

**Interview Guide: NIST Economic Impact Assessment of GPS**  
*Evaluating GPS's Impacts on the Agricultural 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 agricultural sector.

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 agriculture.

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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## Interview Questions

### SECTION I. Respondent Background

1. Please give a brief description of your background.
2. Are you familiar with the use of GPS in the agriculture sector?

### SECTION II. How GPS is Used by the Agricultural Sector

3. Where and how is GPS used in the agricultural sector? What are the primary benefits? (e.g. yields, costs, diversification)
4. We plan to use a recent USDA Economic Research Service (ERS) study on the net benefits of precision agriculture to calculate the economic benefits of GPS. The following table summarizes the primary findings of that study. The following questions will refer to this table.

#### Impacts of precision technologies on net returns and farm operating profit

	GPS soil/yield mapping	Guidance system	VRT
<i>Percentage change in profits from adopting</i>			
Net returns (incl. overhead) Impact of precision technology	1.8%	1.5%	1.1%
Operating profit impact including farm size scale effect	2.8%	2.5%	1.1%
<small>Note: Percentages in second row have been corrected for the "farm size" effect discussed in the text, using the estimated correlation between the adoption and profit sections of each treatment model. GPS = Global Positioning System; VRT = variable-rate technology. Source: USDA, Economic Research Service estimates using data from the Agricultural Resource Management Survey (ARMS) Phase II and III.</small>			

Source: Schimmelpfennig, D. (2016). *Farm profits and adoption of precision agriculture* (No. 249773). United States Department of Agriculture, Economic Research Service.

- a. Is it appropriate to equate the benefits of precision agriculture (PA) technologies to GPS?
- b. Is it appropriate to categorize the uses of GPS into the same categories as precision agriculture: yield and soil mapping, machinery guidance and control systems, variable-rate application technologies?
- c. Are there other uses of GPS in agriculture you can think of that do not fall into these three categories?
- d. ERS calculated these net benefits for corn, and they assume similar benefits for soybeans. They also have PA adoption rates for cotton, peanuts, soybean, and spring wheat. Is it appropriate to assume that the percentage changes in net benefits of PA for

corn and soybeans are similar to the percentage change in net benefits for cotton, peanuts, soybeans, and spring wheat? If not, how would you expect the net benefits of GPS in PA to be different for cotton, peanuts, soybeans, and spring wheat?

- e. Are there other crops where you expect that GPS has had a big impact? Which ones?
  - f. In your opinion, to what extent do the net benefits to GPS come from increased yields vs. lower costs? Can you estimate what percentage of the benefits has come from increased yields vs. lower costs?
5. What level of accuracy is required for the different uses of a location technology like GPS to be useful in agriculture? (refer to categories above)

**SECTION III. If GPS Were Not Available (refer to Attachment describing counterfactual background)**

6. If GPS had not become available, would Loran-C or eLoran have been a viable alternative?
7. Would the decreased accuracy of a Loran-C or eLoran system relative to GPS have an impact on the categories discussed above?
8. If so, can you quantify the impact for each of the PA categories listed above? What percentage of the net benefits could have been realized with Loran-C or eLoran for each category?

**SECTION IV. Unanticipated 30-Day Failure of the GPS System**

9. Now I am going to ask some questions about what would happen to the agriculture industry if GPS failed for 30 days.
  - a. What would the impacts be for different crops in the spring?
  - b. What would the impacts be for different crops in the fall?
  - c. Can you quantify the impact on farmer revenues? What would be the estimated change in increased costs or lower yields?
10. Is there potential for damage beyond the 30-day failure? (e.g. lower yields effecting commodity markets, loss of confidence in GPS)? Please describe.

**SECTION V. Technology Transfer (only for experts that were involved in or knowledgeable about technology transfer related to GPS in agriculture, such as equipment manufacturers)**

11. How did government laboratories influence or support the development and/or transfer of GPS equipment for agriculture?
12. Did industry directly collaborate or interact with government laboratories as part of their R&D process?

## **Section VII. Concluding Questions**

13. Do you have any other contacts we should reach out to?
  
14. 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.

## **COUNTERFACTUAL BACKGROUND**

### *The Agriculture Industry in the Absence of GPS*

In order to accurately assess the benefits of GPS, we consider two counterfactual scenarios: first, the state of agriculture had GPS never been developed, and second, the impact on agriculture if GPS were to fail completely for 30 days.

#### ***Counterfactual A: If GPS Were Not Developed***

Before GPS was available for commercial use in the mid-1990s, farmers had few technologies that allowed them to proactively manage their fields according to spatial characteristics. Without GPS, we assume many producers would continue to manage their operations as before, planting and harvesting as they have done historically without the benefits of precision agriculture.

Our research shows that while most precision agriculture benefits would be lost absent GPS, a technology called Loran – a land-based position, navigation and timing technology similar to GPS that was also under development at the same time as GPS – might have developed in its stead. We assume that without GPS, precision agriculture would have still progressed with Loran, but it would have taken longer to progress and been much more limited in its applications. Those applications that require a location accuracy of more than 10-20 meters, for example, such as variable rate technology and crop dusting, may have evolved using a Loran-based network.<sup>1</sup>

Additionally, not all precision agriculture technologies rely on GPS or require the high levels of accuracy that GPS offers. We assumed that these technologies would have been developed and adopted by some farmers, corresponding to the level of accuracy required for the specific technology. Thus, the technical counterfactual is the net returns to farming using no precision location technologies or those that would be possible using Loran.

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<sup>1</sup> Earlier versions of Loran, known as Loran-C, could reliably provide 18-90 meters of positioning accuracy; a newer standard, known as eLoran, can achieve 8-20 meters positioning accuracy

### ***Counterfactual B: 30-Day Catastrophic Failure of GPS***

A 30-day GPS outage would likely be a shock to agricultural productions and yields, with farmers who had invested in GPS technologies losing the benefits of their precision agriculture techniques. It is unclear to us what kind of efficiency losses would result from farmers having to retrofit or “relearn” how to operate this equipment without GPS enabled, or return to a conventional farming method. The impacts of a GPS outage also depend on its timing – a failure during planting season would have different impacts than a failure during harvest or winter.