SPACE-BASED POSITIONING NAVIGATION & TIMING
NATIONAL ADVISORY BOARD

June 13, 2016

Deputy Secretary of Defense Robert O. Work
Deputy Secretary of Transportation Victor M. Mendez
National Executive Committee for Space-based Positioning, Navigation and Timing
Herbert C. Hoover Building, Room 2518
1401 Constitution Ave., NW
Washington, D.C. 20230

Subject: Spectrum Repurposing and Interference with Space-Based Positioning, Navigation, and Timing (PNT) Services

Dear PNT EXCOM Co-Chairs,

Your Space-Based Positioning, Navigation, and Timing Advisory Board (PNTAB) is writing to express concern over an issue now being (re)considered by the Federal Communications Commission (FCC) with potentially grave consequences for the use of the Global Positioning System (GPS), with wider implications for all other commercial and government satellite systems. The issue concerns the repurposing of frequency bands adjacent to those allocated for use by GPS to allow high-power terrestrial broadband services. Unfortunately, the latest Ligado proposal being considered by the FCC is not materially different from the previous LightSquared proposal which the PNT Executive Committee (EXCOM) unanimously rejected with its January 2012 letter to the National Telecommunications and Information Administration (NTIA), based on the widespread radio frequency interference (RFI) observed in extensive laboratory and live-sky testing conducted in 2011.

The operation of high-power terrestrial mobile wireless transmitters in a frequency band immediately below where GPS operates is arguably the worst possible use of two adjacent radio frequency bands – space-based navigation and terrestrial wireless broadband communications – for the following reasons. First, GPS is not a communications system. It is a radionavigation system that relies upon nanosecond-level (a billionth of a second) synchronization of transmitter and receiver clocks via one-way signals. The 50 bit-per-second data message included in the GPS signal is of secondary importance to the formation of precise measurements of the distance traveled by a radio signal moving at the speed of light. In contrast, terrestrial networks designed for high-speed communications, such as streaming video to mobile phones, transfer data at rates on the order of 10 million bits per second – a fundamentally different use of the radio spectrum than one-way satellite ranging. Second, GPS is a space-based system, subject to the immutable laws of physics that dictate that signals arriving from satellites in orbit over 20,000 km above are weaker than even the miniscule natural radiation generated by the Earth itself.

In fact, the FCC acknowledged the unique nature of satellite systems in its 2003 ruling to allow "ancillary" terrestrial transmitters in the Mobile Satellite Services (MSS) band adjacent to GPS: "*We will authorize Mobile Satellite Service (MSS) Ancillary Terrestrial Communications (ATC) subject to conditions that ensure that the added terrestrial component remains ancillary to the principal MSS offering. We do not intend, nor will we permit, the terrestrial component to become a stand-alone service*."[1] And yet, it is now clear that terrestrial broadband is the primary service proposed for a band previously reserved for satellite services.

In spite of these unique characteristics, many parties are calling for "sharing" of spectrum used by, or adjacent to GPS and other space systems with terrestrial services. True "sharing" of radio spectrum is only possible among ***compatible*** systems. Sharing without compatibility is repurposing by another name, and a recipe for harmful interference. That is why the DOT Adjacent Band Compatibility (ABC) study is so important.

One would also be hard pressed to find a more successful example of true radio spectrum sharing than that of GPS and other Global Navigation Satellite Systems (GNSSs). While billions of people worldwide use GPS and GLONASS signals in the 1559-1610 MHz L1 frequency band every day, careful spectrum management and international regulatory practices have allowed no less than two entirely new GNSS systems (Galileo and BeiDou) and two entirely new regional navigation systems

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[1] FCC-03-15A1. Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands. Release date 10 Feb 2003. (https://apps.fcc.gov/edocs_public/attachmatch/FCC-03-15A1.pdf)

(QZSS and NAVIC, formerly known as IRNSS) to deploy initial services in the last decade without causing interference, because they were proven to be ***compatible*** with the incumbent services.

Within the scope of critical use and investment in the United States alone, a recent GPS Economic Assessment performed for the PNT EXCOM found that over half the US$55B annual benefit of GPS comes from the *Precision* class of GPS receivers. These *Precision* receivers provide sub-centimeter-level positioning accuracy and require picosecond-level measurement precision, which must be protected. In addition, most high-precision receivers utilize more accurate carrier phase measurements and differential networks of receivers, in which interference to one receiver can severely degrade accuracy. Therefore, the interference to precision receivers must be assessed as part of any compatibility study. In addition, thousands of precision *Timing* receivers are used throughout the U.S. critical infrastructure such as cellular networks and electrical power grids. Thus, impacts to precision *Timing* receivers must be assessed against the final, true operational configuration of the proposed Ligado architecture, including both uplink and downlink transmitters.

As noted above, GPS, as well as other established GNSS constellations, are critical to all current and future civil and military PNT applications. A partial list of key application categories amongst 64 specific applications is attached as a sample of what is being put at risk. The list continues to grow each year as a result of global innovations. Because of this critical dependence, and the unique technical features of space-based PNT as discussed above, it is essential that decisions affecting GPS and GNSS spectrum be made using a process that is fully transparent, technically valid, and based on a solid foundation of regulatory precedence. Responsive, comprehensive testing will include actual live-sky testing to ensure real-world compatibility for public safety applications in critical safety-of-life environments, as the stakes are too high for partial regulatory actions based on limited "moving-target" paper architecture plans with unproven effects. The operational "burden of proof" remains on any new entrant seeking to modify long established precedent and worldwide safety practices.

