ECONOMIC IMPACTS OF INFRASTRUCTURE FAILURES

Report to the
President's Commission
on Critical Infrastructure Protection
1997

This report was prepared for the President's Commission on Critical Infrastructure Protection, and informed its deliberations and recommendations. The report represents the opinions and conclusions solely of its developer, Booz Allen & Hamilton.

T A B L E O F C O N T E N T S

EXECUTIVE SUMMARY

Those who cannot remember the past are doomed to repeat it.
George Santayana

INTRODUCTION

This report is provided as an ancillary analysis to the overall assessment of the physical and cyber security of information systems within the U.S. Banking and Finance infrastructure. The initial study, entitled U.S. Banking and Finance Infrastructure Security Assessment, uncovered that the industry is exceedingly generous in investing in security measures in response to catastrophes or "near misses," but typically does not invest beyond the *standards of due care* set by regulation, industry practice, or legal liability (usually determined by precedence in the courts) to defend against the hacker or criminally motivated attack. This report examines empirically the full costs of recovery from three analog "disasters" to determine the economic merit in preventative initiatives vice reactive solutions.

OBJECTIVE

The purpose of this report is to present an estimate of the full economic impact that a disaster has on an infrastructure sector[1] and the nation at large. The magnitude of losses in dollar terms are provided by recoupment and aid sources, such as local and national charities; local, state and federal government agencies; insurance providers; and legal compensatory award fees and punitive damages. However, this study also attempts to analyze the spill-over costs on others within the infrastructure (including effects such as increased regulation and oversight) and post-event impacts on the general public (such as higher consumer prices and losses in public confidence) which leave a lasting, intangible imprint on the quality of life afforded Americans.

APPROACH

This report employs inductive reasoning/logic to meet its objective. It uses specific empirical evidence from three recent actual events—the August 1996 Western power outage, the 1996 ValuJet Flight 592 airplane crash, and AT&T's 1-800 network service failure that affected most of the Eastern Seaboard in 1991—to present estimates of the full economic impact a disaster can have on an infrastructure sector, and the nation at large. This report also identifies the lessons learned by each of the three infrastructures (electrical power distribution, transportation, and

[1] In this study, infrastructure sectors include: Telecommunications; Electrical Power Distribution; Gas and Oil Storage and Distribution; Banking and Finance; Transportation; Water Supply Distribution; Emergency Services (including medical, police, fire, and rescue); and Continuity of Government.

telecommunications) which can, and arguably should, be applied to other infrastructure sectors, including U.S. Banking and Finance.

Selection of Events

Multiple "disasters" were considered[2] and the three events ultimately chosen were selected as appropriate analogs, or "benchmarks" for the U.S. Banking and Finance infrastructure because they were found to have common attributes relative to the:

- Event
- Product/service
- Customers
- Owners
- Industry

Methodology

To conduct this analysis, the research extended beyond the immediate event and explored the spill-over effects a disaster has on the customer, the owner, the industry, and the general public. By taking this approach, specific lessons learned from each event surfaced, and commonalities among the three formed the basis for the conclusions and recommendations presented herein.

For each event, the consequences or economic impacts are:

1. Allocated to **event phase**
   - Primary
   - Secondary

1. Attributed to **affected participants**
   - Losses to the customer
   - Losses to the owners
   - Losses to the industry
   - Losses to the public/quality of life

1. Quantified by **compensation/recoupment sources and economic indicators**
   - Private sources, i.e., insurance, charities, stockholder reserves/profits, legal damages/awards, etc.
   - Federal, state and/or local governments
   - Passed to the public via product/service prices, taxes, quality of product/service, share price, etc.
   - Uncompensated

[2] See Appendix A for a listing of other candidate events.

Sources of Data

This report is based exclusively on publicly available data and information provided from the media, government(s), and other open sources. The turn-around period of this study excludes personal interviews and the in-house generation of complex cost estimates. This study focuses on collecting and examining publicly available financial data from compensation sources and allocating and attributing them to the affected participants and impact phases. While empirical analysis is the intent, some of the data presented is anecdotal and is employed to amplify how far-reaching the effects of an event can be.

FINDINGS - GENERAL

As shown in the following exhibits, the consequences of a disaster occur in two phases, primary and secondary. The primary phase begins with the response to the disaster. Within this phase, the focus is primarily on the immediate losses suffered by the customers and the owner of the failed or impacted product/service (although the industry containing the disaster event and the general public might also experience some immediate effects). This primary phase might last weeks or even months depending on the nature of the disaster. These losses are generally measured by the compensation/recoupment provided by such sources as charities, local, state and federal government aid, insurance carriers, profits, legal damages/awards, etc.

However, the repercussions from an event ripple like waves in a pond over time and can be felt years after the event occurs. These spill-over effects are part of a secondary phase that occurs in the wake of a disaster. This secondary phase tends to be measured in years, even decades. While all participants (i.e., the customers, owners, industry and public) are affected by the secondary phase, spill over effects are generally absorbed into our economy and are observed in broad areas such as quality of life.

FINDINGS - WESTERN POWER OUTAGE

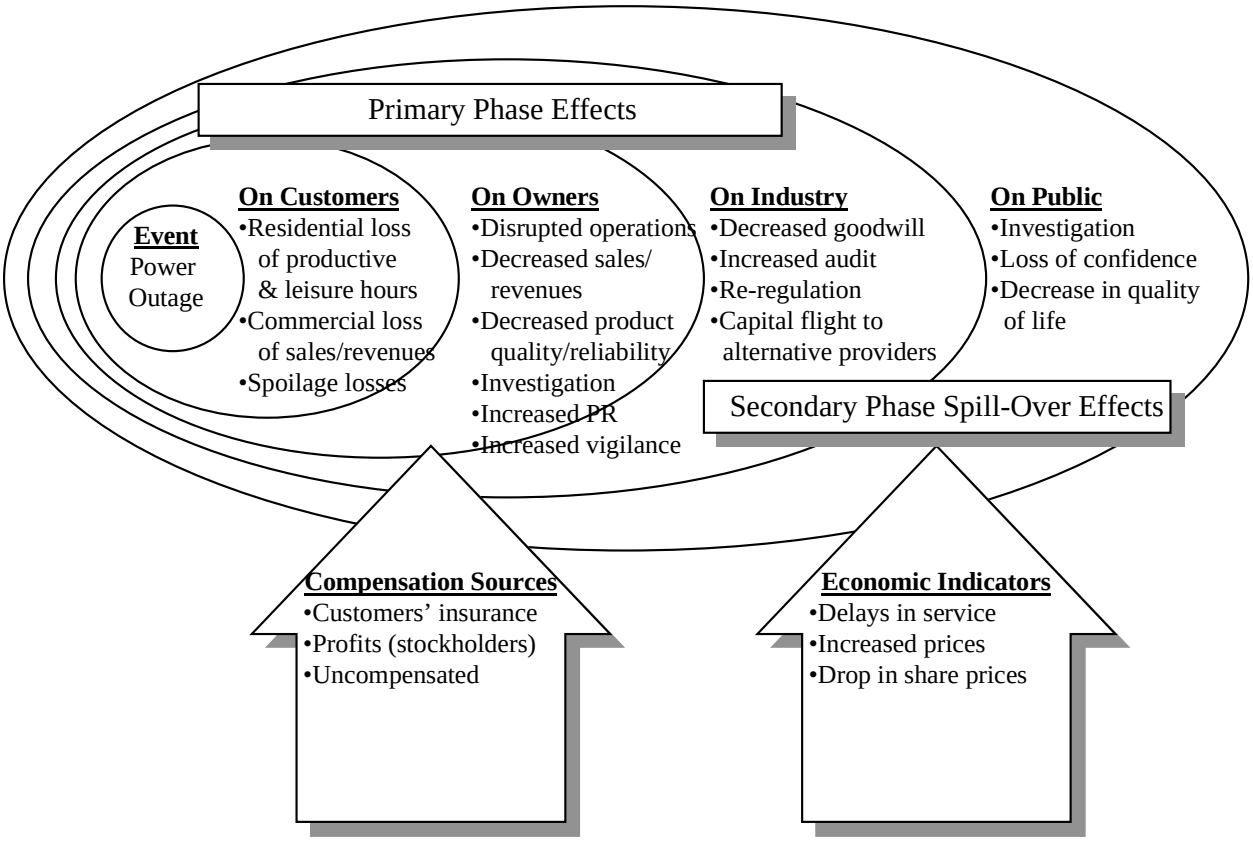
Description and Cause of Event

Over 7.5 million customers in the Western United States found themselves without power, some for as long as 16 hours on August 10, 1996. The outage occurred during a period of record high temperatures and electric loads. This, combined with a greater than normal supply of hydroelectricity (due to above average water supplies in the Northwest), caused high load transfers from and through the Northwest to the Southwest. The high water levels also caused the trees in the region to grow faster than anticipated and some of these overgrown trees interfered with transmission lines. Without realizing the impact several line outages were causing to the overall system, Bonneville Power Administration (BPA) dispatchers monitored its individual system and did not take steps to notify other operators in other regions. These scattered outages, along with some scheduled maintenance activities, contributed to greater system instability.

According to the Western Systems Coordinating Council (WSCC) investigation, line instability and overgrown vegetation were cited as causal factors in the August 10th outage. However, when each of the outages occurred, they were not considered "critical" and therefore the information about the outages was not shared with other companies. This lack of communication between and among the companies that make up the WSCC contributed to, if not caused the outages to occur. Each company viewed each outage as independent events, failing to recognize the intricacies that made them dependent links in a chain. Once the chain began to break, there was no way to stop it.

Economic Impact

A listing of losses, as incurred by the affected participants and estimates of the economic losses to each participant group are provided in Exhibit ES-1 for the Western power outage.



Event	Customers	Owners	Industry	Public
Aug. 10, 1996	~$1-4 B[a]	>$100 M[b]	See below[c]	See below[d]

[a] Estimates of uncompensated losses of residential and commercial productive and leisure hours

[b] Net losses in revenues due to regeneration expenses, equipment damage and expenditures for responding to governmental investigations and hearings.

[c] Costs to date, while certain to be significant, are not yet available. To avoid double count costs to owners, other infrastructure costs would include the establishment and compliance of nation-wide reliability, coordination, and monitoring standards.

[d] Public costs include changes in the business practices and cost structures of the nation's electrical power distribution systems that are likely to be passed on as additional charges to customers.

Exhibit ES- 1: The Western Power Outage Cost and Impact Profile

Based on this study's conservative estimates, the Western power outage has cost several *billion* dollars to date, most of which remains uncompensated. Because of the recent nature of these events, the spill-over effects of pending legislation and other proposals to strengthen the oversight of this relatively self-regulated industry cannot be accounted for in this total.

FINDINGS - VALUJET AIRPLANE CRASH

Description and Cause of Event

On 11 May 1996, Flight 592, a ValuJet DC-9, crashed into the Florida everglades shortly after takeoff from Miami International Airport. All 110 passengers on board perished.

According to what investigators were able to determine, the forward cargo hold of ValuJet Flight 592 was packed with over 100 oxygen generators. Although labeled empty on the shipping documents, at least some of the canisters were not, and none were equipped with safety caps. SabreTech Inc., one of ValuJet's maintenance contractors, admitted that two of its employees had failed to put safety caps for shipping and falsified paperwork indicating that the shipping caps had been put in place.

In addition to the physical cause of the accident, there were many underlying forces that contributed to this accident. Not implementing the National Transportation Safety Board (NTSB)'s 1988 recommendation to install fire detection equipment is part of the story. While outsourcing in and of itself is not unsafe, airline safety requires strong communications and accountability among all groups responsible for the various aspects of safety. This coordinated communications is often difficult to achieve within a single organization, and can be nearly impossible across disparate groups of contractors, especially if no one central figure is responsible for its integration. It was clear during the post-crash investigations that this communication was lacking.

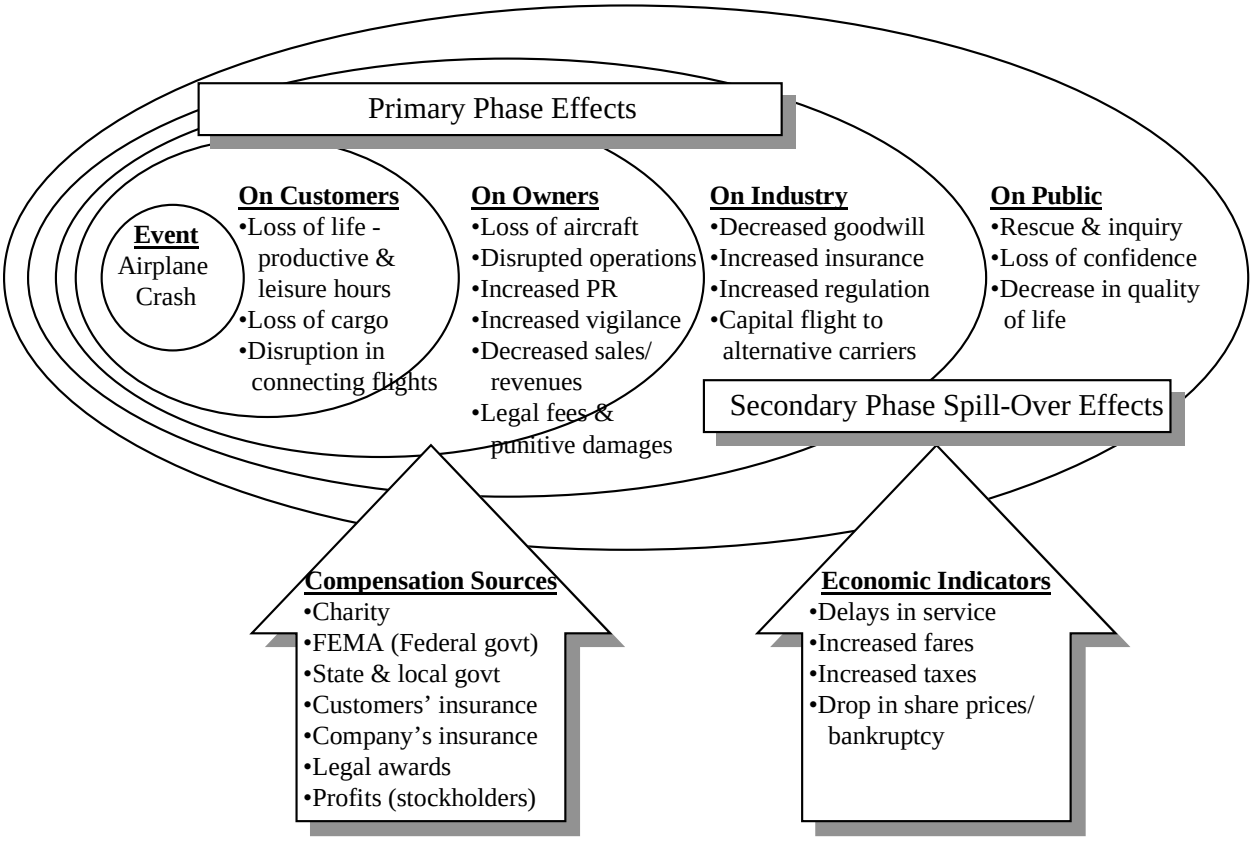
Criticism of the FAA's role in accountability for airline safety has been on the rise since 1993. Former Inspector General Mary Schiavo held a meeting with the FAA in February 1996 to address critical safety issues with ValuJet. At the time of the accident, ValuJet's accident record was 14 times higher than American or United.[3]

Today's low fare airlines compete by offering discounted fares. However, safety is not cheap and evidence is growing that the pressures of competition might be affecting even the regulated portions of this industry—safety and training. ValuJet employed a fleet of older aircraft (averaging 26 years) versus the industry's standard of 15 years. As pressures to compete continue, even the established airlines like Northwest, TWA, and USAirways are using their fleets for a greater number of years.

[3] Fumento, Michael, "Frederico Pena: The Teflon Cabinet Official," February 19, 1997.

Economic Impact

Exhibit ES-2 presents the cost and impact profile for the ValuJet crash. Based on this study's conservative estimates, the ValuJet crash has cost over *$2 billion* to date. Because of the relative recent nature of this event, the long-term effects (or spill-over costs) of pending litigation and other industry-related mandates on ValuJet, and the airline industry as a whole, can not yet be determined accurately.



Event	Customers	Owners	Industry	Public
Flight 592 Crash	~$220-550M[a]	>$550M[b]	>$350M[c]	>$400M[d]

Exhibit ES-2: Airline Crash Disaster Profile

[a] Estimates from insurance providers on the loss of passenger life and cargo.

