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WHAT IS THE IMPACT TO NATIONAL SECURITY WITHOUT COMMERCIAL SPACE APPLICATIONS?

by

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ABSTRACT

The United States is growing more and more economically dependent upon commercial space assets. Commercial space applications are vitally important to the prosperity, economic well-being, and overall confidence of the business climate. Space applications enhance such things as: television broadcast, telecommunications, navigation, and computer network timing. Revenue from space commerce was $97 billion in 2003 and is projected to top $137 billion by 2009. The availability of space systems, especially Global Positioning System (GPS) navigation and timing data, continues to find new uses within industry. This includes: power generation, mapping services, agriculture, and public utilities. Without the use of satellite systems by commercial companies, the impact to the United States economy could be severe in the short term. Over the long term, the national security of the United States can be maintained.

A sudden loss of satellite services could cause economic chaos. The greatest risk to the economy is in overall consumer confidence. When American consumers cannot receive cable TV, satellite TV, cash from ATMs, they may lose confidence and stop spending money; pushing the economy into a recession. The extent of the chaos is dependent upon how quickly critical services such as financial transactions, network timing, and stock market services can be switched to fiber-optic networks. Currently, the fiber-optic network has many terabits of excess capacity. Strong leadership from government officials and a quick conversion to fiber-optic is critical.

Commercial satellites are a critical strength to the United States. They are also a critical vulnerability. The United States must be able to hold and maintain space superiority.

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Introduction

The United States is growing more and more economically dependent upon commercial space assets. National Space Policy and National Defense Strategy require the military to protect our critical space assets and, if necessary, deny the use of space to an adversary. This means the United States must maintain space superiority. Two major treaties affect space operations: the Nuclear Test Ban Treaty and the Outer Space Treaty. Neither of these treaties prohibit the right to defend space assets, which includes attacking a threat as a means of self-defense. Any space-faring nation could develop and place systems in orbit or on the ground that could interfere with or destroy United States commercial space assets. I intend to show that commercial space systems are vitally important to the prosperity, economic well-being, and overall confidence in the business climate. And that although their loss would be devastating in the short term, over the long term, national security of the United States can be maintained.

The United States economy relies upon commercial space assets for many diverse industries. This list includes such things as television broadcast, telecommunications, navigation, and computer network timing. Revenue from space commerce was $97 billion in 2003 and is projected to top $137 billion by 2009.[1] The availability of space systems, especially Global Positioning System (GPS) navigation and timing data, continues to find new uses within industry. Power generation, mapping services, agriculture, and public utilities are improving

their efficiency and reducing costs through the use of GPS satellites. Without the use of satellite systems by commercial companies, the impact to the United States economy could be severe.

A loss of commercial space assets could also impact world globalization. The United States is providing world leadership in globalization. Without our space assets, this endeavor would face a serious setback, thus compromising many economic initiatives around the globe. The result could be an economic recession on a global level.

While there are volumes of material on military vulnerabilities due to reliance on space assets, little has been written on the consequences of losing commercial space applications. As commercial space assets grow and their services become more imbedded in economic growth and stability, their importance to the economy grows. The sudden loss of space applications could cause severe consequences to the United States economy and impede globalization efforts around the world. This paper will review the policy guidance on space superiority, the international treaties that impact space superiority and our present situation. We will then explore the economic growth derived from space assets and the resulting revenue. The discussion will then turn to the impact of a loss of commercial space assets in financial and economic terms. Although difficult to predict, an attempt to determine second and third order effects will show that space systems are vital to maintaining confidence in the business climate and sustaining economic growth.

Chapter 2

United States National Policy on Space

What is Space Superiority?

Air Force Basic Doctrine offers a simple definition for space superiority: "freedom to attack as well as freedom from attack."[2] Doctrine goes on to say that success in all combat mediums depends upon air and space superiority, and that space superiority provides the freedom to conduct operations without significant interference from enemy forces. Air Force doctrine on space operations offers a more robust definition: "Degree of control necessary to employ, maneuver, and engage space forces while denying the same capability to an adversary."[3] Space superiority cannot be achieved without capabilities to ensure the survivability and operational utility of friendly space forces as well as capabilities to deny the adversary use of space.

Having and maintaining space superiority is militarily important because space assets multiply combat effects across all spectrums. Communication, navigation, reconnaissance, and weather satellites offer advantages to the commander in each of the principles of war. Space assets are increasingly becoming dual use platforms for commercial and military use. Our inability to protect satellites will not only affect the military but also the economy.

Today, it is debatable whether the United States enjoys space superiority. There is relatively little threat to our space assets; however, that is because no one has chosen to

challenge the United States in space. If challenged, we are very limited in our ability to maintain space superiority. As other nations invest more in space, they will threaten our space superiority. The United States does not have the luxury to sit back with a "wait and see" attitude while other nations begin to exploit space. In the 1920's and 30's, those nations that did not update or develop the concepts of armor and airpower suffered greatly in the early stages of WWII. We must continue to update policies and weapon systems.

