Communications Sector

Use of Positioning, Navigation and Timing (PNT) Services

These comments are based upon public and private assertions made by representatives of this Critical Infrastructure/Key Resource (CI/KR) sector and PNT subject matter experts that have examined such issues. Some members of CI/KR sectors might not provide public comment out of a desire to avoid disclosing vulnerabilities and/or proprietary information. Therefore, the RNT Foundation is providing this response for the public record "on their behalf." See explanatory notes at the end of this document.

GPS PNT services have been integrated into virtually every technology and are a critical to nearly every facet of life in America. As such, their impact on one sector very much impacts another. For example, the transportation and communications sectors both of rely heavily on GPS, and all sectors rely heavily on transportation and communications. The comments in this response try to address only the ways in which GPS/ PNT services are uniquely used by this sector.

These comments have been structured to respond as directly as possible to the questions posted in the Federal Register (***bold italics*** below).

(a) A brief description of your application(s) of positioning, navigation, and timing services;

Sidebar – Presidential Policy Directive 21 notes that the Communications Sector is a critical infrastructure because it provides an "enabling function" across all critical infrastructure sectors. **Consequently, the Communications Sector's PNT requirements can be considered the requirements for every critical infrastructure sector.**

1 – Synchronization of Cellular Networks These networks normally require GPS or UTC traceable time and a degree of relative phase alignment between non-collocated elements.

2 - Evolving Federal Communications Commission Enhanced 911 (E911) Synchronization plays a key role in mobile location.

3 – WiFi/ Wide Area Local Networks Synchronization is currently little used in WiFi networks, though with constantly evolving demand and alternatives, that may change.

4 - Upcoming Shared Spectrum will require position and synchronization, and offer licensed and unlicensed, WiFi-like services.

5 – Land Mobile Radio & Paging As was seen during the 2007 San Diego accidental GPS jamming incident, Pager Provider Networks are still in use, especially by First Responders (i.e., doctors). As of 2013, the medical industry, particularly doctors and nurses, continued to rely on pagers, even when they might also carry a smartphone. Pagers rely on GPS for timing.

(b) the positioning, navigation, and/or timing performance required for a complementary PNT capability to support operations during a disruption of GPS that could last for longer than a day,

To qualify as a "complementary" system, a new PNT capability would need to:

1. **Provide very wide area, precise, wireless location and timing services.** The timing signal would need to be synchronized with UTC (and therefore GPS, when in it is in operation) and location information would have to correspond to that obtained from GPS as closely as possible.
2. **Have features and/or capabilities not available with GPS.** Without such it would be a "duplicate" or "redundant" service, vice "complementary." Desired features for special-purpose users, such as First Responders and the military, include a signal that is usable under foliage, underground (i.e., garages), indoors and that has a robust, security-capable, data channel for differential corrections and other information.
3. **Likely remain functioning in situations when GPS is disrupted.** The complementary system should have different signal characteristics, and therefore different failure modes, than GPS. These include a signal that is terrestrial based, high power and in a frequency band far distant from that of GPS.

1 – Synchronization of Cellular Networks The Alliance for Telecommunications Industry Solutions (ATIS) has advised the Department of Homeland Security that "…LTE-Advanced frequency and phase requirements are +/- 50 parts per billion (ppb) and 1.5 microsecond (µs), respectively…"[1] A copy of this document is included at the end of this submission.

2 - Evolving Federal Communications Commission Enhanced 911 (E911) +/- 100 nanoseconds[2]

(c) availability and coverage area required for a complementary PNT capability,

Availability – Any system intended to complement GPS should have the same availability as the GPS system.

Coverage - As illustrated in the graphic at the end of this paper, a multi-layer model provides the best PNT resiliency. eLoran complements GPS/GNSS' global coverage, provides continental PNT coverage, and complements or enables local PNT coverage.

