U.S. Department
of Transportation
**Office of the Secretary
of Transportation**

Deputy Assistant Secretary
for Transportation Policy

1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

July 21, 2011

Mr. Karl B. Nebbia
Associate Administrator
National Telcommunications and Information Adminstration
1401 Constitution Ave., NW
Washington, DC 20230

Dear ~~Mr. Nebbia~~ Karl:

As requested by the National Space-Based Positioning, Navigation and Timing (PNT) Executive Committee on May 11, 2011, the United States Department of Transportation (DOT) has performed an operational, economic, and public safety impact assessment of the original LightSquared Concept of Operations (dual 10 MHz channels).

Current and future benefits of GPS provided by DOT's use of GPS-based applications were identified, as well as sunk costs in GPS-based infrastructure. Finally, the risks from LightSquared's signals to DOT's GPS-based mission capability were assessed for aviation, surface, and maritime users that incorporate precision GPS as a fundamental aspect of their operation as described below.

Aviation

GPS currently provides at least $200 million in efficiency benefits for aviation each year. More importantly, GPS safety enhancements are expected to prevent the loss of approximately 800 lives over the next 10 years, with an estimated public safety benefit of about $5 billion. GPS is also an essential building block in the ongoing deployment of the Next Generation Air Transportation System (NextGen), that builds upon current GPS based capabilities. The Federal Aviation Administration (FAA) estimates the cumulative benefits of NextGen to be $23 billion through 2018; and by 2030, the cumulative benefits grow to $123 billion and reduce CO_2 emissions by 64 million tons.

These results likely underestimate the National economic benefits of GPS aviation use to the overall U.S. economy, since they do not include the productivity gains enabled by accelerated cargo delivery; nor the benefits provided to the operators of thousands of military and other public use aircraft used for homeland security, law enforcement, medical emergency and other applications.

The effects of LightSquared deployment would be far-reaching and potentially devastating to aviation. If LightSquared deploys as planned, all current GPS efficiency and safety benefits would be lost, or at least severely reduced, until all aircraft operating in U.S. airspace could be retrofitted over a period of 10 and possibly up to 15 years.

The LightSquared proposal would severely impact NextGen, which relies heavily on GPS-based technologies. In the next ten years, it would result in an estimated impact to the aviation community of at least $70 billion and an additional 30 million tons of CO_2. The FAA and civil aviation community would be facing an investment loss of $6 to $7 billion in GPS-based infrastructure and equipment invested through FY 2011.

If LightSquared deploys as currently proposed, the NextGen investments would need to be replanned and most corresponding benefits would be delayed by approximately 10 years. Planned NextGen investments from 2012 through 2018 that would need to be replanned total approximately $17 billion.

Rail

Positive Train Control (PTC) systems serve to prevent train-to-train collisions, overspeed train derailments, incursions into roadway work zones, and accidents caused by railroad switches left in an incorrect position. All PTC systems require some form of transmission of PNT information. In 2009, the Federal Railroad Administration (FRA) estimated that the safety benefits of PTC system implementation could total more than $673 million over twenty years.

Freight railroads have begun to use the GPS data regarding train position and movement to enhance operational efficiency. Preliminary FRA estimates suggest that railroads could lose productivity gains (most of which accrue to society at large) of up to $29 billion over 20 years.

The FRA estimates that the sunk cost in PTC systems that rely on GPS is over one billion dollars, and that railroads plan an additional $4.3 billion by December 31, 2015 in GPS-based PTC systems to meet the Rail Safety Improvement Act (RSIA) congressional mandate. FRA believes that automated and manual track safety systems that rely on GPS represent a sunk cost of over one billion dollars, counting not only the cost of the GPS location information system, but the total cost of the track inspection systems on the same vehicles. Further, FRA has spent $65 Million on its Automatic Track Inspection Program (ATIP). FRA owns five ATIP vehicles, which use GPS to record the location of track perturbations, including violations, defects and anomalies.

Since the least costly version of PTC uses GPS for transmitting location information, were GPS degraded or completely unavailable, most railroads would have to switch to the transponder-based technology such as that used for the Advanced Civil Speed Enforcement System (ACSES) PTC system currently in place on the Northeast Corridor. FRA estimates that such railroads required to implement a transponder-based PTC system in lieu of a GPS-based system would face increased costs of up to $25 billion over 20 years.

Maritime

The Maritime Administration (MARAD) manages the Ready Reserve Fleet (RRF) which carry the same GPS-based equipment as commercial vessels, and follow U.S. Coast Guard standards for vessel inspection and equipment carriage. In addition to GPS receivers which display constant latitude and longitude positions, there are several integrated ship systems that incorporate the GPS signal as an integral component of the system. These systems and equipment include the Global Maritime Distress and Safety System (GMDSS), Electronic Chart Display and Information System (ECDIS), Radar/ARPA Displays, Ship Steering Systems Utilizing GPS Waypoints, Ship Security Alert System (SSAS), Emergency Position Indicating Radio Beacon (EPIRB), Automatic Identification System (AIS) as well as INMARSAT or Fleet Broadband terminals.

The Saint Lawrence Seaway Development Corporation (SLSDC) uses GPS-based AIS to send vital information such as real-time ship identification, position, heading, and speed to the three Vessel Traffic Control Centers within the St. Lawrence Seaway system. GPS-based AIS has greatly enhanced the safety and efficiency of the waterway and has improved Great Lakes Seaway System maritime security.

A conservative estimate provided by MARAD for all GPS-related equipment that is required to be on a vessel greater than 300 gross tons is $100K. Including the vessels in the RRF with the U.S. commercial and coastal fleet, this approaches half a billion dollars for currently installed GPS-related marine equipment. The half-billion dollar mark would be far exceeded if all the inland commercial vessels that are less than 300 gross tons but still carry GPS receivers or other GPS related marine equipment were included.

The dollar value on potential contributory ship groundings, collisions and allusions could run into tens of billions of dollars in hull, cargo and oil pollution costs not to mention injuries and loss of life as well as economic losses to ports and corporations negatively impacted by a related incident. Any interference or degradation of the GPS signal through LightSquared utilization of interfering frequency bands is unacceptable due to potential safety, environmental and economic consequences. Likewise, the retrofit of GPS marine equipment with filters or other fixes is not practical from a deployment or an economic perspective.

Road

There are many applications of GPS for road applications including driver route guidance, fleet management tracking systems, and drayage truck operations management in and out of our Nation's major ports. GPS also is used heavily at the state DOT level for traffic data and road asset inventory collection, traffic signal timing, work zone site management, etc.

From a safety benefits standpoint, Advanced Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications-based collision warnings and crash avoidance technologies are seen as the next technological leap in improving highway safety. The Intelligent Transportation System (ITS) (JPO) has invested several hundred million dollars over the course of many years in safety-based research that requires GPS positioning to be

effective. Therefore any loss of GPS would prevent the effectiveness of the solutions and jeopardize the considerable research investment made by both the federal government and the major automotive industry in connected vehicle safety research. Going forward, DOT is planning to invest approximately another $100 million in the V2V and V2I related research that utilizes GPS positioning.

A degradation or loss of GPS will prevent the successful operation of V2V and V2I applications, and thereby eliminate the future benefits associated with V2V and V2I safety applications in terms of the lost opportunity to reduce crashes, injuries, and fatalities. Therefore, the transportation industry involved with GPS devices has expressed concern about a loss of operations. If GPS were lost or degraded, millions of devices used for mobility purposes would be impacted. Significant transportation benefits such as decreased travel times, fuel savings, and corresponding environmental benefits based on enhanced efficiency from GPS would most likely be lost.

NDGPS

The Nationwide Differential GPS System (NDGPS) is an enabling technology, providing a highly reliable GPS integrity function to meet the growing public and private sector reliance for transportation, agricultural, environmental, natural resource management, surveying, weather forecasting and other applications. The DOT-funded (inland or terrestrial) NDGPS sites represent $71.8M in direct DOT funding for GPS-based infrastructure (FY 1998 – FY 2011). An additional $25M in funding has been provided state and local partners for specific site development for a total investment of approximately $97.0M.

Based on the reports of the National Space-Based PNT Systems Engineering Forum (NPEF) which was tasked to assess the GPS impacts of LightSquared's deployment plan, and the GPS Technical Working Group (TWG), NDGPS would be unable to operate if LightSquared operations were allowed to proceed as planned.

