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Interview Guide: NIST Economic Impact Assessment of GPS

Evaluating the Uses and Benefits of GPS to the Financial Sector

RTI International is working with the National Institute of Standards and Technology (NIST) to conduct an economic impact assessment of the nation's precision, navigation, and timing (PNT) services provided through the Global Positioning System (GPS).

The study has two objectives:

- Quantify the economic impact of GPS.
- Quantify the economic impact of an unexpected 30-day failure of the current GPS system.

As part of this study, RTI identified an alternative scenario, or counterfactual, to describe what we expect might have happened in the absence of GPS being developed and leveraged for commercial applications. Preliminary research and expert interviews suggest that in the absence of GPS the terrestrial PNT system known as Loran-C would have likely evolved over time to meet some of the needs filled by GPS. Some background on the Loran-C and Enhanced Loran (eLoran) systems are provided in an attachment.

Your perspective will help us quantify the benefits of GPS to the financial sector. For example, we are interested in the economic impact (benefits) the financial services sector gains from the increased precision timing from using GPS.

Your participation is voluntary and confidential; only aggregated information will be included in any deliverables or communications. Additionally, we do not wish to discuss any proprietary or confidential business information, but rather your professional opinion about the role of GPS in financial sector.

Our research products will be an economic analysis, final report, and presentation materials. All deliverables will be publicly available in early 2019 and these will be shared with you as soon as they are released.

If you have questions, please contact:

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- Kathleen McTigue, Technology Partnerships Office, NIST, kathleen.mctigue@nist.gov

Interview Questions

SECTION I. Respondent Background

1. Please give a brief description of your background and how familiar you are with the use of GPS in the financial services sector.

SECTION II. How GPS is Used by the Financial Services Sector

2. What is the role of precision timing in the financial services sector (select all that apply)?
    a. Providing time stamps for trades
    b. Enabling the benefits of High Frequency Trading (HFT) in terms of latency arbitrage and liquidity, factors that may increase financial market efficiency.
    c. Other ____________________

3. Where and how is GPS used in the financial services sector?
    a. What are the alternative or competing precision timing systems that are either used or available?
    b. What backup systems are in place?

4. What was used for precision timing needs prior to GPS?

5. For each of the applications within the financial services sector, when was GPS first used? How long did it take for full adoption throughout the system? What drove the adoption?

6. It is our understanding that the current timing system of choice in financial sites is NISTDC.
    a. What was the history of the technology development
    b. Was R&D done by private-sector companies, government laboratories
    c. Were there collaborations and/or consortiums?

SECTION III. If GPS Were Not Available

7. If GPS had not become available, how would the processes for financial transactions have evolved or adapted?
    a. Would stock exchanges have supported their own system of quartz or atomic clocks?
    b. If atomic clocks were the selected alternative to replace GPS, how many atomic clocks would be needed to provide precision timing to the entire financial sector?
        a. Where would they be located?
        b. What would be the incremental labor cost associated with operating and maintaining them?

8. What would have been the impact on financial services from not having GPS?
    a. No significant impact on trading methods or volume
    b. Current trading volumes could not be supported without GPS and would be ____ % less.
    c. The introduction of HFT would have been delayed by ____ years, but not significantly changed.
    d. Other ____

9. What would have been the approximate cost impact from not having GPS
    a. Negligible – little to no increase in costs associated with providing financial services.
    b. If costs would be greater without GPS, how much money do you think you are saving by using NISTDC based on GPS

   c. If costs would be greater without GPS, alternative systems would have an incremental cost of $____ to purchase/install and $____ to operate per year

10. Would Loran-C or eLoran (as described in the attachment) been a viable alternative to support NISTDC?

11. Would the decreased precision of a Loran-C or eLoran system relative to GPS have an impact on key activities such as High-Frequency Trading (HFT) and time stamping? If so, can you quantify the impact, in terms of:
    a. Decrease in trading volume - _______%?
    b. lost revenue - __________$$ (annual)?
    c. Increased vulnerability to fraud (yes/no)? please describe.

