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Good morning Chairman Everett, Mr. Reyes, and Members of the Subcommittee. I am delighted to be here on behalf of the National Oceanic and Atmospheric Administration, or NOAA, a bureau within the Department of Commerce, to discuss the effects that U.S. space-based assets have on our nation's economy. As the Director of the Office of Space Commercialization, it is my responsibility to promote a robust and responsive U.S. space industry, in part by highlighting the economic significance of space-based assets and activities to policy makers within the U.S. Government. Thank you for the opportunity to testify before you on this important issue.

Space has always fascinated the American public and demonstrated our technological prowess to the world, especially in the context of national security. But over the years, space has also become increasingly vital to our nation's economic interests, presenting lucrative business opportunities and enabling the development of major infrastructures with practical uses here on Earth. In many cases, these activities have become so routine, dependable, and convenient that it is easy for the public to forget that space is involved. But the fact is we would not have CNN, DirecTV ™, XM Radio ™, OnStar ™, or Google Earth ™ if it were not for U.S. space-based assets. Our cell phone networks and ATM's would work less efficiently if they were not synchronized to the Universal Standard Time (UTC) that is distributed by GPS. Our daily weather forecasts would be far less reliable without earth observing satellites. Clearly, space is important to our daily lives, and it is in our economic interest to encourage further development of this "final frontier" of business and to ensure the long-term viability of the U.S. space industry.

For the purposes of this hearing, and recognizing the expert testimony to be delivered by my fellow panelists, I will focus my remarks on three key space activities affecting the U.S. economy: space-based positioning, navigation, and timing (PNT); commercial remote sensing; and the civilian space operations conducted by NOAA.

Space-Based Positioning, Navigation, and Timing (PNT)

On December 8, 2004, the President authorized a new national policy that establishes guidance and implementation actions for space-based PNT programs, augmentations, and activities for U.S. national and homeland security, civil, scientific, and commercial purposes. The Global Positioning System, or GPS, is a form of space-based positioning, navigation and timing, or PNT. The committee knows GPS for its critical role in U.S. national security, having repeatedly proven itself in the battlefield over the last decade and a half. GPS is also vital to several other national interests, including economic development and growth, public safety, homeland security, scientific leadership, and overall quality of life.

Much like the Internet, GPS has evolved from a gadget used by a select few to a critical information infrastructure that touches the lives of most Americans on a daily basis. Thanks to our nation's longstanding policy to make GPS available free of direct user fees to civilians around the world, as well as our long track record of dependable service, tens of millions of users worldwide have embraced PNT technology. These users have integrated GPS into nearly every facet of society including public safety, transportation, finance, and manufacturing, to name a few.

GPS technology can now be found in everything from cars and airplanes to cell phones and wristwatches. GPS is improving productivity in areas as diverse as farming, mining, construction, surveying, taxicab operations, logistical supply chain management, and package delivery. GPS is enhancing public safety by preventing transportation accidents, helping parents keep track of their children, and reducing response times for ambulances, firefighters, and other emergency services. GPS is also furthering scientific aims such as weather forecasting, earthquake prediction, and environmental protection. Furthermore, the precise GPS time signal, derived from atomic clocks, is being applied to critical economic activities such as synchronizing communication networks, managing power grids, and authenticating electronic transactions.

Many sections of federal, state, and local governments rely upon GPS technology to fulfill their missions. Within the Department of Commerce, GPS helps NOAA navigate its vessels, enforce fisheries boundaries, improve local weather forecasts, and survey our nation's coastlines and waterways. The National Institute of Standards and Technology uses GPS to communicate its time standard to customers in industry and to other national laboratories for inclusion in the international time standard. The Census Bureau uses GPS in field enumeration applications to improve efficiency and data quality. The list goes on and on.

Economic Value

The economic value of GPS is difficult to quantify because it is so pervasive and integrated into the fabric of the economy. Counting the total number of GPS users in the world is a challenge, because the technology is often embedded in other products, such as cell phones, and consumers do not even know they are using it. According to one private sector firm, global sales of GPS user equipment currently exceed $20 billion a year and will continue growing at a healthy rate for the foreseeable future.[1]

[1] *Satellite Positioning Systems and Devices,* ABIresearch, 2005.