In conclusion, this assessment has demonstrated significant operational and safety impacts that likely would result in the loss of life and an economic to transportation applications of over $100 billion dollars. More detailed information covering each mode of transportation in the attached appendices.

Please contact me if you have any questions regarding this assessment.

Sincerely,

Joel Szabat

cc:

Anthony Russo, Director, National Space-Based PNT Coordination Office

Appendix A

LightSquared Impact to Aviation Operations
Input Provided by Federal Aviation Administration

Executive Summary

As requested by the Space-Based Positioning, Navigation and Timing (PNT) Executive Committee, the Federal Aviation Administration (FAA) has assessed the impacts of LightSquared's planned deployment on FAA infrastructure and the aviation community. This paper addresses specific questions asked by the PNT NCO.

LightSquared's June 30, 2011 proposal includes: use the *lower* 10MHz channel starting in 2012; operate at "reduced" power; and agree to a "standstill" in terrestrial use of the *upper* 10 MHz channel. LightSquared would begin full use of both bands in 2014.

- LightSquared's initial operations at the lower 10 MHz channel even at "reduced" power levels would impact the aviation use of high-precision GPS receivers.
- We estimate it would take 10 years to design, develop, certify and install modified equipment in the civil aviation fleet.
- LightSquared's planned operations would result in the loss of GPS-enabled operational, economic, and public safety benefits across the National Airspace System.
- The FAA would be compelled to return to dependency on ground-based navigation aids.
- Billions of dollars in existing FAA and GPS user investments would be lost.
- The FAA would also need to replan Next Generation Air Transportation System (NextGen) investments, which would result in additional development costs and delays.

The LightSquared proposal would severely impact NextGen, which relies heavily on GPS-based technologies. In the next ten years, it would result in an estimated impact to the aviation community of at least $70 billion and an additional 30 million tons of CO_2 for the following reasons:

- Loss of benefits from delayed NextGen technologies and procedures
- Loss of existing GPS efficiency benefits
- Loss of existing GPS safety benefits
- Aircraft retrofit costs

A final consideration is the expected international impact of the proposal. The President's 2010 *National Space Policy for the United States of America* states that the U.S. must maintain its leadership in the service, provision, and use of global navigation satellite systems. We believe this proposal could adversely affect U.S. international leadership in aviation. Air carriers and other users could lose confidence in GPS, despite Presidential commitments to the International Civil Aviation Organization on its continued safety and availability. The international market for U.S. satellite navigation technology could be damaged. Demand for non-U.S. systems such as Russia's GLONASS in lieu of GPS, could be stimulated.

1. **Summarize and quantify current and future benefits provided by use of GPS-based applications and any cost-benefit analyses.**

The FAA conservatively estimates that GPS currently provides at least $200 million in efficiency benefits each year. More importantly, GPS safety enhancements are expected to prevent the loss of approximately 800 lives over the next 10 years, with an estimated public safety benefit of about $5 billion. GPS is also an essential building block in the ongoing deployment of NextGen that builds upon current GPS based capabilities. The FAA estimates the cumulative benefits of NextGen to be $23 billion through 2018; and by 2030, the cumulative benefits grow to $123 billion and reduce CO_2 emissions by 64 million tons. These results likely underestimate the National economic benefits of aviation GPS use to the overall U.S. economy, since they do not include the productivity gains enabled by accelerated cargo delivery; nor the benefits provided to the operators of thousands of military and other public use aircraft used for homeland security, law enforcement, medical emergency and other applications.

NextGen is the transformation of the radar-based air traffic control system of today to a satellite-based system of the future. This transformation is essential to safely accommodate the growing number of people who fly in the United States. NextGen implementation makes use of GPS to provide precise and dependable navigation and to support required navigation performance (RNP) airspace and procedures that allow more aircraft to operate safely in a given volume of airspace.

GPS is also an indispensable tool in the daily operation of our Nation's air transportation system that enhances the safety and efficiency of over 35,000 instrument flights per day and an indeterminate number of visual flights. Current GPS aviation benefits include precise positioning and navigation that is used for thousands of instrument approach procedures providing vertical guidance. GPS enables the widespread use of area navigation procedures which provide more direct routes and improve the flexibility of operations and procedure design, thereby reducing delays and improve capacity.

There are three major aviation safety risks that are mitigated through the use of GPS: Approach and landing accidents, controlled flight into terrain (CFIT), and runway incursions.

The frequency of approach and landing accidents has decreased steadily since the FAA's predecessor agencies first began to introduce early instrument landing systems (ILS). As recently as the 1990s, however, this was still a relatively common accident scenario, with nine such accidents to U.S. air carrier aircraft in that decade, four of which were fatal accidents. Since 1999, U.S. carriers have had just two such accidents in U.S. airspace and at least one of those was not GPS-equipped. In addition, key precursors to these types of accidents, such as unstable approaches, have decreased in recent years. GPS and an aircraft capacity to identify its precise location relative to a precisely located touchdown point explain much of this improvement.

The experience has been comparable with CFIT accidents, which for decades had been the most lethal of all accident scenarios. Though CFIT achieved its biggest breakthrough prior to the advent of GPS, CFIT accidents continued through the mid-1990s in air carrier turboprop aircraft and in large U.S.-operated jets while flying in foreign airspace. We also had evidence from the relatively limited data systems of that era that the risk of striking terrain remained with us, as reports of on-board terrain alerts had become stubbornly stable. Enhance Ground Proximity Warning Systems (EGPWS) combine GPS and other technologies to provide look-ahead terrain information to the flight crew and give the crew time to avoid impact.

Protection against runway collisions is a third example of important safety improvements that could be forfeited with the loss of reliable GPS signals. The Volpe National Transportation Systems Center has concluded that the contemporary mix of airport surface moving map displays could prevent one-third of all runway incursions, and that effectiveness will increase as more of the fleet deploys upgraded versions of the equipment, particularly "own-ship" moving maps.[1] This equipment depends on GPS and has been a major factor in the sustained reduction of category A and B incursions, and in the effort to minimize severe ground collisions, as at Milano in 2001 and Quincy, Illinois in 1996. If GPS signals are compromised, all the benefits of this equipment will abruptly disappear.

With respect to General Aviation (GA) the situation is even more dramatic, particularly since glass cockpits became standard equipment in new aircraft, beginning about 2003. Nationally, in the past 5 years fatal CFIT accidents in GA and non-scheduled air carrier operations have decreased 44% from the preceding 5 years, while fatal approach-and-landing accidents and all fatal accidents at night have decreased by 30 percent. GPS and glass-cockpits are a primary explanation for these improvements, and those rapid improvements will likely continue for several more years as GPS-based equipment continues to penetrate the GA market.

With the loss of GPS, those benefits already achieved will be immediately reversed, and the opportunity for even more long-term benefits would be lost. Unlike air carriers, GA losses would not be offset by air traffic control and ILS systems because the GA fleet would either not be equipped with ILS or may not be under air traffic control. The safety impacts and costs to GA would be felt in full and would be severe.

FAA has quantified the safety impact of a 10-year loss of GPS functionality. Using the period 1991-1998 as a reference (the last significant period in which GPS was not in wide-spread civil use), there were nine air carrier accidents which might have been averted had Terrain Alerting and Warning Systems (TAWS) been available and installed on the aircraft. Four of these accidents resulted in a total of 51 fatalities (averaging 6.4 fatalities per year). Another two involved large transports with a total of 185 souls on board, which indicates the potential for higher casualties. On this basis, FAA assumes that the loss of GPS functionality over 10 years would result in at least 64 fatalities for air transportation operators.

To estimate the same benefit for GA, FAA has observed that the number of fatalities attributable to CFIT, approach and landing, and night-flying accidents in the past 5 years versus the previous

[1] See "Mitigating Runway Incursions: A Safety Benefits Assessment of Airport Surface Moving Map Displays," Stephanie Chase, Danielle Eon, and Michelle.Yeh, 2010.

5 years. After allowing for decreases attributable to reduced GA flight hours, the FAA estimates that at least 73 fewer deaths, and perhaps as many as 77, occurred annually during the second 5 year interval due to reductions in these kinds of accidents because of increased use of GPS technology. FAA's estimate of averted fatalities is shown in the following table.