SECTION IV. Unanticipated 30-Day Failure of GPS System

12. If GPS failed unexpectedly, what equipment/systems are in place for precision timing holdover?
    a. How long could the required level of time stamp precision be maintained - _____hours or _____Days?

13. Would financial exchanges be ordered to shut down HFT because they cannot precisely time stamp these trades?
    a. Yes – after ____ hours or _____days.
    b. No – Holdover is sufficient with backup systems to keep HFT operating for 30 days at the required level of precision.

14. What would be the economic impact to the financial system from the 30-day failure?
    a. No impact regular operations,
    b. Decrease in trading volume - _______%?
    c. lost revenue - __________$$ (annual)?
    d. Increased vulnerability to fraud (yes/no)? please describe.
    e. Reduced/delayed availability of financing, or other financial services. Please describe.

15. What would be the impact in operating costs or efficiency?
    a. ____% increase in cost per trade.

16. Is there potential for damage to the existing infrastructure that would need to be repaired/replaced, thus leading to impacts past the 30-failure?
    a. ____% loss in capital assets, resulting from damage to computers and software.

Section IV. Concluding Questions

17. Would you like to share any other comments?

18. Would you be willing to participate in a brief follow-up discussion of your responses to this interview?

THANK YOU for contributing your time and insight to the study.

ATTACHMENT: *Loran as a Counterfactual in the Absence of GPS*

We hypothesize that in the absence of GPS a Loran-based system could have been used by the finance industry to provide some of the frequency and precision timing needs currently being provided by GPS. The following is a brief background on Loran.

The legacy Loran system, known as Loran-C, was introduced in 1957 and operates similarly to GPS in that its primary signal is a timing and frequency message. In the late 1980s and early 1990s, investments were made to expand the coverage of Loran-C to cover the continental United States and improve the precision and accuracy. However, progress on further upgrades to Loran-C stalled as the costs exceeded available funds and as GPS was more widely adopted, eliminating the need for Loran-C in some applications.

In 1994, the U.S. Coast Guard ceased operating the international Loran-C chains, and the 1994 Federal Radionavigation Plan stated that by 2000 support for the remaining domestic Loran-C network would end (Narins, 2004). However, in the late 1990s, interest in maintaining and modernizing Loran-C rekindled because GPS was recognized as a single point of failure for much of the nation's critical infrastructure. An evaluation conducted by the Federal Aviation Administration determined that with some investment in upgrades the Loran-C system could indeed function as a suitable backup in the event of a GPS outage (Narins, 2004). Additionally, some research and development was being conducted to standardize an enhanced Loran (eLoran) system, which would have more capabilities and better precision and accuracy.

While eLoran would not be able to achieve the levels of precision and accuracy available from GPS, proponents claim it could perform sufficiently to support many critical applications. Table 1 provides a comparison of the frequency, timing, and positioning capabilities of the different systems.

Table 1. Precision and Accuracy Performance

	Loran-C	***eLoran***	***GPS***
Frequency	1×10^{-11} frequency stability	1×10^{-11} frequency stability	1×10^{-13} frequency stability
Timing	100 ns	10-50 ns	10 ns
Positioning (meters)	18–90 meters	8–20 meters	1.6–4 meters[a]

Sources: Narins et al. (2004); Curry (2014); FAA (2008)
[a] GPS positioning accuracy varies widely by type of receiver and augmentations being applied. The accuracy quoted here is from the GPS Wide Area Augmentation System (WAAS) 2008 Performance Standard.

References

Curry, C. (2014). *Delivering a national timescale using eLoran*. Lydbrook, UK: Chronos Technology.

Federal Aviation Administration [FAA]. (2008). GPS Wide Area Augmentation System (WAAS) 2008 Performance Standard. Retrieved from https://www.gps.gov/technical/ps/2008-WAAS-performance-standard.pdf

Narins, M. (2004). *Loran's capability to mitigate the impact of a GPS outage on GPS position, navigation, and time applications*. Prepared for the Federal Aviation Administration Vice President for Technical Operations Navigation Services Directorate.