[b] Losses to ValuJet include $400M for the aircraft, plus *annual* lost revenues of $150M.

[c] In 1988 the FAA estimated that legislation requiring smoke detectors to be installed in airplane cargo holds would cost $350M. Although not yet enacted, similar legislation is likely to occur from the ValuJet incident. The total dollar amount will depend upon the extent to which new and/or more stringently enforced regulation are absorbed or passed on to customers.

[d] Public costs include both increases in fares (i.e., those directly passed on to the public) or increased in taxes (i.e., those costs subsidized by government). In 1996 Congress appropriated over $400M for security-related enhancements, including explosive detection technology, which is likely the tip of the iceberg.

FINDINGS - AT&T 1-800 SERVICE FAILURE

Description and Cause of Event

Similar to the Western power outage, this event was precipitated on a warmer-than-usual day in the New York metropolitan area. For days such as this when power consumption loads are heavier than normal, AT&T and New York's Consolidated Edison Power Company had negotiated a power sharing agreement that basically states that AT&T will use its own power when Consolidated Edison's facilities are heavily loaded. At approximately 10 a.m. on September 17, 1991, at an AT&T switching center in lower Manhattan, AT&T switched to its own power. However, critical power rectifiers (devices that change AC power to DC power) failed. Power was provided by a battery back-up system which was designed to operate for six hours. Alarms that were intended to inform technicians that the power system was functioning on back-up battery had been manually disabled and failed to work.

At approximately 4:30 p.m., the shift back to commercial power was attempted and failed because of the same critical power rectifier failure that had gone undetected in the morning hours. The back-up batteries expired and all telephone transmission systems in the facility shut down and voice and data communications controlled by the facility failed. This included air traffic control communications in the New York metropolitan area.

It took AT&T approximately 8 hours to restore service to its entire customer base. In the ensuing 8 hours of the failure, it was estimated that over 5 million calls were blocked.

Based on an internal investigation by AT&T, the September 1991 outage had a strong human component, versus any systemic or fundamental failure of the network's components. According to AT&T's senior vice president-network services, Kenneth L. Garrett, the problem resulted when failures of some power equipment and alarm systems went undetected. This was attributed to a supervisor failing to follow company procedures and physically inspect each of the building's power plants to insure that they are working properly during a conversion from commercial to emergency diesel generator power. Additionally, the alarm bells that should have warned technicians of equipment failures had been manually deactivated. Had the alarms been armed or had such an inspection occurred, the equipment failures would have been discovered and the service disruption averted.[4]

Because this network failure affected so many people and adversely affected air travel, the press devoted attention significant to the event, as did state and federal regulators and Congress. Industry experts were publicly asking if AT&T was asleep at the wheel.

Economic Impact

Exhibit ES-3 presents the cost and impact profile for the AT&T network failure. Based on this study's estimates, the AT&T network failure cost *hundreds of millions of dollars* yet eventually resulted in improved services to the general public.

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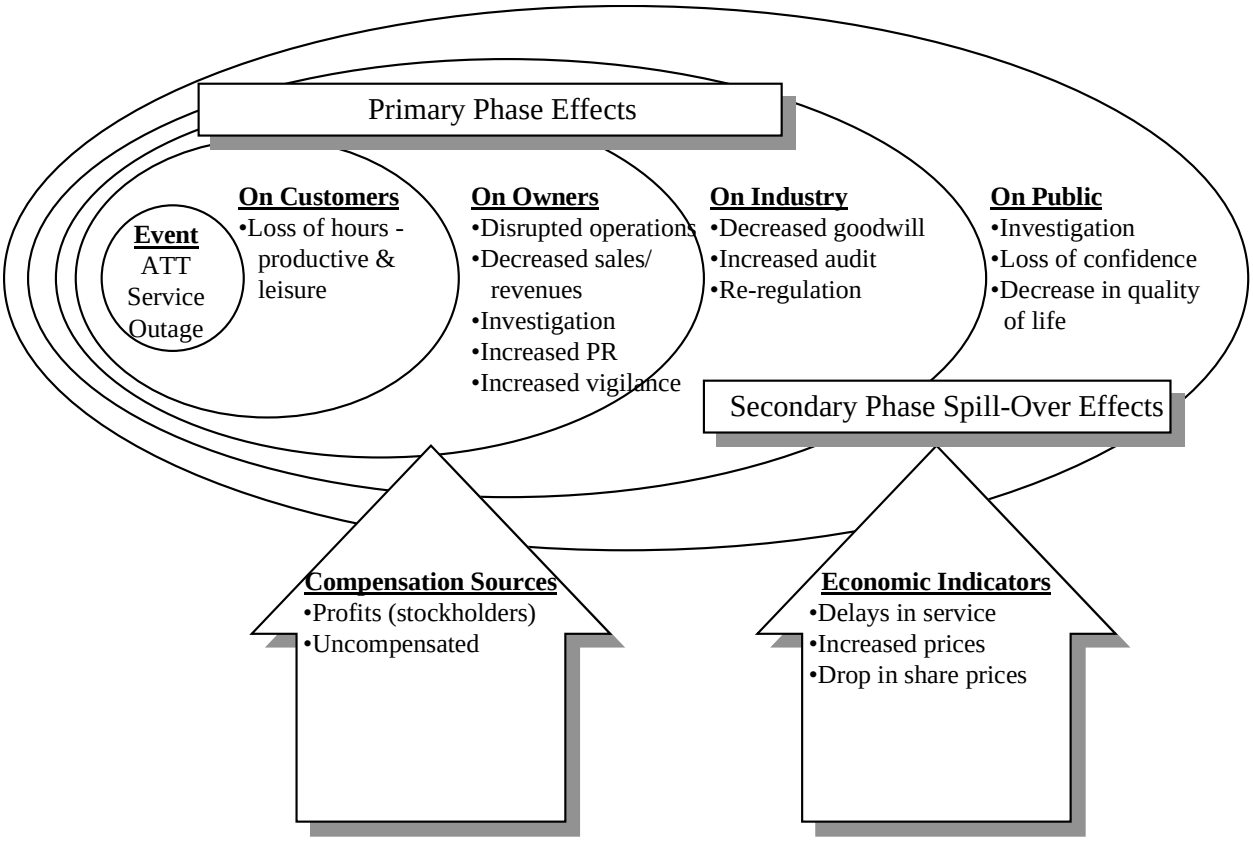
[4] AT&T News Release, September 30, 1991.



Event	Customers	Owners	Industry	Public
East. Seaboard	~$100s M[a]	>$1M[b]	See below[c]	Better service[d]

Exhibit ES-3: AT&T Network Service Failure Profile

[a] Because of the difficulty in estimating the numbers of individuals and business affected by the outage, revenues foregone are conservatively estimated in the hundreds of millions.

[b] Actual costs are likely to be much higher since AT&T (as well as other companies) undertook extensive modernization programs to ensure increased network reliability.

[c] Exact costs to the telecommunications industry are not yet determined, but include substantial administrative costs from new FCC regulations and investigations. For example, in 1992 the FCC imposed new regulations requiring all telecommunications companies to report outages (type and cause) over a certain threshold.

[d] In general, public is better off as a result of the massive improvements and modernization initiatives undertaken by AT&T and other telecommunications providers.

OVERALL CONCLUSIONS

Several common attributes were found among the events examined which have direct applicability to other infrastructures of the U.S. economy, including Banking and Finance.

Attributes of the Customers

Determination of Responsibility

When an event appears to be caused by an un-preventable act of God or nature (e.g., earthquakes, hurricanes, tornadoes, etc.,), it tends to bring out the best in Americans. However, when an event is perceived to be the consequence of someone's action, America quickly demands restitution.

Public Expectations

Americans have grown to have strong expectations of entitlement to superior quality, availability and reliability of products and services. Failure in an infrastructure such as electric power is unacceptable; and is associated with third world nations. Years of steady availability and reliability in certain sectors like telecommunications and power distribution have caused Americans to believe that these sectors can not be affected by disasters. Consequently, failure in these sectors affects the public even more because they challenge the very foundation of our expectations, beliefs and values.

Systemic Failure and the Willingness to Blame "the System"

The initial event itself does not have to have significant losses to cause public outcry. Conversely, large losses do not necessarily result in action. Greatest indignation occurs when an event hits the "this-could-have-been-me" nerve of the American public. Once system failure is perceived by the public to be possible, political action is demanded and inevitably oversight and reform are mandated.

Additionally, when Americans feel betrayed by "the system" they blame the most convenient constituent, regardless of which component is truly responsible. Because the general public usually has no or limited understanding of the relationships and processes beyond the point-of-sales contact, the public typically holds the point-of-sale provider liable. In addition, public response often holds the entire infrastructure/industry responsible as well—regardless of the existence of implied and/or explicit assumption of risk by consumers.

Attributes of the Owners

Outsourcing and the Pursuit of Economies of Scale

Among the most meaningful changes in industry today, technology is providing economies of scale in sectors heretofore relatively unaffected by cyber advancements. For example, data processing at rates unfathomable only decades ago has made outsourcing to mega-processors a necessity to compete in sectors such as telecommunications and the banking and finance industry. Consequently, concentration among a few major suppliers within a sector has grown, with increasingly extensive, intricate and interdependent relationships being the norm.

Back-Office Operations and Intra-Sector Dependencies

Specialization has occurred within most sectors, with separate enterprises providing key functions to the overall infrastructure, e.g., the payments systems and funds transfer networks within the U.S. banking and finance sector. Not surprisingly, there is limited appreciation of, or visibility into, these providers, their processes, and the inter-relationships and critical dependencies occurring beyond the point-of-sales contact.

System of Systems and Inter-Sector Dependencies

Like the ecology system, the dependencies among sectors and infrastructures are necessary, critical, and their delicate balance is often overlooked. While some are obvious, others are less visible but equally critical. For example, one of the largest "victims" of the AT&T network failure was the airline industry, which had to cease operations because control towers could not communicate with each other. In these instances, entire infrastructures are the customers of other infrastructures and house the same feelings of strong entitlement to availability and reliability of services as that of individual citizens.

Laissez Faire Policy and Social Responsibility

Additionally, many of these efficiency-driven vulnerabilities are enhanced in certain sectors by increased de-regulation. In some instances, it can be argued that private enterprises are overly concerned with profits and only marginally responsive to their societal responsibilities.

Accelerated Business Cycle and the Pursuit of Profits

As companies attempt to remain competitive in a world of increased globalization and shrinking product life cycles, the enticement to introduce new product/service offerings, or to implement cost savings measures, before fully considering the possible ramifications is often too great to resist.

Increased Infrastructure Vulnerability

The above shifts in the paradigms of business operations result in a net *increased vulnerability* to the overall industry/infrastructure. Ironically, this initial level of vulnerability (due to outsourcing, intra- and inter-sector dependencies, reduced regulatory oversight and increased competition), is exacerbated as individual participants invest to harden their *individual* walls and limit their *individual* liability, assuming that others are equally diligent. Consequently, this false sense of total security serves to increase the risk of systemic vulnerability.

Increased Threat Capability

Technology has not only increased the vulnerability of certain sectors, it has also unwittingly increased the capability of threats to those sectors. For example, the World Wide Web, the development of international standards and protocols, the de-classification of formerly sensitive information, and increased access through the Freedom of Information Act (FOIA) have all combined to equip individuals with intrusive, and potentially destructive, capabilities. The

ramifications of this power in the hands of a well-funded enterprise with an adverse mission is cause for concern which should be addressed.

TOTAL ECONOMIC IMPACT

In no instance—including those events explicitly excluded from detailed investigation—did the cost of prevention come close to approximating the cost of recovery. The cost of recovery (even without including the values for uncompensated losses) is orders of magnitude greater than rudimentary estimates of preventive measures.

This analysis found that an event is extensive in whom it affects, costly in its recovery, and permanent in its repercussions. Although recovery might not be impossible, the cost to do so is so excessive—especially when including the permanent, secondary impacts, such as increased regulation and higher prices and taxes—that the event should be avoided as much as possible.

Even in "recovery" success stories, the opportunity costs alone are sufficiently exorbitant to warrant avoidance. Opportunity costs are defined as the valuation of an activity based on the value of alternative opportunities that are foregone in undertaking the original activity. In other words, opportunity cost are all the things which are *not* done with the money spent on disaster recovery.

But it is more important to recognize that most losses go uncompensated. Even though hundreds of millions of dollars are spent to compensate the hundreds of victims of an airplane tragedy, relatively little is provided as compensation to the millions that are affected by a power outage or loss of telephone service. Insurance does not reimburse for loss of time and that loss is permanent. Albeit of short duration, there is a distinct loss in quality of life. It is these relatively small, unremunerated losses that are suffered by many which tend to erode most at our overall standard of living.

RECOMMENDATIONS

The following recommendations are based primarily on the lessons learned in this analysis of "catastrophic events," and secondarily on issues identified during preparation of the U.S. Banking and Finance Infrastructure Security Assessment.

Determine Appropriate Standard(s) of Due Care

Most companies, regardless of the infrastructure sector in which they're housed, attempt to proactively manage risk to their enterprises. Unfortunately, they do not always provide sufficient or effective risk mitigating measures. Deficiencies in risk management strategies usually occur because of systemic undervaluation of: the enterprise's vulnerability(s), potential threat(s), or the asset(s) at risk.

Recommendation: Companies should determine appropriate standard(s) of due care and develop corresponding risk assessment and mitigation measures, including performance metrics to ensure that the standard(s) are appropriate and being achieved.

Government Regulated Standards of Due Care

In instances where the assets are considered so valuable to our national fiber, governmental regulation has historically and correctly been implemented to ensure an appropriate standard of due care is employed to alleviate risk.

Recommendation: The cost of recovery dictates that government interdiction and oversight be implemented a priori, and not after the asset is lost.

Industry/Market Standards of Due Care

Industry-wide or market-driven standards are almost always reactive. Because there is no sanctioned method to pass on information, only the participants directly affected by an incident learn from the experience, and no action to shore up vulnerabilities in other industries or infrastructure sectors takes place.

Recommendation: If standards of due care are self-determined, there is an absolute requirement for effective communication of new/changing threats and heretofore unexamined vulnerabilities *at the infrastructure level*, not just to individual participants.

Sharing Information on New/Changing Vulnerabilities and Threats

The events examined in this study revealed that companies do not ignore risk, but rather they are unaware of the vulnerabilities of their enterprises. Obviously, lessons can, and should, be learned from successes and not just failures.

Recommendation: Action should occur not only to make available but proactively disseminate to appropriate parties the "best of class" practices, procedures and technologies proven to minimize the risk and impact of catastrophic events.

Enforce the Standards of Due Care with Behavior-Modifying Sanctions

One aspect of many corporate risk mitigation strategies is to minimize the company's legal exposure/liability. Negligence is typically determined relative to the standard of due care. But if there is no sanction resulting from negligent behavior, then setting standards of due care is useless.

Recommendation: Regardless of method, standards of due care must also include sufficient sanctions levied on participants who do not follow the prescribed "rules" and put the entire industry or infrastructure at risk of a failure. Sanctions need to be significant enough to deter non-compliant behavior.

I. INTRODUCTION

On the whole, the United States has been extremely fortunate considering the number of natural and growing number of physical, manmade, equipment and even cyber threats that face us each day. But certainly for some Americans, the unfortunate and even unthinkable has occurred. Forever etched in our national psyche are the images: the destruction and property loss caused by hurricanes, floods, and earthquakes; the Challenger explosion; and the World Trade Center and Oklahoma City bombings. These events, whether we have been direct participants or innocent bystanders watching the evening news, have had an emotional and economic impact on us and have brought about changes in our lives.

In the wake of any disaster, charities begin their outreach; local, state and federal agencies provide emergency response, aid, investigation and recovery services. The owners of the affected product or service are thrown into the media "circus." We watch as these business owners practice "spin control." After a few days or weeks, the media fervor settles, and we as a nation, begin to move on, but the effects of a disaster do not end when the TV cameras go dim.

I.1 OBJECTIVES

The purpose of this report is to present an estimate of the full economic impact that a disaster has on an infrastructure sector[5]. This report examines not just the immediate losses in terms of dollars (as provided from recoupment and aid sources such as local and national charities; local, state and federal government agencies; insurance providers; and legal compensatory award fees and punitive damages), but also attempts to describe the "intangibles" (such as loss of public confidence) and the spill-over impacts (such as increased regulation and higher consumer prices) which leave a lasting imprint on the quality of life afforded Americans. By recognizing these post-event effects, this report examines the contention that "an ounce of prevention is worth a pound of cure."

