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Interview Guide: NIST Economic Impact Assessment of GPS

Evaluating the Uses and Benefits of GPS to the Resource Extraction Sectors

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 resource extraction sectors, including open-pit mining and oil and gas exploration.

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 resource extraction.

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. Is your experience in mining or the oil and gas sector?

2. How familiar are you with the use of GPS in the resource extraction sectors?

SECTION II. How GPS is Used in Resource Extraction

3. Our preliminary research suggests that GPS is used in mining for:
    a. collision avoidance
    b. exploration
    c. mine operations
    d. mine site surveying
    e. autonomous mining and operations control
    f. remote control of vehicles
    g. vehicle tracking and dispatch
    h. loading systems
    i. material tracking along the supply chain
    j. preserving areas of cultural heritage and high environmental value

    Do you agree with this list? Are there any applications you would add?

4. In the mining sector, is the use of GPS primarily limited to open-pit mines? If not, what other types of mining operations should we be including in our analysis?

5. What level of precision is required for these applications?
    a. collision avoidance
    b. exploration
    c. mine operations
    d. mine site surveying
    e. autonomous mining and operations control
    f. remote control of vehicles
    g. vehicle tracking and dispatch
    h. loading systems
    i. material tracking along the supply chain
    j. preserving areas of cultural heritage and high environmental value

6. When was GPS first used in the resource extraction sector? Which application was the first use of GPS?

7. What percent of mining operations use GPS for at least one of these applications?

8. How would you characterize the pace of adoption since GPS was introduced in the resource extraction sectors?

9. Preliminary research suggests that GPS delivers the following categories of benefits:
    a. Improved productivity
    b. Reduced labor requirements
    c. Improved health and safety
    d. Lower environmental impact

   Would you agree or disagree with these categories of savings? Are there any benefit categories that you would add? From your perspective, how would you describe these benefits in a qualitative way?

10. Are you able to make quantitative estimates of the benefits listed in the previous question for the average mining operation?
    a. Overall mine productivity is improved by _____ %
    b. Labor requirements decrease by ______ %
    c. Use of GPS results in _______ % fewer injuries per year in the average mine
    d. Use of GPS decreases waste from operations by ______ %

11. What was used for these positioning needs prior to GPS?

SECTION III. If GPS Were Not Available

12. In the absence of GPS, do you think other technologies would have emerged to fulfill the same applications?

13. Would Loran-C or eLoran (as described in the attachment) be useful in the absence of GPS? If so, how would the resource extraction use such a system, which delivers a less accurate positioning signal?

14. Can you estimate a percentage of the benefits that would be lost due to lower accuracy under a Loran-C or eLoran usage scenario?

SECTION IV. Unanticipated 30-Day Failure of GPS System

15. Can you describe (in a qualitative way) what the impact of a 30-day failure of GPS would be in the resource extraction sectors? For example, would all work stop, or would work continue, but with less efficiency?

16. Are there technologies in use that could serve as backups in the short term? How would these technologies compare to business-as-usual GPS availability?

17. Can you approximate the changes in:
    a. System operating costs (e.g. fuel costs)
    b. Downtime
    c. Labor costs
    d. Other_______________

SECTION V. Technology Transfer

18. Are you familiar with the technology development history of GPS and devices that use GPS as they relate to the resource extraction sector?

19. Outside of launching and maintaining the GPS constellation itself, did federally funded research support the development and commercialization of any key GPS components that are used in the telematics sector today?

Section VI. Concluding Questions

20. Who else should we contact for this study?

21. Would you like to share any other comments?

22. 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 U.S. 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 x 10^{-11} frequency stability	1 x 10^{-11} frequency stability	1 x 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.