Type Operations	Reduced Fatalities over 10 years	Nominal 10-year Benefit ($ billions)
Air Carrier	64	0.4
General Aviation/Pt.135	730	4.4
Total	794	4.9

These figures are conservative for air transport operations because commercial traffic has increased since the base period, aircraft are getting larger, and they are flying with higher load factors. The total value estimate also does not include assumptions concerning serious injury, minor injury, or property loss. These would normally be considered in a benefit/cost analysis, but are not addressed due to time limitations. For GA, 730 is the low end of estimated fatalities. Thus these estimates should be considered to be the lower bounds of safety benefits directly attributable to GPS on-board functionality.

2. Summarize and quantify total sunk costs in GPS-based infrastructure (prior years to date) and planned investments going forward.

The FAA and civil aviation community would be facing an investment loss of $6 to 7 billion in GPS-based infrastructure and equipment invested through FY 2011. The FAA notes that U.S. taxpayers have already invested over $3 billion in GPS and NextGen through FY 2011. In addition to the FAA's investment on behalf of the taxpayer, the estimated aviation industry investment in GPS equipment for aircraft operating in the U.S. airspace through FY2011 is $3 to 4 billion. This estimate does not include GPS equipage costs for over 13,000 Department of Defense aircraft, 1400 federal department and agency aircraft, and thousands of state, and local government public use aircraft.

If LightSquared deploys as currently proposed, the NextGen investments would need to be replanned and most corresponding benefits would be delayed by approximately 10 years. Planned NextGen investments from 2012 through 2018 that would need to be replanned total approximately $17 billion. These investments include civil aviation industry estimated investments of $9 billion and $8 billion in FAA infrastructure investments. These investments leverage GPS for improved airport access, positioning, and enhanced Automatic Dependence Surveillance (ADS-B) capabilities, and provide the foundation for trajectory-based operations.

3. **To the extent possible, qualify, quantify, and describe risks to your agency's GPS-based mission capability, including "lost benefits" if GPS performance were degraded (or lost) due to LightSquared's signals including the costs to modify (or replace) GPS receiver infrastructure and the time frame required to replace that infrastructure.**

The effects of LightSquared deployment would be far-reaching and potentially devastating to aviation. Proposed LightSquared operations would severely impact the efficiency and modernization of the safest, most efficient aerospace system in the world. LightSquared operations would bring numerous current and planned safety, efficiency, environmental improvements to a halt— jeopardizing U.S. leadership in the modernization of the global airspace system.

More significantly than productivity impacts, if GPS were not available, there would be a public safety impact due to the loss of safety enhancements that are incorporated in aircraft today including TAWS, vertically guided approach capability to reduce CFIT, and "on-ship" displays that utilize GPS technology and reduce the number of runway collision accidents.

Estimated loss of life from 2014 to 2023 as a result of LightSquared impacts to GPS during the 10-year retrofit period is depicted in this table.

Type Operations	Estimated Fatalities during GPS retrofit	Value of Life ($ billions)
Air Carrier	64	0.4
General Aviation	730	4.4
Total	794	4.9

Note that these figures are conservative because they do not include assumptions concerning serious injury, minor injury and property loss that would normally be considered, but are not included here. FAA considers this to be a lower-bound estimate of safety benefits directly attributable to GPS on-board functionality. This estimate could increase as commercial operations and aircraft size increase.

If LightSquared deploys as planned, all current GPS efficiency and safety benefits would be lost, or at least severely reduced, until all aircraft operating in U.S. airspace could be retrofitted over a period of 10 and possibly up to 15 years; however 10 years is used for the purpose of this estimate and is assessed as medium risk. The time required includes development of new GPS standards, product development, test, and standardization activities, and certification approvals.

Additionally, an estimated $17 billion in FAA and civil aviation NextGen investments from 2012 through 2018 would need to be replanned and most corresponding benefits would be delayed by approximately 10 years.

The FAA's analysis indicates that hundreds of thousands of civil aircraft operators would be directly and detrimentally impacted by degradation of GPS services. Not later than 2014, the agency anticipates impacts to:

- 5,800 to 7,250 passenger, cargo, and regional U.S. operated aircraft;

- 2,800 to 4,000 international operators' aircraft from 105 countries;
- more than 61,000 IFR-approved GPS navigation general aviation and air taxi aircraft; and
- the vast majority of 310,000 pilots without instrument ratings that use GPS equipment in visual conditions.

Additionally, there are over 13,000 Department of Defense aircraft, 1400 federal department and agency aircraft, and thousands of state, and local government public use aircraft supporting homeland security, firefighting, law enforcement, search and rescue, and other applications that are not addressed in this estimate.

During the assumed 10-year replanning and aircraft retrofit schedule, the proposed LightSquared deployment would result in the loss of:

- At least $2 billion in baselined GPS aviation efficiency benefits,
- $6 billion for unplanned aircraft retrofit costs,
- $59 billion in NextGen benefits
- 31 million additional tons of CO_2 emissions, and
- 794 lives lost with a public safety impact of $5 billion

Total LightSquared aviation impacts are estimated to be over $72 billion, not including $6 to 7 billion in FAA and aviation user sunk costs.

Based upon input from the RTCA in its advisory capacity to the FAA as well as the National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum, this estimate is based upon the replacement costs of modified GPS aviation antenna and receivers for which no approved technical specification exists today. The 10 year retrofit timeline is assessed as medium to high risk. The cost of retrofitting existing FAA GPS based ground infrastructure is not part of the basis of this estimate.

This estimate does not consider the aviation economic impacts if signal degradation continued unmitigated. Failure to achieve a high level of mitigation would carry a much larger cost. Additionally, the estimate does not account for the inefficiency and expense of replanning NextGen projects and programs.

This operational, economic, and public safety impact assessment is based upon LightSquared's June 30, 2011 proposal and June 23, 2011 LightSquared testimony to the House Transportation and Infrastructure Committee, including use of the lower 10MHz channel starting in 2012 and any use of the upper 10 MHz channel starting in 2014. This assessment assumes the planned power is one-tenth the current authorized power. LightSquared operations at the current power authorizations would be substantially worse than considered in this assessment.

Use of the LightSquared upper channel is unacceptable at any power level, since the LightSquared upper channel interference exceeds the GPS receiver MOPS-related environmental limit by a factor ranging from 4,000 to 80,000, depending upon the assumed operational scenario. LightSquared transmissions in the upper portion of the spectrum in the 2013-14 timeframe would result in the complete loss of GPS aviation capabilities. More significant than that, however, is the lost benefits of current GPS use and NextGen, moving U.S. aviation away

from a safer, more efficient national airspace system based upon GPS and satellite technology, and returning the FAA to dependency on ground-based radionavigation aids.

The FAA cannot conclude that operations using just the lower portion of the spectrum are compatible with civil aircraft receivers without definition of LightSquared's end-state deployment and further study. However, based upon existing data, LightSquared's operations at the lower channel would preclude the following critical capabilities that rely upon high-precision GPS receivers: airfield and flight procedure surveys, flight test tracking, space weather monitoring, and GPS timing for computing resources and many mission critical systems. Impacted FAA GPS timing applications include multiple terminal, enroute, and oceanic automation systems and subsystems; surveillance systems; voice communications and voice recording systems; and maintenance support systems.

The FAA estimate considers several possible mitigation options to retain GPS aviation benefits to aviation. LightSquared's proposal for in-line filtering is assessed as high risk and not feasible. Aviation receiver/antenna sets typically use five or more filter/amplifier stages. Any stage saturated by the higher power LightSquared signal results in degraded GPS aviation performance with safety impacts. Additionally, the proposed in-line filters have not been prototyped and are not expected to meet international standards for GPS performance. The filters reject and interfere with the GPS signal in addition to the LightSquared signal. A medium risk solution requires replacement of both the GPS receiver and antenna. GPS antenna and receiver redesign is assessed as a moderate technical risk. Assuming such a design could be developed that could tolerate the LightSquared signals while still meeting aviation operational requirements, aircraft retrofit costs were estimate to be $6 billion including a cost differential for new equipment and aircraft. Since this assumption is currently unproven, considerable risk is introduced in this estimate. It is also important to note that even if such mitigation could be developed, it is expected to take 6 to 10 years to deploy. U.S market leadership in space-based navigation aviation user and provider equipment and services would also be impacted as other countries could migrate away from GPS to other systems and signals impacting U.S. aircraft operations and national security.