Comments for 1 – 3: Synchronization of Cellular Networks, **Evolving Federal Communications Commission Enhanced 911 (E911), WiFi/ Wide Area Local Networks:**
Coverage should be congruent with national cellular networks and population centers.

4 – Land Mobile Radio & Paging Coverage should be ubiquitous in US territory and throughout the US maritime Exclusive Economic Zone. Land mobile radio systems are used by first responders and others who often operate in unpopulated areas with no or poor cellular service. Wireless, precise, synchronized time to complement GPS will undoubtedly be a FirstNet requirement.

[1] http://www.atis.org/WSTS/papers/COAST-SYNC-2014-Letter_Final.pdf
[2] Ibid

(d) willingness to equip with an eLoran receiver to reduce or prevent operational and/or economic consequences from a GPS disruption,

Note: Our interaction with receiver manufacturers causes us to believe this question to be irrelevant except for the first few years of an eLoran system's operation. Once an eLoran system is in operation and receivers are in wide production, the size, weight, power, and cost (SWAP-C) of the receivers will decrease dramatically. We expect most commercial grade navigation receivers to be "multi-mode", having the capability to receive GPS/GNSS and Loran/eLoran. Many receivers might also include inertial, gyro, CSAC, and/or barometric altimeters. Thus it will not be a matter of a user's "willingness to equip," but rather that the market will be automatically equipping the user. As one manufacturer expressed it: "Except for niche applications, building GPS-only receivers wouldn't make sense."

1 – Synchronization and Mobile Location over Cellular Networks A precise wireless time signal that penetrated and was available inside buildings such as Assisted GNSS (A-GNSS) or eLoran, would have distinct advantages over traditional systems and will provide savings. It could be more reliable, , and be less expensive than current methods. Additional cost savings could be realized by eliminating specialized networks, cable runs and antennas on the roof for base stations located in buildings, especially when the owner of the base station does not also own the building. A-GNSS further provides features for Indoor E911 and Spectrum Sharing while also mitigating common forms of jamming.

2 - Evolving Federal Communications Commission Enhanced 911 (E911) Many law enforcement units have the ability to jam cell phone and GPS signals during exigencies. This can deny time services to an emergency scene just when they are needed most. A second source could provide wireless precise time and location, as well as messaging capability in such events.

(e) current and planned availability of e-Loran capable user equipment,

Loran-C and/or Chayka user equipment is now produced by the governments of China and Russia for internal consumption and use with their national systems. Outside of those countries, Loran-C and eLoran receivers are produced in limited quantities, on demand. RNT Foundation discussions with several large receiver manufacturers have indicated that they would readily pursue development of integrated receivers that include eLoran capability if there were Government support for the provision of eLoran service. The estimated economic order quantity for these vendors is approximately 100,000, although the number of units depends upon the market sector served. Also, once this level of production has been achieved, the size of receivers will undoubtedly be reduced to be compatible with many mobile devices, and the price per unit will drop dramatically (as was the case with GPS technology).

The US Army has extensive information on this as a result of a recent RFI for 50,000 eLoran receivers.

(f) other non-eLoran PNT technologies or operational procedures, currently available or planned, that could be used during a disruption of GPS for longer than a day.

Sidebar: In 2011 Mr. James Caverly, at that time working for the DHS Office of Infrastructure Protection, reported on the department's "**GPS Critical Infrastructure Timing Study: Usage/Loss Impacts/Backups/Mitigation.**" This report has never been made public, to our knowledge. A publicly released presentation based on the report provides information about requirements and backup systems for all critical infrastructure sectors and cites the situation generally as worsening.[3]

1 – Synchronization of Cellular Networks

Base stations are equipped with oscillators of varying quality to provide holdover time for when the GPS signal is disrupted. However, even rubidium oscillators are insufficient to hold time for 24 hours to support LTE.

