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*Behnam Kamali*

*Mercer University, Macon, Georgia*

*Jeffrey D. Wilson and Robert J. Kerczewski*

*Glenn Research Center, Cleveland, Ohio*

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*Behnam Kamali*  
*Mercer University, Macon, Georgia*

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National Aeronautics and  
Space Administration

Glenn Research Center  
Cleveland, Ohio 44135

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Behnam Kamali  
Mercer University  
Macon, Georgia 31207

Jeffrey D. Wilson and Robert J. Kerczewski  
National Aeronautics and Space Administration  
Glenn Research Center  
Cleveland, Ohio 44135

## Abstract

A new transmission technology, based on IEEE 802.16-2009 (WiMAX), is currently being developed for airport surface communications. A C-band spectrum allocation at 5091 to 5150 MHz has been created by International Telecommunications Union (ITU) to carry this application. The proposed technology, known as AeroMACS, will be used to support fixed and mobile ground to ground applications and services. This article proposes and demonstrates that IEEE 802.16j-amendment-based WiMAX is most feasible for AeroMACS applications. This amendment introduces multihop relay as an optional deployment that may be used to provide additional coverage and/or enhance the capacity of the network. Particular airport surface radio coverage situations for which IEEE 802.16-2009-WiMAX provides resolutions that are inefficient, costly, or excessively power consuming are discussed. In all these cases, it is argued that 16j technology offers a much better alternative. A major concern about deployment of AeroMACS is interference to co-allocated applications such as the Mobile Satellite Service (MSS) feeder link. Our initial simulation results suggest that no additional interference to MSS feeder link is caused by deployment of IEEE 802.16j-based AeroMACS.

## 1.0 Introduction

In order to accommodate the large volume of data that is planned by Next Generation Air Transportation System (*NextGen*) for information exchange between different mobile units, such as between aircraft and other airport systems including air traffic management (ATM), airline operational control (AOC), weather and advisory information, and so on, wideband wireless communication technologies are required. To this end the 2007 ITU World Radiocommunication Conference (WRC-2007) took an action that allowed the development of a new international standard of aeronautical mobile route services (AM(R)S) to support airport surface communications in what is known as the microwave landing system (MLS) extension band. The authorized C-band spectrum covers 5091 to 5150 MHz and an additional band 5000 to 5030 MHz may potentially become available in the

future. The Future Communications Infrastructure study completed jointly by the US Federal Aviation Administration, NASA, and EUROCONTROL recommended that this new aviation specific communication technology should be based on the IEEE 802.16e standard (Ref. 1). The proposed standards will be used to support fixed and mobile ground-to-ground and ground-to-air data communications applications and services (Ref. 2).

According to a document published by EUROCONTROL (Ref. 3); *no technical obstacles have been found which would make it impossible to apply this technology for AeroMACS* (Aeronautical Mobile Airport Communications System) (Ref. 4) over the MLS extension band. A major concern about development of AeroMACS over the MLS Extension band is interference to co-allocated applications. In particular, the allocation of the 5091 to 5150 MHz band to the fixed-satellite service (FSS) (Earth-to-space), limited to feeder links of non-geostationary-satellite (non-GSO) systems in the mobile-satellite service (MSS) limits the power levels that are allowed for AeroMACS networks. With this power restriction, the developed AeroMACS network for an airport may leave certain severely shadowed areas with no coverage or very weak linkage. To afford robust communications throughout the airport surface, while limiting the power levels, as well as providing a host of other benefits, this article argues and demonstrates that WiMAX networks based on IEEE 802.16j, the multihop relay specification amendment for 802.16, is most suitable for AeroMACS application.

Section 2.0 of this article provides some introductory remarks on the IEEE 802.16j amendment. In Section 3.0, the IEEE 802.16j based relay systems are defined and classified. The benefits of employing multihop relays are listed. A list of key usage model applications for relay augmented cellular networks is provided. Section 4.0 of this paper briefly reviews the most recent AeroMACS profile to determine whether there are any technical obstacles or challenges in application of IEEE 802.16j-based WiMAX to AeroMACS. The potential benefits of multihop relay configuration for AeroMACS networks are discussed in Section 5.0. The case for IEEE 802.16j based technology against IEEE 802.16-2009 is made in this section. Section 6.0 is devoted to discussion on IEEE-802.16j-based AeroMACS interference to MSS feeder links.

Visualyse Professional software (Ref. 5) is used to make estimations on the level of such interference. Finally, in Section 7.0 some concluding remarks are ventured.

