

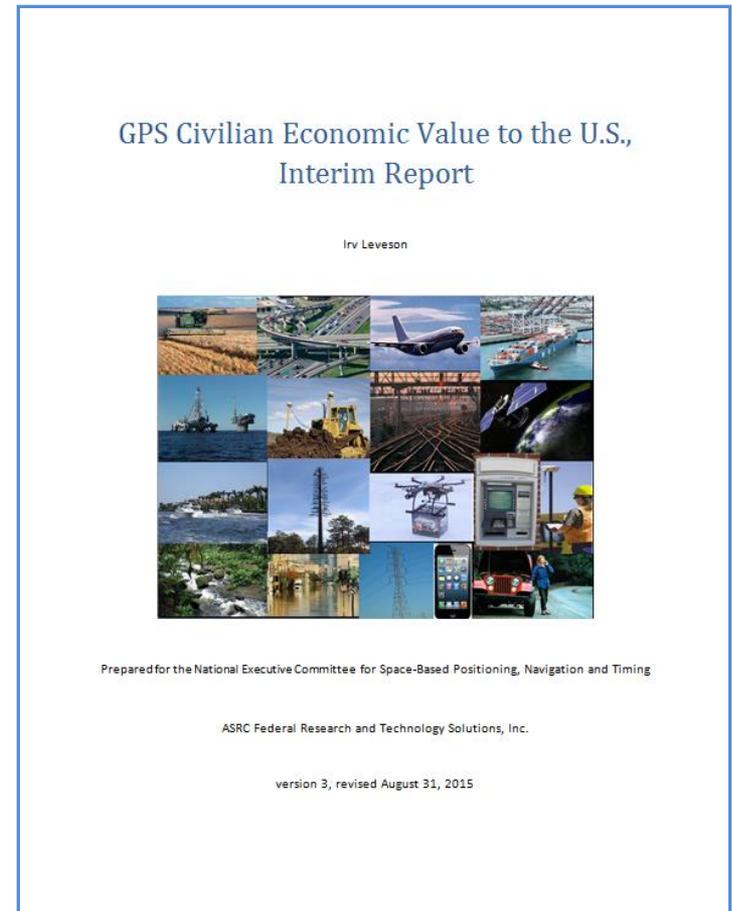
# Value of GPS: Furthering the Analysis

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for October 30-31, 2015 Positioning, Navigation  
and Timing Advisory Board Meeting, Boulder, CO

# The Preliminary Assessment

- Study conducted between December 2014 and July 2015
  - Advised by interagency Economic Study Team consisting of about 24 economists and a half dozen engineers and policy experts
- Presentation at June PNT Board  
<http://www.gps.gov/governance/advisory/meetings/2015-06/leveson.pdf>
- Internal Interim Report, version 3 August 2015



# Scope of Preliminary Assessment

- Market sizes
- Direct economic benefits to the US in 2013
  - Based on productivity, cost savings and cost avoidance (including value of time) and willingness to pay
  - For sectors with better information
- Does not include:
  - Noneconomic benefits such as those to safety-of-life and the environment
  - Some benefits to suppliers or any benefits induced in the rest of the economy
  - International benefits
  - Future benefits
  - Costs of interference with or loss of GPS

# What the Interim Study Did

- Described applications of GPS and their benefits and the GPS economic value chain
- Described benefit concepts and methods
- Reviewed U.S. and international studies of economic benefits of GPS and other GNSSs
- Estimated current U.S. market sizes and adoption for key applications
- Estimated values of current economic benefits of GPS for included sectors
- Reviewed efforts with the inter-agency Economic Study Group
- Presented findings to the June 2015 PNT Advisory Board
- Distributed the internal Interim Report to policy-makers