Equipment sales represent only the tip of the economic iceberg. As with personal computers, the true value of GPS is not in the cost of the equipment, but in the productivity and growth it enables. U.S. industry has created new services and enhanced existing products by accessing GPS capabilities. The Department of Commerce has been working closely with the Department of Transportation to quantify the economic benefits of GPS in terms of the productivity gains enjoyed by civilian users, not just equipment sales. Within the next month, we will be publishing an article in the trade press describing some of our results. The article focuses on the quantifiable economic benefits of the next-generation GPS satellites, which began launching last year. One of the first upgrades that next-generation GPS delivers is a second civilian GPS signal, known as "L2C," which was specifically designed to enhance the commercial utility of GPS. Under the most likely scenario, we estimate L2C could enable over $5 billion in economic productivity benefits over the next 30 years.

L2C is just the first of many new civilian upgrades the U.S. Government making to the GPS constellation over the next decade. For example, the U.S. Government plans to add a third civil GPS signal that will greatly enhance accuracy, availability, and reliability, especially for safety-critical transportation applications. The aviation community is very interested in the third signal because it will help improve both navigation safety and airspace capacity. Having three signals will also reduce downtime for any business operation that uses GPS where signals are easily dropped, such as under trees. The United States is also working with international partners to design a fourth signal that will boost the global availability of space-based PNT, especially in the urban canyons of cities. As these GPS upgrades come online, the importance of space-based PNT to economic, public safety, and other national interests will undoubtedly increase.

Commercial Remote Sensing

The second area I would like to address is commercial space-based remote sensing, which is the collection of earth imagery from space by private sector firms. Space-based remote sensing is another technology that was originally developed for national security purposes, but eventually released for commercial exploitation in the 1990s due to its economic potential. On April 25, 2003, the President authorized a new national policy that establishes guidance and implementation actions for commercial remote sensing capabilities.

Under the 1992 Land Remote Sensing Policy Act, as amended, the Secretary of Commerce is responsible for licensing all U.S. commercial remote sensing satellite systems to ensure they are operated in a manner consistent with U.S. national security, foreign policy, and economic interests. Working closely with other U.S. Government agencies, NOAA implemented a comprehensive licensing and compliance program to support this vital U.S. space and information base, enhance U.S. national and economic security and foreign policy, and leverage new commercial assets for government and public use. The Commercial Remote Sensing Licensing (CRSL) program seeks to facilitate the development of a vibrant, growing, and competitive U.S. commercial remote sensing industry, resulting in a variety of innovative and useful environmental data products to government and industry customers. It also seeks to ensure that U.S. commercial remote sensing space systems are operated in a manner that is consistent with U.S. national security, homeland security, and foreign policy interests. NOAA's CRSL program also supports related senior-level policy development, associated international and interagency coordination, and a variety of outreach efforts to stakeholders in government, industry, and the general public. The program executes program activities on a worldwide scale.

Since 1993, NOAA has issued 26 licenses for the operation of approximately 45 remote sensing systems, representing over $3.5 billion in private sector investments.[2] The first to achieve operational status was the IKONOS satellite, built and launched in 1999 by Space Imaging, now acquired by GeoEye. Capable of capturing earth images at up to 0.82-meter resolution, IKONOS ushered in a new era of commercial competition in high resolution, space-based remote sensing.

As with GPS, commercial satellite imagery has a multitude of ground-based applications spanning many sectors of the nation's economy. Farmers use it to monitor crops for blight and other problems and to deploy localized remedies when needed. Land use managers use it to assess and plan city growth. Insurance companies use before-and-after imagery to verify damage claims after floods, hurricanes, and other disasters. The media routinely adds satellite imagery to news reports to illustrate where important events have occurred. Software developers incorporate satellite imagery into flight simulators, games, and even wireless handheld devices.

Satellite imagery is most useful when combined with GPS, electronic maps, and localized data into a geographic information system (GIS). Perhaps the most popular example of this is the Google Earth™ application, which recently made commercial satellite imagery freely available to almost anyone on the planet via the Internet. Other examples include Microsoft's Virtual Earth™ and Yahoo's similar service. These mapping portals have brought satellite imagery "down to Earth" and have increased public awareness of space-based imagery across the globe.