## 2.0 IEEE 802.16J Amendment: Multihop Relaying

Owing to practical shortfalls arising from early implementation of IEEE 802.16e-based WiMAX networks, the need for some modification and amendment to the standard was recognized early on. In particular, initial field trials of mobile WiMAX products have shown that IEEE802.16e systems provide poor Quality-of-Service (QoS) around WiMAX cell boundaries for indoor users and in areas severely shadowed by manmade structures and natural obstacles. For instance, even with application of advanced signal processing techniques such as OFDM (Orthogonal Frequency Division Multiplexing), MIMO (Multiple Input Multiple Output), and AMC (Adaptive Modulation and Coding); the projected data rates requires SINR (Signal-to-Interference plus Noise-Ratio) levels at the front end of the receivers that are difficult to obtain at the WiMAX cell boundaries or in shadowed areas. To address this issue IEEE802.16j Multihop Relay (MR) Task Group has been working to define a new relay station (RS) that can be used as an extension to the base station (BS) and relay traffic between the BS and the subscriber station (SS). An RS communicates with the macro BSs through a wireless channel and can operate without additional carrier frequency. This eliminates the need for a wired or a dedicated wireless connection to the backhaul network and significantly reduces the installation and operation cost compared with using micro-BSs to cover these areas. By replacing the direct link between a BS and an SS in a poor coverage area with two links with better channel quality, the overall network capacity will increase dramatically (Ref. 6).

The amendment introduces multihop relay (MR) as an optional deployment that may be used to provide additional coverage or provide improved performance/ enhanced capacity in an access network. In relay-augmented networks, the BS may be replaced by a multihop relay BS, MR-BS, and as many RSs as needed. Traffic and signaling between the SS and MR-BS may be direct, or may be relayed by the RS thereby extending the coverage and enhancing performance of the system in areas where RSs are deployed. Each RS is under the supervision of an MR-BS. In a system with more than two hops, traffic and signaling between an access RS and MR-BS may also be relayed through intermediate RSs. The RS may be fixed in location, it may be nomadic, or in the case of an access RS, it may be mobile (Ref. 5).

The allocation of bandwidth and other resources for RSs and SSs may be controlled using one of the two modes; centralized or non-centralized (distributed) scheduling. In centralized scheduling mode, the bandwidth allocation for an RS's subordinate SSs is determined at the MR-BS; whereas in distributed scheduling mode, the bandwidth allocation of an

RS's subordinate SSs are determined by the RS in cooperation with the MR-BS. In other words RSs share resource allocation responsibilities with their superordinate MR-BSs.

The IEEE 802.16j working group was responsible for generating a standard for WiMAX Mobile Multihop Relay (MMR) network. The standard specifies a set of technical issues in order to enhance the previous standards (IEEE 802.16-2009) with the main objective of supporting relay concepts.

## 3.0 Relays: Definitions and Classification

First and foremost among the benefits of deployment of IEEE 802.16j-defined relay is the cost-effective, low-complexity, and easy-to-install-infrastructure alternative that it offers for wireless network radio outreach extension in a variety of situations. Secondly, the relays can provide capacity improvement and throughput enhancement in areas which are not sufficiently covered by the associated BSs. One other important result of deployment of the relay-fortified wireless infrastructure, compared to the all-BS architecture, is the reduction of aggregate output power of the cellular network. For the AeroMACS application, this translates into less interference into co-allocated applications such as MSS feeder link. A partial list of major usage models and applications of relay augmented cellular networks is provided below.

- Extension of radio coverage into areas severely shadowed by buildings or natural obstacles.
- Enhancement of coverage and throughput on or beyond the WiMAX cell footprint boundary.
- Improvement in radio coverage inside a building or a high rise complex.
- Coverage in a dense urban area.
- Coverage in a rural area.
- Temporary coverage and temporary capacity upgrade.
- Network capacity improvement to support intense-usage areas; "hot spots".
- Special coverage challenges, e.g., "coverage hole filling".
- Extension of radio access to moving vehicles such as buses, trains, aircraft.
- Radio coverage over roads and tunnels.

In short, the main aspects for present and future usage of relays are; coverage extension, capacity and throughput enhancement, support for mobility at all levels, cost efficiency, and improvement in frequency planning (Ref. 7).