The scope of degradation to GPS use due to LightSquared's operations is not scalable for the purposes of estimation since the future airspace structure is based upon GPS continuity throughout U.S. airspace. After the LightSquared network is deployed, GPS is expected to be unavailable for planned aviation use over the whole of the continental U.S. based upon FAA analysis and tests. Due to the ubiquitous use of GPS, most operators would find it extremely disruptive and very inefficient to revert to operations dependent upon ground-based radionavigation aids and forfeit the safety enhancements provided by GPS.

Appendix B

LightSquared Impact to Rail Operations
Input Provided by Federal Railroad Administration

1. Summarize and quantify current and future benefits provided by use of GPS-based applications and any cost-benefit analyses that are available.

The most substantial rail-related GPS-based application is Positive Train Control (PTC). Federal Railroad Administration (FRA) regulations, mandated by the Rail Safety Improvement Act of 2008 (RSIA), require Class I railroads[2] and intercity and commuter passenger railroads nationwide to implement PTC systems by December 31, 2015. PTC systems serve to prevent train-to-train collisions, overspeed train derailments, incursions into roadway work zones, and accidents caused by railroad switches left in an incorrect position. All PTC systems require some form of transmission of positioning, navigation, and timing (PNT) information.[3] In 2009, FRA estimated that the safety benefits of PTC system implementation would total $673,801,919 over twenty years, using a 3% discount rate, and $439,705,397 over twenty years, using a 7% discount rate. When installed, FRA believes PTC systems will save 4.3 lives per year, on the average.

Freight railroads have begun to use the GPS data regarding train position and movement to enhance operational efficiency. Preliminary FRA estimates suggest that railroads could lose productivity gains (most of which accrue to society at large) of roughly $15 billion over twenty years, using a 7 percent discount factor, or $29 Billion, using a 3 percent discount factor (based on past analysis of potential system business benefits of PTC). Currently, the BNSF Railway Co. (BNSF) reports using GPS positioning data to track all of its major pieces of mobile equipment, either on-track rolling stock or off track vehicles and machines. BNSF is also feeding the data regarding loaded cars to shippers, which in turn lets shippers better plan for receipt of rail shipments and other logistics. The benefits of better information on arrivals, as well as the ability of railroads to reduce the variability of arrival times, accrue to shippers, who

[2] In 49 CFR §1201, the Surface Transportation Board defines Class I railroads as: "Carriers having annual carrier operating revenues of $250 million or more" after adjusting for inflation using a Railroad Freight Price Index developed by the Bureau of Labor Statistics (BLS). In practice, this means Amtrak and the seven largest railroads.

[3] Positioning means the ability to accurately and precisely determine one's location and orientation two dimensionally (or three dimensionally when required) in reference to a standard geodetic system (such as World Geodetic System 1984, or WGS84). Navigation means the ability to determine the current and desired position (relative or absolute) and to apply corrections to course, orientation, and speed in order to attain a desired position anywhere around the world, from sub-surface to surface, and from surface to space. Timing means the ability to acquire and maintain accurate and precise time from a standard (Coordinated Universal Time or UTC), anywhere in the world and within user-defined timeliness parameters. Timing includes time transfer.

then are likely to move more of their logistical system from highway transportation to rail transportation, saving society from significant congestion and pollution costs, as well as improving overall transportation safety and fuel efficiency.

FRA and railroads also use a GPS-based system to enhance track safety. In the field of track safety technology, almost all railroads' track safety programs use GPS data to locate and monitor track conditions, including defects in track geometry, tie condition, and rail integrity. FRA currently oversees a fleet of five automated track inspection cars. These advanced, specially designed cars utilize the GPS to provide accurate track geometry information and other track related intelligence data to assess compliance with Federal Track Safety Standards. Since 2001, this fleet has inspected 409,853 miles[4] of the U.S. rail network over a span of 2,610 days. With deployment of advanced GPS-based track inspection technologies and through strategic track inspection planning, the FRA Automated Track Inspection Program (ATIP) has achieved a 359-percent increase in inspection frequency in the last decade. Further, railroads use handheld GPS systems to augment automated track inspection efforts. For example , the Union Pacific Railroad Co. (UP) engineering group's System Tie Spotters, have walking inspectors click a button at each defective tie, locating via GPS the ties for the tie replacement program.

BNSF has implemented the Hy-rail (sic) Vehicle Limits Compliance System that uses GPS position information to prevent hi-rail vehicles[5] from exceeding the limits of their authority, preventing accidents that are often fatal.

GPS-based technology used overseas has the potential to reduce highway-rail grade crossing accidents. One such system in the United Kingdom provides information to motorists regarding upcoming highway-rail grade crossings, which can reduce the risk of collisions. Were such systems successfully implemented in the United States, FRA believes that a significant reduction in grade crossing accidents and resulting casualties would be achievable.

2. Summarize and quantify total sunk costs in GPS-based infrastructure (prior years to date) and planned investments going forward.

FRA estimates that the sunk cost in PTC systems that rely on GPS is over one billion dollars, and that railroads plan an additional $4.3 billion by December 31, 2015 in GPS-based PTC systems to meet the RSIA congressional mandate.

FRA believes that automated and manual track safety systems that rely on GPS represent a sunk cost of over one billion dollars, counting not only the cost of the GPS location information system, but the total cost of the track inspection systems on the same vehicles, because the track inspection data is not very useful unless the location of the defect is identified. This estimate is

---

[4] Source: Track Data Management System

[5] *Hi-rail vehicles* are roadway maintenance machines manufactured to meet Federal Motor Vehicle Safety Standards and equipped with retractable flanged wheelsso that they may travel over the highway or on railroad tracks.

based on a rough estimate of the number of track inspection system cars in service, and a rough estimate of the unit cost of such cars.

Further, FRA has spent $65 Million on its Automatic Track Inspection Program (ATIP). FRA owns five ATIP vehicles, which use GPS to record the location of track perturbations, including violations, defects and anomalies. FRA can also use the data from ATIP to refine its track safety standards should it determine that some anomalies that are not defects or violations are nonetheless unsafe conditions, especially if the anomalies led to accidents.

FRA also believes that sunk costs in dispatch and other systems that improve productivity based on GPS data total over one billion dollars. For example, UP, CSX Transportation, and Canadian National Railway (CN) are using a product from Lat-Lon Corporation to track equipment and reduce cargo losses. This equipment, which can be solar powered, is mounted on the piece of equipment to be monitored and is tracked using wayside units. BNSF is using GPS-based equipment to track all of its rolling stock and mobile equipment. FRA cannot provide more exact estimates of sunk costs because such data has never been collected systematically. FRA relies on experience funding joint activities with railroads, and on public statements of railroads regarding their investments in making this estimate.

3. **To the extent possible, qualify, quantify, and describe risks to your agency's GPS-based mission capability, including "lost benefits" if GPS performance were degraded (or lost) due to LightSquared's signals including the costs to modify (or replace) GPS receiver infrastructure and the time frame required to replace that infrastructure.**

If GPS performance was degraded or completely lost, the railroads' safety risk nationwide would increase dramatically. Alternate PNT information sources would be required, which would result in significant increases in PTC implementation costs and the railroads missing the statutory deadline for implementation of December 31, 2015. The engineering efforts to date would become useless. In addition, substantial PTC accident-reduction benefits in the first years would be completely unattainable and foregone. FRA estimates that in each year of full installation PTC will save $39 million in accident costs, including casualty mitigation. The costs of delay will be $39 million for each year of delay with total delay time reaching 6 years. Since the least costly version of PTC uses GPS for transmitting location information, were GPS degraded or completely unavailable, most railroads would have to switch to the transponder-based technology such as that used for the Advanced Civil Speed Enforcement System (ACSES) PTC system currently in place on the Northeast Corridor. FRA estimates that such railroads required to implement a transponder-based PTC system in lieu of a GPS-based system would face increased costs of roughly $18 billion over 20 years, using a 7 percent discount factor, or $25 billion over 20 years, using a 3 percent discount factor.

Since PTC system implementation based largely on GPS is not able to provide a positive return on investment, the increase in cost would only further exacerbate this situation. PTC system implementation costs are roughly 20 times higher than anticipated safety benefits. If GPS were degraded or lost, costs would be roughly 60 times higher than anticipated safety benefits. There would also be a tremendous loss in track inspection productivity and an increase in track-related accidents as automated track inspection vehicles could not be used to detect rail defects.