National Space Policy and National Defense Strategy

The President's National Security Strategy (NSS) states that the United States must: "protect critical United States infrastructure and assets in outer space."[4] Additional guidelines are provided in National Space Policy, dated 19 September 1996. The policy states, "Access to and use of space are central for preserving peace and protecting United States national security as well as civil and commercial interests."[5] Within the policy are National Security Space Guidelines that provide instructions to the Department of Defense:

1. Maintain the capability to execute the mission areas of space support, force enhancement, space control, and force application.
2. Protect critical space-related technologies and mission aspects.
3. Act as the launch agent for defense and intelligence sectors.
4. Pursue integrated satellite control and continue to enhance the robustness of its satellite control capability.
5. Establish requirements for military and national level intelligence information.
6. In concert with CIA, support operational military forces by modifying or augmenting intelligence space systems as necessary.
7. Consistent with treaty obligations, develop, operate, and maintain space control capabilities to ensure freedom of action in space and, if directed, deny such freedom of action to adversaries.
8. Pursue a ballistic missile defense program.[6]

This guidance has been incorporated into the National Defense Strategy (NDS) as follows:

> "Our capability to operate from international airspace and outer space will remain important to joint operations. In particular, as the nation's reliance on space-based systems continues to grow, we will guard against new vulnerabilities. Key goals,

> therefore, are to ensure our access to and use of space, and to deny hostile exploitation of space to adversaries."[7]

The NDS clearly relies on and recognizes the importance of all space-based capabilities to promote United States interests at home and abroad. So why have we not reduced our satellite vulnerability? The answer lies in three areas: current treaty obligations, lack of a perceived threat, and the idea of space sanctuary.

Current Space Treaties, Threats, and Space Sanctuary

The United States has signed several treaties limiting the actions one can take to protect friendly space assets and negate hostile satellites. These treaties were written in the 1960's, before the full potential and future uses of space became apparent. It was a time when getting to orbit was only affordable by a few government entities. The United States and Soviet Union were in the midst of the Cold War and therefore the emphasis was on limiting the potential for an arms race in space. The treaties applicable to this discussion, to which the United States is a party, are the Nuclear Test Ban Treaty and the Outer Space Treaty. Each of these treaties contain numerous articles; only those applicable for this paper are discussed.

Nuclear Test Ban Treaty (1963). This treaty bans nuclear testing except underground testing. The key provisions restrict exploding nuclear weapons in the atmosphere, beyond its limits, including outer space, or underwater.[8]

Outer Space Treaty (1967). Officially called the *Treaty on the Principles of Outer Space, including the Moon and other Celestial Bodies*, this treaty establishes a set of rules on space use and exploration. It specifies that: 1) nations do not have sovereign territorial rights in space; 2) objects carrying nuclear weapons or other weapons of mass destruction will not be placed in orbit, on celestial bodies, or anywhere in space; 3) the moon and other celestial bodies shall be used by all states exclusively for peaceful purposes. The establishment of military bases,

installations, fortifications, and the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden.[9]

The legal scholars and writers are divided on their interpretations of these various treaties. One author tries to argue the term "nuclear weapons" should be considered individually. He proposes that things "nuclear" are prohibited and "weapons" are prohibited.[10] Using this definition, the Outer Space Treaty bans items such as lasers and kinetic energy weapons. A symposium entitled "Lawyers and the Nuclear Debate" refuted this legal hair splitting.

> The term 'weapons' in these agreements [Outer Space Treaty and Agreement governing the Moon] was not defined or otherwise restricted. In the years since 1967 and 1979 science and technology have perfected new generations and families of weapons, including those employing highly focused energy, such as laser weapons, and…particle beam weapons. Pursuant to the general legal principle that which is not prohibited is permitted, it may be concluded that the more recent exotic weapons do not fall within the constraints of the foregoing treaty provisions.[11]

Another debate revolves around the meaning of "peaceful purposes." Does the phrase mean non-aggressive or non-military?[12] The Outer Space Treaty refers to "peaceful purposes" in the same article allowing the use of military personnel. It says, "The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited."[13] This makes it quite clear that peaceful purposes does not mean non-military. The term "peaceful purposes" also appears in Article 88 of the Law of the Sea Convention. This article has been interpreted to mean non-aggressive.[14] One should therefore conclude, the meaning of peaceful purposes, as stated in the Outer Space Treaty, means non-aggressive.