In all RS-augmented standards, the main concept is to complement the BS with less complex, less costly, and easier-to-install relay stations instead of adding new BSs in a broadband cellular network. MR-BS covers an extended area, beyond what the BS alone covers, which is denoted by

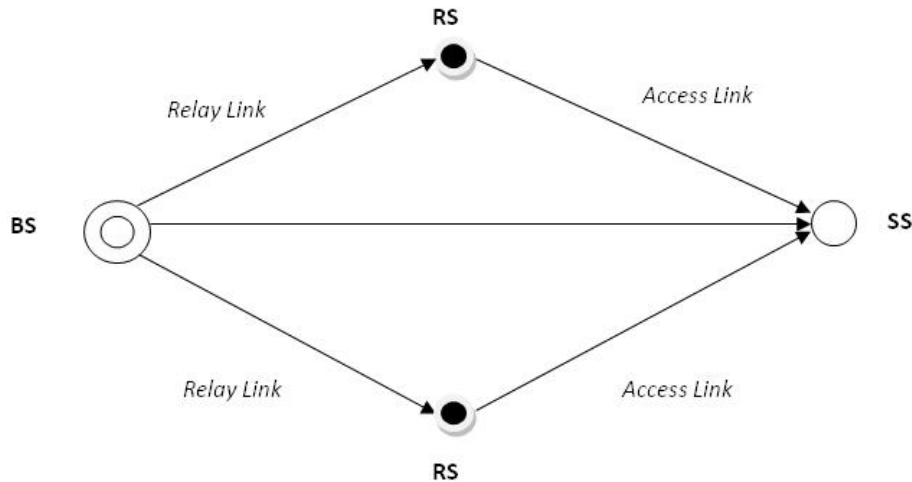


Figure 1.—A simple relay network consisting of two relay stations.

multihop relay cell, MR-cell. MR-BS manages all communications resources within a MR-cell through a *centralized* or *distributed* procedure. Resource management of subscriber stations (SS) may be carried out directly by the BS or via radio links through relay stations. Traffic and signaling between BS and SS may be routed through “*access RSs*” or via a direct link between BS and the SS. Figure 1 shows a simple two-hop relay configuration. The physical channel between the MR-BS and a relay is called a *relay link*, and the channel between an access relay and a SS is termed as an *access link* as illustrated in Figure 1.

In more complex multihop relay networks for which more than two hops may occur, the signaling between the MR-BS and an access RS may be relayed through intermediate RSs. In those cases the link between BS and the access RS, which may include several consecutive relay links and intermediate RSs, is called *relay path* (Ref. 8).

The IEEE 802.16j standard provides the following attributes for air interface between RS and BS-RS as minimum requirements. The 802.16j RS is fully backward compatible to the 802.16e, i.e., no changes are required in the legacy mobile stations. That implies that all SS-BS air interface protocols are supported by an 802.16j relay network with no need for any upgrade in the SS. The RS devices need to support all the licensed bands allocated for IEEE 802-16j-based systems. The network topology that is supported by the RS is limited to point-to-point, i.e., mesh topology is not supported at this point. The IEEE 802.16j standard specifies two modes of scheduling for controlling the allocation of bandwidth for RSs and SSs: *centralized scheduling* and *distributed scheduling*.

Relays may be classified according to their Physical (PHY) layer and Medium Access Control (MAC) layer functionalities. In terms of PHY layer processing, relay stations may be classified as Transparent Relays (TRS); Type II relays in Long Term Evolution (LTE) terminology, and

Non-Transparent Relays (NTRS), or Type I relays in LTE jargon.

- A TRS essentially functions as a repeater that is transparent to the SS and bears no logical connection to it. As such TRS does not transmit preamble, nor does it broadcast control messages such as DL-MAP (Media Access Protocol). The SS served by a TRS receives traffic data from the TRS but control data comes from the corresponding MR-BS.
- An NTRS operates as a “mini BS” and thus is physically and logically connected to the SSs that are connected to it. The NTRS transmits preamble and broadcasts control messages, therefore the MSs served by an NTRS receive both traffic and control data directly from the NTRS.

In so far as MAC functionalities are concerned, RSs can be characterized on the basis of their *scheduling arrangements* and *security capabilities*. In these respects the RS may operate in *centralized* or *distributed* modes. Distributed mode with respect to scheduling means that the RS is capable of scheduling network resources in coordination with MR-BS; otherwise the RS operates in centralized mode. RS in distributed scheduling mode creates DL-MAP and UL-MAP for allocation of bandwidth to its subordinate SS. The same can be said about security, i.e., the RS can be in distributed or centralized mode with respect to security arrangements. A TRS always operates in centralized mode with respect to both scheduling and security. In this case bandwidth allocation and other scheduling procedures are carried out by the MR-BS. The main function of TRSs is network throughput enhancement. On the other hand a NTRS in distributed scheduling and security mode may provide radio outreach extension and higher bandwidth efficiency, as well as throughput enhancement in a WiMAX network. In centralized

scheduling mode all information related to the access link (bandwidth request, channel measurement, etc.) is forwarded to the MS-BS for generation of proper DL-MAP and UL-MAP by the MR-BS on behalf of the RS. This incurs latency in the network. On the other hand a RS with distributed scheduling mode can process the information and generate proper DL/UL-MAPs by itself (Ref. 9).