Use of such vehicles by FRA and railroads has led to significant improvements in track-related accidents. Visual inspection, the likely alternative, takes significantly longer and is not able to identify as many types of rail defects. Although some geographic position information might be derived from wheel rotations, the inspectors on the ground would not have the same level of accuracy with respect to location making this an unviable alternative. FRA believes that these systems could not be replaced, and that service failures and accidents would increase dramatically if GPS was unreliable or unavailable.

FRA and railroads would lose valuable data from track safety monitoring as current GPS systems were withdrawn from service for refitting. FRA cannot estimate how much track defects would increase, but it is reasonable to expect increased accidents costing hundreds of millions of dollars, and increased train delay costs in the billions of dollars, as well as significant decreases in the productivity of railroad track inspectors.

Without GPS, the success of the automated and manual track inspection is in jeopardy and safety gains obtained over the last decade will be lost. As noted above, FRA's ATIP program can be used to refine its regulatory program, as well as its understanding of the role of track geometry in accidents. Without ATIP, FRA, the public and the railroads would lose the benefit of a better track safety regulatory program. There is no comparable non-GPS technology to achieve the same results.

Degradation or loss of GPS would result in lost railroad productivity and could lead to rail network congestion and gridlock. Such a "meltdown" happened in the late 1990's when two large Class I railroads merged but had issues integrating their data systems.[6] Estimated costs of this event exceeded $1.1 billion in lost sales, reduced output, and higher shipping costs. The consequences of such congestion could materially harm the recovering national economy.

LightSquared claims that GPS receivers can be modified to be resistant to LightSquared's signals' interference. Assuming that LightSquared's claims are accurate and that GPS receivers could be modified to filter out LightSquared's signals' interference, if all GPS receivers had to be modified or replaced, the costs would also be significant. LightSquared claims to be exploring such modifications, but FRA cannot estimate the consequences. At a minimum, PTC systems would need to be revalidated, at costs in the $400 million range, and implementation would be delayed by more than a year. The total cost of replacing or modifying GPS systems is highly dependent on the unit cost of such modifications. Until the proposed remedy is revealed, including costs and limitations and any new PNT receiver design FRA cannot estimate total impacts. As there are currently no commercially available receivers that can exclude LightSquared's interference, and given the relatively limited market for PNT systems strictly applicable to railroads, FRA believes the costs would be significant.

Further, FRA would lose potential opportunities to reduce highway-rail grade crossing accidents through the use of GPS-based systems to alert highway users of upcoming crossings. Although

[6] Bernard L. Weinstein, Ph.D. and Terry L. Clower, Ph.D. "THE IMPACTS OF THE UNION PACIFIC SERVICE DISRUPTIONS ON THE TEXAS AND NATIONAL ECONOMIES: AN UNFINISHED STORY," Prepared for the Railroad Commission of Texas by Center for Economic Development and Research The University of North Texas Denton, Texas February 9, 1998.

such systems have not been implemented in the US, the potential to avoid grade crossing accidents would be lost.

Appendix C

LightSquared Impact to Maritime Operations
Input Provided by the Maritime Administration and the Saint Lawrence Seaway Development Corporation

1. Summarize and quantify current and future benefits provided by use of GPS-based applications and any cost-benefit analyses that are available.

MARAD

The Maritime Administration (MARAD) manages the Ready Reserve Force (RRF) which is a fleet comprised of mostly cargo and Roll-On/Roll-Off (RO/RO) vessels, currently numbering 48 vessels, whose mission is to carry DOD cargo for surge sealift purposes or when a commercial U.S.-flag vessel is not available for a cargo lift. MARAD also manages the Maritime Security Program (MSP) which is comprised of 60 U.S.-flag commercial ships which are available for the carriage of DOD cargo, as well as the use of the shipping companies' transportation infrastructure for DOD transportation needs. The RRF carry the same GPS-based equipment as commercial vessels, and follow U.S. Coast Guard standards for vessel inspection and equipment carriage.

In addition to GPS receivers which display constant latitude and longitude positions, there are several integrated ship systems that incorporate the GPS signal as an integral component of the system. These systems and equipment include the Global Maritime Distress and Safety System (GMDSS), Electronic Chart Display and Information System (ECDIS), Radar/ARPA Displays, Ship Steering Systems Utilizing GPS Waypoints, Ship Security Alert System (SSAS), Emergency Position Indicating Radio Beacon (EPIRB), Automatic Identification System (AIS) as well as INMARSAT or Fleet Broadband terminals.

In addition to ship's personnel, another group that makes extensive use of GPS-based equipment is the maritime pilots. Most pilot organizations in the U.S. use a Differential GPS (DGPS) input for their portable units used for ship navigation in U.S. coastal, harbor and river waters. Many of these pilot organizations use their own DGPS laptop systems which they carry aboard to augment the ship's equipment. The pilot laptop electronic chart systems are enhanced with features to promote safer transits than the ship's equipment alone is typically capable of providing.

SLSDC

The Saint Lawrence Seaway Development Corporation (SLSDC) is primarily tasked with safe and efficient vessel navigation of the U.S. portion of the St. Lawrence Seaway, including the two United States-operated locks in Massena, New York: Eisenhower and Snell. On March 31, 2003, the Saint Lawrence Seaway Development Corporation became the first inland waterway in the western hemisphere to implement the GPS-based Automatic Identification System (AIS). AIS is a shipboard broadcasting transponder system operating in the VHF maritime band that is capable

of sending vital information such as real-time ship identification, position, heading, and speed to the three Vessel Traffic Control Centers within the St. Lawrence Seaway system.

2. Summarize and quantify total sunk costs in GPS-based infrastructure (prior years to date) and planned investments going forward.

MARAD

Although the cost for a basic GPS receiver is relatively small, in the order of a couple of hundred dollars, the costs of the integrated ship systems that incorporate the GPS signal as an integral component of the system as listed in answer to question one, can be quite expensive. GMDSS consoles cost approximately $50K installed while ECDIS can cost up to $40K installed. INMARSAT or Fleet Broadband terminals are approximately $35K to install on board a vessel.

A conservative estimate of $100K per ship would include all the GPS-related equipment that is required to be on board a vessel greater than 300 gross tons. This size is generally the vessel size limit that mandates the outfitting all GPS-related safety and navigation equipment for larger vessels. There are approximately 200 U.S.-flag deep sea commercial vessels, and at least an equal number of coastal U.S.-flag vessel of greater than 300 gross tons. Including the vessels in the RRF with the U.S. commercial and coastal fleet, this approaches half a billion dollars for currently installed GPS-related marine equipment. The half-billion dollar mark would be far exceeded if all the inland commercial vessels that are less than 300 gross tons but still carry GPS receivers or other GPS related marine equipment were included. This is an ongoing expense due to replacement costs of outdated or defective equipment, and replacement year requirements such as the phase out of INMARSAT B terminals by the year 2014 to be replaced by Fleet Broadband terminals.

An entire generation of vessels and vessel systems has been designed and built with the anticipated benefits of uninterrupted GPS in mind. Quantifying the costs to these vessels and systems impacted by degradation of the positioning input would be difficult if not impossible. For example, the recent development of Dynamic Positioning utilized by much of the offshore oil industry is dependent on accurately knowing the vessel's position to a high degree of accuracy. Passenger ships and others also use this system in U.S. ports on a regular basis. Similarly, certain vessels use direct GPS waypoint inputs for automated steering. This could affect passenger ship/ferry operations as well as dredging, survey and research operations, among others which could be compromised.

SLSDC

The SLSDC has invested nearly $2.5 million over the years on the AIS/GPS project.

3. **To the extent possible, qualify, quantify, and describe risks to your agency's GPS-based mission capability, including "lost benefits" if GPS performance were degraded (or lost) due to LightSquared's signals including the costs to modify (or replace) GPS receiver infrastructure and the time frame required to replace that infrastructure.**

MARAD

The dollar value on potential contributory ship groundings, collisions and allusions could run into tens of billions of dollars in hull, cargo and oil pollution costs not to mention injuries and loss of life as well as economic losses to ports and corporations negatively impacted by a related incident. Many passenger vessels carry thousands of people, and transit U.S. ports on a regular basis. Any interference or degradation of the GPS signal through LightSquared utilization of interfering frequency bands is unacceptable due to potential safety, environmental and economic consequences. Likewise, the retrofit of GPS marine equipment with filters or other fixes is not practical from a deployment or an economic perspective.

Finally, this situation brings to mind the importance of alternate back-up systems for marine navigation to GPS such as e-LORAN which has recently been discontinued within the U.S.