Commercial satellite imagery also has significant impacts beyond the economy. Remote sensing is a well known form of reconnaissance, and the U.S. national security community purchases large quantities of commercial imagery to augment its own intelligence gathering capabilities. Commercial imagery is also used by human rights groups around the globe to monitor and document events in places such as the Darfur region. NOAA utilizes commercial imagery, coupled with data recorded from National Aeronautics and Space Administration (NASA) satellites and used throughout the federal government, academia and industry, to monitor and protect fisheries and habitats, such as the effects of harmful algal blooms, as well as to assess coastlines, coral reefs, wetlands, and glaciers all over the world.

In the area of disaster response and relief, the commercial space-based remote sensing industry has played a vital role in recent years, collecting tens of thousands of square miles of imagery for dissemination to aid workers around the globe. Following the 2004 tsunami in Southeast Asia and the 2005 earthquake in Pakistan, commercial satellite imagery enabled the U.S. Government and other organizations to assist in damage assessments and rescue relief operations in highly remote areas that could only be observed by satellites. During the record hurricane season of 2005, satellite imagery contributed to the identification of damaged areas, the deployment of rescue and relief operations, and the planning efforts to rebuild Gulf Coast communities. Commercial satellite imagery is also used to help firefighters navigate wildfires by determining which residents should be evacuated, where emergency personnel should be dispatched and where firelines should be constructed.

[2] CRSL Industry Statistics, as reported by NOAA's Commercial Remote Sensing Licensing Program.

Economic Value

Total sales for the entire commercial remote sensing industry, including both aerial photography and satellite imagery, were estimated at $2.6 billion in 2003.[3] According to one leading industry analyst, the space-based segment of that market is worth $300 million today and could exceed $1 billion by 2012. The National Geospatial-Intelligence Agency, or NGA, will spend up to $500 million over five years on commercial imagery through the ClearView program, which expedites bulk purchases of imagery from U.S. commercial satellite operators for use by various agencies across the federal government. NGA is also planning on purchasing higher resolution U.S. commercial imagery as part of its NextView program.

Today, GeoEye and DigitalGlobe are the two main companies leading the U.S. commercial remote sensing industry. GeoEye, formed from the recent merger of ORBIMAGE and Space Imaging, operates three satellites and more than a dozen international regional ground stations. GeoEye's annual revenue is about $160 million from commercial imagery products and services. DigitalGlobe currently operates one satellite and three ground stations. Within a year, both companies will launch new commercial imaging systems with far greater capabilities than the current systems on orbit. The enhanced level of accuracy of data derived from these systems will enable new applications and keep U.S. industry at the forefront of the increasingly competitive global market for satellite imagery.

As I noted earlier, the real value of satellite imagery is unlocked when it is combined with other value-added information into GIS. Quantifying this value in terms of the productivity gained by GIS is difficult. A leading provider of information technology market research stated that overall GIS goods and services revenue totaled $1.84 billion in 2003 and projected a 9.7% rise to $2.02 billion in 2004, but that includes many products that did not incorporate commercial satellite imagery.[4] However, like GPS, sales numbers do not include the productivity benefits realized by customers, only their GIS cost.

NOAA's Space-Based Systems

Over 105 million U.S. households rely on NOAA's weather and environment forecast each day. NOAA, one of the nation's leaders in environmental space-based systems, commands a fleet of meteorological satellites, including the Geostationary Operational Environmental Satellites, or GOES, and Polar-Orbiting Environmental Satellites, or POES. Both are necessary to complement other satellite observations, including NASA's QuikScat and Tropical rainfall Measuring Mission (TRMM) satellites, as well as in situ measurements, to provide a complete global weather monitoring system. These satellites are on duty 24 hours a day to support forecasting and prediction services critical to our economic and national interests, especially during the annual hurricane season. As you may be aware, the hurricane season is from June 1 to

[3] CRSL Industry Statistics, as reported by *Space 2003: Exploring the Future of Space Application*, by OECD, 2004.

[4] Daratech, Inc., *Worldwide GIS Revenue Forecast to Top $2.02 Billion in 2004, Up 9.7% Over 2003* (press release), 19 October 2004, Cambridge, MA.

November 30 and NOAA's official prediction for 2006 is for 13 to 16 tropical storms with eight to ten of them becoming hurricanes.

