.5: Public safety mobile communications operational requirements [Source: Analysys Mason]

These essential operational requirements are unlikely to change in the future, and moving forward a more diverse range network-centric requirements might be envisaged, based on increasing use of sensors and sharing of information, images and video. In particular, the occurrence of various major incidents around the world has reinforced the need for core operational requirements to be maintained in current and future-generation of public safety networks.

While future commercial networks (e.g. LTE) may be able to offer the required range of data services that are envisaged to support the usage scenarios described in Section 4.1, there will still be challenges to ensure that the operational requirements of the public safety sector can be met, particularly as commercial networks are typically optimised for financial return on investment rather than to deliver services across a wide geography (irrespective of population centres), which is what the public safety sector requires.

At present, commercial networks are not deployed to meet the core operational requirements for public safety use for a number of other reasons:

- commercial coverage, even for GPRS, is typically not nationwide and is often limited inside buildings
- 3G and LTE are likely to be deployed in 'islands' of coverage, rather than nationwide
- roll-out of sites will not be at a pace or geographically suited for a public safety network
- queued calls and the ability to control/configure queuing conditions is not provided
- there are no provisions in current standards for pre-emption capabilities or preferential measures which would guarantee capacity for public safety users in times of heavy traffic
- there are no provisions for two-way authentication or integral Direct Mode (i.e. terminal-to-terminal capability)
- there are potential issues with transporting secure information over a shared public network, both in relation to over-the-air conveyance and end-to-end encryption

- redundant switching is required for public safety applications, which commercial networks do not always guarantee
- no single point of failure must exist within the network
- high availability is not guaranteed (e.g. three or four nines of availability at all times is a typical requirement for public safety applications).[10]

10 Availability in time is also specified as 99.9% per year, 99.7% per month and 99% per 24 hours in the Danish response to the ERO questionnaire on PPDR.

5 Evolution of applications in the public safety sector

5.1 Trends in the use of mobile applications in the public safety sector

The public safety sector is following the same trends that are apparent within the wider society for access to a wide range of information on the move, and sharing of knowledge and information.

This, and a number of other trends evident within the public safety sector, is driving demand for mobile data requirements, as summarised in Figure 5.1 below.

Changes to ways of working	Ways of working are changing within the public safety sector – for example, there is a trend towards mobile command and control to enhance the effectiveness and efficiency of incident response. This is driving demand for simultaneous access to a much wider range of applications, which are being used in combination to respond to an individual incident.
Data enhancing voice	Public safety users are increasingly using data applications to enhance the mission-critical voice communications that they rely on for daily use and when managing planned and unplanned major events.
Information-driven operations	Usage scenarios for how public safety users work on a day-to-day basis while out on patrol or away from command centres suggest that usage is evolving towards greater sharing of information from a variety of sources (voice, data and video). The overall purpose and objective of this way of working is to establish common operating picture between all public safety agencies and between officers at incidents and those in HQ command centres, thus improving situational awareness. This has many benefits including better mobilisation of field teams, more timely response and more accurate information available to support decisions on incident response.
Greater awareness and use of multimedia	Increasingly more daily routines are taking advantage of a mixture of different traffic types (i.e. voice, data, images, video), which is supported by the trends towards mobile field operations and mobile offices. This requires access to the same range of applications while in the field as an officer would have while in a command centre. Multimedia applications extend across different network types, from wide-area transmission across field boundaries, through to local area transfer of incident-specific information, to personal area networking and the collection and transfer of data collected by remote sensors and/or tracking devices.

Figure 5.1: Trends affecting public safety sector requirements [Source: Analysys Mason]

The reviewed documents indicate that the range of applications in demand within the public safety sector is extending significantly beyond the 'traditional' core, group-call-based voice and data applications that have been previously associated with the sector. Interactive multimedia services, access to office applications while on the move, and a range of sensing, robotic and telemetry applications are all in demand. In addition, over time it is expected that both the range and the intensity of use of different applications will increase. This requires much higher data speeds and additional dedicated network capacity to be available, with applications being accessible through handheld devices used indoors or outdoors, and to vehicle-based users.

5.2 Alternative evolutionary paths

To explore how demand for different applications might evolve over time, and the impact of this evolution on network requirements (i.e. availability, speed and capacity), a series of alternative evolutionary paths for the public safety market have been developed. These have been built based upon the consensus regarding the range of applications that might be used within the public safety sector in the future, as ascertained from the reviewed documents. This is illustrated in Figure 5.2 below, with the applications shown in comparison to their impact on network capacity requirements (i.e. low to high capacity requirement) and their estimated stage of development (i.e. available now or envisaged in next 3–5 years).

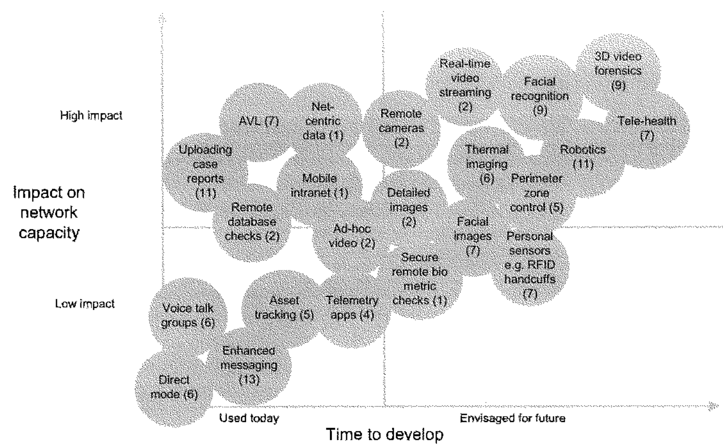

Figure 5.2: *Illustration of how demand for multimedia applications might evolve within the public safety sector, and impact on network capacity [Source: Analysys Mason, various documents[11]]*

Specifically, based on the envisaged range of applications in demand within the public safety sector, and an estimation of the time necessary for them to develop into full operational use, we

[11] Numbers in brackets refer to documents listed in Annex B which make reference to the various applications illustrated in this diagram.

have developed four alternative views of how data and multimedia applications usage might evolve.

These four evolutionary paths are summarised in Figure 5.3 and described in more detail below.

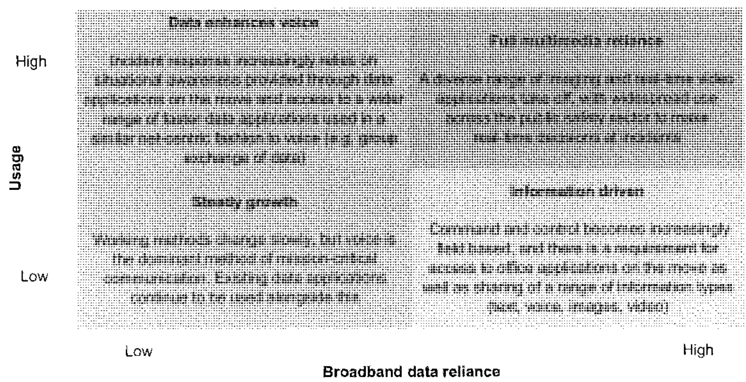

Figure 5.3: *Four alternative evolution paths for use of data and multimedia applications within the public safety sector [Source: Analysys Mason]*

5.2.1 Steady growth

The "steady growth" path represents the base case for market evolution within the public safety sector, under the assumption that there are no major changes to requirements or significant deviations from currently observed usage trends.

In this evolutionary path, there is a continuation of current usage patterns already evident within the sector, with a wider range of data applications being used alongside group-based voice calls. This combination of traffic types (i.e. voice and data) is evident both in daily operations and in responses to major incidents, however, mission-critical communications continue to use voice as the main delivery method, using established networks. Data usage continues to grow, but at a slow pace, constrained by lack of availability of dedicated, secure, data capacity that meets the public safety sector's core operational requirements. The communications strategy is therefore to continue to use the existing generation of dedicated TETRA network, upgraded to TEDS where practical, alongside commercial networks that are used to carry non-mission-critical data. However, it is unlikely that this strategy can be sustained indefinitely, given that the intensity of data usage will inevitably increase in line with current trends (evidenced, for example, by the significant increase in use of ANPR in recent years).

A summary of the implications of this evolutionary path is provided below.

Trend	Continuation of existing trends with greater volumes of data use, but constrained by lack of suitable networks to deliver mission-critical data in high volumes.
Outcome	Minimal changes to existing operational practices, and limited scope to achieve greater efficiencies and responsiveness through new ways of working.
Implications	Public safety users will require longer-term retention of TETRA and TEDS networks to meet voice, narrowband and wideband data functionally. This will constrain the development of new working methods and use of a wider range of data and multimedia applications. Limited additional sector-wide benefits are gained through migration to better, faster and more responsive ways of working, but overall growth in data usage is limited by network constraints.

Figure 5.4: *Summary of "steady growth" evolutionary path [Source: Analysys Mason]*

5.2.2 Data enhances voice

A key driver of the market for public safety applications is the trend towards network-centricity in data and multimedia operations. Similar to when using group-based voice calls, public safety users have a requirement to share data and multimedia applications on a many-to-many basis in order to ensure that everyone involved in a specific incident response is fully briefed on all information and decision making is undertaken accordingly. This manifests in the increasing demand for use of data to improve situational awareness, gained from a mixture of telemetry, sensor and video applications.

The "data enhances voice" path represents this trend of demand for access to data in combination with voice, used in a network-centric way. This path can therefore be summarised as being an extension of the current trends for greater access to data applications being used alongside voice, but with data applications becoming increasingly essential to mission-critical responsiveness. Over time, it is expected that a gradual reduction in group-based voice calls will occur as more and more communication takes place via transfer of data and images.

A summary of the implications of this evolutionary path is provided below.

Trend	Data is used alongside voice to enhance flow of information occurring in daily public safety activities and for incident response. Widespread adoption of data applications means that the capacity available on existing dedicated TETRA/TEDS networks is not sufficient to carry the data traffic that will be generated.
Outcome	Public safety users benefit from significantly greater situational awareness at incident scenes, through sharing and exchange of a range of data and images. Security of data transfer becomes increasingly significant, which limits the usefulness of commercial networks to carry sensitive data traffic.
Implications	Existing dedicated narrowband and wideband networks are not sufficient to accommodate the volumes of data traffic that will occur in everyday use. Commercial networks are not able to deliver the required functionality to accommodate secure data transfer, or the capacity or coverage to achieve the necessary network-centric ways of working. This supports the need for a new generation of dedicated mobile broadband networks.

Figure 5.5: Summary of "data enhances voice" evolutionary path [Source: Analysys Mason]

5.2.3 Information driven

There is consensus amongst various reviewed documents that there is trend towards mobile command and control – in other words, enhancing traditional HQ-based command centres with mobile command centres that are set up to respond to specific events on a daily basis, or set up to assist the smooth operation of major planned events (e.g. New Years Eve celebrations, major sporting events, etc.). This drives demand to establish a common operating picture between the venue/incident and central control rooms, achieved through sharing of various information (voice, images, video). In addition, knowledge-based working requires public safety officers to have access to the full range of applications available to them in the office, whilst in vehicles or on the move.

These applications could be accessed using hand-held devices or through vehicle-based devices. Users will require immediate access to information stored in databases in order to manage command and control from the incident scene. The direction of data is both uplink (in order to transmit various images, data and video from the scene of incidents to central command) and downlink (e.g. from command centre to the incident scene, to assign resources or respond to information requests). There will also be a greater demand for mobile office applications to complete incident reports remotely rather than upon returning to HQ/command centres. As with the "data enhances voice" evolution path, there will be a greater demand for access to a wider range of data and imaging applications to enhance situational awareness and responsiveness. This will include sensory devices to gather information on conditions of buildings and people, and the ability to exchange this information wirelessly between different incident responders. Greater volumes of mission-critical data traffic will therefore emerge, which cannot be delivered by commercial networks operating on a 'best efforts' basis.[12]

12 'Best efforts' in this context refers to data that can tolerate delay or interruption, i.e. is non-mission-critical.

As with the "data enhances voice" evolution path, the "information driven" path will generate data volumes that will exceed the capabilities of existing dedicated narrowband and wideband networks, and require a new generation of dedicated mobile broadband networks.

A summary of the implications of this evolutionary path is provided below.

Trend	There is a demand for access to the same range of applications in the field as those available at HQ/command and control. This includes widespread use of mobile office applications, as well as remote access to databases and ability to view, replicate and update information in real time.
Outcome	Mobile officers and those in command centres have access to a common range of situational pictures, data and other information. This improves responsiveness and the ability for public safety officers to work in crisis situations, as well as to respond to everyday incidents. Applications such as fingerprint recognition, licence plate recognition, and access to criminal records can all be conducted remotely, in real time.
Implications	The need for data applications to be delivered over networks that ensure high availability, resilience and secure communication, and are as reliable as existing TETRA voice networks, is increased as a result of the demand to access a wider range of applications from anywhere, at any time. The need for a more extensive range of mobile applications therefore requires capacity enhancement, similar to the "data enhances voice" path, which is beyond the capability of existing TETRA and TEDS networks.

Figure 5.6: Summary of "information driven" evolutionary path [Source: Analysys Mason]

5.2.4 Full multimedia reliance

In the "full multimedia reliance" path, there is a dramatic increase in both the range and intensity of use of new and innovative data and multimedia applications, including video streaming which is necessary for real-time interactive services such as telemedicine, 3D video forensics and high-quality evidential facial recognition applications. Public safety users start to make significant use of video applications alongside voice and data, driving demand for a wide range of applications to be made available over a common network interface to aid interoperability. Similar to the "data enhances voice" scenario, there is a widespread take-up of a range of data applications used in a network-centric manner. Alongside this, however, video streaming is used to further improve situational awareness at incidents and to enable a common operating picture to be established (e.g. through use of video conference calls, live CCTV video footage streaming, etc.). Future applications such as telemedicine are rolled out to improve access to medical services in rural areas. This requires access to a mobile broadband network covering a wide geographic area in order to reach the remotest areas, since the public safety organisations cannot control where unplanned incidents occur. New ways of working fully evolve so that there is substantially less reliance on HQ/command centres to store, retrieve and deliver information, since users are able to access a full range of applications while on the move.

As with the "data enhances voice" and the "information driven" paths, this evolutionary path will generate data volumes that will exceed the capabilities of existing dedicated narrowband and wideband networks, and require a new generation of dedicated mobile broadband networks.

A summary of the implications of this evolutionary path is provided below.

Trend	There is full reliance upon a wide range of traffic types (voice, data, video) in order to respond to new ways of working, and roll-out of new services such as remote telemedicine and 3D forensics. There is widespread take-up of a wide range of mobile data applications similar to the other evolution paths, alongside new multimedia applications.
Outcome	New ways of working are implemented across the public safety community and users are no longer constrained by having to return to HQ/command centres to complete certain tasks. A new generation of situational awareness applications are used in daily response as well as for major incidents. Public safety users are able to operate more efficiently, making better use of resources and reducing unnecessary travel.
Implications	With the evolution in data and multimedia applications, and the requirement for those applications to be available over a very wide area (to make applications such as remote telemedicine feasible), existing narrowband and wideband networks have insufficient capacity and functionality to meet the requirements of this evolutionary path. Similarly, there are limitations in use of commercial networks due to a lack of full geographic coverage, capacity and ability to carry secure data. This evolutionary path therefore requires the development of a new generation of dedicated mobile broadband networks to deliver more network capacity, higher bitrates and a wider range of applications.

Figure 5.7: Summary of full multimedia reliance evolutionary path [Source: Analysys Mason]

5.3 Mapping of applications to the four alternative evolutionary paths

The range of applications detailed in the various documents reviewed for this study have been mapped to the four alternative evolution paths as described above, in order to provide examples of how the use and range of applications might develop across the different evolution paths.

This mapping is summarised in Figure 5.8 below. Note that the numbers in brackets indicate references to the documents listed in Annex B. It should also be noted that since voice requirements are assumed to remain constant across all of the four evolutionary paths, voice is not included in the mapping table, although it is assumed to remain as an essential requirement for public safety operations.

Figure 5.8: *Mapping of data applications to trends [Source: Analysys Mason]*

Application	*Steady growth*	*Data enhances voice*	*Information driven*	*Full multimedia reliance*
Mobile office	Status messages, either field to field or command to field, are delivered by email in addition to short data/short messages, for resource allocation and incident control [2, 3, 6]	Emails/office applications are used for administrative messages, and access to emails and intranet whilst out of the office improves timely response to requests [1, 2, 17]	Increasing access to web applications (e.g. Intranet and Internet, online access to contacts databases etc.) is made, enabling incident reporting to be handled via mobile devices, reducing the need to return to HQ/command centre to access office applications [2, 5, 6, 17]	Incident-specific information exchanged using web applications (e.g. language translation, web-addressable cameras) in addition to use of a wide range of Mobile Office applications (contacts databases, email, Intranet) [5,17, 18]
Database queries/updates	Database checks conducted in vehicles and via hand-held devices (e.g. passport information, Gazetteer, criminal records, patient records) [1, 2, 6]	Increased ability to updated databases with textual inputs in real time to provide additional incident details, or patient record updates whilst on the move [1, 2, 17]	Additional data updates provided from incidents and uploaded in real time (e.g. visual information, results of biometric checks) [6, 17]	Increasing upload/download of data and updating in real time (e.g. ECG traces) plus development/update of architectural plans of buildings from incident scenes [7, 8, 11]
Location-based applications	Use of geographical positioning tools (e.g. GIS) [2, 6, 8]	Asset tracking (e.g. of people and equipment) with positional information sent periodically to HQ/command centre [2, 6, 7]	Increasing use of self-forming networks (e.g. perimeter tracking at incident scenes and machine-to-machine communications) [1] [2] [6]	Fully integrated tracking / surveillance / image systems used in real time (e.g. to record location and status of fire fighters and people within a building), along with video robotics (e.g. to capture information in explosive environments) [6]
Digital mapping	Used for navigation and access to digital maps [2]	Access to 3D geographic images [1, 2]	Increasing use of images of different types and quality e.g. aerial views of incidents, high quality imagery [1, 2,5]	Live 3D views inside buildings, and mapping of personnel and casualty locations [9]

Biometric monitoring	Use of basic telemetry applications (2, 5)	RFID used for tracking of personnel at incidents (2, 5, 7)	Biometric monitoring of personnel conditions over time (5, 7, 11)	Body worn sensors (e.g. object impact on helmet or vest, RFID-handcuffs) providing real time monitoring and information updates, improving real time structural awareness (7, 17)
Still images	Image and audio capture at incidents (e.g. push images of suspects and missing persons to field officers and images of fingerprints stored in central databases) (1, 2, 6)	Gathering of evidence at crime and incident scenes, and collation of witness information using field devices (e.g. incident scene photo transfers) (1, 2, 7)	Transmission of building floor plans and use of thermal image capture and transmission (1, 2, 7)	Evidential-quality image capture, and/or very detailed images (e.g. burns or other injuries (1, 7, 11)
Slow scan video	Sequence of fixed images exchanged between command centre and officers in the field (2, 8, 11)	Limited motion video captured and available on demand to command rooms and dispatch (5, 6, 7)	Video conference calls between field and command centre to support incident response and decision making (6, 9, 11)	Information captured by surveillance cameras at incident scenes relayed to command centres in real time, forming an essential element of mission critical communications and decision making (17, 18)
Real-time video	Relaying of ad-hoc video and surveillance camera information to control cars responding to incidents, and real-time traffic flow monitoring (7, 11, 19)	Upload of real-time standard definition video (e.g. from cars or handheld devices to command centre) (5, 7, 11, 19)	Live high definition, mission critical video footage transferred between incident and command (e.g. from ambulance to hospital), and use of mobile video conferencing (2, 6, 8)	3D video forensic applications, telemedicine and sophisticated airborne video platforms communicating with mobile devices (6, 8, 17)

6 Options to meet public safety's evolving requirements

6.1 Options to provide mobile broadband services to the public safety sector

As demonstrated in the previous sections, the various documents reviewed for this study indicate a general consensus that a wide range of data and multimedia applications will be required to meet future user demands within the public safety sector. The four alternative evolutionary paths developed for this study illustrate how demand for those applications might evolve over time, in line with changes to ways of working that are already evident with the public safety sector, such as a greater demand for mobile working, and increasing sharing of information to establish a common operating picture, often requiring upload of significant volumes of data of different types (e.g. images, video).

The options available to the public safety sector to deliver the envisaged range of applications under the different evolution paths are as follows:

- continue to use the existing generation of dedicated networks, and upgrade those to deliver wide band functionality (e.g. using TEDS).
- continue to use existing narrowband and wideband networks, and use existing commercial networks to provide additional, non-mission critical, data services
- develop a new generation of mission-critical mobile broadband network solution, either by developing a new generation of dedicated mobile broadband network or by upgrading existing commercial networks (e.g. based on HSPA+/LTE) and engineering their deployment to deliver the required public safety operational requirements of availability, coverage, security and control.

From our analysis, it is clear that, with the exception of the "steady growth" path, each of the other evolution paths will require additional high-bitrate data and multimedia applications beyond the capabilities of existing dedicated narrowband and wideband networks. Similarly, current commercial networks will not be able to support the range of envisaged applications, and in any case will not, as current deployed, meet the operational requirements of the public safety sector in terms of wide area coverage, security, resilience, control and availability.

There is growing evidence of the need for public safety to access multiple data applications simultaneously in order to establish a common operating picture, which requires use of a common infrastructure to avoid the need for multiple handsets and solutions. This is particularly true in the case of responding to major incidents, which require much more intensive use of a wider range of applications but using the same equipment and networks that are used in daily public safety operations. The combination of existing dedicated networks and existing commercial networks does not meet these requirements.

The advancement of network functionality requirements in line with the alternative evolution paths developed for this study is summarised below.

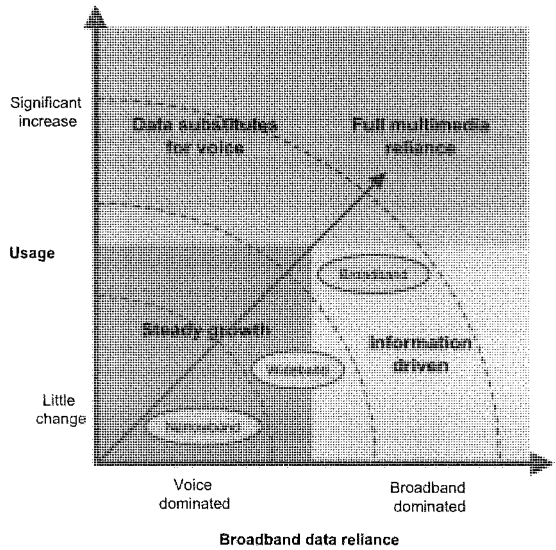

Figure 6.1: *The four alternative evolution paths and their impact on network requirements [Source: Analysys Mason]*

As described in Section 5.2, it appears that the "steady growth" path cannot be sustained indefinitely, given that the intensity of data usage is already increasing in line with current trends (evidenced, for example, by the significant increase in use of ANPR in recent years). This suggests that the only feasible option to meet the future evolution of public safety user requirements is to develop a new generation of mobile broadband network.

This conclusion is further evidenced by the range of usage scenarios that various documents envisaged within the public safety sector, as described in Section 4.1. The range of applications in concurrent use within these different usage scenarios demonstrates that, without a new generation of mobile broadband service being available, the full range of applications within the various scenarios will not be available in practice. This is summarised in Figure 6.2 below.

Figure 6.2: *Benefits of the development of a new generation of mobile broadband services for public safety use [Source: Analysys Mason]*

Usage scenario	*Existing public safety networks*	*Existing public safety networks plus commercial networks*	*Upgraded commercial network or new dedicated mobile broadband networks*
Patient service at car crash	Limited bandwidth to deliver video calls and images of patient injuries from ambulance to hospital, resulting in less timely response	Transferring sensitive patient records between ambulance and hospital not possible over commercial networks due to security and bandwidth limitations, leading to less timely response, and more manual paperwork	Faster identification of crash location, transfer of patient details in real time means improved emergency service response and enables more rapid diagnosis and treatment
Major explosion	Many of the envisaged applications not supported by current networks due to lack of bandwidth and limited data rate (e.g. incident perimeter tracking, real-time video feeds and bio-telemetry), resulting in less timely response, need for more resources and manual recording of information	'Best effort' nature of commercial networks means that they cannot be relied on in major incident situations. Public safety users are limited to using applications available on their dedicated networks, resulting in reduced interoperability, need for more resources, additional manual paperwork and reduced ability for crisis management	Interdepartmental communications maintained through secure, interoperable network, and network dimensioning to enable network-centric voice and data transfer improves efficiency of operational response to major incidents and more effective resource deployment, awareness and management
Traffic stop	Limited ability to capture and transmit information from the scene. ANPR in use today but increasing volumes of use mean that there are capacity constraints	Secure transfer of personal information not possible over a public network, reducing ability to capture and transfer information from the scene and possibly reducing ability to apprehend the criminal	Real-time identification of suspects and criminals, more timely response and better crime response rate
Earthquake	Mobile command and virtual treatment centre not possible using current generation of networks, leading to less effective, slower response, duplication of information and reduced ability to make real-time decisions	Levels of commercial traffic in this urban area would be high and so it is unlikely sufficient capacity can be dimensioned for public safety use. Loss of benefits such as slower response and duplication of information	Virtual treatment centre made possible through availability of higher speed, dedicated capacity leading to real-time diagnosis and treatment, better use of resources, and reduction in ambulance-hospital journeys
Fire at depot	This operational scenario illustrates that the only reliable mission critical communication methods at present are voice and low-speed data, limiting responsiveness and flow of information	'Best effort' nature of commercial networks means that reliable video transfer is not possible, reducing ability to decide upon evacuation in real time, and higher risk to deployed resources	Capture and transfer of building information and images in real time deliver more efficient decision making, better resource deployment and safer working environment for fire fighters
Large international finance summit	Relies on common operating picture being established between mobile command centre at the venue and central control rooms – this requires exchange of a range of information (voice, images, video) that are beyond the capabilities of existing dedicated networks	Transfer of sensitive personal data (e.g. iris or facial recognition) is not possible using a non-secure commercial networks. Requirement for high quality imaging applications to be available inside the venue also limits usefulness of commercial networks that do not always provide the necessary depth of indoor coverage	Capture and transfer of video and images in real time delivers a common operating picture, enabling more efficient decision making, better resource deployment and safer working environment for the summit

6.2 Limitations of upgrading commercial networks for future public safety services

As indicated in the section above, new mobile broadband services to meet future public safety user requirements could, in theory, be provided by upgrading commercial networks and engineering the deployment of these to achieve the specific operational requirements of the public safety sector. However, the consensus of the various reviewed documents is that there are a number of critical limitations inherent in using commercial networks for public safety applications, due to the core operational requirements that public safety communications need to meet.

While in theory it might be possible to upgrade and engineer commercial networks to meet these operational requirements (i.e. build new, shared, LTE networks that are engineered to meet both public safety and commercial user requirements), the balance of evidence in the reviewed documents suggests that this will be unachievable in practice. In particular, there are a number of reasons why commercial operators might be unwilling to make the necessary network changes to support public safety operational needs:

- the public safety sector requires very extensive geographic coverage as well as in-depth coverage penetration inside buildings, irrespective of location, which does not match the typical roll-out requirements of a commercial network
- it is likely to be very expensive to re-engineer commercial networks to achieve all of the public safety sector's operational requirements, and there are questions about whether sufficient incentives exist for commercial operators to do this. For example, typically requirements include the need for battery back-up to be available at thousands of base station sites across the network, and for networks to be designed to ensure that no single 'point of failure' exists either in access or core networks
- even if re-engineering costs are borne by the public sector, there is a risk that the resulting network will then be over-provisioned for commercial use. As such, commercial operators might find themselves having to pass additional costs (e.g. for the ongoing operation and maintenance of the network) on to commercial user tariffs, which is not viable given the competitive nature of the commercial mobile market. As such, commercial operators may not be willing to take on such requirements, given the potential risk to their commercial business
- there are questions about whether some of the public safety requirements are actually achievable. For example, to obtain the necessary layers of redundancy and prioritised access to capacity in urban areas might not be possible (since demand for capacity will also be high from commercial users, and hence reserving capacity specifically for public safety users might not be viable)[13]

[13] Furthermore, if the public users of the network know that in times of a local emergency they will lose the network services, this creates a disincentive for users to subscribe to that network, a risk that commercial operators are unlikely to take on.

- there is a question about whether the required Grade of Service for public safety use can be guaranteed within a network shared with commercial users, particularly in times of very high traffic loading
- there are conflicting views on whether signalling could be encrypted over the air interface in 3G/LTE
- ensuring the specific requirements for carriage of 'restricted' or 'confidential' documents requires careful network planning and approvals, which is complex and costly to achieve
- in conditions of local or national emergency, public networks typically become overloaded as the normal customer base seeks to communicate at the same time, and it is not clear that networks can be dimensioned to achieve the required immediacy and guaranteed access that public safety requires.

A further range of reasons why public safety users have been reluctant to make more widespread use of existing commercial networks, and have favoured the development of their own dedicated networks, are included in the various documents we have reviewed for this study. These include the points summarised below.

Coverage	Commercial operators typically invest in coverage where populations exist, and capacity is designed to maximise revenue generation in those areas, with little incentive to invest in areas of low-density population. Public safety, by contrast, requires ubiquitous coverage across a country's geography for everyday use, irrespective of population densities.
Network design	Re-engineering of commercial networks to meet public safety's requirements might be feasible in theory, but in practice would result in large parts of the commercial network being heavily over-engineered. This is likely to be more costly for the public sector to fund than a dedicated network provisioned to meet the specific coverage and capacity needs of the public safety user based, without having to provision for additional commercial traffic.
Sabotage	There is a view that commercial networks might be more vulnerable to sabotage by criminals that dedicated networks are, if the network is known to be used for public safety communications. Dedicated public safety networks are typically more guarded against sabotage through a range of specific measures e.g. vetted staff, secure fencing at sites, and networks designed to ensure no single point of failure in the event of sabotage, etc.).
Roll-out schedules	There are precise requirements for the roll-out of public safety networks (e.g. the need to align with police/fire/ambulance area boundaries), which do not match typical commercial roll-out strategies.
Risks of shared use	There are risks such as information security, quality of service and control of service level agreements if public safety users share networks with commercial users, which previous experience suggests can be avoided through use of dedicated networks under government control and supervision.
Reliance on commercial operators	There is a reluctance for public bodies to be reliant on a fully commercial operator, in view of the potential lack of control upon future network investment, business plans and financing.

If the upgrading and engineering of commercial mobile broadband networks is not feasible to meet public safety requirements, as this section suggests, the only alternative is to develop a new generation of dedicated mobile broadband networks designed to meet specific public safety requirements. For this to be achievable, additional spectrum will be required.

7 Conclusions

The study has found that, in line with societal trends evident within today's Information Society, a diverse range of data, imaging and multimedia applications are in demand within the public safety sector. Demand for access to a wider range of information is being driven by changes in working practices, which is creating requirements for access to a far wider range of data sources (textual, images and video) that are typical in commercial mobile networks. Sharing of various data types (textual, images, video, etc.) is being used in order to establish and maintain a common operational picture between agencies and between field and central command staff. This is being used to improve responsiveness, aid the deployment of resources, and improve timeliness and decision making in daily public safety operations and when responding to major planned or unplanned events.

Three of the four evolutionary paths developed for this study illustrate the public safety sector's need for a next generation of mobile broadband networks to deliver the range of applications that are envisaged in the future. As there is a limit to the range and volume of data and multimedia applications that existing dedicated narrowband and wideband networks, and existing commercial networks, can provide, if a new generation of mobile broadband networks is not made available, some new applications cannot be delivered. Ultimately, this will affect how already emerging changes to ways of working within the public safety might evolve, and, in the longer term, constrain the further development of the sector.

A new generation of services could in theory be delivered using an upgraded commercial network (e.g. HSPA/HSPA+ or LTE) with network deployment engineered to meet specific public safety requirements. However, as explained in Section 6.2, this option does not appear to be achievable in practice. The only other option is therefore to encourage industry to develop a new generation of mobile broadband networks for dedicated public safety use.

To enable the industry to devote the necessary investment to develop new dedicated networks, there is a need for additional spectrum to be identified, since existing bands are already fully utilised to deliver existing public safety systems.

It should be noted that identifying suitable spectrum is on the "critical path" to support development of a new generation of dedicated mission critical mobile broadband solution, because of the timescales associated with identifying suitable spectrum.

The requirements for additional spectrum are based upon the combination of the various factors identified throughout this report, specifically:

- trends in the range of data and multimedia applications in demand within the public safety sector
- potential increase in user densities and intensity of use for data applications

- specific traffic characteristics of public safety operations (e.g. network-centric ways of working)
- the infrastructure and technical requirements to meet the operational requirements of the public safety community (e.g. availability, security, reliability, latency), and limitations in use of commercial networks to deliver these.

Given the cost of deploying new networks, access to spectrum in bands below 1GHz will ensure maximum commonality with existing dedicated networks deployed in the 380–385/390–395MHz bands, facilitate re-use of assets where possible (e.g. radio sites). Use of spectrum above 1GHz (e.g. around 2 GHz) might be feasible, but would incur significantly higher roll-out costs compared to that below 1GHz, raising questions at national government level as to whether and how the additional costs can be funded.

Based on the reviewed documents, the European dimension to the public safety spectrum requirement is important for a number of reasons:

- the public safety sector is a niche market and therefore benefits from the identification of harmonised spectrum even more than other mobile systems (e.g. GSM or UMTS), because of the smaller user base and resulting lower volumes of equipment and terminals
- even if commercial solutions are adapted to meet specific requirements of a niche sector such as public safety, there are still costs involved in the necessary modifications, and therefore harmonised spectrum availability is key to ensure that manufacturers are able to develop products for a European market. An example of the re-engineering of existing commercial standards to meet niche requirements is that of GSM-R (the railways version of GSM) – although the GSM standard is supported by all major vendors around the world, GSM-R equipment is supplied by relatively few and the availability of harmonised spectrum for the product has therefore been important to reduce costs
- interoperability is an increasingly important requirement within the public safety sector, both to communicate between different public safety authorities within a country, and to communicate across borders. This is evidenced by a number of the documents reviewed for this study. [14]

The lack of available spectrum is therefore a significant barrier to the further development of mobile communications capabilities tailored to meet public safety requirements, until such time as a new, harmonised band can be identified at a European level.

[14] For example, Council of the European Union, Draft Council Recommendation on improving radio communication between operational units in border areas

Annex A: List of acronyms

ANPR	Automatic number plate recognition
AVL	Automatic vehicle location
CEPT	European Conference of Postal and Telecommunications Administrations
ETSI	European Telecommunications Standards Institute
GHz	Gigahertz, 1GHz is equal to 10^9 hertz
GIS	Geographic information system
GPRS	General packet radio service
GSM	Global System for Mobile Communications, the most prevalent international standard for second-generation cellular mobile systems
GSM-R	GSM-Railway, an adapted version of the GSM standard used by Network Rail (UK) and other railway authorities in Europe to provide train-to-track signalling
HSPA(+)	High Speed Packet Access, a protocol that can form an overlay to existing 3G networks to speed up network capacity and transmission rates
ITU	International Telecommunication Union
LTE	Long Term Evolution, the next generation of 3GPP standard, which uses an OFDM radio interface – sometimes referred to as "4G"
MHz	Megahertz, 1MHz is equal to 10^6 hertz
NATO	North Atlantic Treaty Organization, the military alliance of countries in Europe and the USA
OFDM	Orthogonal frequency-division multiplexing, the air interface that is used in WiMAX systems and will be used in LTE
PABX	Private automatic branch exchange, a telephone exchange serving a particular business/office
PBR	Private Business Radio, generic term used to describe the variety of two-way, self-provided, mobile radio systems used by a variety of business users in Europe (including airports, taxi firms, local authorities and the Emergency Services pre-Airwave analogue radio systems)
PSTN	Public switched telephone network
RFID	Radio frequency identification
TEDS	TETRA Enhanced Data Service
TETRA	Terrestrial Trunked Radio, the digital trunked radio standard used by the Airwave service in the UK and in other Emergency Services mobile radio systems in a number of other countries Europe and around the world
UHF	Ultra high frequency, i.e. between 300MHz and 3000MHz
UMTS	Universal Mobile Telecommunications System, the European standard for third-generation cellular mobile systems
VHF	Very high frequency, i.e. between 30MHz and 300 MHz
WCDMA	Wideband CDMA, the technology used in current 3G systems
WiMAX	Worldwide Interoperability for Microwave Access, the technology forming the IEEE802.16e wireless broadband
WGFM	Working Group FM
WRC	World Radiocommunication Conference, the international conference held by the ITU every few years to update the international frequency allocation table
3G	Third-generation mobile systems
3GPP	3rd Generation Partnership Project, a partnership between ETSI and standards bodies in the USA and Asia, responsible for developing industry equipment standards for 3G systems

Annex B: List of documents reviewed for this study

This annex contains a list of the selection of documents from a range of public-domain sources, which have been reviewed for the study.

No.	Document reference	Document title	Author	Version	Publication date
1	Results from last TC-Tetra workshop in Brussels	TETRA Association Future Vision workshop held in Brussels on 25th February 2009	Various	-	February 2009
2	Results from previous TETRA Association workshops on mobile data [*two workshops*]	a. TETRA Association Applications workshop in London (December 2009) and mobile data applications questionnaire b. TETRA Association TEDS workshop (March 2007) and TWC questionnaire (2008)	Various	-	December 2009 / March 2007
3	Results of Analysys Mason study	Exploiting the digital dividend – a European approach	Analysys Mason	Final report	14 August 2009
4	PCWG ad-hoc group studies	Police Cooperation Working Group – Improving radio communication between operational police units in border areas; analysis of the responses received to the data capture exercise on cross border working	Police cooperation working group	-	December 2008 16 March 2009
5	ETSI System Reference Document on future Public Safety and Security (PSS) Systems	TR 102 628: System Reference Document; Land Mobile; Additional spectrum requirements for future Public Safety and Security (PSS) wireless communications systems in the UHF range	ETSI	V1.1.1	10 June 2009
6	Results from ERO questionnaire on PPDR	FM38(09)15 Rev 2 Annex 3, Result of Questionnaire on PPDR	ERO summary in response to CEPT WGFM PT38	Rev 2	April 2009
7	Results from TC-RSS WG4 questionnaire	RRS08_018_ETSI_TR_102_733 and TR 102 734 (Aug draft)	ETSI	V0.0.12	November 2009
8	Results from the expert group on police cooperation	Draft Council Recommendation on improving radio communication between operational units in border areas	Council of the European Union	Draft	20 May 2009
9	Document from MESA	Project MESA; Service Specification Group - Services and Applications; Statement of Requirements (SoR)	MESA	V3.3.1	March 2008
10	EU-TOIA report on digital dividend	Extract: Toia Report on Digital Dividend/2008-09-26 - Text adopted	Rapporteur - Patrizia Toia	P6_TA-PROV(2008)09-24	24 September 2008
11	WIK study	Safety first – Reinvesting the digital dividend in safeguarding citizens	Kenneth R. Carter and Val Jervis	-	5 May 2008

12	PSC-Europe response to digital dividend	PSC Europe response to the digital dividend hearing	PSC Europe	-	11 June 2008
13	EULER End User Requirement	EULER End User Requirements Deliverable 2.3-1	Dimitrios Symeonidis	V0.8	17 September 2009
14	TETRA Association Spectrum Group study	What data service will the future bring – from a TETRA perspective	TETRA Association Spectrum Group	Draft	November 2009
15	Wireless broadband study by Public Safety Spectrum Trust Chairman, Harlin McEwen	Public Safety Radio Communications; Wireless Broadband is not an alternative to LMR mission critical voice systems	Chief Harlin R. McEwen	Draft	12 October 2009
16	Hansard Report	Column 761	Lord Lucas	-	2 December 2009
17	Safecom document	Public Safety Statement of Requirements for Communications and Interoperability	US Department of Homeland Security	Volume II Version 1.2	August 2008
18	Westminster e-Forum	Westminster e-Forum keynote seminar, Emergency Services and Public Safety Spectrum	Westminster e-Forum	Transcript of event	11 June 2009
19	PSC Europe white paper	Public safety first	Jeppe Jepsen	-	-
20	Report for BAPCO	The "Business Case" for Blue Light Spectrum	David Happy	-	26 August 2009

Annex C: Summary of document review

C.1 TETRA Association Future Vision Workshop (Brussels)

Item	*Description*
Document title	TETRA Association Future Vision workshop held in Brussels on 25th February 2009
Author	Various
Publication date	February 2009
Abstract	Various presentations discussing the future vision for TETRA towards a fully integrated ICT solution providing NB/WB/BB wireless communications for "mission-critical" and traditional PMR/PAMR applications, through the enhancement and/or provision of user driven services and facilities and the utilisation of the latest in technology, innovations and standards. The workshop discussed applications including data rate, bandwidth and QoS, user requirements for broadband data, and other areas of consideration in the selection and standardisation of a broadband solution.

Requirements or needs identified in report	The need for the industry to evolve TETRA towards a fully-integrated seamless ICT solution providing NB/WB/BB wireless communications for mission-critical and traditional PMR/PAMR applications.
	Data and image applications are emerging as a strongly needed requirement to improve users' efficiency and safety.
	The fundamental requirements are:
	• Ability to communicate in all locations (100% radio coverage)
	• Instant access at all times (perfect Grade of Service)
	• Never goes wrong (100% reliability)
	• Voice and data (V+D) communications
	• Perfect voice quality in all operational environments (ability to recognise who is talking)
	• Ability to support all V+D applications
	• Private and secure communications when required
	• RF coverage in black spots and outside main network
	• Additional capacity when localised traffic demands are high
	• Fall-back communications if base station and/or network fails
	• Ability to support all non-voice applications (real-time and other)
	• Standardised technology solution providing:
	  ▪ competition
	  ▪ choice
	  ▪ second source security
	• Interoperability:
	  ▪ within the same organisation
	  ▪ within other related organisations as required (e.g. police, fire, ambulance, military, transport, utility, etc.)

- cross-border with other nations as required
- Interworking with other technologies as need (Public Networks, 3G, etc.)
- Evolution:
  - backward compatibility
  - maximum reuse of existing infrastructures
  - future proof
  - enhancement
  - integrated and seamless ICT
- Current mission-critical communication needs to be:
  - dedicated
  - wide-area
  - secure
  - reliable
  - available
  - fit for purpose.

Possible applications identified in report

Real-time applications, where source generates the information to the destination and strict constraint to delay and its variation over the network is fundamental for using the application.

Non-real time applications, where the source has the information and sends it to the destination. Source can send part of the information missing and re-order the packets.

Applications include:

- Automatic stolen car plate recognition (approx 10byte/plate required throughput)
- Biometric check
  - fingerprint required throughput per officer – check rate: 8 people/min
  - y=(8people/min) / (60sec/min) x 1kByte/People =133byte/sec = 1.06kbit/s
- Image transmissions
  - target acceptable resolution: dimension 20kByte = 160kbit/ user
- Face recognition
  - the minimum number of pixels to recognize faces is 40PPF (pixels per foot) the minimum number for reading license plates is 80PPF
- Mobile office
- Database queries
- Video surveillance from the field
- Mobile command centre sharing an accurate situation picture of an incident
- Delivering images, maps and floor plans to the field
- Detailed ECG traces from ambulance to hospital and other telemedicine applications
- Fingerprint identification/authentication
- Image/audio capture
- Geographical positioning

	• Electronic identity document reading • Voice communications • Data connectivity • Optical character recognition (OCR) • Electronic signature certificate management • Cryptography
Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	Not applicable
Possible scenarios identified	Not applicable

Any other relevant information from the report	Possible TEDS broadband solution:
	• Integration of other technologies with TETRA
	  ▪ Use of TETRA 2 infrastructure as the core network
	  ▪ 3G technologies such as HSPA, LTE or EV-DO, UMB
	  ▪ WiMAX (preferably narrowest channel options at lowest designated WiMAX frequencies)
	• TEDS Technology Evolution
	  ▪ Use of wider carriers than TEDS
	  ▪ More spectral efficient channels
	  ▪ Other features under discussion in WG4
	  ▪ Acquisition of new spectrum for interoperable TETRA 2 (plus BB enhancement) networks?
	• Other comparative considerations
	  ▪ LTE, WiMAX and other public BB networks designed for mass market/urban applications
	  ▪ Wider and wider carriers, smaller and smaller footprints
	  ▪ Design criteria: capacity limited, maximum commercial return
	  ▪ No slack capacity for emergency communications
	  ▪ PPDR networks design criteria: coverage limited
	  ▪ Full national coverage essential for PPDR; capacity is not an issue
	  ▪ Narrowest bandwidth/lowest frequency band compatible with required PPDR applications and spectrum availability
	  ▪ NB, WB and BB in the same frequency band
	  ▪ PMR type security, availability and reliability
	• Operational use for video must be understood
	  ▪ What is required in a court case (used as evidence)?
	  ▪ What is required in emergency response?
	  ▪ What is required for surveillance, facial, licence plate recognition?

C.2a TETRA Association Applications Workshop and mobile data questionnaire

Item	*Description*
Document title	TETRA Association Applications workshop held in London on 2nd December 2009 Mobile data applications questionnaire results
Author	Various
Publication date	December 2009
Abstract	Various presentation discussing applications for TETRA.

Requirements or needs identified in report	Security, safety, cost and service are the critical features of an optimal mission-critical data solution, along with a requirement for an integrated system that can be used throughout the response chain (i.e. services all accessible via the same terminal or device) and data services as reliable as TETRA voice.
	
	Customer specific applications that enhance the functionality or usability, versatility and productivity of the TETRA radio terminal for different purposes.
	
	Existing applications require more capacity.
	
	Ability to move office applications into the field.
	
	Operational needs: resilience; availability; security.
	• Ciphering and encryption
	• Mission critical communication
	• Availability of resources under all circumstances
	    ▪ operational even when public networks are congested
	• Resilience
	    ▪ ability to work in crisis situation (major electrical disruption, transmission network failures, etc.)
	• When all public communication infrastructure are out of order, the radiocommunications network should be kept operational.

Possible applications identified in report	Current applications:
	• Collect and share common situation picture
	• Allocate right resources efficiently
	• Distribute and obtain information instantly
	• Collect surveillance, medical, etc. monitoring information
	• Automate administrative routines
	
	Future applications:
	• Fingerprint recognition
	• Licence plate recognition
	• e-Passport reader
	• RFID reader
	• JAVA applications on TETRA terminals:
	    ▪ Access information in remote databases
	        ○ Vehicle databases
	        ○ Criminal records
	        ○ Hazardous materials

	▪ Report location–related information
	  ○ Task progress
	  ○ Intelligence information
	  ○ Support requests
	▪ Push images to field officers
	  ○ Suspects from surveillance camera
	  ○ Missing persons
	  ○ High risk suspects
	• Streaming video
	  ▪ Transmission of live videos simultaneously to/from the central command and field personnel
	  ▪ Relaying ad-hoc videos and surveillance camera to the central command and field personnel
	  ▪ Air-to-ground video
	• Real-time collection of large medical data
	  ▪ Sending full data on a patient's condition from the ambulance
	  ▪ Remote surveillance of smoke divers' vital functions
	  ▪ Remote surveillance of patrolling officers' vital functions
	• Access to geographic images
	  ▪ Aerial photographs
	  ▪ Satellite images and maps
	  ▪ Plans of buildings
	• Remote database queries for passport and biometric details
	• Sending photographs of lost children and wanted people
	• Access too the Fire service 'Gazetteer' for information on HazMats on premises
	• Transmission of live video to and from the central command and field personnel
	• Relaying ad-hoc video and surveillance camera
	• Sending full data on patient's conditions from the ambulance
	• Integrated broadband data services which are emerging as an important PSS need require more bandwidth – ideally two paired 15MHz channel
	• Telemedicine
	• Extensive geo-location capabilities
	• Web applications
	• Full email
	• Over-the-air downloads for software upgrades

Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	There are network availability issues with commercial networks, for example: • Motorway Car Crash – statistics show that the network call volumes increase during a major auto crash. People involved call loved ones, witnesses call for assistance and other drivers call to say that they will be late. What is the impact to data?

	• Major Sport Events – peak GSM/GPRS load times are before, half time and after the match = critical times for secured communications. Historically mobile telephony calls can fail during these periods • Natural disasters and terrorism – after the Madrid bombings; the mobile phone network collapsed at 8:05am and was out of use for eight hours • Public networks do not meet PS user requirements ▪ Coverage, Availability, Security, Resilience, Interoperability ▪ Control, Functionality • Public network operators are able to prioritise PS users, but ▪ When the public is cut off, they call the emergency services to get information.
Possible scenarios identified	Not applicable
Any other relevant information from the report	• Mission critical applications can be optimised to reduce the amount of data that is transmitted over lower bandwidth wireless networks: the communication payload: ▪ TCP/IP – 40bytes ▪ UDP/IP – 28bytes ▪ Radio optimised TCP/IP – 10 to 15bytes • Mobile data helps effectively to: ▪ Collect and share common situation picture ▪ Allocate right resources efficiently ▪ Distribute and obtain information instantly ▪ Collect surveillance, medical etc monitoring information ▪ Automate administrative routines.

C.2b TETRA Association TEDS workshop and TWC survey

Item	*Description*
Document title	TETRA Association TEDS workshop held in Bonn on 27th March 2007 TWC questionnaire in 2008
Author	Various
Publication date	March 2007
Abstract	Various presentations discussing user requirements, technical specifications for TEDS, spectrum and regulatory issues and applications for TEDS.

Requirements or needs identified in report	There is a need for mission critical data and data speeds beyond the TETRA 1 narrow band service.
	The capacity enhancements brought by TEDS are also needed so that systems can handle the load of multiple, concurrent narrow band data services such as database access and ID-card or fingerprint verification.
	The usage scenario in the field seems to be developing towards a network-centric way of working that relies on personalised data and where an overview of the incident is shared, which improves the situational awareness. More and more daily routines are expected to move to take advantage of data and there is a trend towards mobile offices – activities traditionally confined to an office environment are possible in the field.
	Need for the "higher bit rates" in wider channels:
	• Higher bit rates (150–500kbit/s?)
	• Wider channels (150kHz?)
	• Spectrum (2×5–10MHz?)
	• Timing TIP certified product available: 2010?
	Need for TEDS spectrum in PSS (based on re-use factor of 20 or more):
	• One 50kHz layer
	  ▪ 2×20×50kHz = 2×1MHz absolute minimum
	  ▪ 2×30×50kHz = 2×1.5MHz reasonable minimum
	• Double 50kHz layer (100kHz per site)
	  ▪ 2×20×100kHz = 2×2MHz absolute minimum
	  ▪ 2×30×100kHz = 2×3MHz reasonable minimum
	Applications need to work on multiple networks to maximise available coverage area and bandwidth
	Key Nødnett (Norwegian PS Network) TEDS User Requirements:
	• Basic user requirement is for the transfer of 100KB of data (e.g. picture) from a radio terminal within 10 seconds
	• No specific data applications identified at this stage but rather the expectation that there will be a strong operational need for higher speed data applications in the future
	• TEDS upgrade must minimise any disruption to the 'live' network
	• Level of encryption must be at least as good as TETRA 1

Possible applications identified in report	• Personalised information • Mobile command and control – dispatching • TEDS as data only layer – voice services provided by TETRA 1

	• Location tracking
	• Narrow band services
	    ▪ Scanned images (ID-cards) for verification
	    ▪ Database access
	• Wide band services
	    ▪ Video, both uplink and downlink
	    ▪ Messaging including attachments
	    ▪ Maps and drawings, images to vehicles
	    ▪ Remote maintenance – download of terminal configuration, firmware, software
	Top TEDS data applications identified at workshop:
	• Navigation / location tracking / AVL
	• Database queries (medical journal lookup, simple query and image-query)
	• High resolution still pictures (pictures from field, maps, fingerprint, vital data sampling)
	• Instant Messaging / email / news (field-to-field and office-to-field)
	• Electronic forms (paperwork, ambulance, home nurse)
	• Telemetry (sensors in vehicle / on patient)
	• Web browsing
	• Video streaming (surveillance) and video conferencing

Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	No, as commercial data services cannot be expected to be available at all times.
Possible scenarios identified	Not applicable

Any other relevant information from the report	TEDS features:
	• To be included in the TEDS TIP:
	    ▪ Security
	    ▪ Modulation 4/16/64 QAM
	    ▪ Service interaction
	        ○ Voice services offered to user busy in TEDS data service
	        ○ Concurrent voice and data
	    ▪ Quality of Service
	    ▪ TEDS PEI (MEX)
	    ▪ Multi-slot operation
	    ▪ Sectored cells (extended coverage)
	    ▪ High speed
	• Additional TEDS Features which would first need standard update:
	    ▪ Multicast
	• Devices:
	    ▪ Data only TEDS devices
	    ▪ Mobile and hand portable TEDS enabled voice & data devices
	TEDS does not cause significant interference to other systems but TEDS cannot co-exist with military air-ground-air radios.

C.3 Analysys Mason study on digital dividend

Item	*Description*
Document title	Exploiting the digital dividend – a European approach
Author	Analysys Mason, DotEcon and Hogan & Hartson LLP
Publication date	14th August 2009 (Final report)
Abstract	This document summarises the work carried out on behalf of the Information Society and Media Directorate General of the European Commission to ascertain what action needs to be undertaken at EU level to ensure the benefits of the digital dividend are maximised, including: • conducting an inventory of the situation in each Member State regarding the digital dividend • carrying out analysis to understand the demand for the spectrum as well as the social and economic value of potential users • reviewing technical issues, such as technology trends, interference issues • developing a range of scenarios for a co-ordinated EU approach, and a cost/benefit analysis of each approach. The report identifies seven potential uses of the digital dividend – DTT, commercial wireless broadband, services ancillary to broadcasting and programme making (SAB/SAP), broadcast mobile TV, cognitive technologies, wireless broadband for public protection and disaster relief (PPDR) and an innovation reserve. The study offered a set of recommended actions for a co-ordinated approach and a proposed roadmap for implementation.
Requirements or needs identified in report	The need for high bandwidth wireless services. PPDR is widely perceived as a high-value use of spectrum and the value of this use cannot be expressed solely in economic terms, as PPDR systems are used for safety of life and are regarded as necessary government services.
Possible applications identified in report	High-speed data transfer, e.g. paramedics need to transmit medical images and or reports to colleagues ahead of their arrival at the hospital. Real-time video transmission, e.g. to improve efficiency; ability to see what is happening at the scene; and instantly collaborate with central command, co-workers and other agencies.
Possible benefits identified in report	A PPDR network would be a key asset in the development of public health services and security for all, and as such would sustain the quality of life of citizens across Europe.
Can the benefits be realised using commercial networks	Commercially available wireless broadband technologies (e.g. WiMAX and LTE) could offer economies of scale and superior handset availability but may not be sufficiently reliable as they are optimised for different objectives than PPDR.
Possible scenarios identified	Not applicable
Any other relevant information from the report	The emergency services rely on good in-building coverage in order to communicate effectively at the scenes of incidents, and so spectrum below 1GHz is particularly suited to meet their requirements. In its 2008 Communication on "Reinforcing the Union's Disaster Response Capacity" , the Commission stated that "European citizens expect the Union to protect their lives and assets inside the EU" and stated that the "challenge of disaster prevention, mitigation and response…require[s] a comprehensive

approach by the EU to the continuum of disaster risk assessment, forecast, prevention, preparedness and mitigation (pre- and post-disaster), bringing together the different policies, instruments and services available to the Community and Member States working as a team".

Wireless broadband for PPDR (in addition to or to replace existing services) could realistically only be deployed terrestrially using spectrum below 1GHz, deployment at high frequencies would be too costly. It may be possible to deploy such a service in other bands, such as 450MHz, but less spectrum is available and it would require concerted coordination across Member States. Thus the incremental value is either (a) the additional value over and above existing national services; or (b) any extra costs or changes in service quality from using another band.

C.4 PCWG ad-hoc group studies

Item	*Description*
Document title	Police Cooperation Working Group – Improving radio communication between operational police units in border areas; analysis of the responses received to the data capture exercise on cross border working
Author	Police cooperation working group
Version	-
Abstract	Based on two documents – responses from 12 administrations to a questionnaire sent out on cross border working and a technical brief discussing the medium and long term goals for cross border emergency services mobile communications requirements following the survey. The Police Cooperation Working Group created a technical ad-hoc expert group on the future of radio-communications in July 2008, following the EURACOM seminar whose main objective is to identify technical solutions to foster interoperability between police forces, especially in border areas. The document puts together some ideas of how interoperability and cross border communications might be accomplished at a technical level and discusses a number of the issues that arise. The questionnaire addresses the requirements for voice, data, coverage, encryption requirements, spectrum and consideration of using a public network. The outcome of a three country pilot experiment in cross border communications was carried out between Germany, Belgium and the Netherlands was also presented.
Requirements or needs identified in report	• Full interoperability across Europe • Ability to create talk groups across networks • Pan-Europe direct mode capability • Ability to handle biometrics and other imagery and video-mobile broadband capability • Access to both home and local databases (this must be managed carefully with respect to security issues) • End-to-end encryption is preferred but air interface only encryption is accepted by some administrations • Full area seamless communications / interoperability across Europe (ISI?) • Border zone coverage, approx 15km • Access to both home and local control rooms (language issues will be highly significant and may be a greater obstacle than the technical issues) • Ability to create talk groups including home and visiting officers (patch functions) • Point to point calls and telephone interconnect • Automatic location capability for persons and vehicles and assets • Access to home databases and local databases for visiting officers including biometric databases • Harmonised spectrum – spectrum for mobile broadband minimum 2×10MHz, more realistic to look for 2×16MHz. Harmonised spectrum is key to providing full access across borders.
Possible applications	Voice

identified in report	• Full communications with home control room • Access to local force communications control room • Group based communications Data • Biometry • Video (on-line streaming) from field officer • Video (on-line streaming) to field officer • GPS position location information • Database access • Transmission of patient data, maps, building drawings • Others including SDS, SMS, status messaging, situational awareness and common picture functionality
Possible benefits identified in report	More successful and efficient cross border inter-working.
Can the benefits be realised using commercial networks	All the responses provided a consensus that public networks including GSM, 3G, etc. can be used as a backup to dedicated service and for non-critical traffic only.
Possible scenarios identified	Not applicable
Any other relevant information from the report	For a cross border mobile broadband capability European harmonised radio spectrum is an absolute requirement, as it has been for the current voice communications capability. This point needs to be clearly understood and communicated to spectrum management administrations. Failure to achieve harmonised spectrum will remove the possibility for secure and resilient cross border mobile broadband communications for the foreseeable future. A much more difficult situation is cross border communications between TETRA and TETRAPOL networks. Since TETRA is a TDMA based technology and TETRAPOL is based on FDMA the two air interfaces are physically incompatible. There would therefore be limited benefit in the development of an ISI. TETRA networks mainly provide emergency mobile communications in Europe, but there are also some TETRAPOL systems. Most operate at or close to 380/400MHz. Given the difficulties noted above it likely that full successful interoperability will only be achieved across Europe when all the participating countries are: • using a common air interface standard for voice and data • operate a minimum defined set of network features • have deployed a set of agreed configuration parameters • operating in a common frequency band. There is a requirement for the following: emergency call, individual call, group call with units on both sides of a border, duplex individual calls to telephone networks (telephone interconnect), fast set up for group and point to point calls. As countries develop their mobile communications services new technologies are likely to be introduced. The UK is in the process of commissioning the Future Communications Programme (FCP) to replace the Airwave TETRA network for both voice and data communications. No decision has yet been made on the technology to be deployed. FCP will start to enter service from 2014. Cross border issues will need to be considered from the outset of the commissioning process for new networks.

Full interoperability should imply access to local control rooms and the ability to create talk-groups across networks. Effectively this suggests the formation of a super network of interconnected networks. Thought needs to be given to the creation of a standard feature set and the management of this super network capability including issues of confidentiality and national security.

A three country pilot experiment in cross border communications was carried out between Germany, Belgium and the Netherlands. The outcome:

- Four pilot groups were available however, it was not possible to select a national group in a foreign network and it was not possible to indicate which network the terminal was registered
- Emergency calls were transferred to the selected (international) group and audio could be heard by all dispatchers and radios in the three networks within this selected group
- Emergency call signalling was only possible in the network in which the call was initiated, signalling was not transferred to the other networks.
- Possible to make an individual call to another radio when both radios were registered in the same network. The reason for this is that signalling was not being transferred to the other foreign networks.
- Telephone call was supported, however the set up of a telephone call was different for each network.
- Fleetmap – each subscriber that wanted to migrate to another network needed to have a unique ITSI that was not used in the foreign network. In other words, the ITSI needed to be known and equal in all three networks. This was similar for groups and the corresponding GSSI's.

C.5 ETSI SRD on Public Safety and Security (PSS) Systems

Item	*Description*
Document title	TR 102 628 – System Reference Document; Land Mobile Service; Additional spectrum requirements for future Public Safety and Security wireless communications systems in the UHF range
Author	ETSI
Version	V1.1.1 (2009)
Abstract	This document describes the spectrum requirements of future PSS communications for wideband and broadband applications. The document refers to narrowband and wideband PPDR applications in Europe being covered by TETRA Release 1 and TETRA Release 2 (TEDS), but that there is a need for interoperable, secure and wide-area communications for public safety users for wideband and broadband applications. This cannot be accommodated in existing spectrum available to PSS users since that spectrum is already fully used by voice traffic and some data usage. The document summarises spectrum requirements of 2 separate contiguous blocks of 10 MHz plus two separate non-contiguous blocks of 6 MHz dedicated to PSS and harmonised across Europe; the total of 16 MHz for each direction to fit within a tuning range. The required frequency range is between 300 MHz and 862 MHz, preferably in the lower parts of the band. The document advocates allocation of a dedicated spectrum band for harmonised wide-area communications capable of high-speed IP based data applications. Spectrum should be sufficient to meet the requirements of day-to-day PSS traffic and also cater for peak usage during major incidents
Requirements or needs identified in report	• Mission critical PPDR communications are exhibiting an urgent and growing need for inter-operable high-speed data services. • The wideband ECC Decision for 380-470 MHz does not give the PPDR community extra data capability, since the actual spectrum available is insufficient to accommodate high speed data applications • Lack of further availability of spectrum will risk the future development of the PPDR community through inability to support new services requiring more data (e.g. identify cards, photographs, fingerprints), failing to keep pace with societal developments where society is increasingly adopting advanced data applications, and inability to manage major disaster scenarios efficiently • User communities have determined that mobile data is equally as missions critical as voice, and therefore cannot be safety transported over commercial mobile networks. This is because officers will become more and more reliant and dependent on mobile data communications in support of their day-to-day operations • PSS TETRA networks will start being replaced, at least in part, from around 2012 onwards, with new technology needed to support voice, narrowband, wideband and broadband data services and be backward compatible and interoperable with existing (TETRA) networks • Spectrum requirement includes one contiguous component of at least one broadband channel width (10 MHz). Split of spectrum or fragmented spectrum is not viable due to RF front end complexities and difficulties with interoperability • Specific public safety operational requirements include control over security implementation and other operational aspects of the network, redundancy of components on cell sites (e.g. transceivers, site controllers, antennas), redundancy of UPS power supply capability,

	including battery and generator powered supplies, a high degree of network resilience (e.g. overlapping coverage from multiple cell sites), fallback strategies to allow stand-alone operation of sites disconnected from the rest of the network, redundant switching and a high level of RF coverage • DMO is required in all radio terminals, plus availability of the associated repeaters and gateways to provide RF coverage in difficult areas or where base station coverage has been lost • Need for fast communications set-up in combination with a much higher call set-up success rate, typically 99% or even higher for PSS compared to what is offered by public networks
Possible applications identified in report	• At present, operational PSS networks support voice and narrowband data services only. Whilst those applications will continue to be required, others that are needed include video conferencing, video streaming, full satellite navigation, secure passport and bio-metric checks, online access to various databases, full email internet browsing, and improved transfer of files (including maps and pictures) • Ability to move the back office into the field • Sending detailed photographic images of lost or wanted people • Relaying ad-hoc video camera and surveillance camera real time information to patrol cars • Sending detailed maps and plans • Sending biometric data from an incident in real time, rather than having to return to the office • The ability to transfer video data back to incident commanders to make faster and more informed decisions • Cross-departmental communications • References data service attributes from ETSI TS 102 181 of email, imaging, digital mapping, location services, real time video, slow scan video, remote database access, database replication and personnel monitoring
Possible benefits identified in report	• Socio-economic benefits include: saving lives of citizens and public safety officers, minimising damage to properties, faster response, more efficient communications, enhancement of a single emergency communication network with high reliability, availability and security, better co-ordination between different public safety organisations and agencies both nationally and over borders • Potential to enhance investments in European national public safety infrastructures through evolutionary enhancement • Single wide-area coverage network resulting in major cost savings in the network infrastructure compared to use of multiple solutions • Creation of a pan-European or global harmonised set of equipment requirements, resulting in higher economies of scale and lower costs.
Can the benefits be realised using commercial networks	• The mandatory services and facilities required by public safety organisations can only partially be provided on networks designed for commercial use, since those networks cannot be used to carry mission critical traffic • In many commercial networks, data is sent at lower priority than voice, which could be a significant problem for public safety users who often find themselves in areas where voice services are being used intensively, but that data services are also needed

	• Even if a commercial network was designed to meet the operational needs of public safety users – i.e. resilience, QoS, security – many Governments would still need to ensure that ownership of the operator would be under Government control, or alternatively may require continued guaranteed financial viability and/or options to take management control of the network when needed
Possible scenarios identified	• Large fire encompassing 3-4 blocks in a large city or a large forest fire • Large public event e.g. Commonwealth Heads of Government Meeting, G8 Summit, Olympics • High-resolution video communications from wireless clip-on cameras to vehicle-mounted laptop used during traffic stop or response to other incidents, and video surveillance of security entry points such as airports with automatic detection based on reference images, hazardous materials or other relevant parameters • Remote monitoring of patients and remote real-time video view of the single patient
Any other relevant information from the report	• Annex A.2 refers to recent survey conducted by Motorola and APCO of more than 200 public safety administrators and officers in the top 100 US markets regarding current and future use of communications • Annex B.2 refers to technology evolution e.g. narrowband-wideband-broadband

C.6 Results of the questionnaire on PPDR prepared by ERO on behalf of CEPT WGFM PT38

Item	*Description*
Document title	FM38(09)15 Rev 2 Annex 3, Result of Questionnaire on Public Protection and Disaster Relief
Author	CEPT European Radiocommunications Office (ERO) on behalf of CEPT Working Group Frequency Management (FM), project team 38 (FM38), with responses from spectrum authorities, PSS users and industry
Version	Questionnaire issued February 2009, results April 2009 Contained in zipped file ERO_401925899884259
Abstract	The questionnaire was prepared by CEPT WG FM38 and issued to CEPT spectrum authorities/regulators to gather information concerning future mobile radio applications, and associated spectrum requirements, associated with Public Safety and Disaster Relief (PPDR) – also referred to as Public Safety and Security (PSS). Spectrum authorities that participate in the FM38 group were asked to forward the questionnaire to public safety users within their countries (i.e. police, fire and ambulance authorities) and invite them to respond to the questionnaire too. The questionnaire had two purposes (i) to collect information from users to clarify the user requirements and needs for mobile radio applications for PPDR (ii) to invite authorities/regulators to consider possibilities to identify additional spectrum for public safety use, and candidate bands below 1 GHz. 52 replies received – 23 from authorities/regulators, 19 from user organisations and 10 from industry.
Requirements or needs identified in report	Current applications will continue to be required in future, along with a range of new applications, with increasing emphasis on: • Broadband (e.g. real time video surveillance, including live CCTV images and images captured and relayed from helicopters) • Enhanced graphical data exchanges • On-site expert medical support • Situational awareness at fire incidents, to inform control/field decision making • Giving the officer in the field in charge of a major incident the same functions as an operator in the control room ("taking the control room out into the field") • Remote situational assessment and control • Automatic facial recognition • Much higher data rates for database querying, geo-location etc. • Mobile office • Licence plate checks.
Possible applications identified in report	All present applications (listed in table below) also required in future, along with increasing emphasis on much higher data rates to improve efficiency of current applications, mobile control room, mobile office, video surveillance.
Possible benefits identified in report	1. Many of the companies who produce TETRA equipment are based in the UK and therefore the UK export market has benefited from the harmonised development of the TETRA standard 2. Vital for national security reasons

Can the benefits be realised using commercial networks	PSS users have specific operational requirements that public networks cannot deliver: • Resilience – overlapping cell coverage, redundancy of components, multiple backhaul links from individual radio sites, resilient switching (adjacent cells to be connected to different switches), fall back sites, power standby, etc. • Commercial networks do not offer professional radio oriented services (e.g. semi-duplex voice transmission for group calls, direct mode, different user priority levels and pre-emption) • Lack of security with commercial networks • In some countries there are limitations relating to the ownership/share structure of operating companies providing secure Government communications, which prevents use of commercial operators
Possible scenarios identified	Not applicable
Any other relevant information from the report	Questionnaire responses confirm PSS users currently use a mix of dedicated and commercial systems across Europe (TETRA, TETRAPOL, commercial GPRS/3G,satellite, RFID). Emphasis in future is integration i.e. simultaneous voice and video over the same network.