Article 51 of the United Nations Charter speaks of a nation's right to self-defense. The right of self-defense includes taking offensive actions to protect oneself from imminent attack or

the threat of attack.[15] Therefore, as long as the United States is acting in self-defense, future space systems do not violate treaty references to peaceful purposes.

The United States has not experienced a real threat to its space assets. Although the United States has been uncontested in the exploration of space, other nations have taken notice. Some nations already have the ability to destroy our space assets, while others are developing systems to interfere with and/or destroy satellites. In the past, the United States has placed a large measure of confidence on the idea of space sanctuary to protect our satellites. That means we trust another nation's goodwill not to interfere with our space assets. Maintaining space for peaceful purposes is an admirable goal, but total reliance on this concept is not practical or advisable. Throughout history, as soon as technology allowed, man used the land, sea, and air to gain military and economic advantages over friend and foe alike. Space will be no different. With the increased dual use of satellites for military and commercial applications, more must be done to guarantee space superiority. Space assets have given business new ways to improve efficiency, cut costs, and develop new revenue streams. The loss of space superiority and on-orbit satellites could significantly impact the economy.

Chapter 3

United States Economic Dependence on Space

Commercial Growth and Use of Space Assets

The use of space-based assets continues to grow, particularly in communication and GPS satellites. While military assets in space have remained relatively constant, an explosion in the commercial space market has taken place. In 1996, the number of commercial launches surpassed military launches for the first time. Today, satellite services play a vital role in the distribution of broadband content and access to the internet. As noted by the industry itself, "As the backbone to the transparent network, satellites supplement fiber during periods of heavy use, plus they are integral to private networks that transmit financial transactions between banks and link corporate computers."[16] Businesses are expanding their use of satellite services to include financial transactions, payroll accounting, stock market data transfer, environmental monitoring, rescue services, and transportation monitoring to name just a few. Mobile satellite phone service is also a growing market. Satellite phone service, like the broadcast television and internet markets, is capable of filling a niche in remote areas. It has become a tool of choice for ocean going vessels, emergency teams responding to disasters, and to military users.

The airline and shipping industries rely heavily upon satellite services for navigation. The avionics on modern airliners allow them to take-off, fly to their destination and land in zero visibility with little human intervention. Air traffic controllers also use positioning data to track

and monitor airborne routes. Shipping traffic is heavily reliant upon satellite navigation systems to stay within shipping channels and to avoid underwater hazards. Conoco Pipeline Company maintains 6,000 miles of underground pipelines in 14 states. Allegheny Power System maintains 560,000 utility poles and 202,000 overhead transformers. Both companies use GPS to map the location of their assets over large expanses of terrain. When a problem is detected, they are able to respond to the exact location without wasting time and resources searching in remote regions.[17] Montana Department of Natural Resources tags elk with GPS receivers to monitor herd movement, population distributions, and sources of disease.[18] Boeing Satellite Systems is courting General Motors to use both satellite and terrestrial systems for its On-Star service. This would ensure continuous coverage for the services provided by On-Star such as tele-communication, theft prevention, and emergency response. The system can be used to detect and report on airbag deployments, the location of stolen vehicles, or to unlock the doors when the owner is locked out. All new General Motors vehicles are equipped with satellite radio; therefore, adapting the system for On-Star is relatively simple.[19] These industries are dependent upon satellite communication services to provide an enhanced level of safety or an enhanced level of service, both of which consumers have come to expect. Ocean-going vessels use communication systems to talk with shipping controllers, to schedule port arrivals, and to report unforeseen maintenance requirements. Airlines also use telecommunications services to feed video and high-speed internet to passengers on board intercontinental flights.[20] This new service, still under market testing, will soon become an expected standard.

In addition to navigation, GPS provides extremely accurate timing data. This highly reliable, very accurate time source is being incorporated into many commercial applications. Mr. Norman Martello, in an article for *Electric Perspectives*, notes: “Timing data synchronizes

power plant generators to provide electric phase matching and fault detection throughout power grids in the United States. Timing and synchronization is critical to control the generation and distribution loop within the power grid, to share power with adjacent grids, and to identify quickly the location of short circuits within the system."[21] GPS eliminated the need to maintain costly microwave towers which proved to be expensive in remote regions.

Global Positioning System timing also synchronizes the internet and computer networks. In 1995, the internet boasted 3.8 million hosts on 37,000 networks. By 2000, the internet had grown to 71 million online computers.[22] With this increased sharing of information, databases, and financial transactions comes the need for common timekeeping and the internet backbone to support data transmissions. GPS is now the most common source for accurate timing data. In 2000, 40 of the world's 92 publicly accessible internet timing sources relied upon GPS timing. Atomic clocks were the second most used source at 15 of 92. The remaining timing sources were provided by radio signal.[23] Of all these sources, GPS is the easiest to use and least costly to operate. All of this demand for space services has increased the size of the space industry.

