U.S. House of Representatives
Committee on Transportation and Infrastructure
Washington, DC 20515

John L. Mica
Chairman

James W. Coon II, Chief of Staff

Nick J. Rahall, II
Ranking Member

James H. Zoia, Democrat Chief of Staff

February 6, 2012

MEMORANDUM

TO: Members, Subcommittee on Aviation

FROM: The Honorable Thomas E. Petri, Chairman, Subcommittee on Aviation

SUBJECT: A Review of Issues Associated with Protecting and Improving our Nation's Aviation Satellite-based Global Positioning System Infrastructure

PURPOSE

The Subcommittee on Aviation will receive testimony from federal government and industry witnesses regarding the importance of the Global Positioning System (GPS) as a critical part of transportation infrastructure. The subcommittee will also receive testimony on the public policy ramifications of protecting that infrastructure to ensure transportation safety and efficiencies provided by GPS technologies and innovations.

BACKGROUND

The Global Positioning System (GPS) is the global navigation satellite system (GNSS) developed in the United States that provides position and timing information at any place on the globe with a high degree of accuracy. GPS is composed of three different segments: satellites, a ground control system, and receivers. The United States Air Force maintains a constellation of at least 24 satellites that orbit 12,500 miles above the surface of the earth in six orbital planes so that at least four satellites are in view of any point in the world at any given moment.[1] The satellites transmit an encrypted military signal and an unencrypted civilian signal to military and commercial receivers, respectively. These two signals are monitored by the ground control system segment, which ensures the accuracy of the signals by sending periodic updates to the

[1] "The Global Positioning System for Military Users: Current Modernization Plans and Alternatives", The Congressional Budget Office, October 2011, p.2.

satellites.[2] After travelling 12,500 miles from space to the receivers, the GPS's 25-watt signal is weak when it reaches the ground.[3] For GPS to work properly, there must be at least 24 satellites operational. Currently, the Air Force flies 31 operational satellites, and another three satellites fly dormant and stand ready to be reactivated, as needed.[4]

First developed by the military during the Cold War, GPS was made available for civilian use by President Ronald Reagan after Korean Air Lines flight 007 was shot down in 1983 for straying into Soviet airspace due to imprecise navigation.[5] All 269 people aboard the aircraft were killed, including then-sitting U.S. Congressman Lawrence McDonald. Subject to President Reagan's order, the Department of Defense (DoD) began to repurpose GPS for civilian use. GPS was ordered to be made available for civilian use at its intended accuracy level, free of charge by Presidential Decision Directive NSTC-6 in 1996.[6] Selective availability, or the intentional degradation of the GPS signal to reduce accuracy available to commercial receivers, was turned off permanently in 2000.[7] Since then, GPS has evolved into an important part of everyday life as new capabilities have developed. GPS functionality can be found in just about everything with an "on-off" switch, including cell phones, cars, Automated Teller Machines (ATM), farming equipment, and of course, aviation surveillance and navigation equipment.

The use of GPS in transportation, and aviation in particular, benefits safety and efficiency by providing highly reliable, and more accurate position information when compared to the legacy surveillance systems. In aviation, GPS will soon replace radar as the primary surveillance method. The Department of Transportation (DOT) and the Federal Aviation Administration (FAA) already utilize GPS technology in a broad variety of surveillance, navigation, safety, and efficiency applications.[8]

Billions of dollars of federal and private-sector investment as well as millions of U.S. jobs are tied to the future of GPS infrastructure. According to press accounts, the DoD investments into GPS have topped $35 billion since its introduction and continue at roughly $1 billion annually.[9] In addition, the FAA has invested $3.1 billion in GPS to date. FAA investments include:

- $1.7 billion in the Wide-Area Augmentation System, which will enhance the accuracy of GPS and permit aircraft to perform precision approaches in poor-visibility conditions;
- $1.1 billion in automatic dependent surveillance-broadcast (ADS-B), a GPS-based system for air traffic control that will ultimately replace controllers' use of radar to track aircraft in flight;