C.7 Results of the TC-RSS WG4 questionnaire

Item	*Description*
Document title	ETSI TR 102 733 and ETSI TR 102 734, Re-configurable radio systems (RSS): System aspects for public safety and user requirements for public safety
Author	ETSI TC TTS WG4
Version	V0.0.12 (November 2009)
Abstract	ETSI technical reports referring to a feasibility study of the system aspects (703) and requirements (704) for re-configurable radio systems (i.e. cognitive technologies etc.) for public safety. It identifies and defines the requirements of RRS to the public safety domain, incorporating the results of a questionnaire distributed by ETSI TC RRS WG4 to end-users across Europe. The scope refers to re-configurable radio systems only, and does not define requirements/system requirements for a complete radio replacement system for public safety users.
Requirements or needs identified in report	Defines the role of different public safety authorities, e.g.: • Law enforcement – patrolling to identify and intervene in cases of offence to criminal law, criminal investigation, customs verification, law enforcement in the transportation domain (air, road, rail, sea), custody and transportation of criminal convicts • Emergency medical and health service – provide critical and supportive care of sick and injured citizens and the ability to transfer citizens in a safe and controlled environment. Information required by EMS providers includes patient information, medical information, resource information, incident information and geographical information • Border security (including coast guards) – verification of illegal immigration, verification of the introduction of illegal substances, verification of introduction of goods in offence to customs regulations • Fire-fighting – including fire fighting, search and rescue, management of hazardous materials, protecting the environment, salvage and damage control • Protection of the environment (forests etc.) – typically employing sensor devices • Search and rescue • Crisis management – typically requiring situational information/situational awareness. Requirements defined as: joint operations between different PSS users, ability to operate in unpredictable conditions, ability to communicate when networks are unavailable (i.e. direct mode), terminals interoperability, limited budgets, security of various levels, resilient networks, resource management (i.e. support dynamic prioritisation of available capacity) and scalable networks From the user survey (RRS WG4 questionnaire), the following requirements are identified: • Broadband connectivity • Interoperability between different PS users • Avoid need to use multiple terminals • Communications in tunnels/underground/indoors • Increased capacity, coverage, grade of service, voice quality, robustness

	to interference, reduced call set up time. • Messages of large sizes, access to databases, access to web, video, video conferencing, distribution of images and buildings plans, medical information, bio metric data, weather/traffic information, software updates to terminals in real time.
Possible applications identified in report	1. *Verification of biometric data.* Public Safety officers may check the biometric data of potential criminals (i.e. fingerprints facial/iris recognition) during their patrolling duty. The biometric data could be transmitted in real-time to the headquarters or a center with the biometric archives and the response could be sent back to the Public Safety officers. This would be a positive method of identification during field interrogation stops. 2. *Wireless video surveillance and remote monitoring.* In these types of applications, a sensor (fixed or mobile) can record and distribute data in video-streaming format, which is then collected and distributed to public safety responders and command & control centers. 3. *Automatic number plate recognition where a camera captures license plates and transmits the image to headquarters* or a center with the plate data to verify that the vehicles have not been stolen or the owner is a crime offender. 4. *Documents scan.* In patrolling or border security operations, public safety officers can verify a document like a driving license in a more efficient way. Documents scan is also useful in border security operations where people, who cross the borders, may have documents in bad condition or falsified. 5. *Database checks.* This application area includes all the activities where public safety officers must retrieve data from the headquarters to support their work. 6. *Location/Tracking for Automatic Vehicle/Officer Location.* The public safety officer has a GNSS position localizer on the handheld terminal or the vehicular terminal. The positions are sent periodically to the headquarters so that the command centre can organized and execute the operations in a more efficient way. 7. *Transmission of Building/Floor plans and Chemical data.* In case of an emergency crisis or a natural disaster, Public Safety responders may have the need to access the layout of the buildings where people may be trapped or where dangerous chemicals are kept. Chemical data, building or floor plans can be requested to the headquarters and transmitted to the public safety responders. 8. *Monitoring of Public Safety officers.* Vital signs of Public Safety officers could be monitored in real-time to verify their health conditions. This is particularly important for firefighters at fire incidents and officers involved in search and rescue operations. 9. *Remote emergency medical service.* Through transmission of video and data, medical personnel may intervene or support the team in the field for an emergency patient. 10. *Sensor networks.* Sensors networks could be deployed in a specific area and transmit images (thermal) or data to the Public Safety responders operating in the area or to the command centre at the headquarters.
Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	PSS requirements capture routine operations, emergency crisis, major planned events, natural disasters and search and rescue – all of which require ubiquitous communications, and the ability to concentrate capacity in incident areas, which commercial networks do not provide. Lack of network

	capacity is mentioned as a key problem during emergency incidents. The document also cites the following reasons (these relate to why PSS requires re-configurable radio systems in addition to voice/data wide area networks to overcome the limitations of existing public safety communications systems in large incident situations, but some are also valid reasons against use of commercial networks): The locations where emergency and disaster relief operations occur are unpredictable and the availability of communications facilities is not guaranteed in the incident area. Even if wireless communications infrastructure exists in the incident area, the first responders may not have the appropriate terminals. Public safety responders need wide area coverage, e.g., in the event of natural disasters like earthquakes or flooding, where a large area may be affected. Support for wide area coverage and higher transmission output is a conflicting requirement with low power consumption and extended battery life for handheld terminals. Public safety organizations must operate in uncertain conditions and difficult environments both from a physical as well as from a radio propagation point of view, due to the presence of radio interferences or obstacles (man-made or natural). Public safety responders have special requirements regarding reliability, responsiveness and security of their communication systems.
Possible scenarios identified	Refers to four scenarios contained in SAFECOM document from US communications programme of the Department of Homeland Security – Public safety statement on requirements for communications and interoperability: 1. Emergency Medical Services (EMS): Routine Patient Services and Car Crash Scenario. A voice conference call is set up between the ambulance and the hospital, while the vehicle's geo-location as well as the vital measurements and treatments of the patient are recorded and transmitted wirelessly. 2. A residential fire scenario: as in the first scenario, geo-location and vital measurements of multiple victims, first responders and vehicles is wirelessly transmitted; additionally, GIS information on building plans, fire hydrant locations, etc is accessible. 3. A traffic stop scenario: the situation message, the police vehicle's ID and geo-location are transmitted; the suspect car's license plate is read and sent to dispatch, where it's queried against several law enforcement databases, and the results are sent back to the police officer; a video stream of the action is available on demand to dispatch; the officer decides to request backup, the nearest vehicle is located by the backup system and the request is forwarded; when the suspect is arrested, information about the crime, the police officer, etc is loaded onto the RFID embedded in the handcuffs; after the arrest, biometric data from the suspect is sent to dispatch, queried against databases, and the answers are sent back; the officer communicates with the tow truck company; evidence and other information is transmitted to the sheriff's office; the case report is sent electronically to the officer's supervisor. 4. An explosion scenario: here the communications analysis is from the incident commander's point-of-view, while all the first-responder requirements described in the previous scenarios are still considered valid; the various (diverse) units that arrive on the scene form an ad-hoc overlay network and provide information about their location and status; GIS information is available on demand to the commanders; distributed sensors

	on the first-responders relay their readings to central command; a secondary perimeter is set up, and a reverse 911 call is sent to fixed and mobile users (civilian) inside the perimeter to evacuate or find shelter; at the same time, the Department of Transportation is notified to divert traffic from the area; critical infrastructure (gas, electricity) is shut down; the commander decides the explosion is not an accident, and directs field agents to treat it as a crime scene, while calling in detectives to investigate; the number of casualties is assessed too high for local hospitals, so coordination with other medical centers is necessary; at the end of the incident all-but-one of each type of team is released.
Any other relevant information from the report	The two ETSI TR refer to various other documents upon which requirements have been based: ETSI TS 102 181 (EMTEL) requirements for communication between authorities/organisations during emergencies TS70.001 – Service specification group services and applications Project MESA: Service specification group statement of requirements SAFECOM, Department of Homeland Security – public safety statement of requirements for communications and interoperability ETSI TR 102 182 – requirements for communications from authorities during emergencies Project OASIS – European disaster and emergency management system WIDENS (wireless deployable network system) – supported by EC IST Framework programme 6. Builds upon MESA statement of requirements.

C.8 Results from the expert group on police cooperation

Item	*Description*
Document title	Draft Council Recommendation on improving radio communication between operational units in border areas
Author	Council of the European Union
Publication date	20 May 2009
Abstract	The paper discusses recommendations on improving radio communications in border areas and more effective cross-border cooperation including interoperable radio communication systems in border areas and between operational services from different Member States. Difficulties in the use of radio communications in border areas are caused mainly by the lack of interoperable interfaces between current systems, which prohibit effective roaming; needs to be addressed. Therefore, significant improvement in voice and low-speed data interoperable capability could be achieved by interconnecting systems where possible. In the long term, law-enforcement and public-safety radio communication systems will need to support and to be able to exchange high-speed mobile data information. However, current law enforcement, public-safety and public networks may not be able to support this. The document recommends that: • Intersystem interfaces be developed and encourages the European Commission to provide funding for them • CEPT / ECC be tasked to study the possibility of obtaining sufficient additional frequency allocation below 1GHz for the development of future law-enforcement and public-safety voice and high-speed data networks; • European standardisation bodies be invited to start producing a European standard satisfying law-enforcement and public-safety services' operational requirements regarding high-speed data communication and roaming functionality in the medium term • In the long term, after the life cycle of current TETRA and TETRAPOL systems has ended, voice and all data functionalities (high and low speed) be integrated in a tightly integrated solution that provides a migration path including interoperability from existing law enforcement and public-safety systems to the new solution • Member States allocate additional frequencies at national level in a coordinated timeframe in cooperation with CEPT • Member States adopt any appropriate local measures in the short and medium term to improve cross-border cooperation.

Requirements or needs identified in report	• A common network standard or standards operating in harmonised frequencies to facilitate fully interoperable communications;
	• Taking into account investments in existing systems, significant improvement in interoperability in border areas can be achieved as follows:
	  ▪ in the short term, countries with common borders can work together to improve communications with local solutions;
	  ▪ in the medium term, current law-enforcement and public-safety mobile communications systems need to be connected to provide a more effective solution for cross-border communications and facilitate roaming;
	  ▪ in the longer term, a solution for mobile broadband data is required.

	A common standard operating in a harmonised frequency band will make this possible • existing frequency allocations for law-enforcement and public-safety networks may not be sufficient for the development of dedicated infrastructures satisfying operational requirements for high-speed data communication; • there may be opportunities below 1 GHz. to acquire new harmonised spectrum; • in discussing possible additional frequencies, account should be taken of the investments in current networks and also of the increased overall demand for radio spectrum and the fact that it is a scarce resource.
Possible applications identified in report	Not applicable
Possible benefits identified in report	Improve cross border cooperation between operational services
Can the benefits be realised using commercial networks	This was not discussed in length but did mention that current public networks may not be able to support and enable high-speed mobile data information exchange.
Possible scenarios identified	Not applicable
Any other relevant information from the report	Not applicable

C.9 Project MESA

Item	*Description*
Document title	Project MESA; Service Specification Group – Services and Applications; Statement of Requirements (SoR)
Author	MESA
Version	MESA TS 70.001 V3.3.1 (March 2008)
Abstract	Public Safety Partnership Project (PSPP) produced this Technical Specification (TS) during the course of Project MESA (Mobility for Emergency and Safety Applications). It describes the services and applications, which a future advanced wireless telecommunications system should be able to support in order to realize the most effective operational environment for the Sector. Emphasis has been placed on those applications, which current applied technology cannot carry out to the full, but which have been identified by the users and their agencies to be key requirements and capabilities, providing a profile of the common operational and functional requirements of next-generation aeronautical and terrestrial-based, mobile and fixed systems. The document reflects the requirements of public service and public safety agencies to have priority service and system restoration, extremely reliable service, and ubiquitous coverage within a user's defined service area. The document is intended to be a unique source of information in the aim of understanding the often very difficult and dangerous working environments, which the user community is facing, such that Industry can provide the most effective and accurate technical solutions. It establishes an understanding that the advanced needs of the PPDR Sector should be based on a high-mobility, broadband wireless network or related capabilities that allow for the provision of dynamic bandwidth, offering of self healing characteristics and secure network access. Project MESA SoR also reflects the vision of a mobile broadband-shared network that can be simultaneously accessed by multiple users, with multiple applications in a specified geographical area fully independent from availability of public networks and supply of electrical power.
Requirements or needs identified in report	These include but not limited to: • Improvements in spectrum efficiencies. • Incorporation of frequency neutrality and/or agility. • Life-cycle procurements. • Security requirements. • Economical and ergonomically friendly design. • Digital migration in place. • Consistency with existing standards. • Compatibility with multiple international standards. • Two-way communication. • Multiple levels of security. • Multiple levels of availability of service. • End-to-end network integrity. • High-speed, error-free service. • System and network access. • Compliance with the need of the participating nations.

Possible applications identified in report	*Wireless data requirements* include such uses as mobile computing terminal applications, geographic position and automatic location data, emergency signals, transmission of reports, electronic messaging, home incarceration monitoring, and perimeter and vehicle alarms. *Multimedia systems* employing both photographic and fingerprint transmission in conjunction with report automation. *Remotely controlled radio devices* are routinely used for turning on and off surveillance microphones, activating kill switches in vehicles, arming and disarming alarm and monitoring systems, and aiming video cameras. This control can be a one-time data burst or can be a continuous data stream. *Unattended electronic sensors/monitors*, for border surveillance, parolee monitoring and other remote-sensing technologies. *Global location services* for vehicle and personnel tracking, security, and inventory control *Institutional monitoring* such as remote electronic monitoring devise for house arrests and *environmental monitoring* such as real time monitoring of public resources, such as water flow and quality *Telemetry systems* may also provide both an inventory of remaining infrastructure and the control of moving fixed assets, such as fire trucks, snow ploughs, police cars, ambulances, and many other types of equipment used in emergency response, including changeable signs and traveller information radio systems, as well as weather and road condition data transfer from remote sites. *Personal location device* to track the location of an assigned individual for general management purposes and in the event of an emergency. Transmission of forms and reports to central sites from mobile and remote locations. This capability will be used to transmit long data streams to and from central locations and the field in just a few seconds. Video capabilities (real-time and close to real-time) including traffic surveillance, disaster relief, emergency medical services video, point-to-point and broadcast, transmission of videos from field operatives to command and control as well as the other way. Robotic devices for hazardous material and explosive disposal, which require full-motion video that can be transmitted over a short distance (up to 1000 meters), from the control device to the robotic devices. This application may require the use of equipment and technologies developed for explosive atmospheric conditions and/or that will not initiate the explosive device being rendered safe. Lifeguard/water safety personnel often require the support of robotic devices in underwater search and rescue operations, especially when persons, planes, and ships are submerged in water depths greater than 200 feet.
Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	The Project MESA SoR reflects the need for a network that is fully independent from availability of public networks and supply of electrical power that satisfies the following requirements: • Transparent and seamless wide-area network applications. • Include multiple levels of security and data encryption schemes that may be a function of the network or a function of the application or communication device to ensure end-to-end data protection. • Offer robust operational management and control systems capabilities.

	• Reflect the requirements of MESA users to have priority operational services and priority system restoration. • An extremely reliable service model and ubiquitous coverage within a user's defined service area.
Possible scenarios identified	Describes a number of details scenarios in pages 40-43 of the document: • Law enforcement – Court house murder • Law enforcement – U.S. State and Urban Police Response to Earthquake Damage.
Any other relevant information from the report	The document includes a detailed statement of specific/unique requirements for the different government and emergency services organisations, giving examples of application needs - some of which are typically not supported in commercial terminals, which supports the argument about the requirement for dedicated networks (and associated terminals).

C.10 Toia Report on Digital Dividend

Item	*Description*
Document title	Extract: Toia Report on Digital Dividend/2008-09-26 - Text adopted
Author	Rapporteur - Patrizia Toia
Version	24 September 2008
Abstract	European Parliament resolution of 24 September 2008 on reaping the full benefits of the digital dividend in Europe: a common approach to the use of the spectrum released by the digital switchover (2008/2099(INI)).
Requirements or needs identified in report	Confirms the societal value of public safety services and the need to include support for their operational requirements in the spectrum arrangements arising from the reorganisation of the UHF band resulting from the switch-off of analogue services. Considers that the part of the harmonised spectrum at Community level dedicated to emergency services should be capable of providing access to future broadband technologies for the retrieval and transmission of information needed for the protection of human life through a more efficient response on the part of the emergency services.
Possible applications identified in report	Not applicable
Possible benefits identified in report	Societal value
Can the benefits be realised using commercial networks	Not applicable
Possible scenarios identified	Not applicable
Any other relevant information from the report	• Recognises that the increased spectrum efficiency of digital terrestrial television should allow for around 100 MHz of digital dividend to be re-allocated to mobile broadband and other services (such as public safety services, radio-frequency identification and road safety applications) whilst ensuring that broadcasting services can continue to flourish • Acknowledges that coordination at EU level would encourage development, boost the digital economy and allow all citizens affordable and equal access to the information society • Calls on the Members States, whilst fully respecting their sovereignty in this regard, to analyse the impact of the digital switchover on the spectrum used in the past for military purposes, and, if appropriate, to reallocate part of that specific digital dividend to new civilian applications • Emphasises the contribution that the digital dividend can make to the provision of enhanced interoperable social services, such as e-government, e-health, e-vocational training and e-education to citizens, in particular those living in less favoured or isolated areas, such as rural and less developed areas and islands • Encourages Member States to consider, in the context of allocating white space, the need for unlicensed open access to spectrum for non-commercial and educational service providers and local communities with a public service mission • Emphasises that Member States may consider technology-neutral auctions for the purpose of allocating frequencies that are liberated because of the digital dividend and making those frequencies tradable; considers, however, that this procedure should be in full compliance with ITU radio regulations, national frequency planning and national policy

objectives in order to avoid harmful interference between services provided; warns of spectrum fragmentation which leads to the sub optimal use of scarce resources; calls on the Commission to ensure that a future coordinated spectrum plan will not create new barriers to future innovation

- In order to achieve a more efficient use of spectrum and to facilitate the emergence of innovative and successful national, cross-border and pan-European services, supports a coordinated approach at Community level, based on different clusters of the UHF spectrum for uni-directional and bi-directional services, taking into account the potential for harmful interference arising from the co-existence of different types of networks in the same band, the outcomes of the ITU Geneva RRC 06 and WRC 07 and the existing authorisations.

C.11 WIK Study

Item	*Description*
Document title	Safety first – Reinvesting the digital dividend in safeguarding citizens (WIK_white paper_full_final)
Author	WIK Consult
Version	Bad Honnef, 5 May 2008
Abstract	Report produced by WIK and Aegis Systems with input from selected public safety organisations, regulators and TETRA vendors. The report recommends that public safety users require dedicated networks because of the unique technical and operational requirements associated with providing mission critical communications, which are extensive coverage (e.g. excess of 99% geographic coverage), capacity (e.g. public safety networks have to be capable of nationwide call set up with latencies of less than 0.5 seconds), reliability (99.999%) and redundancy (e.g. 1+1 or 1+n redundancy, power supply redundancy is essential, etc.). The report goes on to suggest that sub-1 GHz spectrum is required for public safety networks in order to meet their technical and operational requirements. Suggests that there is a 'moral obligation' to assign spectrum to public safety since PSS services are indispensable. Since emergency response ranges from routine to extreme, might be possible to use some novel spectrum allocation methods e.g. pre-emptive spectrum assignment, to provide a 'core' band for PSS use and additional spectrum that can be used when required – but when not required, can be used for commercial systems. Possible for commercial users to share a PSS networks, but not vice versa (other than for non-mission critical applications) due to the cost, complexity and risks associated with upgrading a commercial network to achieve the ubiquitous coverage, reliability, redundancy and capacity that PSS networks require.
Requirements or needs identified in report	Mission critical applications have unique technical and operational requirements, which are not met by commercial networks, since the latter are optimised for financial return on investment. They require dedicated spectrum and control of their own networks because of the flexibility it affords and ability to meet their own specific requirements of security, robustness, immediacy of communications. Public safety users have different requirements with respect to user terminals compared to commercial users – typically public safety terminals need to be designed for use and support for 5-6 years (as opposed to 1-2 for commercial handsets), due to budgetary considerations, training requirements and reliability. All handsets must have the same user interface and all operate in the same way. Mission critical refers to information that must be transmitted because it is crucial to the successful resolution of the emergency operation, requiring: coverage everywhere, instant access to resources, fixed and deployable networks, ability to support mixed traffic, flexibility, security, resilience, and additional network operation e.g. peer to peer/DMO (terminal to terminal communications without connection via the infrastructure).
Possible applications identified in report	• Remote checking of information such as passports and biometric details • Sending detailed photographic images of children lost or people wanted to officers in the field, so they can act on requests immediately • Providing access to Fire Service 'Gazetteer' which is document containing information on which hazardous materials might be kept in particular premises

	• Transmission of live video information from an incident to central command and control, so they have access to the same images as those in the field (and thereby improve decision making) • Relaying ad-hoc video and surveillance camera real time information to patrol cars responding to incidents • Sending of full data on a patients condition from the ambulance to the hospital • Video streaming (e.g. CCTV on scene) • Online access to contacts database • Email and internet • Ability to move the back office into the field • Real time evidence collection • Licence plate recognition • Traffic light sensors.
Possible benefits identified in report	• Improved establishment of command and control – public safety agencies are increasingly moving to field command (although command and control rooms will still remain) • Dissemination of timely information (e.g. medical records, details of dangerous substances, maps, pictures and videos) • More timely response e.g. able to act on requests immediately • Better decision making – those in command and control and in the field have access to the same information at the same time • Interoperability - possibly public safety interoperability can be achieved using DMO only • Better mobilisation of teams and people • More frequent updates on emergency situational reports • Better preparation (e.g. informing hospitals of likely numbers of casualties and the sorts of treatment required) • Better incident provision from the incident area • Voice is still the central means of command and control for public safety, but they are increasingly using data applications • Better 'location' information e.g. location of fire fighters and people within a building, real time viewing of building plans, better ability for incident commander to take decisions such as building evacuation (e.g. if building is about to collapse) • Real time structural awareness.
Can the benefits be realised using commercial networks	The two main problems with using commercial networks for safety critical applications are availability and performance. Cost to upgrade a commercial network to provide the operational requirements public safety need in terms of resilience, redundancy, capacity and coverage needs to be borne by public sector since it is not commercially viable. Problems of public safety users relying on a commercial network operator include: risk of commercial operator becoming insolvent, risk of commercial operator imposing unexpected price increases, meeting specific information security requirements etc. Having a dedicated network allows public safety users to have control over QoS, SLAs etc. (possible that operation and maintenance could be outsourced to a private company). Current commercial networks do not provide 0.5 second call set up, nor

	99.999% reliability, nor power supply redundancy.
Possible scenarios identified	The report refers to a case study of the Buncefield fire – the explosion of the UK's fifth largest fuel distribution depot in Hertfordshire. Explosion took place on a Sunday when public networks were not being extensively used and in area of low population density, and so public safety users were able to make use of GSM/GPRS on that occasion – no need to ask for priority access to the network on that occasion. Problems in obtaining good voice clarity across all of the incident area were experienced.
Any other relevant information from the report	Annex D of the report summarises its main arguments and counter arguments.

C.12 PSC Europe response to the digital dividend

Item	*Description*
Document title	PSC Europe response to the digital dividend hearing
Author	PSC Europe
Publication date	11 June 2008
Abstract	It is a summary of the response provided by PSC Europe.
Requirements or needs identified in report	ETSI has been developing a system reference document. That document, in its current form, concludes that 2 times 15 MHz would be a reasonable amount of spectrum for the new services. However, there are other applications that would require more spectrum. This figure has been developed by ETSI and communicated to the CEPT.
Possible applications identified in report	Not applicable
Possible benefits identified in report	Value should be considered as judged by the end user and the value to citizens and society, as the value for society is not merely economic but includes important social benefits, and will place a high value on the prevention of accidents and/or the rapid handling of incidents that do occur. Generated value is something beyond just the economic value. Total value cannot always be quantified in economic units. Economies of scale – with European PS Agencies, we have a market size of only a few million devices. Harmonization will therefore have huge impact on prices and therefore the industry and the tax payers Cross-border cooperation – as demanded under the Schengen Agreement. As many EU Member States have common borders with several other Member States and therefore many operations or emergency interventions in common, cross-border operation is a vital component of emergency service provision now and in the future.
Can the benefits be realised using commercial networks	No, as public safety: • Needs an infrastructure that is independent from the common commercial networks • Needs an optimised design to carry out group calls (voice, video and data multicasting) • Needs quick connections • Needs independence • In practice, the commercial operators do not accept to grant pre-emptive priorities to the PS agencies.
Possible scenarios identified	Not applicable
Any other relevant information from the report	The combination of: • operational cross-border requirements, • economic benefit to governments and the funding taxpayers via volume effect on unit cost and • facilitation of industry business case in this limited volume but high-tech market, form a package with overriding justification that allows the EC to proceed with e.g. specific mandate or other appropriate measures. Both for operational cross-border cooperation reasons and for economic reasons that help both the investing taxpayers and the industry to build reasonable business case, harmonised frequency arrangements for the PS Services would permit the emergency agencies to deploy data services in an economically feasible way.

C.13 EULER End User Requirement

Item	*Description*
Document title	EULER End User Requirements Deliverable 2.3-1
Author	Dimitrios Symeonidis
Version	V0.8 (September 2009)
Abstract	The objective of EULER (European Software Defined radio for wireless in joint security operations) is to answer the operational question of how a major civil international crisis can be rapidly resolved jointly given the various types of radios used by different national emergency services. The end user involvement package is organised around a framework for usage scenarios and requirements and systematic methodology for the harmonisation of needs at the European level. The document summarises the End-user involvement framework definition and lists past projects, where the conclusions are summarised and the methodology for requirements classification, requirements harmonisation and matching of the EULER scope are presented. EULER intends to provide added value in comparison to the past projects by providing a harmonised, classified and prioritised collection of requirements from past projects, which includes: • SeBeCom analysis • Wintsec analysis • Safecom analysis • MESA analysis • Chorist analysis. The scenario presented is that of a Tsunami describing first hours operations capabilities, communication flows priority, organisation network composition and communication link requirements.

Requirements or needs identified in report	• Interaction between users
	  ▪ Real-time exchange of information between several authorized emergency personal
	• Applications and services
	  ▪ Data to be transported
	  ▪ Network congestion management requirement
	• Interoperability, adaptability and flexibility
	• Reliability and information assurance
	• Robustness
	• Sustainability
	• Environmental safety
	• Security
	  ▪ Authentication
	  ▪ Access control
	  ▪ Confidentiality
	  ▪ Integrity
	  ▪ Availability.

Possible applications identified in report	• Speech – speech quality, point to point duplex communications, direct mode, ambient listening

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- Short messages – paging services, status monitoring, location services
  - able to identify the requested authorized emergency agent(s), and then deploy the appropriate technology to contact them
  - Status monitoring may include breathing air tank levels, accountability monitoring, distress buttons and vital signs monitoring.
  - Location services provide real-time information regarding the position of personnel or vehicles to a command point. The network must support three-dimensional geo-location information transmission.
- Access to databases
  - Variety of data applications including email (text messages), imaging, digital mapping / geographical information services, location services, video (real-time), video (slow-scan), remote database access, database replication, personnel monitoring
- File transfers
  - Supports bulk file transfer
- Images
  - Support images and scene photo transfers
- Video
  - Incident area network video communication service supporting full-duplex, peer-to-peer, mission-critical video and allow for late entry.
  - Near real-time video streaming.
- Multimedia conferencing
  - Incident area network highly interactive service transaction data
  - The network must support a signalling protocol that is capable of providing session control for both voice and video applications, as well as instant messaging
- Web
  - The network must support World Wide Web browser-based applications
- Email
  - Especially useful in noisy environments, or for difficult-to understand data, such as a license plate or a passport number
- Telemetry
  - Environmental telemetry e.g. waters flow and quality, providing instant information and a timely warning of severe change in conditions and early warnings.
  - Transmission of user and patient monitoring telemetry e.g. from inside the ambulance to the receiving hospital's emergency room
  - Transmission of geographical location data (Galileo) e.g. useful for tracking the location of field officers
  - Network of sensors, which are embedded into the field officer's terminals, such as temperature or dangerous gas sensors.
- Instant messaging – peer-to-peer
- Paging including voice paging to one or more participants
- Quality of service
- Pre-emption

	▪ Within all speech services there may exist a requirement for prioritisation and pre-emption of calls. ▪ This service shall allow an authorized user to intervene in an ongoing authority-to-authority call. • Priorities • Two-way communications • Multi-point to multi-point communications ▪ Belonging to groups ▪ Dynamic group creation/ deletion/ modification ▪ Dynamic Group Number Assignment ▪ Group members ▪ Talk group ▪ Group communication interoperability ▪ Group contain • Dynamic updating of data fields ▪ support two-way operation to accommodate the implementation of "smart" systems that automatically update data fields being transmitted from authorized and authenticated user devices
Possible benefits identified in report	Future public safety communications will benefit from the use of massive data transmissions to improve the efficiency of disaster recovery operations. An efficient radio spectrum management optimises the spectrum sharing between the different public safety organizations according to their respective and evolving needs. Sophisticated spectrum management algorithms, which can adapt to changes in the radio environment, can help using radio spectrum more efficiently. EULER proposes a system in which each subset is able to dynamically change the operating frequency band and bandwidth, is able to reallocate its use of radio spectrum bands, is aware of the existence of other wireless communications systems transmitting in the incident area, has sensing capabilities, and is able to inform the other subsets of its spectrum usage in its coverage. All of this contributes to provide a wireless system that is more reliable and resistant to interferences.
Can the benefits be realised using commercial networks	Not applicable
Possible scenarios identified	First Hours of international, state and local Public Safety Operations in response to a Tsunami. • Tsunami monitoring systems are positioned at strategic locations. • First hours: until local and mobile command centres are activated and connected to country's Emergency Operations Centres (EOC), which can last some days due to inundation and receding water. • Ground based wire and fibre communications to the outside world are temporarily disrupted. • First link establishment of V-UHF radio communications (air-to-ship, air-to-ground, air-to-air, ground-to-ground (voice, video, data)). • Information flow – search and rescue first operators, situation awareness video supported.
Any other relevant information from the report	Not applicable

C.14 TETRA Association Spectrum Group study

Item	*Description*
Document title	What data services will the future bring – from a TETRA perspective
Author	TETRA Association Spectrum Group
Version	Indicated as "draft" (November 2009)
Abstract	The document discusses the killer application for TETRA being mission critical group calls, and then discusses the feasibility of carrying missing critical group calls, and other public safety data applications, over LTE networks. The conclusion is that LTE is unlikely to be feasible to replace private networks in the short term, because (i) the LTE standard would need to be modified to support true multicasting group call capability (currently group calls via LTE are proposed to be delivered through a set of unicast IP streams, which means each member of the call receives his/her own copy of the voice stream. This can lead to quality problems (due to echo) and capacity issues due to the cell load created through transmission of multiple copies of the same IP stream), and (ii) LTE would also need to be modified to support direct mode (i.e. terminal to terminal calls that do not go via the LTE network) (iii) Emergency Services require a range of terminals (rugged, environmentally sensitive, covert) which commercial vendors do not provide, and so this would require special development (refers to the case where the GSM standard was modified for the railways, however the modifications required to GSM to create GSM-R were sufficiently large that whilst GSM is supported by many vendors, GSM-R is limited to very few, and prices for GSM-R are even higher than for TETRA).
Requirements or needs identified in report	1. Group calls where all users on the call, without substantial network overheads and/or cell capacity issues, receive the same transmission simultaneously. 2. Nationwide coverage, including 'difficult' geographies and indoors 3. Layered priorities/pre-emption (i.e. enabling emergency services to have priority access over commercial traffic, and enabling higher ranks of officer pre-emptive access over lower-ranked officers where required) 4. Queued calls, and the ability to configure queuing conditions 5. User prioritisation (e.g. calls cant go ahead until nominated callers join the call) 6. Encryption of different levels (over the air and end to end)
Possible applications identified in report	Mainly refers to existing functionality e.g.: • Direct mode – radio to radio communications outside the infrastructure • Individual calls using half duplex PTT (push to talk) mode • Status messages, which are used as fast efficient messages in addition to the more standard Short Data/Short Message text services • Multiple levels of encryption, both end to end and air interface. • Dynamic group management – providing groups over the air, temporarily or permanently • Broadcast calls, both with static and dynamic user base • Group scanning with talkback functions • Paging from one service into another, and simultaneous services Also refers to the need for dispatcher terminals
Possible benefits identified	Bespoke, privately run networks for the emergency services can be developed to give the required level of terminal ruggedness, environmental

in report	protection, audio levels, battery life, accessories, and resilience, coverage, availability and security at the network level. These factors make it difficult to reuse networks and terminals taken from the consumer market and to obtain the economies of scale that the consumer market brings.
Can the benefits be realised using commercial networks	Primary reason given is that there is currently no standardisation activity going on at present to adapt LTE to meet emergency services requirements, and if there was to be activity, this would take some time to complete. Also refers to the additional cost to modify commercial networks to deliver emergency services functionality [which *assumes* this cost is higher than the cost to deploy a new, bespoke private network for the emergency services]. Reasons listed in the document: 1. A public network provider will want to invest in coverage where the population, and so where the revenue generation is, with little incentive to invest in areas of low-density population. The cost of network expansion may have to be borne by the public safety community alone. 2. The public safety community will – through a tender process – have to select one of the providers, and fund the expansion of that system to provide the required degree of coverage. That in turn will distort competition and may be the basis for litigation. 3. Bespoke mission critical networks are usually designed with higher degrees of resilience, including multiple levels of fallback with emergency power supplies, alternate link routing and local call switching even within a single base station. These facilities are not provided to the same degree on a public network. 4. In conditions of local or national emergency, public networks typically become overloaded as their normal customer base naturally wants to communicate at the same time. It can be difficult to guarantee the public safety community access in these conditions. 5. In high threat conditions, e.g. terrorist threats or in times of war, public networks can be deliberately switched off to prevent terrorist communications for coordination or for remote activation of attacks.
Possible scenarios identified	Not applicable
Any other relevant information from the report	Refers to WiMAX being "easier to deploy for a privately owned mission critical user base", due to network scalability (more flexible bandwidth choices and no need for harmonised paired bands) and less spectrum being needed (i.e. because it uses unpaired spectrum).

C.15 Wireless broadband study by Public Safety Spectrum Trust Chairman

Item	*Description*
Document title	Public Safety Radio Communications; Wireless Broadband is not an alternative to LMR mission critical voice systems
Author	Chief Harlin R. McEwen Chairman, Communications & Technology Committee International Association of Chiefs of Police
Version	Draft (12 October 2009)
Abstract	The paper discusses using wireless broadband for data sharing purposes and the danger of assuming that wireless broadband will offer an alternative to traditional LMR (land mobile radio) mission critical public safety voice systems.
Requirements or needs identified in report	Before LMR systems could be supplanted, broadband services would first need to be deployed to the level that provides the same extensive coverage that mission critical voice systems provide, including in-building coverage in many instances. Because coverage area decreases as data rate increases, covering the same area at the same level of reliability with broadband services will require even more sites than the number used today for voice. If LTE developers were to eventually develop standards for mission critical broadband voice, the public safety community would need to be involved in the equipment development and would need to see it tested and work in the actual public safety environment on a trial basis before they would be convinced it would be reliable enough to use as an alternative to current LMR narrowband voice systems. System operators and users then would need time to procure and deploy appropriate equipment and devices. The reality of broadband coverage build-out, standards and equipment development, testing in the public safety environment, and follow-on procurement means it would likely be 10 to 15 years or more before most public safety entities would be in a position to seriously consider substituting broadband voice for today's LMR mission critical voice solutions. The goal is that a Shared Wireless Broadband Network would give public safety: • Broadband data services (such as text messaging, photos, diagrams, and streaming video) not currently available in most existing public safety land mobile systems • A hardened public safety network with infrastructure built to withstand local natural hazards (tornadoes, hurricanes, earthquakes, floods, etc) that would include strengthened towers and backup power with fuel supplies to withstand long term outages of public power sources • Nationwide roaming and interoperability for local, state, and federal public safety agencies (police, fire and EMS) and other emergency services such as transportation, health care, and utilities • Access to the Public Switched Telephone Network (PSTN) similar to current commercial cellular services • Push-to-talk, one to one and one to many radio capability that would provide a back-up to (but not replace) traditional public safety land mobile mission critical voice systems • Access to satellite services to provide reliable nationwide communications where terrestrial services either do not exist or are temporarily out of service

Possible applications identified in report	Not applicable
Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	The fact is there are currently no standards being developed or even planned to provide such a service. The public safety community has endorsed Long Term Evolution (LTE) as the preferred broadband standard for public safety data products and the latest version of that standard (V8) is strictly a data standard that does not include voice capability. The next version (V9) due in late 2010 or early 2011 is planned to include VoIP capabilities but that version will not have any capability to provide one-to-many communications and talk around (unit to unit) voice necessary for mission critical public safety communications. LTE is a commercial standard that does not recognize the mission critical voice communications needs of public safety. That means that if a first responder cannot reach the network (i.e. a police officer in trouble in a building and his radio unit cannot reach a repeater) or there is no network then the unit is useless. That means no communications and a possible life-threatening outcome for the police officer.
Possible scenarios identified	Not applicable
Any other relevant information from the report	On September 11, 1996, PSWAC released a report setting forth the current and future spectrum needs of public safety. Among the findings of the PSWAC report was that 97.5 MHz of new public safety spectrum was needed by 2010, including 25 MHz within five years (i.e., by 2001). In November 2007, the FCC issued the Public Safety Spectrum Trust (PSST) a nationwide Public Safety Broadband License (PSBL) for 12 MHz of spectrum in the upper 700 MHz band (10 MHz of broadband spectrum and 2 MHz of guard band spectrum). The FCC Second Report and Order also directed that the Public Safety Broadband Licensee would negotiate with the commercial operator(s) to set appropriate rules and technical standards to ensure maximum interoperability, reliability, redundancy, competition, innovation and choices for public safety customers using this spectrum. The network would include a satellite-based element to ensure continuous operations when terrestrial/ground-based equipment is knocked out or in areas where there is no terrestrial service. From January 24, 2008 through March 18, 2008, the FCC conducted Auction 73. Almost all of the 700 MHz spectrum, with the exception of the D Block, was sold with the proceeds reaching almost $20 billion. Although there has been a lot of speculation as to why the D Block was not sold, most in public safety believe it was because the industry had its eye on the unencumbered spectrum that did not include any public safety requirements. On March 20, 2008, the FCC issued an order delaying further D Block action until further notice. One issue raised in the Hearing by some Members of Congress were concerns about how much it will cost to build a nationwide public safety broadband network and how it will be funded. Estimates of $10 billion to $40 billion have been floated without any real supporting documentation. There is general agreement that if public safety and the private sector can leverage existing private and public infrastructure the cost can be significantly reduced. One commercial company has said that if existing commercial infrastructure was used their cost estimate would be about $13 billion. Eventual total cost of the network will also be influenced by local build-out decisions. Some commercial companies who have indicated their interest and support for a nationwide public/private network have said it is feasible to fund a nationwide public/private network through the public/private partnerships envisioned. This appears to be the only current option unless Congress were to fund the build out.

C.16 Hansard Report

Item	*Description*
Document title	Lords Hansard text (debate on the second reading of the Digital Economy Bill) – document reference XEMS1002 – Lords Hansard text
Author	www.parliament.uk (transcript of debate)
Publication date	2 December 2009
Abstract	During the second reading of the Digital Economy Bill, Lord Lucas raised a proposed amendment relating to reserving spectrum for the Emergency Services, suggesting that 15 MHz of spectrum within the band 'allocated by the EU' (referring to spectrum below 1 GHz, and digital dividend spectrum specifically, which is discussed in Council recommendation 10141/09). The amendment asks Ofcom to consider reserving spectrum for Emergency Services use.
Requirements or needs identified in report	"We will want our emergency services to have a really modern and effective system that is equivalent to the iPhone".
Possible applications identified in report	Not applicable
Possible benefits identified in report	1. Many of the companies who produce TETRA equipment are based in the UK and therefore the UK export market has benefited from the harmonised development of the TETRA standard
	2. Vital for national security reasons
Can the benefits be realised using commercial networks	Not applicable
Possible scenarios identified	Not applicable
Any other relevant information from the report	Not applicable

C.17 Safecom document

Item	*Description*
Document title	Department of Homeland Security, Public Safety Statement of Requirements for Communications and Interoperability (including annex on SAFECOM summit)
Author	US Department of Homeland Security Office for Interoperability and Compatibility (OIC)
Publication date	Volume II Version 1.2 (August 2008)
Abstract	Document contains the assembled requirements for system of interoperable public safety communications across all local and national 'first responder' emergency services communications systems. Describes the public safety environment and the types of applications that might be expected to be used in the future. Two volumes exist – volume 1 is a qualitative description of the types of application that might be required, and volume is quantitative (i.e. in terms of specific network performance requirements and metrics).
Requirements or needs identified in report	Requirements include: • Different hierarchies of users and system • Different modes of communication (with/without a network) • The need for security in communications and in information • Support for command and control processes (i.e. mobilisation of teams, prioritisation of communication, decision making) • Describes a 'system of systems' incorporating all public safety communications modal requirements from wide area networks through to local networks, incident-specific networks and personal area networks (e.g. representing the set of devices that an individual public safety officer users) • Ground based and aerial pictures taken at the scene of an incident, to inform follow on action (e.g. alert hospitals to numbers and types of casualty) • Telemedicine techniques require high quality video images to enable viewing of things like patient's burns or skin/bone details • Emergency button for high-priority treatment of emergency calls • Need to establish connection with a large number of users • Ability to restrict access to information to selected individuals.
Possible applications identified in report	Includes a detailed list of different voice, messaging, data, image and video applications for each of police, fire and ambulance services, including who the communication occurs with, for what purpose and with what special constraints. Examples: • Personal area networks e.g. if a bullet-proof vest detects an impact or a fire-fighters helmet is impacted, it can originate a message to the appropriate person • Full duplex, peer to peer and mission critical voice applications • Peer to peer instant messaging • Automated database updating • Bulk file downloads/uploads • Email/internet

	• Biometric identification techniques • Voice language translation.
Possible benefits identified in report	Diagnosis and treatment in routine health cases for remote/rural communities e.g. remote doctor's viewing of a patient.
Can the benefits be realised using commercial networks	Special constraints include: • High priority calls that need to be secured to protect privacy and maintain chain-of-command authority • Very high resolution video pictures • High priority images requiring rapid transportation between different officers • Voice communications needed to authenticate and authorise personnel to follow specific courses of action • Requirement to be able to communicate when local infrastructure may not be operational (e.g. due to a major incident).
Possible scenarios identified	Describes a number of details scenarios in pages 14-18 of the document: • EMS – routine patient services and car crash scenario • Fire – residential fire scenario • Law enforcement – traffic stop scenario • Multi service – explosion, hurricane, earthquake.
Any other relevant information from the report	The document includes a detailed statement of functional requirements for device/terminal features for police, fire and ambulance users, e.g. interfaces, storage requirements - some of which are typically not supported in commercial terminals, which supports the argument about the requirement for dedicated networks (and associated terminals).

C.18 Westminster e-Forum

Item	*Description*
Document title	Westminster eForum keynote seminar, Emergency Services and Public Safety Spectrum
Author	Westminster eForum (transcript of event)
Publication date	11 June 2009
Abstract	The document describes proceedings at the Westminster eForum keynote seminar on public safety spectrum held during June 2009.
Requirements or needs identified in report	Discusses the different functional requirements that the Emergency Services have: • Complete resilience • Pre-emption functionality • Coverage • Confidentiality • Confidence (that a connection can be made immediately) • Operation in remote and extreme conditions.
Possible applications identified in report	Possible need for a portfolio of technologies including sensing devices etc. Requirements for "all functionality in one device" Emergency button functionality important Talk groups/dispatch More data/faster data Transfer of images and pictures.
Possible benefits identified in report	Not applicable
Can the benefits be realised using commercial networks	Commercial networks not designed for resilient communications (comment from Ericsson: can resilience not be provided through emergency services having access to all five mobile networks, rather than just the one? Also, pre-emption functionality is built into 3GPP standards, it is just not fully implemented at present).
Possible scenarios identified	Not applicable
Any other relevant information from the report	Discussion about different spectrum alternatives and digital dividend spectrum. Martin Cave gave presentation on evaluating alternatives – suggesting there is a "substitution margin" between using dedicated networks and using general (commercial) networks, that should be evaluated.

C.19 PSC Europe White Paper

Item	*Description*
Document title	Public Safety First
Author	Jeppe Jepsen
Version	-
Abstract	This white paper discusses the need for spectrum for Public Safety Services (PSS), through the reallocation of Digital Dividend spectrum, putting forward arguments for further dedicated spectrum for mission critical communications and provides a view of the technical and usage characteristics of next generation PSS radio systems.
Requirements or needs identified in report	Need to be able to gain access to a wireless service to increase efficiency, make it easier to share information, reduce costs, while on the move, and using networks, which are secure, reliable, resilient and available across a wide geographic area regardless of population density. The need for ubiquitous coverage and spectrum between current PSS allocations (around 380MHz and 862MHz) is essential. PSS mission critical broadband communications will empower PSS organizations to move human resources into field, increasing situational awareness and facilitating command and control. Broadband communications will be used to collect and disseminate timely information such as medical records, details of dangerous substances, maps, pictures and video to the various emergency responders. Broadband communications can, for example, support Most mission critical operations depend on voice communications and currently have only two 5 MHz-wide blocks available in the harmonised spectrum. There are already problems with supporting voice traffic at major incidents and planned events. The integrated broadband data services, which are emerging for PSS organizations, require more bandwidth - ideally two paired 15 MHz-wide blocks – 15 MHz. for day to-day use and additional 15 for major incidents. PSS organisations require this dedicated spectrum and their own networks because of the flexibility it affords – the ability to meet their own specific requirements so that they can maximise the advantages provided by broadband services. Dedicated networks employing a dedicated spectrum band are widely used today because it is considered the best way to provide secure, robust and immediate communications for PSS radio systems. The spectrum released can provide access to spectrum in the amounts and within the timescales needed by PSS organizations. PSS organisations require their own spectrum to deploy whatever technologies can meet their service and application needs in an appropriately designed network to meet their operational requirements. Also important when identifying spectrum to take into account other considerations including a sufficient size market for the development of equipment by vendors and the cost of ownership of networks required to support the services and the match against future budgets such as economies of scale and potential for inter-operability.
Possible applications identified in report	These include: • remote checking of information such as passport and biometric details • the sending of detailed photographic images of children lost or people

	wanted to officers out in the field so they can act on requests immediately • providing access to the Fire services Gazetteer – a document containing information on what hazardous materials might be kept on a premises • transmission of live video information to the central command and control personnel so they can have access to the same visual information as their personnel in the field • relaying of ad-hoc video and surveillance camera real time information to patrol cars responding to incidents; or • sending of full data on a patient's condition from the ambulance to the hospital.
Possible benefits identified in report	Societal welfare – to protect life, welfare, and property.
Can the benefits be realised using commercial networks	Possibly some services offered by commercial networks are suitable for certain public safety applications. However, because the mission for PSS organisations necessitates specific requirements for robust mission critical communications in terms of access, redundancy and quality of service, these demands are not suited for commercial networks.
Possible scenarios identified	Not applicable
Any other relevant information from the report	There is a significant risk that basing the award of spectrum on price or average utilization will fail to provide PSS users with sufficient spectral resources. The utilization rate of public spectrum ranges from near constant (e.g. some radar systems and fixed point to point radio links), to mostly idle (e.g. some emergency communications spectrum). A dedicated network in a dedicated spectrum band allocated and assigned to PSS users is the best way to ensure secure, robust and immediate radio communications.

C.20 Report for BAPCO

Item	*Description*
Document title	The "Business Case" for Blue Light Spectrum
Author	David Happy
Publication date	26 August 2009
Abstract	This document was written for BAPCO to justify the request for dedicated and harmonised spectrum for blue light services. It discusses the operational need, current policy, why the current system is not working and why it is not possible to quantify a human life.
Requirements or needs identified in report	Changes in operational needs due to: • Terrorist threats (9/11, July bombings etc.) • Natural disasters (flooding in the UK) • Technical advances of mobile technology • Future events e.g. London 2012 Olympics In a serious accident, the ability for services to inter work seamlessly would improve coordination and lead to markedly improved service levels.
Possible applications identified in report	The ability of a police or fire operative to be able to transmit in real-time images of casualties to local Hospital professionals could assist in preparing the Casualty departments with information and knowledge that would otherwise not be available until the triage process started on arrival at Casualty. Missing person tracing and the ability to use technology to "fit" real-time images of suspects with data already held on them is another way in which the UK could "work smarter."
Possible benefits identified in report	Safety of life.
Can the benefits be realised using commercial networks	Possibly but there is not enough spectrum for the network to work properly.
Possible scenarios identified	Not applicable
Any other relevant information from the report	In the USA, there is a nation-wide reservation of 97MHz of spectrum following on from a review of spectrum shortage. During 9/11 there were communication problems that could have been prevented and which led to many avoidable deaths amongst fire fighters. During June 2009, The European Council adopted a Recommendation (recommendation 10141/09) setting out the importance of cross border cooperation between police forces. This follows the so-called "Pruem decision" on the stepping up of cross border cooperation, particularly in combating terrorism and cross-border crime. It is widely recognised that in an increasingly interconnected world, more crime will be of a cross border nature – and that this trend will increase. The Council make several critical recommendations as regards next generation spectrum for the use of the blue light services, including (page 4): "the Electronic Communication Committee (CEPT/ECC) be tasked to study the possibility of obtaining sufficient additional frequency allocation below 1GHz for the development of future law-enforcement and public-safety voice and high speed data networks." And: "that ministries responsible for police and justice be encouraged to contact their counterparts responsible for spectrum policy to ask for their assistance

with the above proposal, given the important role of the national frequency administrations."

The Cave Audit of 2005 at section 8.5 already makes reference to emergency spectrum, and makes clear that the Cabinet Office is responsible where there is an emergency. We have a pandemic now, swine flu, and therefore the circumstances already exist for this provision to be invoked should the blue light services so request.

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PUBLIC SAFETY OR COMMERCIAL USE?
A COST/BENEFIT FRAMEWORK FOR THE D BLOCK

Abstract: The issue of whether the government should assign the D Block of spectrum to public safety or auction the spectrum for commercial use requires an assessment of the relative benefits and costs of these two alternatives. We propose such a framework, and preliminary analysis suggests that the 10 MHz D Block plausibly provides at least $3.4 billion more in social benefits if assigned to public safety rather than to commercial use. Much of this difference is attributable to the unique opportunity to create a contiguous 20 MHz block of spectrum, and to the fact that this opportunity exists only for the public safety community. As for the lost auction revenue, we observe that the loss of auction revenues today is more than offset by the gain of higher auction revenues and lower public safety network deployment cost in the future. Thus, an auction of the D Block adds, rather than relieves, stress to the public budget. Finally, we estimate that if policymakers choose not to give public safety the D Block and instead opt to require service obligations on other 700 MHz spectrum that would permit the encroachment of public safety users during episodes of resource scarcity, then such encumbrances could materially diminish the auction value of any newly allocated 700 MHz spectrum by as much as 86%.

I. Introduction

As part of the reallocation of the spectrum made available by the digital television ("DTV") transition, the Federal Communications Commission boldly attempted to create, and fund, a nationwide interoperable public safety network. To make a very complicated story simple, as part of the DTV transition, Congress set aside approximately 10 MHz of the new spectrum for public safety use (commonly referred to as the "Public Safety Broadband" allocation or "PSB"). When the FCC set up its auctions for the DTV spectrum, it placed the PSB next to a contiguous 10 MHz of spectrum (the D Block) that was to be auctioned, so the theory went, to create a public/private partnership that could be used for both commercial and public safety purposes utilizing both the D Block and the PSB.[1] However, due to the public service obligations imposed on the D Block auction and the questionable logic of the scheme, the auction effort failed, an outcome of little surprise to anyone.[2] Today, three years after the failed auction, the debate about what should be done next about the D Block is fully engaged.[3]

Given the observed failure of the "public/private partnership" approach, the rapid rise in public safety capacity demands, and the unique benefits of combining the PSB and the D Block, the public safety community has requested that the Federal government forgo the auction of the D Block and directly assign it to public safety. This allocation would thus provide for a full 20 MHz of contiguous prime spectrum that could be used to construct a modern, interoperable nationwide public safety communications network.[4] The FCC to date has rejected this request, planning instead to auction the D Block on an unencumbered basis for commercial use (subject to technical capability for public safety broadband use),[5] although the agency has granted some waivers to begin operations in the PSB.[6] In the FCC's view, any shortfall in capacity on the

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1 *In the Matter of Service Rules for the 698-746, 747-762 and 777-792 MHz Bands, Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems; Section 68.4(a) of the Commission's Rules Governing Hearing Aid-Compatible Telephones Biennial Regulatory Review – Amendment of Parts 1, 22, 24, 27, and 90 to Streamline and Harmonize Various Rules Affecting Wireless Radio Services; Former Nextel Communications, Inc. Upper 700 MHz Guard Band Licenses and Revisions to Part 27 of the Commission's Rules Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Communications Requirements Through the Year 2010 Declaratory Ruling on Reporting Requirement under Commission's Part 1 Anti-Collusion Rule*, FCC 07-132, SECOND REPORT AND ORDER, __ FCC Rcd __ (rel. Aug. 10, 2007) at ¶¶ 325-36.

2 *See, e.g.*, Art Brodsky, *Public Safety Doomed "D Block" Auction To Failure*, Public Knowledge Blog (March 26, 2008) (available at: http://www.publicknowledge.org/node/1479); Mathew Lasar, *700 MHz D Block Autopsy: Public Safety Net Concept Was Doomed*, ARS TECHNICA (April 27, 2008) (available at: http://arstechnica.com/old/content/2008/04/700mhz-d-block-autopsy-public-safety-net-concept-was-doomed.ars).

3 Auction 73 was closed on March 18, 2008 (http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=73).

4 *See, e.g.*, Public Safety Alliance, *"What's at Stake"*, available at: http://www.psafirst.org/what-is-at-stake.

5 CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, Federal Communications Commission (March 16, 2010) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296935A1.pdf) (hereinafter the *National Broadband Plan*) at 86.

6 *See In Re Service Rules for the 698-746, 747-762 and 777-792 MHz Bands*, WT Docket No. 06-150; *Implementing a Nationwide Broadband, Interoperable Public Safety Network in the 700 MHz Band*, PS Docket No. 06-229; *Amendment of*

(Footnote Continued….)

public safety network can be resolved by roaming agreements with commercial carriers.[7] And, of course, an auction brings with it the potential to enrich the Treasury with much needed revenues.[8]

Interestingly, the White House has rejected the FCC's proposal and has sided with the public safety community, explicitly calling for the reallocation of the full 20 MHz of contiguous spectrum to build a modern, interoperable nationwide public safety network.[9] Such a position is consistent with the "Public Safety Spectrum and Wireless Innovation Act" recently introduced by Commerce Committee Chairman Senator Jay Rockefeller (D-WV), which would also give public safety the entire 20 MHz of the D Block and PSB.[10] This plan has received wide bi-partisan support,[11] although the FCC was reportedly opposed to it.[12] Other policymakers from both political parties, however, have views more aligned with those of the Commission,

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Part 90 of the Commission's Rules, WP Docket No. 07-100; *Third Report and Order* and *Fourth Further Notice of Proposed Rulemaking*, FCC 11-6, ___ FCC RCD __ (rel. January 26, 2011) at ¶ 4.

7 *A Broadband Network Cost Model: A Basis for Public Funding Essential to Bringing Nationwide Interoperable Communications to America's First Responders*, OBI TECHNICAL PAPER NO. 2 (May 2010) at 1 (available at: http://download.broadband.gov/plan/fcc-omnibus-broadband-initiative-(obi)-technical-paper-broadband-network-cost-model-basis-for-public-funding-essential-to-bringing-nationwide-interoperable-communications-to-americas-first-responders.pdf) (hereinafter *"Broadband Network Cost Model"*); *see also* Jon Peha, *The Public Safety Nationwide Interoperable Broadband Network: A New Model for Capacity, Performance and Cost*, FCC White Paper (June 2010) at 18 ("The network is based on the availability of 10 megahertz of spectrum dedicated to public safety use by Congress, which provides public safety with substantially more spectrum per user than major commercial networks, providing them with the required capacity and performance for critical communications needs. Roaming and priority access will provide additional capacity on up to 70 megahertz or more of spectrum")(available at: http://fcc.gov/pshs/docs/releases/DOC-298799A1.pdf).

8 *See, e.g.*, Oral Testimony of Coleman Bazelon, The Brattle Group, U.S. House of Representatives, Committee on Energy and Commerce Subcommittee on Communications, Technology, and the Internet (June 17, 2010).

9 White House Press Release, *President Obama Details Plan to Win the Future through Expanded Wireless Access* (February 10, 2011) (available at: http://www.whitehouse.gov/the-press-office/2011/02/10/president-obama-details-plan-win-future-through-expanded-wireless-access).

10 Available at: http://commerce.senate.gov/public/?a=Files.Serve&File_id=6321ae2e-fc48-412a-8eaf-15c848bc7047. To alleviate the "spectrum crunch", Senator Rockefeller is also including the bold idea of "incentive auctions" to try to coax broadcasters to free up additional spectrum. According to a study by CEA and CTIA, such incentive auctions can be expected to generate over $30 billion in new revenue, some of which can be used to fund the new public safety network. *See, Broadcast Spectrum Incentive Auctions*, White Paper prepared by CTIA: The Wireless Association and CEA: Consumer Electronics Association (February 15, 2011).

11 http://www.house.gov/apps/list/hearing/ny03_king/dblockreallocation.html.

12 Sara Jerome, *Rockefeller: FCC was "Not Happy" with his Public Safety Communications Plan*, THE HILL (February 6, 2011) (available at: http://thehill.com/blogs/hillicon-valley/technology/142345-sen-rockefeller-fcc-was-not-happy-with-his-public-safety-plan).

and are calling for the prompt auction of the D Block for commercial purposes.[13] This intra-governmental quibbling proceeds unabated as the public safety community waits to build a modern communications network.

Resolution to the D Block issue is a complex problem. Here, we present an economically-valid framework—heretofore absent from the debate—within which we can evaluate the cost and benefits of the relevant alternatives. While we cannot claim to answer every question relevant to the allocation decision and some of our estimates are necessarily speculative (e.g., what is the social value of public safety?), our analysis suggests that the assignment of the D Block to public safety is advised, with a net benefit of $3.4 billion dollars even when we pointedly ignore the benefits of the additional spectrum for the provision of public safety. The cost-benefit calculus depends largely on the benefits arising from the technical and economic advantages of contiguous spectrum and the relatively small impacts of a temporary, incremental increase of 10 MHz of spectrum on market outcomes. While more research on this topic is warranted, we hope future contributions will adhere to an explicit, rational framework for analysis.

II. A Decision Framework

A sensible decision framework begins by recognizing there are costs and benefits to all actions. If alternatives are mutually exclusive, as is the assignment of a *particular* 10 MHz block of spectrum, then assignment to one party excludes assignment to any other. In other words, assignment has an opportunity cost, and the proper accounting of such costs and their offsetting benefits is critical to rational decision making. The goal of public policy is to maximize economic well-being by choosing the option with the highest net value to the people of the United States.

A review of the D Block debate suggests the following characterization. Today, there is 10 MHz of spectrum that can be allocated either for public safety or for commercial purposes.[14] This D Block is contiguous to the 10 MHz PSB block already dedicated to public safety, permitting a unique opportunity for a public safety network of 20 MHz using contiguous

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[13] *See, e.g.*, Sara Jerome, *Blackburn Supporting D Block Auction*, THE HILL (January 24, 2011); Sara Jerome, *GOP Torn Between Homeland Security, Fiscal Restraint in Public Safety Fight*, THE HILL (January 26, 2011) (available at: http://thehill.com/blogs/hillicon-valley/technology/140475-gop-torn-between-homeland-security-fiscal-restraint-in-public-safety-fight); Rep. Henry Waxman, *Emergency System Needs Upgrade*, ROLL CALL (July 8, 2010)(available at: http://www.rollcall.com/features/Technology_Telecommunications/tandt/-48166-1.html).

[14] We ignore other alternatives not part of the present debate.

spectrum.[15] In the relatively near future, according to the FCC and the Obama Administration, there will be much more spectrum available. The Federal government is in the process of adding an additional 500 MHz of spectrum for commercial use, with 300 MHz of that spectrum intended to be online by 2015.[16] The need for additional spectrum for the commercial sector has been established, and the evidence indicates that public safety's current and expected needs exceed 10 MHz.[17] Thus, we assume there will be another 10 MHz that must be allocated to whichever party does not receive the current allocation. However, this new spectrum will not be contiguous to the PSB, and the D Block will not be contiguous to this new spectrum. Additionally, this future 10 MHz block allocation is assumed to be part of a contiguous block, an option likely to become available as the government reassigns 500 MHz of spectrum to commercial uses. The issue, therefore, is about the timing of benefits and costs, with one type accruing now and the other later.

Given this specification, there are two relevant options to consider in a cost-benefit tradeoff. In the first option, the D Block spectrum, which is contiguous to the PSB 10 MHz already assigned to public safety, is allocated to the public safety community, which precludes its auction now to the commercial sector. This choice permits the benefits and costs derived from public safety's use of the spectrum to accrue now, while postponing the benefits and costs from commercial use of this additional 10 MHz of spectrum into the future. That is, allocating the

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[15] *See, e.g.*, Public Safety Alliance, *House of Cards: FCC's Capacity White Paper Built on Assumptions and Conjecture* (July 2, 2010) at 3 ("Since the D-Block spectrum is adjacent to the public safety broadband allocation, it is uniquely positioned to provide the needed additional capacity throughput for a public safety agency's entire coverage area including the cell edge where throughput decreases significantly. Any alternative spectrum offered in other bands will be less efficient. Additional components would be required which would increase the cost and reduce performance of broadband devices. Non-adjacent spectrum blocks of the same size as the D Block will not provide as much throughput capacity, since greater efficiency is achieved through spectrum aggregation.").

[16] *National Broadband Plan* at XII ("Make 500 megahertz of spectrum newly available for broadband within 10 years, of which 300 megahertz should be made available for mobile use within five years."); Remarks by Lawrence H. Summers, *Technical Opportunities, Job Creation and Economic Growth* (June 28, 2010) (available at: http://www.whitehouse.gov/administration/eop/nec/speeches/technological-opportunities-job-creation-economic-growth); *Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband*, Department of Commerce (October 2010)(available at: http://www.ntia.doc.gov/reports/2010/TenYearPlan_11152010.pdf).

[17] Bill Schrier, Chief Technology Officer, City of Seattle, *Public Safety, Government, Wireless and Spectrum*, National League of Cities (May 27, 2010) (""[M]ost urban areas will rapidly outgrow the capacity of the 10 MHz allocated by the FCC for the public safety networks."); Andrew Seybold, *Response to Roberson and Associates, LLC White Paper entitled "Technical Analysis of the Proposed 700 MHz D-Block Auction, dated August 23, 2010, contracted for by T-Mobile USA, Inc."*, (September 10, 2010) at 5 (available at: http://andrewseybold.com/wp-content/uploads/2010/09/ResponseT-MobileWP09-10-10FNL.pdf) ("Data usage has grown on commercial networks in the order of 5000% in only the past three years. Demand will follow the same curve as the commercial broadband sector as new applications and devices become available for Public Safety…").

contiguous D Block to public safety only *postpones* the allocation of an additional 10 MHz for commercial purposes (which the "new" block comes from the 500 MHz of spectrum promised by the FCC and the Obama Administration). In the second option, the D Block is auctioned for commercial purposes now, precluding its assignment for public safety purposes. In this case, the incremental benefits and costs from commercial use accrue now, but the benefits and costs of public safety's use are postponed. Framed in this way, the relevant issue is not whether the 10 MHz is used for public safety or used for commercial use, but rather *when* and *which* 10 MHz is put to use in both, and how the size and timing of benefits compare between these two alternatives.

More formally, let B_s^t represent the incremental benefits and C_s^t the incremental cost of an additional 10 MHz of spectrum assigned to sector s at time t, where s has values P for public safety and A for commercial application, and where t is 0 for the present and 1 for the future. The incremental net value of public safety assignment of the D Block today is $V_P^0 = B_P^0 - C_P^0$ today, and $V_P^1 = B_P^1 - C_P^1$ in the future. In the same way, we have net benefit V_A^0 if the 10 MHz is auctioned for commercial purposes today, and V_A^1 given future allocation. Applying the constraint that each party receives a 10 MHz block, then the best policy decision is simply to take the highest value of the two sums $V_P^0 + V_A^1$ (i.e., public safety now, auction later) and $V_A^0 + V_P^1$ (i.e., auction now, public safety later).[18] The D Block spectrum should be given to public safety if $V_P^0 + V_A^1 > V_A^0 + V_P^1$, or equivalently, $V_P^0 - V_P^1 > V_A^0 - V_A^1$. Notably, all the costs and benefits that enter into these valuations are incremental to the status quo. That is, costs and benefits are measured only for the additional 10 MHz allocation.[19]

Armed with this simple but useful framework, we can provide some meaningful commentary on this important issue and interpret some of the available evidence in a pertinent manner. In what follows, we evaluate some of the evidence and issues using the cost-benefit framework, and we believe this exercise is highly informative.

III. Assigning the D Block to Commercial Use

The total economic benefits of commercial use include profits and consumer surplus, where these benefits are only those added by the addition of 10 MHz of spectrum. As for profits, assuming there are a few relatively homogeneous bidders, the profits from the added spectrum

[18] We ignore the possibility of either party getting both allocations.

[19] The upper 10 MHz of the D Block is already allocated to public safety and a network will be built to use that spectrum. Those costs are not incremental to the D Block.

will be largely dissipated at auction.[20] Based on an econometric analysis of the more recent spectrum auctions in the U.S., if the FCC auctioned the D Block on a truly unencumbered basis, then we could expect the auction to generate revenues in the range $1.3 to $3.3 billion.[21] There are, however, many reasons to expect this range of potential revenues is too high, including the Commission's recent track record of trading off auction revenues for other goals.

First, as seen in the earlier attempt to auction the D Block, public service obligations levied on the commercial license holder substantially reduce the value of spectrum. Only one bid was received in that auction ($472 million) and it was well below the minimum bid established by the Commission ($1.3 billion). The public safety encumbrances, therefore, imposed costs of about $0.8 to $2.8 billion, as reflected in the low bid value.[22] Given the lack of any service rules for the re-auction of the D Block, it is unclear what public safety encumbrances will be placed on the spectrum. The *National Broadband Plan* proposes that the commercial use be "technically compatible with the public safety broadband services," so some constraints will be placed on a commercial winner.[23] If there is an auction, and in light of the current debate, then we suspect there will be significant political pressure to impose public safety obligations on the D Block.[24] Thus, the expected auction revenues should be reduced to account for some types of public service obligations. If these obligations are even half as burdensome as those in the original auction, then the reduction in auction revenue would still be a sizeable 40%.

Second, the Commission has imposed certain obligations on spectrum blocks set for auction. For example, the Commission imposed stringent open platform obligations in the C Block auction of the 700 MHz spectrum, with disastrous results. Indeed, the conditions placed on the C block reduced auction revenues by a whopping 32%, with little to no perceptible benefit.[25]

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[20] G.S. Ford, T.M. Koutsky and L.J. Spiwak, *Using Auction Results to Forecast the Impact of Wireless Carterfone Regulation on Wireless Networks*, PHOENIX CENTER POLICY BULLETIN NO. 20 (Second Edition) (May 2008) (available at: http://www.phoenix-center.org/PolicyBulletin/PCPB20Final2ndEdition.pdf).

[21] Estimated from the regression analysis and data presented in *Using Auction Results, id.* The difference between the lower and upper estimates is based on the REA and Auction 73 premium.

[22] Assuming an unencumbered auction revenue range of $1.3 to $3.3 billion.

[23] *National Broadband Plan, supra* n. 5, p. 76.

[24] *See, e.g., Whitepaper: Technical Analysis of the Proposed 700 MHz D-Block Action*, Prepared for T-Mobile by Roberson and Associates, Inc. (August 23, 2010) (available at: http://fjallfoss.fcc.gov/ecfs/comment/view?id=6015952735), arguing that the D Block can effectively be shared under a public safety obligation. We provide no comment on the legitimacy of the analysis, but simply note that its relevance presumes the FCC will impose a public safety obligation on the D Block and that such obligations reduce expected auction revenues.

[25] *Using Auction Results, supra* n. 20.

Although the Commission did not go as far when it promulgated its recent *Open Internet Order*, the Commission did impose some obligations on wireless network operators and, equally important, threatened to extend the full C Block conditions to other commercial licensees if circumstances warrant.[26] Accordingly, it is not unreasonable to expect that the Commission could extend obligations to the D Block, including C Block-type obligations, and, as such, we expect the auction revenues for the D Block to be lower than a naïve model would predict.

Third, given the Commission's recent *Harbinger* decision[27] and concerns expressed in its *14th CRMS Report* about industry concentration[28], it is also not unreasonable to assume that the Commission may exclude some bidders from the auction.[29] A reduction in the number of bidders, particularly if these potential bidders are large firms, is likely to reduce the expected auction revenue (ceteris paribus).[30]

Finally, the economic health of the country has deteriorated since the bidding in Auction 73. Thus, the D Block auction should not be expected to produce as much revenue as the earlier auctions. Coleman Bazelon estimates that the economic crisis will reduce the expected value of spectrum by approximately 20%.[31]

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[26] *In re Preserving the Open Internet, Broadband Industry Practices*, FCC 10-201, REPORT AND ORDER, ___ FCC Rcd ___ (rel. December 23, 2010) at ¶135 (hereinafter "*Open Internet Order*").

[27] *In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services*, FOURTEENTH REPORT, FCC 10-81, __ FCC Rcd __ (rel. May 20, 2010) (hereinafter "*Fourteenth CMRS Report*").

[28] *In the Matter of SkyTerra Communications, Inc. and Harbinger Capital Partners Funds, Applications for Consent to Transfer of Control*, MEMORANDUM OPINION AND ORDER AND DECLARATORY RULING, DA 10-535 (rel. March 26, 2010) (hereinafter the *Harbinger Order*). For a full discussion of *Harbinger Order*, *see* George S. Ford and Lawrence J. Spiwak, *The Broadband Credibility Gap*, PHOENIX CENTER POLICY PAPER NO. 40 (June 2010) (available at: http://www.phoenix-center.org/pcpp/PCPP40Final.pdf), *and forthcoming in* 19 COMMLAW CONSPECTUS (2011).

