GPS Benefits Data: Availability and Study Needs for Present and Emerging Benefits

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Objectives of Benefit Studies

- To inform policy-making by:
  - Enhancing understanding of applications, constituents, markets, returns on investment, and costs for effective planning and resource allocation
  - Providing a baseline for determining the gain or loss of benefits from alternative developments or courses of action
  - Advancing recognition of the contributions of the program

Uses include:

- Assessing the impact of long term signal interference
- Support for budgeting
- Support for architecture assessment

Long Run vs. Short Run Benefits

- Long run benefits are useful in planning and budgeting
  - They are measured relative to what would occur if GPS never existed
    - Without GPS there would be greater use of alternative technologies
- Loss from temporary denial of benefits is useful in examining security and risk issues, effects of space weather, and other interruptions of service
  - Impacts may be large because there isn't time to adjust production methods
    - Assuming short term interruption effects persist would result in an exaggerated estimate of long run benefits

The Economic Productivity Approach

- Focuses on the benefits of productivity improvements and cost savings, and considers secondary effects on the economy and broader societal impacts
  - Direct economic benefits are calculated building on diverse evidence on efficiency improvements in different applications
  - Additions are made for indirect and induced economic growth effects
    - Indirect effects are impacts on demand for goods and services produced by other industries
    - Induced effects include use in product and process innovation and associated productivity gains and expansion
  - Societal benefits include benefits to life, health, safety, security, and the environment

Allowing for Other GNSS Systems

- In gauging benefits of GPS, benefits of other GNSS systems can be considered incremental to those of GPS since GPS would have existed without them
  - Benefits of other GNSS systems have to be subtracted from combined benefits of multiple GNSS systems in calculating benefits of GPS
    - Less important for earlier studies; very important for determining future benefits
- Benefits of augmentations such as WAAS and EGNOS that are needed for aviation with or without GNSSs should be measured separately from benefits of the GNSS system

Comprehensive Studies

- GPS
  - Aerospace (Leveson) - March 2010
    Current U.S. Economic Benefits of GPS
    (Interim Report)
  - NDP (Pham) - June 2011
    The Economic benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption
- Other
  - Australia
    - Allen Consulting Group - 2008 – high resolution positioning services
    - ACIL Tasman - 2008 – spatial information
  - Europe - various

Aerospace (Leveson) - *Current U.S. Economic Benefits of GPS*: Basis

- Objective: To provide an overall estimate of present and future U.S. benefits of GPS, with detail on benefits in many sectors and applications and information on users and uses
  - Unofficial 2010 interim internal study of 2008 benefits for the National Coordination Office
    - Half of 2-year study; second phase was to focus on future benefits and refine estimates
  - Applications, users and market sizes were examined in a “bottom up” approach
  - “Ball park” estimates of civilian U.S. benefits in 2008 were built up from detailed estimates for 18 application areas
  - Using the economic productivity approach
  - Multipliers for indirect and induced benefits were adapted from econometric studies
  - Non-economic benefit estimates are notional
  - Not all important applications could be included so the overall estimates are referred to as “at least”
- Subsequently extrapolated to 2025 under a preliminary notional baseline scenario that considers market growth and penetration in each application area

Current U.S. Economic Benefits of GPS: Preliminary Findings

- Benefits of GPS to the U.S. in 2008 were in the tens of billions of dollars
- Benefits were concentrated in
  - Precision applications – Agriculture, construction and mining (excluding surveying and mapping)
  - Surveying and mapping, including surveying and mapping firms and surveying and mapping that businesses and governments do for themselves
- Benefits of GPS to the U.S. from 2008-2025 (discounted at 7% above inflation) are illustratively estimated on the order of magnitude of several hundred billion dollars

Current U.S. Economic Benefits of GPS: Categories Estimated

- Commercial applications
  - Reduced vehicle traffic congestion (consumer and business, except fleet monitoring)
  - Monitoring fleet vehicles and mobile workers
  - Aviation
  - Railroad
  - Marine
  - Surveying and mapping businesses
  - Other surveying and mapping
  - Private construction
  - Agriculture
  - Mining
  - Energy
  - Communications
  - Financial services – time stamping transactions
- Consumer applications (largely)
  - PNDs and smart phones
  - Vehicle telematics
  - Automobile navigation
- Government
  - Weather forecasting
  - Floodplain management
  - Surveying and mapping
  - Space weather
- Non-market
  - COSPAS-SARSAT
  - E-911
  - Environment and natural resources (notional)

NDP - *The Economic Benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption*

- Covers direct economic benefits to commercial users
  - Components of estimates are for various dates from 2005-2010
  - Excludes government and households
  - Excludes indirect and induced benefits and non-economic benefits
    - Includes estimate of jobs that rely on GPS technology
- Emphasizes productivity gains
- Assumes the ratio of GPS benefits in crop farming, engineering construction and vehicle tracking is the same in the sum of other commercial industries
- Costs of signal interference estimated for both users and manufacturers
  - Cost to users estimated as all of the (lower bound) GPS contribution to productivity and efficiency, plus the loss in the value of their stock of equipment
    - Considers alternative of 50% loss