This report employs inductive reasoning/logic to meet its objective. It uses specific empirical evidence from three recent actual events—the August 1996 Western power outage, the 1996 ValuJet Flight 592 airplane crash, and AT&T's 1-800 network service failure that affected most of the Eastern Seaboard in 1991—to present estimates of the full economic impact a disaster can have on an infrastructure sector, and the nation at large. This report also identifies the lessons learned by each of the three infrastructures (electrical power distribution, transportation, and telecommunications) which can, and arguably should, be applied to other infrastructure sectors, including U.S. Banking and Finance.

I.2 REPORT STRUCTURE

Following this Introduction, the approach for this economic impact study is described in Section II. In the following three sections, the study presents the individual disaster profiles for the selected events. In each of these three sections, descriptions of the events are presented, followed

[5] In this study, infrastructure sectors include: Telecommunications; Electrical Power Distribution; Gas and Oil Storage and Distribution; Banking and Finance; Transportation; Water Supply Distribution; Emergency Services (including medical, police, fire, and rescue); and Continuity of Government.

by an examination of the immediate and underlying causes for the event. Then, the study attempts to summarize the losses for the customers, the owners, the industry, and the general public. In Section VI of this report, lessons learned and conclusions are presented. Section VII offers recommendations targeted to other infrastructure sectors.

II. APPROACH

To conduct this analysis, the research extended beyond the immediate event and explored the spill-over effects a disaster has on the customer, the owner, the industry, and the general public. By taking this approach, specific lessons learned from each event surfaced, and commonalities among the three formed the basis for the conclusions and recommendations presented herein.

In the report that follows, immediate and spill-over effects of three disasters are examined. Recoupment and aid sources such as the local and national charities, local, state and federal government agencies, and insurance providers were researched to estimate the magnitude of reimbursement provided after these events. The cost impacts on others within the infrastructure and those in other infrastructures are also investigated in this analysis. Finally, through the recognition of "spill-over" and post-event effects, the intangible affects from the "loss in public confidence," are discussed and presented.

II.1 SELECTION OF EVENTS

Multiple "disasters" were considered[6] and are referenced throughout this report to supplement the conclusions derived from the three primary events under analysis. These three events were selected as appropriate analogs to the U.S. Banking and Finance infrastructure because they were found to have attributes common to those identified in the U.S. Banking and Finance infrastructure. Specifically, the following were found to be characteristics of an event in the U.S. Banking and Finance infrastructure:

Relative to the **event**

- The public perceives the event to have been preventable.
- The owner of the affected product or service appears to be ill-prepared or non-responsive to the event - regardless of who's at fault.
- The event warrants nationwide visibility by the media.
- The event has initial and consequential repercussions of significant magnitude.

Relative to the **product/service**

- The product/service is essential to a customer.
- There are no or few immediate substitutes for the product/service.
- Failure/disruption of the product/service is considered a breach of public trust.
- The provision of the product/service is moving from a "private good" to a "public good."

[6] See Appendix A for a listing of other candidate events.

Relative to the **customers**

- Customers have grown to have implicit expectations of entitlement to superior quality, availability and reliability.
- Customers feel they are "held captive" to indistinguishable, bureaucratic, point-of-contact owners.
- Customers have no or limited understanding of relationships and processes of the infrastructure occurring beyond their point-of-contact owner.

Relative to the **owners**

- Ownership of the product/service is typically a privately-owned vice a government-owned enterprise.
- Owners of the product/service experience increased government intervention over time and as their product/service moves from the private to the public realm.
- Owners of the product/service have benefited from economies of scale - either historically or, more recently, through technology.
- Owners have an increasing social responsibility.

Relative to the **industry**

- The industry has become concentrated among a few major owners.
- Extensive, intricate and interdependent relationships exist among participants in the industry and potentially within the infrastructure.
- The industry has been identified as critical to the Nation's well-being (and therefore, is considered by the Presidential Commission).

The three actual events—the August 1996 power outages across the Western U.S., the 1996 ValuJet Flight 592 airplane crash, and the September 1991 AT&T's 1-800 network service failure affecting most of the Eastern Seaboard—were chosen as "benchmarks" for analysis in this study because they have the same or similar characteristics identified above for the U.S. Banking and Finance infrastructure.

II.2 METHODOLOGY

For each event, the consequences or economic impacts are:

1. Allocated to **event phase**
    - Primary
    - Secondary

1. Attributed to affected participants
    - Losses to the customer
    - Losses to the owners
    - Losses to the industry
    - Losses to the public/quality of life

1. Quantified by **compensation/recoupment sources and economic indicators**
    - Private sources, i.e., insurance, charities, stockholder reserves/profits, legal damages/awards, etc.
    - Federal, state and/or local governments
    - Passed to the public via product/service prices, taxes, quality of product/service, share price, etc.
    - Uncompensated

As shown in Exhibit II-1, expanding consequences occur in the wake of a disaster. Response begins immediately in what can be characterized as the primary phase. Within this phase, the focus is primarily on the immediate losses suffered by the customers and the owner of the failed or impacted product/service (although the industry housing the disaster event and the general public might also experience some immediate effects). This primary phase might last weeks or even months depending on the nature of the disaster. These losses are generally measured by the compensation/recoupment provided by such sources as charities, local, state and federal government aid, insurance carriers, profits, legal damages/awards, etc.

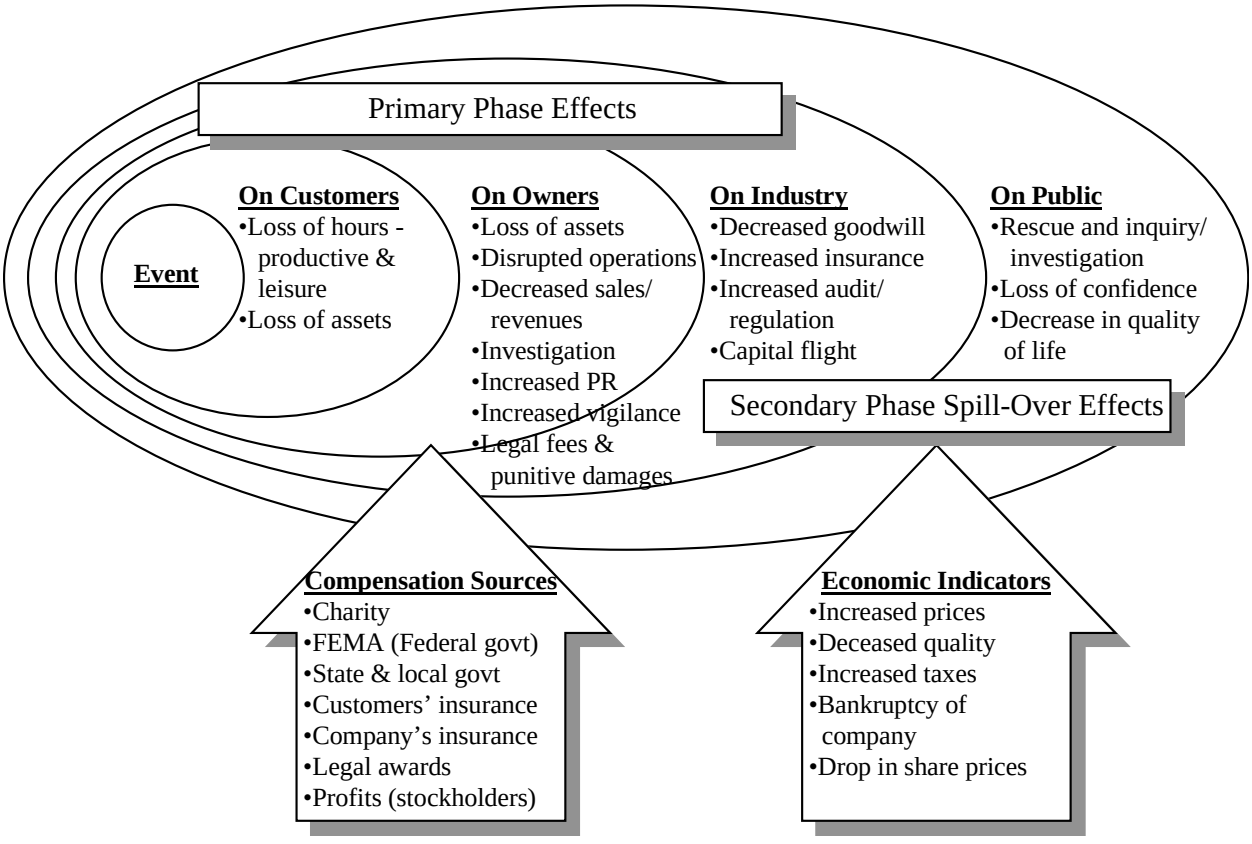


Exhibit II-1: A "Typical" Disaster Profile

Continuing to use the model drawn in Exhibit II-1, the repercussions from an event ripple like waves in a pond over time and can be felt years after the event occurs. These spill-over effects are part of a secondary phase that occurs in the wake of a disaster. This secondary phase tends to be measured in years, even decades. While all participants (i.e., the customers, owners, industry and public) are affected by the secondary phase, spill-over effects are generally absorbed into our economy and are observed in broad areas such as quality of life. For example, in the wake of two major airplane crashes in as many months, ValuJet Flight 592 and TWA Flight 800, family members of the victims of the Pan Am Flight 103 crash in 1988 were interviewed and asked to participate in investigative panels such as the White House Commission on Aviation Safety and Security, demonstrating how, even years later, there are long-term impacts that continue to occur for that disaster.

As the empirical data is presented in the three specific event profiles selected for this study, it generally follows this same timeline, beginning at the event, moving quickly into the primary phase, and working out towards the secondary phase, where the spill over effects of a disaster such as greater regulation within an industry or infrastructure are assessed a value on the economy, and on the nation as a whole.

II.3 SCOPE OF ANALYSIS AND SOURCES OF DATA

This report is based exclusively on publicly available data and information provided from the media, government(s), and other open sources. The turn-around period of this study excludes personal interviews and the in-house generation of complex cost estimates. As provided above, the methodology focuses on collecting, examining and allocating publicly available cost data from compensation sources to the affected participants and impact phases.

Putting a price tag on a disaster of any magnitude is difficult. For example, there is an understandable hesitation on the part of any owner to disclose to the public damaging data about the company's operation failures and losses. Many owners, because of the regulatory environment under which they operate, must make this data available to agencies such as the Securities Exchange Commission (SEC), the Federal Aviation Administration (FAA) or the Nuclear Regulatory Commission (NRC). Still, this is not the same as directly presenting this data to the general public. Thus, some of the data presented in this study has been extrapolated and is clearly an estimate, not actual cost data. This study's authors have been careful to note these distinctions so that it will be clear to the audience when actual data is being quoted and when data has been extrapolated.

For all of these disasters, we will never know with certainty the bottom line costs. Dollars invested by affected owners and others within the industry in aggressive marketing campaigns certainly work to offset the potentially devastating effects a disaster, left unchecked, could have. As Exhibit II-1 tries to illustrate, as the waves from an event ripple across time, the larger the affected participant circle gets. Attempting to quantify the losses sustained or suffered in these outer circles becomes more and more difficult. For example, as a result of TWA airplane crash, airline consumers are required to check-in at the airport sooner, allowing time for the additional security measures that have been instituted as a consequence of this event. Quantifying the loss

in “productive time” for these travelers is a subjective determination which is hotly debated on both sides of the economic equation.

Even more difficult to ascertain are the societal costs and yet for this type of analysis, they can not be overlooked. Thus, some of the data presented in this report is anecdotal, vice empirical and is employed to provide either support or to contradict contentions made.

III. THE WESTERN POWER OUTAGE

As Americans we have come to rely on many things. When we board a plane, we expect to arrive at our destination safely. When we pick up the phone, we expect a dial tone and after dialing, we expect to be connected to the party we are trying to reach. And when we turn on a light switch, we expect lights to illuminate the room. Our entire economy and our daily lives have become completely reliant on electricity—to make our morning coffee, to open our garage door, to power our mobile phones and to run our computers. Because all infrastructure sectors of the U.S. economy rely on energy distribution and supply, availability and reliability are essential. Unlike other power sources such as oil or gasoline, electricity can not be stockpiled. Therefore, when power is disrupted, an immediate cessation of service occurs.

III.1 DESCRIPTION OF THE EVENT

During the early afternoon of August 10, 1996, in the area surrounding Portland, Oregon, high temperatures and high demand for electricity caused two transmission lines to sag and send arcs of electricity into the trees. This caused the lines to short-circuit. This in turn, caused a surge in electricity which, over the next hour, knocked out two additional transmission lines. A third line was forced out of service due to a circuit breaker failure after the second line outage occurred. While none of these line outages were deemed critical by Bonneville Power Administration (BPA) dispatchers, the cumulative impact resulted in a weaker system. BPA adjusted voltages, but did not reduce schedules. Two additional transmission lines and two circuit breakers were out of service for modifications and/or repairs. These out of service outages also contributed to the weakening of the system.

Approximately 45 minutes later, another sagging line short-circuited. Five minutes later, two units at the McNary hydropower dam "sensed" system instability and automatically shut down. One minute later, voltage fluctuations shut down three of the four main connection lines between the Northwest and California. Power was knocked out for up to 16 hours in 10 western states, affecting 7.5 million customers.

In addition to interrupting service on August 10, the outage resulted in the automatic shutdown of 15 large thermal and nuclear generating units in California and the Southwest, keeping the entire region in a compromised condition for several days following the event. Protective relays, which can be likened to surge protectors for PCs, are built into power generating systems to sense "trouble" and automatically shut off the generators to prevent equipment damage.

III.2 CAUSE OF THE EVENT

Background

The electric power industry is undergoing radical change. Just like the telecommunications industry before it, market forces such as competition, privatization, and deregulation are challenging the traditional attributes of the power industry, such as monopoly status, government ownership, and government regulation. Global competition, increasing customer demands,

capital liquidity, the relatively low price of natural gas, and environmental concerns are all driving forces that, when coupled with deregulation of the industry, are creating great change.[7]

New players are entering the power generation and delivery market, and existing utilities are being required to offer open access to their transmission systems. The functions of power generation, transmission, and marketing—which traditionally have been tightly integrated—are now being separated within utilities and, in some cases, even spun off into new companies. Competition, aging proprietary systems, and reductions in staff and operating margins are leading utilities to expand their use of information systems and to interconnect previously isolated networks.

In July 1996, in an effort to complete the deregulation of the power industry, Congress enacted the Electric Consumers' Power to Choose Act. The bill establishes federal mandates for all electric utilities to provide retail choice to all classes of customers by December 15, 2000. After retail choice in a state has been established, state commissions would be prohibited from regulating the rates for retail electricity service. Reasonable and nondiscriminatory access to local distribution facilities would be provided on an unbundled basis to any supplier seeking to provide retail electricity service. These mandated government actions will soon provide the consumers, generation and distribution firms, and power marketers open access to an unregulated electric power industry.

The Western Systems Coordinating Council (WSCC), which is the electrical power distribution service provider for the affected region in the August 10 outage (encompassing a geographic area equivalent to over half the United States) is one of nine regional electric reliability councils in North America. There are 76 electric systems in the WSCC power grid, including Pacific Gas and Electric (PG&E), Sacramento Municipal Utility District, the Santa Clara and Palo Alto municipals, Southern California Edison and San Diego Gas and Electric. The WSCC power grid provides electric service to 59 million people in 14 western states, two Canadian provinces, and portions of one Mexican state.

The western power grid is an intricate web of high-voltage transmission lines. Through careful planning and coordinated communications, the WSCC members are able to buy, sell and transport energy reliably, 24 hours a day. The system works something like this. In the summer, massive volumes of electricity are imported from the Pacific Northwest each day to California to meet increased demand for cooling. In the winter, the flow of power reverses, providing the Pacific Northwest with energy to warm the area's colder climate. On a daily basis, system loads are forecast, generating plants and transmission availability checked, and buy-sell transactions are negotiated between those utilities that have excess power and those that need more power to meet customer's demands. If plants go off line for any unanticipated reason, the load is picked up by "spinning reserves." After peak hours are past, the system is brought down by a sequential removal of generators from the grid, maintaining a balance between demand and supply of power at all times.

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[7] Silverman, Lester, "Electric Power-The Next Generation," *McKinsey Quarterly* (January 1, 1994).