NOAA's GOES are the mainstay of near-term weather and space weather forecasting, and ocean, climate and environmental hazards monitoring. During the record-breaking 2005 Atlantic hurricane season, GOES provided a continuous flow of imagery that helped NOAA forecasters track the storms and issue their forecasts. These accurate forecasts helped minimize the loss of life in the United States from three tropical storms and five hurricanes, four of which—Dennis, Katrina, Rita, and Wilma—were considered major hurricanes.

NOAA's POES provide an uninterrupted flow of global environmental information to support long-term weather, oceanic, and space environmental modeling, as well as tropical storm analysis and forecasting, local weather forecasting, and ecosystem and climate monitoring. The global data from these satellites are used extensively in NOAA's weather and climate prediction computer models. The data are distributed throughout the world through NOAA's website, which saw a total of 206,814,261 hits and provided 6.03 terabytes of data during the week before Hurricane Katrina made landfall.

Future planned capabilities will provide increased observational capacity. These new satellites will provide significantly improved information to the user community, including television meteorologists, private weather companies, aviation and agriculture communities, and national and international government agencies.

Just as the weather on Earth affects the economy, space weather can also create problems that impact businesses, including utility companies, airlines, and telecommunication systems. Space weather includes solar flares, solar winds, and electromagnetic disturbances in the atmosphere that can disrupt electronic and electrical systems on the ground, in the air, and in space. NOAA's Space Environment Center (SEC) utilizes space-based assets including the GOES system to provide national and international warnings of space weather events that can affect people and equipment. SEC operations are jointly staffed by NOAA and the U.S. Air Force and provide forecasts and warnings of solar and geomagnetic activity to users including energy companies, the airline industry, the Department of Transportation, the National Aeronautics and Space Administration, and military and commercial space system operators. Such warnings are critical to the prevention of economic losses from power grid outages, satellite failures, and other avoidable incidents.

Aircraft operating over polar routes are occasionally diverted to avoid the radiation and radio interference that is associated with solar storms and increased solar activity. Diverted polar flights can cost up to $100,000 each because of the additional fuel required. In the period 17-24 January 2005, United Airlines was forced to operate 26 of these less-than-optimum flights due to space weather.[5] Commercial communication satellites are also vulnerable to the effects of space weather. A geomagnetic storm in 1994 damaged two Canadian communication satellites, which were replaced at a cost of about $400 million. Additionally, in January 1997, a geomagnetic

[5] INTEGRATING SPACE WEATHER AND METEOROLOGICAL PRODUCTS FOR AVIATION Genene Fisher, Atmospheric Policy Program, American Meteorological Society, Washington, D.C., 2003

storm severely damaged the U.S. Telstar 401 communication satellite, which was valued at $200 million, and left it inoperable.[6]

NOAA's satellites also contribute significantly to an important international search and rescue system known as COSPAS-SARSAT. The satellite system receives distress radio beacons, which transmit signals via satellite during an emergency. Since the system became operational in 1982, almost 18,000 lives have been saved worldwide, including more than 5,100 lives in the United States.[7] During FY 2005, the system helped save 244 people, including the entire crew of the fishing vessel *Mary Lynn* that was capsized by Hurricane Katrina.

To address the growing requirements for environmental data on national and global scales, NOAA, NASA, and the Office of Science and Technology Policy (OSTP) are leading the implementation of the *Strategic Plan for the US Integrated Earth Observing System,* through the U.S. Group on Earth Observations (USGEO). The U.S. Integrated Earth Observation System is an essential component of the Global Earth Observation System of Systems, or GEOSS, which is a global Earth data collection and dissemination initiative to benefit worldwide stakeholders and decision-makers. GEOSS will allow users to share, compare and analyze a diverse array of datasets, providing the information necessary to mitigate the impacts of natural hazards. GEOSS will provide the global information required to understand the interactions between Earth processes and, thereby, improve the forecasting skills of a wide range of natural phenomena, such as a hurricane in the Atlantic, a typhoon in the western Pacific, and the impact of El Nino throughout the globe. GEOSS will also promote improved decision-making in various sectors, including natural resource management, public health, agriculture and transportation. NOAA's environmental satellite systems and NASA's integrated global Earth system science satellite constellation are among the critical components of the GEOSS initiative.