[29] *C.f.*, Public Knowledge, "Spectrum Reform" ("The best method for ensuring that the spectrum is not simply bought by incumbent broadband providers is by limiting their eligibility to bid – either through a flat prohibition or spectrum caps.")(available at: http://www.publicknowledge.org/issues/spectrum-reform); Gregory Rose and Mark Lloyd, *The Failure of FCC Spectrum Auctions*, Center for American Progress (May 2006).

[30] Auction theory indicates that a reduction in the number of bidders will reduce auction prices in an ascending, second-price auction. *See, e.g.*, L. Phlips, THE ECONOMICS OF IMPERFECT INFORMATION (1988), Ch. 4. Accordingly, a cynical interpretation of the debate might be that the D Block presents an opportunity for some industry participants to buy spectrum at reduced prices due to the likelihood the present Commission will exclude some bidders, and in doing so establish precedent for such exclusions in future auctions.

[31] C. Bazelon, *The Need for Additional Spectrum for Wireless Broadband: The Economic Benefits and Costs of Reallocations*, The Brattle Group (October 2009) (available at: http://www.brattle.com/_documents/uploadlibrary/upload809.pdf).

Given these four factors, we expect the auction revenue from the D Block to be considerably less than the estimated range based on prior auctions ($1.3 to 3.3 billion). An auction of the D Block, depending on the rules, could produce less than $1 billion in revenue, and we suspect this low revenue amount is plausible given the current regulatory climate. We suspect auction revenue is unlikely to exceed $2 billion in the best *plausible* scenario but, again, such predictions are necessarily speculative.

Factors Reducing Auction Value of the D Block

1. Public Safety Obligations
2. Other Obligations, such as Open Internet/Platform Obligations
3. Excluded Bidders
4. Economic Crisis

As for consumer surplus additions, this relatively small addition of spectrum to the commercial sector (currently licensed 572 MHz by the Commission's count) is unlikely to be a game changer.[32] The consumer surplus gains from commercial assignment are limited to what little competitive effects may arise from the added spectrum. To evaluate this issue, we adopt a common, widely-used model of price formation familiar from previous analyses in telecommunications. Assuming Cournot Competition in Quantities, unit elasticity of demand, and a Hirschman-Herfindahl Index ("HHI") of 2500, we estimate the addition of 10 MHz of spectrum will reduce prices by about 0.6%.[33] Given a total market size of $160 billion, consumer

[32] *OBI Technical Paper No. 6*, p. 15 ("547 MHz, in total, is currently licensed under flexible use rules, which allows for mobile broadband and voice services").

[33] Price is defined as $P = cN/(N - 1)$, where c is marginal cost and N is the number of firms, taken to be the numbers-equivalent of the HHI (=1/HHI). Based on recent estimates, we assume an HHI of 2,500 producing an N of 4. *See 14th CMRS Report, supra* n. 27, at 51 (2,848) and Table 41 (2,200). Assuming 547 MHz of spectrum available, the addition of 10 MHz of spectrum is treated as the equivalent of adding 0.07 firms, resulting in a price cut of 0.6%. *See, e.g.*, J. Sutton, *Sunk Costs and Market Structure* (1995), Ch. 3; J.B. Duvall and G.S. Ford, *Changing Industry Structure: The Economics of Entry and Price Competition*, PHOENIX CENTER POLICY PAPER NO. 10 (April 2001) (available at: http://www.phoenix-center.org/pcpp/PCPP10Final.pdf) *and reprinted in* 7 TELECOMMUNICATIONS & SPACE LAW JOURNAL 11 (2001).

surplus gains (net of transfers) from this price cut are then about $600 million, annually.[34] While other models of price formation would yield different results, the Cournot approach used here is familiar, plausible, and implementable using relatively little information.

Another piece of the valuation puzzle arises from the fact that the future 10 MHz of spectrum could be part of a contiguous block. Turning again to the econometric analysis of previous auctions, the auction revenue from a contiguous 10 MHz block is expected to bring a premium of $2 to $6 billion (other things constant).[35] We assume that a 10 MHz block auctioned to commercial use in the future will be contiguous and will have an auction premium of $4 billion (the mid-point of the range).

Turning to the question of value, we can use this analysis to get a rough approximation of $V_A^0 - V_A^1$. Assuming the auction revenues are $2 billion, consumer surplus gains are $0.6 billion annually, the contiguous block premium is $4 billion, and the difference between time 0 and 1 is five years, the value difference from delay of the auction of 10 MHz is about $0.6 billion (= 2B + 2.6B - 4B).[36]

IV. Assigning the D Block to Public Safety

Perhaps the most daunting, yet relevant, question regards the social benefits of "public safety." Such benefits are real but difficult to quantify and, absent immediate crisis, prone to be undervalued. If we faced another event like 9-11 or Hurricane Katrina, we believe the 20 MHz would be allocated to public safety immediately and the network fully funded in a week's time. Fortunately, we are not presently victims of such a crisis and, though the lack of crisis makes the spectrum allocation decision a more difficult one, this is a burden we welcome. For the moment, we choose to set aside the quantification of the benefits of an additional 10 MHz of spectrum for public safety, looking instead at the cost side of equation.

Spectrum is not homogeneous. Not only is the 700 MHz spectrum highly valuable because its technical properties are well-suited for mobile communications, including broadband

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[34] The change in consumer surplus under unitary elasticity is market size in terms of expenditures (about $160 billion in 2010) multiplied by the natural log of the ratio of the new price to the old price. For expenditure data, see *Wireless Industry Indices: Mid-Year 2010 Results*, CTIA (November 2010) (available at: http://files.ctia.org/pdf/CTIA_Survey_Midyear_2010_Graphics.pdf).

[35] *Using Auction Results*, *supra* n. 20.

[36] We assume a discount rate of 4.4%. The discount rate is the government recommended discount rate for social projects evaluated over a twenty-year window. *See* OMB Circular No. A-94, APPENDIX C (Revised December 2009) (http://www.whitehouse.gov/OMB/circulars/a094/a94_appx-c.html).

Internet services, but for the public safety community the D Block has added value because it is contiguous to the PSB, which is already allocated to the public safety community. A contiguous block of 20 MHz of spectrum is substantially more valuable than 20 MHz of non-adjacent spectrum. As noted above, a 10 MHz block of contiguous spectrum in the 700 MHz band is worth about $2 to $6 billion more than a non-contiguous block of the same size.

While this value differential is estimated based on commercial use, much of this premium is based on the lower cost of deploying network for contiguous spectrum, which would likewise apply to public safety. Evidence suggests that the cost of the public safety network using 20 MHz of spectrum is probably about $10 billion.[37] Andrew Seybold, a highly regarded wireless industry expert, suggests that expanding a 10 MHz public safety network to 20 MHz adds about 15% to 25% to network deployment costs.[38] By this standard, the incremental cost of the additional 10 MHz is about $1.5 to $2.5 billion.[39] Alternately, adding a non-contiguous block of 10 MHz of spectrum to the public safety network would cost about $5 to $7.5 billion in deployment costs.[40] Assignment of the D Block to public safety, therefore, is likely to reduce the cost of the public safety network by around $4 billion in network deployment costs alone. Operational costs are likely to be lower as well, perhaps adding billions more to the savings.

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[37] White House, *supra* n. 9 (assigning $7 billion in construction costs); *Broadband Network Cost Model*, *supra* n. 7 ($6.3 billion for a 10 MHz network).

[38] A. Seybold, *Comments on the FCC White Paper: Federal Communications Commission Omnibus Broadband Initiative A Broadband Network Cost Model: A Basis for Public Funding Essential to Bringing Nationwide Interoperable Communications to America's First Responders*, Working Paper (April 26, 2010), p. 15 (available at: http://andrewseybold.com/wp-content/uploads/2010/04/Comments-FCCWP-Final-April-27-2010.pdf). The FCC study, *Broadband Network Cost Model*, *supra* n. 7, claims an additional 10 MHz of spectrum would substantially *increase* the cost of the public safety network, but we find the extreme assumptions of that analysis to be unreasonable and in violation of economic logic. Seybold, *supra* n. 38 also rejects the agency's argument ("The Commission seems to believe that there are only two choices for building out the public safety broadband network. The first choice is its option to essentially combine it with the commercial networks except for some of the radio equipment. The second is to provide a totally separate and standalone network. The FCC does not take into account that between these two extremes is a number of options that can and should be explored.").

[39] Expanding commercial networks is also costly. There is little reason to suspect that the cost of a commercial expansion to additional 10 MHz will be much different than for the public safety community. For example, it was announced that Verizon is expected to spend $4 billion in equipment alone to deploy LTE, which is about $180 million per MHz of 700 MHz spectrum. For 10 MHz, the cost would be about $1.8 billion. *Verizon Wireless Awards Alcatel-Lucent Contract Expected to be Worth US $4 Billion for Ongoing 3G Network Expansion and LTE Build out*, Alcatel-Lucent Press Release (Nov. 4, 2010) (available at: http://www.alcatel-lucent.com/wps/portal/!ut/p/kcxml/04_Sj9SPykssy0xPLMnMz0vM0Y_QjzKLd4x3tXDUL8h2VAQAURh_Yw!!?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=News_Releases_2010/News_Article_002258.xml).

[40] Seybold, *supra* n. 38 at p. 15.

Moreover, the cost to deploy the 700 MHz band is much lower than other bands (some estimates are 70% lower than other bands). Thus, depending on what additional spectrum is provided to the public safety community if they do not receive the current 10 MHz block, the ultimate deployment costs could be substantially higher (though this differential may also apply to the commercial licensee). We leave a more sophisticated assessment of such costs to others, and assume here that the cost difference is $4 billion.

While we have not addressed the benefits of public safety's use of the additional 10 MHz of spectrum, which could be quite large, we can see that the contiguous spectrum premium of $4 billion is itself sufficient to offset the value of commercial assignment of an additional 10 MHz ($0.6 billion). Let Z be the marginal benefits from enhanced public safety created by the combination of the D Block for public safety use. From our cost-benefit framework, the relevant decision criterion for assignment to public safety is

$$V_P^0 - V_P^1 > V_A^0 - V_A^1, \tag{1}$$

approximated here to be

$$Z + \$4 \text{ billion} > \$0.6 \text{ billion}, \tag{2}$$

which plainly holds, even without sizing Z (where Z > 0 and potentially is very large). Even if the 10 MHz provided zero benefit in terms of enhanced public safety, then assignment of the D Block to public safety produces $3.4 billion in additional social value over and above the commercial value of the same block. (Of course, this is a result of the constraints we imposed on the problem, i.e., 10MHz of spectrum would be provided to public safety one way or another.) We have also ignored the value of spectrum currently used for narrowband purposes by public safety that may be repurposed for commercial use as a result of migrating existing public safety capacity demands to the D Block and PSB.[41]

Notably, much of this value spread arises from the unique opportunity to create significant value by allocating a contiguous block of spectrum to public safety, and then doing so in the future for commercial use. This value is foregone by commercial allocation of the D Block today. While some may contest our estimates, it is necessary to account for the economic value arising from contiguous spectrum.

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[41] For example, Section 205(3) of the Rockefeller Bill, *supra* n. 10, requires the Commission to conduct a report within five years of enactment that examines, among other things, to determine whether there is an "opportunity for return of any spectrum to the Commission for auction to commercial providers to provide revenue to the Treasury of the United States."

V. An Alternative: Public Safety Encumbrances on Commercial Networks

Thus far in this analysis, we have assumed that if the D Block is used for commercial services, then an additional, non-contiguous 10 MHz block will be assigned for public safety use in the future. A realistic alternative to this grant of additional spectrum for public safety is simply to impose encumbrances on other 700 MHz spectrum that permit the encroachment of public safety users during episodes of resource scarcity. Unfortunately, however, it was exactly this approach that produced such miserable results in the first D Block auction. There are many complex issues that must be resolved with any sort of sharing scheme of this type, and such resolutions can be very costly. As revealed in Auction 73, public safety encumbrances substantially reduce the value of spectrum. Auctions revenues from an unencumbered D Block would have been about $3.3 billion, whereas the only bid for the encumbered block was a paltry $472 million—a mere 14% of its revenue potential.

Consider, for the moment, that incentive auctions for broadcast spectrum, which have been proposed in the Rockefeller bill, permit the recovery and repurposing of 120 MHz of quality spectrum. One study estimates that the auction revenues from this spectrum would be $35 billion, with a net value of $33 billion after relocation of existing licensees.[42] Our earlier research suggests that these predicted auction revenues are plausible.[43] Applying public safety obligations on this spectrum, however, would materially diminish its value. From the failed D Block, we might conclude that public safety obligations would reduce the auction value of the 120 MHz of spectrum to as little as $5 billion (= 35 × 0.14), a loss in revenues of $30 billion or 86% of its potential. This calculation likely represents the upper boundary of lost auction revenues since it presumes the encumbrances apply equally to all 120 MHz. Alternately, at the other extreme, using the size of the D Block in proportion, the reduction in auction revenues would be more to the tune of $2.5 billion, which is still a sizeable amount and probably more than the sale price of the D Block in a present day auction.[44] Notably, both numbers are underestimates of the total value loss since they measure only the loss in private value from the spectrum. We have ignored in these calculations the higher cost and diminished value to the public safety community (and those they serve) due to the reduced functionality inherent to a sharing of networks purposed mainly for commercial use. The fact of the matter is that no

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[42] *See supra* n. 10.

[43] We estimate a 10 MHz block could yield $3.3 billion in auction revenue. A total of 120 MHz of spectrum, in turn, would render about $40 billion. We note there are factors that could raise or lower auction revenues in the future such as encumbrances, market conditions, the number of bidders, and so forth.

[44] A 10 MHz block is 8.3% of a 120 MHz block. Assuming $35 billion in unencumbered auction revenues, each 10 MHz would bring $2.9 billion (on average). Applying the 14% factor from Auction 73, an encumbered D Block would yield only $408 million in auction revenue, cutting auction revenues by about $2.5 billion.

government agency can guarantee public safety quality access to commercial spectrum on an as-needed basis.

In all, we believe the use of encumbrances will be more costly than the assignment of an additional 10 MHz in the future (as we have modeled the issue above). So that our estimates are conservative, we do not incorporate the costs of this alternative in our calculations. Any proposal adopting this option for supplying spectrum resources to the public safety network should provide a careful study of the loss of auction revenues and the dollar value of the reduced functionality and higher costs of such a network.

VI. Conclusion

The assignment of the D Block spectrum to public safety or commercial use requires an assessment of the relative benefits and costs of these two alternatives. We propose an economically sensible cost-benefit framework in the POLICY BULLETIN. An assessment of the Commission's record and other evidence within this framework suggests that D Block assignment to public safety has a higher value, producing no less than $3.4 billion more in social benefits than commercial use. Much of this difference is attributable to the unique opportunity to create a contiguous 20 MHz block of spectrum, and the fact that this opportunity exists only for the public safety community. We recognize that this issue is complex and our analysis is preliminary. That said, our work includes many of the "big ticket items", such as potential auction revenues. However, the calculations ignore any incremental benefits to society from the use of the additional 10 MHz block by the public safety community. As these gains are likely to be large, the economics seems to lean strongly in the direction of an assignment of the license to public safety. We suggest more research on this topic, but encourage future contributions to adhere to an explicit, rational framework for analysis.

At the forefront of the debate over the D Block is the potential for auction revenue. If the D Block is assigned to public safety, then the auction revenues from the 10 MHz block are forgone. The argument has been made that auctioning the spectrum will provide revenues to help fund the public safety network and perhaps aid in deficit reduction. We argue that this argument is invalid; we observe that the loss of auction revenues today are more than offset by the gain of higher auction revenues in the future and lower public network deployment costs . Thus, the auction adds, rather than relieves, stress to the public budget. Moreover, the Rockefeller bill, which allocates the D Block to public safety, also permits the use of incentives auctions to recover high-quality broadcast television spectrum that can then be re-purposed for mobile services. According to some, this spectrum is expected to generate just over $35 billion in auction revenues, the sum of which could be used for funding the public safety network and deficit reduction. Thus, while the D Block may offer a unique opportunity for the public safety network, it is not exceptional in its ability to generate auction revenues for the federal coffer.

The allocation of spectrum resources is an inherently complex issue. In the case of the D Block, complicating the choice is the fact that while the economic benefits of public safety are exceedingly difficult to quantify, the social goal of ensuring the safety of all Americans is nonetheless at stake. Fortunately, even if we value this security benefit at zero, our analysis shows that allocation to public safety is still preferred even on purely economic grounds. In our view, based on the analysis presented above, and absent evidence to the contrary, we believe the D Block should be combined in a contiguous 20 MHz block for use by the public safety community.

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Information
Technology &
Telecommunications

700 MHz
Broadband Public Safety Applications
And Spectrum Requirements

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CONTENTS

Preface

Since the Public Safety Wireless Advisory Committee (PSWAC) report was released in September 1996, the wireless communications landscape has undergone enormous changes. While it is true that technology has allowed for more efficient use of spectrum resources, it is equally true that public safety's need for spectrum has never been greater. In 1996 there were no broadband wireless networks or applications. Public safety's need for data communications was limited to text in the form of digital dispatch. Even then there was a shortage of spectrum available to public safety. In the interim, public safety wireless networks have continued to fall behind commercial networks in technology and capability.

Today we are at a crossroads. We can either advance public safety communications by consolidating our efforts and resources to create a nationwide public safety broadband interoperable network that supports both data and voice or we can continue to support separate networks on disparate frequency bands using incompatible technologies. We are under no illusion and fully understand that this is a formidable challenge. The vision of a converged public safety data and voice network will not be realized for several years, and then only when public safety is satisfied that broadband mission critical voice is as reliable as existing land mobile mission critical voice networks. Nevertheless, we also understand that if we do not have sufficient spectrum resources, we will never achieve our goal.

Public safety needs additional broadband spectrum that is suitable for both current and future technologies such as streaming video, automated license plate recognition, and biometric technologies including mobile fingerprint and iris identification. The 700 MHz band is ideal for public safety as it provides superior coverage and "in building" performance compared to higher frequency bands. It is imperative that public safety control this spectrum to ensure that the standards established for the Public Safety Nationwide Broadband Wireless Network regarding capacity, interoperability, priority and reliability are maintained at the highest level. Recent incidents have illustrated that commercial wireless services cannot provide the bandwidth and services needed during an emergency.

The existing public safety 700 MHz spectrum allocation is inadequate to support public safety requirements. The D Block spectrum is crucial to the development of the nationwide network because it is adjacent to the existing public safety broadband allocation. Combining the existing public safety 700 MHz spectrum with the D block will simplify network design and deployment, and will reduce handset and mobile device costs. A single wireless broadband network combining the D Block and the adjacent public safety 700 MHz spectrum is the only logical choice to satisfy public safety broadband wireless spectrum requirements. All major national organizations representing police, fire, emergency medical and prominent public safety officials have united in an unprecedented effort to support the reallocation of the 700 MHz D Block spectrum to public safety, and the creation of a truly interoperable public safety wireless broadband network.

Executive Summary

Public safety must plan now for existing and future wireless broadband needs. Many broadband applications are already being used by public safety, often using commercial networks. Public safety envisions utilizing additional broadband applications but requires public safety grade coverage, redundancy and infrastructure hardening conspicuously lacking in commercial wireless networks. This paper lists and describes many public safety wireless broadband applications and their spectrum requirements. As new commercial broadband applications are developed, some of them will undoubtedly benefit public safety agencies.

The currently proposed 700 MHz spectrum allocation is insufficient to support the applications that public safety requires now. The 700 MHz "D block" spectrum scheduled for auction is adjacent to the Public Safety Broadband Licensee (PSBL) 700 MHz Broadband allocation. The adjacent spectrum is critically needed to provide the capacity necessary to support mission critical public safety broadband applications now and in the future. A single wireless broadband network spanning both the D Block and the adjacent public safety 700 MHz spectrum is the only logical choice to support public safety requirements.

Most commercial wireless carriers have committed to deploying a fourth generation wireless technology called Long Term Evolution (LTE). This technology will be deployed worldwide and is supported on the 700MHz band. Once these commercial broadband LTE networks are deployed, public safety will gain access to lower cost infrastructure and user devices, and will reap the benefits of ongoing research and development financed by the commercial wireless industry.

The 700 MHz band is ideal for public safety as it provides superior coverage compared to the higher bands in mountainous terrain and within buildings. If the 700 MHz D Block is auctioned to commercial providers, the lack of available spectrum will force public safety to maintain separate wireless networks for data and voice in perpetuity, forcing public safety to financially support two networks and carry two devices.

A 700 MHz public safety nationwide broadband wireless network supporting both data and voice will for the first time establish true interoperability in public safety emergencies requiring a multi jurisdictional response. The September 2009 Draft of the National Broadband Plan lists an eventual converged data and voice network for public safety as a strategic goal[1]. This vision will never be realized without a commitment by the Federal government to allocate the D Block to public safety now. Auctioning the D block is shortsighted and ultimately prevents public safety from attaining its goal of a dedicated, robust and reliable broadband wireless network. We believe that the future cost savings achieved by a converged public safety data and voice network will far

[1] See Draft National Broadband Plan Dated September 29, 2009 Page 9, National Priorities, Public Safety "Interoperable mission critical voice and broadband network".

outweigh any short term revenue collected from a second auction of the D Block spectrum.

The benefit of allocating the D Block to public safety is very significant while the cost of reallocating the spectum is very small. The Cellular Telecommunications Industry Association (CTIA) has indicated that approximately 800 MHz. of additional spectrum is needed to enable commercial broadband service[2]. While allocating 10 MHz. of spectrum in the D Block would double the broadband spectrum for public safety, removing it from auction represents a reduction of only 1¼ percent of the spectrum requested for commercial broadband. Dedicating additional spectrum for public safety broadband would benefit the entire population, who are served by dedicated Police Officers, Firefighters and Emergency Medical personnel. We therefore urge Congress to place a priority on public safety by directing the Federal Communications Commission to reallocate the D Block to public safety broadband operations.

Appendix A, is an excerpt from New York City's recent Comments filed with the Commission in the Matter of Additional Comment Sought on Public Safety, Homeland Security, and Cyber security Elements of National Broadband Plan -- NBP Public Notice # 8. The excerpt is included at the end of this document to underscore our major points and provide broadband throughput analysis data.

Section One
Public Safety Requires a Robust and Reliable Network

Reducing public safety coverage, reliability or availability requirements in order to attract potential bidders is shortsighted as such a network will not meet public safety's needs. The result will be a false sense of security that will be shattered by catastrophic network failure when the first large scale disaster occurs. All commercial enterprises are motivated by profit, commercial wireless networks are no exception. Their primary responsibility is to their shareholders, not to the welfare of the public.

Public safety's mission is to protect the public, there is no profit motive. Therefore, Public safety communications networks are more akin to military wireless networks rather than commercial wireless networks. The establishment of the Department of Homeland Security and the FCC's recent establishment of the Public Safety and Homeland Security Bureau, as well as the longer established position of Defense Commissioner all serve to underscore the increased threats that public safety agencies must contend with in the post 9/11environment.

[2] Letter from Christopher Guttman-McCabe, Vice President, Regulatory Affairs, CTIA, to Chairman Julius Genachowski, *et al*, Federal Communications Commission, GN Docket No. 09-51, September 29, 2009 ("CTIA Spectrum Needs").

Reducing the minimum required bid price undercuts the very purpose of the auction. Diluting the network coverage and reliability requirements shortchanges public safety. Rather than taking these steps to attract a potential bidder, we urge Congress and the Commission to cancel the D Block auction and assign the D block directly to public safety. This will insure that public safety has sufficient spectrum to deploy a nationwide interoperable mission critical wireless network that will ultimately support both voice and data, alleviating interoperability issues caused by legacy public safety networks operating on disparate frequency bands and incompatible wireless technology platforms.

Section Two
Benefits to Public Safety

Network Control
If public safety owns and operates its own network, or at a minimum holds the spectrum license in a public private joint venture network, they can exert greater control over future technical decisions that effect network performance. Additionally, ownership of the network allows public safety to exert influence over the network design and deployment to satisfy the immediate and future needs of public safety users.

In an emergency it is critical that public safety exert direct control over their critical communications networks. Public safety agencies must be assured that they are afforded the highest priority during emergency situations, even if others are denied service or are otherwise inconvenienced.

The addition the D block licensed to the public safety 700 MHz. allocation will put public safety in a favorable position if a public safety partnership is forged in a particular locality. Other localities may choose to build own and operate their own public safety broadband network. In either case, granting the license for the D Block spectrum through a public safety entity such as the PSBL puts public safety agencies in a better negotiating position if a partnership arrangement is desired. As licensee, public safety will be able to partner with any qualified commercial entity whereas if the D Block is auctioned, public safety can only negotiate with the D Block auction winner.

Guaranteed Access
In order to protect the public and perform their job efficiently and effectively, public safety users require guaranteed access to the communications networks they use. In recent years, public safety users have become increasingly reliant upon commercial networks. During emergencies these networks often fail due to congestion or infrastructure breakdown, since they are not scaled or engineered for emergencies.

On October 11, 2006 New York Yankee pitcher Cory Lidle crashed a small private plane into a 40 story apartment building in Manhattan. Public safety first responders arriving at the scene were unable to use their commercial wireless cell phones due to call blocking resulting from network capacity limitations. All wireless carriers were similarly affected.

Although many of the first responders had "priority access" they were still unable to access the wireless networks in most cases.

Analysis after the event revealed that a large part of the problem was that the commercial wireless networks are simply not scaled and engineered to handle the traffic spikes that result from this type of event. Further analysis revealed that "priority access" was ineffective for two reasons. First, the priority given to public safety is only "top of the queue" priority, rather than preemptive access. Given the location of the incident and the number of news media personnel present, who have learned from experience never to end their call until the incident is over, it is not surprising that few public safety calls were successful. The second factor is that the "access channel" was congested. The network could not recognize the public safety user as a priority user until the call request was recognized by the network. Since the access channel was overwhelmed, the public safety user was competing with all other users for network recognition.

Future Cost Avoidance

Both the National Public Safety Telecommunications Council (NPSTC) Statement of Requirements for the National Public Safety Broadband network and the FCC Third Further Notice of Proposed Rulemaking specify a Push to Talk (PTT) voice capability. As LTE technology matures, we are confident that a mission critical voice capability will become a reality. Setting aside sufficient spectrum for this purpose now will create a more definitive market opportunity for technology suppliers to begin early development of products knowing that a true market exists and that development costs can be recovered through sales of equipment and systems.

In the future we envision a single converged voice and data network for public safety. This vision is also expressed as a national strategic goal in the September 2009 Draft of the National Broadband Plan. If a converged public safety voice and data network becomes a reality, public safety agencies will reap significant cost savings since they will only have to support a single wireless communications network and carry a single device for both data and voice.

At the recent GSMA (Groupe Spéciale Mobile Association) Mobile World Congress, the GSMA announced the acceptance by the majority of wireless network operators of a standard for voice over Long Term Evolution (LTE). The technology will be based on IMS (Internet Multimedia Services). The GSMA believes that IMS voice services could become available over LTE as soon as the middle of 2011.

Reliability

Public safety networks are typically equipped with emergency power backup capability. Most critical public safety radio sites are equipped with a minimum of eight hours of backup power. During the Northeast blackout of August 2003 many cell sites in New York City failed within the first few hours and remained inoperative for the duration of the blackout.

Network Restoration
Public safety staff can restore service quicker than commercial entities. Public safety technical staff can more quickly access sites within disaster areas when commercial providers (civilians) are excluded due to security concerns.

Technical Staff
Public safety technical staff will respond in situations that commercial providers will not. Public safety technical staff are credentialed and screened to a higher standard than commercial provider technical staff and their subcontractors. Commercial providers often use third party subcontractors who are not focused on public safety as their primary commitment. They sometimes employ transient workers whose commitment to the mission is questionable. Such employees are rarely subjected to extensive background checks prior to employment.

During the Northeast blackout of August 2003 electrical power was out in most of New York City for approximately 25 hours. This exceeded the backup power capacity at many NYPD radio sites. However, NYPD Radio Repair Mechanics and Police Officers were able to keep these sites on the air by replacing discharged backup batteries with freshly charged batteries. These batteries weigh approximately 100 pounds and in some cases had to be hand carried up sixty floors. No commercial wireless network provider made a similar effort to maintain service, nor would we expect them to. They simply waited for commercial power to be restored.

Section Three
Long Term Evolution and Spectrum Efficiency

Long Term Evolution (LTE) has been endorsed by the Public Safety Spectrum Trust (PSST), the Association of Police Communications Officials (APCO), the National Emergency Number Association (NENA), and the National Public Safety Telecommunications Council (NPSTC) as the preferred technology for 700 MHz. Public Safety Broadband Network. Verizon Wireless, AT&T, and T-Mobile have all publicly stated their intention to deploy LTE in the United States as their fourth generation (4G) wireless network.

LTE standards are governed by the Third Generation Partnership Project (3GPP), an international wireless standards body. LTE is supported by the 3GPP and most commercial wireless carriers, worldwide. LTE supports channel bandwidths from 1.5MHz. up to 20 MHz. wide.

Spectrum efficiency is improved through spectrum aggregation. The larger the channel size the greater the potential for spectral efficiency. Within LTE, a 10MHz. block of contiguous spectrum provides significantly greater spectrum efficiency than two 5MHz. blocks of non contiguous spectrum blocks.

The current allocation for broadband public safety spectrum consists of two 5 MHz. spectrum blocks, one 5MHz. uplink channel and one 5MHz. downlink channel. Although a public safety broadband network could be created using 5MHz. uplink and downlink channels in the existing public safety broadband spectrum, and another commercial LTE network, could be deployed using the 5MHz. uplink and downlink channels in the adjacent D Block. A better solution is for public safety to be allocated the D Block channels and deploy a network consisting of two 10 MHz. LTE channels, one uplink and one downlink. This solution offers distinct advantages. First, it is more spectrum efficient as it allows higher peak power data rates and higher throughput. Second, it is more economical since the cost to deploy a network consisting of two 10 MHz. channels is approximately the same as the cost to deploy two 5MHz. channels.

The 700 MHz. D Block is the only available spectrum adjacent to the public safety broadband allocation. If the D Block is auctioned rather than being assigned to public safety, state and local governments will pay a much higher price in the future supporting public safety communications than any short term revenue gleaned through a second auction. If a commercial wireless provider chooses a technology other than LTE for the D Block, a guard band will have to be established between the D block and the Public Safety broadband spectrum.

LTE supports channel sizes ranging from 1.5MHz up to 20MHz. A network utilizing larger channels in urban environment will provide substantially greater capacity. In rural areas, larger channels will allow for the deployment of a higher site architecture network employing higher power base stations thereby reducing the number of sites required.

Section Four
Convergence of Data and Voice

As time goes on, it will become increasingly more attractive to build converged data and voice networks. This issue was raised during the PSWAC effort in 1996; however it was not technically feasible at that time. The technical environment has changed dramatically since then. A converged data and voice network solution at 700 MHz is now possible if the Federal Government, public safety and the wireless communications industry decides to move in that direction. It will not be possible if the spectrum is not available.

The National Public Safety Telecommunications Council's (NPSTC) Statement of Requirements published in November 2007[3] and the FCC Third Further Notice of Proposed Rulemaking issued in September 2008[4] both specify a commercial grade PTT voice capability as a requirement of the Public Safety 700 MHz. Broadband Network. We are confident that over time a mission critical voice capability will be developed within the LTE framework.

[3] See NPSTC Public Safety 700MHz Broadband Statement of Requirements pp20-21
[4] See FCC Third Further Notice of Proposed Rulemaking Appendix C, p189(4) and p193 (Table 1)

Federal Agencies are already beginning to use converged voice and data networks for mission critical communications.

> "The vast majority of Federal public safety agencies do not currently use broadband networks to support mission-critical voice communications. The Transportation Security Administration (TSA) of the Department of Homeland Security (DHS) is one exception. TSA uses commercial wireless broadband services in the 800 MHz spectrum for mission critical air to ground communications for Federal law enforcement officers in flight, as that is the only spectrum available for this application. This capability will soon include Voice over Internet Protocol (VoIP)."[5]
>
> "Immigration and Customs Enforcement (ICE), within DHS, is another exception. ICE uses commercial broadband networks for intranet access for laptops and other portable electronic devices, such as Blackberries, and for voice telephony applications. ICE requires exceptionally stringent security to safeguard law enforcement information and therefore allows broadband access only for authorized ICE end user equipment on which the required security controls have been installed and tested. ICE's law enforcement officers have mission-critical requirements for critical demand theater operations. The lack of law enforcement priority on commercial broadband networks also necessarily limits ICE's usage of such systems. Despite such limitations, the Commission should consider whether use of commercial broadband networks, with adequate adoption by public safety agencies, may be a first step in the path to maximized broadband network."[6]

The National Telecommunications and Information Administration (NTIA) shares the view that a converged public safety data and voice communications network will ultimately replace existing narrowband public safety voice networks.

> "As voice and data communications continue to converge, users have a greater expectation for both voice and mobile wireless data capabilities. Broadband systems that can provide reliable, interoperable voice and data systems will likely replace antiquated narrowband voice systems and low data rate networks. If mission critical voice applications are to migrate to broadband, systems will need to have sufficient control channel capability in high congestion areas, especially during special events and large gatherings, to support both a significant increase in text messaging and data traffic and call setup capability for national security and emergency preparedness (NS/EP) communications. Legacy voice networks must be effectively leveraged while the migration to broadband evolves." [7]

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[5] See NTIA Executive Branch Views On Public Safety, Homeland Security and Cyber security Elements of a National Broadband Plan, December 2009; Page 4.

[6] See NTIA Executive Branch Views On Public Safety, Homeland Security and Cyber security Elements of a National Broadband Plan, December 2009; Page 4.

[7] See NTIA Executive Branch Views On Public Safety, Homeland Security and Cyber security Elements of a National Broadband Plan, December 2009; Page 11.

Assuming that the 700 MHz. broadband public safety network will be constructed in any event, public safety should seize this opportunity to include mission critical voice as a required network component as soon as the technology permits, thereby solving voice interoperability issues and standardizing public safety communications nationwide. We realize that mission critical voice over broadband is a not available today and that public safety will not accept this technology until it equals or exceeds the capabilities and reliability of existing mission critical public safety land mobile radio networks. However, we also believe that the eventual convergence of broadband data and mission critical voice on a single network is inevitable. The alternative is to support separate public safety networks for data and voice, construct and maintain incompatible mission critical voice networks using dissimilar technologies on disparate frequency bands, and pay premium prices for narrowband user devices. We view this alternative as unacceptable.

The goal of public safety communications planners should be not only consolidation onto an integrated broadband voice and data network[8], but also an orderly migration of existing public safety mission critical voice communications systems, over time, to a common frequency band and technology platform, which will provide inherent interoperability and improved spectrum efficiency while reducing overall costs in the long term. In order to achieve these objectives, Congress should allocate the 700 MHz. D Block directly to public safety and forgo a second auction.

Section Five
The 4.9GHz. Public Safety Spectrum

Some opponents of our effort to assign the 700 MHz D Block to public safety have suggested that the public safety 4.9 GHz channels provide more than enough spectrum for public safety to deploy broadband networks. The deployment of wide area networks using 4.9GHz public safety channels is impractical for several reasons. First, the number of sites required to provide adequate coverage, especially in an urban environment is staggering. The number of sites estimated to cover New York City alone exceeds 13,000. From both a maintenance and infrastructure perspective 4.9GHz is a poor choice. It may be appropriate to use this technology in small areas for special purposes; however the poor propagation characteristics offset any derived benefit. In some localities 4.9 GHz has been used to implement wireless WANs, however this was done out of necessity, since no other spectrum was available. Currently, there are no other options available to public safety for a broadband network deployment. Another very critical issue is the backhaul requirements of a 4.9GHz wide area network; the number of sites required to provide ubiquitous coverage creates a difficult challenge to deliver backhaul infrastructure to the network. The 4.9GHz public safety channels were intended for hotspot or incident scene use only; they were never intended to be used as a wide area

[8] See Draft National Broadband Plan Dated September 29, 2009 Page 9, National Priorities, Public Safety "Interoperable mission critical voice and broadband network". Page 161 Ensuring public safety requires a high quality network; Goal:" Enhances mission critical voice over time"

network solution. 4.9GHz links can be used to transport video for spontaneous or temporary deployment over short distances.

Public safety emergencies occur in all areas, not merely in pre-defined or anticipated locations. Time is of the essence when lives are at stake. It is far more desirable for public safety first responders to have a wireless network in place that provides adequate broadband coverage in all locations than to call in a special unit to deploy an ad-hoc network. Incidents that unfold quickly or change locations further underscore the need for ubiquitous broadband network coverage rather than relying on ad- hoc networks to be set up and broken down repeatedly. Fixed wireless network assets are a much more permanent, reliable and effective solution for public safety.

The propagation characteristics of 4.9GHz virtually preclude practical wide area network deployment since the range is very limited. Although it is possible to deploy a mesh network to increase the range and circumvent obstructions, this technique severely reduces throughput and adds additional layers of complexity and potential failure. Due to the specifications of the 4.9GHz emission mask, devices deployed on adjacent channels in close proximity may interfere with each other, further reducing throughput.

Connectivity between 4.9GHz devices requires a line of sight path between transmitter and receiver; 4.9GHz signals will not bend around obstructions. These physical channel limitations are especially problematic for deployment in dense urban areas which are the very areas most likely to require the highest data throughput. The inability of 4.9GHz signals to penetrate walls, windows and other common construction materials render them virtually useless indoors.

A wide area 4.9GHz network deployment is inconsistent with the ultimate goal of a constructing a converged nationwide voice and data public safety network utilizing a single user device and operating on a common technology platform. The suggestion that 4.9GHz devices can be deployed over a wide area to provide broadband capability for public safety first responders ignores the coverage limitations of the frequency band. The 4.9GHz public safety channels are more appropriately used as hotspots at known congregation points such as Police Precincts or Firehouses, or at the scene of protracted incidents for the local exchange of broadband data and for Blue Force Tracking purposes.

The majority of public safety broadband applications will require backhaul to remote data bases so that information can be downloaded to public safety responders and to Command and Control facilities so that critical information can be exchanged between headquarters and field units. Ad-hoc 4.9GHz hotspots deployed at incident scenes without the benefit of backhaul do not provide the same level of functionality as access to a permanently installed wireless infrastructure.

Municipal Wi-Fi mesh networks deployed within the last few years by some governmental agencies and private firms have, for the most part, been shut down. This occurred due to the lack of a sound business model, the need to constantly add and relocate access points, the cost of back-haul for these networks and poor in building penetration. The inability of well funded commercial entities to successfully deploy Muni Wi-Fi networks in the lower portion of the spectrum where coverage is better than at 4.9GHz. indicates that this model is not a suitable alternative to the 700 MHz wide-area network planned for public safety.

Section Six
Public Safety Broadband Data Applications

Applications Relevant To All First Responder Agencies

1.) Incident Video

Live incident video has immeasurable benefits to public safety. The ability to stream on-scene video to responding units, operations and communications centers, supervisors and emergency managers can dramatically alter the way public safety responds to major incidents. The ability to share first responder and broadcast video among responding agencies will greatly enhance public safety's ability to manage and contain critical incidents. Integrating Geographic Information System (GIS), sensor and tactical data with video will provide first responders with critical pre-arrival information that will allow a more effective response to critical incidents. Video captured at incident scenes can be wirelessly transmitted to Command and Control facilities or responding mobile units, improving situational awareness and enhancing officer safety.

Incident Video Viewing DL	1150 kbps
Incident Video Viewing UL	28 kbps

2.) Broadband Data Dispatch

Although "digital dispatch" has been available for more than 20 years, its capability has been limited largely to text transmissions by the throughput constraints of current narrowband public safety wireless data networks. A next generation public safety broadband data network will allow broadband data to be transmitted to field units prior to their arrival at the incident location, greatly improving situational awareness.

Advanced consumer wireless features such as photos and video sharing allow citizens to capture incident information and transfer it to public safety dispatch centers. Utilizing a broadband network this information can be wirelessly transmitted to field units responding to an incident. Additionally, this capability will allow dispatchers to attach this information to the incident record, automatically send it to responding units to view or listen to all available data related to the job assignment, including for example an audio file containing the information provided during a 911 call. It will provide critical premises history information such as: prior police response, arrests, weapons, warrants, and crime report histories. This type of information can be critical in determining how the responding officers approach the individuals involved in the incident, or enable them to more effectively conduct their investigation. Broadband data dispatch will reduce radio traffic on voice channels, minimize call backlog, improve response time, improve officer productivity and enhance officer safety.

The NYPD currently responds to an average of 5,000 to 6,000 incidents per day. Over time, the voice component of the public safety dispatch function will decrease, while the broadband data component will increase dramatically. We envision that in the future, pushing broadband data to responding field units will account for 85 to 90 percent of dispatch transactions without the need for voice communications.

Digital Dispatch DL	25 kbps
Digital Dispatch UL	25 kbps
Audio and Video DL	96 kbps
Audio and Video UL	19 kbps

3.) Mobile Incident Command Vehicles
During major incidents and special events, specialty vehicles are dispatched to serve as Mobile Command Posts. These vehicles are typically equipped with multiple communication devices and critical incident management applications and contain radios, cell phones, fax machines and satellite phones. Wireless broadband connectivity will allow two-way transfer of photos, video, and audio clips to and from Headquarters in real time, improving Command and Control and situational awareness for on scene Incident Commanders as well upper echelon command staff not on scene. Additionally, applications that require high bandwidth connectivity can be supported at the incident scene over a single broadband modem.

Incident Video Viewing DL	1150 kbps
Incident Video Viewing UL	28 kbps
Website Viewing DL	90 kbps
Website Viewing UL	25 kbps
Incident Video UL	647 kbps
SFTP Transfer DL	93 kbps
SFTP Transfer UL	92 kbps

4.) Mobile Access to Geographic Information System (GIS)
Mobile units and field commands can download geographic information such as topographical and curb line maps and architectural and computer rendered drawings from government and private municipal data bases. Use of GIS and Computer Aided Drafting and Design (CADD) information will provide invaluable assistance to law enforcement and fire services during routine and major incidents. Incidents such as the Mumbai, India Hotel attack illustrate the need for better tactical information for first responders. This capability replaces the need to carry physical maps that may be out of date. GIS capabilities further provide a means to visually connect different layers of information to improve on-scene situational awareness.

GIS / CADD Request UL	20 kbps
GIS / CADD Request DL	**100 kbps
**file size assumes DWG or similar format and avg sizes	

5.) Blueforce Tracking (BFT)
The location of public safety personnel can be remotely monitored during high risk operations to enhance first responder safety. Fire and police services have been interested in this technology for several years and recent developments in the defense industry now make public safety availability likely in the immediate future. Broadband technology will allow blue force tracking solutions to be available when necessary. Since first responders are typically responding to unplanned incidents there is limited time to deploy ad-hoc or temporary networks for blue force tracking applications. BFT can be used to monitor firefighter and police officer location, and vital signs. Body worn video can be deployed to provide tactical and situational information to field and command personnel.

BFT Data Transfer UL	*25 kbps
BFT Data Transfer DL	*25 kbps
*Assumes polling at 5 second intervals	

6.) Automatic Vehicle Location (AVL)
Real time location and status of public safety agency vehicles can be wirelessly transmitted to the dispatch center, allowing the dispatcher to more effectively deploy the fleet, enhancing command and control and improving efficiency.

Data Transaction UL	40 kbps
Data Transaction DL	**60 kbps
** Estimated average transactions with 5 and 30 sec poll rates	

7.) Supervisory Field Access to CAD and RMS Data
Public safety supervisors need the capability to monitor personnel and incident activity. Monitoring Computer Aided Dispatch and Records Management Systems wirelessly allows field supervisors enhanced situational awareness and allows field units to react rapidly changing conditions. Although this capability has existed for several years utilizing existing data networks, the functionality has been limited by the lack of sufficient bandwidth. Supervisors are limited to text updates and as more users respond to the incident system response times deteriorate. Users are also limited to text based searches of internal databases and have no access to the internet or web based applications. Broadband connectivity will allow supervisors to search multiple databases simultaneously and receive interactive feedback to allow for further refinement of their search parameters. Secure broadband communications will also allow for access to external databases that would otherwise be restricted for security reasons. Narrowband or even high capacity channelized data systems do not have the bandwidth to sustain

multiple users accessing large amounts of information in a concentrated area. This capability was successfully used in the "Miracle on the Hudson" plane crash in January 2009 when NYPD Special Operations Division (SOD) field supervisors monitored CAD data in real time over the NYCWIN network, thereby eliminating the need for constant dispatcher updates.

Data Transaction UL	20 kbps
Data Transaction DL	**22 kbps
Data Trans. + photo/GIS UL	**40 kbps
** Estimated average transactions based on similar NYCWiN traffic	

8.) Real Time Field Supervision
The capability for Field Supervisors to monitor the location and status of mobile units assigned to them without dispatcher assistance. Utilizing AVL and GIS capabilities, field supervisors can view their area of responsibility and "see" the units on a map. AVL will allow the supervisors to select a unit's icon and instantly see status, assignment, duration of service and other related information.

Data Transaction UL	20 kbps
Data Transaction DL	**25 kbps
** Estimated average transactions with 5 and 30 sec poll rates	

9.) Exchange of Broadband Data in the Field
Mobile units operating in the field can exchange data regarding an incident without dispatcher intervention, decongesting voice channels and allowing dispatchers to process incoming job assignments more efficiently. This data may include photos, video or audio files. This capability aids in the positive field identification of suspects, weapons, stolen items or other evidence. The exchange of data in real time between geographically separated team members improves officer productivity and enhances the investigatory process by enabling crimes to be solved faster and more effectively.

Data Transaction UL	22 kbps
Data Transaction DL	*40 kbps
* Estimated average transactions including audio, video and photos	

10.) Wireless Call Boxes
Emergency (911) call boxes can be installed in any location within the wireless network coverage footprint, regardless of the availability of wire line connectivity.

VOIP Call DL	20 kbps
VOIP Call UL	20 kbps

Police Specific Applications

1.) Mobile Crime Scene Units (Detective Division)
Crime scene investigation involves the gathering of evidence and subsequent analysis by specialists at a centralized location. Specially equipped vans staffed by detectives can respond to a crime scene to gather and analyze evidence. Immediate access to critical information will provide invaluable assistance to investigators and lead to more timely apprehensions. The information must be gathered and analyzed quickly and effectively, in real-time. Broadband connectivity will allow immediate analysis of evidence saving valuable time. Crime scene photos, video, forensic data and other information gathered at the scene can be instantly transmitted to the Real Time Crime Center or crime lab for detailed analysis.

Incident Video Viewing UL	28 kbps
Website Viewing DL	90 kbps
Website Viewing UL	25 kbps
Incident Video UL	647 kbps
SFTP Transfer DL	93 kbps
SFTP Transfer UL	92 kbps
Data Transfer DL	*25 kbps
Data Transfer UL	*20 kbps
* estimates based on current data rates from NYCWiN	

2.) Automated License Plate Recognition (LPR)
Public Safety and government vehicles equipped with Automatic License Plate Recognition systems can scan hundreds of license plates within minutes, sweeping an area for wanted or stolen vehicles with little operator intervention. Additionally, LPR systems can be used to enhance officer safety by transmitting real-time vehicle stop information to the dispatcher and automated database inquiries for car-stops. Broadband connectivity will allow agencies to quickly deploy fixed LPR systems to monitor traffic in and out of a defined area or along major roads for major incidents and temporary security operations.

License Plate Reader UL	256 kbps
License Plate Reader DL	22 kbps
Based on actual data rates from NYCWiN	

3.) Mobile or Handheld Summons Issuance
Traffic Enforcement Agents and police officers can issue summonses using hand held and mobile ticket writers connected to the broadband network. These devices can access Department of Motor Vehicles (DMV), National Crime Information Center (NCIC), National Law Enforcement Telecommunications System (NLETS), and agency databases in real time, thereby alerting the agent or police officer to a wanted or stolen vehicle, and verify the accuracy of the data entered. Photos and GIS data can be combined with the

violation for accuracy and real-time location information. Wanted vehicles can be cross-referenced in real-time with violation information to support detectives during an investigation; an activity that normally would take several days can be accomplished in minutes.

Data Transaction UL	20 kbps
Data Transaction DL	20 kbps
Data Trans. + photo/GIS UL	40 kbps

4.) Chemical, Biological, Radiological, Nuclear and Explosive Detection Devices (CBRNE)

Portable, fixed and deployable sensors designed to detect Nuclear, Biological and Chemical agents can be deployed almost immediately or strategically placed in high threat areas for remote monitoring through the broadband network. Wireless connectivity allows the sensors to be relocated rapidly if necessary without regard to wire line connectivity availability, should the threat location change. The City of New York has been testing devices over the NYCWiN network with great success. In the event of a CBRNE incident the information can be monitored at remote locations reducing risk of further exposure to the threat. The devices can also be deployed at major events such as sporting events, concerts and other large gatherings without consideration for wired data connections.

Data Transaction UL	20 kbps
Data Transaction DL	20 kbps
Data Trans. Alarm UL	**25 kbps
** Includes transfer of spectral image for interpretation	

5.) Real Time Crime Center Wireless Connectivity

The NYPD Real Time Crime Center (RTCC) allows investigators to gather, correlate and analyze data from numerous sources at speeds previously unheard of in law enforcement. The RTCC allows Officers in the field to transmit photos or video directly to the RTCC from handheld devices for analysis. Key components of the RTCC include a data warehouse, data analysis software and a video wall. Using these tools, Police Officers quickly analyze data from numerous data bases and establish relationships that otherwise are not immediately apparent. Prior to the establishment of the Real Time Crime Center, data now correlated literally within minutes could have taken days or weeks.

Broadband Wireless connectivity plays an integral role in the operation of the NYPD Real Time Crime Center. The ability to transmit photos and video clips from the field in real time, or from the RTCC to the field, greatly accelerates the investigative process. Currently the NYPD utilizes a commercial wireless provider to supply the broadband wireless connectivity. The implementation of a Public Safety 700 MHz. broadband network would provide a cost savings to the NYPD by eliminating the expense of monthly recurring charges. The 700 MHz. band provides greater in building penetration than the 2.5GHz. NYCWIN network which is used primarily for vehicle based applications. In addition a public safety 700 MHz. broadband wireless network would allow public safety agencies to purchase relatively low cost handheld devices similar to those used in commercial wireless networks.

Data Transaction UL	22 kbps
Data Transaction DL	**160 kbps
Data Trans with photos UL	**80 kbps
** Estimated average transactions	

6.) Transmission of Video from Aviation Units to Terrestrial Mobile Units.
Current technology limits the ability of aviation units (helicopters) to deliver video to multiple terrestrial mobile units. Utilizing wireless broadband connectivity will allow the video feeds transmitted from aviation to be distributed to mobile command posts and responding units. The existing equipment requires the mobile command post to be stationary and erect a receiver directed towards the helicopter. Sufficient bandwidth is required to allow for video distribution to multiple units at the scene, responding to the scene and at remote locations. Broadband wireless connectivity will allow the video to be transmitted to a central repository and re-transmitted to any mobile or fixed unit within the coverage footprint of the broadband wireless network.

Incident Video Viewing DL	1150 kbps
Incident Video Viewing UL	28 kbps

7.) Photo ID
Field Officers can verify the identity of suspects or other individuals being detained, particularly those with common names or without valid identification. This capability enables Officers to detain or release individuals with a much higher degree of accuracy.

Photo ID DL	40 kbps
Photo ID UL	60 kbps

8.) Field Officer Direct Access to Remote Databases
Field Officers can verify the validity of license data without dispatcher intervention. (DMV records, Pistol License data, Peddler Permits etc.)

Data Transactions Text DL	22 kbps
Data Trans. Text + Photo DL	*60 kbps
Data Transaction UL	25 kbps
* estimates based on file sizes from NYPD mobile data photo pilot	

9.) Gunshot Detection

Gunshot detection system have been shown to reduce incidents of gunfire in targeted areas, assist investigators with timely and accurate information and provide invaluable evidence for court cases. The systems rely on strategically placed sensors and some form of line of sight connectivity. In urban areas placement of these sensors can be difficult if not impossible using line of sight communications. Connecting the sensors via broadband affords the user optimal placement options, rapid deployment and critical file transfer capabilities. The incident information and audio files can be instantly sent to the communications center and units in the vicinity to enhance response to gunshot incidents. Additionally, the sensors can be relocated as needed without wire line installation considerations or constraints.

Incident and Audio Transfer UL	*65 kbps
Incident Transfer to Unit DL	80 kbps
Data Transaction Text Only DL	25 kbps
*assumes and average audio file size with 5 seconds of gunshot audio	

10.) Photo and Video Distribution

In an investigation of a crime or missing person the first 30 to 60 minutes are critical to the resolution process. Photos or video of missing or wanted individuals can be distributed to mobile field units in real time improving the likelihood of a successful outcome. (Amber Alert Wanted Persons etc.) The process, if done manually, may take several hours to initiate and distribute the information to the field. Broadband capability will greatly enhance response to these types of incidents.

Video UL from field	*1000 kbps
Photo UL from field	90 kbps
Video DL from Dispatch	*1000 kbps
Photo DL from Dispatch	92 kbps
* Average file sizes – not streaming	

11.) Maritime Surveillance and Monitoring

Port Security is a priority as part of the nation's efforts to protect critical infrastructure and prevent acts of terror. There is the potential for weapons and explosives to enter coastal ports on cargo ships. DHS has stepped up their inspection efforts and port monitoring, however the deployment of a wireless sensor network would greatly enhance the security of our ports. Cargo manifests, ship information and travel itineraries can be made available in real time to Coast Guard and local law enforcement to enhance investigations. Remote sensors can be deployed in strategic locations to assist in early detection of dangerous cargo. These types of systems can only be deployed if sufficient bandwidth is available to allow for exchange of critical information and the monitoring of remote sensors.

Data Transaction UL	20 kbps
Data Transaction DL	120 kbps
Data Trans. Alarm UL	**60 kbps
** Includes transfer of spectral image for interpretation and GIS	

Fire Service Applications

1.) Electronic Command Boards (ECB)

The Fire Department has developed an Electronic Command Board to support fireground operations at the scene of an incident. The ECB allows the Fire Chiefs at the scene of a fire to exchange critical information and provide live updates to the Operations Center. The ECB requires a broadband application to transfer information in a timely fashion. At the scene of many large scale incidents commercial wireless networks are often overloaded and cannot provide the necessary bandwidth for ECB to operate properly. The ECB requires a broadband connection for optimum operation. Fire Chiefs at the incident scene can track responding units and transmit this information to Fire headquarters in real time enhancing Command and Control capabilities.

Data Transaction UL	40 kbps
Data Transaction DL	120 kbps
Data Trans. CADD / GIS	**220-400 kbps
** estimates include transfer of GIS and CADD information	

2.) Wireless Access to Floor Plans, Drawings and 3D Graphical Displays

Responding units and commanders require access to building floor plans, schematic diagrams and 3D graphical displays to enhance situational awareness. For Fire Chiefs at the scene of a major incident this capability allows incident commanders to make informed decisions regarding resource deployment thereby enhancing Firefighter and citizen safety. Early transfer of critical information will allow firefighters to approach the incident tactically thereby reducing initial critical response times.

Data file transfer CADD/GIS DL	300 kbps
Incident Video Viewing UL	1100 kbps
Website Viewing DL	120 kbps
Website Viewing UL	40 kbps
SFTP Transfer DL	93 kbps
SFTP Transfer UL	92 kbps

3.) Wireless Access to Building Department Databases

Access included in Building Department records, including the presence and location of potentially hazardous materials within the incident perimeter enhances situational awareness and Firefighter safety.

Data file transfer CADD/GIS DL	500 kbps
Data file transfer CADD/GIS UL	50 kbps

EMS Applications

1.) Automatic Vehicle Location (AVL) Integrated CAD

The location and current status of all ambulances can be wirelessly fed into the EMS Computer Aided Dispatch computer. The EMS CAD computer uses this information to make recommendations to the EMS dispatcher for the next assignment. Implementation of this type of system can result in a significant reduction in response time.

Data Transaction UL	40 kbps
Data Transaction DL	**60 kbps
Data Transaction for Routing	120 kbps
** Estimated average transactions with 5 and 30 sec poll rates	

2.) Patient Tracking

Family members routinely inquire about the location of their sick or injured relatives. Access to a broadband wireless network allows EMS workers to accurately track patients and provide this information to their family members in near real time, increasing productivity and reducing patient tracking errors.

Data Transaction UL	30 kbps
Data Transaction DL	50 kbps

3.) Real Time Transmission of Medical Data

Medical data such as ECGs, photos or videos of injuries and patient history can be wirelessly transmitted to receiving hospitals in advance of a patient's arrival permitting Emergency Room staff to assemble the appropriate personnel and equipment in advance. Advances in mobile telemedicine equipment enhance the initial diagnosis and field treatment of critically injured or sick patients. Information in the form of broadband data can be exchanged between the on board Emergency Medical Technicians and the hospital medical staff to assist in patient treatment during transport. This data may include photos, video, video conferencing and other forms of medical information.

Information Transfer UL	*128 kbps
Monitor status Streaming DL	*200 kbps
Intranet Access UL	*120 kbps
Patient Video UL (1 way)	*647 kbps
Instructional Access DL	*90 kbps
Video Teleconference DL	*900 kbps
Video Teleconference UL	*900 kbps
Data Transfer DL	*25 kbps
Data Transfer UL	*20 kbps
* estimated	

Governmental Non First Responder Agency Applications

The Public Safety Broadband Wireless Network will support QOS and priority. These mechanisms will allow other municipal lower priority users to access network. Allowing non emergency municipal agencies network access improves overall spectrum efficiency. A few examples are listed below:

Sanitation Department Applications

1.) Automatic Vehicle Location (AVL) and Vehicle Monitoring
Real time location and status of Sanitation Department vehicles is wirelessly transmitted to the Sanitation Department dispatch center, allowing the dispatcher to more effectively deploy the vehicle fleet, enhancing command and control. The AVL application also monitors the status and health of the sanitation vehicles by connecting to the data interface.

Remote vehicle sensors installed in Department of Sanitation vehicles wirelessly transmit vehicle status data to the Department of Sanitation dispatch center. These sensors monitor vehicle health as well as mission status (truck full, sand or salt released, at vehicle location etc.). This data is particularly effective in managing fleet resources during snow removal operations, which are the responsibility of the Sanitation Department in NYC.

Data Transaction UL	40 kbps
Data Transaction DL	60 kbps
Data Transaction for Routing	85 kbps
Supervisory Inquiries UL	60 kbps
Supervisory Inquiries DL	100 kbps
Based on NYCWiN data	

Department of Transportation Applications

1.) Wireless Traffic Signal Control
The Department of Transportation is installing new traffic controllers equipped with broadband wireless modems that communicate with the Traffic Control Center in real time, allowing for the wireless control of traffic signals and eliminating the need for wire line backhaul. New traffic signals can be installed in any location within the wireless network footprint without regard for wire line availability, reducing installation time and expense while eliminating recurring (leased wire line) costs. The wireless modems will also allow DOT to implement ITS enhancements such as emergency vehicle priority access, route information and messaging, and traffic management.

Data Transaction UL	40 kbps
Data Transaction DL	**60 kbps
Data Transaction for ITS (future)	120 kbps
** Estimated average transactions	

2.) Traffic Monitoring
Permanent or temporary traffic monitoring cameras can be installed in any location within the footprint of the broadband wireless network without regard for wire line availability, reducing installation time and expense while eliminating recurring costs.

Data Transaction UL	*40 kbps
Data Transaction DL	*60 kbps
* assumes high traffic patterns during peak periods	

Municipal Government and Critical Infrastructure Applications

Sharing the public safety network with other governmental entities on a priority basis enhances and increases public safety agency's return on investment while simultaneously satisfying the original intent of the public safety broadband wireless network to provide ubiquitous national data coverage for first responders. A few examples are cited below.

1.) Wireless Meter Reading
Water, electric and gas meters read remotely taking advantage of the broadband wireless network and/or its backhaul infrastructure to improve accuracy and reduce labor costs.

Data Transaction UL	25 kbps
Data Transaction DL	20 kbps

2.) Wireless Leak Detectors
Water and gas leak detectors connected to the broadband wireless network can be read remotely in real time. These detectors can be installed in any location within the wireless network footprint without regard to wire line availability; reducing installation time and expense and eliminating recurring (leased wire line) costs.

Data Transaction UL	20 kbps
Data Transaction DL	25 kbps

3.) Bus Locator (AVL)
The real time location and status of municipal buses can be wirelessly transmitted to the bus dispatch center, allowing the dispatcher to more effectively deploy the vehicle fleet, enhancing command and control and providing improved service to the public. In addition, it is possible to monitor engine parameters, and emergency requests from the driver in real time, or an alert basis.

Data Transaction UL	**128 kbps
Data Transaction DL	**40 kbps
** Estimated average transactions with 5 and 30 sec poll rates	

Section Seven
Conclusion

Real time access to broadband data improves the efficiency of public safety personnel by giving them the tools they need to perform their job. The delivery of broadband data to field personnel requires access to a wireless broadband network. The FCC has taken the first steps by allocating spectrum in the 700 MHz band to Public Safety for this purpose. Unfortunately, the spectrum allocation will not meet future public safety demands. However, an adjacent spectrum block, the "D Block" has yet to be auctioned. We appeal to Congress to relieve the Commission of their legal obligation to auction the D Block and we implore Congress to direct the Commission to assign the D Block to public safety.

This document has defined some of the broadband applications public safety can benefit from with the assignment of the D block spectrum, and has demonstrated that the current assignment of two 5MHz channels is insufficient for the task. Although technology advancements will improve network capacity (throughput), they will not outpace demand for broadband spectrum. LTE is a very spectrum efficient technology. Improvements in capacity beyond LTE are possible but the physical limit of the radio channel (Shannon Boundary) will limit the magnitude of these improvements.

A unique opportunity exists to change the paradigm of public safety communications where multiple frequency bands and incompatible technologies create obstacles to interoperability and perpetuate inefficiency. We urge Congress to take the first steps to allow public safety to learn from the mistakes of the past and plan for a future in which wireless broadband networks deployed on a common frequency band using a common technology platform provide public safety with the tools they need for the twenty first century.

We endorse the vision of a broadband public safety interoperable data and mission critical voice network listed as a national priority in the September 2009 Draft National Broadband Plan[9], and in NTIA's "Executive Branch Views on Public Safety, Homeland Security and Cyber Security Elements of a National Broadband Plan"[10]. We believe that in order to achieve this vision, Congress should direct the FCC to forgo a second D Block auction and direct the Commission to assign the D block to public safety.

[9] See National Broadband Plan (September 29, 2009 Draft) Pages 9 and 161.
[10] See NTIA Executive Branch Views On Public Safety, Homeland Security and Cyber security Elements of
a National Broadband Plan, December 2009; Page 11.

Respectfully Submitted,
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APPENDIX A

Appendix A is an excerpt from New York City's recent Comments filed with the Commission. It is included here to underscore our major points and provide broadband throughput analysis data.

Current and Anticipated Needs of the Public Safety Community for Mobile Wireless Broadband Networks and Applications.

New York City is closely monitoring the evolution of Long Term Evolution ("LTE") technology as it relates to both mission critical data and voice applications including duplex phone calls, push to talk, instant messaging and broadcast video. Broadband technologies are developing at a rapid pace and the possibility of LTE supporting "push-to-talk" voice communications must be investigated as an alternative to narrowband technology. The lessons to be learned from past experience is that increasing channel size (broad-banding) rather than reducing channel size (narrow-banding) leads to more efficient use of scarce spectral resources. New York City understands that the LTE standards for voice have not been fully developed and that initial forays into broadband voice communications may be a few years away, however the Commission should act now to ensure that sufficient spectrum is available and that public safety standards are developed for this technology to evolve.

Anticipated Broadband Traffic and Capacity Requirements

Using New York City's experience in building the NYC Wireless Network (NYCWiN) as a basis for analysis our team examined the impact that broadband systems may have in the future operations of the public safety. We have collected important data points by gathering application usage from the NYCWiN network in order to provide real-world operational and performance data for the Commission's discussion on broadband usage. First, the NYCWiN 2.5 GHz broadband system provided a basis to characterize the various types of broadband applications that are in use today by the NYC public safety and public sector users. These applications and associated data rates are seen in table 1 below.

Data Rates	Download (Kbps)	Upload (kbps)
Incident Video upload	12	647
AVL Monitoring	51	4
Website Viewing	90	5
SFTP Transfer	93	92
Field Video Viewing	1150	28
Mobile Audio & Video upload	19	96

Table 1 - Typical Data Rates Derived from NYCWiN

The analysis focuses on two very important areas of consideration necessary in understanding the future needs for spectrum for New York City. First we examined the impact of secure broadband applications and the relation to bandwidth to support these applications. As has been discussed throughout the proceeding related to the 700 MHz spectrum, public safety has a critical need to improve daily operations through the use of mobile and fixed applications and technology.

However, it is important to understand the public safety systems must be designed to function outside of the accepted norm for everyday operations to best understand the bandwidth requirements for first responders. As we have seen many times, commercial systems have shown the greatest amount of stress during major City disasters and special events such as:

- September 11th attacks in New York and the Pentagon
- American Airlines Flight 587: 11-12-01
- Staten Island Refinery Explosions: 2-21-03
- Staten Island Ferry Crash: 10-15-03
- Midtown Building Collapse: 7-10-06
- Cory Lidle Plane Crash: 10-11-06
- Midtown Steam Pipe Explosion: 7-18-07
- Multiple Crane Collapses: March and May 2008
- Miracle on the Hudson: 1-15-09
- Helicopter/Plane Crash on the Hudson 8-8-09
- Annual and Special Events (i.e. NY Yankees Parade: 11-6-09)
-

In many of these instances the commercial networks were overloaded with users confined to a small area rendering the networks unusable. In other cases the networks were rendered inoperable due to the lack of sufficient battery back-up or emergency power. These, as well as other real life examples, demonstrate that commercial networks are not designed to function under the stress of critical incidents and when needed the most, cannot perform as required.

We intend to demonstrate, through our analysis, that first responder and public safety services require significantly more bandwidth and capabilities than is presently allocated to public safety in the 10MHz allocation in the 763-768/793-798 MHz band segment. The City also believes that the most effective approach to a broadband public safety network necessitates the allocation of sufficient spectrum to satisfy current and future needs of First Responders.

Normal Operations Scenario

Using real data from our analysis of NYCWiN applications, and using the projected target numbers for the desired adoption of a broadband network by public safety users in New York City; we examined the impact over time for system bandwidth usage as compared to available system capacity. We used models that are similar to in structure those models used by commercial broadband providers in analysis of their capacity needs, but adapted with assumptions appropriate for public safety usage. Using real world experience and our judgment based on our knowledge of the operational goals of Public Safety and other agency plans for broadband we have defined four classes of applications; vehicle MDT installations, Automated License Plate Recognition (ALPR), operational video, and personnel handheld devices. The model assumes a conservative 5% per year increase in the per user bandwidth requirement for both the MDT and handheld users based on current trends in technology growth and additional system capabilities.

Commercial networks generally use a 5% to 10% available user to active user ratio. In simple terms, at 5% usage the assumption is that 1 out of 20 users will be using the system at any one time. For the public safety environment we determined that the commercial carrier formula is not applicable based on a number of factors. We must assume that these devices are used in the day-to-day operations of a majority of system users and are typically reused by each on-duty shift. The number is not likely to be applicable in heavy daytime operation hours for operational vehicles and handheld personal devices. Additionally, the commercial carrier assumption of 5% to 10% of registered users cannot be applied during events such as parades, demonstrations and other large deployments of public safety personnel. As such, a 25% available to active ratio was used for mobile data terminals in vehicles and a 100% ratio was used for machine-to-machine users such as license plate readers.

Normal Operations Model

Using a simple model based on accepted commercial analysis techniques, we examined scenarios that consider the impact of a 12 year program maturation period for a secure broadband network deployed in New York City at 700 MHz. The model network deployment assumes a comparable street-level coverage design to NYCWiN for the 5 boroughs within New York City and uses the known capacity and bandwidth performance of LTE standard equipment as of this writing. The demand model starts with 1,000 vehicle deployments, 40 LPR units, 100 mobile video assets, and 1,000 mobile handheld users. Over the 12 year period the users adopt the network using an "s-curve" model to a final count of 10,000 vehicles, 1,200 LPR units, 2,000 video assets, and 25,000 mobile handheld users. These numbers come from a conservative analysis of anticipated user demand for a secure network of this type by public safety users in New York City, however the potential if expanded beyond local jurisdictions to State and federal entities could easily exceed 100,000 end user devices.

The demand model is then compared against different levels of aggregate capacity that would be available based on different amounts of spectrum. In the case of a 10 MHz spectrum allocation, as illustrated by the graph in Figure 2, the conservative adoption of a 700 MHz network by agencies would result in the UL demand reaching 75% in year 5 and 100% in year 6; while the DL demand reaches 75% in year 7 and 100% in year 9. The model uses very conservative usage assumptions and bandwidth per user requirements and it is anticipated that it is likely these estimates may be low as secure broadband data access becomes an integral part of everyday operations. The commercial industry equivalent to the plausible underestimation of usage comes in the form of the stress placed on commercial carrier networks by smart phones like the I Phone from Apple. These phones have placed significant stress on the capacity of commercial network data services because of the accelerated adoption of new applications and utilization of bandwidth for these new applications.

The 20 MHz LTE analysis uses the same demand assumptions but increases the available aggregate bandwidth as a result of increasing the spectrum available to the Public Safety network from 10 MHz to 20 MHz. The analysis found that the uplink capacity of the network still reaches the 75% at year 8 but never reaches the 100% mark over the 12 year period. The DL system capacity stays below 75% over the entire period of the 12 years, but it does reach a level of >50% as early as 7 years. It is important to note that just a single major incident will require bandwidth well beyond the everyday operational capacity of the network and sufficient reserve bandwidth must be available to ensure proper operational support during a major incident. We have included a parallel analysis of a major incident in figures 3 and 4 on the following pages.