Elaborate safeguards have been built into the Western interconnected grid. In what the industry calls "islanding," this technique is used as a safety net to prevent total blackouts, minimize the number of customers affected, and minimize the time to restore customer service. During the August 10 power outage, the islanded power plants were tripped to prevent equipment damage and loads were shed to help stabilize the system, thereby avoiding a complete blackout.

Investigation by the WSCC

The WSCC began an immediate investigation into what caused the power to go out on August 10, 1996. The outage occurred during a period of record high temperatures and electric loads. This factor, combined with an abundant supply of water in the Northwest caused high transfers from and through the Northwest to the Southwest. These higher than normal transfers or flows, stressed the transmission system and reduced reliability margins.

According to the WSCC investigation, line instability and overgrown vegetation were cited as causal factors in the August 10th outage. In their final report investigating the outage, the WSCC concluded that BPA was not in fact operating in accordance with Western's minimum standards.[8] According to E. James Macias, Vice President and General Manager of the Electric Transmission Business Unit of Pacific Gas and Electric (PG&E) Company in sworn testimony given on November 7, 1996 to the Congressional Committee on Resources Water and Power Resources Subcommittee, "The Western grid in the United States suffered its second major disturbance in 2 months...the cause of both events was a lack of effective voltage management by exporting utilities in the regions. This lack of adequate voltage management caused a series of line and equipment failures to escalate into massive voltage collapse and grid instability in the Northwest.[9]" BPA was also faulted in the WSCC's final report for failing to keep trees trimmed.

According to BPA Administrator Randal Hardy, another factor was water:

> "This was the highest hydro year we had in 20 years. Normally, run-off ends around June 30th and hence you have lower loading in July and August, the peak load times in California. This year, the runoff went all the way through August, and that created some vulnerabilities that we had not fully understood and which we are now working to understand and correct.[10]"

Additionally, the BPA operators did not fully understand that they were approaching voltage instability and were not aware that operating conditions were insecure. When interviewed after the event, the operators felt that they were within parameters and procedures defined for them. When each the 500 kV line outages occurred, they were not considered "critical" and therefore

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[8] National Information Infrastructure Risk Assessment: A Nation Information at Risk, prepared by the Reliability and Vulnerability Working Group, 29 February 1996.

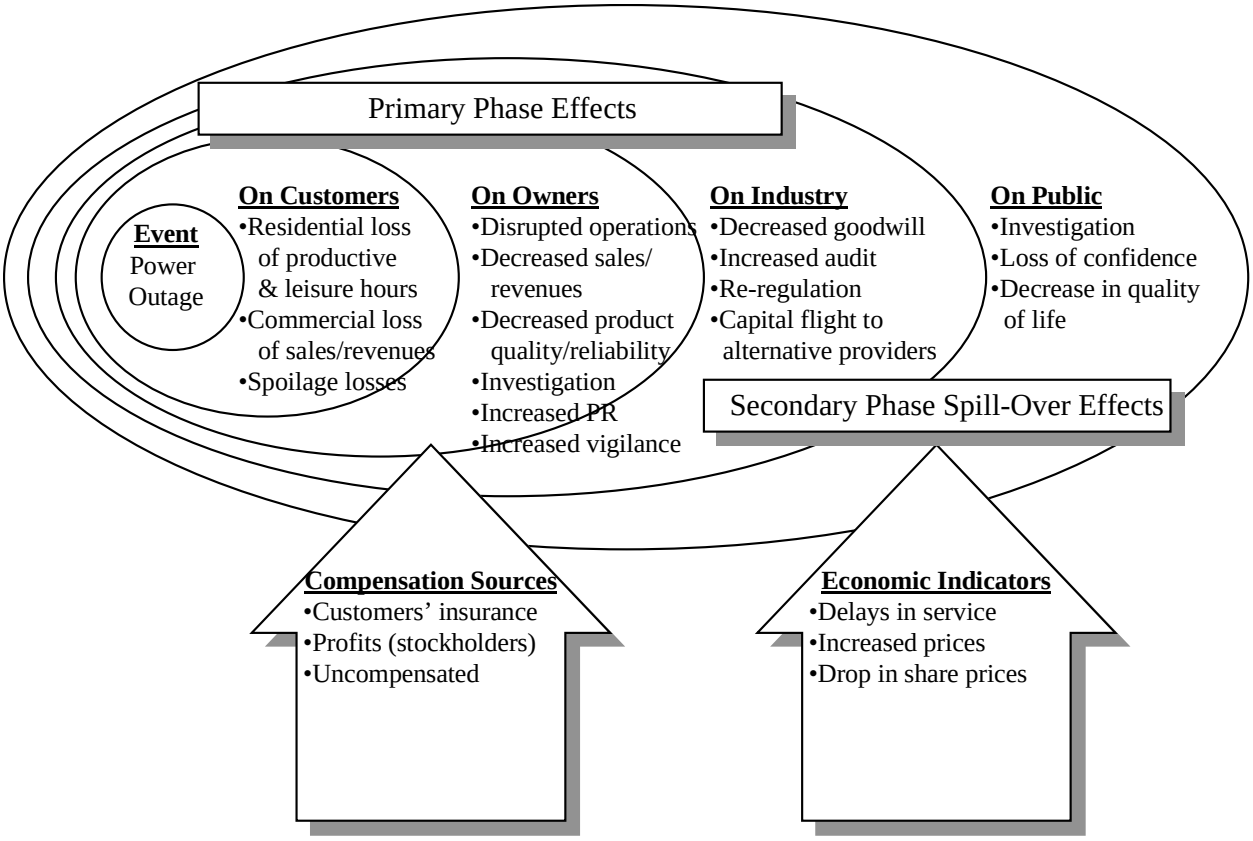
[9] Macias, E. James, Vice President and General Manager of the Electric Transmission Business Unit of Pacific Gas and Electric Company in sworn testimony given on November 7, 1996 to the Congressional Committee on Resources Water and Power Resources Subcommittee, p. 51.

[10] Hardy, Randal, in testimony given to Oversight Hearing before the Subcommittee on Water and Power Resources of the Committee on Resources, House of Representatives, 104th Congress, 2nd session on Issues and Recommendations Concerning the August 10, 1996, Bonneville/Western U.S. Power Outage, p. 10.

the information about the outages was not shared with other companies. This lack of communication between and among the companies that make up the WSCC contributed to, if not caused the outages to occur. Each company viewed each outage as independent events, failing to recognize the intricacies that made them dependent links in a chain. Once the chain began to break, there was no way to stop it.

III.3 TOTAL COST TO DATE OF THE OUTAGE

Exhibit III-1 presents the cost and impact profile for the Western Power outage. Based on this study's conservative estimates, the Western Power outage has cost several *billion* dollars to date—most of which remains uncompensated. Because of the relatively recent nature of these events, the long-term effects (or spill-over costs) of pending legislation and other industry related mandates on individual owners like BPA and proposals to strengthen the regulatory arm of this relatively self-regulated industry can not be accounted for in this total.



Event	Customers	Owners	Industry	Public
Aug. 10, 1996	~$1-4 B[a]	>$100 M[b]	See below[c]	See below[d]

Exhibit III- 1: The Western Power Outage Cost and Impact Profile

[a] Estimates of uncompensated losses of residential and commercial productive and leisure hours

[b] Net losses in revenues due to regeneration expenses, equipment damage and expenditures for responding to governmental investigations and hearings.

[c] Costs to date, while certain to be significant, are not yet available. To avoid double count costs to owners, other infrastructure costs would include the establishment and compliance of nation-wide reliability, coordination, and monitoring standards.

[d] Public costs include changes in the business practices and cost structures of the nation's electrical power distribution systems that are likely to be passed on as additional charges to customers.

The remaining portion of this section presents detailed descriptions of the impact the Western power outages had and the quantitative data supporting Exhibit III-1.

III.3.1 Losses to the Customer

Fortunately, in the case of the August 10, 1996 outage in the Western United States, there were no reports of deaths or major injuries. In fact, there are no reports by any of the major charity organizations like the American Red Cross or the Salvation Army that indicate that they mobilized during this incident. Still, this power outage was more than minor inconvenience for WSCC customers. In an emergency session of the California Public Utility Commission Hearing the outage was characterized as causing significant harm to the people of California.[11] Randy Hardy, BPA's Chief Executive Officer, characterized the outages as a real-time emergency in which their number one priority, once service was restored, was to prevent blackouts in California. "This is a matter of public health and human safety. California is expecting to see record temperatures for the next couple of days. They've lost two major generators that serve their area and they are calling on the Northwest for help."[12] Human health and safety can be threatened during a prolonged power outage. Fire departments, police and hospitals are all dependent upon a reliable supply of electricity to be able to respond to emergencies.

During any power event, public safety personnel are often taxed. According to Capt. Dan Young of the Orange County Fire Department,[13] there was an exponential increase in traffic accidents, tie-ups and delays due to traffic lights rendered inoperable. Hospitals and other critical users had to resort to their emergency back-up procedures and emergency power generation to keep critical service like life-support devices, operating.

At San Francisco International Airport, more than 2,000 travelers were stranded Saturday night due to the August 10th outage.[14] Many restaurants and retail shops and shopping malls had to close their doors and even Disneyland temporarily shut down some of its rides due to power surges. At one California 7-Eleven, owner Shams Makhami had to close his doors, and most of the store's ice cream, milk and deli products were lost during the 4 hours the store was without electricity.[15]

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[11] Characterized by the Commissioner Conlon during the California Public Utility Commission Hearing on the August 10 Disturbance, August 21, 1996.
[12] "BPA, WSCC Take Steps to Bolster System Reliability," Joint News Release: Bonneville Power Administration, Western Systems Coordinating Council, (PR 58 96), August 13, 1996.
[13] Associated Press, "Western Power Outage Affects More Than 4 Million," Durbin, Dee-Ann, 12 August 1996.
[14] *Ibid.*
[15] *Ibid.*

As stated previously, 7.5 million customers were without power, some for as long as 16 hours. Table III-1 shows a breakdown, by region, or affected "island" of customers and the average restoration times for the August 10th outage.

Table III-1
Impact by Regional Island of the August 10, 1996 Power Outage

Region	Customers Affected (mil)	Percent of Customer Affected	Load Shed (mw)	Generation Tripped (mw)	Restoration time (hr)
Alberta	.19	3%	968	146	1
Northwest	.21	3%	2,099	5,689	4
Southwest	4.23	56%	15,982	13,497	6
No. California	2.86	38%	11,440	7,918	9
Totals	7.49	100%	30,489	27,250	9

The WSCC has not prepared a comprehensive economic study to estimate the total costs of this, or its previous outage that occurred just six week prior to the August 10th event. Still, cost estimates from outages of similar magnitude (e.g., the 1977 New York City outage, the 1996 Delmarva outage, etc.,) provide reasonable formulas and models to follow. For example, on May 14, 1996, a single substation suffered an outage which resulted in an 8-hour blackout affecting 290,000 customer through southern Delaware and across the eastern shores of Maryland and Virginia. Michael Conte, an economist at Towson State University estimated the economic loss suffered by local and regional businesses to be as high as $30.8 million.[16] The 25-hour New York City blackout that struck in 1977 cost an estimated $55.54 million in direct costs and over $290,000 million in indirect costs to local government, business, and private citizens.[17]

Using information available about the outage and following a model provided by BPA which measures economic impact as a function of cost per customer for each kilowatt per hour lost, Table III-2 presents the estimated customer cost, broken out by customer type (i.e., commercial, residential, or industrial).

[16] Humphrey, Theresa, "Power Outage Darkens Delmarva Peninsula," *The News-Times* (May 15, 1996).
[17] Office of Technology Assessment figures, as quoted in the National Information Infrastructure Risk Assessment: A Nation Information at Risk, prepared by the Reliability and Vulnerability Working Group, 29 February 1996.

Table III-2
Customer Cost by Sector[18]

Customer Type	Customers Affected (mil)	Load Not Served (mil)	Average Cost to Customer Per Hour (kw/h)	Customer Cost ($ mil)
Commercial	3.74	12.35	$15.82	$ 195.4
Residential	2.25	20.58	$1.42	$ 29.2
Industrial	1.50	8.23	$23.57	$ 194.0
Total	7.49	41.16	$13.60	$ 418.6

Dr. Karl Stahklopf of Energy and Power Research Institute (EPRI) argues these figures underestimated the true economic impact because they do not account for:

- Industrial equipment damage and mandatory costly procedures to purge electricity at the customer end;
- Lost productivity;
- Opportunity costs from lost sales; or
- Costs to the public for maintaining order.

Dr. Stahklopf's estimates, accounting for these additional cost factors, put the costs to customers in the range of between $1—4 billion. This range was seemingly confirmed by testimony presented by PG&E. PG&E estimated that the indirect costs to its serving area, which accounted for two million affected customers during in the August 10th outage, could be roughly assessed at $400 million or ten times PG&E's direct costs.[19]

Still, there is very little compensation (e.g., rebates) to the consumer when a service such as power goes out. When recoupment sources such as the insurance industry were contacted for this study, little data was made available. Certainly some consumers placed claims for lost equipment such as microwaves, TVs, VCRs, telephones, air conditioners etc., that were "fried" during the outage. However, many more did not because of high deductibles on their homeowner's policy.

III.3.2 Losses to the Owner(s)

Impact to BPA

BPA is the largest agency to market power from federal dams in the Columbia River basin. As a power wholesaler in the WSCC region, it has an annual budget of approximately $2.5 billion and

[18] Obtained from conversations with Bill Mittlestaff, Engineer, BPA. The BPA model assumes a 50% residential, 30% commercial, and 20% market breakout.
[19] As given by E. James Macias, Vice President and General Manager, Electric Transmission Business Unit, Pacific Gas & Electric Company, in sworn testimony given on November 7, 1996 to the Congressional Committee on Resources, Water and Power Resources Subcommittee.

has 3,200 employees. BPA owns and operates approximately 80 percent of the high-voltage grid, including some 15,000 miles of transmission lines in the Northwest. As a result of the August 10, 1996 outage, BPA, in voluntarily cooperation with the WSCC, agreed to take the following actions[20]:

- Remove all trees involved in the August 10 disturbance;
- Implement a more aggressive effort to remove additional trees that pose a potential threat to BPA's primary high voltage transmission lines;
- Work with the National Marine Fisheries Service and the Corps of Engineers to temporarily waive fish spill requirements fish operations at the Dalles Dam;
- Report all outages of 500,000 volt transmission lines and other key facilities on its system;
- Conduct a comprehensive study to assess voltage support capability of its system;
- Initiate a review with the U.S. Corps of Engineers to understand the loss of the McNary generators and to prevent their loss in the event of a future disturbance; and
- Work a request from the Secretary of Energy to all power marketing agencies to review reliability issues.

To help offset the fact that two units at PG&E's Diablo Canyon Nuclear Facility continued to be out of service in the days following the outage, BPA, with the concurrence of the U.S. Corps of Engineers and the National Marine Fisheries Service, curtailed spill and allow additional generation to be sent to California. Spill refers to a practice used at dams to meet the Endangered Species Act requirements. Rather than running fish-laden water through turbine generators to produce electricity, the water flows through spillways at the dam. Even without spill, about 25 percent of migrating juvenile fish would travel through sluiceways avoiding the turbines. Of those fish that pass through the turbines, about 15 percent are killed. At the time this event occurred, the National Marine Fisheries Service estimated that 107,000 juvenile fall chinook salmon would pass the dam each day during the three-day emergency period. The overwhelming majority of these fish are hatchery-produced salmon, with only about 20 wild fish listed under the Endangered Species Act passing through the dam on a daily basis. Based on these estimates, the Fisheries Service estimated that in the worst case scenario, a total of four to six listed fish may have been killed due to the spill cutback.[21]

This controversial stand cost BPA much in public ill-will. Especially in the Northwest, advocates of the Endangered Species Act widely portrayed the action as killing endangered fish for power-hungry Californians and stirred a political controversy that lasted over a week.

In 1995, BPA estimated that the spill program resulted in lost revenues averaging $38.3 million per year. During the declared emergency period (August 12-15), BPA increased generation at the

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[20] "BPA, WSCC Take Steps to Bolster System Reliability," Joint News Release: Bonneville Power Administration, Western Systems Coordinating Council, (PR 58 96), August 13, 1996.
[21] "Northwest Helps California Deal With Emergency," Bonneville Power Administration, (PR 59 96), August 14, 1996.