Use of GNSS provided by other nations might be a possibility, though they broadcast in the sae general frequency band and are vulnerable to the same kind of environmental and malicious interference as GPS. Additionally, the wisdom of relying on another nation's system to provide security for US CI/KR may be questionable.

Efforts to provide time over networks are being investigated, but appear to be expensive while not having the desired reliability and accuracy.

2 - Evolving Federal Communications Commission Enhanced 911 (E911) As this is an evolving requirement and program and we will be monitoring its progress.

Explanatory Notes:

1. The Resilient Navigation and Timing Foundation (RNTF):

RNTF is a scientific and educational 501(c)3 non-profit dedicated to helping protect critical infrastructure through (a) stronger laws and better enforcement against jamming and spoofing of GNSS signals, and (b) encouraging strong, difficult-to-disrupt terrestrial systems to complement and provide additional resilience for GNSS.

Our corporate membership includes providers of a broad spectrum of PNT services from development of GPS satellites, to local and indoor positioning systems, and wide area low frequency systems, and some of the world's leading navigation associations. Individual members are concerned citizens and PNT professionals from academia, industry and government.

2. The Reason We Are Providing These Comments:

[3] http://rntfnd.org/wp-content/uploads/James-Caverly-DHS-GPS-PNTTimingStudy-SpaceWeather4-27-111.pdf

Our nation's increasing reliance on GPS location and timing information for a very broad spectrum of technologies represents, in the words of Dr. Brad Parkinson, "… a single point of failure for much of America…" We believe that national effort to provide and encourage adoption of diverse sources of location and timing information, provided by both federal and private entities, are essential to our national and economic security.

We believe responses to this request for comment may be limited by individual companies' reluctance to air their vulnerabilities or the perception that they would be revealing proprietary information.

3. How These Comments Were Developed:

The information provided was developed in coordination with our members who have had extensive interaction with the critical infrastructure sector being addressed. Information available in the media, professional discussion sites and other "open sources" has also been included.

4. eLoran:

The request for comment mentions in several places a possible "eLoran" system. Such technology is not generally known in the United States, even though it was developed here.

For purposes of this response, we presume that the eLoran system mentioned is similar to the one in operation in the United Kingdom as recently described in a paper presented to the Institute of Navigation[4]. With appropriate ASF corrections, this system's accuracy has been measured at less than 25 feet for location and less than 50 nanoseconds for timing. While we understand that the Dutch have improved on these results, the underlying system is still eLoran. While most technologists agree that much better performance is possible with further system development, our presumption is that the system the government refers to is the one described in the referenced paper.

5. The Importance of Quickly Implementing a Complementary System for GPS

We are unable to improve upon the 2004 Presidential National Security Directive 39 issued by President Bush and affirmed by President Obama that identified GPS as essential to our national economy and national security, and mandated acquisition of a "back-up" system – though we agree that a more appropriate descriptor would be "complementary" system.

Since 2004 threats to GPS have increased, as have the number of disruptive incidents per day. The threats range from fleeting local disruptions such as might be caused by a private citizen passing by with an illegal "Personal Privacy Device," to a global outage resulting from malicious intervention or simple human error.

GPS is currently being modernized and made more resilient. It is also being joined by other modern systems, including Galileo (Europe), Beidou (China), QZSS (Japan), INRNSS (India). GLONASS (Russia) is being upgraded over a longer time period to include digitally modulated