SLSDC

The SLSDC has sought to generally understand the impact of the LightSquared network as a distinct, though not unrelated, threat to AIS as that posed by GPS Jammers. Similar to the SLSDC's September 23, 2010 memorandum detailing the impact of GPS jammers to the SLSDC, implementation of the LightSquared network could potentially negatively impact the SLSDC's AIS. While use of AIS is currently geographically based in and around the St. Lawrence Seaway and the Great Lakes, the planned size and scope of the LightSquared project as well as its tentative proximity to the GPS frequency bandwidth is of most concern for the SLSDC.

Any disruption to GPS as a result of LightSquared technology implementation may cause much larger and more systemic impacts to the AIS network than GPS Jammers. The SLSDC's GPS Jammers memorandum is an excellent resource for gathering greater technical and historical information about the AIS. Though with the potential to cause system-wide AIS disruption, GPS Jammers appear more likely to cause locality-based AIS interference. Variables to the impact of the GPS Jammer include the strength of the device used as well as its proximity to an impacted AIS device, like those located on transiting vessels and across the Seaway technical infrastructure. Conversely, geographically separated devices inbuilt to the AIS network infrastructure may be simultaneously and concurrently disrupted by LightSquared technology. Any efforts to widen implementation of the AIS system across the global maritime community would most certainly be hindered given the vast reach of the LightSquared system.

GPS-based AIS has greatly enhanced the safety and efficiency of the waterway and has improved Great Lakes Seaway System maritime security. Accordingly, the SLSDC remains committed to leveraging and utilizing GPS and AIS functionality. To the extent possible, it is in the interest of the SLSDC that LightSquared network technology be thoroughly tested, be executed carefully, and be implemented through frequent and ongoing coordination with all GPS

and AIS stakeholders. The SLSDC would support any DOT-wide initiative to better understand the radius impact of LightSquared technology, including limiting its use to bandwidths most separated from GPS and Automatic Identification System functionality.

Appendix D

LightSquared Impact to Highway Operations
Input Provided by the Federal Highway Administration

1. Summarize and quantify current and future benefits provided by use of GPS-based applications and any cost-benefit analyses that are available.

The Federal Highway Administration (FHWA) focus is primarily at the programmatic and policy level, implementing legislation that supports the development and further enhancement of the nation's road transportation system. Thus, the benefits , current and future, provide by GPS-based applications accrue more to our customers, state and local transportation agencies, than to FHWA, with one notable exception, FHWA's Federal Lands Division. This organization is focused on developing and maintaining road networks on Federal Property. However, there would be a major impact to our customers, state and local transportation agencies, who are responsible for building and maintaining our nation's road infrastructure.

Internally, benefits to FHWA accrue from reduced survey (setting control points, etc) and mapping costs, reduced time to perform project surveys, and automated construction techniques. These operations use dual frequency GPS receivers that are likely to be impacted by LightSquared's proposed broadband network.

Externally, benefits are realized through the following list of applications:

1) Positioning (includes some navigation applications where data is collected over a roadway segment):
    - Real time traffic control,
    - Vehicle tracking and dispatching (includes government (e.g. public safety, transit) and commercial fleets),
    - Determining prime locations for environmental sensors
    - Traffic data collection (including 3rd party/private sector data derived from positioning data),
    - Location stamping remote weather and road condition data from vehicle sensors
    - Work zone site management
    - Work zone performance management
    - Truck size and weight enforcement,
    - Handheld PDA electronic maps (used for navigation and to locate track and maintain all highway features)
    - Personnel locator beacons (used by avalanche and snow plow crews in mountain areas)
    - Emergency transportation operations
    - Transit signal priority systems,
    - Emergency vehicle/first responder signal priority systems,
    - Variable message sign location verification,

- Storm damage survey,
- Right of way control at Highway-Rail interface,
- Bridge health monitoring,

2) Navigation
   - Construction process and quality assurance,
   - On-demand/paratransit services,
   - Goods/cargo routing and delivery,
3) Survey
   - Roadway asset and inventory data collection
   - Establish project control for construction (either new or repair) projects
   - Determine property boundaries,
   - Various survey types including topographic, benthic, bathymetric,
4) Time synchronization
   - remote traffic control devices,
   - telecommunications networks
   - used for synchronizing highway advisory radio transmissions, ensuring adjacent transmitters do not cause interference to adjacent systems

Some of these applications are critical during emergencies. For example, in order to evacuate an affected population from an approaching hurricane, loss of signal timing and, thus synchronization, significant delays in the evacuation process would occur and increase the likelihood of the loss of life. Without the high availability of GPS timing, traffic signal synchronization on the evacuation routes would need to be done manually, slowing any evacuation.

It is difficult to place a dollar value on these benefits, but just the investment in GPS receiver and data networks to support these applications runs into the billions of dollars. State and local organizations will not invest these amounts without significant return on investment.
For reference, one organization, the North Dakota Department of Transportation, suggested that the cost of the loss of GPS to one highway construction survey for one project is on the order of $686,000 annually. Note there may be as many as three dozen projects and hundreds of minor projects ongoing at any given time.

As a second data point for costs, approximately two years ago, the Department undertook an assessment of the NDGPS service to determine what effect the loss of NDGPS would have on road transportation agencies. It was estimated that the impact would be on the order of $100 million dollars, annually. Given that NDGPS relies on GPS and GPS is used even more extensively, a larger dollar amount could be attributed to the loss of GPS. Please see the NDGPS Assessment Final Report for more details.

2. Summarize and quantify total sunk costs in GPS-based infrastructure (prior years to date) and planned investments going forward.

Again, since FHWA does not (with the exception of Federal Lands) purchase this equipment, any value is at best an estimate. As stated in the first question, state and local agencies have invested billions in equipment. In some cases this was to establish real-time GPS networks. In

other cases it is for ancillary equipment to support timing. In still others, it is end user equipment for mapping and surveying. The total outlay has been in the billions.

State and local governments are continuing to invest in new GPS-based hardware to support improvements in transportation. Improvements in reference stations and user equipment necessitate continued purchase of equipment. Existing equipment is generally not surplused, but is traded in, upgraded, or provided to different agencies for other uses. Nationwide, transportation agencies continue to invest in GPS based technologies.

3. **To the extent possible, qualify, quantify, and describe risks to your agency's GPS-based mission capability, including "lost benefits" if GPS performance were degraded (or lost) due to LightSquared's signals including the costs to modify (or replace) GPS receiver infrastructure and the time frame required to replace that infrastructure.**

In the event that GPS were lost or significantly degraded, there would likely be no visible affect on highway transportation for a short period of time, on the order of hours to days, unless a man-made or natural disaster were to occur necessitating the use of deployable systems that relied on GPS for monitoring or timing.

After this short time frame, some deterioration in traffic flow may be noted and the ability of local transportation agencies to monitor the transportation system would degraded. Additionally, the impact on drivers involved in a traffic incident could be deadly if responders are unable to reach them to provide appropriate care within the critical time frame following a severe trauma. Beyond this impact are the increased costs to move freight and otherwise deliver goods to markets across the country. It has been noted that for everyone minute that an incident remains in the highway, 4 minutes of back-up occurs. FHWA has produced documentation on the impacts of traffic incidents -including safety costs -and the cost impact on the economy in two publications available on our website. These include "Quick Clearance Laws and Policies: Best Practices" and "Planned Special Events and the Economy." Following are some statistics from these publications that illustrate the potential impact:

- Traffic Incidents comprise 25% of all congestion problems and waste 925 million hours year of driver time stuck in traffic.
- 1 minute of incident duration leads to 4 minutes of congestion backups
- TIM efforts are credited with reducing annual delay by 129.5 million hours with an associated cost savings of $2.5 billion.
- Since 2003, 59 law enforcement, 12 fire and rescue, and 54 maintenance personnel died after being struck by vehicles along the highway.
- South Carolina's Driver Removal law reduced delay by 11 percent, with an associated cost savings of $1,682 per incident.
- In a five-year study conducted in North Carolina, 1,300 abandoned vehicles were struck, resulting in 47 fatality crashes and over 500 injuries.
- In 2005, 500 fatalities were reported nationally as a result of incidents occurring on the roadway shoulder and median.
- PNT services help to get responders (transportation, police, fire, EMS) to where they need to be quickly and efficiently to clear roadways and to avoid secondary crashes or strike-bys.