The last few years have shown significant growth in space-related industries. The commercial space industry is comprised of the manufacturers, service providers, space applications, and space support services. The manufacturing segment is further broken down into the building of the satellite bus, satellite sensors, launch vehicles, and equipment for ground stations. The service providers include broadcast television, telecommunications, internet, and mobile phone. The space application area includes Global Positioning System (GPS) users, remote sensing (imagery), and weather data. Support services are the external business requirements such as legal service, licensing, and insurance. After a manufacturing slump in the late 1990s and early 2000s due to the dot com failures, and again in 2002 due to over

capitalization, the manufacturing market took an upward swing in 2003. Orders for new satellites went from three in 2002 to 17 in 2003.[24] This in turn improved the space industry job market in the United States as well as other countries.

Figure 1: Space Related Worldwide Employment

		1999	**2000**	**2001** (Projected)	**2002** (Projected)
Leasing Services	United States	2,300	2,785	3,300	3,823
	Rest of World	6,100	6,015	6,778	7,522
Manufacturing	United States	77,900	71,603	88,972	77,413
	Rest of World	60,600	70,409	66,677	93,635
Launch Services	United States	17,600	11,400	19,700	19,100
	Rest of World	14,500	19,200	20,300	18,400
GPS	United States	16,536	18,793	21,532	23,288
	Rest of World	14,086	17,347	19,875	23,288
Remote Sensing	United States	550	650	845	1,098
	Rest of World	2,500	3,700	4,000	4,500
Totals	United States	114,886	105,231	134,349	124,722
	Rest of World	97,786	116,671	117,630	147,345

Source: US Department of Commerce, Office of Space Commercialization, *Trends in Space Commerce* (Futron Corporation) June 2001.

The jobs created by the space industry are typically high paying technical jobs. Employers are looking for engineers, mathematicians, physicists, accountants, etc. These higher paying jobs bring educated professionals with disposable income into communities. This in turn grows the local economy as these individuals demand homes, cars, furniture, and all manner of services. This leads to additional employment opportunities in the community and expands the government's tax base. All this growth is due to the demand for space-related services from the

general population and by businesses that see space as a way to improve efficiency and lower costs.

Growth in the space industry is not limited to United States companies. As technology matures and becomes more affordable, many other countries will develop commercial activities in space, not only for their own use, but also for American businesses. Telesat Canada, Canada's leading satellite operator, recently launched Anik F1-R, a replacement satellite to continue its mission of broadcasting television throughout North America. In addition to television broadcasting, the satellite will transmit internet and multimedia products and will also be used by air traffic controllers to help enhance their current ability to track aircraft in congested skies across the continent.[25] Shin Satellite Public Company is Thailand's first company to own and operate satellites for Southeast Asia. The company operates four communication satellites used for broadcast TV, broadband internet service, and video or voice telecommunications.[26] All commercial satellite communication companies, no matter where they are located, sell or lease airtime to customers of all nationalities. It is not uncommon for dozens of countries to rely upon the same satellite for their communication needs. Therefore, countries are becoming more interdependent on each other to ensure satellite usage is not interrupted either intentionally or by accident. As more and more business moves through space, the economic impact associated with potential satellite loss grows. This growing dependence on satellites, coupled with an inability to protect them, creates vulnerability and could lead to chaos if those assets were lost or disabled.

Space Generated Revenue

As the space industry grows, so too does revenue. The use of satellites reshapes existing services as well as provides new services; these become ingrained in everyday use, and are soon

taken for granted. There is also an inherent trust that these systems will work upon demand. How often does that National Football League (NFL) fan worry that his favorite game will not be televised via his satellite-provided NFL ticket premium service? We have also come to enjoy the speed and convenience of pay-at-the-pump gasoline stations. Satellites are so reliable, that rarely do we consider the consequences when they fail. As a measure of reliability over a 24-hour period, satellites provided the required capacity 99.99% of the time.[27] The high level of reliability promotes the use of satellite services, which leads to more growth. In our everyday lives, consumers think of satellite services as a means for providing television broadcast, internet services, global positioning information, and telecommunications. However, the market has grown larger than those sectors and into other aspects of our society. The satellite broadcast industry is the most visible because it is the largest segment of the services market. The worldwide direct-to-home satellite television market produced $28.6 billion in revenues for 2003 compared to total space revenue of $97 billion for the entire industry. Total revenue is projected to grow to $137 billion by 2009 (See Figure 2).

Figure 2. Worldwide Commercial Space Revenue Forecast ($ billions)

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Infrastructure	51,073	53,818	55,957	58,437	59,694	62,348	63,461
Satellite Services	36,450	40,294	44,327	48,553	51,989	55,473	58,769
Applications	6,968	7,665	8,363	9,435	10,861	11,709	12,878
Support Services	2,412	2,774	2,968	2,619	2,925	2,955	2,659
Totals	**96,902**	**104,550**	**111,615**	**119,036**	**125,470**	**132,484**	**137,766**

Source: International Space Business Council, *2004 State of the Space Industry*, Space Publications LLC, February 2004, 23.