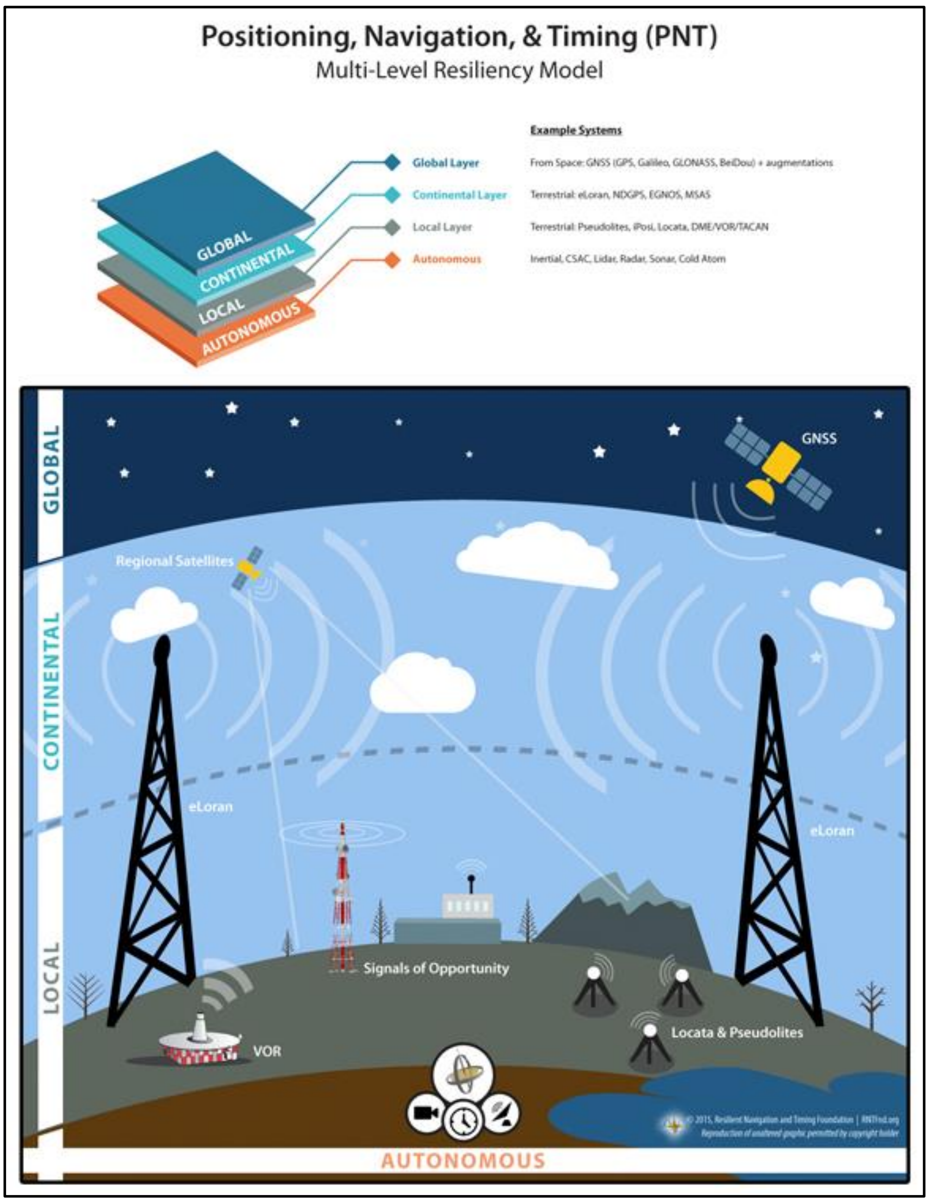
[4] http://rntfnd.org/wp-content/uploads/2015-ION-ITM-Offermans-eLoran-IOC-in-UK-final-4Feb.pdf

signals. These have certain resilience features for GPS. These are all positive developments that should be continued in order to improve the overall resilience of our global PNT architecture.

In April of last year, GLONASS, the Russian satellite navigation and timing system, experienced two unannounced outages, one of which lasted for eleven hours. If this were to happen to the GPS constellation, unless there were complementary systems, such as other GNSS or eLoran, that users had adopted and which would prevent PNT service disruption, the impact to our critical infrastructure and economy would be widespread and serious.

The larger question, beyond those that the Department of Transportation has posed in the Federal Register, is:

What would happen to our CI/KR, to our nation, and to the daily lives of its citizens, should there be a 24-hour disruption of GPS for any reason?