Dalles dam approximately 60,600 megawatts or 361 average megawatts for the 7 day period. At the prevailing rates for surplus energy during that period, this amount of energy resulted in about $1.0 million in sales. Following the emergency, BPA provided spill for an additional four days resulting in an offsetting loss in sales.[22]

BPA Administrator Randal Hardy provided some insight as to the cost to BPA for implementing just a few of these actions, which are summarized in Table III-3.[23] For nearly two weeks after the August 10th outage, BPA was still operating at 67% of its maximum capability, below the limit set by WSCC to ensure that no further outages would be suffered at the hand of BPA.[24] This reduced operating capability was estimated to cost BPA over $1 million in lost revenues.

Table III-3
BPA's Cost to Implement Required Actions

Required Action	Steps Taken or To be Taken	Estimated Cost
Tree Trimming	• Immediate and system-wide check of vegetation on all critical lines (~2,000 miles) • Adoption of a more aggressive tree trimming program and resumption of selective use of herbicide and right-of-way management control	$ 0.25 million $ 1.5 million additional cost in FY97
Reduce Capacity	• Cut operations to 67% of capacity	$ > 1.0 million
Curtail Fish Spill	• Additional generation of power and resulting sale to PG&E • Additional 4 days of spill after the declared emergency period was over	($1.0 million) in sales revenue $1.0 million
Voltage Support Review	• Add additional system reactive capability on the Bonneville system	$ 10-50 million in new costs

[22] Submitted data presented in the Oversight Hearing before the Subcommittee on Water and Power Resources of the Committee on Resources, House of Representatives, 104th Congress, 2nd session on Issues and Recommendations Concerning the August 10, 1996, Bonneville/Western U.S. Power Outage, p. 25.
[23] Hardy, Randal, in testimony given to Oversight Hearing before the Subcommittee on Water and Power Resources of the Committee on Resources, House of Representatives, 104th Congress, 2nd session on Issues and Recommendations Concerning the August 10, 1996, Bonneville/Western U.S. Power Outage, pp. 10-11.
[24] Brazil, Eric, "Utilities Dissect Recent Outage: Hostilities Evident Between PG&E, Federal Agency at Hearing in San Francisco," The San Francisco Examiner, August 22, 1996.

Impact to Other Power Companies

PG&E estimated that the indirect costs to its serving area, which accounted for two million affected customers during in the 10 August outage, could be roughly assessed at $400 million or ten times PG&E's direct costs.[25] Most of PG&E costs were related to the Diablo Canyon Nuclear facility being down for several days after the outage. Company representatives estimated that it cost PG&E an additional $250,000 a day in energy management cost to purchase energy to make up the delta caused by Diablo being down. Even when PG&E brought Diablo Canyon back on line, they agreed to operate at 67% capacity, which cost them an additional $100,000 a day.[26]

In addition to the actions described earlier taken by BPA (whose actions and operations were found responsible for the August 10, 1996 outage), the WSCC required that:

- Power flows on the Pacific AC Intertie be limited to 75 % of maximum capacity pending further study and review by the WSCC; and
- All its members review their tree trimming programs and report any changes that have been or will be implemented.

Further, the WSCC recommended that all utilities review their transmission system's ability to maintain appropriate system voltage levels during system disturbances.

While most utility companies involved in this outage lost revenues, one utility, San Diego Power and Electric actually reporting an off-setting gain by selling over 750 megawatts of capacity off system to PG&E.[27] Still, the majority of power owners involved in this outage lost revenues as summarized in Table III-4.

Table III-4
Estimated Lost Utility Company Revenue (by Region)

Region/Island Affected	Load Not Served per kw/hr (millions)	Average revenue per kw/h[28]	Resellers' Lost Revenue ($)
Alberta	.42	n/a	n/a
Northwest	1.39	4.4 cents	$60,793
Southwest	33.30	6.2 cents	$2,066,667
Northern California	5.80	10.0 cents	$579,666
Total	40.91	8.3 cents	$2,707,126 (exc. Alberta)

[25] Macias, E. James, Vice President and General Manager, Electric Transmission Business Unit, Pacific Gas & Electric Company, in sworn testimony given on November 7, 1996 to the Congressional Committee on Resources, Water and Power Resources Subcommittee.
[26] *Ibid.*, p. 178.
[27] Mr. Guiles, from San Diego Gas and Electric, in sworn testimony before the California Public Utility Commission hearing, August 25, 1996.

III.4 LOSSES TO THE INDUSTRY

America's electric power industry has annual revenues of $185 billion and is larger than the automobile, computer or semiconductor industries.[29] In what one industry representative called "a great wake-up call to put first things first,"[30] the 1996 Western Power outages both hurt and helped this largely self-regulated industry.

Each time a region suffers a major outage, such as occurred in the Northeast in 1965 or in New York City in 1977, the result tends to be that the Government becomes concerned about the reliability of the interconnected systems within the U.S. For example, shortly after the Northeast blackout in 1965, the Federal Power Commission attempted to get legislation passed to give federal regulators a much stronger role in enforcing reliability, but this legislation did not pass. Instead, the industry, in voluntarily cooperation with the Government, formed nine regional councils and the North American Electric Reliability Council. Especially in the WSCC operating arena, the power distribution grid relies on robust interconnected transmission systems to save costs through increased efficiencies. However, these interdependencies also mean that when one or more participants fail to maintain their end of the reliability bargain, the burden is borne by electric consumers and industry resellers throughout the region.

Membership, even today, is not mandatory and the reliability councils such as the WSCC, do not have the authority to sanction members for failures that cause outages. However, in the face of future changes within the industry, almost all share the view that voluntary compliance will no longer be adequate. In fact, throughout the testimony given November 7, 1996, industry leaders consistently recommended:[31]

- Mandatory compliance with established standards, policies and procedures;
- Mandatory membership in regional reliability councils and the NERC; and
- Expanded compliance monitoring, with appropriate incentives, sanctions, or fines.

As a result of the major outage(s) that struck the Western U.S. in 1996, the industry has begun to identify and implement strategies to minimize the potential for more severe outages. Additionally, the cost associated with standardizing the information technology (IT) systems and data is being researched as a viable method to ensure communications and better modeling and simulation across these independently owned and operated utilities.

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[28] Average revenue per kw/h is calculated by the Energy Information Agency, Department of Energy. To derive the average revenue, the operating revenue reported by the electric utility is used. Utility operating revenues cover—among other costs of service—State and federal income taxes and taxes other than income taxes paid by the utility. EIA, Electric Power Annual 1995, Energy Information Agency, Vol. 1, Chapter 5.

[29] Beck, Bill, "Electric Utility Industry Faces Future Challenges," Area Development Online, Sites and Facility Planning, Vol. VII, February, 1996.

[30] Jennings, Renz D, Chairman, Arizona Corporation Commission, in sworn testimony given on November 7, 1996 to the Congressional Committee on Resources Water and Power Resources Subcommittee.

[31] Congressional Committee on Resources Water and Power Resources Subcommittee, November 7, 1996.

III.5 LOSSES TO THE PUBLIC

At this early juncture, it is difficult to assess the public losses. The data presented in the previous sections does hint that this outage will not be without consequences to the public. Based on the large number of findings and recommendations in the WSCC Final Report,[32] utility companies such as BPA will see an increase in operating costs which eventually will get passed on to customers in the form of rate increases.

Stockholders in companies such as PG&E are seeing smaller dividends. While PG&E and other utility companies have a host of reasons for lowering stock dividends, including new legislation that marks lower earnings and greater pressure from the competition,[33] part of the reason has to be the additional cost of implementing all of the recommendations that resulted from the August 10 outage and investigation.

Still, because the Pacific Northwest/Southwest Intertie takes advantage of seasonal diversities between the Northwest and the Southwest to maximize the economic benefits for both regions, it is estimated that it has saved California consumers $1 million a day for the past 30 years. The Intertie is also attributed with significantly reducing pollution, particularly in the Los Angeles basin.[34]

Consumers, once able to make a choice about the utility companies they buy from, may choose those with environmentally friendly policies and procedures, versus lowest cost. Time will only tell, but the long-term impact to BPA for choosing to curtail fish spill operations may be far greater than the four to six wild fish that perished in the days following the August 10, 1996 outage.

Media Handling

The Western outages received intense media and governmental scrutiny. The industry at large suffered from the lack of coordinated communications among the affected utilities. For reporters, there was no central place to contact for information about the outage that was spread across so many states. Because the local utilities did not know the cause, speculation grew in the media and in other communications networks, such as the Internet. When a clearly articulated reason is not given, the door is opened wide for "conspiracy theorist" and others to raise doubts and impact public confidence in the service provider.[35] The complexity of the integrated network worked against the industry's participants in this time of crisis. At one point, there was speculation that fires caused the outage, so official had to later disclaim this as not being a contributing factor to the outage.

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[32] WSCC Final System Disturbance Report, August 10, 1996.
[33] "PG&E Lowers Common Stock Dividend, Reports Third Quarter Earnings," PG&E News Release, October 16, 1996.
[34] Hardy, Randal, in testimony given to Oversight Hearing before the Subcommittee on Water and Power Resources of the Committee on Resources, House of Representatives, 104th Congress, 2nd session on Issues and Recommendations Concerning the August 10, 1996, Bonneville/Western U.S. Power Outage, p. 9.
[35] Cauley, Gerry and Stahlkopf, Karl, "Technical Issues Raised by the Western System Outages of July 2 and August 10, 1996, EPRI

In the wake of the outage, it also became apparent that there was no set of prescribed or *de facto* data standards. This lack of standardization made the job of investigators even more cumbersome as they attempted to gather, assimilate, and coordinate all of the event data that was recorded.

IV. VALUJET FLIGHT 592 CRASH

Perhaps no event can make us pause, take stock, and question, are we doing enough to ensure safety like a plane crash. Unfortunately, in 1996, this question was asked more than once, and the answer in the wake of the ValuJet crash, was no.

IV.1 DESCRIPTION OF THE EVENT

On May 11, 1996, Flight 592, a ValuJet DC-9, crashed into the Florida everglades shortly after takeoff from Miami International Airport. All 110 passengers and crew on board perished. According to Jim Hall, Chairman of the National Transportation Safety Board (NTSB), "about 5 minutes after takeoff, the crew of Flight 592 decided to return to Miami after hearing a noise and reporting smoke in the cabin to air traffic controllers.[36]" The plane plunged nose first into the Everglades, creating an enormous crater.

IV.2 CAUSE OF THE EVENT

Background

Just like the other industries profiled in this study, the completely regulated airline industry underwent great change as it was deregulated over the past two decades. When airlines were regulated, flying was cheaper because the airlines were guaranteed a stable profit—profits they could roll over and use to invest in newer generation aircraft and technology. In the now deregulated marketplace, profits are maximized through cost-cutting measures while deregulation was not intended to adversely affect safety or training, pressures to be competitive in this marketplace have placed a strain on these areas.

The Department of Transportation (DOT), the National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA) all provide an important role in ensuring safety and promoting air travel. The NTSB makes safety recommendations to the FAA as a result of its investigations; however, the FAA is not mandated to accept or implement any of these recommendations. This flaw in the system often puts the FAA in a difficult position, promoting the airlines use (i.e., helping to keep consumer prices low) while attempting to ensure safety. Too often, critics state, the FAA takes the side of the airlines, and does not require safety measures that could save lives. Notably, this includes the FAA's rejection of the NTSB's 1988 recommendation to install fire detectors and fire suppression systems in cargo holds which would have likely averted the ValuJet crash.

ValuJet burst onto the public scene in 1993, offering low-fare, no-frills, short-haul passenger air service. At the time of the crash, its stock had increased sixfold and ValuJet had established itself

[36] Testimony of Jim Hall, Chairman National Transportation Safety Board, before the Committee on Transportation and Infrastructure, Subcommittee on Aviation, House of Representatives, Regarding Issues Raised by the Crash of ValuJet Flight 592, June 25, 1996.

as the most profitable airline in the U.S.[37] ValuJet was able to be profitable, due mainly to their simple operation strategy.

New Economic Model

ValuJet's simple operating strategy was based on the following elements:[38]

- Low cost structure, including low-cost aircraft acquisition, selective outsourcing of maintenance and training; generally a non-union workforce with a flexible wage structure for salaried employees based upon Company profitability and performance; and utilization of proprietary technology, like its customer-direct ticketless reservation system, to minimize operating and administrative costs.
- Labor advantage, providing incentives to relatively low base waged employees, including bonuses and stock options, tied to company performance and profits.
- Targeted fleet acquisition of low cost and complementary aircraft, which provided commonality of parts and training.
- Simplified products and distribution, of single class, no-frills, non-refundable ticketless service that reduced administrative costs, provided real time performance data, and provided a substantial database containing customer information. Additionally, the promotion of its 1-800 line for direct reservations, eliminated the cost of participating in computerized reservation systems and the Airline Reporting Corporation.
- Low fare structure, targeted at leisure and cost conscious business travelers who might otherwise use ground transportation and walk-up business, avoiding direct competition with existing carriers.

By following this simple operating strategy, ValuJet had been able to amass large profits, but industry analysts warned that the cost of these profits might be safety—and unfortunately, they were right.

Causes of the Crash

According to what investigators were able to determine, the forward cargo hold of ValuJet Flight 592 was packed with over 100 oxygen generators. Although labeled empty on the shipping documents, at least some of the canisters were not, and none were equipped with safety caps. SabreTech Inc., one of ValuJet's maintenance contractors, admitted that two of its employees had failed to attach safety caps for shipping and falsified paperwork indicating that the shipping caps had been attach in place.

In addition to the physical cause of the accident, there were many underlying forces that contributed to this accident. As alluded to earlier, not implementing the NTSB's 1988 recommendation to install fire detection equipment is only part of the story. While outsourcing

[37] Frank, Allen Dodds, "Safety Issues May Hurt No-Frills Airlines-Discount Carriers Have to Prove their Reliability to Continue Profits," CNN, May 13, 1996.
[38] ValuJet Prospectus, filed with the Securities and Exchange Commission, October 12, 1996.

in and of itself is not unsafe, airline safety requires strong communications and accountability among all groups responsible for the various aspects of safety. Coordinated communications are often difficult to achieve within a single organization, and can be nearly impossible across disparate groups of contractors, especially if no one central figure is charged with integration. It was clear during the post-crash investigations that critical communication was lacking.

Criticism of the FAA's role in being the accountability arm of this equation has been on the rise since 1993. Former Inspector General Mary Schiavo held a meeting with the FAA in February 1996 to address critical safety issues with ValuJet. At the time of the accident, ValuJet's accident record was 14 times higher than American or United airlines.[39]

Today's low fare airlines compete by offering discounted fares. However, safety is not cheap and evidence is growing that the pressures of competition might be affecting even the regulated portions of this industry—safety and training. ValuJet employed a fleet of older aircraft (averaging 26 years) versus the industry's standard of 15 years. As pressures to compete continue, even the established airlines like Northwest, TWA, and USAirways are squeezing more years of service out their fleets.