Economically, our society is relying more and more on space-based assets to produce revenue and grow businesses. For example, PanAmSat enjoyed steady earnings and a growing business base as the volume of its satellite services increased. In 2000, the company had 21 communications satellites in orbit. According to a company news release, total revenue for the first quarter of 2000 was $299.1 million, up some $106 million from the same quarter the previous year. PanAmSat's release also stated the company has future satellite services already booked that will be worth some $6.1 billion in the coming years.[28]

As shown in Figure 2, of the total 2003 space revenue of $97 billion, $51 billion was generated by the manufacturing market. This translated to significant growth in stock market values for most space manufacturing companies and satellite service providers. (See Figure 3) Growth will level off but is expected to continue. For example, in the first quarter of 2003, PanAmSat's revenue was $199.8 million. This was a return to normal revenue streams after the slump in 2002 and represents a 21 cent per share increase for stock holders.[29] The increased market valuation for PanAmSat is reflected by a 47% increase in the December 2003 share price.

When you look at the growth from 2002-2003, one can see further capital appreciation in many of these companies. Investors are pushing stock prices higher as they see an undervalued industry that has potential for future growth and profit. The wealth that comes with this increased valuation is based upon investor confidence. If that confidence is shaken, investors will move money into other ventures. This will lead to stock devaluations in an amount equal to the level of lost confidence. Stock prices could hit rock bottom. There are many examples of this loss of confidence in the dot com industry. Next, we will look at what might cause a loss of confidence and the potential consequences to the economy and worldwide globalization.

Because of a satellite's reliability and ability to provide services in remote areas, the loss of satellite assets could significantly impact globalization.

Figure 3. Stock Market Values for selected Space Companies ($)

	12/31/02 Share Price	12/31/03 Share Price	% Change
Asia Satellite Telecomm	11.39	18.98	67%
Boeing	32.99	42.14	28%
EchoStar Comm	22.26	33.99	53%
Globecomm Systems	3.75	4.75	27%
Hughes	10.70	15.97	49%
Indosat	10.75	18.00	67%
Lockheed Martin	57.75	51.40	-11%
Northrop Grumman	97.00	95.60	-1%
Orbital Sciences	4.22	12.02	185%
PanAmSat	14.64	21.56	47%
Teleglobe	18.01	22.36	24%
ViaSat, Inc	11.54	19.14	66%

Source: International Space Business Council, *2004 State of the Space Industry*, Space Publications LLC, February 2004, 25-26.

Chapter 4

Economic Impact with the Loss of Commercial Space Applications

"Today, the services provided by communications satellites are woven into the fabric of our lives. They were, and are, the true catalyst for globalization, or the worldwide melding together of different financial and economic systems."

Steven Lambakis
On the Edge of Earth

Computer Networks and Financial Systems

There are many aspects of space that we simply take for granted. The product users are the most vulnerable to a loss of satellite assets. As discussed in chapter 3, the Global Positioning System provides position and timing data. Timing data is needed by virtually all computer networks to time stamp networks at distant ends. This maintains synchronization within network connections. This must take place before any operations can begin. Time stamps allow network encryption, financial transactions, and database access.[30] GPS provides a standard, highly accurate time source. Since the source is available worldwide, network administrators do not need to worry about coordinating timing problems because everyone has the same time source. When this time source is lost, coordination must take place. The question becomes which network's time standard is wrong? What source are both distant ends going to use to provide synchronization? How will you communicate? How will multiple network operators coordinate to sync more than two systems? Some sort of network hierarchy must be developed. To a large extent, GPS timing data has replaced the use of atomic clocks which required maintenance and upkeep. Atomic clocks also require more manual involvement to ensure consistency at network

ends. As the use of atomic clocks and other timing sources such as radio signals decreases, the skill and art of using and maintaining these sources is fading. If it is needed quickly, learning curves will be steep which will lead to additional delays.

All vital networks use some type of encryption. The Federal Reserve, the stock markets and brokerage firms, social security and Medicare are a few examples of encrypted networks that use GPS data.[31] The loss of timing data is less critical to the computers within the network, but it would affect the ability of the network to connect with another network. For example, the computers at Bank of America would continue to operate; however, their computer network would not be able to synchronize with the Federal Reserve system if the time stamps do not agree. Failure to connect means the daily transactions cannot be reconciled. This could quickly become significant. In a study of Year 2000-related foreign exchange failures, a single major bank's inability to settle its trades could reach $3.3 billion per week.[32] That amount was only for foreign stock exchanges. The amounts for daily United States transactions would be higher.