10 MHz LTE Model

Technology	LTE - 10 MHz						
DL Capacity (Mbps)	10						
UL Capacity (Mbps)	3						
Start Year	1						
End Year	12						
User Categories	Initial Number	Final Number	Duty Cycle	DL Data Rate (Mbps)	UL Data Rate (Mbps)	Growth Pattern	Yearly Increase Demand
Vehicles	1000	10000	25%	1	0.25	S-Curve	5%
LPR	40	1200	100%	0.012	0.25	S-Curve	0%
Video Cameras	100	2000	100%	0.012	0.65	S-Curve	0%
Handhelds	1000	25000	5%	1	0.25	S-Curve	5%
# of Sites	200						
Cells/sector	3						

Figure 1 - 10 MHz LTE Model Inputs

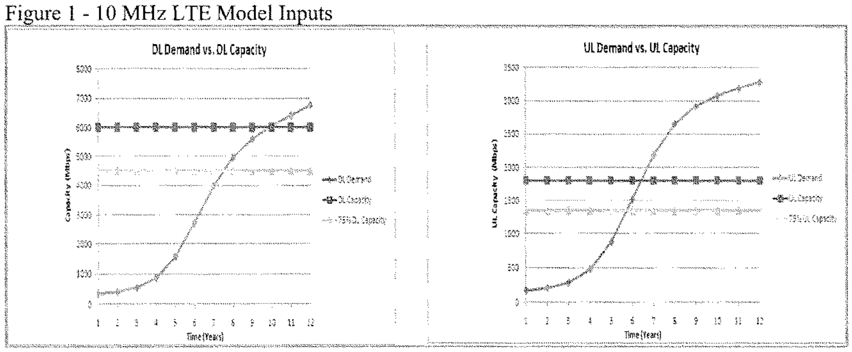

Figure 2 - 10 MHz LTE Capacity Model Graphs

20 MHz LTE

Technology	LTE - 20 MHz						
DL Capacity (Mbps)	21						
UL Capacity (Mbps)	5						
Start Year	1						
End Year	12						
User Categories	Initial Number	Final Number	Duty Cycle	DL Data Rate (Mbps)	UL Data Rate (Mbps)	Growth Pattern	Yearly Increase Demand
Vehicles	1000	10000	25%	1	0.25	S-Curve	5%
LPR	40	1200	100%	0.012	0.25	S-Curve	0%
Video Cameras	100	2000	100%	0.012	0.65	S-Curve	0%
Handhelds	1000	25000	5%	1	0.25	S-Curve	5%
# of Sites	200						
Cells/sector	3						

Figure 3 - 20 MHz LTE Model Inputs

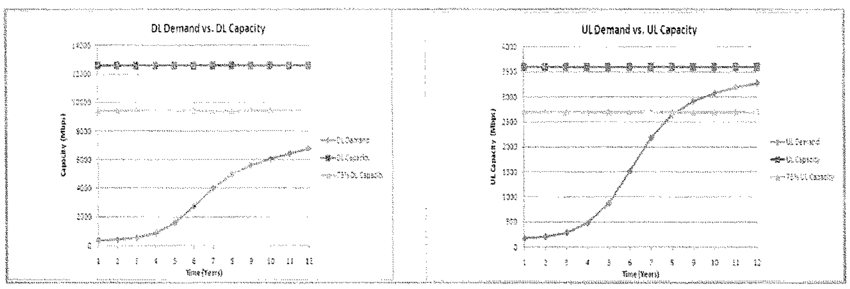

Figure 4 - 20 MHz LTE Capacity Model Graphs

Normal Operations with Voice Application

While the previous section considered only data applications to estimate the total bandwidth demand, in this section we add mobile, enterprise-class Voice as an application and analyzed its impact on overall bandwidth demand. (As standards have yet to be defined for mission critical voice for LTE, we have focused this analysis on non-mission critical use for which reasonable bandwidth estimates can be made) We start with 1000 voice users increasing to 25,000 users at the end of 12 year program maturity period. Voice is a relatively low bandwidth application requiring only about 25 Kbps of bandwidth on both the downlink and the uplink. Current industry estimates of LTE voice capacity are ~160 and ~ 320 simultaneous voice calls in 10 MHz and 20 MHz bandwidth respectively, assuming the entire capacity is dedicated to voice. Under the current assumption of a street-level coverage design of 200, 3-sectored sites, this translates to ~96,000 and ~192,000 total voice users in 10 MHz and 20 MHz bandwidth respectively.

Our assumption of maximum of 25,000 users accounts for only ~26% (~13%) of the total voice capacity if all the 10 MHz (20 MHz) capacity were to be dedicated for voice use. This shows that with the number of assumed voice users, there is still considerable capacity available in the network for other data applications. The charts below show the total demand, including voice, versus available capacity in the network for the two cases of 10 MHz and 20 MHz of bandwidth.

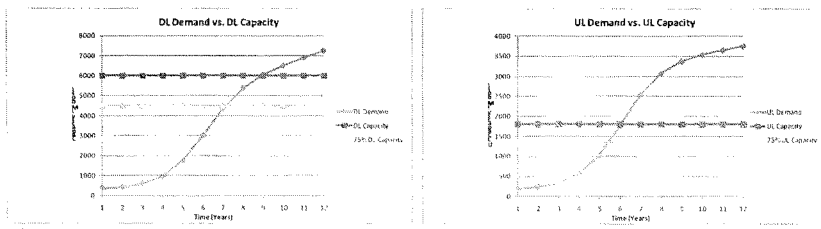

Figure 5- 10 MHz LTE Model Capacity Graphs with Voice

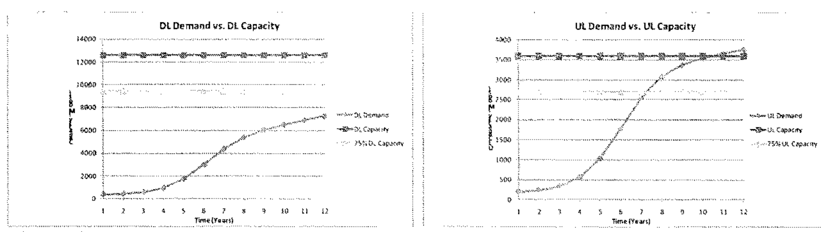

Figure 6- 20 MHz LTE Model Capacity Graphs with Voice

Comparing these charts with the case without voice, we notice a small impact on capacity. For the 10 MHz case, threshold of 75% downlink capacity is exceeded at the end of 7 year instead of 7.5 year without voice, The Tables below illustrates the capacity impact of adding voice for both the 10 MHz and the 20 MHz cases.

75% Capacity Exceeded	With Voice	Without Voice
Downlink	7 years	7.5 years
Uplink	5.5 years	5.8 years

Table 2 - Capacity with and without Voice with 10 MHz LTE Bandwidth

75% Capacity Exceeded	With Voice	Without Voice
Downlink	> 12 years	>12 years
Uplink	7.1 years	8 years

Table 3 - Capacity with and without Voice with 20 MHz LTE Bandwidth

Although the impact of adding voice to the overall capacity is small, this is true only for the number of voice users assumed in this model. If the number of users becomes significantly higher, that would result in a considerable impact on available capacity. Likewise, the model does not take into account the potential impacts on data traffic associated with the yet-to-be-defined implementation of VoIP on LTE. If, for example, the real time nature of VoIP traffic is supported by dedicated channels or bandwidth, the effective bandwidth available to other data traffic could be reduced beyond the linear model assumed in this analysis.

Critical Incident Bandwidth Requirements

While a public safety broadband wireless network provides valuable services to the public safety personnel in the execution of their day-to-day mission operations, it is during an emergency incident brought about by natural or man-made disasters that the potential of a broadband network is truly and fully realized. Public safety networks must be designed and built to meet the most stringent requirements for reliability, availability, quality of service, and security. An important aspect of public safety broadband networks that requires careful consideration is their engineered capacity, and that is strictly a function of the total amount of spectrum available for public safety use. Although the networks can be engineered and hardened to highest standards of reliability and availability, that is meaningful only if there is enough capacity available in the sites serving an incident scene to meet the communication requirements of hundreds, if not thousands, of first responders. A capacity shortfall during a major incident scene would result in blocked and delayed calls, significantly hampering the efforts of public safety personnel to save and protect lives and property. Since an incident can strike without warning at anytime and anywhere in the jurisdictional area of a network, it is imperative that all the sites in the network be provisioned with enough capacity to handle the worst case scenario that would unfold during an emergency situation.

We must assume that a major incident such as the September 11th terrorist attacks on the World Trade Center, if such an incident were to occur again, will require a large and coordinated response by federal, state and local public safety First Responders and support personnel. The purpose of the National Broadband Network is to provide high-speed interoperable data and voice communications for First Responders. The network, under normal circumstances, will be used by the local or regional agencies to conduct day-to-day operations in the conduct of their public safety mission. However, should another terrorist attack of similar proportion occur there will be a large scale response from federal, state and local jurisdictions into the incident area. In the future, when the regional segments of the network are built-out, First Responders and support personnel will be using the network while en-route to the incident and upon arrival at the scene. Because of the dense urban and suburban populations of the greater metropolitan areas there are upwards of 50,000 state and local public safety First Responders in the immediate metropolitan area. In addition, there are many federal agencies that maintain personnel in the area that could potentially respond to a major incident. It is conceivable that the number of active users could increase by approximately 75% if a large response is required.

New York City Critical Incident Response Simulation
In the following section we describe an incident scene in the New York City with the specific objective of estimating how much spectrum is required to adequately meet the communications requirements of First Responder emergency operations.

The incident involves a "dirty bomb" set-off at Pennsylvania Station in Midtown Manhattan. The device was planted in the information and ticket sales area of the Amtrak area and has caused moderate structural damage to the area and has caused secondary damage to the structure above and below Amtrak's Penn Station. The area below the Amtrak section is part of the Long Island Rail Road (LIRR) complex and has damaged passenger corridors and waiting areas. The bomb also damaged the structure above the Amtrak waiting area which is part of the Penn Plaza / Madison Square Garden Complex. Immediately above Penn Station is a large office building that is operating at 75% occupancy.

The "dirty bomb" has released nuclear contaminants throughout the Amtrak and LIRR complexes and into the areas above and below the stations. The bomb also caused fires to break out on all levels including the track levels. The fires are causing a large smoke condition throughout the complex and into the track areas of the LIRR, Amtrak New Jersey Transit, and the New York City Subway. Smoke is also billowing out of the station at the street level exits and blanketing the street area immediately around Penn Station.

Incident Assessment
There are approximately 400 injured passengers on the Amtrak / New Jersey Transit level and 500 injured passengers on the LIRR level, The injuries range from critical and serious near the center of the explosion to minor caused by fleeing passengers and the heavy smoke conditions. There are injuries on three levels of the station and above the station from falling glass and building materials.

The New York City Police Department (NYPD) has initiated a level 4 mobilization setting up command posts in the vicinity of 34th St. and 8th Ave. The FDNY's Command Tactical Vehicle, Mobile Field Communications, and Emergency Medical Field Units are set in the same area. The Office of Emergency Management has set-up their command vehicle on 8th Ave near 34th St. All of the mobile command posts are near each other.

Fire Department of New York City (FDNY) is setting up a hazardous material (HazMat) detoxification / wash-down area on 31st St. and Broadway, while Emergency Medical Services (EMS) has set up their mobile triage vehicles on 31st St. and Broadway.
The Departments of Health and Mental Hygiene and Environmental Protection have responded with their mobile command posts and have placed them in the vicinity of 35th St. and 7th 8th Ave. FDNY will use 34th St. and 8th Avenue for ambulance and bus staging and the NYPD has closed off Broadway, seventh and eighth avenues from 20th St. to 42nd Street.

New York City Transit (NYCT) has been asked to stage busses to begin transporting the injured to area hospitals and has responded with a mobile command center located near the Office of Emergency Management (OEM) command vehicle.

Emergency Response

Because of City's preparedness to handle incidents of this magnitude, there is a swift and coordinated response from a number of different agencies including Police, Fire, Emergency Medical Services, and Office of Emergency Management Services among many others. Each agency, in turn, will respond with several different units trained, equipped, and specialized in handling specific aspects of emergency response. For example, in this particular incident, NYPD will respond with, in addition to patrol vehicles, a number of different specialized units such as Detective Bureau, Intelligence Division, and Mobile Command Posts etc. Table 1 below illustrates the level of effort required to handle a crisis of this magnitude. For each of the major agencies, it lists the different units, the number of units that would be converging at the scene, and typical applications they would be using.

Table 4 - Agency Response

Police Department			
Agency	Qty	Primary Application	Secondary
NYPD Mobile Command Posts Borough and Comm. Div.	2	Requires video from deployed cameras as well as the ability to view video from other sources. Each MCP will deploy a number of wireless cameras and monitor other feeds from other MCPs and agencies. Assume each MCP has 4 cameras	Incident Management, CAD, Internet and mobile data access VoIP Comms
NYPD Emergency Services Command Posts	2	Viewing video from other sources and their own equipment. Assume each vehicle deploys 2 cameras	Incident Management, CAD, Internet and mobile data access VoIP Comms
NYPD TARU Skywatch with 4 cameras each	3	Extensive use of video and specialized equipment.	Incident Management, CAD, Internet and mobile data access VoIP Comms
NYPD CTD Command Vehicle	1	Video feeds, primarily viewing not sending Management of sensors and access to	Incident Management, CAD, Internet

		CTD databases and internet. Access to federal databases and applications. Use of portable sensors for CBRNE	and mobile data access VoIP Comms
NYPD CTD Support vehicles	5	MDSL deployed for mobile detection of CBRNE threats	
Portable Sensors	25	Monitors the levels of toxins and radiation, CBRNE	
Patrol Division Mobile Command and Support Vehicles	3	Video, access to personnel information, databases, CAD, Incident Management	Internet, VoIP Comms, mobile data
NYPD Intel Division Mobile Support Vehicles	2	Access to databases, federal databases, internet, video feeds	Incident Management, CAD, Internet and mobile data access VoIP Comms
NYPD Fleet Services Towing Services	25	AVL	
Fire Department – Includes Emergency Medical			
Agency	Qty	Primary Application	Secondary
FDNY Command Tactical Vehicles	2	Video from CTV and portable cameras, access to FD Operations Center applications, Electronic Command Board, HAZMAT databases	Incident Management, CAD, Internet and mobile data access VoIP Comms
FDNY Field Communications (Includes Command Post)	3	Audio feeds for recording Fireground, video, uplink Fireground to FDOC	Incident Management, CAD, Internet and mobile data access VoIP Comms
FDNY Heavy Rescue	4	Video, Incident Management, CAD	
FDNY Emergency Medical Command Post	1	Video, audio from Fireground	
FDNY Mobile Triage Vehicles	3	Telemetry, video, photos,	Incident Management, CAD, Internet and mobile data access VoIP Comms
FDNY Ambulances	10	AVL, telemetry, CAD, triage applications	Incident Management,

Agency	Qty	Primary Application	Secondary
			CAD, Internet and mobile data access
Office of Emergency Management			
Agency	Qty	Primary Application	Secondary
OEM Mobile Operations Center	1	Video, downlink and uplink for 5 cameras	Incident Management, CAD, Internet and mobile data access VoIP Comms
OEM Temporary Field Operations	1	Connectivity to OEM Operations, databases and applications	Incident Management, CAD, Internet and mobile data access VoIP Comms
Other New York City Agencies			
Agency	Qty	Primary Application	Secondary
Department of Environmental Protection Mobile Operations Center	1	Access to applications, sensors, video	
Department of Health	1	Access to applications, sensors, video	
Department of Buildings	1	Access to applications, video	
NYCT	1	Radio communications, applications	
MTA Police Field Communications Emergency Services	3	Video, applications, databases, internet	
AMTRAK Command Post	1	Video, applications, databases, internet	

Bandwidth Requirements Analysis

We used the model of the expected users, command vehicles and associated applications associated with the response to estimate the total bandwidth demands that would be required during the peak response periods following the incident. We have assumed that the incident area is served by a public safety broadband wireless network that is built using fourth generation Long Term Evolution (LTE) technology and operates in the 700 MHz public safety frequency band.

Table 5 below lists the average capacities available from a single LTE sector using 10 and 20 MHz of spectrum.

Spectrum	Downlink Capacity	Uplink Capacity
10 MHz, (5 MHz Downlink, 5 MHz Uplink)	10 Mbps per sector	3 Mbps per sector
20 MHz, (10 MHz Downlink, 10 MHz Uplink)	21 Mbps per sector	6 Mbps per sector

Table 5 - Spectrum versus Capacity

The aggregate bandwidth requirements of the applications used during the incident can be compared against the available capacity. Estimated bandwidth requirements of typical applications used during at an emergency incident are listed in Table 6.

Application	Downlink Data Rates (Kbps)	Uplink Data Rates (Kbps)
Incident Video Upload	12	647
Field Video	1150	28
Data Access	10	100
CAD Dispatch	50 Kbps	50 Kbps
VoIP	25 Kbps	25 Kbps

Table 6 - Application Data Rates

As illustrated in Table 6, video applications are the most demanding in terms of bandwidth usage. However, it is also a critical application for incident management, sending images in real time from the incident scene to the command and control centers enhancing situational awareness and providing a current and consistent operating picture required for effective and coordinated response. An incident scene will typically have a large number of video cameras streaming information back to the command vehicles present at the scene as well as to the central command and control centers. Command staff personnel from each agency will make extensive use of the video feeds to get a real-time view of rapidly and dynamically changing situation at the incident scene to aid them in their decision making process and to coordinate their response with other agencies.

In the incident scene we have depicted there are 38 simultaneous downlink video streams consuming about 44 Mbps of bandwidth at 1.15 Mbps per video stream. These streams are distributed to the various public safety command vehicles present at the scene. This combined with other applications such as database access, file downloads, telemetry, computer aided dispatch, VoIP results in an aggregate sustained downlink bandwidth requirement of about 60 Mbps.

On the uplink, we have assumed that the agencies will deploy twelve portable or vehicle mounted cameras continuously sending real time images from the incident scene. This utilizes about 9 Mbps of bandwidth on the uplink. Another significant consumer of uplink bandwidth is ambulances sending triage images back to the hospitals to inform them in advance of the nature and seriousness of the injuries. We estimate that EMS will utilize about 2 Mbps of uplink bandwidth. Coupled with uplink usage of other applications, aggregate bandwidth used on the uplink is about 16 Mbps.

The aggregate bandwidth demands in above can be compared against the bandwidth that would be available in an incident scene. Available bandwidth is a function of the number of sectors/sites that would be within range of the incident scene and bandwidth available per sector, as shown in Table 5. Table 7 shows the total aggregate demand at the incident scene and the number of sectors of bandwidth that would be required to fulfill that demand.

Spectrum	Downlink Demand	LTE Sectors Required for DL Demand	Uplink Demand	LTE Sectors Required for UL Demand
10 MHz (5 MHz uplink) (5 MHz downlink)	60 Mbps	6	16 Mbps	6
20 MHz (10 MHz uplink) (10 MHz downlink)	60 Mbps	3	16 Mbps	3

Table 7 - Total Incident Scene Demand

The number of sites that would realistically available to support an incident is a function of the network design and the geographic distribution of the users. In the example provided, given the localized nature of the incident coupled with lower site count due to superior propagation characteristics of the 700 MHz frequency band relative to other higher frequencies such as 2.5 GHz and 1.9 GHz, it is likely that the incident scene would be served by only 3 sectors.

For incident scenario presented and the associated site density, 10 MHz of spectrum will fall considerably short of the required bandwidth demand. 20 MHz of spectrum is barely sufficient to meet the projected demand. We realize, however, that the incident we have utilized in our model represents an extreme case but it is entirely within the realm of possible threats for a large metropolitan city like New York. To meet the extraordinary demands that are placed on a network during emergency situations, we strongly believe that 20 MHz of spectrum is needed in order to prevent the network from being saturated and to continue providing reliable service.

Incident Scene Operations

Incident Scene Response Units	Qty	Primary Application	Secondary Application	DL Data Kbps	UL Data Kbps
Mobile Command Posts	2	Receive 4 video feeds	CAD, internet, incident mgmt, VoIP	9700	442
Emergency Service Unit (ESU)	2	Receive 2 video feeds	CAD, internet, incident mgmt, VoIP	5100	442
Technical Advisory Response Unit (TARU)	3	Uploading 4 video streams	CAD, internet, incident mgmt, VoIP	642	8664
Counter Terrorism command vehicle	1	Receiving 2 video feeds	CAD, internet, incident mgmt, VoIP	2550	221
Counter Terrorism support vehicles	5	Monitor CBRNE threats		500	
Portable sensors	25	CBRNE			625
Patrol Division Mobile Command	3	Video, database access, internet	Internet, VoIP, comms, mobile data	4200	663
NYPD Intel Division Mobile support vehicles	2	Video, database access, internet	CAD, internet, incident mgmt, VoIP	2800	442
NYPD Fleet Services Towing Services	25	AVL			625
FDNY Command Tactical Vehicles	2	Video, ECB, HAZMAT database	CAD, internet, incident mgmt, VoIP	5100	442
FDNY Field Communications	3	Video, Audio	CAD, internet, incident mgmt, VoIP	4200	663
FDNY Heavy rescue	4	Video, Incident mgmt, CAD		5600	
FDNY Emergency Medical Command Post	1	Video, audio		1400	
FDNY Mobile Triage Vehicles	3	Telemetry, video, photos	CAD, internet, incident mgmt, VoIP	4200	663
FDNY Ambulances	10	AVL, Telemetry, triage applications	CAD, internet, incident mgmt, VoIP	2500	2210
OEM Mobile operations Center	1	Video downlink, uplink	CAD, internet, incident mgmt, VoIP	2550	947
OEM Temporary Field Operations	1	database access, data apps	CAD, internet, incident mgmt, VoIP	300	221
Department of Environmental Protection applications	1	video , sensors, apps		1400	
Department of Health	1	video , sensors, apps		1400	
Department of Buildings	1	video , apps		1400	
NYCT	1	radio comms, apps		300	
MTA Police Field Communications Emergency services	3	video, database, internet		4200	
AMTRAK Commend Post	1	video, database, internet		1400	
Total in Mbps				**61**	**17**

Table 8 Incident Scene Operations

City's Response to Commission Questions Regarding Operational Requirements

The FCC has suggested three categories of operational conditions relative to demand; critical, medium and low. For the purposes of this filing we will define the three categories as follows:

Critical – Network usage during a major incident(s) supporting a large scale response to a catastrophic event such as a bombing or natural disaster. This type of incident will initiate responses from local, federal and mutual aid agencies for initial response, rescue and recovery. Using prior incidents as a model the City can expect the number of first responders to grow exponentially as the incident progresses through its various stages and the network utilization to fluctuate between periods of extreme (>75%) utilization, heavy utilization (>50%) and medium utilization (<50%).

Medium – We have assumed that medium usage refers to normal operations during the primary work hours of a public safety agency such as the police department or the fire department. Based on staffing levels the time period for medium usage will span from early morning rush hour for both vehicular traffic and public transportation, through the normal and extended workday, the end of the school day and evening hours until midnight. This period of time from approximately 5:30 AM to 12:00 AM comprises the majority workload of the New York City Police Department. This model also takes into consideration typical tourist and commuter workforce traffic travelling into and out of the City proper. This model will most likely apply to the Fire Department, specifically with regard to Emergency Medical incidents responded to by emergency medical personnel and firefighters.

Low – We assume that the low usage period will consist of the period of time after the evening hours and prior to rush hour when staffing and equipment is deployed at lower levels. Typical public safety models assume that these hours are less busy than other periods and staff accordingly, however the typical per unit workload may remain similar to the workload during busy periods due to reduced staffing.

During critical usage periods we anticipate that the network will first be utilized by First Responders to coordinate multi-agency response to the critical incident and exchange critical information relative to the incident response and operational plans. This may include but not be limited to:

- Incident data from 911 calls and first responders
- Information sharing for HAZMAT and environmental information
- Coordination of response for federal and mutual aid responders
- Video from fixed cameras that are adjacent to the incident
- Maps and GIS data relevant to the area
- Personnel and equipment rosters for logistics
- Building or location information
- Executive / managerial teleconferencing
- Personnel and vehicle tracking

- Incident Management / Situational Awareness
- Mass Notifications
- Traffic Control and Traffic Advisories
- Download and consolidation of surveillance data for forensic analysis

As described earlier we believe that the type of traffic will constantly fluctuate however the usage will remain high during the initial response period. Depending on the severity the initial response may last upwards of 7 to 10 days as the various first responders arrive at the incident scene. The type of network usage will change based on the stage of the incident response. We must assume that the network will be utilized at approximately 75% of capacity for the first stage of response. The network must support the first responders throughout the period of initial response to the incident through the remaining stages of rescue and recovery.

As evidenced during the September 11th terrorist attacks the initial response was tremendous and the logistics aspect was primarily carried out through a manpower intensive effort. Not only were commercial network services overwhelmed at all levels, their infrastructure was severely damaged and ineffective. Public safety responders did not have a broadband wireless networks to supplement the coordination of the massive response effort and relied on inefficient forms of communications for such a complex event.

It must be noted that during this type of incident the City's first responder agencies must also serve the entire City and not just the area of the incident. In a City as large as New York an incident can occur in a small area with a dense population and still only involve a small percentage of the City's area.

For medium theater operations we have assumed the model of normal daily operations of the City's First Responders. In this category public safety will utilize applications designed for routine business processes. The Fire Department's typical usage will consist of dispatch information for fire and medical incidents that will require broadband communications to transfer patient data, location history and HAZMAT information, building plans and maps, driving directions, patient telemetry, AVL and telematics data and other incident related information. Prior to the adoption of NYCWiN none of this information was available to responding units with the exception of on-scene patient telemetry for EMS. As the agencies begin implementing new technology the utilization demand will rise, primarily driven by many factors; new capabilities, features and functions of systems due to the availability of the broadband network and additional bandwidth requirements as more data intensive applications are implemented. For example; the ability to quickly and efficiently transmit patient data, photos and video of patient's injuries, and bio-metric information to a physician and subsequently allow the hospital staff to assist in field treatment via video teleconferencing will provide tremendous benefit to the citizen's of New York City.

The Police Department will soon have the capability to download photos within seconds from their criminal history databases along with other critical information that will support the investigatory process in the field thus saving valuable processing time. The ability to scan bar-coded documents for traffic violations will not only save time and produce more accurate citations, it will also increase officer safety. Automated and bundled transactions will help the officer make sound decisions and alert him/her of potentially dangerous conditions. These capabilities are not available with today's 25 KHz channelized systems. Real-time data collection will create new capabilities for investigators and counter-terrorism personnel by moving data from the field to the data warehouse as fast as it is collected for critical analysis. Scanning a driver's license will provide the officer with the appropriate information within a fraction of the time previously required to type or call in the information request. The database query will return a photo in addition to the standard DMV and warrant information, helping the officer confirm the identity of the person stopped for the violation. These and many more applications will make first responders more productive and effective. But these applications require an appropriate allocation of spectrum and bandwidth to perform as specified under these normal operating conditions.

Low theater operations do not necessarily reduce the bandwidth requirements due to lower staffing or reduced activity. Individual applications will still require sufficient bandwidth to operate efficiently. However, these periods of lower activity offer opportunities for agencies to update their mobile applications and equipment with security patches, new applications and data. The mobile and portable devices and applications should be afforded the same maintenance features benefits derived from a wired network or a commercial cellular network. Updates, new applications and patches should be pushed out from a central source to the edge devices to keep the users and devices in the field, rather than ferrying devices to depots for software updates. Applying the right design parameters to the network and applications will allow for the efficient maintenance of the devices, applications and data ensuring that the mobile workforce is truly mobile.

No matter how carefully bandwidth planning is done on any type of secure public safety wireless network, the network will eventually be placed in a position of stress due to a major incident or an unplanned increase in utilization. There is not enough spectrum available to provide the necessary overhead to assure that bandwidth will be available during critical incidents where users require immediate and high priority access. It must be assumed that utilization will be higher in certain operational scenarios. Once broadband data systems become widely adopted by public safety it is highly probable, based on analogies to commercial systems, public safety networks will be extremely stressed during events similar to September 11th in New York and July 7th in London. During events such as these usage will dramatically increase, and intelligent mechanisms to handle bandwidth must be in place well before the occurrence of a large scale emergency of this type.

In our bandwidth analysis of the incident scene we discussed the various impacts of applications on bandwidth availability during emergencies. It is clear from our analysis that in scenarios where 20 MHz of spectrum is available to public safety the system will be "stressed" during periods where important characteristics of a network need to exist above and beyond what is available commercially. A public safety system must have built-in mechanisms that support Quality of Service (QoS) prioritized by both applications (voice, video, data, etc.) and by the role of the user based on the operational command structure. Next generation wireless technologies such as LTE have included these mechanisms as part of their adopted standards, however the configuration of these controls must be carefully implemented in any network supporting public safety users. It is highly unlikely that commercial carriers will break with their tradition of "best efforts" delivery and offer guaranteed message delivery and bandwidth allocation. Based on the quantity of users they must support it will be difficult to provide priority services to a small number of users when the demand will be so great from the users at large.

New York City is learning valuable lessons from our implementation of the NYCWiN program on how to deploy and operate applications on a broadband network to ensure that the available bandwidth is efficiently and effectively used in high stress utilization conditions. Application planning must include such concepts as intelligent distribution of data based on role, location, and need utilizing prioritized push technologies to control of information flow during peak and stressed network conditions.

Defence Research and Development Canada / Recherche et développement pour la défense Canada

DEFENCE DÉFENSE

700MHz Spectrum Requirements for Canadian Public Safety Interoperable Mobile Broadband Data Communications

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Defence R&D Canada – Centre for Security Science

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Abstract

In response to a request for technical advice by Public Safety Canada on behalf of national public safety stakeholders, the Centre for Security Science conducted a technical assessment of the 700 MHz spectrum requirements for broadband mobile data communications for public safety and security. The impetus to this assessment relates to the Industry Canada call for consultation SMSE-018-10. The goal was to determine how much spectrum is required to meet the needs of the public safety community for mobile broadband wireless data communications within a 20-year time frame. The data demand for recurring emergency situations was modeled through an interactive process with active participation from Canadian public safety stakeholders. In addition, the capabilities of LTE technology to support the data demands were also modeled. The results show that the amount of bandwidth required to satisfy the needs of public safety is greater than 20MHz in the near-to-mid term, and likely to also exceed 20MHz in the long term, despite advances in technology. This result is based on an analysis that applies relatively conservative estimates for the growth in demand for mobile data communications for public safety and security applications, and relatively aggressive estimates for the rate of technological improvement of spectrum efficiency projected into the future.

Résumé

En réponse à une demande de conseils techniques faite par Sécurité publique Canada au nom des intervenants nationaux de la sécurité publique, le Centre des sciences pour la sécurité a effectué une évaluation technique des besoins de la fréquence de 700 MHz pour la transmission mobile à large bande de données destinée à la sécurité publique. C'est l'appel de consultation SMSE-018-10 d'Industrie Canada qui a motivé l'exécution de cette évaluation. L'objectif consistait à déterminer quelle part du spectre est requise pour répondre aux besoins du milieu de la sécurité publique pour la transmission mobile de données à large bande au cours des 20 prochaines années. La demande en données pour les situations d'urgences récurrentes a été modélisée à l'aide d'un processus interactif auquel les intervenants de la sécurité publique du Canada ont participé activement. Il y a de plus une modélisation des capacités de la technologie LTE pour répondre aux demandes de données. Les résultats démontrent que la part de la bande passante nécessaire pour répondre aux besoins de la sécurité publique est supérieure à 20 MHz à court et à moyen terme, et dépassera aussi probablement 20 MHz à long terme, et ce, malgré les progrès technologiques. Ce résultat repose sur une analyse ayant recours à des évaluations relativement prudentes de la croissance de la demande pour la transmission mobile de données à des fins de sécurité publique, ainsi qu'à des évaluations relativement ambitieuses du degré d'amélioration technologique de l'efficacité spectrale dans le futur.

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Executive summary

700MHz spectrum requirements for Canadian public safety interoperable mobile broadband data communications.

Claudio Lucente, MARTELLO DEFENSE SECURITY CONSULTANTS INC.

DRDC CSS CR 2011-01

In response to a request for technical advice by Public Safety Canada and on behalf of the national public safety community, the Centre for Security Science, with technical oversight by the Communications Research Center, conducted a scientific assessment of the 700 MHz spectrum requirements for broadband mobile data communications. This assessment is provided in support of the Industry Canada call for consultation SMSE-018-10.

The conversion of the broadcast television from analog to digital signals and the resulting re-allocation of the channels has attracted significant interest for the vacated RF spectrum on the part of commercial, private, and public entities. In particular, the Canadian public safety community has a strong interest in a segment of the 700MHz spectrum as described in the Industry Canada call for consultation (SMSE-018-10). Given the excellent propagation properties of this frequency band, it views this as a unique opportunity to lay the foundation for a national mobile broadband communications network that will allow various public safety agencies to better plan, coordinate, and execute their missions, for their day-to-day operations and when responding to crisis events.

New technologies and applications are at hand that can enhance situational awareness and improve coordination between public safety personnel. The mobile broadband wireless network must have suitable bandwidth to provide the data throughput required by the many applications required by today's public safety personnel such as real-time video surveillance, vehicle and blue force tracking devices, ambulance patient video. The bandwidth requirements will evidently vary depending on the operations being conducted be it day-to-day routine calls, crowd control, or major emergency situations. Since the network must be designed to provide connectivity that responders can rely on at all time, the bandwidth requirements must be addressed in the context of how responders intend to use the mobile broadband network during emergencies.

In order to assess the requirement with appropriate context and relevance, stakeholders were consulted across the nation, facilitated through linkages provided by the Canadian Interoperable Technologies Interest Group. Three incident scenarios were selected as case studies for public safety stakeholders to develop the incident-response profiles. The profiles consisted of establishing how many resources and assets would be assigned to each incident and, what applications would they make use of during each incident. The incidents that were chosen as case studies represent major but commonly re-occurring events (such as a sports event). We know that catastrophic events of the scale of a major earthquake or a concerted terrorist attack (9/11) would create demands that would far exceed any available spectrum and so such situations were not considered in the analysis.

The data throughput for each application was derived from empirical studies conducted by public safety agencies, support organizations, and research labs. Thus, the Data Demand Model (DDM) is derived from the incident-response profiles and the applications throughput requirements, in addition to growth assumptions over a 20-year horizon. Particular attention was paid to tactical video as it is expected to prevail in enhancing situational awareness and is often critical, particularly to security operations. It is also the largest consumer of bandwidth. As such, various techniques are considered in the DDM to reduce the preserve bandwidth requirement in the presence of video traffic.

Because of the large push by the commercial sector to deploy Long Term evolution (LTE) networks as the 4th generation of cellular system and since the United States has selected LTE as the technology for public safety mobile broadband, using the same technology in Canada would leverage the economics of scale and enhance interoperability between Canadian and US public safety agencies LTE was therefore selected as the basis to develop the Capacity Model for this report. There are substantial research efforts underway to enhance the capacity of LTE and therefore, the Capacity Model introduces a factor to account for a number of anticipated enhancements in spectral efficiency at various intervals over the 20-year horizon of the model.

Finally, the required bandwidth is revealed by correlating the data demand with the capacity. Several fundamental assumptions are used in the models such as the rate at which research into spectral efficiency is transformed into reality and, the number of users accessing the same applications simultaneously. The effect of varying these assumptions on required bandwidth is examined, as is the effect of uncertainty in predictions, which increases with time particularly as we look into the future 15-20 years.

The result of the modeling, taking into account uncertainty factors, shows that the amount of bandwidth required to satisfy the needs of public safety to conduct their missions during commonly re-occurring major emergency situations with modern tools and applications is greater than 20MHz in the near-to-mid term, and likely to also exceed 20MHz in the long term, despite advances in technology. Clearly even with the full 10 + 10 MHz allocated, the community will need to take measures to efficiently manage broadband data communications carefully during periods of peak demand.

Sommaire

Évaluation technique des besoins de la fréquence de 700 MHz réservée à la sécurité publique pour la transmission mobile à large bande de données

Claudio Lucente, MARTELLO DEFENSE SECURITY CONSULTANTS INC.

DRDC CSS CR 2011-01

En réponse à une demande de conseils techniques faite par Sécurité publique Canada au nom de la collectivité nationale de la sécurité publique, le Centre des sciences pour la sécurité, sous la supervision technique du Centre de recherches sur les communications, a mené une évaluation scientifique des besoins de la fréquence de 700 MHz pour la transmission mobile de données à large bande. Cette évaluation vient en soutien à la demande de consultation SMSE-018-10 d'Industrie Canada.

La transition des signaux analogues aux signaux numériques des services de télédiffusion et la nouvelle répartition des canaux ont suscité un vif intérêt vis-à-vis du spectre des radiofréquences libéré chez les entités commerciales, privées et publiques. Le milieu canadien de la sécurité publique s'intéresse énormément à un segment de la bande de 700 MHz tel qu'il est décrit dans la demande de consultation SMSE-018-10 d'Industrie Canada. Étant donné les excellentes propriétés de propagation de cette bande de fréquence, on considère qu'il s'agit d'une occasion unique de jeter les bases d'un réseau national de transmission mobile à large bande qui permettra aux divers organismes de sécurité publique de mieux planifier, coordonner et exécuter leurs mandats, tant dans le cadre de leurs activités quotidiennes que lors des interventions en situation de crise.

Il existe de nouvelles technologies et applications qui peuvent accroître la connaissance de la situation et améliorer la coordination entre les intervenants de la sécurité publique. Le réseau mobile sans fil à large bande doit avoir une bande passante suffisante pour fournir le débit de données nécessaires aux nombreuses applications exigées de nos jours par les intervenants de la sécurité publique, comme la vidéosurveillance en temps réel, les appareils de suivi des véhicules et des forces bleus et la vidéo de patients transportés par ambulance. Les besoins en bande passante varieront évidemment en fonction des activités, qu'il s'agisse d'appels quotidiens de routine, du contrôle des foules ou de situations d'urgence majeures. Puisque le réseau doit être conçu de manière à offrir une connectivité à laquelle les intervenants peuvent se fier en tout temps, il faut tenir compte des besoins en bande passante en fonction de la manière dont les intervenants ont l'intention d'utiliser le réseau mobile à large bande pendant des situations d'urgence.

En vue d'évaluer les besoins en fonction des bons contextes et de leur pertinence, on a consulté des intervenants partout aux pays, grâce aux liens fournis par le Groupe d'intérêt canadien en technologie de l'interopérabilité. Trois scénarios d'incident ont servi d'études de cas aux intervenants de la sécurité publique pour définir les profils d'intervention des incidents. Les profils visaient à établir la quantité de ressources et de

biens qui seraient affectés à chaque incident et à déterminer quelles applications ils utiliseraient dans chaque cas. Les incidents choisis à titre d'études de cas représentent des événements majeurs récurrents (comme une manifestation sportive). Nous savons que les catastrophes comme un important tremblement de terre ou une attaque terroriste concertée (attaques du 11 septembre) engendreraient des demandes qui iraient bien au-delà de tout spectre disponible. Par conséquent, de telles situations n'ont pas été prises en considération dans l'analyse.

Le débit des données pour chaque application a été obtenu à partir d'études empiriques effectuées par des organismes de sécurité publique, des organismes de soutien et des laboratoires de recherche. Par conséquent, le modèle de demande de données repose sur les profils d'intervention aux incidents et les besoins des applications en débit des données, ainsi que sur les hypothèses de croissance pour les 20 prochaines années. On a porté une attention particulière à la vidéo à des fins tactiques puisque celle-ci devrait s'imposer pour améliorer la connaissance de la situation et s'avère souvent essentielle, notamment aux activités de sécurité. C'est aussi elle qui utilise le plus de bande passante. Le modèle de demande de données a donc pris en considération diverses technologies pour réduire le besoin de bande passante réservée en présence de trafic vidéo.

En raison de l'offensive du secteur commercial visant la mise en place de réseaux LTE en guise de 4^{e} génération de système cellulaire et puisque les États-Unis ont choisi la technologie LTE pour la transmission mobile à large bande de la sécurité publique, l'utilisation de la même technologie au Canada permettrait de faire des économies d'échelle et améliorerait l'interopérabilité entre les organismes de sécurité publique des États-Unis et du Canada. La technologie LTE a donc servi de base à l'élaboration du modèle de capacité du présent rapport. D'importants travaux de recherche sont en cours en vue d'améliorer la capacité de la technologie LTE. Par conséquent, le modèle de capacité introduit un facteur qui tient compte de certaines améliorations prévues de l'efficacité spectrale à divers intervalles au cours des 20 prochaines années du modèle.

Enfin, la bande passante nécessaire est déterminée par la corrélation entre la demande de données et la capacité. Les modèles utilisent plusieurs hypothèses de base, comme la vitesse à laquelle la recherche sur l'efficacité spectrale se transforme en application pratique et le nombre d'utilisateurs accédant simultanément aux mêmes applications. On examine les répercussions d'une variation de ces hypothèses sur la bande passante ainsi que l'incidence de l'incertitude dans les prédictions, qui augmente au fil du temps puisqu'il s'agit d'une évaluation portant sur les 15 à 20 prochaines années.

Les résultats de la modélisation, qui tient compte des facteurs d'incertitude, démontrent que la part de la bande passante nécessaire aux activités du milieu de la sécurité publique ayant recours aux outils et aux applications modernes lors de situations d'urgence majeures et récurrentes est supérieure à 20 MHz à court et à moyen terme, et qu'elle dépassera probablement 20 MHz à long terme, et ce, malgré les progrès technologiques. De toute évidence, même avec une pleine attribution de 10 + 10 MHz, la communauté devra prendre des mesures pour gérer efficacement et prudemment la transmission de données à large bande pendant les périodes de demande de pointe.

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Acknowledgements

This work was supported by Defence Research and Development Canada Centre for Security Science through the Public Security Technical Program (PSTP) subproject EMSI-02-302 (Contract # U6800-117762/001/SQ Addendum #1). We would like to thank the federal scientists of the Communications Research Centre for their technical support and oversight of the project. We also wish to acknowledge the cooperative sharing of information from various Canadian first responder agencies, facilitated through links provided through the Canadian Interoperability Technology Interest Group.

1 Introduction

The demise of analogue broadcast television and the resulting re-allocation of broadcast television channels has attracted significant interest for the vacated RF spectrum on the part of commercial, private, and public entities. In particular, the Canadian public safety community has expressed a strong interest in a segment of the 700MHz spectrum. It views this moment in time as a unique opportunity to lay the foundation for a national mobile broadband communications network that will allow various public safety agencies to better plan, coordinate, and execute their missions, whether it is for their day-to-day operations or when responding to crisis events.

Such a network could enable interoperable broadband communications among Canadian public safety entities and with international agencies during joint operations, such as with the US Department of Homeland Security, provided that technology and spectrum are aligned between Canada and the US. It would enable the goals of Canada's National Strategy for Communications Interoperability[*].

The demands placed on a mobile broadband data communications network by the public safety community depends strongly on the nature of the missions it executes and the applications it uses during those missions. Situational Awareness (SA) and the ability to coordinate broadly and effectively in improvised circumstances are fundamental capabilities in order to execute a mission in the safest and most expedient manner possible. Whereas, currently, voice communications via Land Mobile Radio (LMR) is the most commonly used method to coordinate and establish SA, it is expected that tactical video, will play an increasingly important role to enhance SA, while LMR will remain the key voice communications tool for the foreseeable future.

Mobile broadband data services will give rise to new applications and innovative uses for data communications by the public safety community. It is envisaged that access to a mobile broadband network will extend to a user-group that is peripheral to first responders and those that occupy supporting roles. As such, the data demands will be driven by the use of new tools, new users, and new applications which, in turn, will foster greater reliance by first responders on the tools and supporting community in the response to incidents.

The goal of this study is to determine how much spectrum is required to meet the needs of the Canadian public safety community for mobile broadband wireless data communications within a 20-year time frame. The results of this study and its conclusions are derived from the correlation of the community's data demands and the capacity of 4th Generation wireless technology to support the applications that first responders intend to use. Fundamental assumptions are validated and inputs are obtained via an interactive process with active participation from public safety stakeholders and federal government researchers. The methods, assumptions, and results are benchmarked against similar studies that have been performed in the USA. [1, 3, 21]

[*] http://www.publicsafety.gc.ca/prg/em/cisapc-scicpa-eng.aspx

1.1 The 700MHz band

The channelization of the Canadian 700MHz band is under study by Industry Canada and so the US 700MHz spectrum allocation is shown here for reference. Figure 1.1 illustrates the US channelization plan for the 700MHz spectrum. Note that Band-14 (circled) spans 10MHz in the down-link (758MHz – 768MHz) and 10MHz in the up-link (788MHz – 798MHz). If the FCC and US Congress allocate the D Block to public safety then that would represent 2x10MHz of spectrum. In this report references to 10MHz LTE pertain to either the up-link or down-link channel bandwidth. When referring to both the up-link and down-link channel bandwidths then it is stated as 10+10MHz or 20MHz.

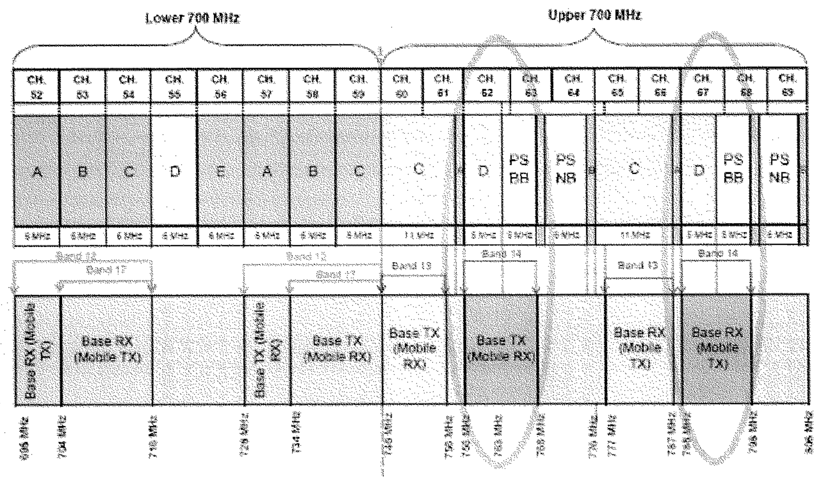


Figure 1.1: US channelization plan for 700MHz spectrum

2 Methodology

The bandwidth required to support public safety operations is based on a number of factors, of which the two most important ones are:

a) Usage in terms of data demand

   The data demand, expressed in bits per second, is defined by the sum of the Up-link and Down-link data rates required to sustain the various applications needed to support public safety's data communications needs in day-to-day operations and when responding to emergency situations.

b) Network infrastructure

   The amount of bandwidth required to carry the data demand is based on the network infrastructure selected, the communications protocol, and the network architecture.

In this Chapter, the methodology used to define both the data usage and the bandwidth, based on the infrastructure is discussed. The data demand is derived and quantified in §3.

2.1 Usage

The process to establish the data demand is illustrated in Figure 2.1. It involves public safety stakeholders to define how they would use a mobile broadband network and what applications they would make use of. The demand is evaluated for day-to-day operations and for three incident scenario case studies, which represent recurring emergency situations typically encountered by public safety agencies. The case studies are described in §3.1. The Model includes a demand growth factor to account for applications which the stakeholders did not identify or, at the time of the survey, could not predict using in the future.

Once the data demand model was established, another round of feedback was undertaken to validate the assumptions. The Data Demand Model was also reviewed and validated as a sound technical approach with Canadian Government scientists.

Several sources were used to determine the application data rates. These are discussed in more detail in §3.3.1.

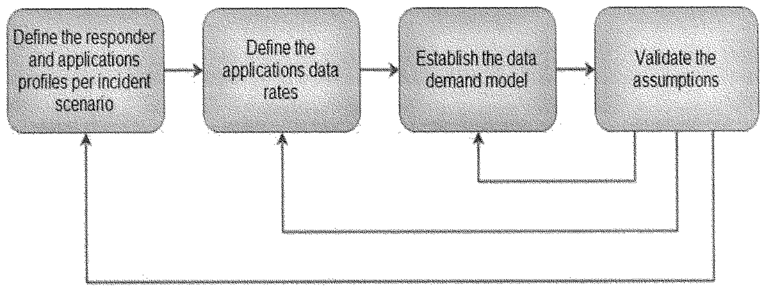


Figure 2.1: Process to develop the Data Demand Model

2.2 Network Infrastructure

The Capacity Model is based on the capabilities of Long Term Evolution (LTE). LTE is the latest generation of mobile broadband technology being deployed by commercial carriers around the world for their 3.9G networks with a migration path to LTE-Advanced (4G). Figure 2.2 illustrates the actual and announced deployments of LTE globally. A large uptake of this technology is expected to drive cost down and provide more incentives for the development of new features and capabilities. In addition, the US Federal Communications Commission (FCC) has recently mandated that public safety broadband networks must use LTE. Canadian public safety can leverage the economies of scale driven by the commercial carriers and be interoperable with US public safety organizations by selecting LTE as the network infrastructure technology for public safety in Canada.

LTE is currently being deployed commercially at Rel.8 and in pilot stages for a small number of public safety agencies in the US. The 3GPP organization is currently defining Rel.9, 10, and 11. Each successive release introduces new capabilities and especially, improved spectral efficiencies. This is discussed in §4.2.

The Capacity Model and related assumptions were also reviewed in detail with Canadian Government scientists having expertise in the wireless communications domain and the approach was judged to be technically valid and appropriate for the purposes of this study.

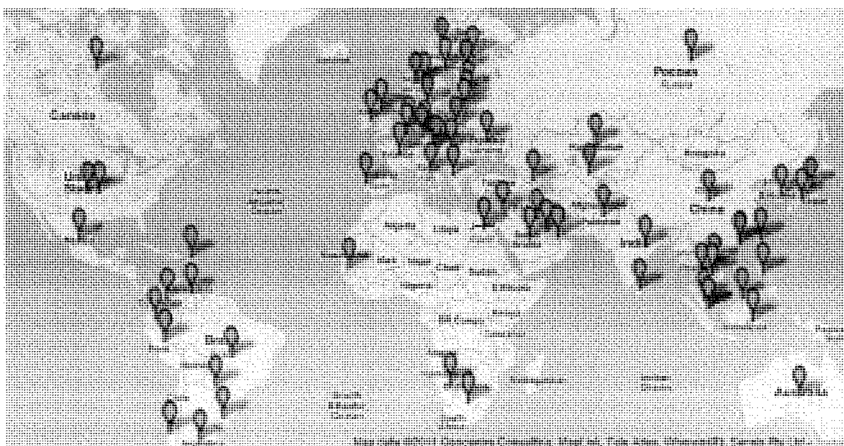


Figure 2.2: Locations with actual LTE deployments (blue markers) and announced deployments (red markers) [*]

[*] www.ltemaps.org

3 Demand for mobile data communications

The need for responders to communicate and access information is felt most acutely during the response to an incident. During these events the mobile broadband network will see the greatest demand for data throughput. Figure 3.1 illustrates that an incident is a localized event and so, unlike day-to-day operations where the data demand is spread over a territory that spans multiple cell sites, an emergency event will drive data demand from within a small geographic area.

Although an incident may arise anywhere on land or on water across the entire Canadian territory, this study focuses on the data demands from public safety agencies in a mid-to-large size urban setting. It is assumed that the deployment of a mobile broadband network will launch in urban centers first before expanding to sub-urban and, eventually rural areas. Urban centers will have the greatest density of users and greatest number of recurring events requiring the intervention of public safety and security forces.

It is important that sufficient capacity be available during an emergency event, as well as suitable congestion management policies to effectively deal with peaks in demand that exceed the instantaneous available capacity. The assertion of congestion management mechanisms must not impede the ability of the responders to execute their mission during the events.

In this section the foundation of the Data Demand Model (DDM) will be described. It considers the demand for data communications during an emergency event overlaid on the data demands of day-to-day operations.

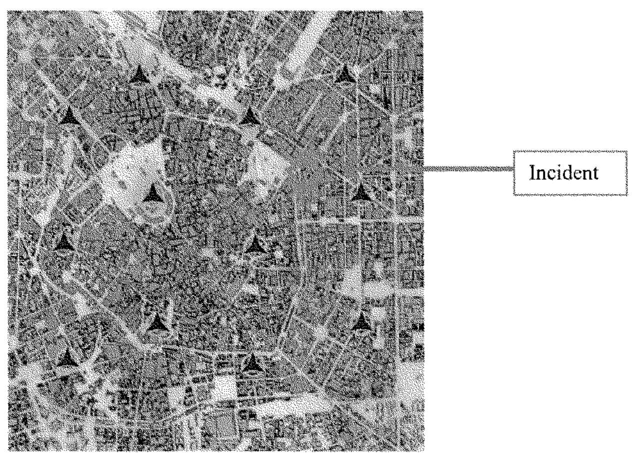


Figure 3.1: Illustration of a localized incident in a multi-cell network deployment.

3.1 Incident scenarios

In consultation with first responder stakeholders and in alignment with similar assessments recently performed in the US, the estimate of the data demands were based on common occurrences and predictable incidents. Three hypothetical, but plausible scenarios have been identified to serve as case studies. These case studies represent events that public safety agencies expect to encounter and for which Standard Operating Procedures (SOP) have been formulated. They are:

- Chemical Plant Explosion and Fire
- A Severe Multi-Vehicle Accident
- Sports Event Riot

A number of representatives of the public safety community from across Canada contributed to defining the nature of the response to each scenario in terms of the number and types of responders and support agencies, and what applications the stakeholders would use during each event. Below are descriptions of the incident scenarios that were used as case studies.

Catastrophic incidents such as a major earthquake or a major terrorist attack are not modelled in this study since the magnitude of the response at that time would overwhelm any mobile data network dimensioned for more routine events such as those which are considered here. Other measures would be required such as diverting or extending capacity from surviving commercial networks.

3.1.1 Chemical Plant Explosion

This case study was adapted from a scenario developed by the Wireless Innovation Forum – Public Safety Special Interest Group* and is based on a hypothetical scenario of a chemical plant explosion, with events drawn from a number of sources including the chemical plant explosion scenario developed as part of the US DHS SAFECOM Public Safety Communications Statement of Requirements/TR-8 Broadband Task Group, and analysis of actual events of the fire at a hazardous waste transfer plant in Apex, NC, in October 2006. This scenario is relevant to other types of incidents such as an explosion at a refinery.

Narrative

A large explosion occurs at a 75,000 sq.ft chemical plant in the industrial area of a mid-sized city. The blast shatters windows of buildings in the immediate vicinity. There are a significant number of casualties both from within the chemical plant and outside. Multiple sensors detect and report the incident to the 911PSAP. Within minutes the 911PSAP is also flooded with calls from motorists, pedestrians, and residents. Soon, commercial cellular networks become overloaded.

Air quality sensors around the area detect hazardous substances emanating from the site of the accident. The wind speed and direction reported from environmental monitoring stations indicate that the chemical plume will drift over a residential area with an elementary school, a high school, a library, a hospital, and numerous retail businesses. As it drifts over roads and highways car accidents ensue and some motorists abandon their cars to escape the plume on foot.

Debris expelled by the explosion damages a nearby electrical sub-station, causing a localized power failure.

* http://www.wirelessinnovation.org

First responders report that a type of liquid is escaping from the chemical plant and flowing into the on-site retention basins. However, the condition of the basins is unknown.

3.1.2 Severe Multi-Vehicle Accident

This case study is based on serious accidents that are likely to occur for any of a number of reasons, such as poor weather, driver fatigue, mechanical failure, etc… This scenario is also relevant for a train derailment, aircraft emergency landing, and other similar situations.

Narrative

It's early winter and the temperature is rising from many days below freezing to settle just around the freezing mark with precipitation turning to ice pellets. Icy patches form on a highway running through a major urban centre and a foggy mist reduces visibility.

The flow of traffic on the icy highway in front of a semi-trailer comes to a rapid halt and the driver realizes he is unable to stop in time to avoid colliding with the cars in front. He attempts to swerve but his tractor regains traction while the trailer does not. The rig jack-knifes and flips over the median finally, landing onto its side on the opposing lanes. Vehicles immediately following the tractor/trailer are unable to stop and collide with it. Others, while swerving to avoid it cause accidents in their adjacent lanes. A similar scene is playing out on the opposite side and an oil tanker is also involved. It has also ended up on it side. Oil is leaking but no fire has started. The trailer has a hazardous products sign on the rear door.

Drivers are injured and some of them are trapped in their vehicles. Other drivers fearing that a fire will start, abandon their vehicles on both sides of the highway and run along the highway's shoulders.

All traffic stops on both sides of the highway.

3.1.3 Sports Event Riot

This case study is based on a riot that arises from a victory celebration of a local sports team. Although the premise is a sports event, the scenario is also relevant for any large event that attracts crowds and protesters with the potential for violence.

Narrative

It's mid-June and we're in overtime of game 7 of the Stanley Cup finals when the unimaginable happens at Maple Leaf Gardens – the home team scores an incredibly fluky goal. After a seemingly interminable moment, stunned audiences explode with joy. Crowds empty into the streets from the Garden, bars, cafes, and homes from all areas of the city. Soon many streets are clogged with people and the downtown core becomes a grid-locked parking lot.

Emotions rise and without notice the celebration turns ugly. Gangs begin to break store-front windows. Looting ensues. Cars are set alight. Riots break out spontaneously in various parts of the downtown core and the rioters quickly move from one area to another. They twitter to help coordinate their movements.

A number of people are injured by flying debris and others are trampled by surging crowds in tight quarters. Some riot police officers and rioters are also injured.

3.2 Day-to-day operations

In addition to demands for data during incidents, mobile data communications plays a vital role during the day-to-day operations for public safety and security, and other municipal and government agencies. It is conceivable that in urban environments these agencies would share a single mobile broadband data network. Some examples of day-to-day operations are:

- Issuing traffic citations
- Fire-fighting
- Health emergencies
- Patrols
- Incident reporting
- Database querying and records look-up
- Work-site inspections
- Maintenance and waste management services
- Public transit
- Utilities: meter reading, service upgrades or restoration

Incidents, when they arise, do not displace day-to-day operations. Incidents occur while day-to-day operations continue.

Table 3.1 illustrates the profiles for the three incident scenario case studies of §3.1 and for Day-to-Day Operations in terms of the number and types of assets that are assigned to each situation. For the purpose of quantifying the number of devices that generate or consume data, this study defines "assets" as vehicles and assumes that data communications devices are detachable so they can be vehicle-borne or person-borne.

3.3 Applications

In a poll conducted among representatives of the Canadian public safety community (municipal police forces, RCMP, Fire Services, Emergency Medical Services, Provincial Emergency Management, and National Search and Rescue), the participants indicated which applications they were likely to use across a mobile broadband data service. The City of New York, in its analysis of 700MHz spectrum requirements, identified a similar set of applications[3]. The candidate applications are listed in Table 3.2. They are broadly categorized as:

- Video Applications
- Collaborative tools
- Monitoring
- Database access and records upload
- Messaging

The same representatives also identified the main applications they were likely to use during emergencies. The results are shown in Table 3.3.

Assets	Chemical Plant	Multi-Vehicle Accident	Sports Event Riot	Day-to-Day Operations
Mobile Command Posts				
Fire Services	1	0	0	
EMS	2	0	1	
Police	1	1	1	
Fire chiefs and commanders				
Division	1	0	0	
Platoon	2	1	0	
Department	1	1	0	
District	3	2	0	5
Deputy Chief	1	0	0	
Safety officer	1	1	0	
Fire-fighting vehicles				
pumper trucks	8	3	0	15
ladder trucks	3	1	0	5
Specialized Fire Services Units				
Rehab unit	1	0	0	
Rapid intervention unit	2	1	0	
Rescue unit	2	1	0	
Air mgmt	1	0	0	
Hazmat	4	3	0	
Public safety trained security officers	0	0	4	
Public safety apparatus	0	0	6	
Portable sensors	12	0	12	
Medical/paramedical				
1st Responder Units	12	6	10	20
Bike Medics	0	0	8	8
Ambulances	30	15	15	110
Specialized and supervisory EMS Units				
Emergency Task Force	2	2	6	2
Buses	1	1	1	1
Trucks	1	1	1	1
Supervisors	6	4		12
Public Order units	0	0	6	0
Police patrol units and vans				
Cruisers	15	10	80	420
Vans	2	2	10	33
Inspectors	0	2	8	1
License Plate Readers	0	0	0	30
Utilities, municipal services, govt civil agencies				
Electrical	2	0	0	50
Gas	2	0	0	30
Buses	2	1	5	1000
Public Works	3	1	4	200
Judicial Services	0	0	1	0
Transport ministry	0	1	0	20
Environment ministry	1	1	0	20

Table 3.1: Response profiles for three incident scenarios case studies and Day-to-Day Operations

Video applications	Database access and records upload
Surveillance video	GIS information
Tactical video	still images
Ambulance patient video	Building plans and information
Public Transit video	Hazmat inventory
Video conferencing	medical records
News feeds	NG911 video file
	Weather information
Collaborative tools	internet access
Electronic Command Board	Patient triage
Computer-Aided Dispatch	Traffic advisories
Records Management System	e-Ticketing
	Vehicle Registration
Monitoring	Biometric data
Automated Vehicle Locating	License Plate Reader
Blue Force Tracking	
Vital signs monitoring	Messaging
Automotive telemetry	SMS
Tracking evacuees	MMS
	email

Table 3.2: Broadband data applications

	Surveillance video (ext)	Tactical Video	Patient video	Public Transit Video	Video conference	News feeds	Collaborative tools	Database access	Messaging	Monitoring
Mobile Command Posts	RCV	XMT-RCV		RCV	XMT-RCV	RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
Fire Services										
EMS										
Police										
Fire chiefs and commanders	RCV	RCV			XMT-RCV	RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
Division										
Platoon										
Department										
District										
Deputy Chief										
Safety officer										
Fire-fighting vehicles	RCV	XMT-RCV				RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
pumper trucks										
ladder trucks										
Specialized Fire Services Units	RCV	RCV				RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
Rehab unit										
Rapid intervention unit										
Rescue unit										
Air mgmt										
Hazmat										
Public safety trained security officers										
Public safety apparatus										
Portable sensors										XMT
Medical/paramedical	RCV	RCV				RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
1st Responder Units										
Bike Medics										
Ambulances	RCV	RCV	XMT		XMT-RCV	RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
Specialized and supervisory EMS Units	RCV	RCV				RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
Emergency Task Force										
Buses										
Trucks										
Supervisors										
Public Order units										
Police patrol units and vans	RCV	XMT-RCV		RCV	XMT-RCV	RCV	XMT-RCV	XMT-RCV	XMT-RCV	XMT
Cruisers										
Vans										
Inspectors										
License Plate Readers										
Utilities, municipal services, govt civil agencies				XMT				XMT-RCV	XMT-RCV	XMT
Electrical										
Gas										
Buses										
Public Works										
Judicial Services										
Transport ministry										
Environment ministry										

Table 3.3: Association of broadband data applications to public safety assets and direction of data flow.

3.3.1 Applications performance requirements

Table 3.4 lists the data rates used in the Data Demand Model. They are separated into UL and DL directions since the LTE spectral efficiencies are different for UL and DL.

	Datarates (kbps)		
Video applications	DL	UL	
Surveillance video HR	1536	0	streamed to Users on demand
Surveillance video LR	64	0	streamed to Users on demand
Tactical video LR	64	64	distribution of tactical video for composite view; constant streaming
Tactical video HR (monitor)	1152	1152	Viewing video imagery on monitors; per selected feed.
Ambulance patient video (LR)	0	64	distribution of patient video for composite view; constant streaming
Ambulance patient video (HR)	0	768	Viewing video imagery on monitors; per selected feed.
Public Transit video (LR)	64	64	distribution of public transit video for composite view; constant streaming
Public Transit video (HR)	384	384	Viewing video imagery on laptops; per selected feed.
Video conferencing	384	384	per User
News feeds	768	0	streamed to Users on demand.
Collaborative tools	50	50	average data rates per user.
Emergency Management System			
Computer-Aided Dispatch			
Records Management System			
Database access and records upload	50	20	average data rates per user.
GIS information			
still images			
Building plans and information			
Hazmat inventory			
medical records			
NG911 video file (pre-recorded)			
Weather information			
internet access			
Patient triage			
Traffic advisories			
e-Ticketing			
Vehicle Registration			
Biometric data			
License Plate Reader	50	256	
Messaging	40	20	average data rates per user.
SMS			
MMS			
email			
Monitoring	30	60	occurs in the background and is assumed to be a constant rate
Automated Vehicle Locating	5	10	
Blue Force Tracking	5	10	
Vital signs monitoring	5	10	
Automotive telemetry	5	10	
Tracking evacuees	5	10	
CBRNE sensors	5	10	

Table 3.4: Applications data rates (kbps).

The following are the different types of video traffic used in the model:

a) Surveillance video HR: scaled from the Incident Video High Resolution (HR) because of the wider angle scene captured by fixed surveillance cameras. Capable of full-motion 30fps.

b) Incident video HR: based on empirical data used in the report by the City of New York to the FCC. [3]

c) Ambulance Patient Video HR: near-field scene capture.

d) Public Transit video HR: mid-level frame rate 15fps, near-field scene capture

e) Video conferencing: near-field scene, mid-level frame rate15fps.

f) News Feeds HR: lower resolution than surveillance or incident video. Full-motion.

g) LR video (Surveillance, Incident, Patient, and Public transit): low-rate transmission of un-viewed video streams. See §3.3.2.1 for further discussion on dual-rate video.

The US National Telecommunications and Information Administration's (NTIA) recommended minimum data rate for tactical video for Standard Definition viewing is 768 kbps for H.264, also known as MPEG-4 Part 10, or AVC (advanced video compression). [4]

3.3.2 Video traffic management

Video applications represent the largest consumer of capacity on a broadband network. As such, management of this application merits particular attention. In this section we will discuss various approaches to make more efficient use of video applications. The techniques described in the following sections will be used in the Data Demand Model to minimize the bandwidth required by the various video applications.

3.3.2.1 Dual Rate Video

As discussed in §3.3.1 the data rate requirement for video depends on the intended use. For example, a high resolution video would be required to view a wide-angle scene on a monitor and be able to distinguish relatively fine details but a much lower resolution video would be needed for simple traffic monitoring,. Figure 3.2, shows a typical picture of a traffic surveillance camera. In order to read license plates from this scene a much higher resolution stream would be required.

However, it is highly unlikely that video captured at high resolution would be needed continuously for its details. Therefore, in order to limit bandwidth, we include in the Data Demand Model a component for dual-rate video, where the lowest data rate is set to 64Kbps and the maximum rate is as given in Table 3.4 for the different types of video. Dual-rate video is a variation of Adaptive Rate Video currently used by Apple, Adobe, and Microsoft, albeit each with their proprietary algorithms[5]. Although video is sampled at the highest rate possible at the source, it is transmitted at low resolution (LoRes) if it's not viewed.

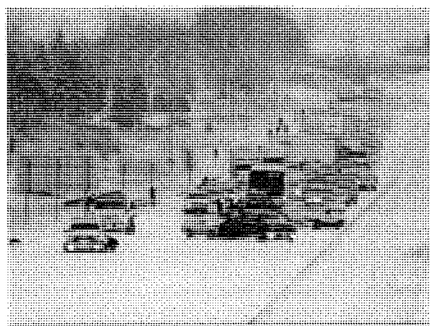
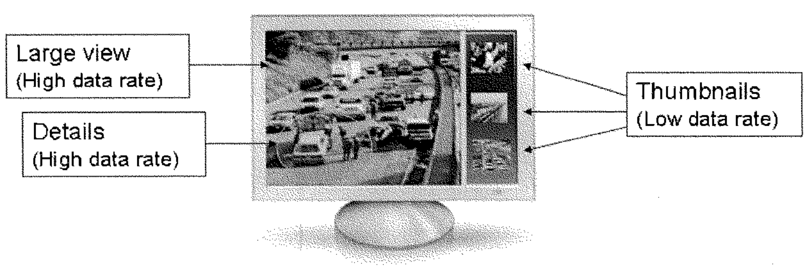


Figure 3.2: Scene captured from a surveillance camera.

Figure 3.3 illustrates one video stream being viewed, thereby sent at high resolution (HiRes), and three video streams displayed as "thumbnails" which are not actively viewed. The latter are carried across the broadband data network at 64Kbps. In this example if a viewer selects from one of the thumbnail scenes, the selected scene would switch to HiRes mode and the previously viewed one would become a thumbnail and revert to LoRes mode.

Figure 3.3: Illustration of one actively viewed video stream and three "thumbnail" streams



In Figure 3.4 sources V1 and V4 are displayed as thumbnails on viewers M1-M4 only. As such their uplink data rates are 64Kbps, whereas V2 and V3 are viewed in expanded mode so they are uplinked at the HiRes data rates.

The DDM applies a video de-rating factor (VDF_{HiRes}) to the average HiRes video data rate, which takes into account the number of sources of video (VS) and the number of authorized viewing instances (VI). VDF_{HiRes} is expressed in Eq.(1):

$$VDF_{HiRes} = 1 - [(VS - 1)/VS]^{VI} \quad (1)$$

3.3.2.2 Video management policy

Another way to manage video traffic is to limit the number of video sources admitted into the pool of viewable feeds and to limit the number of authorized viewers. This is a policy matter that requires an Operations Support System (OSS) to be able to assign higher priority to some video sources over other sources. For example, in the case study of the Chemical Plant Explosion, video feeds from police cruisers that are re-directing traffic around the affected area may be assigned lower priority than video feeds from fire-fighters.

The OSS would need to permit ad hoc adaptation of the policy to react to evolving circumstances. Following from the previous example, police video feeds may have a higher priority while they are on-route to the incident site and then be assigned a lower priority when the fire-fighters arrive.

The DDM includes a second bandwidth-preserving component by limiting the number of viewable HiRes and LoRes video feeds at any one time. Table 3.5 outlines the video management policy as implemented in the DDM.

Table 3.5: Video Management Policy

	Emergency Operations Centre	Incident Command Vehicles	Authorized First Responders *
Max simultaneous HiRes views	8	2 (each)	1 (each)
Max simultaneous LoRes thumbnails	no limit	10 (each)	3 (each)
Max number of simultaneous video conferencing participants	4	4	4

* not all First Responders would be authorized or equipped to access video feeds. It would be specific to the incident.