## 4.0 AeroMACS Profile Draft; Are There Any Technical Obstacles?

The most recent version of the AeroMACS Profile draft published on December 15, 2010, documents the adaptations required for the IEEE 802.16-2009 standard to provide wireless data communication service to fixed and mobile platforms in AeroMACS (Ref. 10). The proposed standard would support ground-to-ground and air-to-ground data communication services, including but not limited to Collaborative Decision Making (CDM), Surveillance Broadcast Systems (SBS), and System Wide Information Management (SWIM). The transmission requirements for these applications demand data rates that range from a few hundred Kbits per second to hundreds of Mbits per second.

User applications for transport over AeroMACS have been classified into the following five categories:

- Air Traffic Management (ATM)/Air Traffic Control (ATC)
- Aeronautical Information Management and Meteorological Data (AIM/MET)
- Owner/ Operator
- Airport Authority
- Airport Infrastructure

It is noted that these applications may have different performance characteristics, security needs, and QoS requirements. Operational applications requiring access to AeroMACS will continue to emerge as the modernization of national and international airspace systems progresses.

In order to minimize hardware development to implement the standard, while maximizing the utilization of “*Commercial-Off-The-Shelf*” (COTS) components, it was decided that AeroMACS should be developed based on WiMAX (IEEE 802.16) technology. However, it is required that WiMAX technology be extended over the aeronautical band of 5091 to 5150 MHz. This is one of the major required adjustments of WiMAX technology for AeroMACS applications, as WiMAX was originally developed for different bands of frequencies.

Other than those issues related to general application of 16j technology to any scenario, it appears that there are no

additional technical challenges in application of IEEE 802.16j-based WiMAX to AeroMACS. Nevertheless, a more thorough study of this important subject is in order and is highly recommended.

## 5.0 Multihop Relay Configuration for AeroMACS

This section is devoted to discussion of particular airport surface radio coverage situations for which the IEEE 802.16-2009-WiMAX system either fails to offer a viable solution, or the resolution it provides is inefficient, costly, or excessively power consuming. In all these cases, it is argued that IEEE 802.16j-based technology offers a much better alternative with the application of multihop relays.

- When a portion of an airport is significantly shadowed by a new obstacle, such as a building constructed for a new terminal in an airport, a 16j-defined transparent or non-transparent relay can be added to the airport network to provide higher capacity and acceptable QoS to the shadowed area. Adding a relay to an already established network does not require network reconfiguration and radio resource reallocation. The alternatives that IEEE 802.16-2009 offers are; the addition of another BS to the system which requires network redesign and entails reallocation of resources, or an increase the output power of the other BSs, which may or may not resolve the problem while increasing the total airport system output power.
- Short-term coverage for areas temporarily blocked (e.g., by construction), or coverage for areas on a temporary basis because of special circumstances (e.g., special events) may be readily provided by a TRS or a NTRS. This is where a mobile relay may be most suitable.
- If a station is outside of the airport area but needs connection to the AeroMACS network, an RS (as opposed to a BS) can be used to establish the connection.
- Coverage to single point assets on the airport surface that are outside of the BSs coverage area can readily be rendered by an RS. This may be particularly suitable for airport security equipment such as cameras.
- Relays may be also used to provide coverage to other airport assets such as lighting systems, navigational aids, weather sensors, wake vortex sensors, etc.
- Relays may provide coverage to relatively small areas on the airport surface outside of the BS cell footprint, including permanently shadowed areas.
- Multihop relays may be used to provide coverage to airport surface locations outside of the base station



coverage area where there are relatively few users. The IEEE 802-2009 alternative would either add a new BS to the network for a few users, or increase the power of the current BS's in the system.

- Multihop relays enable increased link physical layer security for single point connections through a narrow beam antenna, for example to assets at or beyond the airport perimeter.
- Spectrum efficiency and/or network capacity may be improved by application of spatial diversity. This is feasible with IEEE 802.16j with RS.
- Multihop relays may be applicable to large airports with dense/complex operations where localized spectrum saturation may occur. Additional capacity may be obtained in dense areas by deployment of TRSs as an alternative to adding more BSs and/or smaller cells.