1200 G Street, NW
Suite 500
Washington, DC 20005

P: 202-628-6380
F: 202-393-5453
W: www.atis.org

March 11, 2014

Via Email
Helen Jackson (helen.jackson@hq.dhs.gov)
NSTAC Designated Federal Official
Department of Homeland Security
NPPD/CS&C/SECIR Division

Re: Recommended Updates to Telecom Vulnerability to Loss of GPS Signals Documentation

Dear Ms. Jackson:

The Alliance for Telecommunications Industry Solutions (ATIS), on behalf of its Copper/Optical Access, Synchronization and Transport (COAST), wishes to provide the attached document containing recommendations to the Department of Homeland Security to update and verify the information contained in *National Security Telecommunications Advisory Committee (NSTAC) Report to the President on Commercial Communications Reliance on the Global Positioning System (GPS) (2008 NSTAC Report)*.

ATIS is a leading technology and solutions development organization. Through ATIS forums, nearly 200 companies address priorities such as cloud services, device solutions, emergency services, cyber security, network evolution, and quality of service. COAST, one of ATIS' 15 industry forums, develops standards and technical reports related to telecommunications network technology pertaining to network synchronization interfaces over copper and optical mediums, and hierarchical structures for U.S. telecommunications networks. COAST Synchronization (SYNC) Subcommittee is responsible for validating the network interface standards developed within COAST, to ensure successful synchronization between carriers.

Wireline and wireless networks have dramatically changed since the publication of the *2008 NSTAC Report*. The progression of new infrastructure and technologies significantly impact synchronization of network interfaces. These changes have resulted in the exposure of commercial communications systems to the loss of GPS signal. LTE and LTE-Advanced systems are particularly sensitive to this loss of signal, and the risk of such loss has increased. Therefore, COAST SYNC believes there is value in validating the assumptions made in the *2008 NSTAC Report*.

Letter to H. Jackson
March 11, 2014
Page 2

In the attached document, COAST SYNC identifies the specific report assumptions that should be verified against a recommended series of contemporary technology considerations. COAST SYNC also proposes a study be launched to consider the vulnerability of current communications systems and threat scenarios.

If you would like additional information or if you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

Thomas Goode
ATIS General Counsel

cc: Ken Biholar, ATIS COAST Chair
Bill Szeto, ATIS COAST Vice Chair
Lee Cosart, ATIS COAST SYNC Chair
David Overdorf, ATIS COAST SYNC Vice Chair
Jackie Voss, ATIS Manager, Global Standards Development
Steve Barclay, ATIS Director, Global Standards Development

Recommended Updates to Telecom Vulnerability to Loss of GPS Signals Documentation

A number of communications systems and requirements have changed since the publication of the February 28, 2008, *National Security Telecommunications Advisory Committee (NSTAC) Report to the President on Commercial Communications Reliance on the Global Positioning System (GPS) (2008 NSTAC Report)*. The following concerns have been identified by the Alliance for Telecommunications Industry Solutions (ATIS) Copper/Optical Access, Synchronization and Transport Committee (COAST) based on the *2008 NSTAC Report* relating to the exposure of commercial communications systems to a loss of the GPS signal:

- There are new requirements for more accurate synchronization. Universal Coordinated Time (UTC) traceable time and relative phase alignment between non-collocated elements are required and are more difficult to achieve without GPS. These transitioning wireless technologies require expensive backup systems to holdover at a temporary loss of the GPS signal. For example, LTE and LTE-Advanced frequency and phase requirements are +/- 50 parts per billion (ppb) and 1.5 microsecond (μs), respectively, at the air interface. It is a significant challenge and expense to meet these requirements during a GPS outage.
- The evolving Federal Communications Commission enhanced 911 (E911) location requirements lead to a significant synchronization requirement of approximately +/- 100 nanosecond (ns) accuracy to UTC at the air interface for most macro cell towers. With the LORAN systems decommissioned, GPS is currently the only technology that can meet synchronization requirements for E911 as there is no other widely available access to UTC time of day in the United States. As a result, there is a stringent GPS UTC requirement at base stations.
- There is an industry migration from time-division multiplexing (TDM), synchronous optical network (SONET) based infrastructure, toward an all-IP network. This will result in the removal of portions of SONET as the base transport, and the implementation of native IP networks (*i.e.*, those with no synchronization support). The native IP networks themselves cannot provide frequency, phase and time; therefore, GPS is required for synchronization applications. Thus, there is an increased vulnerability to the loss of GPS.