3.3.2.3 Multimedia Broadcast Multicast Service

Multimedia Broadcast Multicast Service (MBMS) over an LTE wireless network allows the same video stream to be viewed simultaneously by multiple subscribers with only minimal overhead penalty. One stream consumes capacity in the down-link direction irrespective of the number of simultaneous viewings. [6]

Figure 3.3 illustrates the function of MBMS through an example of 2 downlink users, M1 and M3, viewing the same scene from V2. Only one feed is streamed in the downlink direction to serve 2 simultaneous viewers.

When there are more viewers than sources of video, MBMS can be treated as a gain which reduces the amount of downlink traffic. MBMS Gain is calculated according to Eq. 2.

$$\text{MBMS Gain} = \frac{[\#\text{ of viewers}] \times [1 - \text{MBMS overhead}]}{[\#\text{ of video sources}]} \tag{2}$$

where MBMS overhead is 10%.

If the number of sources exceeds the number of viewers, then MBMS gain is set to 1 and MBMS overhead is 0.

MBMS was released by the 3rd Generation Partnership Project * (3GPP) as part of Rel.6 (High Speed Uplink Packet Access – HSUPA) in Dec.2004 and further updated in 2009. LTE Rel.9 includes E-MBMS (Enhanced MBMS), which supports multi-cell reception for improved spectral efficiency at cell-edge.

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* www.3gpp.org

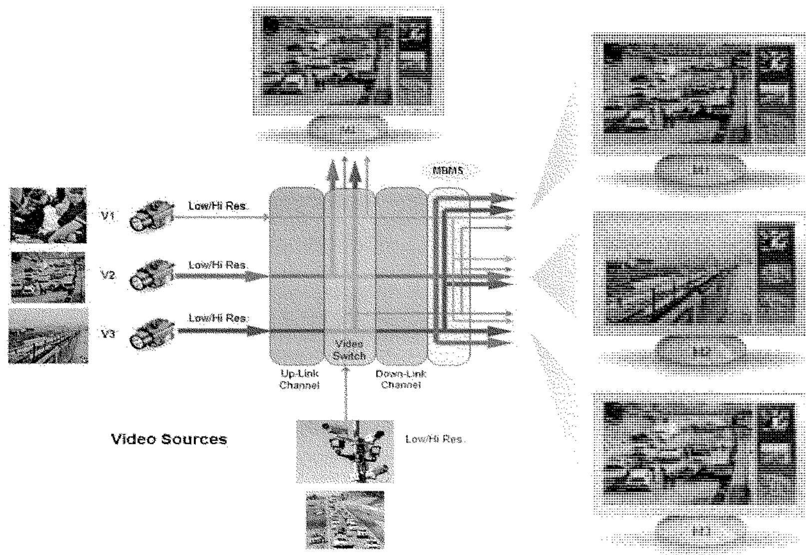

Figure 3.4: Illustration of MBMS function.

3.4 Growth Projections

The global demand for mobile broadband data is experiencing exponential growth in the commercial space fueled primarily by the continued deployment of laptop and netbook computers, and smartphones. Figure 3.5 illustrates the forecasted global demand for mobile broadband data.

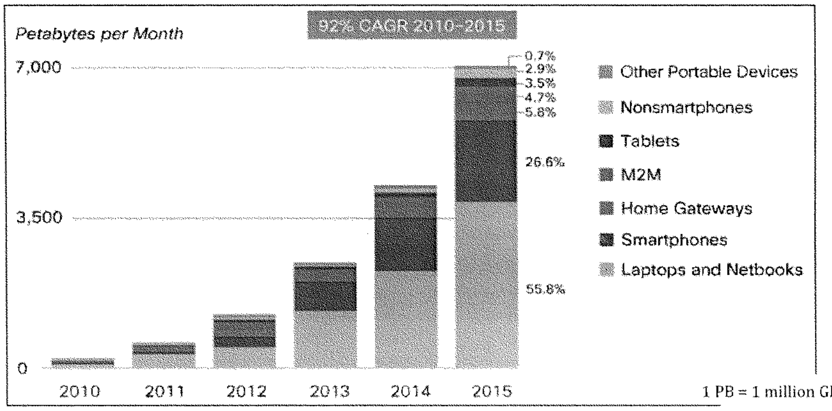

Figure 3.5: Forecasted global demand for mobile broadband data [7].

It is unlikely that public safety's demand for mobile broadband data will experience the same exponential growth, in part because the amount of spectrum allocated for public safety is less than what is allocated for commercial users. Nonetheless, there are growth drivers that will affect public safety's demand for mobile data. For example:

- Adoption rate among public safety agencies of devices which allow access to a mobile broadband network. In a given city, region, or territory the rate at which responders will be equipped with the capability to access a broadband network will be strongly affected by budgets allocated for this purpose.
- Introduction of new applications and tools that have not yet been identified in Table 3.2. Innovative new applications and tools that increase safety, improve the way missions are executed, and increase cost effectiveness are highly desirable. It is foreseeable that public safety agencies will adopt new applications and tools over time as they are vetted for stability, as SOPs are created and validated, and as budgets permit. New applications and tools are expected to increase the data throughput requirements.
- Organic growth of the public safety community in line with the growth of the general population.

The DDM has a growth component in the model to account for the contributing elements above as summarized below.

a) Rate at which public safety agencies will equip their staff with capabilities to access a broadband wireless network: **40% of responders equipped at YR-1 followed by 10% per year incremental growth.**

b) Rate of growth of data throughput required by new applications and tools: **5% per year.** It is assumed that the applications of Table 3.2 will be deployed in the 1st three years and that new applications would be introduced starting in Year-4

c) Organic growth rate of public safety personnel and assets: **3% per year.**

3.5 Data Demand Model (DDM)

The demand model uses the following elements:

a) The number and mix of responders that converge onto typical incidents. Table 3.1.

b) Applications that public safety will likely use with a mobile broadband network. Table 3.2.

c) How the applications are used and by whom. Table 3.3.

d) Applications data rates. Table 3.4.

e) Video Management Policy. Table 3.5.

f) Multimedia Broadcast Multicast Services (MBMS) DL gain.

g) Growth projections according to §3.4

3.5.1 Variables

In addition to the above factors, the DDM uses a number of variables. These are listed below in Table 3.6.

The Statistical Gain (SG) is also referred to as over-booking factor and accounts for the fact that not all Users are accessing data at the same time, thus the sum of the Users' data rates is divided by the SG. The City of New York report states that during an incident, first responders make more intense use of the communication tools and, therefore, use SG = 4, compared to SG = 20 during normal operations.

Typically, SG is a static value that network engineers assign to their dimensioning models. The thesis cited as a reference here proposes an approach whereby SG could be specific to the application[8]. So, some applications would have different SG than others. As shown in Table 3.6, the DDM uses different values of SG, which are:

- SG = 4 for streaming video and interactive applications,
- SG = 10 for video conferencing,
- SG = 1 for monitoring applications.

Table 3.6: List of Variables used in the Data Demand Model.

Video management policy	Incident scenarios	Day-to-Day Operations
Number of simultaneous HR feeds that can be viewed at EOC	8	8
Number of simultaneous LR feeds that can be viewed at EOC	balance of feeds	
Number of simultaneous HR feeds that can be viewed at MCV	2	2
Number of simultaneous LR feeds that can be viewed at MCV	10	10
Number of simultaneous HR feeds that can be viewed by selected 1st Responders	1	1
Number of simultaneous LR feeds that can be viewed by selected 1st Responders	3	3
Number of simultaneous video conferencing participants	4	4
Number of Patient Videos that can be viewed simultaneously at med.ctr.	4	40
Number of fixed Surveillance video cameras (not backhauled with LTE)	4	100
Number of live News feeds	1	6
Multicast Broadcast Multimedia Services (MBMS) overhead	10%	10%
Statistical Gain		
streaming video	4	20
video conferencing	10	20
interactive applications	4	20
background polling application	1	1
Growth variables		
Penetration rate for mobile broadband services (per year)	10%	10%
Growth of the user community - assets and people (per year)	0%	3%
Introduction of new and as-yet uknown applications and devices (annually, after year-3)	5%	5%
Area of Operations		
size of the territory (sq km)		630
radius of a cell (km)		2
number of sectors in a cell		3

EOC means Emergency Operations Centre.
MCV means Mobile Command Vehicle.

3.5.2 Growth Rate

The growth rate of the data demand is assumed to be 5% per year, compounded annually. This is the same value that is used in the City of New York report, which the authors state as being conservative. In §4 the aspect of error in the estimates will be discussed. The actual increase in demand that will be experienced depends on many variables. Some examples:

- Public safety is currently not using some applications due to limited BW availability. When a broadband network is in place, the experience may be higher than what is assumed in this model.

- New tools will appear that will support different types of responses to incidents or day-to-day use. This could increase the data demands of the response profile in the future.

- Lessons-learned from the response to incidents will lead to changes in Standard Operating Procedures, which could have an impact on how tools and applications are used, which ones are used, at what time, and to what degree of intensity.

The model also assumes that a policy is in place to manage the use of incident video and the consumption of video feeds, in general. Video is the application which demands the most bandwidth and, as such, a video management policy would limit the amount of video transmitted on the wireless network.

The Model does not account for improvement in efficiencies for various applications. For example, video coding has migrated from MPEG-2 to MPEG-4, which essentially improved the coding efficiency by 50%. But, a counter-balancing assumption is that software applications become more complex and less efficient in their performance.

3.6 Data Demand profile

Figure 3.6 shows the DL, UL, and aggregate data demand for the 3 incident scenarios added to day-to-day operations, including the effects of compounded growth in demand.

From YR-1 to YR-10, the growth in demand is dominated by the 10-year capital investment plan to equip public safety. Each year 10% of the user group is equipped, culminating in 100% of the users being equipped in YR-10. From YR-11 to YR-20, the growth in demand is driven by the growth factors discussed in §3.4.

The projected growth of data demand for public safety is in sharp contrast with the projected growth for the commercial segment, as seen in Figure 3.5. Whereas the commercial growth follows an exponential trend, the growth for public safety demand follows a quasi-logarithmic trend. The projected growth in commercial demand fuels a vigorous research environment into methods to be able to cope with the expected demand. This will be discussed further in §4.

Another assumption is that the capital investment to equip public safety with the tools and applications that are considered in this study is made incrementally over a 10-year period, with 1/10th of the investment made each year. The responder profiles and applications in Tables 3.1, 3.2, and 3.3 are for a fully equipped responder community, which corresponds to YR-10 in Figure 3.6.

The responder profiles for each incident case study and application data rates have a strong influence on the demand. The incidents that were selected as case studies could have been different, which would have resulted in higher data demands.

For comparison purposes the City of New York published a demand growth profile and is highlighted in Figure 3.7. Note the inflection in the slope, which indicates that the growth in demand slows down after the inflection point, around year-8.

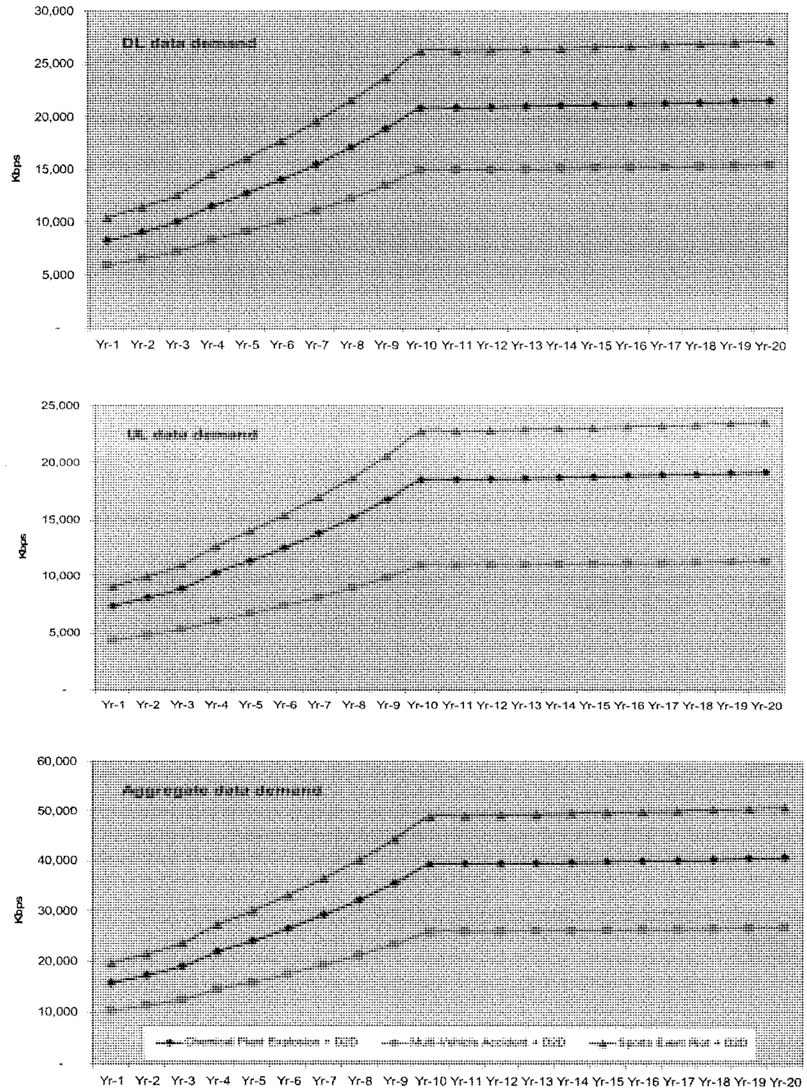

Figure 3.6: Data demand profiles for DL, UL, and Aggregate, including growth effects and day-to-day operations.

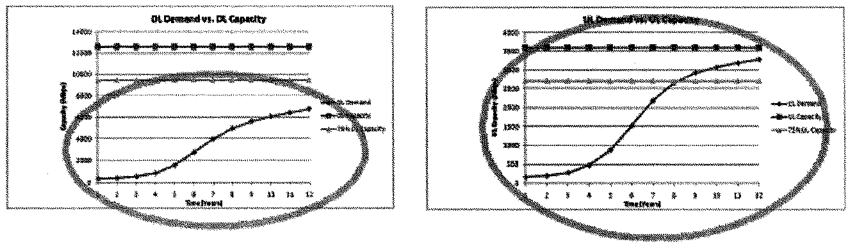

Figure 3.7: Data demand growth profile as reported by the City of New York [3]

4 Capacity model

The Capacity Model establishes how much data can be transported over an LTE system. The model treats Up-Link and Down-Link directions separately since LTE spectral efficiency is asymmetric. The 3GPP has released specifications for Rel.8 and 9, and there is on-going work to define the specifications for Rel.10 and 11. There is also substantial research activity at university and industry levels on ways to improve efficiencies. New features for LTE will one day be implemented and the benefits will be realized, perhaps not to the same extent as predicted, but we can reasonably expect the capacity to increase as the vendor community transforms the research into commercially viable products.

Some technologies, currently under development or the subject of research, were examined for their potential to increase spectral efficiency. Based on these, a hypothetical technology roadmap was established in order to quantify spectral efficiency improvements in the Capacity Model. The various technologies that were examined are described in §4.3.

In §4.4 are the basic assumptions that are considered in the Capacity Model.

4.1 Long Term Evolution (LTE)

Long Term Evolution is the latest standard for mobile wireless access from the same industry group that developed the specifications for GSM and UMTS/HSPA, namely 3GPP. LTE improves upon the performance of previous generations of wireless systems in terms of increased capacity, reduced latency, and support for multimedia applications. Its current release, Rel.8, is referred to as 3.9G. LTE-Advanced (Rel.10) with even superior performance is intended as the first release to cross the threshold into 4G. Some of the key specifications are:

- Peak downlink data rates: 326 Mbps (4x4 MIMO [1]); 173 Mbps (2x2 MIMO) in 20 MHz bandwidth.
- Peak uplink data rates: 86 Mbps with a single transmit antenna in 20 MHz bandwidth.
- Latency: 5ms or less.
- Backwards compatible with: GSM, CDMA-One, UMTS, and CDMA2000
- Able to operate in Frequency Division Duplex (FDD) and Time Division Duplex (TDD) modes.
- Able to operate in carrier bandwidths of 1.4MHz, 3MHz, 5MHz, 10MHz, and 20MHz.
- Frequency bands: as shown in Table 4.1 for FDD and Table 4.2 for TDD[*]

[*] TDD approved in Europe, China, India, Japan, Malaysia, Australia.

Table 4.1: LTE frequency bands for FDD

LTE BAND NUMBER	UPLINK (MHZ)	DOWNLINK (MHZ)
1	1920 - 1980	2110 - 2170
2	1850 - 1910	1930 - 1990
3	1710 - 1785	1805 -1880
4	1710 - 1755	2110 - 2155
5	824 - 849	869 - 894
6	830 - 840	875 - 885
7	2500 - 2570	2620 - 2690
8	880 - 915	925 - 960
9	1749.9 - 1784.9	1844.9 - 1879.9
10	1710 - 1770	2110 - 2170
11	1427.9 - 1452.9	1475.9 - 1500.9
12	698 - 716	728 - 746
13	777 - 787	746 - 756
14	788 - 798	758 - 768
17	704 - 716	734 - 746
18	815 - 830	860 - 875
19	830 - 845	875 - 890
20	832 - 862	791 - 821
21	1447.9 - 1462.9	1495.5 - 1510.9
22	3410 - 3500	3510 - 3600

Table 4.2: LTE frequency bands for TDD

LTE BAND NUMBER	ALLOCATION (MHZ)
33	1900 - 1920
34	2010 - 2025
34	2010 - 2025
35	1850 - 1910
36	1930 - 1990
37	1910 - 1930
38	2570 - 2620
39	1880 - 1920
40	2300 - 2400
41	3400 - 3600

4.2 The concept of Spectral efficiency

Spectral Efficiency (SE) is a measure of how much information can be carried in a transmission bandwidth normalized to 1Hz, expressed in bps/Hz. It is the key parameter by which to determine the capacity of a wireless network. SE is a function of the signal to noise ratio (SNR) because a higher SNR allows the signal component to occupy more states and thus carry more information. Figure 4.1(a,b) illustrates a sample constellation of signal states for 16QAM and 64QAM modulation. 64QAM can transport 50% more information than 16QAM, but due to the higher density of signal states, 64QAM requires a higher SNR than 16QAM. This is why User Element (UE) which are closer to the base station can support a higher data rate. Since SNR is lower at greater distances from the transmitter, UEs which are at the cell edge have lower data rates.

Spectral Efficiency is also affected by interference. Similarly to noise, interference reduces the space between signal states and leads to a higher probability of incorrectly detecting the instantaneous state of the received signal. In cellular networks interference is a major impairment to spectral efficiency and is the subject of significant research for ways to mitigate its negative effects on SE. However, the effort to improve SE by increasing SNR delivers correspondingly fewer gains relative to the increases in SNR since SE has a logarithmic relation to SNR. Claude Shannon in his seminal paper on the Theory of Communications [1] postulated the mathematical relationship between channel capacity and SNR. His theory is illustrated in the graph of Figure 4.2. SNR is expressed as Eb/No which is the normalized form for SNR.

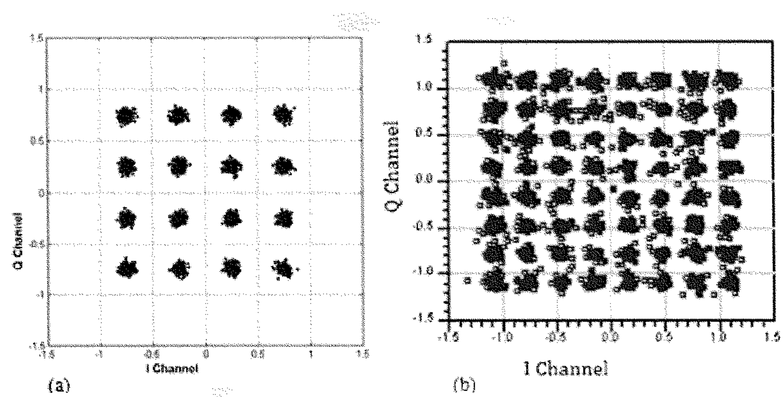

Figure 4.1: Signal state constellation diagrams for (a) 16QAM and (b) 64QAM with noise-induced impairments.

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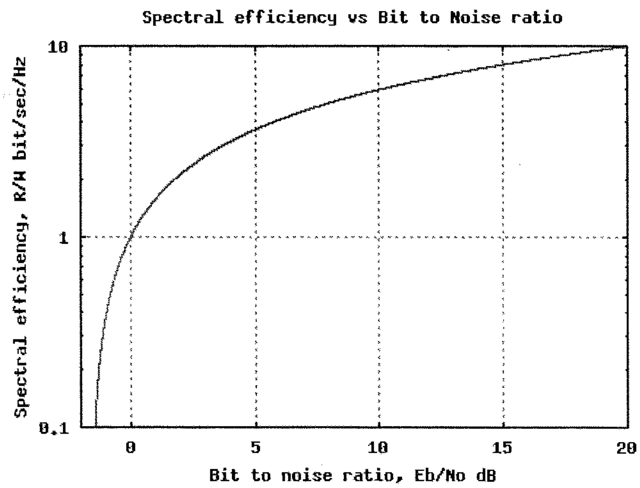

Figure 4.2: Relationship between Spectral Efficiency and Signal-to-Noise Ratio.

4.2.1 Interference effects

Inter-cell interference is one the most important factors limiting the spectral efficiency of a cell. When interference power is combined with Additive White Gaussian Noise (AWGN), the Signal to Interference + Noise Ratio (SINR) ratio is reduced. A User Element (UE) with low SINR means that it must operate at a lower modulation index to keep packet error ratios to an acceptable level for the applications used by the particular UE. A lower modulation index means that the spectral efficiency is reduced for that UE, which in turn reduces the average spectral efficiency for the cell. In essence, higher interference, lower SINR, lower modulation index, lower spectral efficiency.

Figure 4.3 illustrates a typical case where interference triggers the hand-off of the UE from one base station (eNB) to anther eNB. As the UE moves away from its serving eNB, the signal power of the serving source reduces, while the signal power of the adjacent eNB increases. While the UE is still served by the left-hand eNB, the signal from the right-hand eNB appears as interference. Thus the UE experiences a reducing SINR (reducing spectral efficiency) as it moves towards the cell edge. The hand-off process is initiated when the SINR reaches a threshold point.

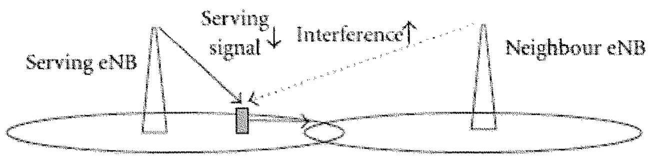

Figure 4.3: Reducing SINR as the UE moves towards the edge of the serving eNB [10].

Interference effects are more significant at cell edges and where cell sectors overlap. A typical cell would be configured into 3 or 6 sectors. Figure 4.4(a) illustrates a 3-sector cell.

One approach cellular network engineers use to mitigate interference is to assign different frequencies to adjacent sectors. In Figure 4.4(b) the Frequency Re-use (FR) factor is 3, but in practice may be as high as 7. The consequence of this approach is to assign 1/3 to 1/7 of the RF spectrum to each sector. Each sector would then have 1/3 to 1/7 of the aggregate throughput.

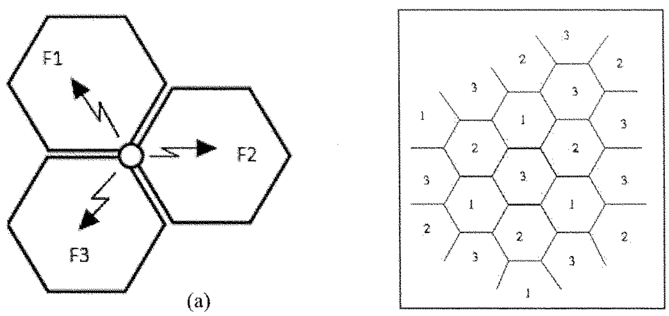

Figure 4.4: (a) frequency assignments in a 3-sector cell with FR = 3; (b) network frequency assignments for FR = 3.

Maximizing throughput by various interference mitigation strategies is a rich area of study and will be examined further in this section. The sections that follow review some of the technologies more frequently found in technical literature and oft-cited research.

4.3 Spectral Efficiency Roadmap

Each new generation of wireless technology improves upon the capacity of the previous one. LTE, currently at Rel.8 and Rel.9, will continue to evolve new capabilities into Rel.10, 11, and beyond. Some of the new capabilities will increase spectral efficiency. The Capacity Model assumes a progressively increasing spectral efficiency. Some of the technologies currently under development or in early stages of research are discussed below. Their potential impacts on spectral efficiency are included in the Capacity Model as illustrated in Table 4.3. The SE Roadmap is specific to the Capacity Model. The actual sequence of technology deployment may differ from that shown in the table or the values of SE may also be different.

Table 4.3: Spectral Efficiency Roadmap specific to the Capacity Model.

	T0: YR1-3	T1: YR4-6	T2: YR7-9	T3: YR10-12	T4: YR13-15	T5: YR16-18	T6: YR19-20
bps/Hz	LTE Rel.8	Fractional Frequency Reuse	Adaptive Fractional Frequency Reuse; 4x4 MIMO	Multi-User MIMO	Cooperative Multi-Point	Dirty Paper Coding	Femto-cells Relays
DL	0.686	0.860	1.060	1.329	1.923	2.398	2.849
UL	0.300	0.375	0.457	0.652	1.051	1.485	1.737

4.3.1 Fractional Frequency Reuse

One of the most active areas of research is to increase the throughput of LTE systems by mitigating the effects of inter-cell interference. Inter-cell interference is a dominating factor in limiting the throughput. An important goal is to reduce the FR factor to as near unity as possible. Figure 4.5 illustrates that with FR=1 the network bandwidth is essentially available in each sector. With FR=3, the network BW is divided by 3. Fractional Frequency Reuse (FFR) is made possible by the X2 communications link between LTE base stations. The mechanisms that are applied in a coordinated manner between eNBs are known collectively as Inter-Cell Interference Coordination (ICIC). ICIC-enabled FFR can achieve lower values of FR such as 3/2 as illustrated in Figure 4.6.

FR factor affects the total network capacity (TNC) as in equation (3). A lower value of FR increases total network capacity.

$$\mathrm{TNC} = \frac{[\#\text{ of cell sites}] \times [\#\text{ of sectors/site}] \times [\mathrm{SE}] \times [\text{available BW}]}{\mathrm{FR}} \qquad (3)$$

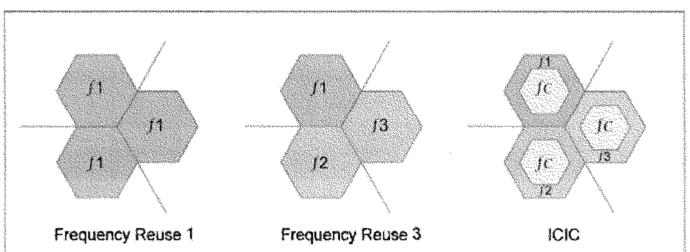

Figure 4.5: Frequency re-use plans FR=1, FR=3, and Fractional Frequency Re-Use (FFR).[11]

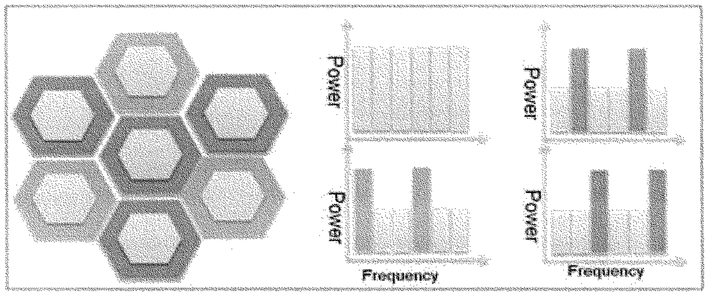

Figure 4.6: Illustration of FR=3/2 using ICIC and associated Power Bandwidth Profiles.

Adaptive Fractional Frequency Reuse (AFFR) is a closed-loop scheme that uses the Channel Quality Indicator feedback from the UE in order to dynamically adapt the scheduling, power level, and channel assignment to the UEs. In addition, AFFR coordinates the actions among all the adjacent eNBs. Simulation results indicate that near unity FR can be obtained. See Table 4.4 for a comparison of simulated LTE sector throughputs for N=1 and AFFR. In the cited article, N ≡ FR. AFFR achieves 99% of the throughput of FR=1.

Table 4.4: comparison of simulated LTE sector throughputs for N=1 and AFFR [12]

	FR =1	AFFR
Sector Throughput (Mbps)	8.01	7.89

4.3.2 Multiple Input Multiple Output (MIMO) techniques

MIMO techniques are used to improve SE. One MIMO scheme, referred to as Spatial Multiplexing (SM), can be used to transmit multiple information streams simultaneously from eNB to the UE. MIMO is also used to cancel interference on streams carrying the same information. LTE Rel.8 is able to dynamically adapt the MIMO scheme in order to maximize throughput using feedback from the UE. This is known as Closed Loop MIMO (CL-MIMO). Figure 4.7 illustrates 2x2, 3x2, and 4x4 MIMO configurations.

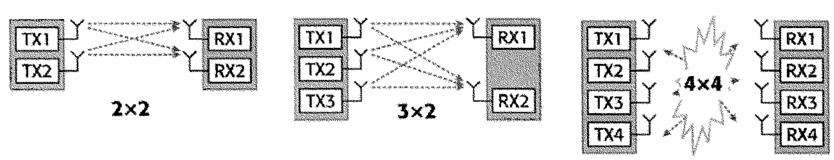

Figure 4.7: Transmitter and receiver arrangements for 2x2, 3x2, and 4x4 MIMO.

Table 4.5 refers to SU-MIMO (Single User MIMO). In this arrangement, the eNB transmits on multiple antennas, whereas the UE transmits on one antenna but receives on multiple antennas. The SE for 2x2 and 4x4-MIMO is given in Table 4.5.

Table 4.5: Average spectral efficiencies for down-link and up-link for 20MHz bandwidth [13] [14]

Down-Link	Spectrum Efficiency		Mean User Throughput		Cell-Edge User Throughput		
	[bps/Hz/cell]	x UTRA	[bps/Hz]	x UTRA	[bps/Hz]	x UTRA	
E-UTRA 2x2 SU-MIMO	1.56	x3,0	0,16	x3,0	0,04	x2,3	Rel.8
E-UTRA 4x4 SU-MIMO	2.41	x4,6	0,24	x4,6	0,08	x4,8	Rel.10

	Spectrum Efficiency		Mean User Throughput		Cell-Edge User Throughput		
Up-link	[bps/Hz/cell]	x UTRA	[bps/Hz/user]	x UTRA	[bps/Hz/user]	x UTRA	
E-UTRA 1x2	0.681	x2.2	0.068	x2.2	0.0044	x2.0	Rel.8
E-UTRA 1x4	1.038	x3.3	0.104	x3.3	0.0094	x4.2	Rel.10

Figure 4.8 compares average spectral efficiencies across different channel bandwidths. The spectral efficiency for 10MHz bandwidth is ≈98% of that for 20MHz bandwidth.

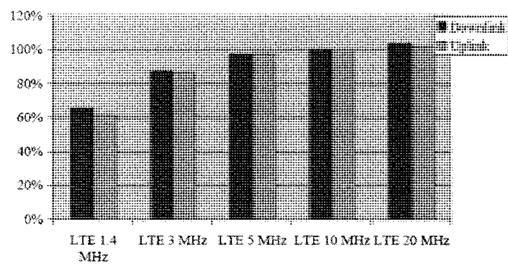

Figure 4.8: Comparison of spectral efficiencies relative to 10MHz channel bandwidth[15].

4.3.3 Multi-User MIMO Uplink

Multi-User MIMO-UL (MU-MIMO-UL) is the equivalent of spatial diversity in the Uplink direction. As in the previous case, interference is estimated from the received signals using Successive Interference Cancellation . Figure 4.9 illustrates a block diagram for the MU-MIMO-UL. Note the feedback from the UE towards the eNB.

This technique can provide ≈ 70% improvement in UL spectral efficiency relative to LTE Rel.8. Refer to Figure 4.10 for a comparison of various techniques being researched by Deutsche Telkom Laboratories to improve SE.

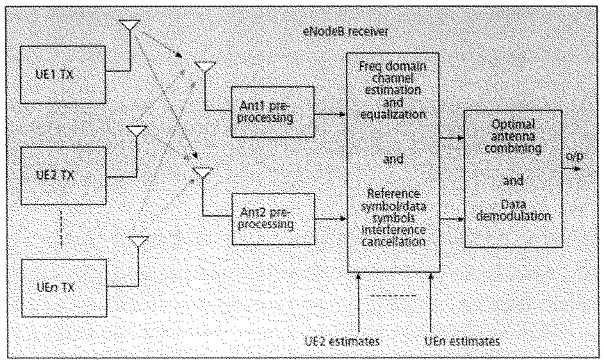

Figure 4.9: MU-MIMO-UL block diagram [12]

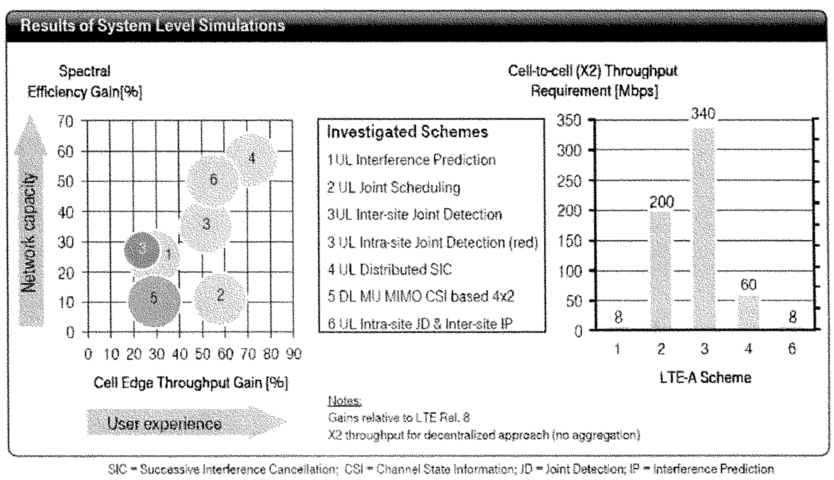

Figure 4.10: Spectral Efficiency Improvements under study. [17]

4.3.4 Multi-User MIMO Downlink, Coordinated Multi-Point

Coordinated Multi-Point (CoMP) with Organized Beam-forming improves the SE at the cell-edge. The average cell throughput is also increased. In organized beam-forming eNBs exchange scheduling and beam-forming information so that multi-site scheduling can be performed. This reduces inter-cell interference. Figure 4.11 illustrates the principle of CoMP. Simulation shows that SE in the DL can be improved by up to 1 bps/Hz using this technique..

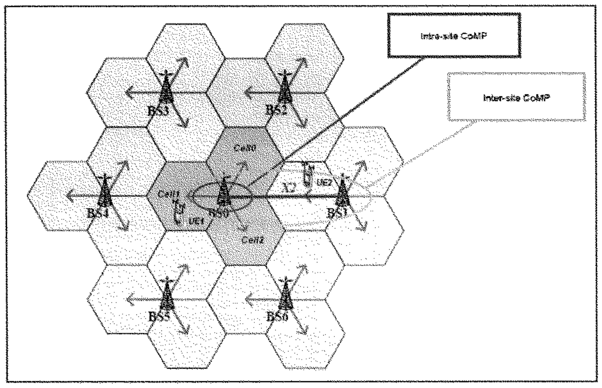

Figure 4.11: Coordinated Multi-Point conceptual diagram [18].

4.3.5 Dirty Paper Coding

Dirty Paper Coding (DPC) is a technique whereby the data is pre-coded at the transmitter using interference information fed back from the UE on the side channel referred to as Channel State Information (CSI). In essence, the transmitter adapts to the interference. Information theorists have presented mathematical arguments that DPC with CSI feedback can approach the performance of Gaussian Noise channels, thereby almost completely cancelling the interference. [19]

Other researchers arrived at numerical results which indicate that DPC can improve the SE of 2x2 MIMO systems by up to 0.8 bps/Hz, and improve the SE of 4x4 MIMO systems by up to 1.35 bps/Hz. [20]

4.3.6 Femto-cells and decode/forward Relays

Femto-cells and relays are used to increase the capacity in a specific location such as malls and conference centres. Femto-cells off-load traffic from the macro node. Relays are used to fill in gaps in coverage from the macro node. See Figure 4.12 for an illustration of the use of Femto cells and Relays.

Both approaches increase capacity although it can be difficult to quantify in general terms since the actual gain is implementation-specific. The Capacity Model assumes a 10% increase in UL and DL SE through the use of Femto-cells and Relays.

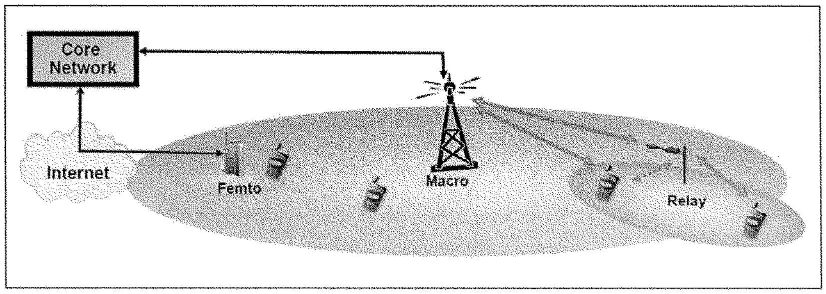

Figure 4.12: Femto cells and Relays used to augment the capacity of a Macro cell.

4.4 Input data and assumptions

The following input data and assumptions and have been used in the Capacity Model.

1. Spectral efficiencies stated in Table 4.5 represent the average of reported results from a number of LTE system and sub-system vendors. They are:
   - Alacatel-Lucent
   - Huawei
   - InterDigital
   - Motorola
   - NEC
   - Nortel
   - Nokia-Siemens
   - Samsung
   - Qualcomm
   - Texas Instruments

2. The introduction of new technology into a network will likely encounter implementation issues and the Capacity Model assumes that there will be a gap between anticipated SE improvements vs. realized improvements. However, the Model also assumes that the gap will reduce in time as the technology matures and implantations issues are worked out. Therefore, the Model applies a de-rating factor to the SE according to the profile: 33%, 25%, 10%, 5%. This means the SE improvement is de-rated by 33% when first introduced, 25% after 3 years, 10% after 6 years, and 5% after 9 years. The un-derated SE values are in Table 4.6. These values are <u>not</u> used in the Capacity Model, but serve as baseline from which de-rating factors were applied.

3. New technology is introduced in the LTE network in 3-year intervals. Even though some technology could be available sooner than it is introduced in the Model, it is assumed that budgets will constrain the ability to procure and update existing facilities. Another assumption is that public safety agencies will be somewhat conservative in upgrading. There will also be some time spent to pilot the upgrades before introducing them into live networks.

4. It is assumed that an incident is a localized event that would be contained geographically within one sector.

5. For FR=3 and FFR, an overlap of 25% is assumed between adjacent sectors. When AFFR is introduced the Model approaches FR=1 and as such no additional capacity is factored into the Model due to overlapping sectors since closed-loop ICIC mechanisms are intended to avoid duplicate scheduling of UEs.

6. SE is a dependent upon the speed of the UE. The Model assumes that the speed of most responders is <3kph at the scene of the incident. LTE SE is higher for lower speeds.

Table 4.6: Un-derated Average Spectral Efficiency (b/s/Hz/sector) not used in the Capacity Model.

	T0	T1	T2	T3	T4	T5	T6
DL	1.529	1.529	2.362	2.362	3.543	3.543	3.897
UL	0.667	0.667	1.017	1.729	1.729	2.729	3.002

5 RF spectrum requirements

This section discusses the results of correlating the data demand with capacity, which is the RF spectrum (bandwidth) required for public safety. It presents the nominal bandwidth and the error introduced by the uncertainty of future predictions. In §5.2 a sensitivity of the bandwidth is analyzed as a function of two key variables. There is also an analysis which presents to what degree public safety would have to back off their requirements in order for 5+5MHz to satisfy the reduced requirements.

Figure 5.1 is an illustration of the growth of data demand (from Figure 3.6) compared to the growth of Spectral Efficiency (from Table 4.3), with YR1 as the reference point. The difference in the growth rates is notable. Given the pressures that commercial carriers face due to the exponential nature of the growth in demand they are experiencing (see Figure 3.5) from commercial users, with no sign of abating, it is expected that they will continue to invest in new technologies to cope with the anticipated growth in data demand. In fact, there is an intense level of research into improving the spectral efficiency of mobile broadband networks 10. The cited article cites a further 64 references.

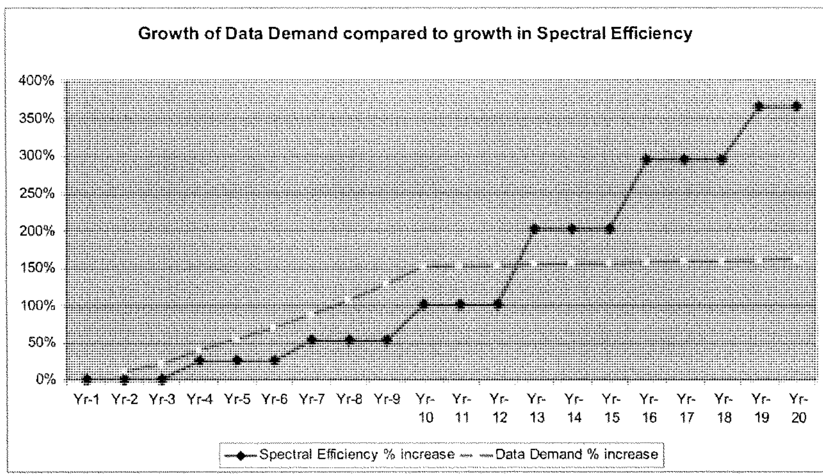

Figure 5.1: growth of data demand compared to the growth of spectral efficiency

It is very difficult to predict what will happen in the future, especially over a 20-year period. Even though it may be easier to predict what the demand could be in the next 1 or 2 years, or what technology would likely be developed in the near-term, there is nonetheless an uncertainty in whatever prediction is made. The degree of uncertainty becomes larger for prediction-horizons that are further out in time.

The Capacity Model has factored an estimating error into the predictions for RF spectrum. Figure 5.2 shows the same growth projections as in Figure 5.1, but also shows the effect of uncertainty using a 10% annually compounded estimating error for demand and the same for SE.

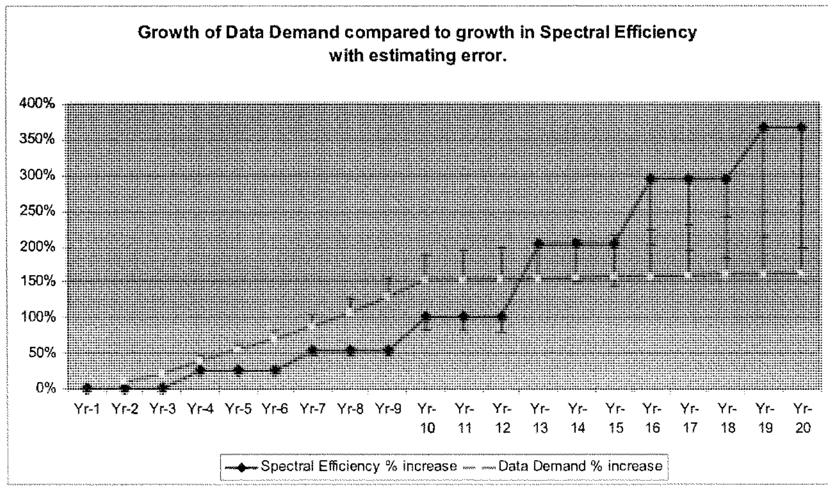

Figure 5.2: Growth of demand and SE with 10% annually compounded estimating error applied to demand and SE.

5.1 RF spectrum requirements – results

This section presents the bandwidth requirements using the inputs below. Alternative scenarios based on sensitivity to SE and SG are examined in §5.2.

(i) Data Demand profiles as shown in Figure 3.6,

(ii) SE values from Table 4.3,

(iii) Estimating error due to uncertainty of predicting future events as shown in Figure 5.2.

Equation (4) is used to calculate the aggregate required bandwidth (BWr):

$$\text{BWr (MHz)} = \frac{\text{DL Data Demand (kb/sec)}}{\text{DL SE (b/sec/Hz)} \times 1000} + \frac{\text{UL Data Demand (kb/sec)}}{\text{UL SE (b/sec/Hz)} \times 1000} \qquad (4)$$

Figure 5.3(a,b,c) shows the RF spectrum required for an LTE network to provide sufficient throughput to support the data communications needs for the 3 incident case studies, namely Chemical Plant Explosion, Multi-Vehicle Accident, and Sports Event Riot, respectively. The graphs also show the influence of estimating error. In each graph two curves are shown: one curve for the RF Spectrum required to support the aggregate (UL+DL) data demands for the specified incident, and one curve for the aggregate Usable BW based on a 10+10MHz allocation.

Since an incident is a localized event, only one sector's capacity is available, plus the overlap from the adjacent sector. At the outset, the usable capacity within one sector in either UL or DL direction is the Network capacity (based on 10+10MHz) ÷ 3 (FR) x 1.25 (sector overlap) x 75% (frequency re-use efficiency). If 20MHz is allocated, then only 6.25MHz is actually usable in a sector until further improvements in Frequency Reuse are implemented. The Model assumes that, over time, 95% of the Network capacity becomes available within a sector.

The period where RF spectrum requirement increases (YR1-10) is dominated by investments in LTE UE for the User community. Once the user community has been fully outfitted with LTE UE devices, the subsequent period (YR11-20) is dominated by investments in the LTE eNB infrastructure. These investments are characterized as improvements in spectral efficiency. The effect of introducing improvements in SE can be seen in the graphs as step-wise reductions in required bandwidth.

The following conclusion can be drawn from Figure 5.3:

1. Improvements in spectral efficiency outpace the growth in demand and so it is expected that the applications will require progressively less bandwidth when the penetration of LTE devices in the public safety community has saturated and the investments are turned towards accelerating the improvements in the infrastructure. According to Figure 5.3, the saturation point is at YR10.

2. 10+10MHz (UL+DL) is insufficient spectrum in both UL and DL to meet the data communications needs of public safety during commonly recurring incidents, given the anticipated spectral efficiency of LTE for the near-to-mid term.

3. When LTE technology becomes more spectrally efficient, 10+10MHz could be sufficient spectrum to support the data communications requirements for less severe incidents. This may occur beyond YR15 for benign incidents such the multi-vehicle accident.

4. When estimating error is included, 10+10MHz is insufficient spectrum for all cases throughout the 20-year horizon.

5. There is a significant gap between required spectrum and usable spectrum. During the events of the nature considered in this study, public safety will most likely not be able to use all the applications they identified, nor in the manner in which they expect to use them. In order to deal with situations where demand exceeds capacity bandwidth management policies will need to be established, access privileges would need to be asserted, controlled and monitored, and the use of applications will need to be prioritized. The policies and procedures could be re-visited over time as greater efficiencies are introduced into the network.

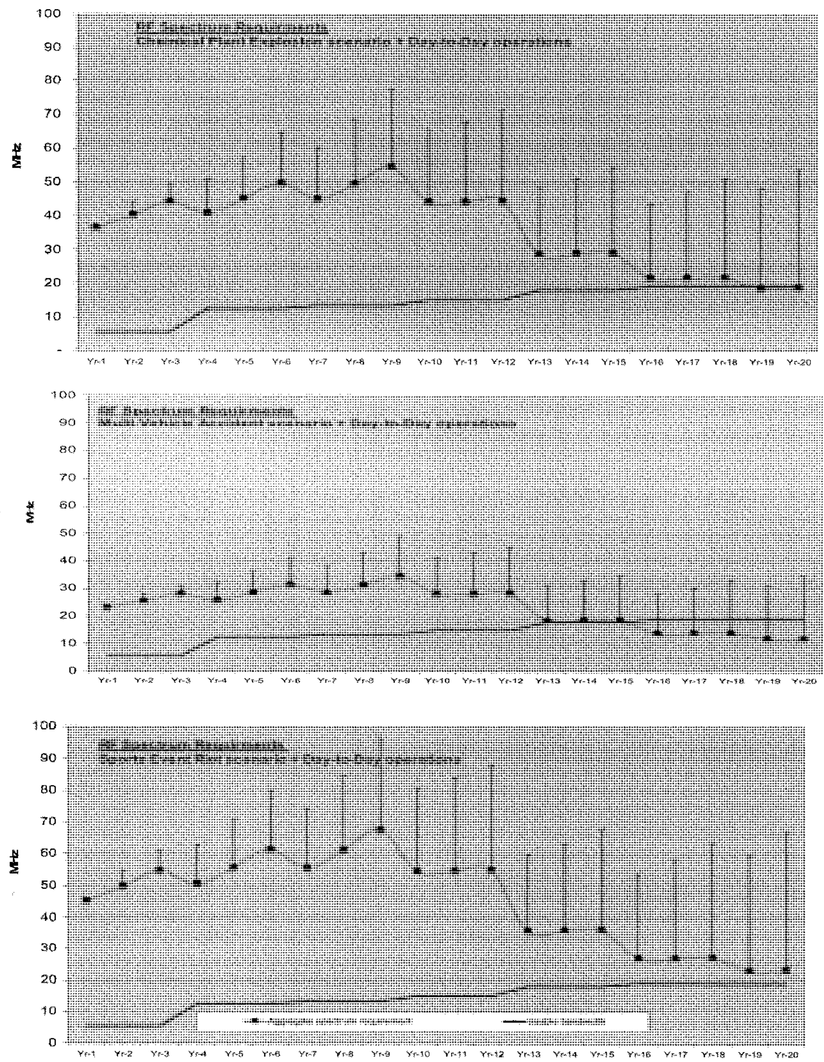

Figure 5.3: Aggregate (UL+DL) RF Spectrum requirements

5.2 Alternative scenarios

The effects of varying some key parameters on RF spectrum requirements will be examined in this section. Two cases examine the effects of aggressive approaches to dimensioning the network. Of course, the results show that less RF spectrum is needed. However, the conclusions of §5.1 remain essentially the same. The only exception would be for less severe incidents, where 10+10MHz would likely be sufficient when technology improves, but 5+5MHz would likely be insufficient.

A third scenario examines how aggressively the parameters need to be adjusted in order to reduce the data demand such that all three incident case studies can be fulfilled with 5+5MHz of RF spectrum.

5.2.1 Accelerated introduction of higher spectral efficiency.

In the Model, de-rated SE values are used to account for slower adoption of new technology in public safety networks due primarily to more restrictive budgets in municipalities or government than in commercial carriers. Public safety will likely have a longer vetting process before adopting new technologies. There would also be less economic/business pressure to upgrade the technology in public safety than in commercial networks.

If the public safety network were to be upgraded at the same pace as a commercial network, this scenario examines the effect of optimistic values of spectral efficiency on required RF spectrum. The un-derated SE values of Table 4.6 are reproduced below. The resulting required RF spectrum is shown in Figure 5.4 (a,b,c).

(copy) Table 4.6: Un-derated Average Spectral Efficiency (b/s/Hz/sector) not used in the Capacity Model

	T0	T1	T2	T3	T4	T5	T6
DL	1.529	1.529	2.362	2.362	3.543	3.543	3.897
UL	0.667	0.667	1.017	1.729	1.729	2.729	3.002

5.2.2 Lower intensity of use of the network.

A key factor in the data demand model is the over-booking factor (OBF). Since first responders will make more intense use of their data communications tools during an incident than during non-emergency situations, the Model uses an OBF ratio of 4:1 for streaming video and interactive applications. Commercial users also make more intense use of the network during emergencies. During these events typical OBF ratios of 20:1 or 50:1 for commercial users no longer apply.

Nevertheless, in this scenario the OBF for streaming video and interactive data is doubled from 4:1, as in the Model, to 8:1. The results for the three incidents case studies are illustrated in Figure 5.5(a,b,c).

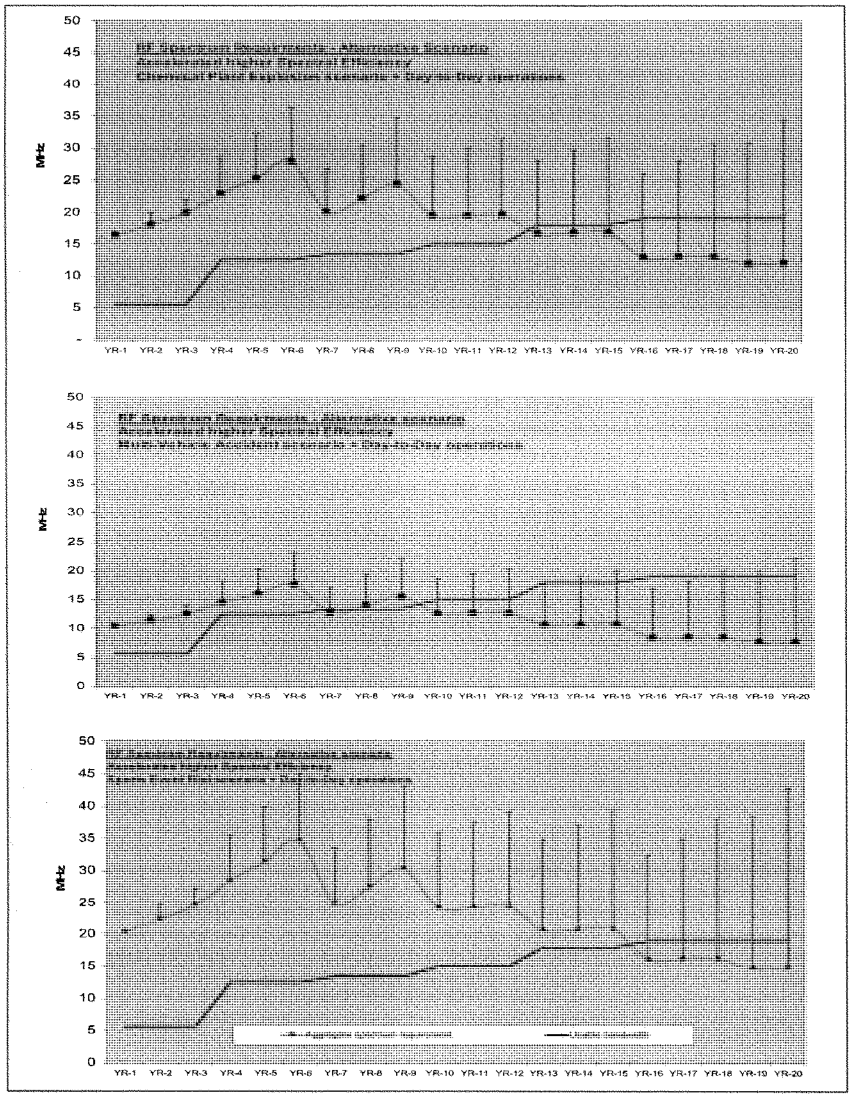

Figure 5.4: Aggregate (UL+DL) RF spectrum requirements considering accelerated improvement in SE.

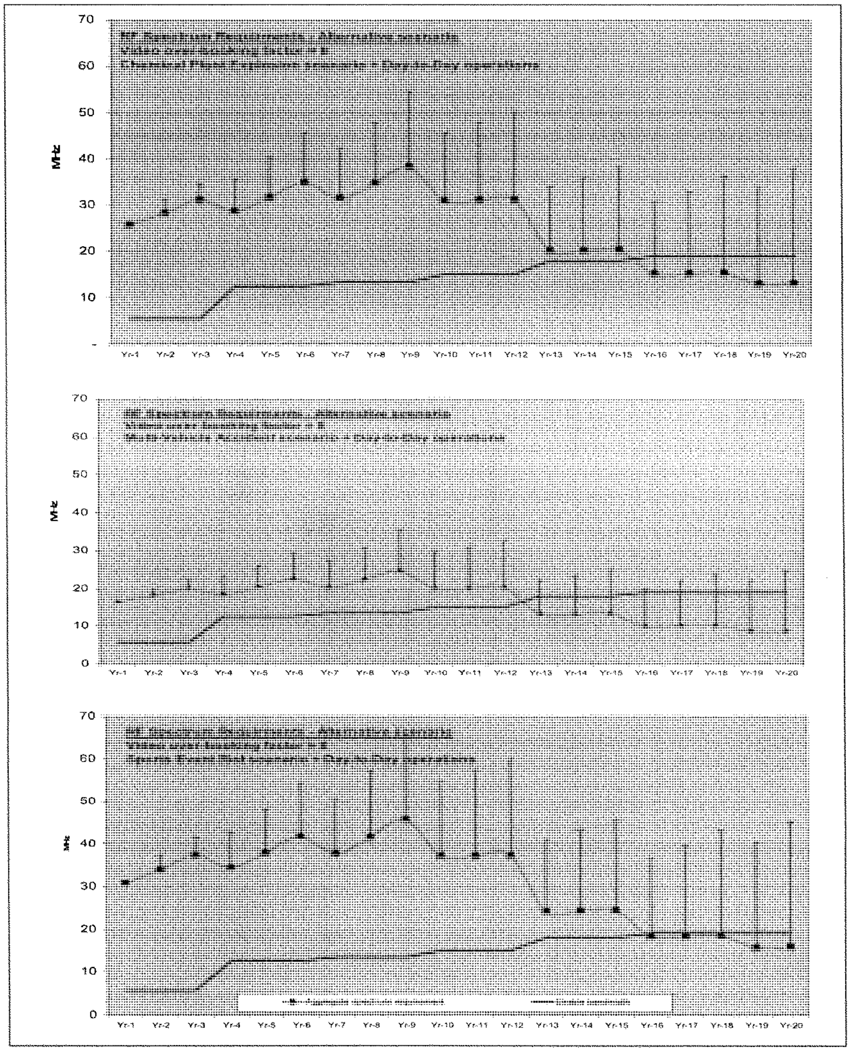

Figure 5.5: Aggregate (UL+DL) RF spectrum requirements considering aggressive OBF.

5.2.3 Level of compromise required to fit into 5+5MHz

Three parameters are simultaneously varied in order to determine how far public safety would have to back off from their requirements in order to fit into 5+5MHz of spectrum. The three parameters are:

- Video data rate
- Over-booking factor
- Spectral efficiency

In Figure 5.6(a,b,c) are graphs of RF Spectrum requirements which can be satisfied with 5+5MHz allocation. In order to fit into this profile, the following adaptations to the Model were made.

a) Video data rates were reduced by 50% compared to the values in the Model.

b) Over-booking factor was set to 20:1

c) Spectral efficiency was set to the un-derated values as in §5.2.1.

This means that in order for the data demands of the three incident case studies to be satisfied with 5+5MHz of the spectrum,

1. Video would not be usable to distinguish people, labels on chemical containers, or other similar level of detail.
2. The use of the network would have to be scaled back so that 1 in 20 users would be able to send or receive data simultaneously versus 1 in 4. One in 20 is the same OBF used by commercial carriers to dimension their networks for consumer-grade service.
3. New technology would need to be evaluated and implemented by public safety at the same pace as commercial carriers.

Item 3 above is based on optimistic expectations for technology roll-out. Items 1 and 2 would restrict the ability of first responders to make beneficial use of the network during emergencies. They would have to make significant compromises compared to how they intend to use a mobile broadband network if only 5+5MHz of spectrum would be available.

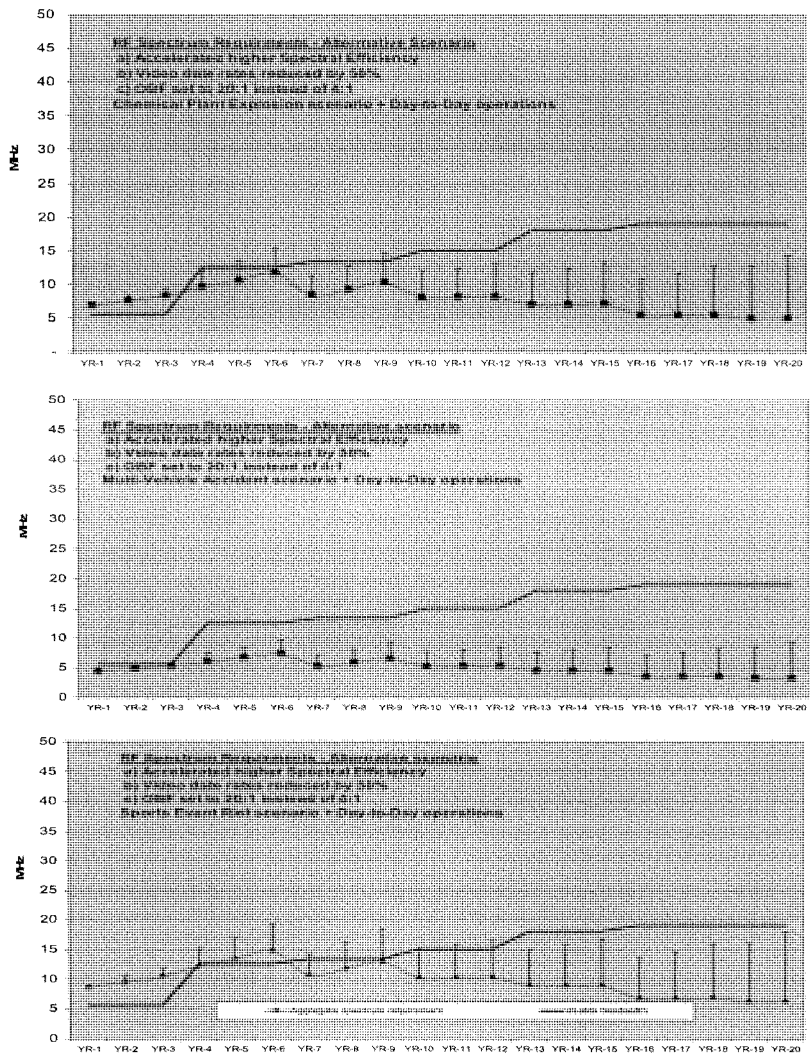

Figure 5.6: Level of compromise needed to fit spectrum requirements into 5+5MHz (UL+DL)

6 Conclusion

The question of how much bandwidth a mobile broadband network requires to meet the needs of public safety is answered by examining how the public safety community would use the technology and what throughput the technology offers.

This study followed a similar approach that others have taken to establish the anticipated usage. That is, to determine the data demand for incident scenarios of emergency events which are recurring in nature. Representatives from Canadian public safety stakeholders provided their views on how they anticipate using a mobile broadband network for three scenarios and how they would use the network in the course of their day-to-day operations.

The throughput requirements for each application that public safety could use were established based on empirical results from other studies and in consultation with the Communications Research Centre of Canada. The data demand profiles were determined from the anticipated usage and the applications data rates.

Correlating the data demand with the spectral efficiency of the mobile broadband network yields the required bandwidth. The analysis is performed for a 20-year horizon. LTE is the technology used in the study.

This study attempts to present a balanced perspective on demand and on capacity. It is unique in examining the effects of anticipated advances in technology to improve spectral efficiency over time and ways to manage high data-rate traffic such as video. The introduction of estimating error into the model is an innovative approach to quantify uncertainty of predicting future demand and capacity.

The key conclusions that are derived from this study are:

a) 10+10MHz is insufficient bandwidth to support the needs of public safety in the 10-15 year horizon.

b) Improvements in spectral efficiency will likely outpace public safety's demand for data and as a consequence, the requirement for bandwidth should begin to attenuate beyond YR10, which is the point when penetration of LTE devices in the public safety community is expected to saturate.

c) Despite the rapid pace of technical innovation, the ability to meet the needs of public safety with 10+10MHz of spectrum in a distant future, ie beyond 15 years, is not evident, but it is likely that 10+10MHz will not be sufficient at that time either..

In anticipation of being granted 20MHz of spectrum, and for the foreseeable future, congestion management will be an essential component of the mobile broadband network. The public safety community should develop policies and procedures, and make use of appropriate bandwidth management technology in order to avoid congestion-related issues during emergency situations.

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In response to a request for technical advice by Public Safety Canada on behalf of national public safety stakeholders, the Centre for Security Science conducted a technical assessment of the 700 MHz spectrum requirements for broadband mobile data communications for public safety and security. The impetus to this assessment relates to the upcoming Industry Canada call for consultation SMSE-018-10. The goal was to determine how much spectrum is required to meet the needs of the public safety community for mobile broadband wireless data communications within a 20-year time frame. The data demand for recurring emergency situations was modeled through an interactive process with active participation from Canadian public safety stakeholders. In addition, the capabilities of LTE technology to support the data demands were also modeled. The results show that the amount of bandwidth required to satisfy the needs of public safety is greater than 20MHz in the near-to-mid term, and likely to also exceed 20MHz in the long term, despite advances in technology. This result is based on an analysis that applies relatively conservative estimates for the growth in demand for mobile data communications for public safety and security applications, and relatively aggressive estimates for the rate of technological improvement of spectrum efficiency projected into the future.

En réponse à une demande de conseils techniques faite par Sécurité publique Canada au nom des intervenants nationaux de la sécurité publique, le Centre des sciences pour la sécurité a effectué une évaluation technique des besoins de la fréquence de 700 MHz pour la transmission mobile à large bande de données destinée à la sécurité publique. C'est l'appel de consultation SMSE-018-10 que lancera bientôt Industrie Canada qui a motivé l'exécution de cette évaluation. L'objectif consistait à déterminer quelle part du spectre est requise pour répondre aux besoins du milieu de la sécurité publique pour la transmission mobile de données à large bande au cours des 20 prochaines années. La demande en données pour les situations d'urgences récurrentes a été modélisée à l'aide d'un processus interactif auquel les intervenants de la sécurité publique du Canada ont participé activement. Il y a de plus une modélisation des capacités de la technologie LTE pour répondre aux demandes de données. Les résultats démontrent que la part de la bande passante nécessaire pour répondre aux besoins de la sécurité publique est supérieure à 20 MHz à court et à moyen terme, et dépassera aussi probablement 20 MHz à long terme, et ce, malgré les progrès technologiques. Ce résultat repose sur une analyse ayant recours à des évaluations relativement prudentes de la croissance de la demande pour la transmission mobile de données à des fins de sécurité publique, ainsi qu'à des évaluations relativement ambitieuses du degré d'amélioration technologique de l'efficacité spectrale dans le futur.

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Emergency, management, planning, communication, Interoperability, 700 MHz, Broadband Communication, LTE, Long Term Evolution, video, public safety network, spectrum, allocation, data, mobile, technical, assessment.

Mr. WALDEN. Thank you very much, Chief.

Now I would like to welcome for his testimony Dr. Coleman D. Bazelon with The Brattle Group.

We welcome you, and thank you for being here today.

STATEMENT OF COLEMAN D. BAZELON

Mr. BAZELON. Thank you, Chairman Walden, Congressman Markey, members of the committee. It is an honor to speak here today.

This committee is considering an important issue of spectrum policy that will have profound impacts on the development of wireless broadband. I am sure everyone is familiar with the projections of demand for wireless broadband, including forecasts of wireless data demand virtually doubling every year for the next few years. Industry capacity will struggle to keep up.

Rising demand will be met, in part, by rapidly building out spectrum acquired at auction——

Mr. WALDEN. Doctor, could I just ask you to move that microphone a little bit closer? We are having a little trouble hearing. Thank you.

Mr. BAZELON. Is that better?

Mr. WALDEN. Much better.

Mr. BAZELON. Thank you.

Carriers will also use other techniques to increase effective capacity, such as Wi-Fi offloading, off-peak transmission and on-device storage, and innovative pricing schemes aimed at reducing peak usage.

Nevertheless, if future demand for wireless broadband services is to be met and those services are to remain affordable, it is clear that new allocations of spectrum will be needed. Absent those additional allocations, much of the potential benefits of mobile broadband to consumers and the economy will be lost.

Exactly how much more radio spectrum is needed for wireless broadband is uncertain. Given the uncertainty, policymakers should apply a principle of spectrum reallocation. Based on current allocations, if a higher-valued use exists, spectrum should be reallocated from the lower-valued use to the higher-valued use.

Our economy benefits when resources are moved to higher-valued uses. Other bands of spectrum should be examined with this principle of spectrum reallocation in mind. As long as there are financial gains and additional consumer welfare to be had from reallocating more spectrum, further reallocation should take place.

This principle of spectrum reallocation has been applied to the television band twice before. First, the initial cellular allocations were from the upper reaches of the UHF band originally allocated to TV broadcasters. Then, as a result of the digital television transition, the 700 megahertz band was reallocated to wireless broadband and public-safety uses.

Or perhaps I should say, the principle of spectrum reallocation has almost been applied twice to the TV band. The D block remains unassigned. There seems to be three options: assign the D block to public safety, auction it for wireless broadband uses with public-safety obligations, or auction it without public-safety obligations.

I have testified before and reiterate today my belief that auctioning the D block unencumbered with any public-safety obligations would be best. Last summer, I told this committee that I estimated a well-structured auction of the D block would raise between $3 billion and $4 billion, and I believe that to still be true.

The loss in value from public-safety obligations on private licensees or the relatively small amount of cost savings to public safety from an additional 10 megahertz of spectrum suggests that an unencumbered auction would put the D block to its highest-valued uses.

There is an option to apply the principle of spectrum reallocation to the TV bands again through the use of incentive auctions. One of the key advantages of incentive auctions is that they are designed with the principle of spectrum reallocation in mind. That is, by design, they will not reallocate spectrum from a higher-valued use to a lower-valued use.

My colleague, Charles Jackson, and I are working on a detailed analysis of what an incentive auction of the television bands might produce. This research was sponsored by the High Tech Spectrum Coalition, but today I am testifying on my own behalf. I want to provide the committee with a few highlights of our preliminary findings.

An incentive auction could clear 120 megahertz of spectrum that could be reallocated to wireless broadband uses. Broadcasters that do not participate in the auction or whose bids are not accepted in the auction will not have any diminution in their service areas. At a minimum, 4 full-powered broadcasters would remain in every top-30 market, serving the same households they do today, although probably more than 4 existing stations would continue broadcasting by moving to VHF channels, co-broadcasting with other broadcasters, or adjusting their service areas.