## 6.0 AeroMACS Interference to MSS Feeder Links

A major concern about deployment of AeroMACS over the 5091-5150 MHz band is interference to co-allocated applications, in particular to the feeder links of non-geostationary-satellite systems in the mobile-satellite service (MSS). The Globalstar Satellite Constellation is an example of an existing operational MSS system that operates feeder links in this band (Ref. 11). The potential for interference between AeroMACS and MSS feeder links limits the power levels that are allowed for AeroMACS networks (Ref. 8). Analytical methods and computer modeling have been employed to test and measure the level of interference posed by AeroMACS networks to co-allocated applications. At the NASA Glenn Research Center the software program Visualyse Professional (Ref. 5) has been utilized to estimate the limitations of AeroMACS transmitter output power levels in order to avoid unacceptable interference with MSS feeder link signals (Ref. 12). A similar approach was previously adopted by MITRE Corporation (Ref. 13). In both of these models a single BS per airport was assumed and an airport was viewed as a power emitting point on the contiguous United States global surface. The antenna directivity pattern for each of the 497 towered airports was selected randomly in order to reflect a more realistic scenario.

To compare interference performance for IEEE 802.16-2009-based AeroMACS with IEEE 802.16j-based AeroMACS, six model cases were created and simulated. Two of these cases (Cases 1 and 4) represent all-BS airport networks, while the other cases (Cases 2, 3, 5, and 6) represent mixed BS-RS networks. The output power of a BS antenna (or a sector of a BS antenna) is assumed to be 100 mW, and the output power of an RS antenna is assumed to be 3 dB lower, i.e., 50 mW. The relative directions of the BS and RS antenna beams are shown in Figure 2 to Figure 7 for each case.

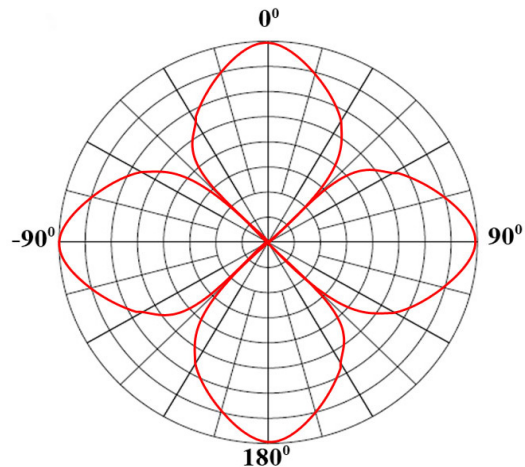


Figure 2.—Case 1: An all-BS network with four BS antenna beams oriented at 0°, 90°, 180°, and -90°.

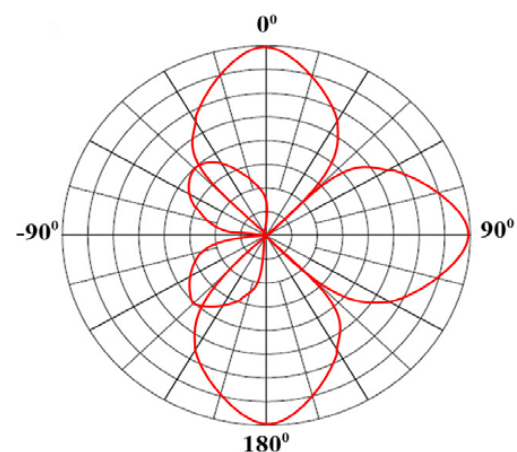


Figure 3.—Case 2: A mixed BS-RS network with three BS antenna beams oriented at 0°, 90°, and 180° and with two RS beams oriented at -45° and -135°.

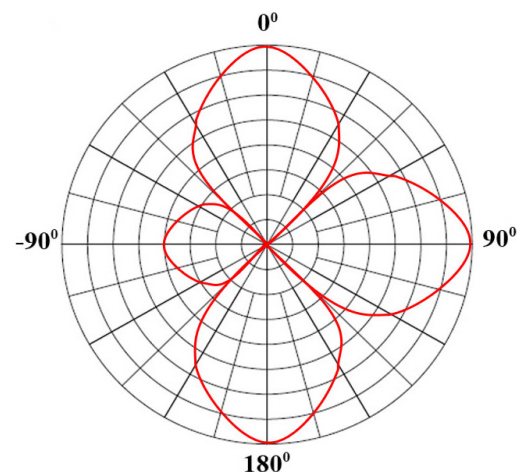


Figure 4.—Case 3: A mixed BS-RS network with three BS antenna beams oriented at 0°, 90°, and 180° and with one RS beam oriented at -90°.