Twenty-five years ago, the banking industry used reel-to-reel tapes to reconcile daily transactions. At the end of the banking day, a tape was run of all transactions and sent via courier to the Federal Reserve. Reconciliation was conducted by the Federal Reserve in the early morning hours. It was not until the next day that a bank received its formal ledger from the Federal Reserve. In the event of a network failure a similar type of system could be reinstituted using compact disks; however, there are no procedures in place to perform this task. It could take days to put a system in place. A long delay would add to people's apprehension and loss of confidence.

A single failure like this could easily lead to chaos. Recall the impact of PanAmSat's Galaxy 4 satellite outage in 1998. The malfunction interrupted television and cable

transmission, rendered idle millions of pagers and blanked out thousands of private networks that operate such services as fast-pay pumps at gas stations. It was estimated that the failure disrupted pager services for tens of millions of people in the United States.[33] The failure of one satellite caused this wide-spread disruption. Try to imagine that type of impact multiplied across many systems simultaneously. It is a nightmare scenario. The Honorable Emmett Paige, Jr., Assistant Secretary of Defense for Command, Control, Communications, and Intelligence stated in testimony to congress regarding Year 2000 computer network issues, "If a particular system fails, we have generally learned how to work around an individual failure. However, if a problem, that happens to be common in most of our systems, were to cause failures in all of those systems at the same instant, the consequences might be catastrophic."[34]

Over time, the loss of timing data can be remedied. The unknown variables are how many networks are affected and the availability of alternate time sources. With many networks across the globe facing the same problem, coupled with a limited availability of alternative timing methods, a ruthless bidding contest would stretch available supply channels. Using alternate timing sources requires manual intervention on both networks to ensure synchronization. How would these individuals communicate? Communication satellites powering the mobile phone networks are also susceptible to loss. Unless our networking experts are using a fiber-optic network, they will not be able to communicate. In addition, unless that computer network is also connected overseas via an ocean-based fiber network vice a satellite network, the connection will not be possible. Computer networks and communication utilities that were using satellite teleport facilities will move quickly to obtain excess fiber network capacity. Due to the size of the problem and the demand for service, this will not occur quickly enough to satisfy the public's confidence. If the delay is prolonged, it will impact payrolls,

benefit payments, banking, stock transactions, and power grids. The public will become uneasy and lose confidence. Without strong leadership this could lead to panics and riots.

There is also a significant impact to just-in-time inventory management. Many companies have reduced storage costs and freed up capital by not maintaining a large supply of parts on-hand. This is possible due to computer networking. As new goods are ordered, requests to parts suppliers are simultaneously made. This ensures a just-in-time delivery of parts. It reduces expenses and improves profitability. If businesses are forced to return to holding a large supply of parts on-hand, profitability will decrease, which will lead to a loss of investor confidence and lower stock prices. This sequence of events, repeated throughout many businesses, will start a cascading cycle of second and third order effects.

Some of the more direct impacts are easy to identify; however, there will be numerous second and third order effects that will be difficult to predict. History offers numerous examples of human behavior when people are uneasy about the market place. The stock market crash of 1929 caused thousands of individuals to withdraw money from banks. It did not take long for banks to deplete their cash reserves. Once the assets were gone, the banks failed, leaving many people destitute. The withdrawal of capital from the nation's money supply dried up lending and investment opportunities which inhibited growth. Consumers started to panic and stopped spending what little money they had left. The job markets contracted due to decreased sales which led to more business failures. Soon the nation was in a depression. One only needs to look at Hurricane Katrina for a more recent example. Soon after the hurricane, rumors abounded that gasoline supplies were running low. Consumers panicked and started a run on gasoline stations which led to a self-fulfilling prophecy. A large demand was placed on gas supplies at the same time that suppliers were unable to provide additional resources. Customers sat in gas

lines for hours to fill their tanks, all the while getting worried over their future ability to buy gas. This demand caused gas prices to rise to exorbitant levels, over $5.00 a gallon in some areas. This rise in prices further led to reductions in consumer spending due to less disposable income and fewer trips to the store in order to save fuel. This action increased speculation of a post-hurricane recession.