Payments to broadcasters in the incentive auction would probably not be more than about $15 billion and likely would be much less. Expected revenues from auctioning 120 megahertz of spectrum would likely exceed $35 billion. So an incentive auction would be expected to raise at least $20 billion for deficit reduction or for other priorities Congress may have, such as funding a public-safety network.

Finally, in closing, I would like to remind the committee that the real beneficiaries of spectrum reallocations are consumers. Broader access to higher-bandwidth wireless networks at lower cost is the real benefit of applying the principle of spectrum reallocation. The benefits to consumers are generally estimated to be 10 to 20 times auction receipts. Consequently, the cost of inaction in reallocating these valuable spectrum bands is very high.

Thank you very much.

[The prepared statement of Mr. Bazelon follows:]

Oral Testimony of Coleman Bazelon, The Brattle Group, Inc.
U.S. House of Representatives, Committee on Energy and Commerce
Subcommittee on Communication and Technology
April 12, 2011

Chairman Walden, Ranking Member Eshoo, members of the committee, it is an honor to speak here today.

This Committee is considering an important issue of spectrum policy that will have profound impacts on the development of wireless broadband. I am sure everyone is familiar with the projections of demand for wireless broadband, including forecasts of wireless data demand virtually doubling every year for the next few years. Industry capacity will struggle to keep up. Rising demand will be met in part by rapidly building out spectrum acquired at auction in the past few years and re-farming the older allocations in order to deploy newer, more efficient technologies. Carriers will also use other techniques to increase effective capacity such as WiFi offloading, off-peak transmission and on-device storage, and innovative pricing schemes aimed at reducing peak usage. Nevertheless, if future demand for wireless broadband services is to be met and those services are to remain affordable, it is clear that new allocations of spectrum will be needed. Absent those additional allocations, much of the potential benefit of mobile broadband to consumers and the economy will be lost.

Exactly how much more radio spectrum is needed for wireless broadband is uncertain. Given this uncertainty, policymakers should apply a principle of spectrum reallocation—based on current allocations, if a higher valued use exists, spectrum should be reallocated from the lower valued use to the higher valued use. Our economy benefits when resources are moved to higher valued uses. Every band of spectrum should be examined with this Principle of Spectrum Reallocation in mind. As long as there are financial gains and additional consumer welfare to be had from reallocating more spectrum, further reallocation should take place.

This Principle of Spectrum Reallocation has been applied to the television band twice before. First, the initial cellular allocations were from the upper reaches of the UHF band originally allocated to TV broadcasters. Then, as a result of the digital television transition, the 700 MHz band was reallocated to wireless broadband and public safety uses. At the conclusion of the digital television transition, rights to the 700 MHz band were more valuable for wireless broadband services than broadcasting, and were reallocated to wireless service providers accordingly.

Or, I should say that the Principle of Spectrum Reallocation has *almost* been applied twice to the TV band. The D block remains unassigned. There seem to be three options: assign the D Block to public safety, auction it for wireless broadband uses with public safety obligations or auction it without public safety obligations. I have testified before, and reiterate today, my belief that auctioning the D Block unencumbered with any public safety obligations would be best. Last summer, I told this Committee that I estimated a well structured auction of the D Block would raise between $3 billion and $4 billion and I believe that to still be true. The loss in value from public safety obligations on private licensees or the relatively small amount of cost savings to public safety from an additional 10 MHz of spectrum suggest that an unencumbered auction would put the D Block to its highest valued uses.

There is an option to apply the Principle of Spectrum Reallocation to the TV bands again through the use of incentive auctions. Incentive auctions are two-sided or dual auctions. On one side is a reverse or procurement auction where broadcasters bid offers to return their current broadcast licenses and on the other side is a forward auction where unencumbered spectrum is sold through standard FCC auction procedures. A portion of the proceeds from the forward auction are used to compensate the broadcasters who offer their current licenses in the reverse auction. One of the key advantages of incentive auctions is that they are designed with the Principle of Spectrum Reallocation in mind. That is, by design, they will not reallocate spectrum from a higher valued use to a lower value use.

My colleague Charles Jackson and I are working on a detailed analysis of what an incentive auction of the television bands might produce. This research was sponsored by the High Tech Spectrum Coalition, but today I am testifying on my own behalf. I want to provide the Committee with a few highlights of our preliminary findings.

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would continue broadcasting by moving to VHF channels, co-broadcasting with other broadcasters and adjusting their service areas.

- Payments to broadcasters in an incentive auction would probably not be more than about $15 billion, but would likely be much less.
- Expected revenues from auctioning 120 MHz of spectrum would likely exceed $35 billion.
- An incentive auction would be expected to raise about $20 billion for deficit reduction or for other priorities Congress may have such as funding a public safety network.

Finally, in closing, I would like to remind the Committee that the real beneficiaries of spectrum reallocations are consumers. Broader access to higher bandwidth wireless networks at lower cost is the real benefit of applying the Principle of Spectrum Reallocation. The benefits to consumers are generally estimated to be 10 to 20 times auction receipts. Consequently, the cost of inaction in reallocating these valuable spectrum bands is very high.

Mr. WALDEN. Thank you for your testimony.

We will now turn to Ms. Mary N. Dillon, the President and Chief Executive Officer of U.S. Cellular.

We are delighted to have you here before the subcommittee this afternoon. Thank you, and look forward to your testimony.

STATEMENT OF MARY N. DILLON

Ms. DILLON. Thank you, Chairman Walden, Congressman Markey, and the rest of the committee. It is a pleasure to be here today.

As you know, throughout its very brief history the wireless industry has provided consumers and businesses with an ever-evolving array of innovations—first, of course, voice communications, and now broadband. In fact, wireless has become an essential service for most Americans today. The growth in demand for mobile services in recent years has been absolutely dramatic, and it really shows no signs of abating. We must ensure that wireless networks are able to continue to meet America's growing needs for access to information and communication.

Today's hearing on spectrum raises several important issues currently facing the wireless industry, and they also have broader implications for the Nation's economy and safety. And those issues are: first, the critical need for additional spectrum to meet growing consumer demand for mobile services; secondly, the need to provide an interoperable, nationwide public-safety communications network; and, third, the need for rules that maximize the efficient use of that spectrum going forward.

Of these topics, the most important is the increasing demand for mobile services and the need to make more spectrum available. There is widespread agreement among carriers, the high-tech industry, the FCC that we are, in fact, facing a severe spectrum shortage in the next few years.

My written testimony contains additional facts, but it is very intuitive and I think we can all appreciate how increasing consumer demand for high-tech devices and the services they provide are placing enormous strain on networks and, in turn, creating critical need for more spectrum.

For example, smartphones and tablets are the fastest-growing segments of wireless, and they drive 24 and 122 times more data usage than traditional handsets alone, respectively. So it is really no wonder that data traffic has tripled in 2010 for the third year in a row.

There is also widespread public support for freeing additional spectrum for mobile uses, as demonstrated in a recent nationwide survey that we conducted where we saw that nearly 60 percent of Americans support making more spectrum available to wireless carriers.

As the leader of a company that consistently gains awards for our high-quality network and our overall consumer satisfaction, I am very concerned about the consequences to consumers of severe network congestion, where video would freeze and calls would drop and surfing the Web could become very slow. In addition, potential innovation in areas such as health care and education would suffer as well.

So, remember, of course, it will take years following the passage of legislation before auctions are complete, spectrum is cleared, and services are deployed. So that is why time is of the essence and why Congress really should act now. So what should you do?

First, the most efficient way to meet this rise in demand is to give the FCC the authority to conduct incentive auctions for whatever underutilized broadcaster spectrum exists. And the most effective way to maximize the value of is licensed spectrum is to structure auctions in small blocks rather than in large mega regions or national slots so that U.S. Cellular and other small carriers, in fact as many companies as possible, have a fair opportunity to bid and to be successful. More participants will mean more money for the Treasury and more competition in the marketplace.

Second, we must determine how to provide public-safety agencies with a network that meets their needs. And we believe there are three policy principles that should govern that decision. First, a national, interoperable broadband network should be deployed quickly. Second, there should be an opportunity to expand competitive broadband services and also serve the needs of public safety. And, third, the first two policy considerations must ensure that there is an efficient use of the spectrum as well as taxpayer dollars.

Now, U.S. Cellular has previously supported the concept of a regional public-private partnership model and the FCC's broadband plan to recommend a commercial auction of the D block. So, while we do see ways where the transfer of spectrum to public safety might work, we continue to believe that an arrangement where commercial operators conduct and operate the network at their expense and then work in partnership with regional public-safety agencies to ensure it meets their needs represents a unique and fiscally sound solution.

And, third, we need to update the rules that govern the use of spectrum with regard to interoperability and ubiquitous availability of mobile services. In order to maximize consumer benefits, auctions should be structured to guarantee that services deployed over newly available spectrum are capable of being used with maximum efficiency. Legislation should mandate that carriers be required to deploy network services that are interoperable across the industry. For example, wireless carriers should not be able to deploy 4G handsets that only work in a limited subset of the 700 megahertz spectrum, as is happening today. Without interoperability, consumers and public safety will not be able to seamlessly travel and have access to the data services that they need on other networks or take their devices to other carriers if they should choose to switch.

And, lastly, I would ask that any consideration of broadband deployment not lose sight of the needs of people living in rural communities, who deserve access to the same kind of mobile voice and data communications that consumers in urban areas enjoy. While it is not the central focus of this hearing, as you consider reforming USF, remember there are still rural areas today where calls drop, access is very limited, and dead zones are quite common in the community.

So thank you very much.

[The prepared statement of Ms. Dillon follows:]

Critical Need for Additional Spectrum to Meet Growing Consumer Demand for Mobile Services

Mary N. Dillon
President and Chief Executive Officer
United States Cellular Corporation

Hearing of the House Subcommittee on Communications and Technology on "Using Spectrum to Advance Public Safety, Promote Broadband, Create Jobs and Reduce the Deficit"

April 12, 2011

INTRODUCTION

Chairman Walden, Ranking Member Eshoo, and members of the Committee, it is a pleasure to appear before you today. My name is Mary N. Dillon and I am President and Chief Executive Officer of United States Cellular Corporation. Today's topic is one of great importance to the wireless industry and wireless consumers, as well as to jobs and growth across all sectors of the U.S. economy.

U.S. Cellular is the sixth largest mobile operator in the U.S., serving over 6 million customers in rural, suburban, and urban markets in twenty-six states. We are members of the Rural Cellular Association as well as CTIA – The Wireless Association. We provide award-winning call quality and customer service. U.S. Cellular was rated the best cellphone service provider by Consumer Reports in January 2011[1], and has received numerous J.D. Power awards over the last five years.[2]

U.S. Cellular's networks serve the needs of consumers, businesses and public safety agencies. Our commitment to meeting customers' needs includes the on-going deployment of cell towers and advanced technologies to provide voice and broadband services to many unserved and underserved areas. Our aggressive investment in third-generation broadband networks already reaches about 98 percent of our customers. Our customers demand a high-quality mobile service for business and personal communications, and our wireless services provide critical infrastructure for jobs and economic growth in all types of communities.

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[1] Consumer Reports, "Consumer Reports cell-service ratings: AT&T is the worst carrier," ConsumerReports.org (Dec. 6, 2010).
[2] J.D. Power, "U.S. 2011 Wireless Call Quality Performance Study – Volume 1: Overall Wireless Call Quality Momentum Halts Due to Shifts in Wireless Call and Data Usage Patterns," JDPower.com (Mar. 3, 2011) (JDPower 2011).

Like other wireless carriers, U.S. Cellular needs and seeks to acquire additional spectrum to facilitate its deployment of fourth-generation broadband services and to meet the rapidly growing demand for wireless services.

CONSUMERS DEMAND MORE BROADBAND WIRELESS SERVICES, REQUIRING MORE NETWORK CAPACITY

Throughout its brief 25-year history, the wireless industry has been able to provide consumers and businesses with an ever-evolving, expanding array of innovative products and services. Carriers initially offered only voice communications, but now provide a wide range of broadband services, including high-speed data, video, and Internet services. What was once a novel, niche offering for only the most sophisticated users has become an essential service that vast numbers of consumers have come to depend upon in their daily lives for business as well as personal communications.

The range of new mobile services is huge and the growth in demand for these mobile services is breath-taking. In 2010, mobile data traffic nearly tripled, for the third year in a row.[3] And yet, the emergence and penetration of mobile data usage is still at an early stage; Cisco forecasts that the volume will grow 21-fold from 2010 to 2015.[4] Consumers' skyrocketing uses of innovative mobile services are creating economic growth and jobs. As FCC Chairman Genachowski recently highlighted in speaking to the CTIA annual convention, the number of mobile applications downloaded grew to 5

[3] Cisco, "VNI Mobile U.S. Fast Facts" (Mar. 2011).
[4] Id.

billion in 2010 from just 300 million in 2009; and mobile online shopping brought in nearly $4 billion in revenue in 2010, up from $1.4 billion in the prior year.[5]

Think about your own experience. I venture to say that virtually everyone in this room today now relies on one or even several mobile devices including a smartphone, tablet, or other mobile technologies every day, even every hour – both for business and personal communications. In fact, mobile data devices are arguably the most important consumer products that exist today. To help you understand the explosion of mobile data traffic, let's look closer at smartphones and tablets. Smartphones generate 24 times more traffic than a basic wireless handset, and consumers are rapidly shifting to these devices.[6] In 2010, smartphones accounted for 35 percent of all handset connections, and average data traffic per smartphone doubled during that year.[7] Smartphone sales in the U.S. are expected to increase by 42% this year.[8] Tablets, the fastest-growing category of devices, average about 122 times the mobile data traffic of a basic handset, and analysts project sales of 55 million tablets this year.[9]

Demand for these products and services will continue to increase at an accelerating rate. U.S. Cellular and other carriers want to ensure that wireless networks will be able to meet consumers' and businesses' growing needs for high-speed, reliable and ubiquitous access to data, other information and an expanding universe of applications.

Consumers use and enjoy mobile broadband technologies and services without thinking about what needs to go into the carriers' networks to support them. While the

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[5] FCC Chairman Julius Genachowski, "Remarks as prepared for delivery: CTIA Wireless 2011" at 5 (Mar. 22, 20110).
[6] Id.
[7] Cisco, supra.
[8] http://www.gartner.com/it/page.jsp?id=1550814
[9] Genachowski, supra, at 4-5.

future holds great promise for the industry, and, in turn, for innovation and job creation, there are headwinds threatening growth and the ability to service demand that need to be addressed by Congress to ensure that this promise is fully realized. Despite heavy investments in networks by carriers, and advances in technologies for devices and network infrastructure to support broadband services, there is one key element of wireless networks that is in critically short supply -- spectrum.

MORE SPECTRUM FOR WIRELESS CARRIERS THROUGH INCENTIVE AUCTIONS OF UNDERUTILIZED BROADCASTER SPECTRUM

The focus of this hearing, "spectrum," raises several of the most important issues confronting the wireless telecommunications sector today – in reality, these are key issues confronting all sectors of the nation's economy and society in all communities. There are three issues I highlight for you that merit your time and action if the industry is to achieve its potential over the next few years. Those issues are:

1) The critical need for additional spectrum to meet growing consumer demand for mobile services;

2) The need to provide a nationwide interoperable mobile broadband public safety communications network; and,

3) The rules that should govern spectrum usage going forward.

Of these topics, I believe the most important is the increasing demand for mobile services. In short, to meet this demand, more spectrum must be made available.

There is widespread agreement among carriers, the high-tech community, and the government that we are facing a severe spectrum shortage in the next few years. Here are a few examples.

First, the FCC's National Broadband Plan (released in March 2010) points to the growing demand for mobile broadband services and recommends that the federal government make 500 megahertz of spectrum newly available for broadband within ten years, of which 300 megahertz should be made available for mobile uses within five years. "More efficient allocation and assignment of spectrum will reduce deployment costs, drive investment and benefit consumers through better performance and lower prices." [10] Without prompt actions to make more spectrum available, the shortage will increase despite the fact that new fourth-generation technologies are more spectrum efficient.

Second, it has been reported that the consumer benefits from freeing up spectrum for mobile broadband could reach $300 billion.[11]

Third, the Consumer Electronics Association (CEA) and other representatives of technology companies strongly support increasing spectrum for broadband services based upon the increasing demand they see in the business and consumer marketplace for their devices and services. In February 2011, CEA (promoting growth in the $186 billion U.S. consumer electronics industry) stated: "Our nation's global competitiveness depends on broadband and ensuring that our finite spectrum is allocated to the most efficient and economically beneficial wireless services.... CEA and its members look forward to expanding wireless broadband, and in particular advancing the President's

[10] FCC, National Broadband Plan: Connecting America at XII (Mar. 2010).
[11] Genachowski, supra, at 9.

call for incentive auctions to redeploy underused broadcast spectrum for wireless broadband while reducing the federal deficit."[12] Similarly, the Information Technology Industry Council said: "Making additional spectrum available for commercial services as called for in the National Broadband Plan is going to be critical in creating jobs, driving innovation, and cultivating the technologies of the future."[13]

Fourth, and this is a key point that is frequently omitted from discussions about the availability of spectrum, international comparisons demonstrate that the United States uses wireless spectrum more intensively than other major industrialized nations, but lags in identifying new spectrum for mobile broadband services. The United States has more wireless subscribers served per megahertz of spectrum allocated (a measure of efficient use of spectrum), and has by far the highest average consumers' minutes of use per month. Yet, while the United States struggles to make significant additional spectrum available for wireless broadband services, in recent years, Japan has identified 400 MHz of new spectrum for auction; Germany 350 MHz; the UK 355 MHz; and each of France, Italy, Canada and Spain more than 250 MHz.[14]

There is widespread public support for freeing additional spectrum for commercial mobile uses. A recent nationwide consumer survey commissioned by U.S. Cellular shows that nearly 60 percent of the American public supports making more spectrum available for wireless carriers.

[12] Consumer Electronics Association, "CEA Applauds President Obama's Focus on Wireless Spectrum" (Feb. 10, 2011).
[13] Information Technology Industry Council, "Technology Industry Launches High Tech Spectrum Coalition" (Sept. 23, 2010).
[14] Data compiled by CTIA – The Wireless Association; Letter from CTIA – The Wireless Association and Consumer Electronics Association to Senators Rockefeller and Hutchison and Representatives Upton and Waxman (Mar. 17, 2011).

In a recent speech to the CTIA convention, Chairman Genachowski referred to spectrum as "our invisible infrastructure…the oxygen that sustains our mobile communications."[15] He's right about that assessment. Without additional spectrum becoming available, consumers' wireless experiences will suffer. As the leader of a company that consistently wins awards for its high quality network and overall consumer satisfaction, I shudder to think about the consequences of severe congestion where video freezes, calls are dropped, congestion pricing becomes a common offering, and surfing the web turns into an unbearable crawl.

Consumers have been experiencing the adverse effects of demand for mobile services challenging or even outstripping wireless network capacity. Consider first the quality of voice calls. According to semi-annual studies by J.D. Power, voice call quality (measured by the incidence of problems in seven areas, including dropped calls, static/interference, and failed call connection on the first try) steadily improved from 2003 through 2009. However, the recent growth in demand for mobile services, particularly mobile data and video traffic, halted this trend. The most recent study found that average problem rates for users of traditional handsets rose by 2 problems per 100 calls in just six months. On average, wireless customers in the Washington, D.C. metro area experienced 18 problems per 100 voice calls, and nationwide smartphone customers experienced 13 problems per 100 voice calls.[16]

As for wireless data performance problems, data service quality issues include slow downloads and Internet searches as well as unavailable and dropped connections.

[15] Genachowski, supra, at 5.
[16] JDPower 2011, supra; J.D. Power, "2010 U.S. Wireless Call Quality Performance Study – Vol. 2," JDPower.com (Sept. 9, 2010).

iPhone customers generated a tremendous surge in traffic. Network congestion led to strong consumer concern with network quality.[17] Moreover, slow, unreliable data services threaten to choke off new mobile applications, including machine-to-machine communications that could increase economic productivity and energy efficiency. One recent engineering analysis of mobile broadband by Rysavy Research concluded: "While carriers will attempt to alleviate congestion in the short-term by offloading traffic using femtocells and picocells, mobile innovation will falter without access to the substantial additional spectrum that American consumers and businesses will soon need, and the consequences of inaction for the nation are unacceptable."[18]

Without more spectrum, innovation and competitiveness in areas such as health care, education, and small business will be impeded. That is why Congressional action here is crucial. Also remember that it will take years following the passage of legislation before auctions are completed, spectrum cleared and services deployed. That's why Congress must act now.

So what should Congress do? The most efficient way to meet this rising demand is to give the FCC the authority to conduct incentive auctions for whatever underutilized broadcaster spectrum may be identified. Doing so will improve services, unlock innovation, and generate significant funds that Congress can determine how best to utilize.

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[17] Consumer Reports, supra.
[18] Rysavy Research, "The Spectrum Imperative: Mobile Broadband Spectrum and its Impacts for U.S. Consumers and the Economy – An Engineering Analysis" at 4 (Mar. 16, 2011).

RULES FOR SPECTRUM AUCTIONS, PUBLIC SAFETY, INTERCONNECTION AND UNIVERSAL SERVICE FUND

The most effective way to maximize the value of licensed spectrum is to structure auctions in small area blocks rather than national or mega-regional swaths. Auction structures providing for national or mega-region licenses preclude U.S. Cellular and other smaller carriers from being able to bid or compete effectively and win in such auctions. That in turn significantly reduces the revenues such auctions could generate.

Any legislation to authorize auctions must ensure that as many companies as possible can effectively bid and win licenses. More licensees mean more competitors in the marketplace, greater innovation and customer satisfaction, and, in a positive case of synergy, increased revenues to the Treasury.

As part of the goal of effective allocations of spectrum for mobile broadband uses, we must determine how best to provide public safety agencies with networks that meet their needs. Since 2007, U.S. Cellular has been actively engaged in the debate over what to do with the 700 MHz D block spectrum. We believe there are three policy principles that Congress should consider and that can be accommodated simultaneously in one set of rules.

- First and foremost, a national interoperable broadband network should be rapidly deployed meeting public safety's technical and availability requirements;
- Second, there should be opportunities to expand competitive broadband services subject to the needs of public safety, such as access to additional capacity in the case of emergencies; and
- Third, the first two policy considerations must ensure there is an efficient use of public resources and taxpayer dollars.

Importantly, the needs of public safety and commercial users for additional spectrum and cost-effective networks are mutually assisting, not inherently conflicting.

In testimony before House subcommittees on two prior occasions, U.S. Cellular supported the approach of a regional public-private partnership model.[19] We also supported the recommendation in the FCC's National Broadband Plan for a commercial auction of the D block. While we can see ways where, with proper legislative safeguards, a proposal to reallocate the spectrum to public safety could succeed, we still believe a public-private partnership model has merit. An arrangement in which commercial operators construct and operate the shared network at their expense and then work in partnership with regional public safety governing bodies to ensure interoperability and prioritization of use for the first responder community represents a unique and fiscally sound middle ground solution.

Finally, we need to update the rules that govern the use of spectrum with regard to interoperability and ubiquitous availability of mobile services. In order to maximize consumer benefits, auctions must be structured to guarantee that services deployed over newly available spectrum are capable of being utilized with maximum efficiency.

Legislation should mandate that carriers be required to deploy networks and services that are interoperable across the industry. If interoperability is not addressed, consumers (including public safety) will be unable to seamlessly roam on other networks and consumers will be unable to take handsets to other carriers if they choose

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[19] LeRoy T. Carlson, Jr., "Area Licensing: A Solution for the Public/Commercial Partnership in the 700 MHz D Block," Testimony before the House Committee on Homeland Security, Subcommittee on Emergency Communications, Preparedness and Response (Sept. 16, 2008); Joseph R. Hanley, Testimony before the House Subcommittee on Communications, Technology and the Internet (June 17, 2010).

to switch providers. Requiring interoperability will also have the benefits of fostering greater competition, reducing the prices of handsets and devices, and ensuring there is consumer choice in the marketplace.

As the Committee focuses on mechanisms to facilitate deployment of broadband services to consumers, please don't lose sight of the fact that there are consumers who live in rural areas that are non-economic to serve and, therefore, need some form of assistance. Today, that assistance is met through the Universal Service Fund, which I know needs to be updated and made to be more efficient. While this issue is not the central focus of this hearing, it does relate to spectrum policy as wireless carriers are going to continue to be challenged to build out and manage operations and maintenance in these areas. How Congress and the FCC handle the wireless portion of that program will have serious ramifications and I look forward to talking with you further about those concerns.

As an advocate for mobility on this panel, I urge you to ensure that consumers in the most rural portions of this country have access to the same kinds and quality of mobile voice and broadband services as those in urban areas. That was the standard called for in the 1996 Act and I see no reason that it should not be a goal today. As you and the FCC consider reforming USF, remember there are rural areas today where calls drop, access is very limited, and dead zones are commonly known throughout the local community. Despite what some of the largest carriers might advertise or tell you, their networks do not completely cover the nation. Mobile services are not available nationwide, and for these rural areas USF support is essential to finishing the job of a truly ubiquitous network.

CONCLUSION

In closing, let me reiterate my strong support for adoption of incentive auction legislation to increase the spectrum available for commercial mobile services. I also reiterate my desire that we solve the public safety debate as part of expanding the spectrum available for commercial mobile services, through a public-private partnership for the D block.

Thank you for the opportunity to testify today and I look forward to answering any questions you may have for me.

Mr. WALDEN. Thank you for your testimony.

We are going to go now to Mr. Bob Good, who is the Chief Engineer of WGAL–TV in Lancaster, Pennsylvania.

Mr. Good, thank you for being here. We look forward to your testimony.

STATEMENT OF ROBERT GOOD

Mr. GOOD. Good afternoon, Chairman Walden, Congressman Markey, and members of the subcommittee.

My name is Bob Good, and I am assistant general manager, director of operations, and chief engineer of WGAL–TV in Lancaster, Pennsylvania. I am testifying on behalf of Hearst Television, Incorporated, which owns and operates 29 television stations across the country, including WGAL–TV.

Less than 2 years ago, during the DTV transition, billions were spent upgrading facilities, purchasing converter boxes for viewers, educating viewers of the impending switch. In the process, the FCC repacked the television band and local broadcasters gave back 108 megahertz of spectrum, freeing up space for public safety and new commercial wireless services. From over-the-air HD signals to new multicast channels, broadcasters across the Nation are providing a more diverse and richer viewing experience.

Free over-the-air local broadcast television is not only the Nation's most watched and trusted platform for local news, virtually every local station, including mine, works hand-in-hand with first responders to provide public-safety information in time of local emergencies.

Local broadcast television is relied upon by 99 percent of the American people. In fact, some 43 million Americans depend exclusively on free over-the-air broadcasts as their only source of television. Many of these viewers are impoverished, elderly, live in rural areas, and/or are members of an ethnic minority. These are our viewers and your constituents, and it is essential that Congress not leave them behind in the consideration of spectrum reallocation.

I am an engineer, and I am here to offer an overview of WGAL–TV's transition experience and a real-world perspective on some of the technical issues that would accompany another repacking of existing broadcast spectrum.

The FCC staff and wireless industry propose to remove 20 of the current 37 channels in the UHF broadcast band. This would be a reduction of more than 50 percent of existing UHF broadcast channels. The consequences of that proposal, if implemented, would be staggering. The relocation of channels is not a simple matter of flipping a switch. The substitution of one channel in one market will create a domino effect across the entire country. One channel change in Chicago, for example, would require a channel change in Kalamazoo, which would require changes in Lansing, and in turn affecting Detroit, and so on and so forth.

The Lancaster market is bounded by five other television markets, including Philadelphia and D.C. After the repacking following the DTV transition, our station was initially authorized to transmit at a low power level to protect other stations from interference. That created significant gaps in our over-the-air coverage, and many of our longstanding viewers lost WGAL. Even some cable systems, with their tall towers and high-gain antennas, lost over-the-air access to our signal. That prevented them from retransmitting our station to their subscribers.

Within days of the transition, we received thousands of viewer complaints, and we still do. Today, we still haven't reached a point where our station's coverage replicates our pre-DTV service area. We are not sure, frankly, if it ever will.

We have petitioned the FCC for several power increases, and we have plans to install six new translator stations at a collective cost of at least another $1.5 million. That is on top of the $2.5 million we already spent on the DTV transition. Local viewers have also incurred additional costs by having to buy new home antennas to receive our VHF digital signal.

Unfortunately, this new repacking proposal has the potential to be more difficult. This time around, any repacking process would start with fewer alternative channels to assign to stations and the likelihood of greater interference for more closely packed channels. Also, due to the FCC's white spaces decision, we will have to contend with thousands of new unlicensed devices that have been authorized to operate in television bands.

Additionally, during the DTV transition, we had the luxury of operating two channels simultaneously, one analog and one digital. This time broadcasters would have to make a flash cut, because additional channel capacity no longer exists. That means that the viewers will not have adequate time to prepare for another repacking. The level of service disruption to your constituents could be unprecedented.

Broadcasters take their public stewardship commitment seriously, and we look forward to expanding and enhancing the important service our industry provides to you and your constituents. We will continue to work with the committee to strike an appropriate balance in achieving the Nation's overall communications policy goals.

Thank you. I will be happy to answer any questions you might have.

[The prepared statement of Mr. Good follows:]

Testimony of Robert Good
Assistant General Manager, Director of Operations, and Chief Engineer
WGAL-TV, Lancaster, PA

Before the House Energy and Commerce Committee
Subcommittee on Communications and Technology

April 12, 2011

Good afternoon Chairman Walden, Ranking Member Eshoo, and Members of the Subcommittee. Thank you for the invitation to appear before the Subcommittee. My name is Robert Good, and I am the Assistant General Manager, Director of Operations, and Chief Engineer for WGAL-TV in Lancaster, Pennsylvania, which is owned by Hearst Television Inc. I am here today on behalf of our company.

As an engineer, I am conversant with the technical issues associated with over-the-air television broadcasting and the technical implications for local television stations and viewers that would result from the reallocation of existing television broadcast spectrum to other users. My remarks focus on the extent to which broadcasters utilize their current digital spectrum, the technical challenges and expenses for those stations affected by a reallocation, and the impact of reallocation on their viewers and your constituents.

Broadcasters After the Digital Transition

Just 22 months ago, all full-power television stations in the United States returned their analog spectrum to the federal government and transitioned to an all digital television service. As part of the transition and in recognition of the technical advantages digital broadcasting affords stations and viewers, broadcasters agreed to narrow the band of spectrum allocated for broadcast television by some 108 MHz. The government then reallocated a portion of that spectrum for public safety and auctioned some for wireless mobile services. But the digital transition was not only about reallocating spectrum. The change to digital transmission significantly increased the diversity of over-the-air viewing choices and enhanced the technical quality of local television broadcast service for all Americans. From over-the-air, high-definition signals to the simultaneous broadcast of multiple streams of free, over-the-air television programming, broadcasters across the nation are providing a more diverse and richer viewing experience for their viewers and your constituents.

Broadcasters have always had a unique status among federal spectrum holders. We are required by statute and regulation to use our licenses to serve the needs and interests of our local communities. We take that obligation seriously. At Hearst Television, we are now delivering with our newly assigned digital spectrum a wide variety of new, diverse, and, in our view, vital and essential program services.

For example, at WGAL, in addition to our traditional, highly rated local and national network and syndicated programming, we are now providing additional programming on a new digital multicast channel consisting of a variety of national network, children's, special local news, local public affairs, public safety, weather, emergency, and other informational programming. We are looking, as I speak, at providing additional programming on our digital channels, and we are working with a coalition of stations to broadcast our programming to mobile receiving devices.

Our company owns 29 television stations and provides a wide variety of national and local entertainment, sports, Spanish-language, children's, news, public affairs, public safety, and public service programming on 57 digital channels, in the aggregate, in 26 of 29 markets. The new digital multicast channels are not *marginal* program services. These services are very popular with our viewers and your constituents. Our company will launch another new national network television service in 9 more markets this summer. We are also developing a national mobile content service to deliver on-demand video viewing.

Other broadcasters throughout the country are doing the same. According to a January 2011 analysis by SNL Kagan, by the end of 2010, the total number of digital channels provided by broadcasters (including HD channels, multicast channels, and mobile digital channels) increased to 2,518 – more than double the number of over-the-air broadcast offerings available before 2008. As of the end of 2010, the percentage of commercial television stations offering multicast channels had increased to 71%, thereby doubling the channel options for viewers with 1,240 additional digital channels, of which 142 were Spanish-language network affiliates. And just last week, a group led by Ambassador Andrew Young and Martin Luther King III announced plans to launch a new television network aimed at African-Americans, which will be distributed through the new multicast channels of local stations.

Beyond multicasting, some 70 stations that are part of the Open Mobile Video Coalition have recently launched a new mobile digital television service. Another group of broadcasters (the Mobile Content Venture) has announced plans to provide mobile DTV to 40% of the U.S. population by the end of this year, and the Mobile500 Alliance, another coalition of broadcasters, likewise is accelerating the roll-out of mobile digital television service nationwide.

Broadcasters across the country continue to experiment with new entertainment, ethnic, foreign language, children's, specialty, sports, public affairs, local news, public safety, and informational programming and mobile television services. Your constituents place great value on those services. As we sit here today, my engineering colleagues within the broadcasting industry are gathered at the National Association of Broadcasters (NAB) Convention in Las Vegas reviewing new equipment and learning about new technologies that will, in coming months, further enhance the over-the-air viewing experience for our viewers and your constituents.

Broadcast television is a vibrant, robust and ever-expanding service. Today, 99% of the public relies on local television stations (received over-the-air, by cable, telephone wires, and satellite) for diverse program services, including local and national news and public safety information. Indeed, among all media platforms, recent reports by the Pew Research Center Project for Excellence in Journalism confirm that broadcast television is the primary source of journalism for the American people.

It is also important to note that nearly 43 million people (including low income viewers, the elderly, and minority groups) currently rely exclusively on over-the-air television. Consumer interest in *free*, over-the-air television service is growing. Just last week, *Consumer Reports* stated that nearly one and a half percent of former pay-TV subscribers have "cut" the pay-TV cord and that seven percent (approximately nine million additional pay-TV subscribers) are considering it. Consumers have become increasingly aware of, and are relying on, the multiple new program services and the enhanced viewing experience now provided for free over-the-air by their local television stations for free.

The Debate Over Spectrum Reallocation

Continuation of the nation's universal, over-the-air television broadcast service and expansion of wireless broadband services are not mutually exclusive. Broadcasters do not oppose voluntary incentive auctions and the reallocation of broadcast spectrum, if, in fact, the auction and reallocation of broadcast spectrum is truly "voluntary."

For an auction process to be truly voluntary, it must be voluntary both for those stations that elect to participate in the auction and for those stations that elect to retain their licenses and continue delivering to their communities the full panoply of benefits of the digital transition. The public debate continues, moreover, on whether the reallocation of broadcast spectrum is, in fact, necessary for wireless broadband at this time. Point-to-multipoint transmission to the public of the most popular video programming and essential public safety and emergency information by broadcast stations, for instance, is a vastly more efficient utilization of bandwidth than point-to-point transmissions of that content by wireless carriers.

I also note that the technical advances now taking place in transmission and receiver technology will enhance the efficiency of *all* spectrum licensees. I anxiously await news from my engineering colleagues at the NAB Convention this week on the latest technical advances in this respect.

While I am not an expert in the various legal and public policy issues associated with spectrum reallocation, I can offer an engineering perspective on some of the technical issues that accompany the reallocation of existing broadcast spectrum and the impact of reallocation on our viewers and your constituents.

Broadcast Band Repacking

The National Broadband Plan issued by the FCC staff in March 2010 called for reallocation of 120 MHz of spectrum from television broadcasting to other users, including wireless carriers. Some, including the Commission, argue that the most efficient and useful way for this reallocation to occur would be through the creation of a single contiguous, nationwide spectrum block. Thus, if an additional 120 MHz were transferred from broadcast bands, broadcasters would lose 20 channels of current spectrum (each broadcast channel occupies 6 MHz of spectrum).

Some of these channels might be cleared from stations that elect to participate in the incentive auctions. In other cases, however, the FCC, of necessity, would have to require a broadcaster to move its operations to a new channel in order to clear channels on a nationwide basis. This process is referred to by regulators and the industry as "broadcast band repacking" or simply "repacking," and it could adversely affect more than 600 local television stations and millions of viewers across the country. The precise number would depend on the specific channels and the number of channels targeted for clearance, and on the number of stations that elect to participate in the incentive auction process. As explained below, the impact of repacking on stations and their viewers would be significant.

The Impact of the Repacking Process on Broadcast Stations

The removal of broadcast operations from one channel to another is not a simple or easy process. Each channel assigned to a broadcaster has its own specific block of frequencies, and, in turn, the equipment designed for that channel is designed for the transmission characteristics of that specific 6 MHz. It is not as if a local station, for example, could simply flip a switch or two and suddenly switch from channel 41 to channel 24. Rather, a station would confront a number of technical and financial considerations, all of which would be exacerbated this time around by potential interference to and from unlicensed devices operating in white spaces.

Technical Considerations

Major technical challenges will be encountered with further repacking of broadcast channels. The first results from the unique characteristics of the spectrum bands allocated to over-the-air broadcasting. The spectrum currently utilized for that purpose consists of three separate bands: the low VHF Band - channels 2-6 located between 54-88 MHz; the high VHF

Band - channels 7-13 located between 174-216 MHz; and the UHF Band - channels 14-51 located between 470-698 MHz (except channel 37, which is allocated to a different service).

Each of these bands has different propagation and data transmission characteristics. The UHF band is optimally suited for digital broadcasting. UHF also provides the most flexibility for future uses of broadcast spectrum, especially transmission to mobile devices. On the other hand, stations in the high VHF band will need greater power to replicate their analog service areas with digital over-the-air service, and also face greater challenges in the provision of mobile television services. We experienced virtually all of these at WGAL in connection with our most recent transition from a UHF channel to a VHF channel. And the third spectrum band, the low VHF television band, is less well suited for digital broadcasting. Broadcasters have discovered – notwithstanding the FCC's earlier projections – that the low VHF band has significant signal reception issues with digital and is subject to objectionable interference from other electronic devices.

CEA/CTIA and the FCC have suggested that reclaimed broadcast spectrum should be 120 MHz contiguous between 572 MHz and 698 MHz, or in other words, 20 channels of the current 37 channels in the UHF band. If that approach were taken, the number of existing UHF broadcast channels would be reduced by more than 50%. The consequences of that proposal for the affected stations and your constituents would be staggering.

A key issue associated with repacking is precisely how closely television channels could be packed together without experiencing or causing interference to each other and to other devices. Spectrum allocation is complex. It requires careful and knowledgeable technical planning and coordination.

Channels must be allocated far enough apart (a) to avoid over-the-air interference with each other and with other devices, and (b) to assure that television viewers continue to have access to a watchable picture. Television channels can be placed only so close together, and the challenge of harmonizing separate channels without causing objectionable interference is not limited to channels within a single market. Channel allocations must be harmonized with stations in adjoining markets, and those have to be further harmonized with stations in markets adjoining those markets, and so on down the line, i.e., the "daisy chain" effect. And even though digital broadcast channels can be spaced closer together than analog channels (which is why broadcasters were able to return 108 MHz of spectrum in the digital transition), at the end of the day, the laws of physics cannot be ignored.

Interference concerns are not limited only to the signal of one station interfering with another. Now that the FCC has opened up broadcast bands for use by so-called "white space" devices, local stations and your constituents must now be prepared to cope with potential interference from literally thousands of new unlicensed devices. Further reductions in channel spacing would inevitably result in increased television interference and a reduction in the use by your constituents of unlicensed devices in white spaces. And if interference results from repacking, our viewers and your constituents would lose access to the broadcast programming they currently enjoy- the full extent of that loss has not yet been determined by the FCC.

And, the above technical concerns do not begin to capture the problems that would result if broadcasters are forced by the FCC to *share* channels, as some have suggested. The technical challenges and costs associated with that proposal would be even more complex, and would impose even greater costs on stations and it would result in a greater loss by your constituents of local television broadcast service.

Capital Costs

In addition to signal interference and challenges to reception, broadcast band repacking will require affected stations to incur substantial new capital expenditures to purchase and install new equipment. While some have suggested equipment replacement costs would be relatively low, a conservative, best case, average estimate of the costs incurred by each broadcast station to replace its equipment is in the neighborhood of $1 million to $1.5 million for a UHF-to-UHF channel move. The average station will need to upgrade or replace about 30% to 50% of its broadcast transmission equipment (antenna, transmission line, and other related equipment): all of which was just upgraded to facilitate the digital transition and has yet to be fully amortized. Stations that rely on boosters or translators - as some of my company's stations do - to assure that those who live in rural areas receive a good local broadcast signal would incur significant additional costs. For example, my company's station KOAT-TV in Albuquerque relies on 32 translators and two full power satellite stations to reach the rural areas of New Mexico. Were the station to be required to change channels, many of those translators and satellite stations would likely be affected.

Repacking costs will vary, and for some stations the costs will be substantially higher than for others, particularly for stations that were early digital adopters. The early adopters based their transition on the first-generation digital transmission technology. Some of the more recent equipment, however, provides stations more flexibility to convert to a new channel (particularly a UHF-to-UHF channel switch where the channels are close together), all of which, of course, would mitigate some of the equipment replacement costs. The reality, however, is that each station will confront its own, unique technical and practical challenge and expense from repacking. A shift to another channel could mean signal power level changes or other coverage alterations that would necessitate the construction of a new broadcast tower or translator stations, removal of an old tower to a new location, or a combination of all of the above. And while all of these challenges will vary from station to station, they could be even greater this time than the last time depending on the specific channel and station involved.

If VHF channels were to be used to replace reallocated UHF channels, the costs for the affected stations would escalate, and the service area of each of those stations would be compromised. Transitioning from a UHF channel to a high VHF channel would require close to 100% replacement of transmission equipment, tower issues, etc., which could push a station's repacking costs in excess of $4 million. Much of the additional costs result from technical differences between the UHF and high VHF bands. Those transmitters would need to be replaced, rather than retuned; transmission lines may be incompatible and may need to be replaced; power levels would need to be adjusted to a new propagation characteristic; and a network of translator stations may need to be constructed. That is precisely the process we have had to go through at WGAL, and we are still engaged in that process 22 months after the transition and currently plan to construct six new translators to compensate for loss of coverage resulting from the transition.

Stations that would be required to shift to a low VHF band would suffer the most. A digital signal in the low VHF band would require an impractical and unrealistic increase in power to overcome background interference from other devices and maintain the station's service area.

Consumer Impact

There are obvious consumer issues associated with repacking. Broadcasters spent more than $1.2 billion for consumer education efforts during the digital transition. Estimates are that the government expended, at least, in excess of $100 million more. The consumer education campaign was designed to ensure that viewers were adequately prepared for the transition. Even with this all-out consumer education campaign, Congress felt it necessary to delay the transition by an additional four months to ensure that the American people had adequate time to prepare.

A new and additional "broadcast band repacking" transition would have a similar consumer impact. While it is true that any new transition would not carry with it the need for consumers to buy new set-top boxes, some consumers, for certain, would have to purchase new equipment. The recent digital transition forced consumers not only to buy a set-top box or new television set, but many also had to purchase a new home reception antenna. Since most stations were assigned a UHF channel during the transition, some retailers stocked UHF-only reception antennas, and consumers using those antennas would quickly discover that those antennas are not designed to receive VHF signals. Therefore, broadcasters moving from a UHF to a VHF channel, particularly in markets that currently are dominated by UHF channels, would have to develop and deploy a massive, new consumer education campaign on the antenna issue to avoid the loss of viewers, rating points, and advertising dollars.

Moreover, the most recent digital transition was a *staggered* transition, in that broadcasters were able to broadcast *two* signals—digital and analog—simultaneously for a considerable period of time in advance of the cutover date. The ability to broadcast on two channels allowed consumers to locate and acquire antennas, and adapt gradually to the new channels of their local stations. Unfortunately, viewers would not have this luxury during a second "repacking" transition. Without sufficient spectrum that would allow repacked stations to operate on an interim basis on two signals simultaneously, stations will be confronted with a "hard cut" in which they would switch off their old signal on the same day they switch on their new one. The level of viewer disruption, confusion, and dissatisfaction could well be unprecedented.

Local viewers would need to be given adequate notice of and time to prepare for any cutover. To further complicate the matter, not all stations would be able to institute a "flash cut" on the same date—it would depend on when their old channel allocations are licensed for wireless use. In addition, consumers would need to be informed about the need to rescan their set-top boxes or television sets, and the potential need to purchase a new home antenna to prevent loss of their local stations. Finally, consumers would need to know, depending on the specific channels used for the transition, that they may lose access to mobile digital or other new services. To address consumer complaints and assist viewers, stations would have to invest in a new, additional—and substantial—education campaign, one perhaps more extensive than that of the recent digital transition.

Conclusion

In short, the reallocation of broadcast spectrum and repacking of broadcast channels would have important implications for our viewers and your constituents. And, it would impose significant financial costs on the affected stations and will likely result in a material diminution of existing free, over-the-air television broadcast service. Our company, the NAB, and broadcasters across the nation are prepared, nevertheless, to work cooperatively with the Committee, with other Members, and with the Commission to strike an appropriate balance in achieving the nation's overall communications policy goals. We, as broadcasters, take our public stewardship commitment seriously, and we look forward to expanding and enhancing the important service we provide to you and your constituents.

Thank you for allowing me to appear before you today. I will be happy to answer any questions you might have.

Mr. WALDEN. Thank you, Mr. Good. We appreciate your being here today.

Now we would like to go to Mr. Julius Knapp, the Chief, Office of Engineering and Technology at the Federal Communications Commission.

We welcome you here and look forward to your testimony, sir.

STATEMENT OF JULIUS P. KNAPP

Mr. KNAPP. Thank you. Good afternoon, Chairman Walden, Congressman Markey, and members of the subcommittee. I appreciate the opportunity to speak to you today.

Mobile broadband holds great promise for economic growth, for creating jobs, for improvements to our quality of life, and for our global competitiveness. However, the explosion in demand for mobile broadband services is putting a strain on the limited supply of spectrum available for mobile broadband.

As you have heard, today's smartphones consume 24 times as much data as traditional cell phones, and the recently introduced tablets consume about 120 times more spectrum. Analysts have projected that there will be a 35 to 60 times increase in mobile broadband traffic over the next 5 years.

All we need to do to verify these projections firsthand is look in the palm of our hands at our wireless devices and how we use them. We check our e-mails, monitor the news and weather, get directions, watch sporting events and other programs that stream live to our phones.

Only a fraction of wireless users have these capabilities today, but the number is rapidly increasing. My little 3-year-old granddaughter doesn't yet know how to spell but she sure knows how to work the iPhone.

While we must continue to drive efficient use of spectrum, improvements in efficiency are not going to be enough. We will be facing a spectrum crunch in which demand for spectrum will exceed the supply by the year 2014 unless we promptly take action to make more spectrum available.

To address these challenges and seize the opportunities of mobile, the FCC is moving forward aggressively with a comprehensive mobile broadband agenda. Over the past year, the Commission has taken actions to open up additional spectrum for wireless broadband, including opening up spectrum in the 2.3 gigahertz band for mobile use and providing greater flexibility to offer terrestrial service in the mobile satellite spectrum. We have also freed TV white spaces spectrum, the most significant amount of unlicensed spectrum that we have made available in 25 years, to enable new technologies like Super Wi-Fi.

For more than a year, the Commission has conducted and we have now completed a baseline spectrum inventory. We have developed two tools, LicenseView and the Spectrum Dashboard, that are online and provide unprecedented transparency into the use of spectrum.

Our baseline spectrum inventory, together with our extensive prior work on spectrum, has allowed us to determine that the best opportunities for providing access to suitable spectrum for wireless broadband services lie in the TV broadcast bands and the mobile satellite service bands.

Nearly 20 years ago, Congress authorized and the FCC implemented a breakthrough, market-driven policy to better allocate this scarce resource: spectrum auctions. The idea was the right one at the right time, and, since 1993, spectrum auctions have not only raised more than $50 billion for the Treasury but have also generated hundreds of billions of dollars in private investment and productivity gains and enabled new competition that has dramatically lowered prices for consumers and accelerated the pace of innovation, which, in turn, has helped grow our economy.

Voluntary incentive auctions are the next tool for bringing market-based mechanisms to bear on spectrum allocation. Under this proposal, Congress would grant the FCC the authority to run two-sided, voluntary spectrum auctions in which current licensees would voluntarily contribute spectrum and would, in return, receive a portion of the proceeds from the auction.

Last week, 112 of the Nation's leading economists from across the ideological spectrum released a letter they had signed endorsing incentive auctions. The economists who signed this letter include Nobel and Nemmers Prize winners, former members of both Republican and Democratic administrations, and FCC chief economists who served under chairmen of both parties.

We recognize that some are concerned that voluntary incentive auctions will come at the expense of TV broadcasting. To the contrary, we believe that voluntary incentive auctions can be conducted in a manner that encourages a healthy and robust broadcasting industry.

While realignment of broadcast stations will be necessary to ensure efficient use of the spectrum freed up from an incentive auction, our proposal seeks to limit the number of stations that would need to switch frequencies as part of the realignment process. For those that do, we would work to limit any loss of service to over-the-air television viewers and would fully reimburse the broadcasters for any costs associated with relocating.

No stations would be required to move from the UHF band to the VHF band unless they freely chose to do so in exchange for a share of the auction proceeds. And, finally, because digital technology allows stations to use virtual channel numbers, even if a station's actual channel number changes through realignment, it can continue to have the former channel number display on television screens and set-top boxes.

In closing, let me suggest that voluntary incentive auctions are the right idea at the right time. I thank you for your attention.

Mr. WALDEN. Mr. Knapp, thank you. Thank you for your good work and thank you for testifying today.

[The prepared statement of Mr. Knapp follows:]

Statement of
Julius P. Knapp
Chief, Office of Engineering and Technology
Federal Communications Commission

Hearing on Using Spectrum to Advance Public Safety, Promote Broadband, Create Jobs, and Reduce the Deficit

Before the
Subcommittee on Communications and Technology
Committee on Energy and Commerce
U.S. House of Representatives

April 12, 2011

Good afternoon Chairman Walden, Ranking Member Eshoo, and Members of the Subcommittee. I appreciate the opportunity to appear before you today.

A little over a year ago the FCC developed the country's first National Broadband Plan to identify the key strategic issues our country faces in making broadband available to all Americans and to make recommendations for achieving that goal. The National Broadband Plan placed unprecedented emphasis on mobile broadband, in part because no other sector now holds more promise for economic growth, for creating jobs, for improvements to our quality of life, and for our global competitiveness.

Mobile Broadband Services and Devices Are Revolutionizing our Lives. Mobile broadband services and devices are revolutionizing virtually every aspect of the way we live, work and play. Only a few short years ago wireless networks and cell phones offered one simple but important capability - - to make voice telephone calls and call 9-1-1 from almost anywhere.

Today's wireless networks can do so much more - - they provide access to the Internet, location based services, streaming video content, and many other capabilities.

Wireless networks are evolving from the 3G services that gave us our first taste of mobile broadband connectivity, to 4G services that rival the connectivity many people enjoy today on their desktop computers.

Smartphones are getting more powerful and their operating systems are getting smarter. In the 4th quarter of 2010, smartphones outsold PCs worldwide – 101 million to 92 million. The commercial tablet market didn't even exist until a couple of years ago. Now, the iPad2 is backordered for several weeks.

Health care is being transformed by remote medical monitoring devices that can help diabetes patients track their glucose levels or heart disease patients monitor cardiovascular data. These new devices will vastly improve quality of care, reduce medical costs, and most importantly, save lives.

The energy sector is creating the smart grid, which relies on wireless technologies to reduce our fuel consumption and save money.

Education is also being transformed by mobile broadband, with wireless services enabling broadband service to schools and classrooms in rural areas. The backpack of textbooks that many of us once carried to school as children is being replaced by digital textbooks the size of a composition notebook that can be updated instantaneously.

An entire new industry has emerged based on the creation of applications, or "apps," for wireless devices, built upon the ingenuity of entrepreneurs and small businesses. This industry barely even existed just a couple of years ago. In 2009, people downloaded 300 million mobile apps. Last year, that number increased more than 16 times to 5 billion downloaded mobile apps.

We could barely have imagined these possibilities just a few short years ago, yet we have just begun to scratch the surface. The revolution is only just beginning.

Mobile Broadband Growth is Vital to Growth of Our Economy and Creation of Jobs. There is perhaps no other sector that is more vital to growing our economy and creation of jobs. Consider the following data points:

- Analysts project tablet sales of 55 million worldwide this year, making it a $35 billion dollar industry.
- By 2015, the "apps economy," is projected to generate $38 billion in sales.
- In 2009, mobile online shopping brought in $1.4 billion. Last year, it jumped to nearly $4 billion.
- According to the High Tech Spectrum Coalition, over the next five years, investments in 4G wireless technologies will create 205,000 U.S. jobs.

Companies like Groupon and Living Social, which are moving aggressively into the mobile space, are each hiring more than 150 employees ... a month.

The 4G buildout itself is an engine for job creation. According to industry reports, deploying the 40,000 towers needed for these next-generation mobile networks will create 53,000 jobs and help us reach the goal the President set to bring 4G service to 98 percent of Americans in the next 5 years.

The bottom line is that mobile broadband is being adopted faster than any computing platform in history, and it could surpass all prior platforms in its potential to drive economic growth and opportunity.

There Is A Looming Spectrum Crunch. Spectrum - - the airwaves - - is our invisible infrastructure. It is the oxygen that wireless networks and devices need to operate and thrive. Without adequate spectrum, calls are dropped, service is unreliable and data speeds slow to a crawl, chilling the development of all of the wonderful things I've discussed earlier.

The Commission has worked hard to increase the supply of spectrum available for mobile broadband, increasing the amount available by about threefold. That sounds pretty good until your start to take a look at the demand side of the equation.

Smartphones consume 24 times as much data as traditional cell phones. And for tablets that number is about 120 times. And then there are all the industries that are just beginning to rely on wireless technologies for the more efficient delivery of service - - health care, energy, public safety, transportation and education among them -- all of which will add to the load that will need to be carried on the wireless networks.

Some analysts forecast a 35X increase in mobile broadband traffic over the next 5 years. Cisco has projected a nearly 60X increase between 2009 and 2015.

All we need to do verify these projections first-hand is look in the palm of our hands at our wireless devices and how we use them. We check our e-mails, monitor the news and weather, get directions, and watch sporting events and other programs that stream live to our phones.

Only a fraction of wireless users have these capabilities today, but the number is rapidly increasing. My little three year-old granddaughter doesn't yet know how to spell, but she sure knows her way around the screen of an iPhone.

This explosion in demand for spectrum is putting strain on the limited supply available for mobile broadband. We certainly must continue to drive efficient use of the spectrum, but efficiency improvements are not going to be enough. We will be facing a spectrum crunch, in which demand for spectrum will exceed supply, by early 2014 unless we promptly take action to make more spectrum available. Otherwise, consumers will face dropped calls, slow or no service and skyrocketing prices for mobile data.

The FCC Has Established A Comprehensive Spectrum Agenda. To address these challenges and seize the opportunities of mobile, the FCC is moving forward aggressively with a comprehensive mobile broadband agenda as set out in the National Broadband Plan.

We have eliminated unnecessary restrictions on the use of certain spectrum bands. This has allowed us, for example, to open 25 megahertz of spectrum in the 2.3 GHz band, which is already being used for broadband in Korea.

We initiated a proposal to provide greater flexibility to offer terrestrial service in the frequency bands that are allocated for mobile satellite service. Last week the Commission adopted rules to implement this proposal.

We freed up TV "white spaces" spectrum – the most significant amount of unlicensed spectrum in 25 years -- to enable new technologies like "Super Wi-Fi." We are working hard to put all the pieces in place to enable making new innovative "Super Wi-Fi" devices available and providing new services before the end of this year, if not sooner.

We are driving more efficient and innovative uses of spectrum – taking action to spur dynamic spectrum sharing and secondary markets for spectrum, as well as facilitating development and deployment of femtocells, smart antenna technology, and technologies like Wi-Fi that can use unlicensed spectrum to off-load traffic from cellular networks.

The Commission is working to remove obstacles to robust and ubiquitous deployment of 4G mobile broadband (*e.g.*, regulatory barriers related to tower sitings). It's been estimated that removing red tape and expediting approval processes could unleash $11.5 billion in new broadband infrastructure investment over two years.

We are also collaborating with the National Telecommunications and Information Administration to support an Executive Order issued by the President to free up 500 megahertz of spectrum for broadband, almost double what is currently available. Our Spectrum Task Force issued a public notice inviting comment on fast track spectrum bands that NTIA identified for wireless broadband service and on the spectrum bands that are candidates for further study to meet the 500 megahertz goal.

The FCC Has Completed A Baseline Spectrum Inventory. For more than a year the Commission has conducted – and has now completed – a baseline spectrum inventory. The Commission's baseline inventory is one of the most substantial and comprehensive evaluations of spectrum in its history. We have developed two tools – LicenseView[1] and the Spectrum Dashboard[2] that provided unprecedented transparency into the use of spectrum.

The Spectrum Dashboard, released last year, identifies how non-Federal spectrum is currently being used, who holds spectrum licenses and where spectrum is available. The Commission just released Spectrum Dashboard 2.0, an upgraded version that provides more granular information about spectrum holdings, including the ability to determine the extent of licensing within counties and on tribal lands, and offers additional insights on the secondary market in spectrum licenses through the addition of leasing information.

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[1] *See* http://reboot.fcc.gov/license-view.

[2] *See* http://reboot.fcc.gov/reform/systems/spectrum-dashboard.

LicenseView is a comprehensive online portal to information about each spectrum license. It presents data from multiple FCC systems in a searchable, user-friendly manner.

Our work leading up to and in creating and maintaining a spectrum inventory has provided the necessary information to determine how best to unleash significant additional spectrum for wireless broadband within the next ten years. It has enabled us to obtain a more complete picture of what spectrum is dedicated to what purposes and where spectrum can be made available for flexible use, including mobile broadband.

The task of identifying spectrum for wireless broadband services must take into account a number of factors. These factors include the need for large blocks of contiguous spectrum to accommodate the latest technologies and provide opportunities for new entrants and competition. Our baseline spectrum inventory has allowed us to determine that the best opportunities for providing access to suitable spectrum for wireless broadband services lie in the TV broadcast bands and Mobile Satellite Service Bands.

The Commission Seeks Authority to Conduct Voluntary Incentive Auctions. Through the years, the Commission has been granted authority and the flexibility to smoothly transition spectrum from one service to another while ensuring the continued viability of existing services. Nearly 20 years ago, Congress authorized and the FCC implemented a breakthrough, market-driven policy innovation to better allocate this scarce resource – spectrum auctions. Previously, spectrum was allocated through comparative hearings and lotteries. The shift to auctions was a way to use market forces to drive spectrum to its most valuable uses.

The idea was the right one, and since 1993, spectrum auctions have not only raised more than $50 billion in revenue for the Treasury, but also generated hundreds of billions of dollars in private investment and productivity gains and enabled new competition that dramatically lowered prices for consumers and accelerated the pace of innovation, which in turn has helped grow our economy.

As recommended in the National Broadband Plan, the Commission is seeking authority to move to the next generation of market-based auction policy. Voluntary incentive auctions are the next tool for bringing market-based mechanisms to bear on spectrum allocation.

Under this proposal, Congress would grant the FCC the authority to run two-sided, voluntary spectrum auctions, in which current licensees would voluntarily contribute spectrum and would in return receive a portion of the proceeds of the auction. The voluntary incentive auction proposal is an incentive-based, market-driven path to tackle America's spectrum crunch and would provide a capital infusion for licensees that choose to participate with some or all of their spectrum, strengthening their economic position.

The Commission can initially apply this market-based tool to the mobile satellite services and broadcast television bands, which as I mentioned stand out as falling within the frequencies appropriate for mobile use that have sufficient bandwidth to offer clear opportunities for increased spectrum access.

Estimates show that the revenue potential of voluntary incentive auctions could reach $30 billion. Based on past experience, some estimate that the consumer benefits of freeing up spectrum for mobile broadband would be 10 times higher than the value that spectrum generates at auction. An auction market value of $30 billion would translate to broad consumer benefits of $300 billion.

Last week, 112 of the nation's leading economists from across the ideological spectrum released a letter they had signed endorsing incentive auctions. The economists who've signed this letter include Nobel and Nemmers Prize winners, former members of both Republican and Democratic administrations, and FCC Chief Economists who served under Chairmen of both parties. The letter states:

> Congress has another chance to give the FCC a valuable tool to increase the efficiency of spectrum use in the United States by granting the FCC the authority to auction spectrum it controls at the same time as it auctions spectrum licenses held by commercial entities. Auction design and practice is sufficiently advanced that the FCC can successfully implement this type of auction. Incentive auctions can facilitate the repurposing of spectrum from inefficient uses to more valuable uses while minimizing the transaction costs incurred. Giving the FCC the authority to implement incentive auctions with flexibility to design appropriate rules would increase social welfare.

The economists' letter follows one sent earlier this year by associations representing more than 2,000 companies with over $1 trillion in revenue, calling on Congress "to swiftly pass legislation allowing the FCC to conduct voluntary incentive auctions" and calling these auctions "critical to furthering innovation and growing jobs in America."

Voluntary incentive auctions are the right idea at the right time. It's essential that we move quickly – not only because of the benefits of action, but because of the costs of inaction. If we do nothing in the face of the looming spectrum crunch, many consumers will face higher prices – as the market is forced to respond to supply and demand – and frustrating service – connections that drop, apps that run unreliably or too slowly.

We Support Ensuring a Healthy and Robust TV Broadcasting Industry. We recognize that some are concerned that voluntary incentive auctions will come at the expense of TV broadcasting. To the contrary, we believe that voluntary incentive auctions can be conducted in a manner that encourages a healthy and robust broadcasting industry.

While realignment of some broadcast stations will be necessary to ensure efficient use of the spectrum freed up in an incentive auction, our proposal seeks to limit the number of stations that would need to switch frequencies as part of the realignment process. For those that do, we would work to limit any loss of service to over-the-air television viewers and would fully reimburse them for any costs associated with relocating. No stations would be required to move from the UHF band to the VHF band unless they freely chose to do so in exchange for a share of the auction proceeds. Finally, because digital technology allows stations to use virtual channel numbers, even if a station's actual channel number changes through realignment, it can continue to have its former channel number display on television screens and set-top boxes.

Conclusion. If there is one point worth repeating, it is that we must continue to seize every opportunity to free up spectrum for mobile broadband, including through the use of new tools like incentive auctions, so that this finite resource can continue to be an engine for economic growth, job creation, innovation, competition, improvements to our quality of life, and for our global competitiveness. I thank you for your attention and would be pleased to answer any questions you may have.

Mr. WALDEN. Now we would like to go to Peter K. Pitsch, the Executive Director of Communications Policy and associate general counsel of Intel. Welcome.

STATEMENT OF PETER PITSCH

Mr. PITSCH. Thank you. Good afternoon, Chairman Walden, Congressman Markey, members of the subcommittee. It is a pleasure to testify before this committee on this issue of whether or not to grant legislative authority to the FCC to conduct incentive auctions.

Intel strongly supports passage of such legislation this year. Intel, along with Alcatel-Lucent, Apple, Cisco, Ericsson, Nokia, Qualcomm and Research In Motion, formed the high tech spectrum coalition to advocate specifically for passage of this legislation.

Today I want to make three points. First, the U.S. is facing a severe mobile broadband spectrum shortfall. Second, voluntary incentive auctions would help address this problem. Third, incentive auctions can prudently be implemented on the broadcasting spectrum now.

First, as many already noted, including Julius Knapp, longtime friend, United States faces a severe global broadband spectrum shortage. In the interest of time, suffice it to say I strongly concur, would only add that it is important to recognize that the FCC's command and control administrative process for reallocating spectrum does not work well. Furthermore, the low hanging spectrum band suitable for mobile use already have been reallocated.

Incentive auctions can break this logjam which brings me to my second point: Voluntary incentive auctions would help address our Nation's spectrum shortfall in a way that is beneficial to incumbents and to new users, to taxpayers and society. The voluntary nature of the process would ensure that incumbents who choose to sell and mobile broadband operators who choose to buy spectrum both would be better off. Also, taxpayers will benefit because incentive auctions, by reducing transactions problems and the holdout problems, can produce valuable cleared spectrum.

Much of the revenue raised from the spectrum would go to the U.S. Treasury. For instance my fellow panelist, Coleman Bazelon and his colleague, Chuck Jackson, in an analysis underway for the high tech spectrum coalition estimate that those benefits might well exceed $20 billion. But most importantly, and the reason why I am here today, is that the gains, the long-term gains to consumers and society for lower prices, more minutes, less congestion were valuable services dwarf the gains to the broadband operators, the broadcasters or the taxpayers. Economists Hazlett and Munoz estimate conservatively that the benefits to consumers would be on the order of 10 times the private gains and the taxpayers effects. The net gains to consumers could easily be in the hundreds of billions of dollars.

Lastly, the U.S. policy leadership in this sector could create a global competitive advantage, fostering American jobs and innovation. Conversely, if our broadband networks become more congested, if prices go up, then the creation of innovative services will be stymied and American workers and consumers will be denied valuable jobs and services.

Finally to, my third big point, incentive auctions can be used prudently to reallocate TV spectrum, a full 120 megahertz of TV broadcasting spectrum now.

In the interest of time, I will just summarize a few points, but hopefully in the Q&A session, we can get into the objections that have been made. My contention is that they are either wrong or misplaced. Over-the-air broadcasting will remain available. Broadcasters whose channels are repacked could, should, and would be fully compensated. They would be kept whole. I would add, however, that the repacking process was never intended to be, itself, made voluntary, and that if we were to make the repacking process voluntary we would give holdout power to the broadcasters who are on these clear bands of contiguous spectrum. Either they wouldn't exercise their holdout power collectively and we wouldn't get the spectrum, or there would be virtually no money leftover for the taxpayer.

So in sum, Intel strongly urges the members of this subcommittee and Congress to act this year to give the FCC broad authority to conduct voluntary incentive auctions. Such legislation represents one of the most important opportunities to free up much needed additional spectrum for mobile broadband. The benefits to U.S. consumers, taxpayers, and American society would be enormous. Thank you.

[the prepared statement of Mr. Pitsch follows:]

Before the

Subcommittee on Communications and Technology

United States House of Representatives

Hearing on "Using Spectrum to Advance Public Safety, Promote Broadband, Create Jobs, and Reduce the Deficit"

Statement of Peter K. Pitsch

Associate General Counsel

Executive Director, Communications Policy

Intel Corporation

April 12, 2011

SUMMARY OF MAJOR POINTS. Using voluntary incentive auctions, the FCC could free up much-needed additional spectrum for mobile broadband use by inducing incumbent licensees to relinquish their spectrum for a share of the ultimate auction proceeds.

The U.S. is facing a severe mobile broadband spectrum shortfall. New technology and investment can help meet the burgeoning increases in mobile data demand, but the allocation of additional spectrum should play a vital role in relieving congestion and promoting prosperity, jobs, and innovation.

Voluntary incentive auctions would help address this spectrum shortfall. The voluntary nature of the process ensures incumbents who choose to sell and mobile broadband operators who choose to buy spectrum both would be better off. Taxpayers will benefit because incentive auctions – by reducing transactions costs and holdout problems – can produce valuable cleared spectrum. The gains to society and the economy from lower prices, more minutes of use, less congestion, and new more valuable services would be in the hundreds of billions of dollars.

Incentive auctions can be prudently implemented on broadcasting spectrum now. Over the air TV broadcasting would remain available to those consumers who rely on it. The costs of broadcasters whose channels are changed (*i.e.*, repacked) would be covered. But, making repacking voluntary would give many broadcasters "hold-out" power – leaving little, if any, money for the U.S. Treasury. Inventorying spectrum and using incentive auctions can and should proceed in parallel. Finally, the bidding process can be kept competitive to ensure that broadcasters do not earn unreasonable windfalls.

Intel urges the members of this Subcommittee and Congress to pass legislation this year to give the FCC broad authority to conduct voluntary incentive auctions.

Introduction

I am Peter K. Pitsch, director of Intel's global spectrum and communications policy efforts. Intel is the world's largest semiconductor manufacturer and a world leader in computing innovation. We design and build the essential technologies that serve as the foundation for the world's computing devices. We strive to accelerate the convergence of computing and communications through silicon-based integration.

Prior to joining Intel twelve years ago, I worked on telecommunications policy issues at the FCC from 1981 to 1989 as chief of staff to Chairman Dennis Patrick and as chief of policy and planning for Chairman Mark Fowler and in private practice from 1989 to 1998. In total I have worked on spectrum and other telecommunications policy issues for nearly 30 years.

It is an honor to appear before this Subcommittee to testify on the benefits of granting the FCC legislative authority to conduct incentive auctions. Intel strongly supports passage of legislation giving the Federal Communications Commission broad legislative authority to conduct incentive auctions. Intel, along with Alcatel Lucent, Apple, Cisco, Ericsson, Nokia, Qualcomm and Research in Motion, formed the High Tech Spectrum Coalition (HTSC) to advocate specifically for enactment of such legislation.

Using voluntary incentive auctions, the FCC could free up much-needed additional spectrum for mobile broadband use by inducing incumbent licensees to relinquish their spectrum for a share of the proceeds generated from the auction of the cleared spectrum. The benefits to U.S. consumers and taxpayers from making this additional spectrum available for mobile broadband use would be enormous.

Today I wish to make three points:

- The U.S. is facing a severe mobile broadband spectrum shortfall.
- Voluntary incentive auctions would help address this spectrum shortfall.
- Incentive auctions can be prudently implemented on broadcasting spectrum now.

The U.S. is facing a severe mobile broadband spectrum shortfall.