After a week without GPS, additional deterioration and greater impact to the long term maintainability of the transportation infrastructure would occur. In the event of a large natural disaster, the effect could be significant in both lives affected and cost to rebuild the infrastructure.

Loss of GPS would result in decreased efficiency to goods movement and "just-in-Time" deliveries as it becomes more difficult to accurately track commercial shipments. Shipping companies would revert to previous methods od tracking including voice communications with commercial vehicle operators to determine the cargo's location and estimate delivery schedules, as well as identify an problems encountered during shipment.

Appendix E

LightSquared Impact to Intelligent Transportation System Operations Input Provided by the Research and Innovative Technology Administration

1. Summarize and quantify current and future benefits provided by use of GPS-based applications and any cost-benefit analyses that are available.

The Intelligent Transportation System (ITS) Joint Program Office (JPO) does not have any quantifiable dollar amounts associated with future benefits related to GPS-based applications. However we will be collecting benefits data in conjunction with National Highway Traffice Safety Administration (NHTSA) staff over the next two years in support of the Vehicle-to-Vehicle (V2V) NHTSA regulatory decision. In addition, the Department's V2V and Vehicle-to-Infrastructure (V2I) safety applications rely on GPS positioning solutions, and when deployed in sufficient numbers, V2V and V2I applications could potentially provide a significant future benefit in terms of tens of thousands of reduced crashes and the associated injuries and fatalities. These benefits are estimated to be quite significant when V2V and V2I are fully deployed. However, without the collection of the NHTSA data, we are not able to quantify the dollar amounts of the benefits at this time.

2. Summarize and quantify total sunk costs in GPS-based infrastructure (prior years to date) and planned investments going forward.

The ITS JPO has invested over the course of many years, several hundred million dollars in safety based research that requires GPS positioning to be effective. Therefore any loss of GPS would prevent the effectiveness of the solutions and jeopardize the considerable research investment made by both the federal government and the major automotive industry in connected vehicle safety research. Going forward, the Department is planning to invest approximately another $100M in the V2V and V2I related research that utilizes GPS positioning.

3. To the extent possible, qualify, quantify, and describe risks to your agency's GPS-based mission capability, including "lost benefits" if GPS performance were degraded (or lost) due to LightSquared's signals including the costs to modify (or replace) GPS receiver infrastructure and the time frame required to replace that infrastructure.

A degradation or loss of GPS will prevent the successful operation of V2V and V2I applications, and thereby eliminate the future benefits associated with V2V and V2I safety applications in terms of the lost opportunity to reduce crashes, injuries, and fatalities. Additionally, many of the mobility applications (dynamic routing, navigation, tracking, etc.) also rely on GPS solutions. Therefore the transportation industry involved with GPS devices has expressed concern about a loss of operations. Therefore, If GPS were lost or degraded, the millions of devices used for mobility purposes would be impacted. Significant transportation benefits such as decreased

travel times, fuel savings, and corresponding environmental benefits based on enhanced efficiency from GPS would most likely be lost.

Appendix F

LightSquared Impact to Commercial Motor Vehicle Operations
Input Provided by the Federal Motor Carrier Safety Administration

Executive Summary:

The Commercial Motor Vehicle (CMV) industry employs numerous devices that leverage the GPS signal and provide operational, safety, and security benefits. Although FMCSA, as an agency, is able to leverage the availability of locational data for the benefit of its safety oversight and enforcement programs, the Agency itself does not have any major programs that solely rely on the integrity, accuracy and continuity of GPS signal availability. There are no substantial Agency-specific GPS-based infrastructure costs to date or planned for the future.

The sunk costs for motor carriers' and their industry partners' development of GPS based technologies are also generally unknown. Furthermore, due to the nature of GPS use in the highway CMV industry, we do not anticipate any unique challenges for our Agency, CMV industry or our stakeholders that would differ from those that would be already covered under other DOT Agencies that rely more heavily on GPS signals, such as Federal Aviation Administration (FAA), Maritime Administration (MARAD) and Research and Innovative Technology Administration (RITA).

For the following reasons, FMCSA does not believe it has sufficient information to carry out a meaningful economic impacts analysis as requested:

- The technology cost-benefits analyses performed to date in the CMV industry do not isolate GPS signal dependency effects,
- In the CMV industry, GPS-enabled technologies are used for both regulated and non-regulated applications, and hence, a comprehensive estimate of technology penetration for GPS-enabled systems and products are generally unknown,
- There does not appear to be consensus on the nature and extent of the interference that was observed from tests on LightSquared's new technology, even though the tests were performed by independent parties,
- There does not appear to be consensus concerning the current or near-term availability of countermeasures to the observed interference, or the costs of those countermeasures,
- There does not appear to be consensus over how, and at what cost, newer generation GPS systems can be designed to be robust against this interference.

Given the extent of the unknowns, FMCSA was only able to compile the information below, which highlights some economic impact numbers identified in past studies that have relevance to the availability of the GPS signal.

Assumptions:

In preparing this response, the following assumptions were made:

1. Interference from LightSquared's new broadband service would primarily affect signals within a 0.25mile radius of its 38,000 planned terrestrial towers[7], representing an approximately 7,500 sq-mile (~0.2% of land) area across USA.

2. Interference in the affected region will manifest itself as GPS system reporting degradation, but the devices would self-recover to normal operation outside of the high interference zones.

3. The interference could be mitigated in newer GPS systems altogether with design changes (at unknown development and unknown incremental device costs); therefore, only legacy GPS systems would be likely to be adversely impacted.

The primary focus areas that leverage GPS in the trucking industry are:

Operational Efficiency Improving Technologies

These systems include fleet management systems, driver route guidance, commercial vehicle specific routing assistance for time- or distance optimization, pickup and delivery optimization, drayage truck operations management in and out of Nation's major Ports. Most large fleets use fleet management systems that optimize their routing, pickup and delivery schedules. These systems are often based on GPS positioning of their assets. Generally, the systems update vehicle locational data at intervals of 15 to 60 minutes, and at locational precisions of generally 10-100 meters. Thus, the need for high update rates, high accuracy or high integrity of continuous availability of GPS signals are much less stringent when compared to other transportation applications.

However, if the GPS system interference caused by LightSquared's new Broadband service can cause problems that may create lasting effects other than temporary interference, substantial efficiencies would be lost. A Motor Carrier Efficiency Study [8](MCES) conducted in 2009 concludes that there are inefficiencies totaling more than $9.67billion per year in Loading and Unloading, $900m/year in Waiting in Ports, and $2.7 billion per year in Driven Empty Miles (Table 2 in MCES report). These inefficiencies are being addressed –in parts- with GPS based technologies.

Highway Safety Improving Technologies

---

[7] On-Star's report to FCC, File No. SAT-MOD-20101118-00239; Call Sign S2358

[8] http://www.fmcsa.dot.gov/facts-research/research-technology/report/RRT_09_015_MCES.pdf

Existing systems include Driver Monitoring systems, which is a new and upcoming technology whereby individual driver's driving characteristics are monitored with on-board sensors, including GPS, and cameras. There is no independent study quantifying the economic benefits of this technology. In today's systems, the required GPS accuracy and continuous availability requirements are the same as for the operational systems described in the previous paragraph. The other key area where GPS signals are heavily relied upon (from accuracy, high frequency and high integrity availability stand points) is in emergency response vehicle (ERV) operations, such as fire-and-rescue equipment. The population size of ERVs would be relatively small; legacy GPS systems on these vehicles would likely need to be replaced (Assumption 3).

From a safety benefits standpoint, the most important upcoming technology that would be impacted is the Connected Vehicle initiatives spearheaded by RITA. Advanced Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications based collision warnings and crash avoidance technologies are seen as the next technological leap in improving highway safety. While GPS integrity risks posed by LightSquared heavily impacts these initiatives in a domain where commercial motor vehicles would also be participating,

Security Improving Technologies

Hazardous material (HM) -load tracking and cargo theft prevention are critical areas of importance not only from a safety and economic impacts standpoint but also for their national security implications. Solutions to these concerns rely heavily on GPS signals for periodic or event-triggered monitoring of vehicles and/or loads. There have been studies where economic impacts of these solutions have been explored. For instance MCES study suggests that the potential socio-economic gains in resolving cargo theft and pilferage problems in the commercial motor vehicle industry are in the order of $15-$30b annually. A 2004 study "Hazardous

Materials Safety and security Technology Field Operational Test Evaluation" quantifies costs and benefits for tracking of HM cargoes and the highway CMVs transporting them. Although these technologies often involve GPS signals[9], the main difference between the general freight operational applications and HM applications is the location tracking rate – for HM, the locations may be updated as often as every 5 minutes. It is unknown how the interference from LightSquared's terrestrial towers may impact the tracking requirements of these systems. The same study cites that at the time of the study there were approximately 709,000 trucks associated with 26,760 U.S. fleets hauling HM. FMCSA is not aware of publicly-available data on the percent of fleets/vehicles currently featuring cargo theft prevention systems.