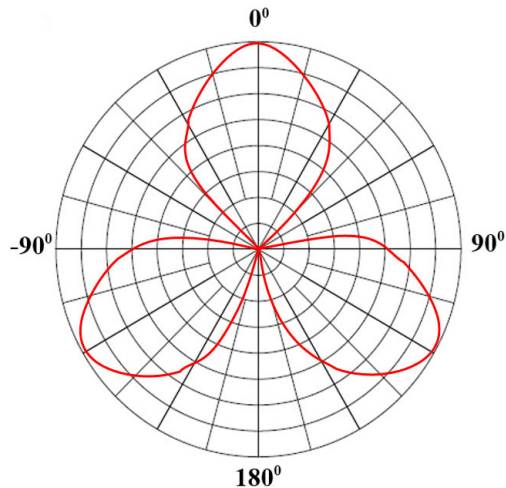


Figure 5.—Case 4: An all-BS network with three BS antenna beams oriented at 0°, 120°, and -120°.

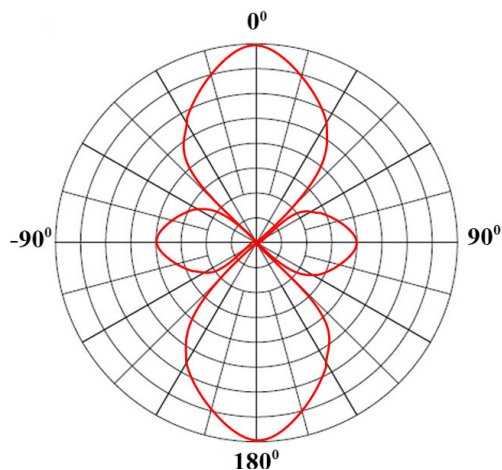


Figure 6.—Case 5: A mixed BS-RS network with two BS antenna beams oriented at 0° and 180° and with two RS beams oriented at 90° and -90°.

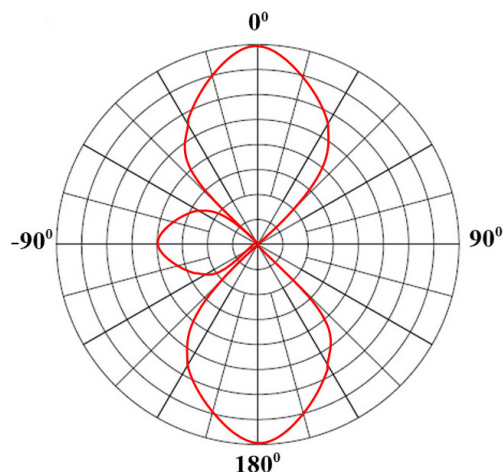


Figure 7.—Case 6: A mixed BS-RS network with two BS antenna beams oriented at 0° and 180° and with one RS beam oriented at -90°.

For each of the six cases, all of the 497 towered airports in the contiguous United States were assumed to have the given antenna gain pattern, but the direction corresponding to 0° was randomized from airport to airport. Ten runs each with a different randomization were generated for each case. An example of the resulting interference power profile at low Earth orbit (LEO) is shown in Figure 8 for one of the runs with Case 1. For each run, the position (in Northern Canada) and value of the maximum aggregate interference power was recorded. Figure 9 illustrates the simulation results and Table I shows the corresponding average maximum interference power and standard deviations.

With four 100 mW beams spaced 90° apart, Case 1 has close to an omnidirectional gain pattern. Thus the different randomization runs have little variation in maximum interference power as shown in Figure 9 and reflected by the small standard deviation in Table I. In Case 2, one of the BS beams has been replaced by two RS beams, thus the total power radiated is the same at 400 mW. Figure 9 and Table I show that the average maximum interference power is almost identical to that of Case 1, but there is a larger spread among the ten randomized runs due to the asymmetrical nature of the gain pattern.

Both Cases 1 and 2 generate interference power higher than the threshold of -157.3 dBW established so as to limit the increase in the MSS feeder link satellite receiver's noise temperature to less than 2 percent (Ref. 14). In Case 3, one of the BS beams is replaced with an RS beam, reducing the total radiated power from 400 to 350 mW. It is seen in Figure 9 and Table I that this is enough to reduce the maximum interference power below the threshold value.

The total radiated power is decreased further to 300 mW in both Cases 4 and 5. Case 4 has three BS beams, while Case 5 has two BS beams and two RS beams. The maximum interference power decreases as expected and as in the comparison between Cases 1 and 2, there is not much difference between the results of Cases 3 and 4, although there is somewhat more variation among the randomized runs in Case 4.