This vital importance of protecting the Radio Navigation Satellite Service (RNSS) for all GNSS constellation services is also institutionalized within the International Telecommunication Union (ITU) Radio Regulations, which have been adopted by the U.S. with treaty-level status. So unless the United States plans to take an exception to the existing Radio Regulations, we have a national requirement to protect RNSS bands from interference. Also, protection of critical RNSS bands is in direct support of National Space and PNT Policies and has therefore been publicly advocated by the United States in international forums for decades. This enables the full potential of multi-constellation GNSS receivers to be realized by the U.S. and allied partners, with the promise of increased availability, accuracy, and integrity for all classes of space-based PNT users. Therefore, interference impacts to both GPS and GNSS receivers must be assessed in order for prudent regulatory decisions to be made.

As testing continues on these receiver types in support of reaching technical truth for any potential regulatory action, the PNTAB, representing expertise from all major GPS sectors, also insists that the 1 dB degradation Interference Protection Criterion (IPC) is the only acceptable method for protecting space-based PNT services. The 1 dB IPC is backed by decades of regulatory precedence and has been used to protect GPS and other radio systems such as radars. Most recently, the 1 dB IPC was mandated by the NTIA for the 2011 National PNT Engineering Forum (NPEF) testing of the LightSquared proposal, the results of which are cited in the January 2012 PNT EXCOM letter to NTIA[2].

Other GPS receiver metrics such as position error are products of the receiver's navigation algorithms, not the radio "front end" of the GPS device where harmful interference first occurs. GPS/GNSS receivers must therefore be protected in all phases of operation, including signal acquisition and reacquisition, when these receivers are most susceptible to interference. The 1 dB IPC achieves this goal, and is especially critical to ensure safety-of-life applications can be assured in busy spectral environments where multiple emitters will operate.

In summary, the PNTAB recommends the following six key criteria for assessing interference to GPS and GNSS applications:

1) Adhere to the 2012 EXCOM letter guidance to ensure that new spectrum proposals "are implemented without affecting existing and evolving uses of space-based PNT services"

2) Strictly apply the 1 dB degradation Interference Protection Criterion (IPC)

3) Protect all classes of GPS receivers, including precision and timing receivers

4) Protect GPS receivers in all receiver operating modes, including signal acquisition/reacquisition

5) Protect all uses of all emerging GNSS signals

[2] PNT EXCOM letter to NTIA, 13 January 2012, (http://www.gps.gov/news/2012/01/lightsquared/2012-01-13-LightSquared-letter-to-NTIA.pdf)

6) Use maximum authorized transmitted interference powers and propagation models that do not underrepresent the maximum power of the interfering signal (particularly consider the impact of multiple transmitters creating additive interference)

The PNTAB strongly endorses the Department of Transportation (DOT) Adjacent Band Compatibility (ABC) assessment as the most scientifically valid approach to date for protecting space-based PNT based on the above criteria. We urge the PNT EXCOM to ensure the ABC study is provided the time and resources necessary to complete its work, and to base its regulatory recommendations on the results of the study when they are available. We also wish to express our gratitude to DOT for their tireless efforts to preserve GPS services as a matter of national priority.

Finally, it is important to note that what happens in this matter will establish regulatory precedence that will be applied to repurpose frequency bands adjacent to those used by all other commercial and U.S. government satellite systems. We therefore urge U.S. regulators to carefully consider the long-term consequences of any such regulatory decisions. If what amounts to a dangerous regulatory experiment is allowed to occur in the spectrum adjacent to GPS - the central pillar of U.S. commercial, scientific, and military PNT services - no space system foundation is safe.

Respectfully,

John Stenbit

John Stenbit
Chair, National Space-Based PNT Advisory Board

cc:
NASA Administrator, Hon. Charles F. Bolden
NASA Deputy Administrator, Hon. Dava Newman
PNT National Coordination Office (NCO)
PNT EXCOM Departments and Agencies

Attachment 1:

Twelve Major GPS Application Areas – *64 Examples*
(Red Underlined are ***Precision*** Examples)

Application Area	Example Applications
Aviation	Area navigation, **approach**, **landing up to Cat III**, **NextGen**
Agriculture	AutoFarming: crop spraying, **precision cultivating**, **yield assessment**
Automotive	Turn-by-turn guidance, OnStar, **driverless cars**
Emergency and Rescue Services	911, ambulance, fire, police, **rescue helicopters**, emergency beacons, airplane and ship locaters, OnStar
Intelligent Transport	**Train control and management**, UAVs, **Intelligent Highways**
Military	Rescue, **precision weapon delivery**, unit and individual location, CONUS test and training range safety, control
Recreation	GeoCaching, control of models, hiking, outdoor activities
Robotics and Machine Control	**Bulldozers**, **Earth graders**, **mining trucks**, **oil drilling**
Scientific	**Earth movement** and **shape**, **atmosphere**, weather forecasting, climate modeling, ionosphere, **space weather**, **tsunami warning**, soil moisture, ocean roughness, wind velocity, snow, ice, and foliage coverage.
Survey and GIS	**Mapping**, environmental monitoring, tagging disease outbreaks
Timing	Cell phone towers, banking, power grid
Tracking	Fleets, assets, equipment, shipments, children, Alzheimer’s patients, wildlife, animals, law enforcement, criminals, parolees