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[2] CBO, October 2011, p. 3.
[3] Ibid., p. 4.
[4] http://www.gps.gov/systems/gps/space/
[5] The Washington Post: "Now we know where we stand, and it's about time", Curt Suplee, November 3, 2009.
[6] Presidential Decision Directive NSTC-6, The White House, March 28, 1996.
[7] Testimony of The Honorable Roy W. Kienitz, Under Secretary for Policy, U.S. Department of Transportation before the Subcommittees on Aviation and Coast Guard and Maritime Transportation, U.S. House of Representatives, June 23, 2011.
[8] GAO Report: Global Positioning System: Challenges in Sustaining and Upgrading Capabilities Persist, September 2010 (GAO-10-636).
[9] "LightSquared Plans Hinge on Outcome of GPS Interference Debate" by Peter B. de Selding, Space News International, March 4, 2011.

- $100 million toward the implementation of performance-based navigation procedures, which allow aircraft to fly fuel-efficient routes and flight profiles, saving time, expense, and greenhouse gas emissions; and
- $200 million in the Ground-Based Augmentation System, which allows for more precise navigation after takeoff and on approach,

Additionally, the FAA's Capital Investment Plan calls for $2.2 billion of further investment in GPS-related NextGen systems until fiscal year 2013.[10] The FAA estimates by 2013, in addition to DoD spending, up to $10 billion of public and private sector investments will have been made in civilian GPS uses. According to the FAA, over 360,000 civil aircraft are currently equipped with GPS-enabled avionics.[11]

Under the direction of the United States Air Force, the DoD is managing a GPS modernization program. In maintaining and modernizing the GPS system with new encryption systems, the DoD has $22.3 billion in planned upgrades to, and replacement of, the current constellation by 2030.[12] Among the satellites that will be replaced are ten, classified by the Air Force as the Block IIA satellites, that have flown for over twenty years, tripling their expected service life.[13]

Importance of GPS to the Economy

The importance of GPS cannot be overstated. According to the DOT, sales of GPS navigation devices exceed $20 billion worldwide each year. Tens of millions of cars across the United States are equipped with GPS navigation receivers. An estimated $3 trillion in economic activity relies on GPS for tracking, timing, and navigation. According to the Deputy Secretary of Transportation, Roy Kienitz, regardless of the quantification of benefits, "the decision to provide GPS as a free service constitutes one of America's greatest economic gifts to the world since the Marshall Plan."[14] According to a recent study, the GPS industry supports over 3.3 million U.S. jobs annually. The direct economic benefits of GPS technologies to commercial GPS users are estimated to be over $67.6 billion per year in the U.S. [15] The ubiquitous use of GPS in transportation safety and navigation has made it a critical element of transportation infrastructure in the United States, and around the world.

In 2004, the DOT was appointed to be the lead federal agency guiding government policy for all federal civilian uses of radio spectrum, including GPS. In that capacity, the Department

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[10] Fed. Aviation Admin., *National Airspace System Capital Investment Plan, FY 2012-2016* (May 2011), *available at* http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/operations/sysengsaf/cip/files/FY12-16/FY12-16_CIP_Complete_May_2011.pdf.

[11] According to the FAA, this figure includes 5,800 Passenger, Cargo, and Regional carriers, 2,800 International carriers, and 352,000 General Aviation and Air Taxi operators.

[12] "The Global Positioning System for Military Users: Current Modernization Plans and Alternatives", The Congressional Budget Office, October 2011, p.9.

[13] http://www.gps.gov/systems/gps/space/

[14] Testimony of The Honorable Roy W. Kienitz, Under Secretary for Policy, U.S. Department of Transportation before the Subcommittees on Aviation and Coast Guard and Maritime Transportation, U.S. House of Representatives, June 23, 2011.