Economic Value

The weather on Earth has direct impacts on the economy, and one of the most critical functions of NOAA satellites is to support the nation's weather and climate enterprise. Data from NOAA satellites complement other observations, which are essential to ensure NOAA's sophisticated computer models use the most current information. These computer models simulate future weather, ocean, and climate conditions. Weather and climate sensitive industries account for about one-third of our nation's gross domestic product. The affected industries include finance, insurance, tourism and travel, real estate, retail and wholesale trade and manufacturing.[8]

Total annual federal spending for weather information, including satellite data and information, is about $25 per household (including aviation and defense, in addition to NOAA). A detailed national survey[9] revealed the average value of all current weather forecast information from public and private sectors is approximately $109 per household, with a total national value of $11.4 billion per year. This survey also showed the annual value of improving the daily forecast

[6] Green, Arthur W. and Brown, William, *Reducing the Risk from Geomagnetic Hazards*, USDOI and USGS Fact Sheet 177-97.
[7] Cospas-Sarsat Information Bulletin No. 18, February 2006, NOAA Press Release 2006-008, NOAA, U.S. Department of Commerce
[8] Dutton, John A., *Opportunities and priorities in a new era for weather and climate services,* Bulletin of the American Meteorological Society, September 2002, volume 83, no. 9, pp 1303-1311.
[9] Lazo, J. and Chestnut, L., *Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector,* report prepared for NOAA's Chief Economist by Stratus Consulting, Boulder, CO, November 2002.

in terms of more accurate one-day and multi-day forecasts, geographic detail, and frequency of updates is $16 per household, or $1.73 billion per year. The average value of weather forecast information relative to the total federal spending produces an annual benefit-cost ratio of 4.4:1 to U.S. households alone, or net national benefits of $8.8 billion a year. This does not include benefits in agriculture, transportation, construction, or benefits to households in other countries that rely on weather information from the United States.

In a typical hurricane season, NOAA's forecasts, warnings, and the associated emergency responses result in a $3 billion savings.[10] Two-thirds of this savings, $2 billion, is attributed to the reduction in hurricane-related deaths, and one-third of this savings, $1 billion, is attributed to a reduction in property-related damage because of preparedness actions.[10] Advances in satellite information, data assimilation techniques, and more powerful computers to run more sophisticated numerical models, have lead to more accurate weather forecasts and warnings.

Today, NOAA's five-day hurricane forecasts, which utilize satellite data, are as accurate as its three-day forecasts were 10 years ago. The additional advanced notice has a significant positive effect on many sectors of our economy. Accurate five-day forecasts for hurricanes can provide the time necessary for people to implement plans to secure their lives and businesses. Accurate five-day forecasts for hurricanes are important to the agricultural, fishing and energy industries, to name a few. For example, these forecasts can save the offshore oil and gas industry significant amounts of money by helping determine if and when operational systems should be taken off-line. Estimates indicate that the value of existing 48-hour hurricane forecast information to oil and gas producers averaged roughly $8 million per year during the 1990s.[11] These accurate forecasts can also help the fishing industry by providing enough time for fishermen to get their boats and equipment to a safe harbor.

In Closing

Today, June 21st, marks the first day of summer and thousands of families from your states will begin their vacation adventures. Many of these families will use navigation systems in their cars to help them get to their destination – with the assistance of space-based systems. Many of these families will explore our national parks and wilderness areas – with the assistance of space-based systems. Many of these families will explore our oceans and coasts – with the assistance of space-based systems.

I want to thank you again for inviting me here today to discuss the economic value that space brings to our economy in the areas of space-based PNT, commercial remote sensing, and NOAA's space-based systems. The future benefits of space to our economy are constrained only by American imagination and creativity. I am happy to answer any questions that you may have.

[10] Willoughby, Hugh. *Costs and Benefits of Hurricane Forecasts*, minutes of the 55th Interdepartmental Hurricane Conference, 5-9 March 2001, Orlando, FL.

[11] Considine, Timothy J., Christopher Jablonowski, Barry Posner, and Craig H. Bishop, *The Value Hurricane Forecasts to Oil and Gas Producer in the Gulf of Mexico*, Journal of Applied Meteorology: Vol. 43, No. 9, pp. 1270-1281.