Mobile data demand is burgeoning. Private and FCC analyses predict that mobile data traffic will increase 25 to 40 times in the next four years.[1] These projections are consistent with Intel's experience. Smart phones, tablets and notebooks are accessing much more video. 61M Americans now have smart phones ... and that number is growing fast.[2]

New technology and investment can help, but the allocation of additional spectrum should play a vital role in relieving congestion and promoting prosperity, jobs, and innovation. The pace of improvements in radio technology, while impressive, will not keep pace with the

[1] The Yankee Group estimates that mobile data traffic will increase 25 times by 2014. Yankee Group, *Spectrum-Rich Players Are in the Driver's Seat for Mobile Broadband Economics*, June 2009. Cisco estimates that such traffic will increase 40 times over the same 4 year period [from .09 exabytes/month in 2009 to 3.6 exabytes/month by 2014]. See Cisco, "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015," white paper, February 2011, downloaded on March 18, 2011 from: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/whitepaper The FCC projects that 2014 demand will be 35 times greater than that of 2009. See "Mobile Broadband: The Benefits of Additional Spectrum," FCC Staff Technical Working Paper, October 2010, Federal Communications Commission, Washington, DC, p.9.

[2] Remarks of Chairman Julius Genachowski, Federal Communications Commission, FCC Spectrum Summit, "Unleashing America's Invisible Infrastructure," Washington, D.C., October 21, 2010. Moreover, the percentage of Americans age 12 and older who have a smartphone has more than doubled in the past year, from 14 percent to 31 percent of the population according to a new national survey. *Arbitron Inc./Edison Research, The Infinite Dial 2011: Navigating Digital Platforms* (rel. April 5, 2011), available online at *http://www.edisonresearch.com/home/archives/2011/04/the_infinite_dial_2011.php*

increase in mobile data demand. Nor will off loading to WiFi networks, splitting cells and other such techniques solve the problem.[3]

All available alternative ways of freeing up more spectrum for mobile broadband use should be considered. In addition to incentive auctions, reforming the Commercial Spectrum Enhancement Act to give federal government users more tools to clear spectrum, giving private users more flexibility to innovate and change use, and inventorying existing uses should be considered.

But, it is important to recognize that the FCC's "command & control" administrative process for reallocating spectrum does not work well. The "low hanging" spectrum bands suitable for mobile use already have been reallocated. And even in easier situations, the administrative reallocation process can be extraordinarily slow and inefficient. For example, the 20-year cellular delay cost U.S. society tens of billions of dollars.[4]

Incentive auctions would help address the mobile spectrum shortfall.

Voluntary incentive auctions would help address our nation's spectrum shortfall in a way that is beneficial to incumbent and new spectrum users, taxpayers, and consumers and society. First, the voluntary nature of the process ensures incumbents who choose to sell and mobile broadband operators who choose to buy spectrum both would be better off. This point bears

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3 "While carriers will attempt to alleviate congestion in the short term by offloading traffic using femtocells and picocells, mobile innovation will falter without access to the substantial additional spectrum that American consumers and businesses will soon need, and the consequences of inaction for the nation are unacceptable." *Rysavy Research, The Spectrum Imperative: Mobile Broadband Spectrum and its Impact for U.S. Consumers and the Economy, An Engineering Analysis*, at 4 (March 16, 2011), available online at http://www.mobilefuture.org/page/-/rysavy-spectrum-effects-301611.pdf

4 Jeffrey H. Rohlfs, Charles L. Jackson & Tracey E. Kelly, n/e/r/a, "Estimate of the Loss to the United States caused by the FCC's Delay in Licensing Cellular Telecommunications," at 1, November 8, 1991 (revised).

emphasis: incentive auctions will reallocate spectrum only when the parties to the transactions view the spectrum's new use as more highly valued than its existing use.[5]

Second, taxpayers will benefit because incentive auctions – by reducing transactions costs and holdout problems – can produce valuable cleared spectrum. Much of the revenue raised from auctioning this spectrum would go to the U.S. Treasury. For instance, economist Coleman Bazelon and engineer Chuck Jackson, in analysis underway for HTSC, conservatively estimate taxpayer gains from using incentive auctions to clear 120 MHz of broadcast spectrum to be in excess of $20 billion.

Most importantly, the gains to consumers and society from lower prices, more minutes of use, less congestion, and new more valuable services would be enormous and dwarf the gains to incumbents, broadband operators, and taxpayers. Economists Thomas Hazlett and Roberto Munoz estimate that these consumer gains would likely be ten times greater than the private and taxpayer gains.[6] Thus, the net gain to consumers from clearing 120 MHz of broadcast spectrum would be in the hundreds of billions of dollars. Lastly, U.S. policy leadership in the mobile broadband sector could provide a global competitive advantage for American jobs and

[5] See Letter by 112 economists to President Barack Obama, Stanford Institute for Economic Policy Research, April 6, 2011.

[6] Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, RAND Journal of Economics, Vol. 40, No. 3 (Autumn 2009), , at 425 (available online at http://mason.gmu.edu/~thazlett/pubs/Hazlett.Munoz.RandJournalofEconomics.pdf). "Empirical research undertaken a decade ago found the annual consumer surplus associated with U.S. cellular telephone licenses (issued in the 1980s) at least 10 times as large as annual producers' surplus (Hausman, 1997; Rosston, 2001). Today, U.S. wireless phone market data yield an annual consumer surplus estimate of at least $150 billion. The total revenue obtained from selling all wireless licenses (not just for mobile telephony) is just $53 billion. Given that the latter is a present value and the former an annual flow, these data suggest that the ratio (CS to PS) is much above an order of magnitude."

innovation. Conversely, if our broadband networks are congested or service prices are high, the creation of innovative new services will be stymied and American workers and consumers would be denied valuable services.

Incentive auctions can be prudently implemented on broadcasting spectrum now.

Intel believes that a prime candidate for use of voluntary incentive auction authority should be 120 MHz of the spectrum band currently being used for over the air television broadcasting. Four main objections have been raised: (1) consumers would lose access to over the air TV broadcasting, (2) channel moving or repacking would harm broadcasters who choose not to participate in the auction, (3) the use of incentive auctions should be postponed until a spectrum inventory is complete, and (4) broadcasters would earn a windfall. These objections are either misplaced or wrong.

First, over the air TV broadcasting would remain available to those consumers who rely on it. As we discovered in preparation for the DTV Transition, most (roughly 90% of) U.S. households currently receive their TV broadcast content from cable and satellite operators; less than 10% of US households rely exclusively on over the air TV broadcasting. Moreover, analysis underway by Bazelon and Jackson shows that many full power TV stations would continue to operate. And their estimates are conservative, because they do not factor in those stations that would choose to continue over the air operation by moving to the VHF band or by sharing a channel with another station.

Second, broadcasters whose channels are changed (*i.e.*, repacked) would be kept whole and there will be ample funds to cover their costs. The Bazelon/Jackson analysis will show that the costs of repacking these broadcasters are relatively small—less than $900,000 per full power station on average and under one billion dollars in total. They also will find that there is sufficient tower space to ensure that repacked broadcasters could continue to serve their current coverage areas.

But, it is critical to note that the repacking process should not be made voluntary. The FCC already has authority to mandate that a particular broadcaster move channels, *e.g.* from channel 39 to channel 29. This repacking authority is necessary in order for the FCC to clear and then auction large contiguous blocks of spectrum (as opposed to smaller "swiss cheese" blocks) which are most efficient for mobile broadband use. Making repacking voluntary would give many broadcasters "hold-out" power. In that case clearing large contiguous bands would require that these broadcasters agree on how to exercise their hold out power. Even if they do agree, they would capture virtually all of the auction revenues raised by reallocating spectrum from TV broadcast to mobile broadband use – leaving little, if any, money for the U.S. Treasury.

Third, the spectrum inventory process should not delay the use of voluntary incentive auctions on this band. While Intel supports inventorying current spectrum use, this exercise should not delay the expeditious adoption of legislation granting the FCC incentive auction authority. Again, given the voluntary nature of incentive auctions, they will only reallocate spectrum when the new mobile broadband use is more highly valued by the marketplace than the spectrum's existing use. So there is no need to delay the use of incentive auctions; in fact, the cost to consumers of delaying such reallocations would be enormous—in the billions of dollars. Inventorying spectrum and using incentive auctions can and should proceed in parallel.

Fourth, the bidding process can be kept competitive to ensure that broadcasters do not earn unreasonable windfalls. It will be important for the Commission to impose strong anti-collusion rules, as they have done in the past. Also, the FCC should have the flexibility to reduce the amount of spectrum cleared nationally or in a particular market below 120 MHz if they believe broadcasters' bids are too high. If bidders put in a bid for more than they are willing to accept, they may find that their offer is rejected, but the price paid to an accepted bidder is higher than the price they would have been willing to accept. The prospect of this happening should help keep the bidding process competitive. Using these and other auction design tools, the FCC should be able to ensure that broadcasters who choose to relinquish their spectrum licenses would receive auction proceeds reasonably related the enterprise value of a broadcasting operation.

Some commentators object to broadcasters receiving any inducement to relinquish their spectrum. It is important to stress, however, that revenues shared with incumbents should not be regarded as windfalls if the alternative is administrative gridlock. Under current spectrum allocations there are numerous instances of inefficient spectrum use that the administrative process is ill-equipped to change. As a result, consumers and society are currently suffering a significant windfall loss because large blocks of spectrum are allocated to lower value uses. Rather than creating a windfall for incumbents, this new auction tool would create a tremendous gain for consumers and society.

Conclusion

Intel urges the members of this Subcommittee and Congress to act expeditiously to give the FCC broad authority to conduct voluntary incentive auctions. Such legislation represents one of the most important opportunities to free up much-needed additional spectrum for mobile broadband and to reform the spectrum allocation process. The benefits to U.S. consumers, taxpayers and society would be enormous.

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Committee on Energy and Commerce
U.S. House of Representatives
Witness Disclosure Requirement – "Truth in Testimony"

PETER K. PITSCH
INTEL CORPORATION
APRIL 8, 2011

ATTACHMENT – Answer to Question 5. – Federal Grants or Contracts

Agency	Intel Group	Title	Description	Value	Execution Date	Expiration Date
USG Agency	IAG/Intel Labs	Copper Valley Technology Investment Agreement [TIA]- H98230-08-3-0011	HPC-related projects	[redacted]	24-Apr-08	24-Apr-11
	Intel Labs	Copper Valley: Chenango Valley	Silicon Photonics	$29.4M	[redacted]	[redacted]
	IAG	Copper Valley: Cedar River	System Level Interconnect and simulator	$13.7M	[redacted]	[redacted]
USG Agency	Intel Labs	Lightening Point OT for Prototypes, Section 845 Agreement H98230-10-9-0021	Silicon Photonics.	$22.2M*	9/29/2010	5/25/2012
DARPA	Intel Labs	APD Avalanche Photodetectors in Silicon Photonic TIA HR0011-06-3-0009	Avalanche Photodetectors in Silicon Photonics Low-cost, High Volume APDs - Option 2	$2.2M**	11-Sep-06**	Q1 2011***
DARPA	Intel Labs	UHPC TIA: HR0011-10-3-0007	Ubiquitous High Performance Computing;	$18.9M	7/1/2010	7/1/2014
USAF Academy	Intel Labs	USAFA Cooperative Agreement : FA7000-11-2-0001	Research: Secure Enclaves Project and TelePlace Software. 4 other projects could be added as new funding is obligated	$5.5M****	12/20/2010	11/11/2011

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NSF	Intel Labs	Computing Innovation Fellows Program – Subaward from Computing Research Association [CRA] for CIFellow Ilya Wagner; CIF-258	Research: Verification of microprocessor circuits.	$90K	10/30/2009	10/29/2010
NSF	Intel Labs	Subaward from CRA for CIFellow Lillian Chang. CIF-B-125	Research: Dexterity in Robot and Human Systems	$90K	11/1/2010	10/31/2011
NSF	Intel Labs	Subaward from CRA for CIFellow Xiaoning Ding: CIF-B-173	Research: Shared Resources for fast memory access and value stores in cloud computing environments	$90K	11/1/2010	10/31/2011
USG agency	IAG	Cape Point	Uncore Technology Research	$3M	4/1/2011	12/16/2011

*LP: Currently only $8M of funds have been released

** APD – this project consists of 3 parts, starting in September of 2006, as follows:

- Base: $290K September 2006
- Option 1: $1.1M December 2007
- Option 2: I have $2,025,968 as the amount in September 2009

*** The APD contract has ended, exact date is an estimate

**** The USAFA agreement: Currently only $1.9M of funds have been released

Mr. WALDEN. Mr. Pitsch, thank you. We appreciate the testimony of all of our witnesses today. We will move into our questions, and as you can see, we have a good turn out of our members and look forward to your answers.

Mr. Pitsch, let me go right back to you, because you suggest we should auction or give the FCC authority to do an auction right away. Do you support, then, the FCC following through on the auction authority they have today on the D Block?

Mr. PITSCH. Chairman Walden, Intel doesn't have a position on——

Mr. WALDEN. Why?

Mr. PITSCH [continuing]. Public safety.

Mr. WALDEN. Just wondered. Never mind, you don't have to answer that. Dr. Bazelon, let me go to you. The question I have, your testimony and your evaluation of the value of the auction, one of the issues that has come up in recent days—and I hear from everybody on every side of all these issues, let me assure you, and that is a good thing—is that with the potential proposed merger of AT&T and T–Mobile that you might not have as many entrants into an auction. Do you find that plausible, possible and just knowing that merger—do you see that as having an affect on the value of an auction?

Mr. BAZELON. So let me begin by saying that I am here representing my own views solely. The broad spectrum value is long-term supply and demand forces in this industry. And I don't believe that the pending merger changes any of those fundamental demands for spectrum were supply of spectrum. So I don't suspect that it will have any long-term effect on the value of spectrum.

Mr. WALDEN. All right, thank you.

Deputy Chief Dowd, Congress now allocated 24 megahertz of spectrum for public safety use in the DTV legislation 6 years ago, which I supported. In your testimony, you say that 2-way voice is, and I quote, "an extremely limited service that fails to meet the modern needs of public safety," correct?

Mr. DOWD. Yes.

Mr. WALDEN. And so, I am curious then, why do you think public safety community, including NYPD, chose to use more than half of the allocated spectrum to expand that very legacy voice service?

Mr. DOWD. Well, the issue there is that, you know, that was done a number of years ago, when the potential of broadband and its ability to transform how public safety does its business had not yet been fully realized. So there were a couple of things going on there. Number 1, you had a mandate from the FCC for folks to narrowband their radio systems and that they had dedicated that spectrum for that purpose.

Mr. WALDEN. All right.

Mr. DOWD. The issue there is that you have over 30 States that are building out on that spectrum because a lot of them, kind of like led into this and were end of life on their existing systems and therefore, needed to build out on that spectrum. You know, if we had a preference—if voice on broadband were ready for public safety prime time, we would prefer to put that spectrum into a broadband capability. But the reality is, it is out and it is necessary right now for narrowband.

Mr. WALDEN. So when the technology comes in the full view and availability, do you see then a migration over to voice on——

Mr. DOWD. Yes, our——

Mr. WALDEN. That would free up a lot of spectrum, probably half of what you are using today.

Mr. DOWD. Well, it has the potential to free up a lot of spectrum in other areas too. And that is one of our main arguments for the D Block is that if you had sufficient spectrum to do all of your communications capability, voice data, video, all of those things in broadband, then that would potentially, in the long term, free up spectrum that public safety has now to return to the FCC and also potentially to free up that 700 narrowband spectrum, again, the long term. But the problem with trying to use that spectrum now for broadband purposes is simply the fact that it is necessary for narrowband.

Mr. WALDEN. Well, and obviously we are not going to get anything down in the very short term here, so when we get it done, we want to get it done right for the long-term and make sure we only invest in this correctly and appropriately going forward and efficiently.

Senator Gorton, maybe I can turn to you, and Chief Dowd, you may want to comment on this. Because we have heard public safety wants to run its own networks, there is no—I don't think have you any argument with that context. However, in my own State of Oregon, the Oregon wireless interoperability networks ballooned in costs to over $150 million and failed to meet its benchmarks.

We know in San Francisco Bay Web is currently under investigation for apparently some alleged improprieties. So we are trying to figure out how we make sure we have an interoperable network that you can rely on, your men and women can rely on, and taxpayers can rely on. So maybe, Senator Gorton, what safeguards are in place to ensure public safety gets that capacity in the time of crisis? And could public safety benefit from a public private partnership as recommended by some?

Mr. GORTON. The answer to that question is overwhelmingly in the affirmative, Mr. Chairman. It would probably happen quicker, and almost certainly happen at less expense, your experience in Oregon is, by no means, unique. On a related but independent matter, remember how much money the FBI has spent on computerization, billions and billions of dollars wasted because the holdover metal structure for contracting for these things is so slow that the technology is well beyond them by the time that they have implemented a certain system, and I think that Chief Dowd's answer to your last question illustrates that. By the time they get something up and operating, something else is better that is out there.

I just have to come back to my principal point, however. Unless you feel that there is an extra 25 to $50 billion out there somewhere, not only to reallocate the spectrum, but to help governments that don't have any money to do it themselves, to do it through a Federal subsidy. And unless you feel that that is worth giving up at least an equal private investment in spectrum that can be used right now with all its jobs, this is an almost irrelevant argument. I don't think that money is there. I don't think your appropriations committees are going to come up that at any time in the immediate future, so a public-private partnership is going to be best for both side sides of the——

Mr. WALDEN. I am a minute and 40 over my time. So I will yield now and to turn to the gentleman from Massachusetts, Mr. Markey.

Mr. MARKEY. Thank you, Mr. Chairman, very much. Mr. Knapp, how much of a spectrum that we need do you think we can garner just from a more efficient use of the spectrum that we already have?

Mr. KNAPP. We are going to need to continue to apply efficient techniques.

Mr. MARKEY. A significant percentage?

Mr. KNAPP. A fair percentage, it is hard to put a number on it.

Mr. MARKEY. More than 10 percent?

Mr. KNAPP. More than 10 percent, it is an ongoing process.

Mr. MARKEY. More than 10 percent, less than 50 percent.

Mr. KNAPP. Ten percent, less than 50 percent, probably somewhere in there.

Mr. MARKEY. OK, good. And so we can get a big chunk of this problem solved just by ensuring that there is more efficient use of the spectrum. And as you have to work under the Communications Act of 1934, you have certain public interest principals you have to abide by, huh?

Mr. KNAPP. Of course.

Mr. MARKEY. In putting this together. And a lot of that goes to public safety, but also ensuring that there is spectrum out there so that we have further economic growth in our country as well?

Mr. KNAPP. Of course.

Mr. MARKEY. That is your job, your division that you are responsible for?

Mr. KNAPP. With others, yes.

Mr. MARKEY. Thank you. Now, Mr. Good, you seem to be saying that the broadcasters can go along, as long as it is voluntary, and as long as is there a no interference. And if we can meet those two criteria, and you are going to be very tough as an engineer in ensuring that those criteria are met that the broadcasters are open-minded in the reallocation of spectrum if they are compensated and interference is not created for other stations that are along that same perspective, is that correct?

Mr. GOOD. Well, yes, voluntary but as long as the broadcasters are held harmless.

Mr. MARKEY. That is what I am saying. And by "held harmless," you mean that they are compensated and that——

Mr. GOOD. Coverage areas are the same and they are back exactly where they were as far as coverage and the quantity of viewers they can get their signal.

Mr. MARKEY. And you think that can worked out as long as everyone is open-minded and engineers of common sense and goodwill from all sides are able to get together and agree upon those principles?

Mr. GOOD. That tends to bring us to repacking.

Mr. MARKEY. Yes.

Mr. GOOD. And I am not confident that we can achieve that type of coverage in that scenario.

Mr. MARKEY. Now, obviously, the broadcasters are a big part of our safety response capacity, because people turn to radio, people turn to television to get their information, so we want to make sure that those local broadcasters are there.

So, Chief, if we come over to you, in terms of the approach which the public safety community is bringing to these issues, just so it can be reduced down to a simple kind of set of principals that you are bringing here to the process. The public safety community wants a specifically allocated part of this spectrum just getting over to the public safety community so that they can make sure that there is a specifically dedicated network construction that has voice, video, data so that what happened on 9/11 does not reoccur; is that correct?

Mr. DOWD. That is correct.

Mr. MARKEY. And is there a way in your mind of reconciling that goal with other interests that other people who testified here today have in terms of the economic goals that are also here and testifying and of interest to the country as well?

Mr. DOWD. Well, certainly. In our view, in public safety, we have gone to great lengths over the last couple of years to consolidate on this issue. And let me point out that that is probably a historic consolidation of public safety support this. Here on the right, you see a chart that I brought, it indicates two organizations, the Public Safety Alliance on the right, which represents every public safety organization and many other governmental agencies that support our position. And on the left is what is referred to as the Connect Public Safety Now Coalition. The good and distinguished Senator represents them here today according to his written testimony. I have to point out though, however, that there is no one in public safety that supports that position.

Mr. MARKEY. I see.

Mr. DOWD. As far as the flexibility and reconciling these issues, you know, we can certainly do that. We are looking to do public private partnerships, but we don't want to put the cart in front of the horse. We want to make sure that public safety gets the mission critical——

Mr. MARKEY. My time is going to run out. Are you having conversations with the group that Senator Gorton represents, are there any conversations going on? Chief, answer that and——

Mr. DOWD. Well, there is not too many people to have conversation with.

Mr. MARKEY. Ah.

Mr. DOWD. You know, there are a couple of major commercial entities that are a part of that. But again, to stress it, you know, listen, the Senator is a man of high integrity and I know that his position is a sincere one. But quite frankly, we question the credentials of this coalition.

Mr. MARKEY. Senator, you deserve an opportunity to respond to your question.

Mr. GORTON. Well, of course, if your position is that you want to get something free and get it subsidized, you are all going to join in on that, it is an easy position to take. Give it to us and then give us all the money that is necessary to carry it out. That doesn't answer the question, and of course, they would prefer that to any kind of public private partnership.

The question is, are you going to give it away? Are you going to come up with a huge new Federal program? Are you going to subsidize it? I don't think you are. And I think once you announce a position like that, I imagine that the work back and forth, the consultations between the private sector that wants to buy this spectrum and the public spectrum will be constructive and will be successful.

Mr. MARKEY. I just want to say, Chief, on a bipartisan basis, I just want to say that public safety is our highest priority throughout this entire process, I hope you know that.

Mr. DOWD. If I may comment on that, and again, having heard testimony and questions before this committee before the characterization that public safety wants something for free, I mean, why do we want it? We want it because we know we need it to protect the people of this country. So I am puzzled as to what the expectation is should public safety pay for the spectrum? Because if public safety pays for it, guess where the money comes from? From the taxpayers, so I don't understand the logic of that comment.

Mr. MARKEY. Thank you for your service, sir.

Mr. WALDEN. Move on to Mr. Terry for 5 minutes.

Mr. TERRY. Thank you, Mr. Chairman. Staying somewhat on that theme. One of the accusations is not the right term, but information is that not all of the spectrum currently assigned public safety is even being used now. So Senator Gorton and Deputy Chief Dowd, once again, thank you for your service and your willingness to come down here. We should have an office for you.

And Mr. Knapp, if you could answer or retort or put into perspective that statement that public safety isn't using all of the spectrum that they are assigned now. Senator, are you aware if there is squatting occurring now on public safety spectrum?

Mr. GORTON. I can't claim to be an expert on that subject. I don't believe it is, but I don't believe it is because they are squatting, I believe it is almost certainly because they don't have the money to do it.

Mr. TERRY. Chief?

Mr. DOWD. I am not sure what spectrum you are referring to. But again, in my prepared comments, one of the things that we are saying to you, and we would love the opportunity—we know there are a lot of new members on this committee and this is a new issue for them, and there are a lot of things they have to address, but we want to engage you in detail on this.

One of the things public safety is suggesting is that if we get enough spectrum in this new and future technology to do all our capabilities within that spectrum, within that broadband capability, that there will be opportunities to return other spectrums, like the spectrum that the NYPD uses now, UHFT band for land mobile radio system. Over time, if we have the capability to do everything in the broadband network that would be fully interoperable, which we can't on UFT band, then certainly, why wouldn't we want to return that spectrum? And your question as to what spectrum we may be squatting on, I am not sure what spectrum you are referring to.

Mr. TERRY. All right. Mr. Knapp, can you clarify?

Mr. KNAPP. Sure. Public safety operates in multiple different frequency bands.

Mr. TERRY. 800.

Mr. KNAPP. Yes, part of what is where we are with the interoperability issue. I would venture that the spectrum is generally used by public safety. The one band that comes into focus is 700, and the narrow band channels we know are not used everywhere in the country and we have initiated a public notice to try to gather more information to get a better handle on how much it is being used.

Mr. TERRY. Thank you.

Then Senator Gorton, going back to you and your testimony, and Mr. Markey has already helped frame this, but you talk about a public and private partnership that technology is available to assure that public safety communications can have priority access on commercial 700 megahertz network. Didn't we try that once and there were no bidders?

Mr. GORTON. I think your FCC witness is better able to answer that. But the answer to that question is yes. There were no bidders when those requirements were so onerous as to not worth it, that did not make it worth it to bid. However since then, we have financed the study by the chief technology—former chief technology office of—office of Motorola, who I do believe has come up with a system under which the spectrum would be valuable to the private sector and would have an automatic override in case of public service—public safety necessity. We don't——

Mr. TERRY. I don't, Senator. I want to interrupt, so I can get Ms. Dillon, because she is part of this discussion too.

Is there technology today that would incent you or other wireless carriers to bid on this knowing that, at some point, public safety can come in and say we want it?

Ms. DILLON. Yes, well, we have proposed that on a regional basis, a public partnership private model works. And potentially, it is one of the reasons that it didn't work in the last auction, it was on a nationwide basis. So for us, we believe that carriers of our size and smaller, there is two reasons why we believe this sort of——

Mr. TERRY. So if we break it down into regions or smaller——

Ms. DILLON. Yes. And we have incentive to then work on a region-wide basis. If we were granted a license today in western Iowa, our priority would be to build that out, and certainly we would work with public safety to meet their needs as well.

Mr. WALDEN. I might just put this in perspective, some data I had seen. Public safety has 97 megahertz of spectrum allocated to it with about 2 million users. And by comparison, although they are different missions, Verizon has 115 megahertz of spectrum with 91 million users. So it really gets down to, in terms of spectrum, there is a wide variation on who uses what and for what purpose.

I would turn now, I believe Mr. Barrow was here when the gavel fell, but Mr. Dingell is also here. I don't know how you all want to——

Mr. BARROW. Mr. Dingell has been kind enough to allow me to go first, but I would like to defer my turn, but not waive my time to questions to Ms. Matsui as the presiding ranking member, if that is OK with the Chairman.

Mr. WALDEN. I am happy if you all are happy, that is all we are here for.

Ms. MATSUI. Thank you, Mr. Barrow, and thank you, Mr. Walden. We all know that the cost of constructing a nationwide public safety system will be substantial. This question is to Senator Gorton, and also the Chief. Aside from whether the deeplog is reallocated to public safety and added to the public safety existing 700 megahertz broadband spectrum, how do we ensure that the speech front spectrum is built out in the most efficient manner achieving interoperability while keeping the prices within reach given the Federal and State budget crisis?

Mr. GORTON. Well, I think you can assure that best by an auction system in which those users who think that the spectrum is worth most are willing to bid most, and have such conditions on them that allow their use in emergencies by the public sector. I think history indicates a formal straight-out allocation set by Congress or by someone else is not likely to result in that degree of efficiency. The chairman referred to the fact that we began the incentive auctions, or auctions, back in the 1990s, I was on the Senate Commerce Committee at the time.

Ms. MATSUI. Right.

Mr. GORTON. I think the history of dealing with spectrum in that fashion has proved itself time and time again.

Ms. MATSUI. I know the chief differs. Chief?

Mr. DOWD. Well, again, you know, as I said in my prepared comments, I made the statement that public safety based on its years of experience in dealing with commercial networks, knows that we cannot rely on public networks as a backup during mission critical and critical times. We know that those systems fail. So the notion or the suggestion that we would use those networks at those points is just an unworkable model. And the other problem is, that there would be an expectation that we would have to pay it for that service, and when we say "pay," that is the taxpayers that has to pay.

Ms. MATSUI. That is right. Now, it is my understanding that public safety has an assigned spectrum and provided with Federal funding before to achieve interoperability. I know there is been some successes but we still haven't achieved full interoperability especially on a Nationwide basis. What needs to be different this time so that we don't repeat history, Chief?

Mr. DOWD. Again, the issue there is why we are not interoperable is that a long history of issuing public safety spectrum in a patchwork fashion. So on a nationwide basis, you have public safety all over the spectrum map, so to speak. The only way you are going to fix that successfully is if you dedicate enough spectrum in the new technology so that we can be seamlessly interoperable across the country, and also give us the flexibility to utilize that spectrum for other purposes in government, public utilities and potentially, in public private partnerships. We have no objection to that.

Ms. MATSUI. I see the Senator is disagreeing, but I have a follow-up question to that. Go ahead, a quick comment there.

Mr. GORTON. Ms. Matsui, are you going to pay for it? The Chief says, well, gosh, if we have to buy it, the taxpayers have to pay for it. Well, you represent the taxpayers too, all of those taxpayers.

The real question is, how much are the taxpayers going to pay, less if there is huge private investment in it, clearly very much less. And who is going to provide a more efficient use, almost certainly, history shows the private sector will do so.

Ms. MATSUI. OK. All right, I have an additional question here. How do you envision a plan for how the development and deployment of public safety broadband network would be managed, would there be a Federal entity to oversee it? Who should possess ultimate responsibility and accountability for ensuring achieving of nationwide interoperability, Chief?

Mr. DOWD. Yes, the answer is that there would have to be some sort of entity created by the Federal Government to have oversight of this effort in order to coordinate it, to ensure interoperability and consistency in the use of the spectrum and other issues that have to be addressed. That being said, each regional area, each locality has its own unique public safety concerns, and the network of networks would have to have the flexibility so public safety could do their job locally while still being interoperable with everybody else.

Ms. MATSUI. Senator, would you think there would be another entity here?

Mr. GORTON. I think the Chief made my case. Works for another Federal agency. If you think that is a good idea, go do it.

Ms. MATSUI. I want Ms. Dillon to get involved.

Mr. DOWD. I apologize. I didn't suggest that there should be another Federal entity. I suggested that there should be an entity created to oversee this.

Ms. MATSUI. OK. Ms. Dillon, do you have any additional thoughts about that?

Ms. DILLON. The question?

Ms. MATSUI. About whether there should be another entity, a Federal entity to oversee it or any other entity?

Ms. DILLON. I think there are probably lots of options, the PSSP, it could be on a statewide or a Federal basis, but we do believe that the notion of working on a local basis on the 700 megahertz spectrum with compatible technology around the country, but manage and operate on a local basis would make sense.

Ms. MATSUI. I see my time is gone, thank you.

Mr. WALDEN. Thank you, Ms. Matsui. We will go now to Mr. Shimkus for 5 minutes.

Mr. SHIMKUS. Thank you, Mr. Chairman. I knew that the spectrum is a big broad area, but I knew it would come down to D Block and additional 10 megahertz. And I will try to move away from that for a few minutes too, but it is something I have dealt with because I authored the first 911 Wireline bill, I chair the E–911 caucus, now the Nextgen Communication caucus. And I have been very involved in the use of new technology to help first-line responders. I am a little bit—no one wants to have this fight, Chief. We all want to get there.

You mentioned in Hurricane Katrina. Didn't the public safety network fail, and it was a commercial wireless that was able to help the communications?

Mr. DOWD. The fact that it may have failed doesn't justify the——

Mr. SHIMKUS. No, I am just making a point. And I think also we have broadcasters here, wasn't the public broadcasters during Katrina who helped get back on the air to help inform the public, wasn't that correct, Mr. Good?

Mr. GOOD. The Hearst Company has a station in New Orleans, and that is WDSU, and that station was on the air through the event and a great expense and effort to do, but it was there and present.

Mr. SHIMKUS. And that is really, even when we go to the broadcasters, which is also very important debate that we have, and their spectrum is their responsibility to be able to provide real-time information. With all the new gadgets, it is still amazing that more people are getting information over the radio band on their car—instead of satellite, instead of all this stuff. They are still getting more information for free over the air, which we forget about a lot of times, and their public safety responsibilities.

Senator Gorton and Chief Dowd, Mr. Knapp, how are the public safety waivers progressing and what can we learn from these waivers that help us on these broader questions? You know what I am referring to is the original 10 megahertz that you all have.

Mr. GORTON. I am going to have to defer that answer to someone else.

Mr. SHIMKUS. Well, maybe Chief can help us out. Chief?

Mr. DOWD. Well, I can only speak for New York City, and quite frankly, we are engaged with a number of vendors to do pilot projects on that spectrum in order to understand better——

Mr. SHIMKUS. So how long have you had this block?

Mr. DOWD. Since they were granted, that was last year sometime. Was it June?

Mr. SHIMKUS. So nothing other than Research, nothing has moved forward yet?

Mr. DOWD. Well, no. Other than, again, planning.

Mr. SHIMKUS. I know that takes a long time. It is bureaucracy, it is government. Mr. Knapp.

Mr. KNAPP. The waivers you are talking about, I think, were granted in May of 2010, it takes a bit of time to get them up and running. I can provide for the record an update to the status of all of those.

Mr. SHIMKUS. Thank you. And going back to, Ms. Dillon mentioned a regional approach. Those of us in rural, small town America are kind of worried that if this goes to the public safety folks, that regional small town, poor areas will get left out because it will focus around the major metropolitan areas. Now that is important if you are from the major metropolitan area. But Senator Gorton, can you talk to me, and Chief Dowd and Ms. Dillon, on the regional aspect? Would a regional approach solve some of my concerns?

Ms. DILLON. That is our contention that certainly there is room for a lot of players to play here in terms of both providing for public safety, maximum efficient use of available spectrum, which is not going to be solved simply by engineering alone. There was a question asked earlier, if it was only engineering, we wouldn't need to look to spend more money on spectrum. But we do believe that there are many ways we can look at smaller regional areas and make sure that all parts of the country are considered. And we believe that if it went only on a national basis that it would, in fact, be the urban areas built out first, which makes sense from an economy of scale perspective.

Mr. SHIMKUS. And I want to finish up. So Chief, do you have anything on the regional approach? I only have 12 seconds.

Mr. DOWD. OK.

Mr. SHIMKUS. Well, let me go to Mr. Knapp. Just so we just talk about the spectrum as a whole. If the FCC is correct, and mobile demand is poised out to its capacity in the future, what are the consequences for consumers?

Mr. KNAPP. Dropped calls, slow data rates, services that don't work very well. And as the carriers are likely to respond, with setting higher prices for consumptions, consumer prices go up.

Mr. SHIMKUS. Thank you. Typical economics 101 supply and demand, I would say, right?

Mr. KNAPP. Correct.

Mr. SHIMKUS. Thank you. Thank you, Mr. Chairman.

Mr. WALDEN. Thank you, Mr. Shimkus. I want to add on to your notion of everybody being involved in Hurricane Katrina. Don't forget the ham radio operators, too.

Mr. SHIMKUS. Who, who?

Mr. WALDEN. The amateur radio operators.

Let's go now Mr. Dingell from Michigan, the esteemed former chairman of the committee for 5 minutes.

Mr. DINGELL. I thank you, Mr. Chairman, and I thank my good friend from Georgia for your kindness to me.

Mr. Knapp, these questions to you, I would appreciate a yes or no answer. And it may be that at some future time you want to come back with some further answers with regard to this and we will see when that comes. Mr. Knapp, I believe you were involved in drafting the spectrum provisions to the national broadband plan, yes or no?

Mr. KNAPP. Yes.

Mr. DINGELL. Mr. Knapp, it has been reported that those who drafted the proposal contained in the NPB failed to take into account the channel reservations of the Canadians which we are bound to honor by treaty. Were the Canadian channel reservations taken into account in the proposals that I have mentioned, yes or no?

Mr. KNAPP. No, and the report acknowledges that.

Mr. DINGELL. That is going to cause some problems, isn't it?

Mr. KNAPP. And as we have done further work, we are doing just that, we are taking into account the Canadians and we are talking to the Canadians.

Mr. DINGELL. Now, Mr. Knapp, let's turn to a market with which I am familiar, namely Detroit. Detroit is the tenth largest market in the country, it has 14 stations licensed in the Detroit DMA, is that your understanding?

Mr. KNAPP. That is correct.

Mr. DINGELL. Now, Mr. Knapp, the MBP recommends relocating 120 megahertz from the broadcast television to the wireless broadband access. I understand that if the Canadian channel reservations that were taken into account, there would not be any available channels for any of Detroit's 14 stations; is that correct?

Mr. KNAPP. No, I don't believe that will be correct.

Mr. DINGELL. I am sorry?

Mr. KNAPP. No. I don't believe that will be correct.

Mr. DINGELL. It is not correct, OK. We will come back to that because I think it merits further consideration. Put it another way, if less than 120 megahertz were reallocated and even one Detroit station were to be relocated, would there be a channel available for that station, yes or no?

Mr. KNAPP. I would just preface that we will have to go through the process, but yes, we are confident that there will be.

Mr. DINGELL. I am hearing two answers. On one hand, I am hearing you tell me that it is not correct, that there would be no channels available to the 14 Detroit stations. And then I am hearing some doubt in your remark. What is the truth of this matter? Why is it that—why is it I am hearing these things, and why is it you can't give me firm, full assurances that you have taken already into consideration with regard to my city the availability of channels? What is the answer to that?

Mr. KNAPP. Because the repacking will depend on which stations decide to participate in the incentive auction and we don't know which those will be.

Mr. DINGELL. So that information is not, at this time, available to us, we are forced to speculate what will be the consequences of that, is that right?

Mr. KNAPP. Of course, it will depend on which stations participate.

Mr. DINGELL. I must assume we have two borders, the Canadian border and Mexican border. I must assume that the Canadian channels are going to create, a, perhaps, a common problems stretching all the way from the Maine coast through Vermont, Rochester, Buffalo and onto Detroit stretching and then on west to where the Senator comes from, am I right?

Mr. KNAPP. Those areas would be taken into account in the repacking and negotiations with Canada.

Mr. DINGELL. Do we have assurances that that is so or is that just your pious hope and expectation?

Mr. KNAPP. I believe that we can do that. We won't know until we have completed——

Mr. DINGELL. So we don't know.

Now, Mr. Knapp, finally on a related note, you state in your written testimony no stations would be required to move from the UHF band to the VHF band unless they freely chose to do so in exchange for a share of the auction proceeds. Does the Commissioner believe that the broadcaster would receive a portion a voluntary incentive auctions proceeds only if the broadcaster agrees to move from the UHF band to the VHF band, yes or no?

Mr. KNAPP. Only if they—yes.

Mr. DINGELL. So.

Mr. KNAPP. If they stayed where they were, there would be no change.

Mr. DINGELL. It looks to me here a little like we are buying a pig in the poke, where the commissions come up here and they are going to do all the wonderful things and we don't know exactly what they are going to do.

Now just one last question: Do you have statutory authority to do this. Do you have to have statutory authority?

Mr. KNAPP. We would need statutory authority for incentive auctions.

Mr. DINGELL. So when are we going to get the precise character of what it is you are doing so that we can know what it is that we are voting for or against?

Mr. KNAPP. What we are seeking is the authority to conduct the incentive auctions, it would be voluntary. Once we conducted the auction and saw who was going to participate and worked with the stakeholders, that is when we would know the final plan.

Mr. DINGELL. Am I to assume that this same problem is going to plague us on the Mexican border?

Mr. KNAPP. We also will need to negotiate with Mexico.

Mr. DINGELL. You have comforted me but little. Thank you for your kindness.

Mr. WALDEN. And you are not the first witness to achieve that high praise.

Mr. KNAPP. Thank you.

Mr. WALDEN. We go now to Mr. Latta for 5 minutes.

Mr. LATTA. Well, I thank the chairman and I thank our witnesses for being here today, it is very, very important subject, and as you can tell from the questions from the members.

Ms. Dillon, if I could kind of go back to what Mr. Terry and also Mr. Shimkus were talking about again, talking about the small, the auctioning in the small area of blocks, and also providing for other smaller, not mega-region type folks to be buying into the spectrum. Could you define what a smaller carrier would be?

Ms. DILLON. What a smaller carrier could be?

Mr. LATTA. Right.

Ms. DILLON. I would suppose anybody who is operating on a less than national basis, like ourselves and there is many others that are smaller than us. And so back to the question of auctions, in fact, I think history would show that when the auction—when the spectrum is auctioned on a less than national basis, more money can be raised. There are more participants in the room. So there was a question earlier about AT&T and T–Mobile, if that deal goes through it underscores even more so the opportunity and the need to have less than national swaths here for the auction because there will, in fact, be more bidders in the room and more bidding means—raises the prices and more money for the Treasury.

Mr. LATTA. Let me at least follow up on that if I may. Again, if you are a smaller carrier, will you be able to come to the table with as much money?

Ms. DILLON. Well, it is all relative. We are not going to buy on a national basis because it is not relevant for our business but we have spectrum before and we would be interested in bidding on more, and I am sure other carriers would as well. It is really the life blood of our business. And we see the need for spectrum in spite of a tremendous amount of efforts around engineering and innovation, which we are really proud of as an industry. There is a need for more spectrum as well. So for any carrier to continue to compete, we need more spectrum.

Mr. LATTA. Thank you. Mr. Good, if I could go back and ask you a question with the incentive auctions being approved, what cost would you anticipate the broadcasters would incur?

Mr. GOOD. That is a question that is totally unknown at this point. I can't answer that. I would have to have a crystal ball. I can tell that you our company doesn't plan to take advantage of that.

Mr. LATTA. OK. Thank you. And Mr. Pitsch, how would you see that by freeing up additional spectrum how that helped manufacturing in America because, you know, I come from a manufacturing area of the country, and how would you see that spectrum freeing up helping manufacturing?

Mr. PITSCH. Well, as Mr. Knapp has pointed out, given the burgeoning demand for mobile data, if we don't get more capacity, more spectrum, prices are going to have to go up, congestion will increase, new services won't be available. So I would contend, and I think the members of our coalition will contend that if we get the type of spectrum freed up that the FCC, the administration, lots of folks have recognized as needed, then we are going to enable new services and create jobs, it is going to be mean lower prices and this important part of our information infrastructure is going to be more robust.

So I can't give you a precise number. Frankly, I am fairly distrustful of these fancy-dancy econometric models. But I think the basic insight of Congressman Shimkus is fairly right, is economics 101. If we get more capacity, we are going to have lower prices, less congestion, more minutes, and that is going to be good for American consumers and workers.

Mr. LATTA. Could you define new services?

Mr. PITSCH. Well, I think many of the video rich applications that consumers are using on Smartphones, the tens of thousands of apps could be considered new services. I think we are only limited by the fertility of the imagination of the American people here. If we look at all of the trends from my company in the silicon area, the semiconductor area, to compression technologies, and storage technologies, and the digital technologies, the 4G technologies in the wireless area, if we marry all of those improvements, there is an enormous opportunity for growth and innovation.

Mr. LATTA. Thank you. Mr. Chairman, I yield back.

Mr. WALDEN. We turn now to the gentleman, Mr. Barrow.

Mr. BARROW. I thank the Chairman. Ms. Dillon touched on some of the practical considerations and in actually conducting a voluntary incentive auction regime, so I want to explore that just a little bit.

You know old Aesop, that old fable spinner told a bunch of fables. One of them he titled the Fable of the Dog in the Manger. This is the story of the dog that made his bed in a manger of hay. He couldn't eat the hay, but he would snap and snarl at animals that could whenever they would come by. And the moral of the fable is folks often begrudge others what they can't use themselves or won't use themselves. That is a negative characteristic of human nature in some folks. I think it could actually describe a practical real world problem if folks end up, through no motive of their own, begrudging folks what they can't use. And so you can imagine lots of license holders with enough money to get a license, but not enough money to be able to develop it. You can find folks scattered to hell and gone who have got licenses all over the place, but the buyers and sellers aren't together. It seems to me that bringing folks together who have the spectrum but would rather have the money, together with folks who have the money would rather have the spectrum is something we can all agree on, and it is something we would all want to get behind some way or another.

But Ms. Dillon touched on some of the practical considerations in talking about that you can't do this on a dime, creating this marketplace and market opportunity is going to entail some consideration and some practical consideration. So Ms. Dillon, based on your experience at U.S. Cellular, have you all ever acquired any of your licenses in an auction format?

Ms. DILLON. Have we all—I am sorry——

Mr. BARROW. Have you acquired any of your licensing authority as the result of an auction format? Have you gotten any of what you have to use through the auction process.

Ms. DILLON. Yes, we have.

Mr. BARROW. How long, based on your experience, if have you had any idea, how long did it take between the time that the spectrum was identified as being available on the one hand, and the time of the resulting auction on the other, how much——

Ms. DILLON. Honestly, I would probably need to get back to you with our specific experience, because our last auction, or purchase to spectrum predated my time at U.S. Cellular, but it is my understanding that it is not a fast process. The process of making it available, conducting an auction, clearly spectrum and then deploying services is probably a multi-month, multi-year process.

Mr. BARROW. I imagine the next phase, the time we actually buy the spectrum and of course auction you can actually deploy services is going to take a far greater period of time. Based on your experience, what kind of time are we talking about there? Because we talked earlier in testimony about the fact the crunch times coming in 2014 which is right around the corner. Generally speaking, give us some idea of how long it would take between the time someone acquires a broadband spectrum through an auction an the time they can actually deploy services over what they bought?

Ms. DILLON. Yes, it is my understanding that it is probably a multi month, 18-month to 2-years process. But I would like to come back with specific examples from our experience. I think more importantly the point is and that is why there is urgency, the spectrum crunch is on us now, and there is engineers around this industry very hard at work driving efficiencies, deploying LTE fourth generation networks to drive more efficiency, and to handle the demand, but we believe that the need is now to start that process because it is time consuming.

Mr. BARROW. Thank you, Ma'am. We have got some dogs out there sitting on a bed of hay and they want to sell it to the other animals. We ought to encourage that as much as we possibly can. Thank you very much, and I yield back the balance of my time.

Mr. WALDEN. Thank you, Mr. Barrow. At the price of hay—well, anyway. We are going to go to Mr. Bass now for 5 minutes.

Mr. BASS. Thank you, Mr. Chairman. Senator Gorton, welcome back, fellow Dartmouth alumnus. This is my first hearing on spectrum policy. When I left the Congress 4 years ago, we were completing the debate on DTV, whole new set of issues. Now we heard about the imperative that we move forward on this; we reviewed, I think, adequately, the debate that exists between public safety and the rest of the telecommunications economy.

Senator, can you expand a little bit on your testimony regarding the timing advantages of public private partnership resulting in public safety having access to the 700 megahertz spectrum now?

Mr. GORTON. Well, I think all of history has shown that the private sector has actually built out the spectrum that it received much more rapidly than the public sector has done. The chairman that started this hearing, what, I think four goals of the hearing: Reducing the deficit, increasing investment, adding needed spectrum, jobs and public safety. The only way, the only possible way of reaching all of those goals with what is at issue here is to go through a public auction procedure. The capital to exploit that will be available, no one is going to bid on it unless they are going to use it, and use it fairly properly. And that I think inevitably is going to lead to a public private partnership because the public safety community will then want that to happen.

I am convinced that, in fact, it will happen. If, on the other hand, this is, the spectrum is given away, it isn't going to be used until the money is available from the taxpayers at one point or another, in multi billions of dollars to do so. And in this economic situation, that is going to take a long, long time.

Mr. BASS. I think you testified as to the cost. You thought the cost might be something in the vicinity of $50 billion, can you elaborate on that?

Mr. GORTON. That would be the upper end of the estimates we have, but first, you lose the 3 or $4 billion from not having the auctions, and again, that is going to cost somewhere between $25 and $50 billion, or maybe more, to build it out. And bluntly, that is all going to be taxpayers money. If it is bid for, the money comes in and goes against the deficit, and the buildout is private sector.

Mr. BASS. Mr. Pitsch basically defined his ideas giving the FCC authority to conduct voluntary incentive auctions as quickly as possible. We know that Chief Dowd, what his position is. Do others of you have different variations on this issue as to what the appropriate legislative remedy is, or course of action is for the issue before us, the spectrum? Anybody have any further comments? If not, it looks like we have got it nailed. I will yield back to the chairman.

Mr. WALDEN. OK, I guess we are ready to go to a vote. I now recognize the gentlewoman from Tennessee, Ms. Blackburn, for 5.

Mrs. BLACKBURN. Thank you, Mr. Chairman, and I thank all of you for your patience. I think it is so evident here today that there is such a demand and a request for spectrum. I had someone in my office earlier today for a meeting, and we were talking a little bit about the spectrum, as you would well imagine, and the need for it and the need for broadband expansion because of the estimation that within the next few years, we are going to have not a billion but a trillion devices that are going to be connected to the broadband.

And when you look at all of the help IT, just take my district there in Nashville and Memphis, and up to the Kentucky line. Look at that swath, I would like to say it is a creative community, a lot of entrepreneurs, a lot of people that are inventing and innovating. And you look at the auto engineering, and you look at the digital music labels and distribution systems and the entertainment distribution systems and you look at the health infomatics and health IT components and all that we are doing. It is no wonder that pretty soon you are going to hit that trillion number. That means we are going have to have more access; you certainly can see how this debate is going to tee up and everybody wants a little bit more room on the spectrum.

Mr. Bazelon, I want to come to you and talk a little bit about the mobile DTV. Last year about this time, in May, we will forever be known as the May floods in Tennessee. And 47 of our counties ended up as federally-declared disaster areas. Well, WSMV in Nashville broadcast in mobile DTV, and we had a lot of constituents that kept up with what was happening through those floods through that format. And let's just say if there were to be spectrum relocation and some of this was to be relocated so that companies like Cellular South or Ms. Dillon's U.S. Cellular could get on there and access some of that spectrum. Would my constituents in Tennessee have difficulty pulling in that mobile DTV band?

Mr. BAZELON. It would be impossible to say the specifics of what would happen in your district.

Mrs. BLACKBURN. What would your estimation be, your best guess?

Mr. BAZELON. I think the answer to your question is that there will be more available bandwidth to your constituents from having reallocated television spectrum. You are quite right that on the other side of the mobile television broadcasting, there may or may not be less of that, depending on what the choices the broadcasters in your district make are, but the clear point is that any value they place on that service, any value that is placed on that service can be compensated for in an auction. And as my principle spectrum reallocation suggests that the spectrum shouldn't be reallocated if it is, in fact, more valuable for that service, and the auction is there to help discover the answer to that question.

Mrs. BLACKBURN. OK. Mr. Good.

Mr. GOOD. Well, my company is involved in mobile TV, and it certainly has the ability to provide a lot of public service, as you described. People can see what is happening. And I just question, you know, we talk about mobile wide band. Why can't television be considered part of the solution rather than a problem that has to be set aside? It can provide that service, and it still continues to provide the public service to——

Mrs. BLACKBURN. Let me interrupt you. I did have a question for you because when we hear a lot about relocating spectrum, and you know, saying, well, it could weaken this or it could weaken our coverage for that, and you have a TV station there.

Let me ask you this: As you transferred your signal from analog over into the DTV and going into the DTV transition, did any of your viewers ever have trouble pulling your signal down? Was there a problem with them doing it? And what percentage of yours can no longer receive your broadcast today, or has there been any diminishment of your market area?

Mr. GOOD. The conversion from analog to digital has been a very difficult situation for my station, sure. We initially went from channel 8 analog to channel 58 digital. That channel was out of bands. So eventually, it ended the process. Bands are repacked. We have to go back to channel 8, went back to channel 8 digital. In the meantime, because of the repacking, other stations have been dropped in close to us. We operate on channel 8. There was another channel 8 dropped in in Brunswick, New Jersey. Channel 9 was dropped into Bethlehem, Pennsylvania. All those things impact on the power levels you are able to broadcast with.

We went from 110 kilowatts to 5.4 in the digital world. We have gone back to the FCC through consultants and attorneys and have gradually worked up in steps to 32.2 kilowatts. That still falls short. We still have complaints from viewers. We had thousands of complaints initially. We still get complaints. We have one cable system that despite their best efforts——

Mrs. BLACKBURN. But you are using the mobile DTV?

Mr. GOOD. At that point, we were not.

Mrs. BLACKBURN. OK. But you are now?

Mr. GOOD. There are stations within my company that are.

Mrs. BLACKBURN. Mr. Pitsch, did you have something you want to add? I am over my time and I need to yield back.

Mr. WALDEN. Go ahead.

Mr. PITSCH. Thank you. Just very briefly to make two points.

It is important to separate the vacating sharing process from the repacking process, and the decision to vacate or share or move to a VHF band, that is only going to occur if the parties to the transaction both agree that the new use is going to be higher value. That is what it means because it is voluntary.

I think Mr. Good is quite correct to be concerned about repacking costs. I think we have to address those. I think Congress should make clear that they are kept whole, but just very briefly, the new spectrum would likely be worth $35 billion. The money to the Treasury would likely be $20 billion. Even if we doubled our own estimate and met the numbers in Mr. Good's testimony, we are talking $2 billion. So I think this problem, if it is put in the proper context, shouldn't cause or derail this important reform.

Mrs. BLACKBURN. Thank you. I yield back, Mr. Chairman. Thank you for your courtesy.

Mr. WALDEN. Indeed, and before I go to Mr. Scalise, I am going to ask unanimous consent to put in the record a statement of the National Association of Broadcasters. I believe it has been cleared with the minority. Without objection, so ordered.

And now, I would turn to the gentleman from Louisiana, Mr. Scalise, for 5 minutes.

Mr. SCALISE. Thank you, Mr. Chairman. Appreciate the first of what I guess would be a few hearings on this important issue.

I know right after Hurricane Katrina, we experienced with Chief Dowd, I know you and some of your colleagues experienced in New York after September 11, and that was that you literally had first responders cut off from the ability to communicate. I know it was said by some that we went from the Jetsons to the Flintstones in a matter of moments, where literally you could not communicate, towers were knocked down, power was off, and it literally sent us back, it seemed like, to the stone ages in terms of communication and being able to get that vital information sent from local responders on the ground to others, and I know personally when I would go into the city in those first few days after trying to deal with issues, that is how I learned to text message because you couldn't use your cell phone but yet a text message could get through. And I think I burnt out a couple of phones just trying to get text messages to people because that was the only way you could get communications, and obviously, that is not a situation that we should have to deal with.

And 4 years after September 11, we were still in that position, and here yet another 6 years later, we are still, it seems like, in that position. And so I think that challenge we face, as the FCC faces, is how we finally build an interoperable network.

I know you addressed some of this earlier in your questions, but as we look at the cost of building that out, the spectrum that would be used to build that out, as you look at the money that would be generated from an incentive auction to supply some of that money, have you addressed that yet of how those could play hand-in-hand, Chief Dowd?

Mr. DOWD. Sir, let me be clear. Some of the numbers that are being thrown around here today are grossly overinflated. Those are estimates of how much it would cost if you were building a public safety network from the ground up. That is not the case. We already have existing infrastructure that can be leveraged. There are other infrastructure that can be leveraged. We have talked about public and private partnerships, public utilities. So the cost is more likely going to be in the $10 billion range rather than the idea of $25 or $50 billion. It is simply not going to be that expensive.

So, again, looking at how we move forward in this, clearly what has become evident from many independent studies that have been done is that 10 megahertz of spectrum is simply not going to be enough for public safety. I have four studies right here, and of course, I would like to enter them for the record if that is permissible.

Mr. WALDEN. Absolutely. With your testimony, without objection.

Mr. DOWD. That indicates that 10 megahertz of spectrum for public safety is simply not enough. So, as we move forward on this effort, again, we want to engage in the maximum flexibility to leverage the network, the public safety network, in order to ensure that we are as efficient as possible while still being able to accomplish the primary mission, which is mission-critical public safety capability. But that doesn't mean we don't want to use that network or allow for, for example, with smaller cellular companies around the country to make partnerships with public safety in those regions where it is appropriate to utilize that spectrum.

The problem here is, again, we understand the fiscal realities of this, but the fact of the matter is we simply cannot, in today's environment and the threats that this country faces, not have enough spectrum to do the job. It is like suggesting that the Navy, when they are building an aircraft carrier because of a lack of funding should sell half the steel from the buildout of the aircraft carrier so that it can be funded.

You simply to need to have the resources you need to have, and the finite resource here is spectrum, and again, I point to the studies. These are real studies, real evidence of the use of public safety in broadband that indicates that 10 megahertz of spectrum is simply not going to be enough to do the job.

Mr. SCALISE. Thank you. Mr. Knapp, I don't know if you want to respond to that as well as—just really quickly if you can respond because my clock is running here. I am almost out. Do you want to——

Mr. KNAPP. Well, it is more than just the technical problem, and most of the disagreements about exactly how much spectrum is going to be needed centered on projections of the use and concerns about when there is an emergency and there is a crisis, that is when the demand blooms.

Mr. SCALISE. The broadcasters and the wireless carriers are saying that they are using their spectrum efficiently. I don't know if you want to comment on whether one technology is more efficient than the other or just address that.

Mr. KNAPP. Well, the different technologies have different applications, and we like to think we are driving all of them to efficiency.

On the wireless side, there have been tremendous advances through cellularization, smaller and smaller cells. At the cellular show, I saw a number of vendors that are introducing even more efficient techniques. So this is something we at the Commission are continuing to encourage and drive.

Mr. SCALISE. And final question, when you talked to—I am not sure what your process has been, but if you do, as you go forward with a voluntary incentive auction, the assumption would be that there would be willing participants who would volunteer to participate in that auction, and Mr. Good has said he wouldn't want to be involved in something like that. But have you talked to other stations? How do y'all poll to determine what kind of interest there would be to see if you could generate the $35 billion or so that have been discussed?

Mr. KNAPP. It clearly would be voluntary. The chief of our media bureau, Bill Lake and his staff, have been talking to literally hundreds of broadcasters. They conducted seminars, Webinars, about it where we have had about 500 different participants, so we know there is interest.

Mr. SCALISE. So they have expressed interest? Some have expressed interest?

Mr. KNAPP. Absolutely. At the end of the day, it will be up to them individually once they see the plan and what they might get in return for them to make those decisions.

Mr. SCALISE. Thank you, Mr. Chairman. I yield back.

Mr. WALDEN. I thank the gentlemen for his questions. I want to thank each of the witnesses for your testimony today and for your very candid and forthright answers to our questions. Our record will remain open for 10 days if other members of the subcommittee who either were here today or could not be here today have questions, they could submit to you. I would appreciate your responses in writing to that.

We will have additional hearings on this issue. We want to make sure that our brave men and women who protect us and defend us have the equipment they need and a communication system that works wherever they are in our country. We want to make sure the taxpayers are protected as well, and so we have a lot of issues we are going to flesh out here. That is why we are going to have several hearings. I want to make sure members of the subcommittee have every opportunity to get their questions answered and learn as much as they can about a very complex issue.

We hope to only go through this once in terms of allocating this spectrum, and so we want to make sure we get it right. And so we are going to take our time. We are going to do that. We will have additional hearings. We will announce that schedule along the way here, probably not today.

And with that, I again thank you all for participating, and with that, the hearing is adjourned.

[Whereupon, at 3:40 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

STANFORD INSTITUTE FOR ECONOMIC POLICY RESEARCH
SIEPR

Gregory L. Rosston
Deputy Director

April 6, 2011

President Barack Obama
The White House
1600 Pennsylvania Avenue
Washington, DC 20500

Dear President Obama,

We are 112 economists who specialize in telecommunications, auction theory and design, and/or competition policy. We understand that Congress is considering legislation that would give the FCC explicit authority to run "incentive auctions" in which it would have the ability to distribute some portion of the auction proceeds to licensees who voluntarily give up their license rights. We support such an effort and think it would increase spectrum efficiency in the United States.

Spectrum policy is very important for the United States economy. In 1993, Congress took the important, but politically controversial step of authorizing spectrum auctions. The decision led to substantial benefits including more efficient spectrum allocation and substantial revenues for the U.S. Treasury. The Federal Communications Commission ("FCC") worked with auction experts to develop the simultaneous multiple-round auction that worked in the United States and has been replicated around the world.

Congress has another chance to give the FCC a valuable tool to increase the efficiency of spectrum use in the United States by granting the FCC the authority to auction spectrum it controls at the same time as it auctions spectrum licenses held by commercial entities. Auction design and practice is sufficiently advanced that the FCC can successfully implement this type of auction. Incentive auctions can facilitate the repurposing of spectrum from inefficient uses to more valuable uses while minimizing the transaction costs incurred. Giving the FCC the authority to implement incentive auctions with flexibility to design appropriate rules would increase social welfare.

Historically, the FCC allocated spectrum for specific uses such as television, radio, or satellite services. Spectrum rules are meant to resolve conflicting uses, much as a city might engage in zoning to protect homeowners from noisy or dirty industrial developments. Because of changing technologies, demand, and relative costs, old spectrum allocations based on out-of-date assumptions have become inefficient, wasting valuable spectrum resources. Existing laws do not give the FCC the tools it needs to allow spectrum to be reallocated efficiently and quickly from

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old uses to newer, currently more valuable uses.

The United States has a long tradition of relying on private market transactions to guide resources to their highest value uses. Voluntary transactions in free markets ensure that trades happen only when the buyer and seller both benefit. Just as for most assets, when radio spectrum is used inefficiently and appropriate property rights are in place, the potential buyers and sellers will be encouraged to find terms that capture and share the benefits of transitioning spectrum to higher valued uses.

Transitioning spectrum to more valuable uses is relatively easy and almost spontaneous when simple, single transactions can provide most of the joint benefits. But repurposing radio spectrum can entail complex transactions involving several parties. For example, a buyer may be reluctant to acquire licenses piecemeal because of the risk that it might fail to aggregate a sufficient quantity of appropriate licenses. However, a centralized auction that incorporates package bidding helps assure the buyer that it would not be saddled with an inefficiently small aggregation of licenses, and also allows a buyer to compare alternative acquisition strategies more systematically. A centralized marketplace can also reduce the transaction costs and hold out problems that sometimes arise when the ability to set up a service requires negotiating rights from many different parties (sometime referred to as a "thicket of rights" or "anticommons" problem). For example, current broadcast licenses have many overlapping geographic areas; it might be difficult to come to satisfactory agreements in a timely manner with a sufficient number of incumbent licensees in any particular geographic area, or enough geographic areas across the country, to establish a viable wireless service.

Implementing an efficient "incentive auction" will require substantial thought and care – we look forward to working with the FCC to develop an efficient auction system and to address potential concerns about the auction and how it will work. The original simultaneous multiple-round auction system implemented in 1994 was novel, but the FCC was able to implement the path-breaking auctions that were the basis for successful auctions around the world. We expect that the same will be true of incentive auctions.

Sincerely,

Paul Milgrom   A. Skrzypacz

Paul Milgrom	Gregory Rosston	Andrzej Skrzypacz
Stanford University	Stanford University	Stanford University

Cc: Austan Goolsbee, Chairman, President's Council of Economic Advisors
Eugene Sperling, Chairman, National Economic Council

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May 17, 2011

The Honorable Greg Walden
Chairman, Subcommittee on Communications and Technology
Committee on Energy and Commerce
United States House of Representatives
2125 Rayburn House Office Building
Washington, DC 20515-6115

Dear Chairman Walden:

Attached are Slade Gorton's responses to your written questions following up his testimony on April 12, 2011 at the hearing entitled "Using Spectrum to Advance Public Safety, Promote Broadband, Create Jobs, and Reduce the Deficit."

If we can provide you with any further information on this matter, please let us know.

Cordially,

Pamela

Pamela Garvie

cc: The Honorable Anna G. Eshoo, Ranking Member,
Subcommittee on Communications and Technology
carly.mcwilliams@mail.house.gov

Attachment

RESPONSES OF HON. SLADE GORTON

Responses to Questions of Hon. Greg Walden

1. **Public safety officials have approximately 100 MHz of spectrum, 24 MHz of which we cleared in the 2005 DTV legislation specifically for an interoperable broadband network. We also provided $1 billion in that legislation, bringing the 10-year total to $13 billion. How have these resources been utilized to bring public safety users an interoperable network?**

As your question suggests, public safety has already been provided with considerable spectrum and economic resources to build and operate an interoperable network. Unfortunately, those resources have not produced the desired result. Much of the 700 MHz spectrum that was allocated from broadcasters is dedicated for narrowband operations that would not be part of any interoperable network. Much of the other spectrum that public safety has been allocated in the past is also used for narrowband operations and none of it for a nationwide interoperable network. While I'm not familiar with how all of the $13 billion you reference was spent, it is my understanding that virtually none of it was spent on building an interoperable network. Instead, I understand that most of that money was used for individualized, local public safety projects generally unrelated to an interoperable network. In the future, Congress must be assured that any funds designated for an interoperable network are actually spent to build and operate that network.

2. **What's the right governance model for the interoperable network, regardless whether we re-allocate the D-block? Who should run the network? Who should build it? Who should pay for it? How should we allocate its use for commercial purposes during the majority of time when public safety demand is low?**

Governance. It is important that the governance is structured so that the network is truly interoperable on a nationwide basis. The network cannot be a loose confederation of otherwise independent public safety systems – that's what we have today. Some Federal supervision would appear to be appropriate to achieve this goal.

Funding. Given the severe restraints imposed by the budget deficit, it is unrealistic to think that Congress could or would dedicate general taxpayer revenues to build a public safety network today. Instead, Congress should auction the D Block spectrum and use that revenue, along with whatever revenues are generated from the sale of other spectrum, to build a public safety network. The D Block licensees could give public safety access to tower sites and other important resources, reducing the costs that public safety will incur to build its broadband network on the spectrum currently allocated for that purpose.

Use of Public Safety Networks for Commercial Purposes. Public safety could generate additional revenues for this task by making its network available to commercial licensees. Any such leasing should be done on a non-discriminatory basis, of course. It may also be appropriate for NTIA or the FCC to oversee this leasing. I understand that the technology that both the public safety and commercial systems will use – long term evolution, or LTE – will permit precisely this type of shared access without compromising public safety's priority access to the network.

3. How do public safety's network needs vary between rural and urban America? What does that mean for how we build this network?

Public safety entities in rural and urban locations are best able to assess their respective requirements. Regardless of how those needs differ, however, it is important that the public safety network be interoperable across all areas of the country. Urban and rural first responders should have an opportunity to customize the part of the network built in their areas to meet local needs, but the core feature of the network – interoperability – must remain.

Questions for the Record
Deputy Chief Charles F. Dowd
NYPD Communications Division
Subcommittee on Communications and Technology
Using Spectrum to Advance Public Safety, Promote Broadband, Create Jobs, and Reduce the Deficit
April 12, 2011

The Honorable Greg Walden

1. **During questioning at the hearing, you indicated that the public safety community would be willing to return spectrum in exchange for the D Block. What spectrum do you envision public safety relinquishing in such an exchange?**

Since LTE is a new technology and public safety communications are mission critical, public safety agencies including the NYPD are understandably reluctant to specify an exact amount of spectrum that they would be willing to give up at this time. However, I hasten to add that if public safety's needs are met by the 700MHz. public safety broadband network, there would be no reason, technically or economically to retain large blocks of spectrum in other bands. In particular, public safety data networks now operating on 25Khz. channels would be the first to be replaced by a public safety broadband wireless network.

2. **If Congress were to change existing law to permit the reallocation of the D Block directly to public safety, how would the nation's public safety entities build the network needed to operate on both the D Block and its existing 24MHz. allocation?**

As the D Block is adjacent to the Public Safety broadband spectrum, the cost to build a broadband network spanning both the existing Public Safety broadband and the D Block is only marginally greater than building a broadband network on the public safety broadband spectrum alone. The notion that the entire 24MHz. of spectrum cleared in the 2005 DTV legislation and assigned to public safety was allocated for a public safety broadband network is inaccurate. Half of the 24MHz. cleared by the DTV transition is allocated for public safety narrowband channels, which primarily support mission critical voice applications.

The requirement for contiguous spectrum is important since LTE increases in spectrum efficiency as the channel bandwidth increases. Doubling the channel bandwidth more than doubles the channel capacity. This is the essence of broadband and is one of the reasons that it is more spectrally efficient than narrowband. The wider the channel bandwidth the more spectrally efficient LTE becomes. The D Block is the only available spectrum that is adjacent to the public safety broadband 700MHz. spectrum. Furthermore we maintain that if the D bock were to be auctioned to a commercial entity, the resulting network deployed would cause interference to the adjacent public safety 700MHz. broadband network, decreasing its capacity.

3. **Public safety officials have approximately 100MHz. of spectrum, 24MHz of which we cleared in the 2005 DTV legislation specifically for an interoperable broadband network. We also provided $1 billion in that legislation, bringing the ten year total to $13 billion. How have these resources been utilized to bring public safety users an interoperable network?**

As you correctly point out, public safety is currently assigned over 100 MHz. of spectrum. The notion that the entire 24MHz. of spectrum cleared in the 2005 DTV legislation and assigned to public safety was intended specifically for an interoperable broadband network is inaccurate. Half of the 24MHz. cleared by the DTV transition is allocated for public safety narrowband channels, which primarily support mission critical voice applications.

Spectrum is not a homogenous resource. Public safety spectrum allocations are scattered throughout many frequency bands. The physical characteristics of the various frequency bands differ greatly.

Fifty MHz. of the public safety spectrum you reference is in the 4.9GHz.band. This frequency band has very poor propagation characteristics which make any wide area network deployment cost prohibitive. It is used primarily for incident scene broadband data applications and limited local surveillance video. Much of the remaining public safety spectrum is not available nationwide. Furthermore, public safety frequency allocations are scattered throughout the RF spectrum on many disparate frequency bands, which impedes interoperability.

Patching channels from different bands as a means of achieving interoperability is cumbersome and spectrally inefficient; requiring special purpose external devices. Differences in propagation between the various frequency bands render some frequency bands more appropriate for a high architecture design, such as traditional land mobile radio networks; while other frequencies are better suited for a lower architecture design such as modern commercial cellular networks.

The funds allocated by Congress have largely been spent upgrading and improving existing narrowband public safety voice and data radio systems, and installing patches and gateways to enable interoperability across multiple frequency bands and disparate proprietary radio technologies. Although this approach as led to a higher level of interoperability, it is very inefficient from both a spectrum management and a financial standpoint.