CMV Enforcement Improvements

In April 2010, FMCSA published a final rule that established new performance requirements for electronic on-board recorders (EOBRs), used to record drivers' hours-of-service information. (Recording of HOS information is required under 49 CFR 395). The April 2010 rule mandates the use of these devices only for motor carriers found by the Agency to have severe HOS violations. The Agency published a follow-on Notice of Proposed Rulemaking in February 2011

[9] http://ntl.bts.gov/lib/jpodocs/repts_te/14095_files/index.htm

that would significantly expand the population of motor carriers required to use EOBRs. This rule does not specifically require EOBRs to use the GPS signal and the spatial and timing accuracy requirements[10] are similar to those for other motor carrier operational oversight applications, and the nature of the interference foreseen is based on our stated Assumptions.

In addition, FMCSA is working with RITA's Intelligent Transportation Systems Joint Program Office and Federal Highway Administration on Smart Roadside Initiative (SRI) and Wireless Roadside Inspection (WRI) projects which aim to streamline roadside inspection processes through the use of technologies that leverage wireless connectivity and GPS-based timing and positioning information among others. The MCES report indicates that weigh in motion systems have the potential to provide $461m/year in societal benefits. While aspects of SRI and WRI may use GPS based functions for such tasks as geo-fencing, timing and positioning, there is no existing study that isolates the benefits uniquely attributable to GPS signal use.

[10] Positioning accuracy is stated in terms of "nearest town". Minimum update rate of positioning logging with the stated accuracy is every 60minutes. Maximum allowed deviation from coordinated universal time is 10minutes.

Appendix G

LightSquared Impact to Nationwide Differential GPS
Input Provided by the Research and Innovative Technology Administration

1. Summarize and quantify current and future benefits provided by use of GPS-based applications and any cost-benefit analyses that are available.

The Nationwide Differential GPS System (NDGPS) is an enabling technology, providing a highly reliable GPS integrity function to meet the growing public and private sector reliance for transportation, agricultural, environmental, natural resource management, surveying, weather forecasting and other applications. NDGPS service is provided free of direct user fees to meet the needs of federal agencies, state agencies, industries, universities and the general public.

NDGPS provides support infrastructure for several U.S. DOT research projects, and bears opportunities for future cross-modal transportation safety, security, efficiency and emergency response applications. NDGPS is the only existing national infrastructure system potentially capable of providing a timing reference to backup GPS.

At the direction of the National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT EXCOM), RITA completed a systems analysis and user assessment of current and potential future NDGPS requirements for transportation and other applications. "NDGPS Assessment: Final Report" estimated return on investment on NDGPS funding in terms of Federal cost avoidance alone was estimated conservatively at 87:1; the value of private sector and state and local government use of NDGPS far exceeds this figure. (http://www.navcen.uscg.gov/pdf/ndgps/ndgps%20assessment%20report_final.pdf)

There are many possible opportunities for NDGPS use across surface transportation and other terrestrial applications. A selection of these opportunities includes:

- Under National Security Presidential Directive (NSPD)-39, "U.S. Space-Based Position, Navigation, and Timing Policy," DHS is responsible for "the use of positioning, navigation, and timing capabilities and backup systems for ... Federal, State, and local governments." NDGPS is an existing national infrastructure system that is being researched to provide a non-GPS broadcast system timing reference to backup GPS timing.
- DOT is continuing to pursue potential high accuracy (HA-NDGPS) upgrade (1 cm accuracy). The HA-NDGPS research program goal is to develop an inexpensive technique to achieve sub-decimeter active navigation (vs. static positioning) using existing infrastructure to the maximum extent possible. Results to date indicate that HA-NDGPS has the potential to enable Intelligent Transportation System and Intelligent Railroad System safety technologies and other dynamic location-based applications in both urban and rural areas, and significantly improved services to existing users.

- The U.S. Department of Agriculture (USDA) sponsored a 2011 study, "evaluating the potential for new civil user services that could be provided from NDGPS sites," which identified fifteen classes of technical concepts, at different levels of technical readiness, which could be enables through current, expanded, or enhanced NDGPS services. All will require budget, requirements, and policy decisions by other civil agencies or the private sector to pursue. These categories include:
    1. GPS Monitoring
    2. Positioning (Ranging) Source (GPS backup)
    3. Timing Source (GPS backup)
    4. HA-NDGPS – Expanded Coverage
    5. GPS Pseudolites
    6. Diplexing Signals
    7. NDGPS + WAAS Applications
    8. New NDGPS Messages
    9. NDGPS Compass
    10. Broadcast Telecommands/Remote Commands
    11. Signal Overlays
    12. Networked NDGPS Corrections
    13. Wi-Fi / Internet Access
    14. Real-Time NDGPS Info on Internet
    15. Tropospheric Modeling.

2. Summarize and quantify total sunk costs in GPS-based infrastructure (prior years to date) and planned investments going forward.

The DOT-funded (inland or terrestrial) NDGPS sites represent $71.790 M in direct DOT funding for GPS-based infrastructure (FY 1998 – FY 2011). An additional $25M in funding has been provided state and local partners for specific site development for a total investment of approximately $97.0M.

Pending Congressional action, planned investments going forward include:

- Annualized operations and maintenance: $5.6M/year
- Recapitalization of NDGPS equipment: $4.0M
- Completion of NDGPS single coverage across 100% CONUS (seven sites): $5.6M
- Completion of NDGPS dual coverage across CONUS (26 sites): $46.8M

3. **To the extent possible, qualify, quantify, and describe risks to your agency's GPS-based mission capability, including "lost benefits" if GPS performance were degraded (or lost) due to LightSquared's signals including the costs to modify (or replace) GPS receiver infrastructure and the time frame required to replace that infrastructure.**

Based on the reports of the National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum (NPEF) which was tasked to assess the GPS impacts of LightSquared's deployment plan, and the GPS Technical Working Group (TWG), NDGPS would be unable to operate if LightSquared operations were allowed to proceed as planned.

As a cross-modal service, NDGPS is funded through the Research and Innovative Technology Administration (RITA), but RITA has no mission requirements for NDGPS. However, NDGPS provides mission capabilities to other Federal agencies and their partners at all levels of government, all of which would lose NDGPS availability if LightSquared were allowed to operate as planned. RITA cannot estimate the costs or schedule for mission agencies to replace the NDGPS infrastructure with another service, or even if such a replacement is possible.

In addition to providing a real-time broadcast of differential corrections, the combined NDGPS utility provides a robust operational backbone to the U.S. Department of Commerce and other users for the following activities:

- National Oceanic and Atmospheric Administration's (NOAA) Continuously Operating Reference Station network that enables post-processing survey applications, Web-enabled location solutions, and maintenance of the National Spatial Reference System;
- NOAA's Earth System Research Laboratory for short-term severe weather and precipitation forecasts, and transportation safety research applications; and
- Ionospheric monitoring by NOAA's National Weather Service Space Weather Prediction Center.

A non-exhaustive selection of other community uses includes:

- State DOTs and Highway Community – survey, construction, quality, asset management, roadside management, law enforcement, snowplow guidance.
- DHS – GPS Interference Detection and Monitoring program.
- USACE – dredging, underwater surveying, aids to navigation.
- St. Lawrence Seaway – Supporting navigation in the St. Lawrence Seaway, in cooperation with Canada.
- Department of Agriculture/Department of Interior and Resource Management Agencies – one meter real-time positioning and navigation for lands and environmental management, fire management and safety.
- State and local government agencies – state and local transportation, natural resources, environmental protection, agriculture, and parks agencies.
- National Precision Farming Association – optimized plowing of crop rows, tailored applications of seeds, fertilizer, water, pesticides, precise leveling of fields.
- Professional Land Surveyors – precision survey, mapping, Geographic Information Systems
- Research Requirements – Alliance of Automobile Manufacturers, Advocates for Highway and Auto Safety, Association of American Railroads, FHWA, FRA.