## Summary of Preliminary 2013 US GPS Benefit Estimates

	<b>Application Category</b>	<b>Range of Benefits</b> (\$ billions)	<b>Mid-range Benefits</b> (\$ billions)
A. Confident	A Precision Agriculture – grain*	10.0-17.7	13.7
B. Indicative	A Construction – earthmoving with machine guidance*	2.2-7.7	5.0
C. Notional	A Surveying – independent and in sectors	9.8-13.4	11.6
	A Timing – average of eLoran and GEOs estimates	.025-.063	0.044
	A Air Transportation	.119 -.168	0.144
	C Rail Transportation – Positive Train Control	.010-.100	0.055
	C Maritime Transportation – private sector use of nautical charts and related marine information*	.106-.263	0.185
	A Fleet Vehicle Connected Telematics*	7.6-16.3	11.9
	B Consumer and other non-fleet Vehicle – average of estimates based on willingness-to-pay and value of time*	7.3-18.9	13.1
	<b>TOTAL</b>	<b>37.1-74.5</b>	<b>55.7</b>

- Includes a portion on benefits from purchased input cost savings.

Note: A spreadsheet error in the June 2015 PNT Advisory Board meeting slides affecting only the total has been corrected and rounding of small values has been carried out at a more detailed level.

# Information Gaps

- Large gaps exist in information on productivity and cost savings
  - Many applications lack studies with any estimates, reliable estimates or estimates for more than narrow uses
  - Existing studies often predate major technological advances while use of GNSS is increasing rapidly in many sectors
- Information on market size, penetration and growth from market research firms, which tends to capture recent developments, is based on greatly varying sources and methods
  - There are major gaps and great divergence in estimates, especially in new or rapidly growing areas like LBS
  - Often definitions and descriptions of methods are insufficient and information is largely proprietary
- Systematic research is needed to fill in gaps in market size, GPS adoption, productivity and cost savings
  - With before and after studies comparing many cases or locations as well as with individual case studies

## Applications with insufficient benefit information include:

- Non-vehicle LBS such as asset tracking, locating people and value in maritime navigation
- GIS applications except for surveying
- Value of GPS as a timing standard and GPS timing use in several sectors
- Construction other than earth moving
- Open pit mining
- Forestry
- Health
- Education
- Weather
- Science
- Space

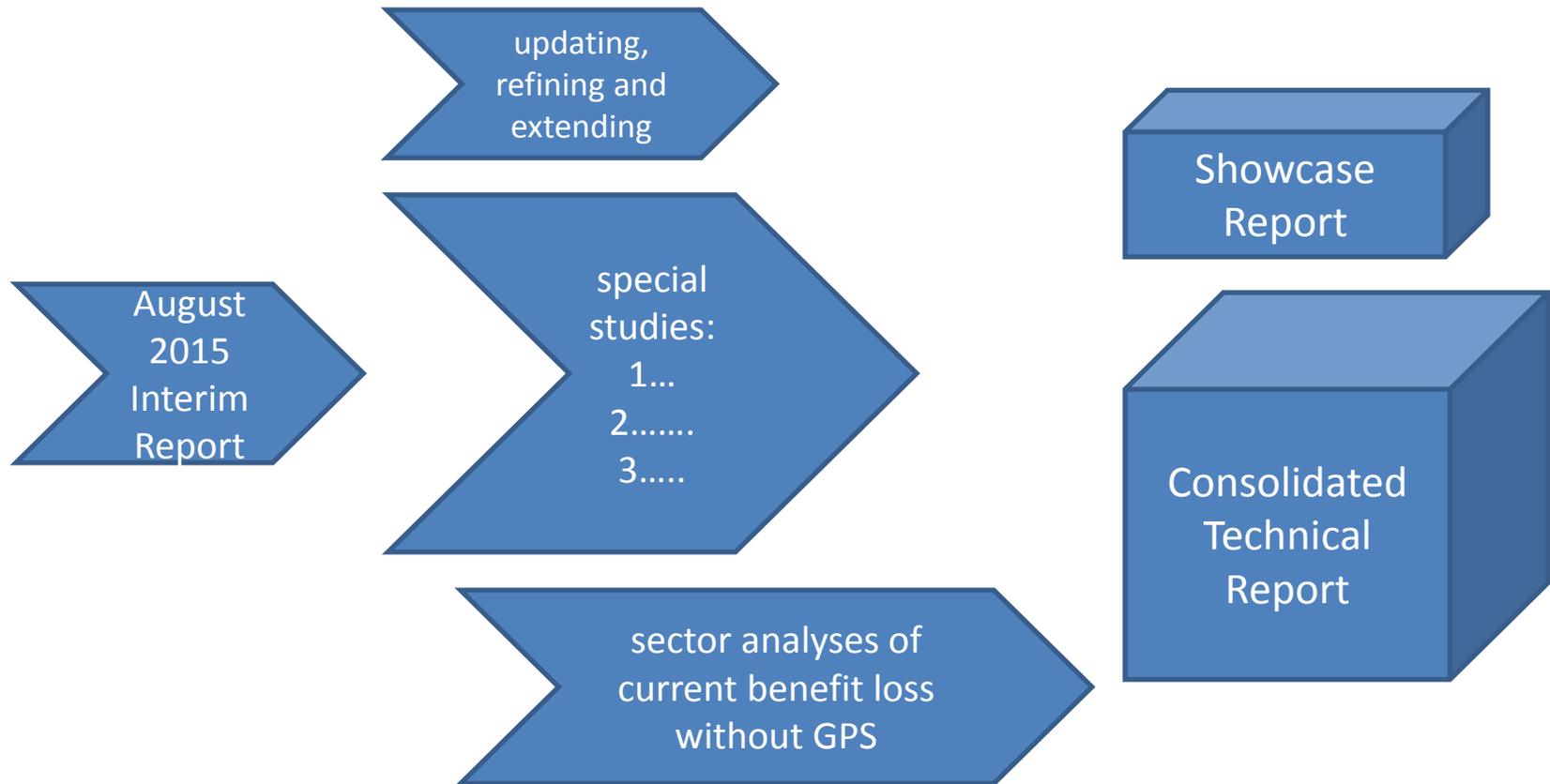
# Further Research That Would Be Useful in This Study (1 of 2)