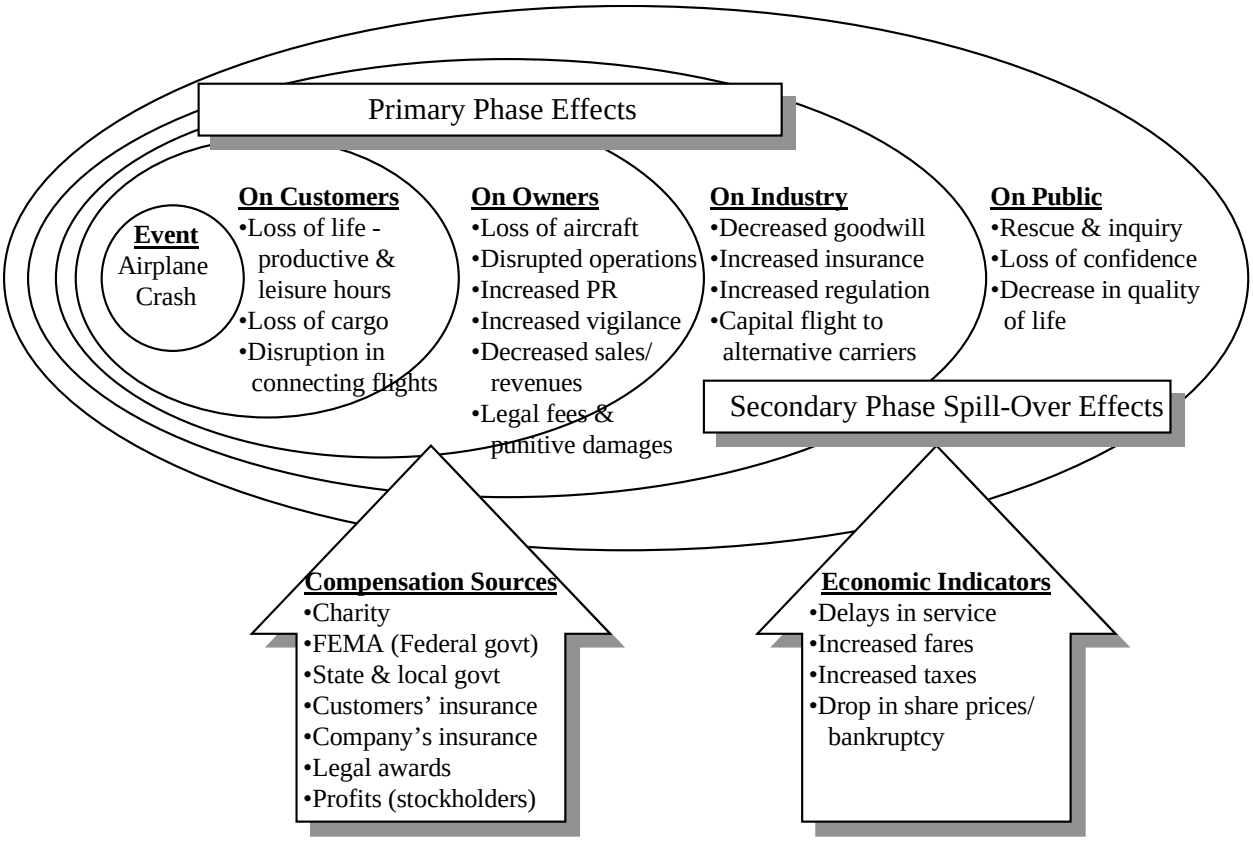
Airline Management and Corporate Culture

ValuJet's corporate culture has been likened to that at NASA, prior to the launch of the Challenger. There was tremendous pressure to "tow the company line." Bad news of any kind could have had a disastrous affect on the company's astounding financial performance by making market analysts worried. Because ValuJet rewarded its employees with bonuses and incentives based on profits and company performance, there was little tolerance for dissent. And with profits so high, the costs associated with safety were sacrificed. Flight attendants were hired through temp agencies; hiring was done by outsiders, and maintenance was outsourced. Even with the FAA raising concerns about its safety record prior to the May 11 accident, ValuJet's overwhelming success as a start-up, low-fare airline made all involved slow to act.

Total Cost to Date of the Crash

Exhibit III-1 presents the cost and impact profile for the ValuJet crash. Based on this study's conservative estimates, the ValuJet crash has cost over *$2 billion* to date. Because of the relatively recent nature of this event, the long-term effects (or spill-over costs) of pending litigation and other industry-related mandates on ValuJet, and the airline industry as a whole, the total cost of this plane crash can not be, at this time, accurately determined.

[39] Fumento, Michael, "Frederico Peen: The Teflon Cabinet Official," February 19, 1997.



Event	Customers	Owners	Industry	Public
Flight 592 Crash	~$220-550M[a]	>$550M[b]	>$350M[c]	>$400M[d]

[a] Losses to ValuJet include $400M for the aircraft, plus *annual* lost revenues of $150M.

[b] In 1988 the FAA estimated that legislation requiring smoke detectors to be installed in airplane cargo holds would cost $350M. Although not yet enacted, similar legislation is likely to occur from the ValuJet incident. The total dollar amount will depend upon the extent to which new and/or more stringently enforced regulation are absorbed or passed on to customers.

[c] Public costs include both increases in fares (i.e., those directly passed on to the public) or increased in taxes (i.e., those costs subsidized by government). In 1996 Congress appropriated over $400M for security-related enhancements, including explosive detection technology, which is likely the tip of the iceberg.

Exhibit IV-1: Airline Crash Disaster Profile

IV.3 LOSSES TO THE CUSTOMER

One hundred and ten people perished on May 11, 1996 in the ValuJet Flight 592 crash. Putting a value on these lives is difficult but there are formulas that the insurance industry has applied. To date, this has not yet occurred as litigation regarding the crash is still pending. How much ValuJet finally pays out in settlement costs will be determined by the ages and the occupations of each of the passengers who died, expert say. For example, the family of the San Diego Charger

running back who was onboard Flight 592 could be paid tens of millions of dollars based on his potential earnings. Every airline is required to carry liability insurance of at least $600 million per event—ValuJet's liability coverage was $750 million. Most individual claims will be settled for between $2-5 million, making the range $220-550 million in compensation to family members.

Other customers who held reservations with ValuJet had to make alternative arrangements with other airlines. While ValuJet did rebate these customers, those that went to alternative airlines had to pay the delta between ValuJet's average ticket price of only $72.75 and walk-up and last minute fares that could be in the range of $150-$1500 per passenger, per ticket.

IV.4 LOSSES TO THE OWNER

Stockholders saw their profits dwindle. In the period April-June 1995, profits were $16.9 million, or 28 cents a share, compared to the same period in 1996, where stocks were valued at 10 cents. On May 18, 1996, ValuJet was the most actively traded issue on the Nasdaq market, with more than 23 million shares traded, a 10 fold increase in volume.[40] By May 21, ValuJet stock had lost 39 percent drop from its $17.88 price on May 10, 1996, one day before the crash.[41]

ValuJet, since its first public stock offering in 1994 had increased a remarkable 784 percent in its first 16 months, making it the most successful start-up, low fair airline of all time.[42] In 1995 alone, ValuJet saw its profits triple to $68 million while their revenues soared to $368 million. By March 31, 1996, ValuJet was operating 47 aircraft and providing 286 daily flights.[43] But on June 30, 1996, after the fatal crash on May 11th and a suspension of service order on June 17, 1996, the economic demise had begun to occur. (See Table IV-1.) The carrier had $207 million cash-on-hand, $185 million in working capital, a current assets to current liability ratio of 2.7 to 1, total assets of $521.5 million, and retained earnings and stockholders' equity of $88.6 million and $165.4 million, respectively.[44] ValuJet paid the FAA $2 million to compensate for the costs of the special inspections conducted. To reduce costs during this period of suspension, ValuJet furloughed more than 90 percent of its personnel (Approximately 3,600 of 4,000 employees). While the FAA approved resumption of service by September 30, 1996, the losses suffered by ValuJet were significant.

Table IV-1
ValuJet's Economic Performance Changes Drastically After the Crash

Period ending Date	Operating Income (millions)	Net Income in millions	Revenues in millions
31 Dec 1995	$ 107.7	$ 67.7	$ 367.7
30 June 1996	$ (8.7)	$ 1.1	$ 191.0

[40] Pilgrim, Kitty, "ValuJet Shares Plunge-Carrier Works to Stave Off Bankruptcy," CNN, June 18, 1996.
[41] "ValuJet Co-Founder Sells 1.5 Million Shares, CNN, May 21, 1996.
[42] Namie, Gary, "Lessons Form the ValuJet Crash," 1996.
[43] Data found in the Financial Position section of FAA filing order 96-8-45.
[44] *Ibid*.

Table IV-2 illustrates additional data that supports the economic ramifications associated with the May 11, 1996 crash. According to the consolidated unaudited statement of operations filed with the Securities and Exchange Commission for the period ending September 30, 1996, ValuJet reported the following:[45]

Table IV-2
ValuJet's Reporting Earning/Losses as of September 30, 1996

	Three months ending 9/30/1995	Three months ending 9/30/1996	Delta
Total Operating Revenues	$ 109,295,882	$ 310,919	$ (108,984,963)
Total Operating Expenses	$ 72,624,306	$ 30,257,322	$ (42,366,984)
Total Other Expenses (income) net	$ 654,275	$ 4,923,421	$ 4,269,146
Net Income (loss)	$ 22,661,139	$ (21,944,824)	$ (44,605,963)
Net Income (loss) per share	$ 0.38	$ (0.40)	$(0.78)

According to ValuJet, other effects of the accident included:

- ValuJet sold off or leased a large portion of its fleet to reduce operating expenses;
- ValuJet had to refund fares paid by customers affected by the airline's shutdown and those whom opted for other travel plans;
- ValuJet laid-off or furloughed most of its employees and could not guarantee future employment because of the its uncertainty about reestablishing previous service levels;
- ValuJet was unable to meet certain financial covenants under certain of the Company's secured debts;
- The expansion of ValuJet's operations will be subject to FAA and Department of Transportation approval for an indefinite period of time; and
- ValuJet's inability to predict how the accident would affect load factors and yield;

For the period ending December 31, 1996, ValuJet's flight operations expenses were higher, due to the extended period of time that the Company's operations were suspended, additional training costs incurred at the restart, and changes to the Company's compensation structure to reduce the percentage of compensation represented by bonuses. Flight attendants salary levels were adjusted upward and the regular quarterly bonus portion of their compensations was eliminated. The cost of hull insurance also increased substantially on October 1, 1996. Additionally, the airlines maintenance costs were higher, again due to the suspension of operations. These cost included storage fees for aircraft not being utilized in the suspension period. Advertising cost

[45] Form 10-Q for ValuJet, Inc., filed on 1996-11-14, Securities and Exchange Commission.

were also higher, attributed to the resumption of operations being spread over a reduced revenue base caused by lower service levels and load factors. ValuJet placed a value related to the shutdown and other nonrecurring expenses at $67,994,000.

The DC-9 lost in the Everglades was insured for $4 million, more than its book value. In addition, ValuJet liability insurance for an accident is $750 million, which is anticipated to be enough to cover all claims from the accident, although at this time, it is impossible to say for certain. In addition to the claims brought forth by victims families, other lawsuits against ValuJet are pending, including some brought against the company by shareholders, who claimed to be misled by ValuJet.

While every airline crash investigation has its own unique characteristics, the ValuJet crash was followed by an unprecedented month-long recovery effort to locate victims and aircraft parts. The NTSB investigation was complicated by the extremely hot temperatures and the fragile environment of the Everglades. According to the NTSB, the ValuJet investigation was the most challenging on scene investigation in its history. NTSB spokespeople had to convey the destruction of the impact, the remoteness of the site, and the difficulty of the recovery to family members.[46] Highlighting the need for a single source of data at such a highly emotional time for family's, Congress passed the Aviation Family Disaster Act of 1996 giving the NTSB the responsibility for aiding families of aircraft accident victims and coordinating the federal response to major domestic aviation accidents.

The FAA, which stepped up its investigations of the airline in the wake of the May 11 tragedy, listed 34 different problems found with the carrier, including work signed off but not performed and safety problems discovered but not fixed. That led the FAA to allege 14 specific violations related to inspection, maintenance and recordkeeping. These finding caused the FAA to shut down ValuJet.

IV.5 LOSSES TO THE INDUSTRY

Fatal accidents in commercial aviation in the US is less than .3 per million departures. "The infrequency of commercial aviation accidents has complicated the response to such disasters. For example, when TWA Flight 800 crashed on July 17, 1996, it had been over twenty years since that airline's last fatal accident. Most crashes overwhelm state and local response teams, and take a tremendous toll on airline employees, who must immediately begin addressing the concerns of family members at the same time that they are coping with the loss of their own colleagues."[47] The ValuJet and the TWA crashes forced the industry to look carefully at their media relations and their ability to respond compassionately to distressed consumers.

While ValuJet's stock values plummet, other major carriers stock performed better, indicating that the public's faith was being placed in the more established airlines with strong safety records. Yet, much of these profits had to be rolled over into stepped up marketing campaigns to

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[46] Testimony of Jim Hall, Chairman National Transportation Safety Board, before the Committee on Transportation and Infrastructure, Subcommittee on Aviation, House of Representatives, Regarding the Treatment of Families After Airline Accidents, June 19, 1996.
[47] *Ibid*.

distinguish other low-cost airlines from ValuJet. For example, Southwest Airlines, whose safety record is one of the best in the industry, found themselves defending their record and making the distinction between low-cost and safety. Kiwi Airlines, which in the immediate wake of the ValuJet crash, saw increased sales, ultimately lost a great deal. Primarily due to the increased media focus on low-cost airlines, Kiwi's safety record was scrutinized by the public press and the FAA. Today, Kiwi International is virtually out of business, operating just a fraction of its former routes.

McDonnell Douglas, the manufacturer of the doomed aircraft also suffered, as most aircraft manufacturers do in the wake of a crash and in the ensuing investigation. For example, prior to the crash, ValuJet had planned to purchase 50 new aircraft from McDonnell Douglas for $1 billion. This plan was put in peril by the accident. While McDonnell Douglas was still trying to avert having the deal voided by offering financing assistance late last year, it appears unlikely that ValuJet will be able to live up to the original terms of the agreement.

Contract Maintenance/Outsourcing

The White House Commission on Aviation Safety and Security found that outsourcing, in and of itself, is not a problem if performed by qualified, and FAA certified companies.[48] Still, outsourcing, in this case, and in general terms, has been the found to be a contributing factor, if not a cause in other major accidents and incidents reported by the NTSB and FAA.

In 1988, a similar accident involving undeclared and improperly packaged hazardous materials inside the fiber drums. During a flight to Nashville, TN, smoke was detected in the passenger cabin and the floor above the cargo compartment was hot and soft. Flight attendants moved, passengers away from the affected area, the aircraft landed safely, and the passengers were evacuated. After this incident, the NTSB recommended that the FAA require:

- Fire detection systems
- Fire extinguishing systems
- Better fire blocking materials in cargo compartments

The FAA rejected these recommendations, saying that its $350 million cost was too much for the airline industry.[49] On May 31, 1996, NTSB again found themselves issuing urgent safety recommendations that the FAA prohibit the transportation of oxidizers and oxidizing materials in cargo compartment that do not have fire or smoke detection systems.[50]

In the wake of the accident, long-time FAA administrator Anthony J. Broderick, associate administrator for regulation and certification, took an early retirement, rather than being asked to leave his post. FAA Administrator David Hinson acknowledged bearing some responsibility for

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[48] *Ibid.*
[49] "FAA Said to Refuse to Release Airline Safety Rankings," Reuters, March 25, 1997.
[50] Testimony of Jim Hall, Chairman National Transportation Safety Board, before the Committee on Transportation and Infrastructure, Subcommittee on Aviation, House of Representatives, Regarding Issues Raised by the Crash of ValuJet Flight 592, June 25, 1996.

the accident and stated that the "FAA did not accurately judge the airworthiness of ValuJet before the crash.[51]"

As early as 1976, after a crash of a DC-6 in Van Nuys, CA, the NTSB was urging the FAA to "remind airlines of their responsibility for ensuring the adequacy of the maintenance of their aircraft and components, even if the maintenance is contracted to outside repair stations.[52]" The NTSB also recommended that the FAA review its surveillance procedures for certified repair stations. This review was urged to ensure these facilities were following proper maintenance manuals. Again, in 1982 after the Air Florida crash into the 14th Street Bridge in Washington, D.C., the NTSB found that there was not sufficient communications between the airline and the maintenance contractor, specifically about de-icing 737s.

"The ValuJet tragedy has shone a spotlight on an evolution that has occurred in segments of the airline industry. The Board has traditionally been expressing its concerns about airlines carrying our their own maintenance programs properly. Now, we are looking at what some have dubbed a "virtual airline"—one that provides transportation but conducts none of its own maintenance or training.[53]"

IV.6 LOSSES TO THE PUBLIC

Commercial aviation generates over 300 billion annually, and accounts for close to 100 million American jobs.[54] According to then Secretary of Transportation, Frederico Pena in 1995, "start-up airlines were providing tremendous savings to the American public—indeed $ 6.3 billion over the last year.[55]" However, in the face of devastating accidents like ValuJet's, and serious questions about the airworthiness of other low fare airlines like Kiwi, the public's confidence in air travel is shaken. This lack of confidence causes some degree of flight from the industry to alternative, "safer" modes of transportation.

The lack of confidence also manifest itself in calls for more stringent controls for the industry. In its final report, the White House Commission on Aviation Safety and Security urged government and industry cooperation, communications and partnership. Additionally, it urged performance monitoring and measurement as key ways to ensure that its recommendations for change are implemented.[56] In 1996 alone, several major pieces of legislation were enacted that change the airline industry. More legislation is pending. Some of this legislation will result in increased security measures that will ultimately increase the price of an airline ticket and increase the amount of time a traveler will need to devote to airline travel (i.e., getting to the airport a half hour earlier than required before). These additional security related procedures are not without a price tag. In 1996, Congress appropriated over $400 million for security-related enhancements, including explosive detection technology.[57]

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[51] Meckler, Laura, "Under Fire For ValuJet Crash, FAA Announces Big Shakeup," Associated Press, June 18, 1996.
[52] *Ibid.*
[53] *Ibid.*
[54] White House Commission on Aviation Safety and Security, "Final Report to President Clinton, 12 February 1997.
[55] Fumento, Michael, "Frederico Pena: The Teflon Cabinet Official," February 19, 1997
[56] *Ibid.*
[57] *Ibid.*

Still, there is a price to pay for safety, whether in time or in additional cost, and in general, Americans are willing to pay the price rather than facing the consequences of not. While we gamble, we want the odds to be stacked in our favor.