[15] "The Economic Benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption" by ndp consulting. Author is Nam D. Pham, Ph.D. June 2011. According to the report, 3.3 million jobs rely on GPS technology. 130,000 in GPS manufacturing and 3.2 million in downstream commercial GPS intensive industries.

has also come to represent a host of non-transportation related uses of spectrum. According to the DOT, "GPS is essential for the operations of first responders, search and rescue, resource management, weather tracking, energy independence, critical infrastructure such as dams and power plants, financial transactions and banking, surveying and mapping, and industries such as precision agriculture, where the ability to water and fertilize plants with centimetric accuracy increases conservation, reduces waste run-off, and saves American farmers up to $5 billion, annually."[16]

GPS is an American invention, available for use around the world. U.S. leadership in satellite-based navigation technology, and the endless opportunity for innovation in its potential uses, has enabled job growth in the U.S.-based technology sector.[17]

GPS Reliability At Risk

Military receivers are equipped with classified anti-jamming capabilities, but the question of equipping commercial receivers with this capability raises concerns over weakening the military's strategic advantage over adversaries around the world. Commercial availability of anti-jamming capabilities could potentially put the weapons of war the U.S. has developed over the last few decades into the hands of its adversaries. Because of the relatively weak signal strength, the unencrypted commercial signal is susceptible to interference, whether intentional or not.

For instance, in the spring of 2010, the Federal Communications Commission's (FCC) New York Office of the Bureau of Enforcement received complaints about GPS failures at the Newark Liberty Airport. A GPS-based landing system was experiencing intermittent failures. Upon investigation, it was discovered that the driver of a truck was using a personal jamming device to disable the GPS locator on his company's truck. In this case, the driver was unintentionally disabling the airport devices as he drove past the airport on the New Jersey Turnpike.[18] The Communications Act of 1934 prohibits the use of jammers, and FCC rules prohibit the manufacture, importation, marketing, sale or operation of jamming devices within the United States.[19] However, such devices are available and risk both intentional and unintentional consequences of GPS operations.

More recently, the reliability of the GPS signal, a critical element of transportation safety infrastructure, has been under threat from a commercial interest, LightSquared Subsidiary, LLC (LightSquared). The company is seeking to stake a claim to spectrum near the GPS allocation to establish a terrestrial telecom network despite the FCC's conditions to resolve GPS interference concerns. The FCC did not pursue enforcement action against LightSquared under the applicable statute and rules because LightSquared has not yet begun operations. However, it is conceivable that the agency could theoretically pursue an enforcement action against

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[16] Testimony of The Honorable Roy W. Kienitz, Under Secretary for Policy, U.S. Department of Transportation before the Subcommittees on Aviation and Coast Guard and Maritime Transportation, U.S. House of Representatives, June 23, 2011.

[17] Ibid.

[18] Notice of Unlicensed Operation served to Anoy Wrat of Carteret, New Jersey by Enforcement Bureau Northeast Region, Federal Communications Commission. Case Number EB-10-NY-0062, Document Number W201032380068. May 18, 2010.

[19] Title 47 U.S.C. § 301, §302(b), §333, §503, and §510; Title 47 C.F.R. § 2.803

LightSquared based on previous enforcement actions taken if its network, once turned on, interferes with the GPS signal.[20]

In any event, the FCC has repeatedly exercised a policy of protecting the spectrum used by GPS for compatible purposes. The L-Band frequency has been historically reserved for low power communications between satellites and mobile earth stations.[21] According to the DoD, the frequency band 1525-1559 MHz was originally allocated exclusively for Mobile Satellite Service (MSS) Space-to-Earth signals (for example: Inmarsat and Iridium) and terrestrial systems were not permitted. Beginning in 2003, the FCC authorized terrestrial transmissions in the MSS band as Ancillary Terrestrial Component (ATC) transmissions, which were intended to fill in gaps in the coverage of satellite signals. The initial FCC MSS ATC service rules were designed to ensure that terrestrial parts of the networks remained truly ancillary and as mitigation for potential interference to other systems such as Inmarsat and GPS.[22] The FCC has, in every order since 2003, maintained that ATC transmissions must remain ancillary to satellite transmissions, and more recently, that any attempt to establish a full terrestrial network would only be allowed if GPS interference issues are resolved. For more details regarding the history of authorizations in the L-Band, and the manner in which the FCC has protected against interference, see the subcommittee's briefing memo for the June 23, 2011 hearing entitled, "GPS Reliability: A Review of Aviation Industry Performance, Safety Issues, and Avoiding Potential New and Costly Government Burdens".