1. Develop benefit estimates for **additional sectors** where possible
  - Benefits of Location-Based Services other than vehicle are expected to be large
2. Refine economic benefit estimates, update and add sectors based on additional data and reports and more extensive interviews to **leverage existing data**
3. Examine technologies in greater detail and seek **expert opinion** to better assess the shares of benefits attributable to GPS in each sector
4. Estimate indirect and induced effects and assess impacts of GPS on **tax revenues and jobs**
5. Estimate selected values of current **safety-of-life benefits** in critical applications and explore possible magnitudes of environmental benefits
  - Safety-of-life benefits are expected to be large

# Further Research That Would Be Useful in This Study (2 of 2)

6. Estimate the nature and orders of magnitude of benefits of GPS to **other regions and the world**
7. Assess potential **future** applications and markets and make projections of future market penetration and values of economic and safety benefits of GPS to the U.S. under alternative scenarios
8. **Estimate orders of magnitude of current economic impact of impairment or full loss of GPS availability, both short and long term** under alternative scenarios, including rough estimates of economy-wide impacts
  - E.g. communications, aviation, electricity, water, maritime, LBS
9. Conduct further analyses of the costs of **loss of GPS** and explore possible values **in the context of rapidly evolving future use**
10. **Integrate analyses and findings into 1) a “showcase report” designed to appeal to a general audience, and 2) a full technical report and briefings covering all stages of the analysis**

# A Possible Study Flow



# Illustrative Magnitudes of Additional Components

- Inclusion of additional sectors could possibly add \$10-\$20 billion to direct economic benefits
- Indirect and induced benefits could add another \$20-\$50 billion
- Safety-of-life benefits could be \$20-\$30 billion per year
- The US has about 1/5 of the world's GDP but less than 5% of its population. Global benefits of GNSS could be 4 or 5 times those of the US
- If benefits grow at the same rate as they are discounted (e.g. 7%), the present value of benefits over the next 15 years will be 15 times current annual benefits
- Some of the cost of losing GPS is suggested by the loss from power outages. Weather-related outages alone cost users over \$25 billion per year between 2003 and 2012 and far more in extremes

# Next Steps

- Assemble recommendations of the PNT Board
- Convene the Economic Study Team to advise on sectors and approaches for in-depth research
- Develop a work plan for updating and extending the existing work and implementing new data collection and analysis
  - Including benefits of GPS and loss without GPS
- Present recommendations to the PNT EXCOM

