RESILIENT NAVIGATION and TIMING FOUNDATION

Financial Services 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 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).

Primary References for this submission are (1) information provided in a briefing to the US National PNT Advisory Board by Mr. Andrew Bach of Juniper Networks[1] and (2) corresponding research and reporting done by "Inside GNSS."[2]

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

1 – Precision Operational Analytics. The systems supporting the financial services industry process hundreds of millions of transactions a second. Precise, synchronized time is required to ensure the proper functioning of both the hardware and software.

2 – Trading Algorithms. Precise, synchronized time is essential for knowing when information was created and determining temporal relationships. The industry processes almost a billion messages per second. Absolute time is not currently required, but precise relative time is.

3 – Market Transparency & Regulatory Compliance. Accurate time stamps are needed to demonstrate that transactions are done in the proper sequence. Financial markets are increasingly international and are impacted by global regulations. In Europe, the Markets in Financial Instruments Directive II[3] will require all market participants to use the same precise synchronized time. In the United States Sarbanes Oxley, the Order Audit Trail System, and Visa Payment Card Industry Data (PCI) Security Standard, and other requirements, address the need for precise time in transactions. The US Financial Industry Regulatory Authority, Inc. (FINRA) has recently proposed new rules for time standards and synchronization which could impact industry requirements.

[1] http://www.gps.gov/governance/advisory/meetings/2014-12/bach.pdf
[2] http://www.insidegnss.com/node/4355
[3] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0065

(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.

European regulators are proposing that timestamps be expressed in a level of precision at one microsecond.[4] FINRA in the US has proposed a tolerance standard of 50 milliseconds[5].

We foresee regulatory requirements increasing to match the ability of the technology in the long term. Practical considerations driving this hypercompetitive industry processing billions of messages per second may drive use of greater time precision, when available, in the much shorter term.

(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 these comments, 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.

A European Securities and Markets Authority (ESMA) report, dated 22 May 2014, indicates that the majority of trading venues are already coordinated with GPS time, and further states that the deployment of these systems might be costly and technically challenging. ESMA's view is that each trading venue and market participant should rely on an atomic clock to issue timestamps. An eLoran timing alternative would be less costly, less technically challenging, and, when used in concert with other solutions (i.e., GPS, atomic clocks, or NTP/PTP) would provide trusted time.

ESMA has asked for industry comment on its proposed requirement to synchronize clocks to the microsecond level. ESMA has invited industry responses to its preliminary view that business

[4] http://www.esma.europa.eu/system/files/2014-548_discussion_paper_mifid-mifir.pdf
[5] http://www.finra.org/industry/notices/14-47

clocks be accurate at least up to the microsecond level. Additionally, they propose that, in principle, one microsecond should be the maximum divergence permitted with respect to the reference atomic clock.

Time stamping is currently done to 100 microseconds. Proposed regulations may move this requirement to one microsecond. New regulations are moving towards an absolute time reference for post mortems of events. Timing questions include: what part of the packet are we time stamping to, the beginning or the end? How precise does our timing solution need to be to be able to make this distinction?

(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."

The willingness of the financial industry to be an early adopter of the technology will depend upon the price point of the equipment, as well as regulatory and market pressures. Timing is typically done using some form of PTP server in the data center, with a commensurate monthly fee. Timing is usually done using software, which can be jittery. What is important to the financial sector is the source of time and the cost of providing this time. At present, there may be no traceability to a sovereign time scale (e.g., NIST, BIPM, KRIS). The financial industry would consider anything that could act as a PTP source (e.g., GPS and/or eLoran). Industry spokesmen acknowledge it would be useful to not have to access the roof or exterior of a building.

(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.[6]

The financial services industry uses a variety of atomic clocks and network timing to supplement GPS time. Current timing sources and stamping methods are evolving to meet rapidly emerging customer and regulatory demands. The industry is actively working to:

- Secure authoritative timing references,
- Develop a timing solution accurate to one microsecond per transaction across data centers,
- Develop a uniform epoch across the industry,
- Develop the ability to time stamp every transaction to the required precision, and
- Develop analytics to measure the performance of the transaction environment at 100's of millions of transaction per second.

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:

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

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

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[7]. 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 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.

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

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?