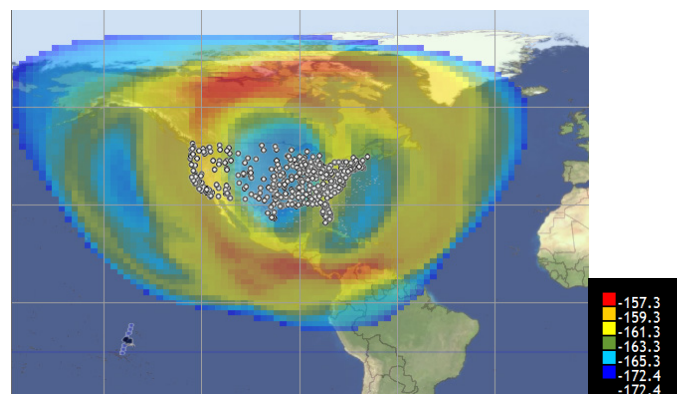


Figure 8.—Aggregate interference power at LEO from 497 airports each with a randomized orientation of the antenna gain pattern for Case 1, the scale is in dBW.

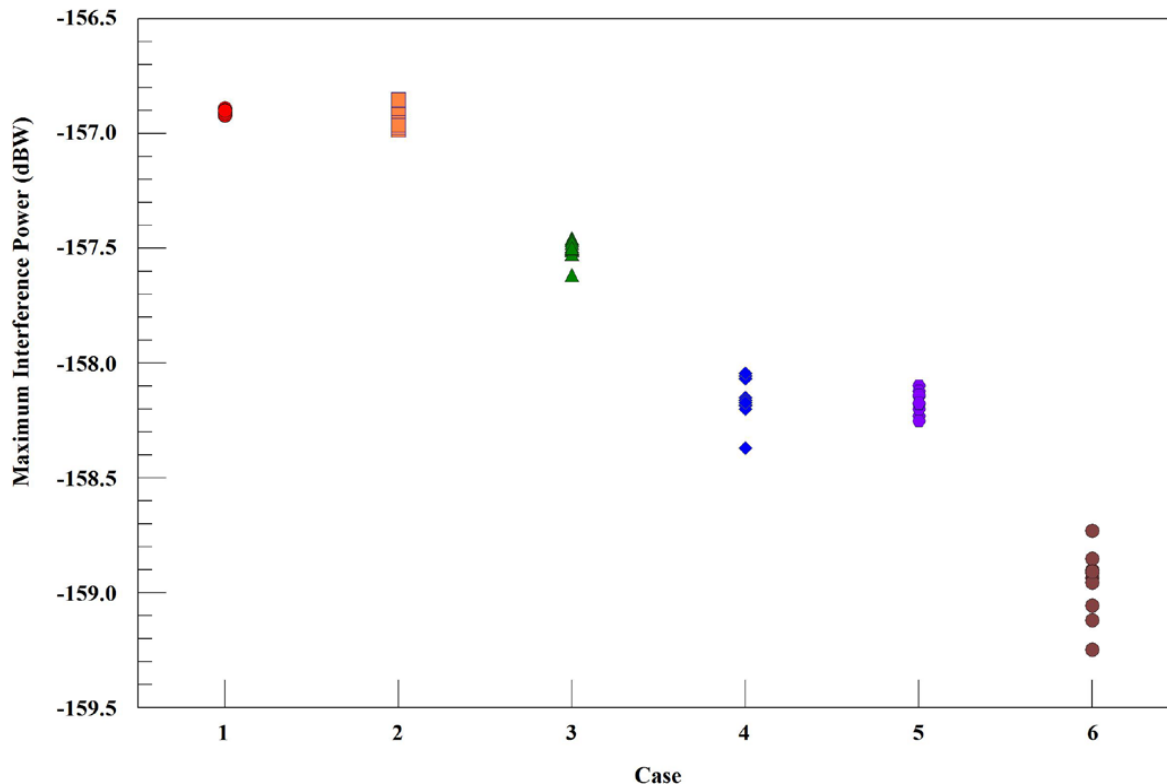


Figure 9.—Simulated maximum interference power for 10 randomized runs for each of the six antenna configuration cases shown in Figure 2 to Figure 7.

TABLE I.—AGGREGATE INTERFERENCE POWER POSED BY ALL 497 CONTIGUOUS U.S. TOWERED AIRPORTS INTO MSS FEEDER LINK FOR VARIOUS AeroMACS CONFIGURATIONS

Case	Configuration	Output power, mW	Average maximum interference power, dBW	Standard deviation, dBW
1	Four BS beams at 0° , 90°, 180°, and -90°	400	-156.91	0.01
2	Three BS beams at 0° , 90°, and 180° and two RS beams at -45° and -135°	400	-156.92	0.05
3	Three BS beams at 0°, 90°, and 180° and one RS beam at -90°	350	-157.50	0.04
4	Three BS beams at 0°, 120°, and -120°	300	-158.16	0.09
5	Two BS beams at 0° and 180° and two RS beams at 90° and -90°	300	-158.17	0.05
6	Two BS beams at 0° and 180° and one RS beam at 90°	250	-158.96	0.15

Case 6 radiates 250 mW with just two BS beams and one RS beam. The maximum interference power decreases again as expected and the spread among the runs is higher than in any of the other cases because of the increased asymmetry.