# Summary

- The objective is to develop information on the value of GPS and the loss of benefits in its absence
- Progress has been made in estimating direct economic benefits of GPS to the US, emphasizing sectors with better data
- Major gaps in availability and quality of information need filling in – including both market size and adoption and GPS impacts
- Important components can be added
  - Some indirect benefits and all benefits induced in the rest of the economy
  - Safety of life and the environment
  - International benefits
  - Future benefits
- Estimation of loss of benefits due to interference with or denial of GPS can proceed at the same time as additional benefit estimation
- The next steps are to more fully formulate plans to further the analysis and to initiate a series of efforts to fulfill the mission

# SUPPLEMENTARY SLIDES

# EXCOM Tasking

"Lead interagency team in consultation with National Space-Based PNT Advisory Board to develop a way forward for an updated, authoritative GPS Economic Benefits Assessment (OPR: DOC; OCRs: DHS/NASA)"

# Value of Benefit Information

- Informing policy-making by:
  - Enhancing understanding of applications, constituents, markets, returns on investment, and costs for effective planning and resource allocation
    - Support for program planning, architecture assessment, budgeting and legislation
  - Assessing outcomes of long-term initiatives or developments
  - Providing a baseline for determining gain or loss of benefits from alternative developments
  - Advancing recognition of the contributions of the program
- The impact of benefit information on its users depends on constant reinforcement through repetition and demonstration of use in specific contexts

# Economic Impact vs. Economic Value

## Economic Impact

- Direct economic impact refers to measures of the **importance** of sectors that are using a good, service or technology. It is measured by revenue, expenditures or value added
  - Value added subtracts the costs of purchased inputs from a sector's revenue to provide a measure of the resources used from that sector. It avoids double counting due to purchases of one sector from another when magnitudes for multiple sectors are to be combined

## Economic Value

- Economic value is the **addition** to the value of the output of the economy from the provision of a good or service or the introduction of a technology
  - Benefits are measured relative to what would have been expected if the service or technology did not exist
  - Direct economic value is the increase in value in using sectors
  - Total economic value includes increases in value to suppliers and value induced in the rest of the economy

# Measures of Economic Value

- Productivity and cost savings, including
  - Productivity gains
  - Cost reduction
  - Avoided costs
  - Value of time saved
- Willingness to pay and willingness to accept
- Consumer surplus (value to consumers above the amount paid)
  - When benefits are measured by productivity or willingness to pay, consumer surplus is included
- Producer surplus (value to producers above the amount received)
  - Producer surplus is included in revenue
- Effects on value of property
- Value of information – expected benefits of alternative choices when probabilities of outcomes are known

# Economic Values Can Be Assigned to Life and Health

- Health and safety improvements can be assigned dollar values based on reductions in loss of income, medical costs, injury, disability, and lost lives
- Savings in lives is measured by economists as the value of a statistical life (VSL)
  - VSL is used to compare risks associated with small changes in probabilities of death for large groups. It is not intended to be used to assign values to the worth of individuals
  - VSL has been estimated in many studies, notably based on the higher incomes people are willing to accept to go into risky occupations

- **Federal agencies issue guidelines that typically value one lost life at around \$10 million**
  - OMB has reportedly recommended using no less than \$5 million
- **Values assigned to injury depend on severity**
  - For example, FAA guidelines value a severe injury at 26.6% of a fatal injury and a critical injury at 59.3% of a fatal injury

# Comparison with Alternatives (counterfactuals)

- The most common method of assessing value is as the additional benefits of the new technology or service compared with benefits of an earlier technology or service that was in use when the new technology or service became available
- If because of technological changes or market conditions, other alternatives would have been expected to evolve in the absence of the new capabilities, benefits of the new technology or service can be compared with those alternatives
  - These “dynamic counterfactuals” require development of scenarios for technologies and markets
- Dynamic counterfactuals are especially appropriate 1) when other technologies or services were already developed or in partial deployment at the time the technology or program being studied became available, or 2) when strong pressures would have been expected to generate development of an alternative to the earlier technology or service
  - While scenarios about alternatives that would have evolved are subject to uncertainty which involves low *precision*, they can provide a more *accurate* measure of incremental benefits than assuming older technologies would have remained in use
  - Failure to take into account benefits of expected changes in technology and markets can result in a large overestimate of benefits