V. SEPTEMBER 1991 AT&T NETWORK OUTAGE

Ironically, it took a disaster to launch the telephone's popularity and place in American society. In 1878, a train crashed in Tarriffville, CT. Forward-looking doctors in nearby Hartford had had Alexander Graham Bell's "speaking telephone" installed. A local druggist who learned of the crash telephoned the entire community of doctors, who rushed to the scene and administered aid. This event, as all disasters do, garnered the attention of newspaper journalist, and the positive coverage of the telephone's usefulness made it famous—an item everyone had to have.

Since the late nineteenth century, Americans have relied on the telephone as a convenient and accessible means of communications. Just as we rely on telephones being available (whether private or public), we rely on their performance. However, during the latter part of the 1980s and the beginning part of this decade, the telecommunications industry, and AT&T in particular, experienced a rash of outages. For this study, the September 17, 1991 outage was selected, not because it was the longest outage, or the largest, but because of its impact to another critical infrastructure sector, transportation.

V.1 DESCRIPTION OF THE EVENT

Similar to the Western power outage described in earlier, this event was precipitated on a warmer than usual day in the New York metropolitan area. For days such as this when power consumption loads are heavier than normal, AT&T and New York's Consolidated Edison Power Company had negotiated a power sharing agreement that basically states that AT&T will use its own power when Consolidated Edison's facilities are heavily loaded. Power sharing agreements such as these are commonplace and the transition from commercial power to AT&T's internally-generated power was considered routine.

At approximately 10 a.m. on September 17, 1991, at an AT&T switching center in lower Manhattan, AT&T switched to its own power. However, critical power rectifiers (devices that change AC power to DC power) failed. Power was provided by a battery back-up system which was designed to operate for six hours. Alarms that were intended to inform technicians that the power system was functioning on back-up battery had been manually disabled and failed to work.

At approximately 4:30 p.m., the shift back to commercial power was attempted and failed because of the same critical power rectifier failure that had gone undetected in the morning hours. The back-up batteries expired and all telephone transmission systems in the facility shut down and voice and data communications controlled by the facility failed. This included air traffic control communications in the New York metropolitan area.

It took AT&T approximately 8 hours to restore service to its entire customer base. In the ensuing 8 hours of the failure, it was estimated that over 5 million calls were blocked.

V.2 CAUSE OF THE EVENT

Background

The telecommunications industry has undergone drastic changes in the past two decades. Through the landmark 1984 restructuring of or divestiture of the Bell System (Ma Bell), the

industry has seen the telecommunications market expand and grow. The introduction of emerging technologies such as fiber optics, cellular communication and now, information technology and information management systems has helped change the telecommunications industry. AT&T operates a large, switched network providing long-distance service to residential and business customers. This network is controlled by customizable software to provide a wide-range of services. Considerable redundancy is built into the AT&T network as a means of achieving reliable service. The growing reliance on computerized programs and computer equipment has removed some of the human element involved in providing telecommunications services. Gone are the days of party lines and local operators that direct calls via switchboards. Still, human error was blamed for the outage on September 17, 1991.

Investigation of the Event

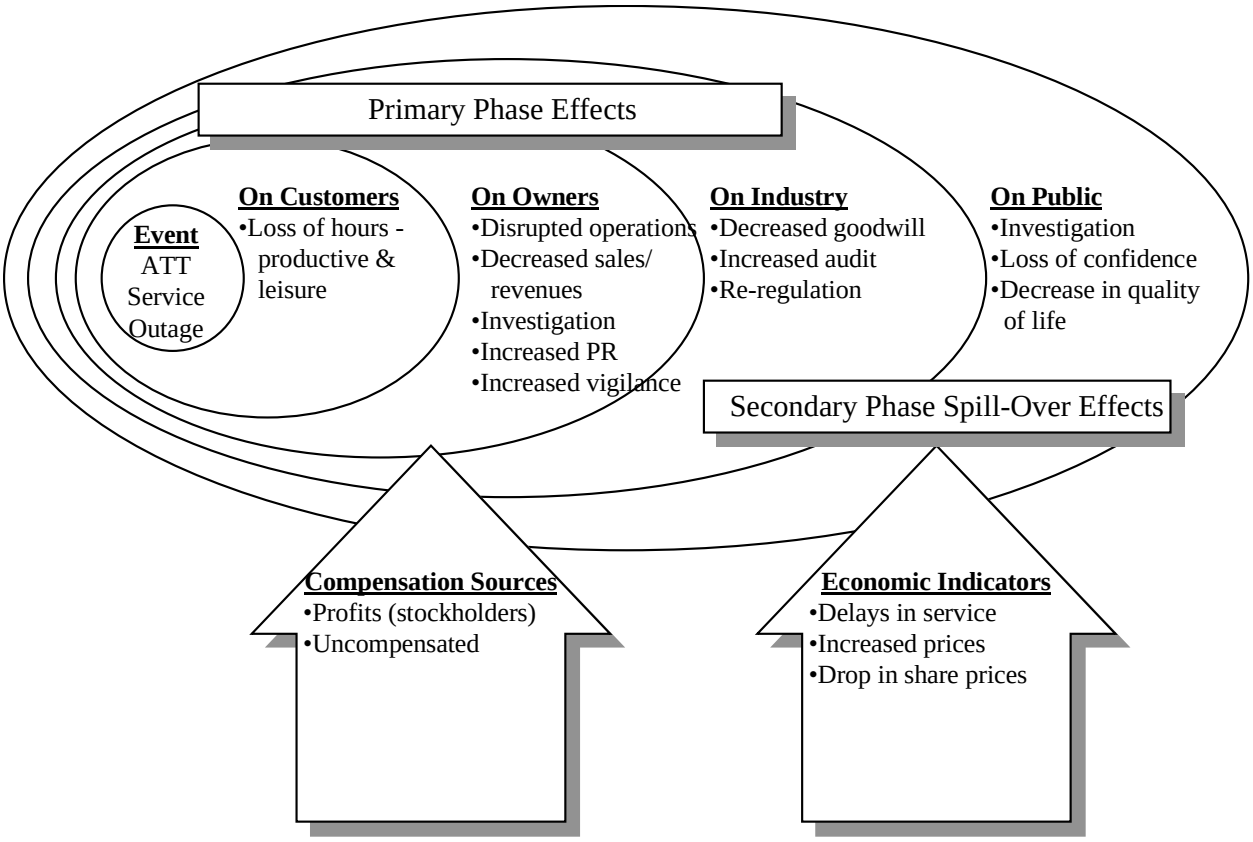
Based on an internal investigation by AT&T, the September 1991 outage had a strong human component, vice any systemic or fundamental failure of the network's components. According to AT&T's senior vice president-network services, Kenneth L. Garrett, the problem resulted when failures of some power equipment and alarm systems went undetected. This was attributed to a supervisor failing to follow company procedures and physically inspect each of the building's power plants to insure that they are working properly during a conversion from commercial to emergency diesel generator power. Additionally, the alarm bells that should have warned technician that there were equipment failures had been manually deactivated. Had the alarms been armed or had such an inspection occurred, the equipment failures would have been discovered and the service disruption averted.[58]

Because this network failure affected so many people and adversely affected air travel, the press devoted attention to the event, as did state and federal regulators and Congress. Industry experts were publicly asking if AT&T was asleep at the wheel.

Total Cost to Date of the Outage

Exhibit V-1 presents the cost and impact profile for the AT&T network failure. Based on this study's estimates, the AT&T network failure cost *hundreds of millions of dollars* yet resulted in improved services to the general public.

[58] AT&T News Release, September 30, 1991.



Event	Customers	Owners	Industry	Public
East. Seaboard	~$100s M[a]	>$1M[b]	See below[c]	Better service[d]

[a] Because of the difficulty in estimating the numbers of individuals and business affected by the outage, revenues foregone are conservatively estimated in the hundreds of millions.

[b] Actual costs are likely to be much higher since AT&T (as well as other companies) undertook extensive modernization programs to ensure increased network reliability.

[c] Exact costs to the telecommunications industry are not yet determined, but include substantial administrative costs from new FCC regulations and investigations. For example, in 1992 the FCC imposed new regulations requiring all telecommunications companies to report outages (type and cause) over a certain threshold.

[d] The general public is better off as a result of the massive improvements and modernization initiatives undertaken by AT&T and other telecommunications providers.

Exhibit V-1: AT&T Network Service Failure Profile

V.3 LOSSES TO THE CUSTOMER

Air Travelers

Consumers, especially air travelers, lost on September 17, 1991. These 85,000 stranded passengers in New York and New Jersey could not even notify loved ones or business associates of their delays because the telephones were down, frustrating and infuriating even the calmest of in the crowd. (One of these 85,000 passengers happened to be the FCC Chairman.)

AT&T network failure disrupted FAA voice and data communications serving air route traffic control centers in the Northeast U.S. The FAA leased private lines from AT&T to interconnect airports with the New York Air Traffic Control Center in Ronkonkoma, Long Island. This center handled all airline flights within a 200 mile radius of New York, and was linked by telephone lines to radio transmitters, which relay instructions and final approach procedures to pilots in the air.

According to the Common Carrier Bureau, the Ronkonkoma center lost 84.2% of its primary radar sites, 84% of its radio channels, 86.8% of its telephone lines, and 58.8% of its computer links to Westbury, Boston, and Washington, D.C. Controller-to-controller links were cut 85.7%, and radar data lost 53.3% of its computers, a partial back-up system lost 62.5% of its telephone line and 55.5% of its emergency sites.[59]

The Ronkonkoma center lost power at 4:35 p.m. and FAA immediately issued "ground stop programs" throughout the nation for planes bound for the New York area, either diverting the planes or landing them through the limited available channels.

Three New York/ New Jersey area airports, LaGuardia, Kennedy, and Newark, closed for several hours, air traffic at Boston and Washington's National airports were severely disrupted, and delays occurred nationwide. Over 1,100 flights were directly affected. The FAA estimated that the air traffic service disruption in New York resulted in 516 aircraft delays, with an additional 119 delays of flights en route to New York occurring at other airports. The Air Transport Association determined flight delays to total 688 hours.[60] There were also 658 flights that had to be canceled because of the outage.[61] Table V-1 estimated the cost to air travelers, based on delay cost data from the FAA.

Table V-1
Estimated Cost to Air Travelers Based on AT&T Network Failure

	Number Affected	Total Hours of Delay Time	Average Delay Per Person	Average Delay Cost Per Hour*	Total Cost Impact to Travelers
Passengers	85,000	688	1.2 hours	$42	$4,760,000**

Table V-2 presents an estimate of the cost to the airline industry for this 8 hour disruption, which rippled through to Washington, D.C. and Boston, and still was not resolve until late the next day

[59] "Report by the Common Carrier Bureau on the January 4, 1991 AT&T Network Disruption", given before the Subcommittee on Telecommunications and Finance, Committee on Energy and Commerce, U.S. House of Representatives, October 1, 1991, April 7, and May 13, 1992
[60] Lavitt, Michael, "AT&T Switching Station Power Failure Wreaks Havoc with NY Area Traffic", Aviation Week and Space Technology, Sept. 23, 1991
[61] Statement of Norbert A. Owens, Deputy Associate Administrator for Air Traffic, Federal Aviation Administration, Before the Subcommittee on Telecommunications and Finance, Committee on Energy and Commerce, U.S. House of Representatives, October 1, 1991, April 7, and May 13, 1992

(Airlines had to reroute traffic and move planes around because they had not arrived at their destinations the night before).

Table V-2
Cost Estimates for Air Traffic Disruptions

Number of Flights Affected	Total Number of Hours Telephone Service Out	Average Cost Per Hour Per Delay/Cancellation*	Financial Impact
635 delayed	~ 8	$1,570	$ 1,033,060
658 canceled	~ 8	$ 1-2 million[62]	$8-16,000,000
Total 1,298 Flights	~ 8		$9-17,000,000

Cost Impact to Other Operating Businesses

While area airports were most affected, many large New York businesses faired better. Corporations and brokerage houses which depend heavily on long-distance and voice transmission had backup plans in place that provided at least some network redundancy.[63] And since the outage occurred after the formal close on Wall Street, the impact was not as great as it could have been. It has been estimated that the value of telephone transactions that take place daily on Wall Street exceed one trillion dollars.[64]

According to Contingency Planning Resource, many types of businesses are negatively affected when service, such as telecommunications or a power failure occurs. Table V-3 summarizes average cost per business per hour. These figures begin to give us a glimpse of what other industries might have lost as a result of this outage.

Table V-3
Business Losses Due to Service Disruptions

Business Type	Financial Impact of System Failure Per Hour
Brokerage Operations Finance	$ 5,600,000—7,300,000
Credit Card/Sales Authorization Finance	$ 2,200,000—3,100,000
Pay-Per-View Media	$ 67,000—233, 000
Home-Shopping (TV) Retail	$ 87,000—140,000

Business Type	Financial Impact of System Failure

[62] "Information Superhighway--An Overview of Technology Challenges," Report to the Congress, United Stated General Accounting Office, January 23, 1995, p. 17.
[63] Lavitt, Michael O. "FAA Planning Lapses Linked to AT&T-Caused Flight Delays", Aviation Week & Space Technology, January 13, 1992, p. 52
[64] "Information Superhighway--An Overview of Technology Challenges," Report to the Congress, United Stated General Accounting Office, January 23, 1995.

	Per Hour
Catalog Sales	$ 60,000—120,000
Airline Reservations	$ 67,000—112,000
Tele-Ticket Sales	$ 56,000—82,000
Package Shipping	$ 24,500—32,000
ATM Fees	$ 12,000—17,000

V.4 LOSSES TO THE OWNER

Perhaps AT&T's Chairman, Robert E. Allen, stated it best in a letter he prepared to the 272,000 AT&T employees in the wake of the September 17, 1991 network failure event.

> Clearly, communications has become so critical an element to the functioning of society and the economy, as well as to the assurance of public safety, that any breakdown at all has serious consequences for someone, somewhere. Disruptions to service are not new. But, now that modern technology lets our systems carry such high volumes of calls and because people are so dependent on communications, a communications problem today affects far more people and many more activities than ever before. In short, service reliability has never been more important.

In addition to losing customer confidence, the outage had significant economic ramifications. As summarized in Table V-4, AT&T lost an estimated three quarters of a million dollars of revenues from calls in that 8 hour period.

Table V-4
Lost Revenue From Blocked Calls

	Calls Blocked	Calls Blocked Adjusted for Retries[65]	Revenue* Adjusted to Account for Retries
International	471,000	287,310	$68,954.40
Domestic	4,556,000	2,779,160	$666,998.40
Operation Services	155,000	94,550	$22,692.00
Total	5,182,000	3,161,020	$758,644.80

* Lost Revenue assumes an average revenue per long distance call of $.06 per minute where average length of call is 4 minutes indicating $.24 of revenue per call.

Even prior to the September 17, 1991 failure, AT&T had embarked on a $150 million effort to replace all older power plants, including those in the New York region by year's end. As a direct result of the failure, AT&T conducted a thorough check of all alarm systems and procedures at all critical office and at all other locations with the same power plant configuration as the

[65] The January 4, 1991 outage reported that about 39% of the calls blocked represented retries.????

affected switching center in lower Manhattan. Additionally, AT&T intensified employee training to ensure that all employees understand how to respond to alarms and that they closely follow company procedures was embarked as an immediate consequence of this network failure.

This event, on the heels of several other major telecommunications service disruptions in the industry focused the nation's attention on the issue of reliability of today's, and tomorrow's, telecommunications networks.

When AT&T experienced a failure on January 15, 1990, it was clearly an embarrassment to the company. Within days of the service interruption, AT&T's CEO Robert Allen officially apologized in full page ads in major newspapers across the nation. In his letter, Allen said,

> "AT&T had a major service disruption last Monday. We didn't live up to our own standards of quality, and we didn't live up to yours. It's as simple as that. And that's not acceptable to us. Or to you. We understand how much people have come to depend upon AT&T service, so our AT&T Bell Laboratories scientists and our network engineers are doing everything possible to guard against a recurrence. We know there's no way to make up for the inconvenience this problem may have caused you."

