

**Interview Guide: NIST Economic Impact Assessment of GPS**  
*Evaluating the Uses and Benefits of GPS to the Location-Based Services 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 location-based services (LBS) sector. We are dividing LBS into three broad categories:

1. Personal vehicle navigation (i.e., turn-by-turn driving directions)
2. E911
3. Other apps and services using LBS, including
  - a. Traffic information
  - b. Personal navigation (walking directions)
  - c. Social (including check-in apps and dating apps)
  - d. Gaming (e.g., Pokémon Go)
  - e. Fitness (e.g., tracking apps for runners)
  - f. Search (e.g., searching for something on Google shows local results)
  - g. Ride-hailing (e.g., Uber and Lyft)
  - h. Smart home

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 location-based services.

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:

- Alan O'Connor, Principal Investigator, RTI, [aconnor@rti.org](mailto:aconnor@rti.org)
- Kathleen McTigue, Technology Partnerships Office, NIST, [kathleen.mctigue@nist.gov](mailto:kathleen.mctigue@nist.gov)

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## Interview Questions

### SECTION I. Respondent Background

1. Please give a brief description of your background.
2. How familiar are you with the use of GPS for LBS, including E911 and personal navigation?

### SECTION II. How GPS is Used: Personal Vehicle Navigation

3. What augmentations are used to provide turn-by-turn directions for personal navigation devices or mapping apps on smartphones (e.g. pre-loaded map data)?
4. What level of positioning accuracy is required for personal navigation? Recognizing that different services require different accuracy levels, please elaborate on areas for which you can speak from experience.

### SECTION III. How GPS is Used: E911

5. How does the E911 system use GPS location information?
6. Is there a statutorily required level of accuracy for E911?

### SECTION IV. How GPS is Used: Other Location-Based Apps and Services

7. What level of positioning accuracy is required for location-based apps, including social, gaming, and local advertising? Recognizing that different services require different accuracy levels, please elaborate on areas for which you can speak from experience.

### SECTION V. If GPS Were Not Available

8. In the absence of GPS, how do you think LBS would have developed?
9. Would a Loran-C network with national coverage provide sufficient performance for:
  - a. E911?
  - b. Personal navigation?
  - c. Other location-based apps and services?
10. Would an eLoran network with national coverage provide sufficient performance for:
  - a. E911?
  - b. Personal navigation?
  - c. Other location-based apps and services?

### SECTION VI. Unanticipated 30-Day Failure of GPS System

11. If GPS failed unexpectedly, what would be the immediate impact on:
- d. E911 service?
  - e. Personal navigation?
  - f. Other location-based apps and services?
12. Would E911 continue to function normally as long as wireless networks are able to function?

#### **SECTION VII. Technology Transfer**

13. Are you familiar with the technology development history of GPS and devices that use GPS as they relate to the resource extraction sector?
14. Outside of launching and maintaining the GPS constellation itself, did federally funded research support the development and commercialization of any key components that are used in the telecom sector today?

#### **Section VIII. Concluding Questions**

15. Who else should we contact for this study?
16. Would you like to share any other comments?
17. Would you be willing to participate in a brief follow-up discussion of your responses to this survey?

**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

	<b>Loran-C</b>	<b>eLoran</b>	<b>GPS</b>
Frequency	1 x 10 <sup>-11</sup> frequency stability	1 x 10 <sup>-11</sup> frequency stability	1 x 10 <sup>-13</sup> frequency stability
Timing	100 ns	10-50 ns	10 ns
Positioning (meters)	18-90 meters	8-20 meters	1.6-4 meters <sup>a</sup>

Sources: Narins et al. (2004); Curry (2014); FAA (2008)

<sup>a</sup> 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.