One of the major cost factors in the current public safety radio environment is the high cost of proprietary subscriber units manufactured specifically for public safety, as noted by FCC Chairman Genachowski in his letter to the Honorable Henry A. Waxman, dated July 20, 2010, quoted below.

> "The staff of the FCC's Public Safety and Homeland Security Bureau (Bureau) believe that proprietary solutions and market dominance play an important role in the problems with interoperability, innovation, cost and competition in the market for public safety communications equipment. This conclusion is consistent with the National Emergency Communications Plan (NECP) issued by the Department of Homeland Security, which states (page 24) that "[t]he proprietary nature of many communications technologies creates an ongoing challenge to system connectivity and establishing interoperability among them." Similarly, Dereck Orr, the Program Manager of the Public Safety Communications Research Program of the National Institute of Science and Technology recently testified before the Committee on Science and Technology,

Subcommittee on Technology and Innovation, that interoperability is impacted by the proprietary nature of public safety communications equipment."

"Bureau staff and many outside experts have found proprietary solutions to have a significant impact on the cost of public safety communications equipment. This, perhaps, is illustrated best by comparing widely-available commercial wireless and the proprietary public safety narrowband communications equipment. For example, the staff's research has found that while a state-of-the-art consumer cellular device typically costs a few hundred dollars, a typical land mobile radio for public safety communications may cost as much as $5,000. This is at least partly because public safety is unable to capture the benefits of competition and economies of scale associated with equipment and devices that are manufactured for the commercial consumer marketplace, Commission staff expect that leveraging the commercial mass market could reduce costs for public safety devices substantially – even with such requirements as ruggedizing, many experts suggest that handset costs should be measured in hundreds of dollars not thousands."

4. With several high-profile public safety network projects delayed or under investigation, if Congress put safeguards in place, to ensure that public safety gets the capacity it needs, in times of crisis, would public safety benefit from having commercial providers build a robust network for public safety and commercial users?

Although capacity is a concern it is not our only concern, one of the primary reasons for the failure of the D Block auction was a requirement that the auction winner partner with public safety and build a network to public safety standards which are much more stringent than commercial standards, and provide service nationwide including in areas where there were insufficient customers to support the network and still provide the network owners with a positive return on their investment.

Public safety networks are typically equipped with emergency power backup capability. Most critical public safety radio sites are equipped with a minimum of eight hours of backup power. Public safety technical staff can restore service quicker than commercial entities since they can more quickly access sites within disaster areas when commercial providers (civilians) are excluded due to security concerns. Simply put, public safety technical staff will respond in situations that commercial providers will not.

The experience of the NYPD illustrates this point. During the Northeast blackout of August 2003 many commercial cell sites in New York City failed within the first few hours and remained inoperative for the duration of the blackout. Electrical power was out in most of New York City for approximately 25 hours. This even exceeded the backup power capacity at many NYPD radio sites. However, NYPD Radio Repair Mechanics and Police Officers were able to keep these sites on the air by replacing discharged backup batteries with freshly charged batteries. These batteries weigh approximately 100 pounds and in some cases had to be hand carried up sixty floors. No commercial wireless network provider made a similar effort to maintain service, nor would we expect them to. They simply waited for commercial power to be restored.

5. What's the right governance model for the interoperable network, regardless of whether we reallocate the D-block? Who should run the network? Who should build it? Who should pay

for it? How should we allocate its use for commercial purposes during the majority of time when public safety demand is low?

A national governance entity (NGE) organized as a non-profit organization should serve as the primary governance entity to oversee the deployment of the700MHz. public safety nationwide broadband network. This group should be composed of public safety communications officials and subject matter experts who would be responsible to set minimum network specifications and requirements that regional network builders would be required to follow. This organization would also set national network policy. Local network builders should be responsible for day to day network operations including provisioning and radio access node (RAN) maintenance.

A federal grant program should be established to provide funding for local entities to build regional networks that would become part of a nationwide "network of networks". These funds should be administered by the National Governance Entity.

In order to maintain financial viability and improve spectrum utilization, public safety licensees should be allowed to seek network users among closely related agencies and industries if there is sufficient capacity on their networks after the needs of first responders are met. Once again, local control is a key element and one size does not fit all. It is entirely possible that in New York City there will be a sufficient number of public safety eligible users who fit the Commission's narrow interpretation of Section 337 to populate the network to a sustainable level. However, in many areas of the country this will not be the case. Accordingly, we urge the Commission to broaden its interpretation of Section 337 to include all government entities, local, county, State, Tribal and Federal. In addition, critical infrastructure providers such as utility companies would be an appropriate fit[1]. Many emergency situations such as natural disasters require public safety agencies to work closely with utility companies to restore service in the aftermath of hurricanes, forest fires, earthquakes, snowstorms or floods. We concur with comments filed by the State of New Mexico, that the Commission has the legal authority to allow public safety operators to share spectrum with Critical Infrastructure entities. Since utilities exist in virtually every jurisdiction and have expressed a desire to utilize the public safety nationwide broadband network, we believe that they can partner with public safety in this endeavor. The participation of utilities and other critical infrastructure providers can help to offset ongoing network expenses and required upgrades.

6. How do public safety's network needs vary between rural and urban America? What does that mean for how we build this network?

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[1] *See National Broadband Plan, Chapter 16, Public Safety; page 315-316; Administrative System "Public safety licensees should also be able to allow non-public safety partners to use their spectrum on a secondary basis – that can be preempted- through leasing or similar mechanisms. Partners could include critical infrastructure users such as utilities connecting to the Smart Grid. However, any revenue collected by a public safety entity for such use must be used to build or improve the public safety broadband network."*

Rural jurisdictions face coverage challenges since they encompass vast sparsely populated areas that nevertheless require public safety radio system coverage. Coverage within buildings is challenging in both urban and rural communities, but is obviously more of a concern in dense urban areas. Rural areas will be more able partner with critical infrastructure entities such as electric and gas utility companies since they will likely have fewer public safety first responders, resulting in a certain amount of spare capacity to offer potential partners; however the number of potential partners will be quite limited. The issue of capacity is the same in rural or urban areas when large numbers of first responders need to coalesce at the scene of the emergency.

The geography in rural areas will dictate a higher site design so that larger areas can be covered by fewer radio sites. Conversely, urban areas will require a lower site architecture design to increase capacity by reusing spectrum at closer intervals. The propagation properties of the 700 MHz. band will inherently provide a certain amount of indoor coverage, however it will be necessary to install in building radio systems in the form of pico-cells, femto cells and distributed antenna systems in the largest buildings to ensure public safety grade coverage.

7. During a Senate Commerce Committee hearing earlier this year, meeting, several witnesses from the Public Safety Alliance testified that they would be willing to lease public safety spectrum for commercial use on a secondary basis, when public safety demand is low. Should Congress require that all revenue generated from secondary use leasing of public safety spectrum be deposited into the U.S. Treasury for Federal deficit reduction? If not, who should receive revenue and what specific requirements should be placed on the use of the money.

We join with many of our fellow waiver recipients in advocating partnerships with critical infrastructure providers in jurisdictions where public safety network capacity demands permit. In areas where the number of public safety users is small, we should allow critical infrastructure users onto the network to help mitigate the cost to public safety. This however would likely require Congressional legislative action. Reducing network costs by leveraging existing public safety infrastructure and entering into partnership agreements with critical infrastructure entities such as electric and natural gas utilities in our mutual interest. To some extent however, the users of the network may be required to help bear network operating costs. To that end, our goal should be to maximize the number of users on the proposed 700 MHz. nationwide broadband public safety wireless broadband network without overloading it, thereby reducing the cost per user while ensuring network access for first responders. Revenues generated by partnering with utilities and other critical infrastructure entities should be used to defray ongoing network operating costs. Costs can be further reduced by sharing radio sites and backhaul facilities with commercial entities. In the longer term, migrating legacy public safety mission critical voice and data to the 700 MHz. nationwide broadband public safety wireless broadband network can further reduce costs by eliminating duplicative services and utilizing lower cost non-proprietary user devices.

Answers of Mary N. Dillon
President & CEO of U.S. Cellular® Corp
May 17, 2011

The Honorable Bob Latta

1. In your testimony on page 10 you talk about auction spectrum in small area blocks. Can you explain a little bit more about that idea?

   The most effective way to maximize both the value and public interest benefit of licensed spectrum is to offer licenses in smaller geographic areas rather than national or mega-regional swaths. Auction structures providing for national or mega-region licenses, or allowing large carriers to tie up large areas through package bidding, preclude U.S. Cellular and other smaller carriers from being able to bid and win spectrum they could use to grow and provide competition in the marketplace. Furthermore, reduced participation in the auction itself results in less active bidding and lower revenues for the Treasury.

   Any legislation to authorize auctions must ensure that as many companies as possible can effectively bid for and win licenses. More licensees mean more competitors in the marketplace, greater innovation and customer satisfaction, and, in a positive case of synergy, increased revenues to the Treasury.

2. Should incentive auctions be approved, what costs do you expect to be incurred for broadcasters who agree to participate?

   I do not expect the broadcasters to incur any net cost whatsoever for participating in a voluntary incentive auction but instead, I expect them to profit from the sale of their spectrum. Once they sell their spectrum, they still have options to continue broadcasting by channel sharing or by moving to VHF. Additionally, for those who choose not to participate in the auction, I expect any cost incurred from repacking after an incentive auction would be covered by auction proceeds.

The Honorable John D. Dingell

1. Should repacking of broadcasters' spectrum be voluntary? Please explain your response.

   Repacking of the spectrum cannot be voluntary for broadcasters. Not only would the broadcaster have undue holdout power in the auction but they would stand in the way of a contiguous block of spectrum that is needed for mobile broadband. I do believe that broadcasters should be compensated for the costs they incur as part of a repacking process.

2. If the Congress is to consider legislation granting the Federal Communications Commission the authority to conduct voluntary incentive auctions, should consideration of such legislation be delayed until after an inventory of all spectrum is completed? Please explain your response.

A spectrum inventory is not only good policy; it is necessary to locate additional spectrum for mobile broadband. However, it would be bad policy to use the need for a spectrum inventory to delay the public benefits that would flow from an expeditious incentive auction. In October, the FCC released a report indicating that our nation needed 275 MHz of additional spectrum for mobile broadband by 2015. Therefore an inventory should not delay moving forward with incentive auctions. The broadcast spectrum is, in the aggregate, underutilized spectrum that is well suited for mobile services. An incentive auction will drive this spectrum toward its highest and best use. While it may be beneficial to find out what spectrum outside of the broadcast band is available, there is no doubt that the broadcast spectrum will need to be part of the solution and we should not delay the opportunity to more productively deploy this scarce national resource.

Response of Robert Good
Assistant General Manager, Director of Operations, and Chief Engineer
WGAL-TV, Lancaster PA
to
Questions of the House Subcommittee on Communications and Technology
Following the April 12, 2011 Subcommittee Hearing

May 19, 2011

The Honorable Greg Walden

1. **In your experience what is the minimum spectral separation that is needed between broadcast users to avoid interference problems?**

For broadcasting, interference is a phenomenon that occurs at the customer's television receiver and prevents or degrades a viewer's ability to receive the desired video and audio signals broadcast or transmitted due to the presence of undesired signals from other broadcast stations or other sources. The extent and nature of the interference will vary from station to station and viewer to viewer. Interference is a function of a number of factors, including, but not limited to: distance between television stations operating on the same channel, those operating on immediately adjacent channels, the power levels at which the stations are operating, terrain, obstructions, weather and atmospheric conditions, the extent to which other devices (wireless devices, power generators, etc.) emit objectionable radiation, and, equally important, how well the viewer's television receiver is built to reject interfering signals. Taking all this into account, the FCC calculates the minimum distance that stations operating on the same or adjacent channels can be relative to each other, and makes assignments accordingly with these minimum distance separations as criteria. This is both a logical and reasonable approach.

The spectrum efficiency of the current broadcast system is constrained by how well a television receiver can reject adjacent television channel interference in the same area. Improving spectrum efficiency (i.e., reducing the FCC's minimum distance separation criteria) would require better built television receivers that can reject higher levels of interference from other signals and other sources. Today's television receivers were not designed or built to reject interference from more closely packed channels or from other unintentional radiators such as computers, wireless devices, and other consumer and commercial devices. The VHF band is especially susceptible to interference of this nature.

In order to make sure all new television receivers had better interference protection, government mandated rules would be required and existing television receivers would have to be replaced. The cost of replacement of all existing sets would be staggering.

The FCC, in Section 73.610(b) of its Rules, requires specific mileage separation between stations operating on the same or adjacent digital channels at specified antenna heights and power levels. Real world, practical experience with the digital service, however, has shown these separations to be inadequate in avoiding objectionable interference in certain areas.

2. **Based on your experience in the DTV transition, how can incentive auctions be configured to help broadcasters move from one channel to another?**

I have no expertise in the Commission's auction process. However, broadcasters whose stations currently operate on UHF channels would have no incentive to change channels if the new channel would result in a reduction in the station's service area or reduce the level of services (HD, multicast, mobile) the station can currently provide.

On the other hand, each broadcaster whose station now operates on a digital VHF channel would certainly have an incentive to change to a UHF channel if a UHF channel, suitable to the broadcaster, were offered. However, we think finding a suitable UHF channel, as discussed below, is highly unlikely.

Regardless, any broadcaster that voluntarily makes a channel move should be fully reimbursed for all costs associated with the move. Broadcasters have just spent billions of dollars to transition from analog to digital television, and they should not be expected to bear any additional costs, even if their existing service could be replicated with an alternative channel.

3. **What are the relative costs and performance tradeoffs if a broadcaster moves just a few channels away versus more channels? What are the relative costs and performance tradeoffs if a broadcaster moves within the UHF band versus from the UHF band to the VHF band?**

The actual cost and performance tradeoffs will vary greatly for each broadcaster, but in every case, the costs will be significant.

In the UHF television band, moving only one or two channels away should generally result in less cost than moving by more than two channel positions since a UHF station will be more likely be able to use or retune some of its current equipment (e.g., transmitter, power service, etc.) in such circumstances.

While coverage and propagation are similar if a move involves only a few channel positions away in the UHF band, performance tradeoffs depend on interference from other channels within the market, in adjacent markets, and other factors. And this is likely to be the case in virtually every move. So, while moving only a few channel positions away may, in theory, be "predicted" to have similar coverage, the new channel could be "short spaced" to another channel in an adjacent market resulting in interference and a loss of service coverage.

Based on the "real world" experience our company has had at our station, WGAL-TV, Lancaster, Pennsylvania, we can confirm both (1) the out-of-pocket equipment and installation costs and (2) more critically, the enormous performance differences between the UHF band and high band VHF for digital television service.

WGAL was required to install digital facilities for an interim digital channel in the UHF band (Channel 58) during the last transition. It was an "out-of-core" channel, and we were required to surrender that UHF channel and return to the VHF band (Channel 8) at the conclusion of the digital transition. Unfortunately, there were no acceptable UHF band stations available to us at that time.

Both of these digital channels were and are authorized to operate at full power. Our first digital UHF Channel, Channel 58, out performed our digital VHF Channel 8. We have also found, even operating at 32.2 kW ERP, that our present Channel 8's performance does not equal the performance of our former analog VHF Channel 8 at 110 kW ERP or our former digital UHF Channel 58 at 97 kW ERP. In fact, we are currently seeking permission from the FCC to increase our power to 59 kW ERP to recapture and restore our traditional coverage area. The VHF band power levels that were "predicted" by the FCC to replicate our VHF former analog coverage area were greatly underestimated. In fact, the FCC is currently suggesting that further power increases may be a partial solution for increasing the viability of high band VHF television stations. As far as low band VHF channels go, the general consensus is that these channels are unacceptable for digital television because of multiple factors – susceptibility to electrical noise (natural and man made), various noise from digital devices, etc.

In short, (a) countless viewers who receive service from stations currently operating in the UHF band would, inevitably, lose service if those stations were required to move to the VHF band; and (b) the out-of-pocket costs to move within the UHF band are, in general, less than the cost of moving from the UHF band to the VHF band. At a minimum, a UHF-to-UHF change most likely would require a new antenna, harmonic filters and mask filters for many stations. In some cases, a new transmitter would not be required. However, the unknown financial impact of required directional antennas and the type of antenna that is required to replace a station's present antenna would significantly impact the costs of the transition.

Below are our costs to purchase and install a digital UHF television transmission system for WGAL-TV.

UHF Antenna and Transmission Line		$405,317
UHF Digital Transmitter		$986,054
Installation and Building Modifications		$131,186
Attorneys and Consultants		$ 20,000
Technical Staff Costs – Design/Install		$ 50,000
	Total	$1,592,557

These costs were mitigated to some extent in our case because we were able to side mount our new UHF digital antenna on our existing tower. We also had existing building space available, and we were able to remain on our present site. The costs would have increased substantially if we had not had the ability to utilize present components of our existing facility. (*Note*: The costs cited above include one digital UHF transmitter. We did not plan for a backup transmitter for this installation because we knew that the life of the system would end when the transition was completed—that, of course, will not be the case for stations that make a permanent change.)

However, since we had to vacate UHF Channel 58 at the end of the last transition and since there were no longer any full power UHF Channels available in our market to replicate our former service, we were forced to move back to VHF Channel 8 and incur additional costs in excess of $1 million. Below is a *conservative* estimate of the cost to purchase a typical digital VHF television transmission system similar to that used by WGAL.

VHF Antenna and Transmission Line		$500,000	(Estimated)
VHF Digital Transmitters		$725,000	
Installation and Building Modifications		$138,086	
Attorneys and Consultants		$ 20,000	
Technical Staff Costs – Design/Install		$ 50,000	
	Total	$1,363,156	

Once again, our costs were mitigated by the fact we were able to utilize our existing tower, antenna and transmission line, building space, and site. Others may not be so fortunate going forward. Without these advantages, the costs above would escalate accordingly. Nor do the estimated costs above take into account the extent of additional power required to replicate UHF coverage—nor the cost to a station of the inevitable loss of service under the best scenario.

The costs to a station for a new, permanent channel relocation if all these factors are taken into account would be substantially more than the estimated number above that we incurred for WGAL.

4. What challenges are there for a broadcaster changing from one UHF channel to another?

There are significant challenges for broadcasters changing channels, both in the practical sense of implementing the change and in the costs. Some of the challenges of changing from one UHF channel to another UHF channel, from one VHF channel to another VHF channel, or from VHF to UHF are similar. But, again, there are variables in each case.

Unlike the previous transition, where the analog over-the-air service was available during the build out of DTV, changing channels going forward would require interruption of existing over-the-air service possibly for several weeks and, perhaps, months. Some of these challenges would include removal of the existing transmitting antenna and replacing it with a new one, replacement of the existing transmission lines, and in many instances replacing the existing transmitter or exciter, and/or modifying or strengthening the tower structure to accommodate the new equipment. In addition, the head-end equipment of cable and satellite companies that retransmit broadcast station signals will likely need to be replaced and/or modified. An obvious issue is who would pay for those modifications.

Moreover, in some parts of the country, such as the northeast where many television stations are located, it most likely would prove to be very difficult (if not impossible) to find spectrum for all stations that chose to remain on the air. Even if it is possible to find available channels, it most likely would require that the stations utilize directional antennas, resulting in a loss of service. Directional antennas are used to mitigate interference issues for stations that operate in close proximity to each other on the same channel as well as for stations that are operating on distant adjacent channels. Use of a directional antenna would make it impossible to replicate the coverage area previously provided by an existing omni-directional antenna. That would be a major negative outcome for viewers and stations.

Much has been discussed about the desirability of a "flash cut." A "flash cut" means that a station operates on its present channel until the day of the transition, at which time the station "flash cuts" and switches to another channel. The following explains some of the problems with that process.

First, many UHF stations utilize slotted pylon single-channel antennas and those antennas are usually mounted on the top of the transmitting tower. A "flash cut" for those stations would be extremely expensive and difficult. A station would need a second side mounted antenna operating on its new channel to perform a "flash cut" to a new channel. After the transition, the station would replace the antenna on the top of the tower.

Towers, in general, are designed to support *only* the antenna and equipment that was intended to be placed on the tower at the time it was designed. Before two antennas can be mounted on the tower, a structural analysis of the tower would be required to determine if the tower could support the weight and wind load of both antennas. In some cases, costly structural changes would be necessary to enable the tower to withstand the additional weight and stress imposed by the changes. These structural changes, generally, consist of replacing various tower components (cross members, diagonal bracing, etc) while the tower remains in service. Needless to say, the risks associated with this process are significant. Only after the tower has been modified to meet the revised loading and stress requirement could the additional side mounted antenna and the tower top antenna be switched. And in the process, the tower is in jeopardy. In some cases, a replacement tower may be required.

Skilled tower crews are required to perform this tower work and there are but a handful of these crews working in the United States. This factor cannot be overlooked in any discussion of a further transition. Their work is exceptionally dangerous because they are dealing with processes that require the removal of an antenna, weighing tons, from the top of a tower, lowering it to the ground, pulling up the new antenna and installing it on top of the tower. All of this must be done in a precise manner or the tower will fail with human life loss and destruction of an expensive asset.

It is anticipated that in some cases, a station's existing transmission line could be reused but there are instances where that would not be feasible. If a new transmission line has to be installed, the current line would remain in place until after the conversion. Two transmission lines on a single tower would require additional tower space and create additional tower stress and loading issues.

Some UHF stations are operating with panel antennas that have the ability to work on any UHF channel. These antennas are frequently used where multiple stations elect to use the same antenna or in the case where a special directional antenna pattern is required for a station. In these cases, the antenna may not need to be replaced, and the second UHF channel may be added without further antenna cost. The potential problem with this concept is that the new channel assignment most likely will not have the same pattern that was required for the station's present channel assignment. Thus, in some cases, it will simply not be possible to modify the antenna system to conform to a different pattern. And if not, then the station will have no choice but to replace the entire antenna and the cost issues then would be similar to those cited in the first example.

Finally, modern digital UHF transmitters generally can cover the UHF band with minor changes. However there are some components that are channel specific. Several of these devices include such things as Harmonic Filters, Mask Filters, Combiners, etc.

In addition, it will be likely in some cases, due to the channel change and the antenna used, that more power and energy would be required to provide a replication of existing coverage. If that is the case, additional RF power generating equipment would be required, and the cost of that additional equipment and power could be considerable. In fact, some transmitter buildings may not have the space for, nor the power required to operate, this additional equipment. In that case, the building would have to be expanded and additional power provided. In some center city installations it may be impossible to obtain either.

In summary, the costs will vary from station to station, but in each case, the cost would likely exceed $1 million and could run to $2 million or $3 million or more depending on the circumstances. The practical challenge of avoiding a long-term disruption of service while the channel change is underway would be daunting. The larger concern would be the potential for permanent reduction in coverage and loss of service to viewers. And, as noted, the reality is that in some parts of the country, replacement UHF channels simply do not exist.

5. What regulatory obstacles exist that are making it harder for broadcasters to develop next generation services? What other provisions could we put in spectrum legislation to help reduce those barriers?

In addition to the concerns of television broadcasters about spectrum reallocation as expressed in my testimony, and in response to the Subcommittee's questions, we are also deeply concerned that the FCC, in response to cable and satellite companies, will impair and compromise the ability of local stations to negotiate for market-based rates in exchange for allowing cable and satellite carriers to retransmit and resell their signals. Stations are equally concerned at the prospect the FCC will arbitrarily modify existing television markets to allow MVPDs to import non-local duplicating stations or otherwise weaken or eliminate the existing local station program exclusivity rules.

Television broadcasters are also concerned that the *local* ownership rules preclude their ability to achieve operating efficiency through common ownership that would enable them to compete more effectively with cable, satellite, and Internet companies that deliver hundreds of national television program and video services, most of which are not subject to the same ownership or other regulatory constraints imposed by the FCC on local broadcasters.

* * * * *

The Honorable Bob Latta

1. **Should incentive auctions be approved, what costs do you expect to be incurred for broadcasters who agree to participate?**

These costs are described in above responses to Chairman Walden's questions. As discussed above, the out-of-pocket transition costs to broadcasters are only part of the total costs. The larger costs would be potential for loss of coverage and service. And in that connection, Congress should take into account the cost to viewers and constituents of the permanent loss of free, over-the-air local television services by their local stations.

2. **Based on your experience in the DTV transition, how can incentive auctions be configured to help broadcasters move from one channel to another?**

I have no expertise in the Commission's auction process. However, I would think few, if any, broadcasters anticipate relinquishment or replacement of their station's channel assignment without knowing more about the amount of the proceeds that would be remitted to them in a spectrum auction proceeding. The law of economics might suggest that at *some* price, broadcasters would be willing to vacate or replace their channels, but that price may be so high, for a variety of reasons, that the actual number would not justify the reallocation process.

On the other hand, if suitable UHF channels could be obtained, many broadcasters now operating in the VHF band would have an incentive to change channels. The challenge, as noted below, would be to find suitable UHF replacement channels.

Regardless, any broadcaster that voluntarily makes a channel move should be reimbursed for the costs associated with that move. Broadcasters have just spent billions of dollars to transition from analog to digital television, and they should not be expected to bear additional costs.

* * * * *

The Honorable John D. Dingell

1. **Should repacking of broadcasters' spectrum be voluntary? Please explain your response.**

Yes. The repacking contemplated by the FCC staff plan will clearly not be voluntary. The FCC staff proposal would reallocate 120 MHz of television spectrum through the reallocation of a *nationwide* spectrum block of 20 contiguous channels (6 MHz per channel). It has been suggested that Channels 31-51 would be reallocated. The means, in short, that Channels 31, 32, 33, 34, 35, 36, (37 is not used for television broadcasting), 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51 would be removed from existing television service. The truly massive level of disruption of service to communities and viewers across the country is self-evident.

If Channels 31-51 were reallocated and removed from existing television service, the service would then have to be "repacked" into the remaining 17 UHF channels (Channels 14-30) and the challenge would be compounded further by the fact that Channels 14-20 are currently shared with public safety agencies already in some areas of the country.

The simple reality is that the 20 reallocated UHF channels cannot conceivably be "repacked" into the remaining 17 UHF channels without an enormous curtailment of free, over-the-air television coverage and service; and few, if any, broadcasters are likely to accept a massive diminution of coverage or service on a "voluntary" basis. Experience with the recent digital transition has shown that the VHF band (especially the low VHF band) is seriously flawed for television service, so the only truly viable band for television service in the UHF band. Congress can change its laws, but it cannot change the laws of physics.

As the Committee is aware, the issue here is not only the adverse impact the reallocation of spectrum would have on broadcasters, but, also, the substantial adverse impact it will have on viewers and the local broadcast service on which they rely for news, information, entertainment and life-saving public safety and emergency information.

2. **If the Congress is to consider legislation granting the Federal Communications Commission the authority to conduct voluntary incentive auctions, should consideration of such legislation be delayed until after an inventory of all spectrum is completed? Please explain your response.**

Yes. No less authority than Commissioner Michael Copps stated last month in a C-SPAN interview that the FCC, itself, should "have a better idea of what's going on with spectrum" and he added that, in fact, no one has "the foggiest idea right now what spectrum is being used for what purpose." [*Broadcasting and Cable*, April 1, 2011, p.5]

If the FCC does not know the extent to which currently allocated spectrum may already be available for broadband expansion, the auction and reallocation of broadcast spectrum on a nationwide basis would clearly seem premature—and may well be unnecessary in order to address projected wireless carriers' capacity constraints in a limited number of urban markets.

3. **Do you expect channel relocation subsequent to spectrum reallocation would impact the deployment of mobile TV? Please explain your response.**

Yes. As noted in my testimony and in response to the questions of Chairman Walden, the reallocation of existing broadcast spectrum would leave less spectrum available for transmission by local stations to mobile receiving devices as well as create interference issues that will have negative consequences for the deployment of mobile DTV in many areas, especially the northeast and other major metropolitan areas.

In addition, for technical reasons, the VHF band is not well-suited for mobile DTV, and wireless providers do not want the VHF band for mobile broadband because of those same technical limitations.

* * * * *

The Honorable Doris O. Matsui

1. **During the DTV transition, one of the local channels in Sacramento experienced some problems in the high VHF band. The antennas my constituents purchased during the digital transition were able to pick up only signals in the UHF band. That resulted in an inability to view that particular channel. As a result, the television station elected to purchase the antennas at a cost of about $100 each and distribute them to the viewers. Are you aware of similar situations and do you anticipate that there is a potential for similar issues to appear as we consider repacking in the future? If so, how can we best address such potential problems in advance as well as after they arise?**

As noted in response to Chairman Walden's Question 3 above, our experience with a high VHF band channel (Channel 8) at our station in Lancaster, Pennsylvania, confirms that high band VHF channels are inferior to UHF channels for delivery of digital television programming. (And as noted, low band VHF channels (2-6) are essentially not suitable for digital television service.)

The reception difficulties experienced by your constituent broadcaster in Sacramento are consistent, not only with our experience in Lancaster, but with that of digital broadcasters across the country who are operating on high band VHF channels. And as did the Sacramento station, we have gone to great length at our station to mitigate the reception difficulties. But the fact remains, notwithstanding the FCC's projections to the contrary before the digital transition occurred, the VHF channels have experienced enormous signal propagation challenges.

* * * * *

Federal Communications Commission
Washington, D.C. 20554

May 18, 2011

The Honorable Greg Walden
Chairman
Subcommittee on Communications and Technology
Committee on Energy and Commerce
U.S. House of Representatives
2125 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Walden:

Attached please find my responses to the additional post-hearing questions from my appearance before the Committee on April 12, 2011. Please let me know if I can be of further assistance.

Sincerely,

Julius P. Knapp
Chief,
Office of Engineering and Technology

The Honorable Greg Walden

1. **How much contiguous spectrum do we need to clear to create a viable swath for wireless broadband?**

Response: As more and more Americans use smart phones, laptops, and other devices to access the Internet wirelessly, they use more capacity on the airwaves. Smart phones are now outselling computers worldwide. Smart phones use 24 times as much data as traditional cell phones, while tablets like the iPad can use as much as 120 times as much. FCC staff has performed detailed analyses to project the effect of this trend. What we have found is that, under any reasonable set of projections about the future of mobile broadband, demand for spectrum for wireless services will soon outstrip the available supply.

For this reason, the Commission has proposed to free up 500 MHz of spectrum for mobile broadband over the next 10 years, with 300 MHz of that coming in the next 3 years, which is consistent with the President's Wireless Innovation and Infrastructure Initiative.

2. **In your experience what is the minimum spectral separation that is needed between broadcast users to avoid interference problems?**

Response: Television broadcast signals need to be protected from other signals on the same channel (co-channel) and on the first channels immediately adjacent on either side (first adjacent channels). The Commission's rules protect stations' service areas by prohibiting one station's interference contour (the predicted geographic contour at which the station's signal could cause interference) from overlapping another station's predicted service contour (the predicted geographic contour within which viewers are expected to be able to receive a station's service). The amount of separation needed varies because stations' service and interference contours vary significantly depending on their transmit power, antenna height and antenna pattern. To protect broadcast stations from interference by signals of other services that operate in the TV bands, such as land mobile radio and broadcast auxiliary services, our rules require compliance with fixed separation distances or provide for other appropriate interference avoidance requirements.

3. **What are the relative costs and performance tradeoffs if a broadcaster moves just a few channels away versus more channels? What are the relative costs and performance tradeoffs if a broadcaster moves within the UHF band versus from the UHF band to the VHF band?**

Response: The cost of changing frequencies is generally lowest if a station moves only one channel to either side of its current channel (*i.e.*, moves to a first adjacent channel). In this situation, a station can often use the same antenna, transmitter (other than the frequency generating exciter) and other parts of its transmission path. Frequency changes resulting in moves to channels that are more than one channel away are more expensive, and the costs of such moves vary depending on, among other things, how much of its transmission system the station must replace.

The costs of channel shifts will vary depending on the circumstances for each particular station. Channel shifts between the VHF and UHF bands, for example, will require the station to replace the transmitter as well as the antenna and transmission line. In addition, UHF operations usually require higher power than VHF operations and the transmitters for higher power operations are more expensive. Channel shifts within a band typically require only replacement of the antenna and transmission line.

With respect to performance, our experience has shown that digital television signals create more reception problems with VHF signals than with UHF signals, especially for consumers using indoor antennas. This is due to the relatively poor performance of indoor antennas in receiving VHF signals in the presence of local sources of electrical noise, such as computers and DVD players. VHF channels also do not transmit mobile DTV signals as effectively as UHF channels. The Commission has, however, launched a proceeding to look into ways to improve VHF reception and is seeking comment on providing a 6 dB increase in the maximum allowable transmitter power for VHF stations and applying minimum performance standards for new indoor antennas as ways to enhance VHF reception.

4. **How can/does the FCC ensure that white space devices don't interfere with broadcast signals?**

   Response: The Commission's rules protect television stations from interference from white space devices in several ways. The white spaces rules require that white space devices obtain channels for operation from a database system, which uses geolocation provided by a device to identify the channels that are available at the device's location. The available channels are calculated using the distance standards in the rules that prohibit white space devices from operating within specified distances of the service contour of a television station. These distance standards vary depending on the power of the white space device, and in some cases antenna height. In addition the rules include technical standards for the devices that further ensure against harmful interference. For example, personal/portable devices are limited to 40 milliwatts of power, which is less than 20% of most cell phones; fixed devices may operate at up to 4 watts of power but are not permitted to operate on channels adjacent to TV stations. There are other provisions that protect against interference to wireless microphones that operate in the TV broadcast spectrum.

5. **Your office currently has a proceeding open on VHF reception issues. Could you elaborate on how the work you're doing could improve the viability of the VHF band for some broadcasters?**

   Response: The Commission opened the proceeding in part to explore the viability of the VHF band for some broadcasters, and we are in the process of working through the ideas presented. Two ideas in particular that have emerged as potentially increasing the value of the VHF band for broadcasters are: (1) increasing the maximum allowable transmitter power for VHF stations; and (2) applying minimum performance standards for new indoor antennas.

6. **CTIA and CEA, the High-Tech Spectrum Coalition, and the President's Office of Science and Technology Policy have indicated that they believe that an incentive auction could be accomplished without adverse impact on broadcasters. Do you concur?**

   Response: Yes. Over-the-air broadcast television provides a critical service to local communities, and the Commission is committed to maintaining a strong over-the-air television broadcast service. Under our voluntary incentive auction proposal, no broadcaster would be required to give up spectrum involuntarily. Those stations that want to continue to broadcast on all or part of their current 6 MHz channel would be able to do so. Alternatively, a station could decide to stop broadcasting and contribute all of its spectrum to the auction; team up with other stations in its market and share a channel; or move from the UHF to the VHF band, all in exchange for a share of the auction proceeds. That share of the auction proceeds would provide a capital infusion for licensees that choose to participate, strengthening their economic position and their ability to offer innovative new services.

To ensure that the spectrum freed up in a voluntary incentive auction is useful for mobile broadband, the FCC may need to assign new frequencies to some television stations through a realignment process. We intend to minimize the number of stations that need to change frequencies and fully support reimbursing broadcasters for any costs incurred in relocating. Our goal is to limit any inconvenience to broadcasters and ensure a robust over-the-air television broadcast service.

7. How are the public safety waivers progressing? Will we be able to learn things from the waivers that help us answer some of the broader questions about public safety broadband networks?

Response: In May 2010, the Commission adopted an order granting, with conditions, twenty-one waiver petitions of various public safety entities (Petitioners) seeking authority for early deployment of public safety broadband networks.[1] The order established LTE as the technology platform for these deployments and also required adherence to a number of technical criteria. It also required Petitioners to enter spectrum lease agreements with the Public Safety Spectrum Trust, which holds a nationwide license for the 700 MHz public safety broadband spectrum.[2] On May 12, 2011, the Commission adopted an order granting a public safety waiver for the State of Texas, with conditions that mirror those in the previously-granted waivers.[3]

The Waiver Order requires Petitioners to submit quarterly reports addressing their progress in the areas of planning, funding and deployment. A status update for each Petitioner, based on the information contained in its most recent quarterly report or other public filing, is provided below. Petitioners marked with an asterisk were the recipients of funding under the Broadband Technology Opportunities Program (BTOP).

Petitioner	Status
City of Boston	No timeframe set for RFI/RFP; exploring funding possibilities.
City and County of San Francisco, City of Oakland, City of San Jose, CA*	Planning deployment of pilot network, Project Cornerstone.
State of New Jersey*	RFP planned for Q2 2011.
City of New York	No deadline for procurement set; exploring funding possibilities.
City of San Antonio, TX, on behalf of the San Antonio Urban Area Security Initiative Region	Exploring funding options for a smaller scale initial project; has engaged two available vendors.
City of Chesapeake, VA	Continuing to develop an RFI; re-evaluating its funding strategy.
State of New Mexico*	"Actively building" its network[4].
City of Charlotte, NC*	Issued revised RFP, Q2 2011.

[1] Requests for Waiver of Various Petitioners to Allow the Establishment of 700 MHz Interoperable Public Safety Wireless Broadband Networks, PS Docket 06-229, *Order*, 25 FCC Rcd 5145 (2010) (*Waiver Order*).
[2] The State of Alabama did not enter a spectrum lease agreement.
[3] Requests for Waiver of Various Petitioners to Allow the Establishment of 700 MHz Interoperable Public Safety Wireless Broadband Networks, PS Docket 06-229, Order, DA 11-863 (rel. May 12, 2011).

State of New York	RFI/RFP timeframe dependent on identifying a funding source.
District of Columbia	Engaged in regional planning; exploring funding possibilities.
County of Maui, County of Hawaii, County of Kauai, City and County of Honolulu, and the State of Hawaii	Does not intend to issue RFI/RFP in foreseeable future; lacks funding.
City of Seattle, WA	No timeframe set for RFI/RFP; re-evaluating its funding strategy.
Adams County, CO Communications Center*	Expect to sign vendor contract by early May.
City of Pembroke Pines, FL	Engaged in discussions with potential vendors.
Los Angeles Regional Interoperable Communications System (LA-RICS)*	In negotiations with vendor selected through RFP.
Iowa Statewide Interop. Comms. System Bd.	In planning stage.
Calumet, Outagamie and Winnebago Counties, WI	Issuance of RFP likely dependent on obtaining funding.
Mississippi Wireless Communications Commission*	RFP responses under review; expect to complete review process during Q2 2011.
City of Mesa, AZ and the TOPAZ Regional Wireless Cooperative	Issued RFP and received responses, Q4 2010.
State of Oregon	In planning stage.
State of Alabama	No spectrum lease agreement.
State of Texas	Waiver granted this month, so no status report yet required.

The *Waiver Order* also observed that these early deployments might assist the Commission in understanding additional issues that may arise for public safety in connection with the larger goal of establishing a nationwide, interoperable broadband network and serve to better inform all parties as the Commission moved forward with the related rulemaking proceedings. In this regard, as a condition of receiving waivers, the Petitioners were required to participate in the demonstration network sponsored by the Public Safety Communications Research program, a partnership among the National Institute of Standards and Technology, the National Telecommunications and Information Administration and the District of Columbia. In addition, several of the Petitioners have formed a working group through which they, among other things, share information and experiences among themselves and with other states and localities, as well as with the Commission and other Federal agencies.

8. How do public safety's network needs vary between rural and urban America? What does that mean for how we build this network?

Response: The challenges in delivering wireless broadband services to rural areas, such as low population densities, challenging terrain and greater geographic distances, are significant. For a

[4] The State of New Mexico filed its April 2011 quarterly report with a request for confidential treatment. Its status update is drawn from comments it filed publicly in PS Docket 06-229.

network that is to be interoperable on a nationwide basis, they are even more so. Network deployment must ensure network coverage availability for public safety users even in the most rural or remote areas, with a baseline of interoperability to allow first responders anywhere in the nation to send and receive critical voice, video and data seamlessly to save lives, prevent acts of crime and terror and reduce injuries. Unless network coverage availability is ensured for public safety users in rural areas, the network cannot be truly nationwide or interoperable. The need to overcome these challenges and the associated costs demonstrate the critical importance of sufficient funding to ensure that the network extends to rural areas.

9. In the absence of legislation, does the FCC currently have authority to rearrange the channels on which TV stations broadcast?

Response: Yes. 47 U.S.C. § 316 gives the FCC the express authority to modify broadcast licenses in the exercise of its spectrum management power, including the authority to modify channel assignments. *See* Community Television, Inc. v. FCC, 216 F.3d 1133, 1141 (D.C. Cir. 2004) (affirming the Commission's authority under Section 316 to issue initial DTV licenses to existing broadcasters through rulemaking); Committee for Effective Cellular Rules v. FCC, 53 F.3d 1309, 1320 (D.C. Cir. 1995) (affirming the FCC's authority under Section 316 to assign new channels to existing licensees without accepting competing applications). *See also* NBC v. U.S., 319 U.S. 190, 217 (1943) (recognizing the FCC's broad spectrum management authority); NAB v. FCC, 740 F.2d 1190, 1198 (D.C. Cir. 1984) (same). Likewise, licensees have no vested interest in any particular channel or frequency and no right to expect that their licenses will not be subject to validly promulgated rule changes. *See, e.g.*, 47 U.S.C. § 304 ("No station license shall be granted by the Commission until the applicant therefor shall have waived any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise."). The courts have suggested that the Commission's Section 316 license modification authority does not extend so far as to permit it to make such fundamental changes in the license terms or the conditions of operation that the action must be justified under another source of authority (*e.g.*, one or more of the Commission's general powers listed in 47 U.S.C. § 303, its initial licensing authority under 47 U.S.C. § 309, or its authority to revoke licenses under 47 U.S.C. § 312). *See* Community Television, 216 F.3d at 1141 (rejecting the argument that the FCC exceeded its authority under Section 316, and reasoning that "the FCC has not wrought a fundamental change to the terms of those permits and licenses. Broadcasters will begin and end the transition period broadcasting television programming to the public under very similar terms").

10. Broadcasters have expressed concerns that a repacking of the broadcast band would result in loss of signal coverage in some areas. How can an auction address these concerns?

Response: Realignment would not necessarily result in loss of signal coverage in some areas. To ensure that the spectrum freed up in a voluntary incentive auction is useful for mobile broadband, the FCC will need to assign new frequencies to some television stations through a realignment process. We intend to minimize the number of stations that need to change frequencies and fully support reimbursing broadcasters for costs incurred in relocating. Our goal is to limit any inconvenience to broadcasters and ensure a robust over-the-air television broadcast service.

We fully appreciate the need to consider completely the potential effect of realignment on signal coverage areas. The appropriate vehicle for such an analysis is through a rulemaking, where the issues implicated can be considered in an open and transparent process. This is the approach that the Commission followed in developing the rules and policies that led to the successful recovery of 108 megahertz of spectrum from TV channels 52 – 69 during the DTV transition. To be clear, our request for voluntary incentive auction authority is not based on any predetermined outcome as to the amount of spectrum that must be recovered and does not assume that there will be a reduction in stations' service areas. We are fully committed to maintaining a strong over-the-air television service.

The Honorable Mary Bono Mack

1. **The FCC has 20 Megahertz of spectrum in the AWS-2 Band which appears to be ready for immediate mobile broadband usage. Does the FCC have a plan in the near-term to begin the auction process for this spectrum? If so, can you please provide us with a timeline the auction process? If not, can you tell us what may be delaying this process?**

   Response: The twenty megahertz of spectrum at 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz, which is often referred to as "AWS-2," is spectrum in the Commission's pipeline. However, band configuration issues could potentially limit the use of these bands for broadband. Commission staff is therefore currently considering the best ways to maximize the value of this spectrum, as well as the unassigned AWS-3 band at 2155-2175 MHz, for mobile broadband use. Among other things, staff is analyzing potential synergies (*e.g.*, lower equipment and deployment costs) between these bands and other nearby bands that could be purposed for broadband. Additionally, NTIA is currently studying whether any Federal spectrum in the 1755-1850 MHz band, which could potentially be paired with AWS-2 or AWS-3 spectrum, could be reallocated for commercial use or shared with commercial users.

2. **I understand that the Office of Engineering and Technology is responsible for the experimental licensing at the FCC and most of that licensing information is available to the public. Can you provide information to the Committee on how many experimental licenses, or STAs, have been granted to use spectrum in the 1755-1780 MegaHertz band over the past five years, along with the geographic coverage of such licenses? Also, what segments in the 1755-1780 MegaHertz band are most frequently granted experimental authority and whether they operate in the top 25 metropolitan areas?**

   Response: The FCC's Experimental Licensing Program is administered by the Office of Engineering and Technology. Under the rules, the Commission permits a broad range of experiments in all services as well as development of military systems by government contractors. All records in the database are available for public search and inspection and can be accessed on the web at https://apps.fcc.gov/oetcf/els/reports/GenericSearch.cfm.

   Regarding the 1755-1780 MHz band, the Experimental Licensing System database (as of May 10, 2011) indicates that 52 experimental licenses and 132 STAs have been granted over the previous five years. In general, these licenses cover much wider frequency bands, and the 1755-1780 MHz segment is only a small portion of the spectrum each licensee is permitted to use. The 184 grants cover areas across the entire United States and provide for a widely disparate set of applications. An examination of the database reveals that most of the grants were for military applications (68) and device immunity testing (60). The remaining 54 grants covered tests of communications equipment, ultra-wideband equipment, trade show demonstrations, and antenna testing to name a few. Among the top 25 metropolitan areas, the Commission has granted experimental authority in the 1755-1780 MHz band in 19 of these markets plus one license with nationwide coverage and one that covers all of California. The 19 metropolitan areas covered by these grants are: New York; Los Angeles; Chicago; Dallas-Fort Worth; Philadelphia; Washington, DC; Miami-Fort Lauderdale; Atlanta; Boston; San Francisco; Phoenix; Seattle; Minneapolis-St. Paul; San Diego; Tampa; Baltimore; Denver; Sacramento and San Antonio. An Excel spreadsheet is attached showing the relevant data.

The Honorable Bob Latta

1. **In your testimony you mentioned the spectrum inventory that the FCC has been undertaking. Could you explain a little bit about how the technical process of how the FCC went about inventorying spectrum?**

   Response: Beginning with the development of the National Broadband Plan, the FCC commenced a systematic process of drawing on the information across disparate FCC systems and rules to present a meaningful picture of spectrum management for the public. In addition, FCC staff engaged in numerous discussions with NTIA to ensure that we had its input into our work. From this process, it became clear where the meaningful opportunities to free up spectrum for mobile broadband existed.

   One outgrowth of this process was the Commission's concerted effort to make information about spectrum holdings and uses more transparent. In particular, the FCC has developed two tools – LicenseView[5] and the Spectrum Dashboard[6] – that reflect our understanding of where the most significant spectrum opportunities lie. The data in the Spectrum Dashboard is based on information currently stored in the FCC's electronic licensing records and our rules, such as the table of frequency allocations. Although the public could previously access bits and pieces of this information through various databases on the FCC's website, it resided in different places and contained technical language and terms of art that were difficult for the general public to understand. In contrast, the Spectrum Dashboard provides "one-stop shopping" for much of this information, using plain language and providing new data aggregation and display functions, such as mapping capabilities.

   LicenseView enables users to digest complex licensing information through a simple and easy-to-use online portal. The tool includes data for active licenses from all of the Commission's licensing systems, which include CDBS - Consolidated Database System, COALS - Cable Operations and Licensing System, ELS - Experimental Licensing System, IBFS - International Bureau Filing System, and ULS - Universal Licensing System. LicenseView pulls data from all of these systems on a regular basis to provide an accessible, up-to-date picture of spectrum licensing. This new tool provides an overview of FCC license management data that is at the core of the agency's mission..

   The Spectrum Dashboard and LicenseView represent a key element of our spectrum inventory because they include much of the information that informs the Commission's spectrum planning. The baseline spectrum inventory has enabled us to bring detailed technical information to bear on spectrum management, and we intend to continue enhancing the spectrum inventory and building the functionality of the Spectrum Dashboard and LicenseView to expand public access to our spectrum inventory.

2. **I've heard reports that 2013 would be the soonest the FCC could put together an incentive auction, even if Congress gave the agency the authority today. Can you describe what preparations need to go into that, and if the FCC is granted the authority, what will be done to insure that an incentive auction is truly voluntary?**

   Response: An auction is inherently a voluntary process in which bidders make offers to buy or sell at given prices. In an incentive auction, broadcasters will be given an opportunity to specify the prices at which they are willing to discontinue over-the-air broadcasting, as well as their willingness

[5] *See* http://reboot.fcc.gov/license-view.
[6] *See* http://reboot.fcc.gov/reform/systems/spectrum-dashboard.

to accept other options, potentially including channel sharing and/or relocating from the UHF band to the VHF band. Broadcasters can choose to participate or not. If they do participate, they can further indicate their readiness or reluctance to accept any of these options by submitting relatively low or high prices, respectively.

The voluntary incentive auction process will work best if broadcasters choose to participate. Hence, the FCC intends to design an auction process that broadcasters feel will be fair to their interests. This process will include several opportunities for broadcasters and other interested parties to weigh in on the rules, auction design, timing, and other aspects of the process.

With respect to the process leading up to an auction, should Congress grant the Commission the authority to conduct voluntary incentive auctions, the agency would commence a rulemaking proceeding seeking comment on the service rules for the spectrum to be auctioned, including rules that would address the incentives and options to be provided to incumbent broadcasters for participating in the auction. At the conclusion of this rulemaking process, the Commission would implement its decisions by seeking comment from prospective auction participants on the auction design and auction procedures, including reserve prices. After appropriate notice and comment, the Commission would release a public notice setting forth the auction procedures and key dates for the auction process. As is its practice in all auctions, the Commission would ensure that broadcasters and other interested parties were given sufficient time to develop business plans, assess market conditions, evaluate equipment availability and become familiar with the service rules and auction procedures. Prior to its spectrum auctions, the Commission typically prepares a tutorial to educate potential participants in Commission auctions on the application requirements, and we envision a similar process to educate potential bidders before a voluntary incentive auction. After providing a period for the filing of short-form applications to participate in the auction, Commission staff will review the applications for compliance with its rules, noting any deficiencies. Applicants will then be provided with an opportunity to cure the deficiencies and submit their upfront payments, after which staff will determine the qualified bidders for the auction and release a public notice announcing the qualified bidders. These steps will help to bring about a successful auction.

3. **If Congress fails to enact any spectrum legislation including authorizing incentive auctions, how much spectrum below 3 GHz would be available today for auction that could be used to provide licensed mobile broadband services?**

   Response: The National Broadband Plan set a goal of freeing an additional 300 megahertz of spectrum for mobile broadband services within five years and 500 MHz of spectrum within 10 years. As noted in the Broadband Plan, the FCC presently has 50 megahertz of spectrum below 3 GHz in the pipeline that could be auctioned toward this goal. The 50 megahertz consists of the following bands:

   - *Advanced Wireless Services 2 (AWS-2).* This band consists of 20 megahertz of paired spectrum in two 10 megahertz blocks. Each of the blocks presently faces challenges that limit its broadband potential. The FCC is studying ways to combine these blocks with other spectrum to create a larger, more valuable band for auction.

   - *Advanced Wireless Services 3 (AWS-3).* This band consists of 20 megahertz in a single unpaired block. The band is adjacent to one half of the Advanced Wireless Services 1 (AWS-1) band that was auctioned in 2006. As noted in the Broadband Plan, the band would be more valuable for broadband if it was paired with an equivalent block in the 1.7 GHz range. NTIA is currently investigating the possibility of repurposing some federal spectrum to enable this pairing.

- *Upper 700 MHz D Block.* This band consists of 10 megahertz of paired spectrum adjacent to the 700 MHz band that was auctioned in 2008. The disposition of this band is under active consideration by Congress in relation to the deployment of a nationwide public safety broadband network.

The National Broadband Plan noted that voluntary incentive auctions would be a useful, market-based mechanism to expand mobile broadband in spectrum currently used for television broadcast and certain mobile satellite services. Together, these bands could represent up to 160 megahertz of spectrum—more than three times the amount spectrum currently in the FCC's auction inventory.

The Honorable John D. Dingell

1. **During the Subcommittee's April 12, 2011, hearing on spectrum use, you indicated that you believe if 120 Megahertz were reallocated from broadcast television to wireless broadband access and Canadian channel reservations taken into account, there would be sufficient channels available for all of Detroit's 14 stations.**
   a. **Is this still your understanding? Please explain your response.**

      Response: The Commission's plan for recovery of television spectrum is to make television channels available for new broadband services using a voluntary incentive auction. The incentive auction would provide broadcasters with the option to voluntarily contribute their spectrum to the recovery process. The amount of spectrum that could be recovered from this process would depend on the number of stations that volunteered their channels and the markets in which they are located. Under this process, no stations would be required to relinquish their channels or to cease to operate their broadcast services – if stations did not agree to participate, we are committed to maintaining spectrum so that they can stay on the air. In other words, if none of the stations in Detroit chose to participate in the voluntary incentive auction, they would all continue to operate, and we would seek to minimize any detrimental impact from realignment of the spectrum. While the National Broadband Plan noted 120 MHz as a goal, the ultimate amount of spectrum repurposed to wireless broadband in a voluntary incentive auction will be determined by the market. We expect many stations will choose to participate, but we will not compel any station to take part in an auction in order to achieve the 120 MHz goal.

   b. **Please submit an analysis of Detroit and other surrounding markets to support your answer that there will be sufficient channels for all of Detroit's TV stations. Please describe how channel relocation would affect broadcast stations in these markets. Specifically:**

      i. **Does your analysis assume Detroit stations and stations in surrounding markets will participate in the incentive auction and exit the market? If so, how many do you assume will turn in their channels? Please explain the basis for the reasoning underpinning this assumption.**

         Response: We do not know which stations in Detroit, if any, would choose to participate in a voluntary incentive auction. Nor do we know which stations would choose to participate in any other market. While we can speculate as to which stations might participate in a voluntary incentive auction, this would create the erroneous impression that we have pre-determined the outcome of a voluntary incentive auction. We are also concerned that doing so could have a serious detrimental impact on those stations' current businesses.

      ii. **Does your analysis assume that some stations in Detroit, as well as stations in other markets, will share channels? If so, how many do you believe will pursue this option? Please provide data as to which stations will share and with whom.**

         Response: Channel sharing is an option that the Commission has proposed to provide as a means for stations to contribute spectrum to a voluntary incentive auction while continuing to provide broadcast television service. We do not at this time have any indication as to how many stations or which specific stations may choose to share channels.

iii. **Does your analysis protect all Canadian assignments and allotments (analog and digital)? Does your analysis protect Class A, LPTV, and Translator stations? Does your analysis protect land mobile/public safety operations that may exist in Detroit or surrounding markets? Please explain your response.**

Response: The United States negotiates with Canada (and also Mexico) on matters affecting the use of spectrum. We have traditionally included protection of Canadian assignments and allotments as appropriate in our agreements with that country. We would expect to conduct similar negotiations with Canada in matters affecting the recovery of a portion of the television spectrum and have incorporated the capability to account for protection of Canadian television facilities, both assigned and allocated, in our analysis tools.

iv. **Does your analysis assume any changes in a station's protected service contour or coverage area? What are the changes, if any, from their current coverage areas, both in terms of population and geographic coverage. Please identify the stations and the anticipated losses, if any. Please also provide the methodology you are using to predict these coverage areas. Is this methodology the same as that employed by the Commission to determine DTV coverage areas during the 2009 DTV transition? If not, please explain why not.**

Response: Our analysis tools have the flexibility to include a variety of types and degrees of protections for stations' service areas. We initially used a spacing approach in analyses supporting the estimates of auction revenues and more recently have developed the capability to protect stations' service contours, using the same methods that were used to determine and protect coverage in the 2009 DTV transition.

v. **Does your analysis assume that a station may be moved from the UHF band to the VHF band? Will any UHF stations be moved to the low VHF band (channels 2-6) or the high VHF band (channels 7-13)? Please delineate the breakdown.**

Response: Our analysis capabilities provide for stations to choose to voluntarily move from a UHF channel to a VHF channel for a price set by the station. We are not planning to require stations to move from UHF to VHF channels.

2. **Channel availability in Detroit is a function of channel availability in surrounding markets. In your analysis, in order to accommodate stations in Detroit, did you assume that there would be fewer TV channels available in surrounding markets (*e.g.*, Toledo, Lansing, or even Cleveland)? Please provide a regional analysis indicating the channel availability for TV stations in adjacent and surround markets that affect channel availability in Detroit.**

   Response: Under the voluntary incentive auction approach that we are considering, channel availability in all markets would be a function of the stations that voluntarily choose to participate in the incentive auction. That is, the channels that would be available for recovery in individual markets would depend only on the channels in those individual markets that choose to participate in the auction. However, the channels that are actually selected for recovery will depend on those that are most needed to maximize the clearing of contiguous blocks of spectrum in a channel realignment process. In this regard, the Commission would first determine the amount of spectrum it could recover based on the channels that were voluntarily made available by station licensees in the voluntary incentive auction and, as part of that process, determine the number of channels from those volunteering their spectrum it needed to recover from each individual market to meet its spectrum recovery goal. It would then select channels to recover from the individual markets based on their price – the channels selected for recovery from the group of channels available in each market would be those that were priced the lowest.

3. **In the *Notice of Proposed Rule Making in Innovation in the Broadcast Television Bands Allocations, Channel Sharing, and Improvements to VHF*, ET Docket No. 10-235, FCC 10-196 (released November 20, 2010), the Commission noted the importance of its new Allotment Optimization Model:**

   > **As part of its effort to improve the efficiency of U/V Band spectrum use, the Commission has undertaken the development of a model for optimizing the assignment of channels to television stations nationwide. This model, the Allotment Optimization Model (the "AOM" or the "Model"), allows the user to optimize broadcast channel assignments when clearing spectrum for new uses, subject to technical and other constraints. An initial version of this model was used by the staff in developing the spectrum analyses underlying the recommendations for recovery of U/V Bands spectrum set forth in the *Plan* and the Technical Paper. We anticipate that the fully developed model will be completed and validated in the near future for use in subsequent stages of this process to increase the efficient use of the U/V Bands and facilitate ongoing wireless innovation. *Id* para10.**

   a. **Please provide all of the details of the "initial version" of the model that was used by the staff in developing the spectrum analyses set forth in the National Broadband Plan and Technical Paper. Specifically, please provide the methodologies, algorithms, predictive coverage models, and interference assumptions that underpin these analyses.**

      Response: The Commission released the details of the initial version of the model in a Technical Paper that was released in June 2009 entitled "Spectrum Analysis: Options for Broadcast Spectrum." The details of how the model works were provided in the appendices to the Technical Paper. Appendix C describes the optimization model formulation, and Appendix D describes the Longley Rice predictive coverage model and interference assumptions.

The Paper can be found on the FCC's broadband.gov website at http://download.broadband.gov/plan/fcc-omnibus-broadband-initiative-(obi)-technical-paper-spectrum-analysis-options-for-broadband-spectrum.pdf.

b. **The Commission promised that it will make public its new Allotment Optimization Model. Please provide the date on which the Commission anticipates making this AOM model public. Will the model be made public before the House of Representatives considers legislation dealing with cast band? If not, please explain your response. Further, should members of Congress have an opportunity to review this model to assess whether TV stations in their districts will be affected by the application of this new model? Please explain your response.**

Response: The Allotment Optimization Model (AOM) is a tool that would assist the FCC in realigning TV stations as part of a voluntary incentive auction process, after stations have expressed their willingness to participate (or not participate) in any of the proposed options for taking part in a voluntary incentive auction. Commission staff have continued to refine the model since releasing the Technical Paper, but the final structure will depend on the parameters set by Congress in legislation authorizing the Commission to undertake voluntary incentive auctions, as well as on the public rulemaking process at the FCC.

4. **Should repacking of broadcasters' spectrum be voluntary? Please explain your response.**

Response: To ensure that the spectrum freed up in a voluntary incentive auction is useful for mobile broadband, the Commission will need to assign new frequencies to some television stations through a realignment process. We intend to minimize the number of stations that need to change frequencies and fully support reimbursing broadcasters for any costs incurred in relocating. Our goal is to limit any inconvenience to broadcasters and viewers while maintaining a strong over-the-air television broadcast service.

5. **If the Congress is to consider legislation granting the Federal Communications Commission the authority to conduct voluntary incentive auctions, should consideration of such legislation be delayed until after an inventory of all spectrum is completed? Please explain your response.**

Response: No. The Commission has conducted a baseline spectrum inventory to better understand the overall spectrum landscape. This baseline inventory is one of the most substantial and comprehensive evaluations of spectrum in the Commission's history. Through our systematic process, we have developed two tools – LicenseView and the Spectrum Dashboard – that reflect our understanding of the location and availability of our most significant spectrum opportunities.

Our steps to date in creating and maintaining a spectrum inventory have provided the necessary information to determine how best to unleash significant additional spectrum for wireless broadband within the next ten years. They have enabled us to obtain a more complete picture of what spectrum is dedicated to what purposes and where spectrum can be made available for flexible use, including mobile broadband. Most importantly, they have confirmed that the MSS and broadcast television bands stand out as falling within the frequencies appropriate for mobile use and have sufficient bandwidth to offer clear opportunities for increased spectrum access, making them the best possible candidates for initial application of voluntary incentive auctions to free up additional spectrum for mobile broadband in the near term.

Conducting a spectrum inventory is inherently an iterative process, and the Commission will continue to enhance its baseline spectrum inventory. However, due to the increasing demand for wireless broadband services that has been estimated to exceed the supply of spectrum to offer such services over the next several years, the cost and time it would take to complete an exhaustive inventory – a minimum of tens of millions of dollars and at least several years – and the baseline spectrum inventory the Commission has already completed, we should not delay the benefits of meeting the market demand for wireless broadband today and in the very near future.

6. **Does the Commission expect channel relocation subsequent to spectrum reallocation would impact the deployment of mobile DTV? Please explain your response.**

Response: The Commission's current rules permit and encourage the development of mobile DTV, and we do not believe our voluntary incentive auction proposal would negatively affect any broadcaster's planned rollout of mobile DTV service. A broadcaster that wants to use its spectrum for mobile DTV will be able to do so, either by not contributing any spectrum to a voluntary incentive auction or by contributing some spectrum to the auction and using some of its remaining spectrum for mobile DTV.

The Honorable Doris O. Matsui

In October of last year, the FCC issued a report titled "Mobile Broadband: The Benefits of Additional Spectrum." The report concluded that our nation needed an additional 275 MHz of spectrum. If Congress failed to enact any spectrum legislation, how much spectrum below 3 GHz would be available today for auction that could be used to provide licensed mobile broadband services?

Response: The National Broadband Plan set a goal of freeing an additional 300 megahertz of spectrum for mobile broadband services within five years and 500 MHz of spectrum within 10 years. As noted in the Broadband Plan, the FCC presently has 50 megahertz of spectrum below 3 GHz in the pipeline that could be auctioned toward this goal. The 50 megahertz consists of the following bands:

- *Advanced Wireless Services 2 (AWS-2).* This band consists of 20 megahertz of paired spectrum in two 10 megahertz blocks. Each of the blocks presently faces challenges that limit its broadband potential. The FCC is studying ways to combine these blocks with other spectrum to create a larger, more valuable band for auction.

- *Advanced Wireless Services 3 (AWS-3).* This band consists of 20 megahertz in a single unpaired block. The band is adjacent to one half of the Advanced Wireless Services 1 (AWS-1) band that was auctioned in 2006. As noted in the Broadband Plan, the band would be more valuable for broadband if it was paired with an equivalent block in the 1.7 GHz range. NTIA is currently investigating the possibility of repurposing some federal spectrum to enable this pairing.

- *Upper 700 MHz D Block.* This band consists of 10 megahertz of paired spectrum adjacent to the 700 MHz band that was auctioned in 2008. The disposition of this band is under active consideration by Congress in relation to the deployment of a nationwide public safety broadband network.

The National Broadband Plan noted that voluntary incentive auctions would be a useful, market-based mechanism to expand mobile broadband in spectrum currently used for television broadcast and certain mobile satellite services. Together, these bands could represent up to 160 megahertz of spectrum—more than three times the amount spectrum currently in the FCC's auction inventory.

May 17, 2011

Chairman Greg Walden
Subcommittee on Communications and Technology

Dear Chairman Walden:

Enclosed are my answers to Congressmen Latta's and Dingell's written questions regarding my testimony before the Subcommittee on Communications and Technology on April 12, 2011 at the hearing entitled "Using Spectrum to Advance Public Safety, Promote Broadband, Create Jobs, and Reduce the Deficit."

Thank you again for asking Intel to testify before the Subcommittee on this important topic.

Sincerely,

/s/ Peter K. Pitsch

Mr. Peter K. Pitsch
Associate General Counsel, Intel

cc: The Honorable Anna G. Eshoo, Ranking Member,
Subcommittee on Communications and Technology

Attachment

The Honorable Bob Latta

1. **What will happen if the spectrum shortfall is not addressed? And can you talk about the specific benefits of wireless innovation for rural America?**

If the spectrum shortfall is not addressed in a timely manner, our nation's mobile broadband networks will become more congested and service prices will increase. Consumers and society will suffer substantial costs and losses from fewer minutes of use, lower quality of service, and foregone innovative services. The creation of innovative new services will be stymied and American workers and consumers would be denied well-paying jobs and valuable services.

On the other hand, if Congress passes legislation to address the spectrum shortfall in a timely manner (as discussed during this hearing), consumers will realize significant gains from freeing up additional spectrum for mobile broadband– on the order of ten times greater than the gains to private operators and taxpayers.[1] Indeed, the net gain to consumers from clearing 120 MHz of TV Band spectrum for mobile broadband use (or put differently, the opportunity cost of not clearing this spectrum) would be in the hundreds of billions of dollars.

The specific benefits of wireless innovation for rural America would be significant for rural businesses and consumers. Wireless applications are inherently more useful than wired services in rural areas where wired solutions are more expensive on a per user basis and where the benefits of being connected to other consumers and businesses are particularly helpful.

[1] Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, RAND Journal of Economics, Vol. 40, No. 3 (Autumn 2009), , at 425 (available online at http://mason.gmu.edu/~thazlett/pubs/Hazlett.Munoz.RandJournalofEconomics.pdf). "Empirical research undertaken a decade ago found the annual consumer surplus associated with U.S. cellular telephone licenses (issued in the 1980s) at least 10 times as large as annual producers' surplus (Hausman, 1997; Rosston, 2001). Today, U.S. wireless phone market data yield an annual consumer surplus estimate of at least $150 billion. The total revenue obtained from selling all wireless licenses (not just for mobile telephony) is just $53 billion. Given that the latter is a present value and the former an annual flow, these data suggest that the ratio (CS to PS) is much above an order of magnitude."

Moreover, incentive auctions have the potential to clear TV Band spectrum which is uniquely valuable in sparsely populated areas. This spectrum has tremendous propagation characteristics which make it attractive to build low-cost, coverage networks in rural areas. Indeed, *non capacity constrained* networks built using this 700 MHz band spectrum are estimated to cost a fraction of what networks operating on 2.5 GHz spectrum would cost.[2] These cost savings would make it feasible to offer lower cost, fixed-wireless broadband as well as additional mobile broadband services for rural businesses and consumers.

2. How would freeing up additional spectrum affect the manufacturing sector in America?

Freeing up additional spectrum is likely to have a very positive impact on the manufacturing sector in America. Overall, the manufacturing sector, as well as other sectors of the U.S. marketplace, will enjoy the lower prices, less network congestion, and new services provided by 4G wireless broadband networks. Freeing up additional spectrum to enable our nation's 4G wireless broadband networks is critical to enabling U.S. workers and companies to compete – and win – in an increasingly global marketplace.

Regarding the semiconductor industry in particular, every device that connects to wireless networks contains semiconductors and many of them are made in the U.S. For example, roughly 75% of Intel's microprocessor manufacturing is done here in America (while more than 75% of Intel's revenue comes from outside the U.S.) and more than half of Intel's employees are located in the U.S. The continued growth of the wireless industry will spur innovation and investment in microprocessor

[2] *See* Peter Cramton Presentation dated November 2007: *700 MHz spectrum has a ten-fold coverage advantage over 2.5 GHz spectrum*. (http://www.justice.gov/atr/public/workshops/telecom2007/submissions/227839.htm).

manufacturing and other manufacturing sectors in this country. Access to new bands of spectrum for wireless broadband will advance these investments, as well as research and innovation here in America.

The Honorable John D. Dingell

1. Should repacking of broadcasters' spectrum be voluntary? Please explain your response.

The repacking of broadcasters should not be made voluntary. The FCC currently has the legal authority to mandate that a particular broadcaster move channels, *e.g.* from channel 39 to channel 29. In conjunction with voluntary incentive auctions, this repacking authority would enable the FCC to clear, and then auction, large contiguous blocks of spectrum which are most valuable for mobile broadband service.

Broadcasters whose channels are repacked should be kept whole, however, and voluntary incentive auctions will generate ample funds to cover these repacking costs. Our estimates show that the costs of repacking the affected broadcasters would be approximately $800,000 per full power station on average and under one billion dollars in total. Our analysis also demonstrates that the repacked broadcasters should be able to broadcast from their current towers and serve their current coverage areas.

Changing the law to make repacking voluntary would give many broadcasters "hold-out" power which would deprive either consumers or US taxpayers of significant benefits. In that case, clearing large contiguous bands would require that the broadcasters with holdout power agree among themselves on how to exercise their hold out power. If they failed to reach agreement, then consumers would be denied the benefit of clearing contiguous spectrum. On the other hand, if the broadcasters were able to reach agreement, they would then be able to capture virtually all of the auction revenues raised by reallocating spectrum from TV broadcast to mobile broadband use – leaving little, if any, money for the U.S. Treasury.

2. **If the Congress is to consider legislation granting the Federal Communications Commission the authority to conduct voluntary incentive auctions, should consideration of such legislation be delayed until after an inventory of all spectrum is completed? Please explain your response.**

A spectrum inventory exercise should not delay adoption of legislation granting the FCC incentive auction authority. Given the voluntary nature of incentive auctions, the process will only reallocate spectrum when the new mobile broadband use is more highly valued by the marketplace than the spectrum's existing use. So there is no need to delay the FCC's use of incentive auctions; in fact, the cost to consumers of delaying such reallocations would be enormous—in the billions of dollars. In short, inventorying spectrum and using incentive auctions can and should proceed in parallel.