# Allocating Benefits among Programs

- Often benefits are the result of contributions of multiple program elements, programs or technologies
  - For example, obtaining benefits of electronic nautical charts depends ship bridge systems, GPS, weather information and communications
- There is usually no scientific way to allocate benefits among contributors. Nevertheless, judgments must be made
  - Basing allocations on assessment of several experts can increase acceptance but may not increase reliability
- Sometimes it is possible to measure incremental changes in one program when others do not change or to hold changes constant statistically
  - However, effects of the sum of individual changes may not provide a correct indication of effects when multiple programs or inputs change at the same time
- Implications of alternative allocations should be tested when estimates are used to see if decisions would be affected

# Example of Estimating GPS Benefits for Precision Agriculture

- The focus is on grain and large farms because of importance and availability of data
  - The market value of grain sold in farms with sales of \$250 million or more in 2012 was \$111.5 billion after excluding government payments and non-grain items
    - This is taken as the value for 2013
  - Systems using GNSS were estimated to save 10%-15% in operating costs and purchased inputs based on a composite of estimates of several studies
  - Yield increases associated with improved plant health were estimated to increase yields by 8%-10%
    - These are in addition to cost savings and also apply to both operations and purchased inputs
    - They include surveying only if integrated with the operation of machines
- Adoption of any GPS technology on heavy equipment was taken as 68% in 2013 based on a John Deere estimate for large grain farms of 65% in 2011 and 70% in 2014
  - The contribution of GPS vs. other technologies and GNSSs associated with its use was assumed to be 60%-70%

# Updating, Refining and Extending

A study to leverage the Interim Report analysis could:

- 1) Refine some of the estimates and expand descriptions of applications
- 2) Update the values for growth from 2013 to 2015
- 3) Include any applications for which additional estimates could be made from readily available data, i.e. those not requiring special studies
- 4) Add estimates of safety-of-life benefits**
- 5) Add partial estimates of environmental benefits and discuss others
- 6) Discuss partial estimates of benefits for sectors that are not included because information is too fragmented
- 7) More fully estimate indirect benefits (to suppliers) and roughly estimate benefits induced in the rest of the economy**
- 8) Estimate impacts on jobs and tax revenues**
- 9) Extrapolate international benefits
- 10) Project future US benefits

# Lessons Learned

- A major part of any benefit study is improving knowledge of users and applications
- It is important for benefit studies to include both economic benefits and non-economic benefits such as those to safety-of-life and the environment
- Studying future benefits can help plan programs and provide benchmarks to assess them
- It is necessary to be eclectic with regard to methods of measuring benefits because of varying availability and characteristics of data
- Separating impacts of jointly operating programs or technologies requires rough judgments
- Choosing alternatives without GPS for comparison with GPS requires understanding of changing technologies and markets

# Leveson Biography

Dr. Leveson has strong analytical skills in economics, business and public policy and extensive experience analyzing programs, markets and technologies. His background includes strategic and economic consulting and research in private industry, prominent research organizations, and government.

Dr. Leveson has done extensive work on GNSS markets and issues for over 10 years. He has been an independent consultant since 1990. He has served as a consultant to the Aerospace Corporation and is an Adjunct Fellow at the Hudson Institute. He is a consultant to ASRC Federal Research and Technology Solutions, LLC. and to Alion Science and Technology.

Dr. Leveson holds a Ph.D. in economics from Columbia University. Prior to establishing Leveson Consulting he served as Senior Vice President and Director of Research of Hudson Strategy Group, Director of Economic Studies of the Hudson Institute, Assistant Administrator for Health Systems Planning for the New York City Health Services Administration and as a research director for the New York City Planning Commission. He also was an economist with the RAND Corporation and an analyst with the National Bureau of Economic Research. Dr. Leveson is a member of the Institute of Navigation, the American Economic Association and the National Association for Business Economics.

His books include *Economic Security, American Challenges, Western Economies in Transition* (co-ed.), *The Future of the Financial Services Industry* (main author), *Analysis of Urban Health Problems* (co-ed.) and *Quantitative Explorations in Drug Abuse Policy* (ed.).

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