Based on the changing environment and technological advances since the publication of the *2008 NSTAC Report*, ATIS COAST SYNC recommends the following:

- The assumption that GPS outages would be localized and of a short duration should be revisited.
- The assumption regarding spoofing should also be revisited. At the time of the report, spoofing was not considered a significant concern because GPS spoofing technology was in its infancy, immature and not widely known.
- The "30 day" assumption for wireline networks should be revisited. This assumption was based on Rubidium clocks maintaining stable frequency outputs to TDM systems and SONET elements for up to 30 days in holdover.
- The "24 hour" assumption for wireless networks should be revisited. This assumption was based upon impact of GPS loss to the +/- 16 ppb frequency stability needed to insure +/- 50 ppb accuracy of the RF carrier at the air interface. During loss of GPS, the oven controlled crystal oscillators (OCXO) deployed in many base stations may not maintain a phase alignment for 24 hours at 1.5 μs.
- The evaluation of the phase performance of crystal-based oscillators used in LTE base stations in the presence of temperature fluctuations. This is important because the phase performance of crystal-based oscillators varies widely with temperature fluctuations. This was not considered in the *2008 NSTAC Report*.

- The use of accurate UTC time, called "Time of Day," and the use of differential phase accuracy should be considered. At the time of the *2008 NSTAC Report*, neither was part of the timing architecture and therefore was not considered.

The operation of critical infrastructures relies on communications networks, which in turn depend on GPS availability. Consequently, it is necessary to verify and validate each of the above assumptions taking account of the following:

- New and more broadly available technologies exist that can cause GPS outages of long duration and across vast areas.
- GPS spoofing is now a demonstrated threat.
- Some legacy wireless technologies require only frequency synchronization (*i.e.*, GSM) while other legacy wireless technologies (*i.e.*, CDMA) require phase accuracy (10 μs). Current wireless technology (*e.g.*, LTE-TDD and LTE-Advanced) requires more precise phase (1.5 μs) synchronization.
- Rubidium and OCXO cannot maintain accurate phase for any significant duration.
- Outage durations of short, medium, and long term and the geographic scope of outages need to be defined.

Additionally, COAST SYNC notes that there may be other issues associated with the loss of GPS that may impact wireless services. We acknowledge that it is not possible for COAST to assess such issues without additional input. This is because techniques for timing and synchronization in wireless services are based on non-public vendor-specific or proprietary implementations. It is likely that different wireless equipment vendors have different methods for timing and synchronization, and the impact of a loss of GPS will vary depending on the equipment used.

Based on the above, COAST SYNC urges that a careful study be performed on the vulnerability of current communication systems and threat scenarios. This study should:

1. Evaluate phase performance requirements for current technology, particularly with a loss of the GPS signal over a localized region.
2. Engage wireless service providers and equipment vendors to evaluate how GPS outages will impact wireless services.
3. Engage wireless equipment vendors to study the holdover capability of crystal-based oscillators (*e.g.*, OCXOs) used in mobile base stations in dynamic environmental conditions (*e.g.*, temperature variations).

ATIS COAST SYNC looks forward to participating in this proposed study and welcomes the opportunity to assess the vulnerability of, and recommend corrective measures for, this critical infrastructure.