These results reveal that under equal output power transmission for each airport and each configuration, there is no additional interference into MSS feeder link from the 16j-based AeroMACS as compared to that of all-BS AeroMACS network. It is the total power that is radiated from each airport that is most important; the distribution is only of secondary importance.

In summary we make the following observations that are the key conclusions of this preliminary simulation study.

- *No additional interference to the MSS feeder link is caused by deployment of IEEE 802.16j-based AeroMACS.*
- *The total antenna output power level has the dominant effect on AeroMACS interference to co-allocated applications. Antenna orientation and directivity, and whether the network employs all-BS configuration or BS-RS architecture, play an insignificant role in this regard.*

## 7.0 Summary and Future Work

This article makes a case for IEEE 802.16j WiMAX system as a feasible technology for AeroMACS. Practical shortfalls arising from early implementation of IEEE 802.16e-based WiMAX networks demanded a new amendment to the IEEE 802.16e standard; the IEEE802.16j is such an amendment. This amendment allows for relay stations to be used as an extension to the BS and relay traffic through a wireless channel and can operate without backhaul connection. The usage of RSs significantly reduces network complexity, output power emission, and installation and operational costs.

For AeroMACS, IEEE 802.16j-based technology provides feasible radio coverage at airport surface for situations in which the IEEE 802.16-2009-WiMAX system either fails to offer a viable solution, or the resolution it provides is inefficient, costly, or excessively power consuming. A rather long list of future studies can be envisioned at this point and many more will be added, should the IEEE 802.16j-based technology be adopted for AeroMACS. In this article we have glanced at the most recent AeroMACS profile and have found no additional technical challenges for application of IEEE 802.16j-based WiMAX to AeroMACS. However, there is a need for thorough examination of the present, as well as future drafts of the AeroMACS profile to ensure that there are no insurmountable technical challenges for application of 16j to AeroMACS.

A critical future study relates to the type of relays that are appropriate for AeroMACS applications. TRSs and NTRSs may be used for capacity improvement and radio outreach extension, respectively. The selection of relay type has a number of implications related to the DL and UL frame structure, PHY layer and MAC layer protocols, latency, and interference level within the AeroMACS network and into co-allocated applications.

Challenges and technical complications of applications of the IEEE 802.16j amendment need to be studied. In particular PHY and MAC layer difficulties that arise from inclusion of relays in the network, especially in MR-BS, must be exhaustively investigated. The MR-BS system ought to be modified to accommodate both SSs and RSs.

A more meaningful comparison is made between the interference effects of IEEE 802-2009 and IEEE 802.16j technologies if the airport size is taken into consideration (small, medium, large airports). Simulation runs with Visualyse Professional should be conducted for other relevant scenarios. These scenarios should be carefully identified and selected. Comparison between interference levels and other key system parameters, such as the size and shape of coverage area, throughput/ capacity, and cost of the system, should be made between the two alternatives.

In our simulation effort we have focused on the network transmission side. An interesting future study is addressing the question of how to model the user transmission side and then investigate the interference effect to co-allocated applications.

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14. ABSTRACT A new transmission technology, based on IEEE 802.16-2009 (WiMAX), is currently being developed for airport surface communications. A C-band spectrum allocation at 5091 to 5150 MHz has been created by International Telecommunications Union (ITU) to carry this application. The proposed technology, known as AeroMACS, will be used to support fixed and mobile ground to ground applications and services. This article proposes and demonstrates that IEEE 802.16j-amendment-based WiMAX is most feasible for AeroMACS applications. This amendment introduces multihop relay as an optional deployment that may be used to provide additional coverage and/or enhance the capacity of the network. Particular airport surface radio coverage situations for which IEEE 802.16-2009-WiMAX provides resolutions that are inefficient, costly, or excessively power consuming are discussed. In all these cases, it is argued that 16j technology offers a much better alternative. A major concern about deployment of AeroMACS is interference to co-allocated applications such as the Mobile Satellite Service (MSS) feeder link. Our initial simulation results suggest that no additional interference to MSS feeder link is caused by deployment of IEEE 802.16j-based AeroMACS.					
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