A widespread loss of all or numerous satellites will have a global affect on the world economy. Second and third order effects are easier to see in hindsight than they are to predict ahead of time, especially when it comes to satellite services which have become embedded in many parts of the economy. Money and finances project power and wealth; this leads to prosperity and confidence. When the ability to access money and finances is removed, an individual's daily routine is interrupted. This begins a cascading effect driven in part by human behavior and partially by the actual loss of services. One can see both of these examples in the stock market crash and Hurricane Katrina aftermath. If the networks that process and reconcile payments (mortgage, automobile, credit card and student loans), taxes (sales, corporate, income, and social security), and financial transactions (grocery store, retail clothing, restaurant, accounts receivable) are not quickly restored, a loss of confidence will result. When automatic teller machines, instant check-writing approval, and credit and debit card processing stops, individuals will try and turn to cash. When checks do not clear the banking system quickly, business will not have funds to make payroll or tax payments. Without tax payments, cities cannot provide services or make payroll. When individuals revert to cash, there will not be enough cash in the system to supply the demand. Additionally, individuals with large amounts of cash draw attention. Those that are without means to obtain basic needs may turn to violence. As observed

during Hurricane Katrina, this will place a greater demand on law enforcement and create further distrust and loss of confidence.

Strong leadership would need to step forward quickly to reassure the public, but how does that leadership communicate in a world of video and audio connections made possible via communication satellites? When information flow is disrupted it spreads to many areas of the media. For example, even the news print industry relies upon satellite services to obtain information from various news sources. The way to stop fear is through information, but without communication satellites, this task is problematic and increasingly complicated. Satellites carry most of the national network broadcast for both video and audio. It is beamed from point to multipoint teleport facilities which take the satellite signal and feed it to local fiber networks. The same is true for audio links which accompany the video feeds. Television stations could broadcast to their local markets, but they would not have a live broadcast from a national leader.

Fiber-optic cable would definitely fill part of the gap, but the key unknown variable is how quickly transmissions could be rerouted? A side issue to reconfiguration is that telephone usage is also dependent upon computer networks and fiber-optics. If computer networks fail due to a loss of timing, the extent of the impact on the phone system would be based upon how quickly telephone switching equipment loses its network timing. Unless rectified, the ability to coordinate routing changes from satellite-based transmission to fiber-based transmission would be slowed even further. Not only could this delay a national leadership response, but the loss of phone lines would add to the people's anxiety and accelerate their loss of confidence.

Companies with excess fiber capacity would be deluged with requests for service. They could not possibly accommodate all the demands for a quick return of service. They would be

understaffed to handle the requests, both at the customer service level and at the technician level. This will delay the restoration of services.

Globalization

The world economy runs off the United States economy. Any country or business that wants to successfully sell products to a large population with disposable income needs to penetrate the United States market. The amount of disposable income available to an American family cannot be equaled. If American consumers pull back due to failed networks or panic, this would immediately impact global markets starting in two particular areas: telecommunication services and the international stock markets. Satellite telecommunication is enabling worldwide globalization. The ability of satellites to deliver services to remote regions without great amounts of land-based infrastructure has created new entrepreneurs. India has a large population of highly educated technicians. Indian entrepreneurs want to complete your taxes, read x-rays, trace lost luggage, and write new software, all from Bangalore, India.[35] Satellite communications have made India a leading country in handling technical service call centers for computer equipment and software. This is providing jobs and wages to areas previously struggling to provide employment for an educated under utilized work force. These workers, with money in their pockets, are demanding additional services thus creating more employment within their region. These inroads will evaporate without satellite telecommunications capability.

Further consideration must be given to the type of information affected by the satellite loss. While the Galaxy 4 outage was an inconvenience, the service outage was not catastrophic. The international stock markets depend on both secure computer networks and tele-communications. Without the ability to post transactions and conduct trades, companies cannot

capitalize or provide returns to shareholders. If the outage affected the world's financial markets such as transmission of stock exchange information, International Monetary Fund or World Bank transactions, or Federal Reserve Bank settlements, the impact could be profound. The world financial community is interwoven; investor confidence and speculation rule the day. If that confidence is shaken and investors pull back, the world economy can be impacted. To understand this point, one only needs to look at the impact of the World Trade Center attacks on the New York financial district. When New York Stock Exchange computers went down, exchanges around the world could not open or were very limited in their trading. It took several days to restart the markets. Once the markets reopened, investors were nervous and stock prices declined. The same scenario is possible with a sudden loss of numerous communication satellites. This makes space superiority a vital interest.

Counter Argument

The loss of satellite TV, television network broadcast, pay-at-the-pump service, video teleconferencing, and GPS navigation would cause a huge inconvenience and an upset population. Some critical areas, such as emergency response, aircraft and shipping navigation would experience greater problems, but they have back-up navigation systems. The most critical loss would be the GPS timing data, but again this is a worst-case example. A satellite outage may not occur to all commercial satellites simultaneously. Instead of being destroyed, it is more plausible that satellites may be jammed, thus causing only a temporary loss of the system.