Radio spectrum is a finite resource, and its allocation is managed by the FCC. Spectrum that is currently allocated for use by broadband networks is highly valuable, given the market opportunity for the licensees of that spectrum. There are sectors of the telecommunications community that warn of a spectrum shortage crisis in order to advance an agenda of repurposing cheap spectrum held by some into broadband network spectrum.

Consequences of GPS Interference

For the past year, there was a proposal to repurpose spectrum located near the spectrum used by GPS, and stakeholders across the economy cited grave concerns.

i. GPS Reliability Issues Faced by the Department of Transportation (DOT):

As discussed earlier, navigation and the operation of transportation systems today are heavily dependent on GPS. In the aviation sector, GPS also provides more accurate position information than legacy surveillance systems (including radar). With the higher degree of accuracy and precision offered by GPS for aeronautical surveillance and navigation, the safety of the national airspace system has been greatly improved. Furthermore, GPS usage within the aviation industry is widespread, with over 360,000 civil aircraft currently equipped with GPS-enabled avionics.

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[20] Notice of Unlicensed Operation served to Anoy Wrat of Carteret, New Jersey by Enforcement Bureau Northeast Region, Federal Communications Commission. Case Number EB-10-NY-0062, Document Number W201032380068. May 18, 2010.

[21] "L-Band" broadly refers to the frequency range from one to two gigahertz, a portion of which is allocated for MSS operations. Specifically, 1525-1559 MHz is domestically and internationally allocated for transmission from satellites to mobile earth stations and 1610-1660.5 MHz for transmission from mobile earth stations to satellites.

[22] GPS Interference Information Paper, Office of the Secretary of Defense, March 11, 2011.

In addition to concerns regarding the effect of GPS reliability and interference on current operations, the DOT must also weigh potential negative impacts on the FAA's air traffic control modernization program. For the past several decades, the FAA has been implementing the planned modernization of the national airspace system, known as NextGen. NextGen will include a transition from radar-based aircraft surveillance and management to a satellite-based system to achieve both safety and efficiency benefits. Billions of taxpayer and industry dollars have already been invested in the NextGen program. A chief concern at the DOT is that GPS interference problems might cause delays in much-needed NextGen benefits, or jeopardize the NextGen effort altogether.[23]

According to airline industry experts, the U.S. airline industry has lost 160,000 jobs over the last ten years. Implementation of NextGen will create nearly the same amount of jobs nationwide over the next four years. If U.S. airlines were required to install filters and or replace GPS receivers on approximately 7,000 commercial aircraft to accommodate the repurposing of MSS spectrum, NextGen implementation would be delayed by up to ten years, thereby prohibiting this job growth.[24]

The United States is also a signatory member of the United Nations' International Civil Aviation Organization (ICAO), an important institution which ensures international harmonization in aviation standards and regulations. The President and Secretary General of ICAO cosigned a letter to the FCC Chairman expressing concerns about the potential impact of GPS interference to current aviation operations, as well as modernization efforts underway in the United States and Europe.[25]

ii. GPS Reliability Issues Faced by the DoD:

As the custodian of the GPS services, the DoD's primary concern is the continued availability and reliability of the GPS signal to Federal, commercial, and personal users. Specifically, the DoD is concerned about any ground-based system that would transmit a high-powered signal preventing GPS receivers from successfully receiving the GPS signal. According to the DoD, the increased signal via a ground network for commercial mobile voice and Internet service would effectively operate as a GPS jammer and potentially degrade accuracy or cause a GPS receiver to completely lose its connection to the GPS signal. Potential harmful interference to GPS receivers from a prolonged interruption of GPS could come in many forms, for example: loss of service due to GPS receiver front end saturation due to insufficient filtering of ATC signals, or loss of accuracy as a result of loss of GPS signals.[26]

[23] According to the FAA, NextGen Programs at risk include ADS-B, RNP/RNAV, WAAS, LAAS, Cockpit Display of Traffic Information (CDTI), and Ground-Based Augmentation System (GBAS).
[24] Testimony of Mr. Tom Hendricks on behalf of The Air Transport Association of America, Inc. before the Subcommittee on Aviation and Subcommittee on Coast Guard and Maritime Transportation, June 23, 2011, P.3.
[25] ICAO President and Secretary General letter to FCC Chairman Julius Genachowski, June 13, 2011.
[26] GPS Interference Information Paper, Office of the Secretary of Defense, March 11, 2011.

Moving Forward: Potential Mitigation Strategies

Currently, there are prohibitions in place for personal jammers used by unauthorized personnel. The FCC is authorized to take enforcement action against those who use unauthorized transmitters to maliciously interfere with other radio signals, including GPS.

Over the last year or so, much has gone into the evaluation of the prolonged interference posed by LightSquared's proposed network, and what to do about it. On January 13, 2012, the Deputy Secretaries of the Departments of Transportation and the Defense issued a joint assessment, carried out in accordance with testing protocols issued by the National Telecommunications and Information Administration, of the proposed repurposing of the neighboring spectrum, and the impacts on the reliability of the GPS signal. After working with LightSquared for a year, their findings were as follows:

> "It is the unanimous conclusion of the test findings by the National Space-Based PNT EXCOM Agencies that both LightSquared's original and modified plans for its proposed mobile network would cause harmful interference to many GPS receivers. Additionally, an analysis by the Federal Aviation Administration (FAA) has concluded that the LightSquared proposals are not compatible with several GPS-dependent aircraft safety-of-flight systems. Based upon this testing and analysis, there appear to be no practical solutions or mitigations that would permit the LightSquared broadband service, as proposed, to operate in the next few months or years without significantly interfering with GPS. As a result, no additional testing is warranted at this time."[27]

While LightSquared disputes these findings, the company's efforts to repurpose MSS radio spectrum for terrestrial use, and the resulting GSP interference, have raised important public policy questions for the transportation community. Among the issues that will be explored at the hearing are: 1) whether the benefits of GPS warrant protection of the signal for military and commercial users, 2) whether the GPS signal, as a critical element of transportation infrastructure, should be protected from interference as a matter of written policy or law, and 3) what ideas for mechanisms the government can utilize to protect the GPS signal from future interference.

[27] Deputy Secretary of Defense Ashton B. Carter and Deputy Secretary of Transportation John D. Porcari to Assistant Secretary for Communications and Information Lawrence E. Strickling, U.S. Department of Commerce, January 13, 2012.

Witnesses:

Panel I

The Honorable John Porcari
Deputy Secretary
U.S. Department of Transportation

Mr. Vincent Galotti
Deputy Director
Air Navigation Bureau
International Civil Aviation Organization (ICAO) of the United Nations

Panel II

Mr. Thomas L. Hendricks
Senior Vice President of Safety, Security and Operations
Air Transport Association

Captain Sean Cassidy
First Vice President
Air Line Pilots Association

Mr. Craig Fuller
President and CEO
Aircraft Owners and Pilots Association

Mr. John M. Foley
Director, Aviation GNSS Technology
Garmin AT, Inc.

Dr. Scott Pace
Director, Space Policy Institute
Elliott School of International Affairs
The George Washington University