After this event, AT&T announced their plan to offer a rebate of service on Valentine's Day to make up for the loss during the January 15, 1990 failure.

Not missing the opportunity to turn this event towards competitive advantage, rival MCI took out full page advertisement in New York offering their own long distance services for the "next time that AT&T goes down." The offering did entice some, and to this day, AT&T continues advertising campaigns luring customers back.

In the wake of the September 17, 1991 network failure, Allen again used the a media campaign to express his regret and his commitment to management practices, that should have ensured that AT&T systems worked reliably. This time; however, he fell short of offering any rebates to affected customers.

The AT&T outage sparked renewed concerned and surprise that the FAA relied solely on one carrier. The FAA did not have a private back-up system outside the public switched network and did not have redundant, alternative facilities or a dedicated and secure primary or back-up systems. Largely as a result of the September 17, 1991 incident, AT&T lost its sole source contract with the FAA. The GSA approved the installation of the Leased Interfacility National Airspace System Communications System (LINCS).[66] With LINCS, backup routes would be available in case of a cable failure and problems at a central office would now affect only one or two radars or radios in that area.

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[66] "Report by the Common Carrier Bureau on the January 4, 1991 AT&T Network Disruption", given before the Subcommittee on Telecommunications and Finance, Committee on Energy and Commerce, U.S. House of Representatives, October 1, 1991, April 7, and May 13, 1992

V.5 LOSSES TO THE INDUSTRY

Recognizing that a catastrophic failure ultimately affects everyone and the common good is best served by cooperation at a time of emergency, the telecommunications industry took a stand. In February 1992, a consortium of about 15 major telecommunications carriers signed an agreement of mutual aid to restore service in the case of "critical disruption to their telecommunications networks supporting the New York City Metropolitan Region." This landmark agreement stipulates the procedure to be followed during a network emergency affecting high-capacity transmission facilities.

Further, as a direct result of the September 17, 1991 outage, the Federal Communications Commission (FCC) established the Network Reliability Council, a federal advisory committee charged with making recommendations aimed at preventing telephone network outages and limiting their impact. Government regulators and legislatures took up the call for increased assurances of reliability.

In February 1992, the FCC adopted rules that required local and long-distance telephone companies to notify FCC within 90 minutes of its onset, any outage that affects at least 50,000 customers and that last 30 minutes or longer. The FCC further required a complete written report on the incident within 30 days. By the end of the year, the FCC had lowered the reporting threshold to 30,000 customers, where it remains today.

V.6 LOSSES TO THE PUBLIC

While the public's confidence in AT&T was definitely challenged, AT&T's long tradition of performance allowed it to weather the "storm" of this failure relatively well. Certainly, AT&T did lose customers to rival long distance companies as a result of the September 17, 1991 failure. Still, on the whole, people did not begin to seek out alternative methods to communicate.

Some will argue that even the Telecommunications Act of 1996 is an indirect result of the failures in the early 1990s. Given the magnitude of the telecommunications industry and its criticality to other infrastructures, the wake up call AT&T received on September 17, 1991 actually has been a gain for the public at large.

Now, the FAA's critical communications have built in redundancies, which help to ensure our safety and provide a greater degree of reliability of service.

VI. CONCLUSIONS

Several common attributes were found among the events examined which have direct applicability to other infrastructures of the U.S. economy, including Banking and Finance.

VI.1 ATTRIBUTES OF THE CONSUMERS

Determination of Responsibility

To begin, when an event appears to be caused by an un-preventable act of God or nature, (e.g., earthquakes, hurricanes, tornadoes, etc.,) it tends to bring out the best in mankind in general, and Americans in particular. The nation responds immediately and charitably, without provocation and without thoughts of requital. (Clearly, hurricane Andrew, last year's floods of the Mississippi River valley, and the recent flooding in North Dakota are evidence of Americans' generosity and compassion.)

But the underlying issue is not preventability; it is *responsibility*. As Americans, we defend greatly the right of individual choice - even if those choices put us in harm's way. (For example, legislation is not enacted to prevent re-building on flood plains even though it would obviously prevent future damage. Likewise, motorcycle helmet laws are being repealed at the state level, contrary to the medical evidence of their value.) However, when an event is perceived to be the consequence of someone's action, America quickly demands restitution.

Public Expectations

Some of this outrage is due to that fact that Americans have grown to have strong expectations of entitlement to superior quality, availability and reliability of products and services. Americans have come to believe that our planes don't crash, our electricity does not falter, and our telephones always ring. Failure in these infrastructures is unacceptable; equivalent to that of a third world nation. Consequently, failure in certain sectors scares us even more because they affect the very foundation of our beliefs and values.

Systemic Failure and the Willingness to Blame "the System"

We also found that the initial event itself does not have to have significant losses and that large losses do not necessarily cause action. (While the "losses" to Rodney King were limited, the ensuing backlash was clearly the result of perceived systemic violations of the Afro-American community's public trust in the nation's law and order system. Conversely, thousands of Americans had died as a result of AIDS, but not until the media highlighted deaths resulting from the systemic failure of the nation's blood supply to remain free from HIV contamination, did significant action occur. Likewise, thousands of Americans were killed annually as the result of drunk drivers, but not until habitual offenders - whom "the system" could not remove - were made visible by MADD's media blitz, did action occur.) By tapping into the this-could-have-been-me nerve of the American public, the media clearly highlights *systemic failure* and helps to flame the

embers of retribution. Once system failure is the product of public perception, political action is demanded and inevitably oversight and reform are mandated.

Additionally, when Americans feel betrayed by "the system" we blame the most convenient constituent, regardless of which component is truly responsible. Because the general public usually has no or limited understanding of the relationships and processes beyond the point-of-sales contact, the public typically holds the point-of-sale provider liable. In addition, public response often holds the entire infrastructure/industry responsible as well - regardless of the consumers assumption of risk. (For example, even though ValuJet's calamity was attributed in part to the outsourced baggage handlers and maintenance providers, ValuJet was held liable in the public's eye, with the responsibility shared across all of the air travel industry - including airports, travel agents, baggage handlers, etc., regardless of their immediate involvement.)

Finally, there is also a growing willingness to blame others in general (re: "the system") regardless of actual fault and the assumption of risk. With the increased lottery mentality associated with legal suits and damage awards, Americans "want their cake and to eat it too" when it comes to bearing the consequences of an event. (While the law suit against McDonalds for serving hot coffee seemed frivolous, the message these legal awards send to providers of services and products do not go without consequence.)

VI.2 ATTRIBUTES OF THE SUPPLIERS

Outsourcing and the Pursuit of Economies of Scale

There are several meaningful changes in the underlying means of providing products and services to the end consumer. For example, technology is providing economies of scale in industries heretofore relatively unaffected by cyber inroads. (For example, data processing at rates unfathomable only decades ago has made for outsourcing to mega-processors a necessity to compete in sectors such as telecommunications and the banking and finance industry). Consequently, concentration among a few major suppliers within a sector has grown, with increasingly extensive, intricate and interdependent relationships among participants being the norm. (Ironically, while much of the Emergency Services infrastructure, i.e., medical, police, fire and rescue services, is being outsourced to reduce costs and increase quality, the increasing numbers of 911 failures and overuse suggests that outsourcing can have severe negative consequences if not managed properly.)

Back-Office Operations and Intra-Sector Dependencies

Not surprisingly, there is also limited appreciation of, or visibility into, the relationships and processes occurring beyond the point-of-sales contact, e.g., the telephone company's routing/switching networks, or the inter-company sales of energy among supposedly "competing" utilities providers. Interestingly, it is not just average citizens who have trouble comprehending the complexity of back-office operations. The heads of many of the point-of-sales services don't fully recognize these relationships either, as demonstrated in the lessons learned by the banking and finance community from the World Trade Center bombing.

System of Systems and Inter-Sector Dependencies

Like the ecology system, the dependencies among sectors and infrastructures are necessary, critical, and oft overlooked as to how delicately balanced. Obviously, the telecommunications infrastructure is highly dependent on electrical power distribution, and a significant portion of gas and oil storage and distribution relies heavily on the transportation infrastructure. But as technological advances, so too do the dependencies on other sectors. For example, one of the largest "victims" of the AT&T network failure was the airline industry, who had to cease operations because control towers could not communicate with each other. The inter-dependencies are highlighted even more when one considers how air travelers could not even call their connections to inform them of their predicament. In these instances, entire infrastructures are the customers of other infrastructures and house the same feelings of strong entitlement to availability and reliability of services as that of individual citizens.

Laissez Faire Policy and Social Responsibility

Additionally, these efficiency-driven vulnerabilities are enhanced in certain sectors by increased deregulation. For example, one can assert that the 1996 summer power outages throughout the Midwest and AT&T's 1-800 network service failure to the Eastern Seaboard were due, in part, to decreased or non-existent government oversight. In some instances, it can be argued that private enterprises are overly concerned with profits and only marginally responsive to their societal responsibilities. Did Exxon feel that the costs of policing their own "licensed" carriers were outside their business responsibilities before the Exxon Valdez accident?

Accelerated Business Cycle and the Pursuit of Profits

As companies attempt to remain competitive in a world of increased globalization and shrinking product life cycles, the enticement to introduce new product/ service offerings, or to implement cost savings measures, before fully considering the possible ramifications is too great to resist. Certainly the unchecked sales of derivatives by Bearing's Hong Kong office in 1996 and AOL's recent "Unlimited Access" debacle indicate that the rush to profits is fraught with peril.

VI.2.1 Increased Infrastructure Vulnerability

The above shifts in the paradigms of business operations result in a net *increased vulnerability* to the overall industry/infrastructure. Ironically, the initial level of vulnerability (due to outsourcing, intra-sector dependencies, reduced regulatory oversight and increased competition), is exacerbated as individual participants invest to harden their *individual* walls and limit their *individual* liability, assuming that others are equally diligent. Consequently, this false sense of total security serves to increase the risk of systemic vulnerability.

VI.2.2 Increased Threat Capability

Technology has not only increased the vulnerability of certain sectors, it has also unwittingly increased the capability of threats to those sectors. For example, the World Wide Web, the development of international standards and protocols, the de-classification of formerly sensitive information, and increased access through the Freedom of Information Act (FOIA) have all combined to equip individuals with intrusive (and destructive) capability beyond their intentions. The ramifications of this power in the hands of a well-funded enterprise with a destructive mission is cause for alarm.

VI.3 TOTAL ECONOMIC IMPACT

This analysis found that an event is extensive in who it affects, costly in its recovery, and permanent in its repercussions. The costs of recovery are momentous, if not unbearable. Although recovery might not be impossible, the cost to do so is so excessive - especially when including the permanent, secondary impacts, such as increased regulation and higher prices and taxes - that it should be avoided as much as possible.

Even in "recovery" success stories, such as the public relations campaign the American Red Cross undertook to recapture the goodwill lost when the nation's blood supply was suspect of contamination by the HIV/AIDS virus, the opportunity costs alone are sufficiently exorbitant to warrant avoidance. The opportunity cost to regain public image is startling, even in non-critical sectors. For example, AOL's share price remains almost 30 percent below its "pre-event" value, despite significant investments in spin control.

But it is more important to recognize that most losses go uncompensated. Even though hundreds of millions of dollars are spent to compensate the hundreds of victims of an airplane tragedy, relatively little is provided as compensation to the millions that are affected by a power outage or loss of telephone service. Insurance does not reimburse for loss of time and that loss is permanent. Albeit of short duration, there is a distinct loss in quality of life and it seems nothing can be done. It is these relatively small, unremunerated losses that are suffered by many which tend to erode most at our overall stand of living.

In no instance - including those events explicitly excluded from detailed investigation - did the cost of prevention come close to approximating the cost of recovery. The cost of recovery (even without the uncompensated losses) is orders of magnitude greater than rudimentary estimates of preventive measures.

VII. RECOMMENDATIONS

The following recommendations are based primarily on the lessons learned in this analysis of "catastrophic events", and secondarily on exposure to issues uncovered in the performance of the U.S. Banking and Finance Infrastructure Security Assessment.

VII.1 DETERMINE APPROPRIATE STANDARD OF DUE CARE

Most companies, regardless of the sector in which they're housed, attempt to manage proactively risk to their enterprises. Unfortunately, they do not always provide sufficient or effective risk mitigating measures. Deficiencies in risk management strategies usually occur because of systemic undervaluation of: the enterprise's vulnerability(s), potential threat(s), or the asset(s) at risk.

VII.1.1 Government Regulated Standards of Due Care

In instances where the assets are considered so valuable to our national fiber, governmental regulation has historically and correctly been implemented to ensure an appropriate *standard of due care* is employed to alleviate risk. For example, air travel is obviously regulated, i.e., the standard of due care is explicitly specified and universally applied to all participants, to ensure the public's safety (i.e., that American lives are protected). Additionally, utility providers have been regulated, in large part, to ensure that uninterrupted availability and reliability of service is not jeopardized. Therefore, in many instances the asset value mandates that government interdiction and oversight be implemented a priori, and not after the asset is lost.

VII.1.2 Industry/Market Standards of Due Care

However, in many instances, the standard of due care is not set by the government, but rather, it is determined by the market forces on, and the (limited) experience of, individual enterprises whose behaviors are witnessed by others. Consequently, industry-wide or market-driven standards are rarely proactive, and are almost always reactive. For example, the World Trade Tower bombing could be classified as a near-miss event from which certain banking and finance providers quickly revised their security position because of previously unrealized vulnerabilities.

Because there is no sanctioned method to pass on information, only the participants directly affected learn from the experience, and no action to shore up vulnerabilities in other sectors takes place. Thus, if standards of due care are self-determined, there is an absolute requirement for effective communication of new/changing threats and heretofore unexamined vulnerabilities *at the infrastructure level*, not just to individual participants.

VII.1.3 Sharing Information on New/Changing Threats

As an analogy, America On Line (AOL) clearly underestimated the external demand (threat) to its existing capacity (vulnerability), and the consequences to its corporate image (value of its goodwill asset). Could they have learned anything from AT&T's

service disruption (due in part to overwhelming demand against underestimated response capacity) to have helped prevent their predicament, had that information been made available?

VII.1.4 Sharing Information on New/Changing Vulnerabilities

The events examined in this study revealed that companies do not ignore risk, but rather they are unaware of the vulnerabilities of their enterprises. ValuJet did not realize how vulnerable they were to the competence of subcontracted/outsourced cargo handlers and maintenance providers. Likewise, the Western power outages could have been prevented had the consortium looked at service provision from a holistic perspective; and thus removed the vulnerability to single point failure and put into place redundancy at the total system (or infrastructure) level.

VII.1.5 Sharing Information on Countermeasures

Obviously, lessons can, and should, be learned from successes and not just failures. Action should occur to make available and fully disseminate to appropriate parties the "best of class" practices, procedures and technologies proven to ensure the avoidance of catastrophic events.

VII.2 ENFORCE THE STANDARDS OF DUE CARE WITH BEHAVIOR-MODIFYING SANCTIONS

On aspect of many corporate risk mitigation strategies is to minimize the firm's legal exposure/liability, with negligence typically determined relative to the standard of due care set by regulation, industry practice, or legal liability (usually determined by precedence in the courts). But if there is no sanction afforded by negligent behavior, then setting standards of due care is useless.

The sanctions associated with ignoring standards of due care vary greatly among sectors. For example, the sanctions applied to ValuJet are severe, especially when viewed against the sanctions utility companies receive when they fail to provide expected service. To overcome the extreme pressure to ignore vulnerabilities and threats in the pursuit of profits and monetary reward is difficult to say the least. Candidate sanctions include holding individual CEOs and stockholders legally liable for corporate violations. Regardless of method, to be effective, standards of due care must also include sufficient sanctions, such that non-compliance will motivate participants to modify their behavior.

APPENDIX A

Telecommunications

- AOL's Unlimited Access Debacle
- AT&T's 1-800 Service Eastern Seaboard Network Failure

Electrical Power Systems

- Summer 1996 Western Power Outages
- 1977 New York City Blackout

Gas and Oil Storage and Distribution

- Exxon Valdez Accident

Transportation

- TWA Flight 800/ValuJet Crashes
- Midwestern Floods
- Drunk Driving Fatalities

Water Supply System

- Midwestern Floods

Emergency Services (Medical, Police, Fire and Rescue)

- HIV/AIDS-Scare in Red Cross Blood Supply
- Rodney King Riots
- Overuse/Failures of 911

Continuity of Government

- Unabomber/U.S. Postal System
- Oklahoma City Bombing

APPENDIX B

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