If a large percentage of GPS satellites were destroyed or inoperable, computer network timing would not be lost instantaneously. For classified Department of Defense networks, the United States Naval Observatory is developing a capability to allow a network server to "coast" for a year in the event of a loss of GPS signal.[36] For commercial networks, this could be more

problematic; the result is difficult to predict. As noted earlier, 40 of the 92 public access time servers utilize GPS as the timing source. The remaining 52 time sources could provide some network timing, but not without difficulty. First, if many additional users attempt to access the non-GPS time source, the server could crash or slow down. This would cause the network administrator to restrict access. If the timing servers crash, a timing loss will not occur immediately; however, network problems will occur over time. It would take time to attempt to resolve the problem by acquiring additional non-GPS time sources and bringing them online.

There are some other mitigating factors to consider. The most vital networks, such as banking, stock exchange, Federal Reserve, must surely operate on a restricted access time server. There are approximately 61 restricted time servers listed in open source material.[37] These servers would not become overloaded with additional users and, as long as they provided an alternative time source, would allow the vital networks to continue operation. This is speculation, because these networks do not disclose their timing sources.

The issue of lost telecommunication and internet capability must also be addressed. The Galaxy 4 outage affected a wide range of the population but it was a small isolated incident. The inconveniences caused by this outage were resolved within several days by redirecting communication links to other company-owned satellites, but this was only possible because of excess capacity. If other satellite resources were not available, many of Galaxy 4's functions could have been rerouted through ground-based capacity such as fiber optic.

Tyco International recently sold its 37,000 miles of Pacific undersea fiber-optic cable which connected three continents. Tyco's trans-Pacific cable has 7.6 terabits of capacity. This is three times more capacity than the combined total of all other cable along the route. Only a fraction of Tyco's capacity is being utilized.[38] Tyco is only one of several companies that

provide undersea fiber cable. There is significant excess capacity to allow continued transmission of internet and computer network data. However, the transition would not occur quickly, thus causing delays and service outages. For example, cable television broadcast requires large amounts of bandwidth. This might be more difficult to accommodate than financial transactions or databases. Once sourced, the ground-based capacity must be negotiated and then reprogrammed into circuits and computer systems. Interoperability problems could be a factor. All these steps will likely lead to delays in service restoration. It is easy to visualize, but hard quantifying the chaos as various companies scramble for ground-based capacity.

With a loss of numerous satellites, the space manufacturing industry would have large orders to fill. Economically, this would not hurt their bottom line. The service providers on the other hand would be devastated until additional satellites are placed in orbit. Virtually their entire work force would lose employment. This would impact thousands of jobs, and probably force many companies into bankruptcy.

Chapter 5

Conclusion

Commercial satellite services have become embedded in our society. Individuals and businesses depend upon satellites for financial transactions, entertainment, communication, navigation, weather forecasting, timing data, and more. A sudden loss of satellite services could cause economic chaos. The extent of that chaos is dependent upon how quickly critical services such as financial transactions, network timing, and stock market services can be switched to fiber-optic networks. Industries that use point-to-multipoint communications, such as broadcast TV and the stock markets, would be more severely affected than industries that send information point-to-point such as the banking industry.

The undersea fiber optic network has many terabits of excess capacity. This terrestrial capacity is capable of handling the lost bandwidth from critical space assets. The key factor is getting critical services rerouted from space assets to terrestrial assets. Many teleport facilities are becoming dual use; that is, they send data via both satellite and fiber optic. The media chosen depends upon system availability and efficiency. Dual use facilities are in a better position to quickly transition to fiber optic than facilities that transmit via satellite only.

A loss of satellites places some jobs at risk. The jobs most affected are those in the entertainment and support services. Although some companies would go bankrupt, most of these job losses would be temporary. Once replacement satellites were launched, the job market would return and new companies would come forward. Satellite manufactures and launch

providers would have a boost in market demand until satellite constellations were replaced. This would take several years and produce healthy profits.

The largest risk to the economy is in overall consumer confidence. When American consumers cannot receive cable TV, satellite TV, cash from ATMs, or buy gas via pay-at-the-pump, they may lose confidence and stop spending money. That could have a greater impact than the loss of satellite services. The potential for this scenario is lessened by quick conversion to fiber optic and strong leadership from government officials, but consumer confidence is both fragile and fickle. One can rarely predict and influence consumer confidence levels.

The world operated without satellite services for many years. A complete loss of all satellites will not cause life to end, the sun to stop shining, or prevent food from growing. Civilization will not collapse. The basic needs of food and water will not be severely affected. There will be short-term confusion within the transportation industry but deliveries will continue. Until replacement satellites are launched, society will revert back to the days before space assets. People will then fully realize how much they depended upon space assets and satellite applications to make their lives easier. While an economic recession may result, national security can be maintained through redundancy and excess capacity of fiber optic cable.

Space Policy and National Defense Strategy require space superiority. The health of the economy requires it. There are no treaties which protect satellites or prohibit their destruction. The United States must be able to hold and maintain space superiority.

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