National Economic Assessment for GPS: Information and Analysis Needed

- Aviation benefits
- Precision applications
- Intelligent transportation systems
- Household benefits
- Timing benefits
- Scientific benefits
- Government benefits
- Health and safety benefits
- Environmental benefits
- Value of joint benefits of multiple constellations
- Military benefits of unclassified uses
- System investments and user costs
- Future benefits and costs for alternative system, technology and market developments
- Cost impacts of disruption based on benefits of specifically affected commercial and government applications

Estimation of Direct Benefits and Long Run Loss of Benefits

- Requires information on:
  - Market size of application
  - Total productivity impact of introducing GPS in application
    - Above what would occur in the absence of GPS
  - Share of productivity impact attributable to GPS
    - Other changes or use of resources may usually accompany introduction of GPS in the application
  - Percentage of total productivity impact lost if disruption
    - Net of possibilities for mitigation
  - Future changes in the above

Availability of productivity studies

- Sufficient in agriculture, construction, mining, surveying and mapping and fleet tracking
- How representative are available studies?
  - Are productivity impacts greatest in the applications where productivity is easiest to measure?
  - Information includes actual use, controlled experiments that may not fully reflect real world conditions, best practices that differ from typical practices, case studies subject to publication bias and testimonials

Assessing Future Benefits

- Estimating U.S. benefits under alternative future scenarios provides a framework for examining the implications of and stimulating thinking about potential future changes and their implications
  - Reflecting changing technologies and systems, growth of market potential, market penetration, creation of new markets, and societal contexts

The scenario approach:

- Highlights major themes and directions
- Improves understanding of the combined influences of many developments and clarifies their collective impacts
- Provides comprehensive information about benefits under possible outcomes
- Facilitates comparisons of benefits under alternative conditions

Concluding Remarks

- A lot of information exists on benefits and utilization of GPS but it is incomplete, widely scattered, of uneven quality, and often not up to date
- Significant efforts have been made to synthesize the information but much more need to be done, especially to make information more current
- A picture of overall benefits is emerging, but differences between methods and estimates need to be reconciled to narrow the range
- Detailed benefit information for key sectors is needed for policy
  - Key sectors need to be identified according to the policy to be addressed
- Policy requires understanding future as well as present benefits
- Application-specific analysis is needed to assess the effects of actions that would cause loss of benefits
  - Taking account of both technological and economic considerations

Supplementary Slides

Some Elements that Could be Incorporated Into Future Scenarios

- Impacts of L2, L5 and L1
- Timing of the constellation evolution (including dual launch)
- Size of the constellation evolution
- Evolution of other GNSSs
- Features of GPS III stages
- Evolution of ground control
- Evolution of wireless and other communications systems
- Evolution of receivers
- Evolution of technological supplements for use indoors and in obstructed areas
- NextGen evolution
- Intelligent transportation systems evolution
- Evolution of networks for precision users and communications
- Evolution of distributed devices and location-based services
- Evolution of energy applications
- Evolution of government applications
- Evolution of environmental applications

Australian Studies

- Allen Consulting Group 2008 study of high resolution positioning services
  - Estimated Australian productivity gains for agriculture, mining and construction and projected market penetration rates to 2030
  - Aggregate effects were calculated using an econometric input-output model of the economy that included both economic benefits to using firms from assumed cost savings and higher outputs and benefits to upstream and downstream industries
- ACIL Tasman 2008 study of the value of spatial information in Australia
  - Estimated productivity effects and levels of adoption for each spatial information application for the year 2006-2007
  - The sector productivity values were entered into an econometric input-output model of the economy to take account of secondary effects on other sectors, including productivity changes in other sectors and expansion of resources

Assumptions of Study of High Resolution Positioning Services in Australia

Productivity and Adoption Assumptions for High Resolution Positioning Services in Australia					
	Productivity Gain		Adoption		
	Conservative	Optimistic	2008 Level	Maximum with a standardized national network at 2030	Maximum without a standardized national network at 2030
Agriculture					
Controlled traffic farming and inter-row sowing	25%	35%	5% of cropped land	80%	70%
Mining					
Accurate selective mining	5%	10%	15% of mine sites	80%	65%
Autonomous haul trucks	10%	20%	0%	60%	50%
Construction					
Precision site survey	0.4%	0.6%	60% of projects	90%	72%
Earthmoving machine guidance	1.3%	2.6%	15%	60%	40%
Source: Allen Consulting Group, *Economic Benefits of High Resolution Positioning Services*, Final Report, November 2008, Table 6.1 http://www.crcsi.com.au/pages/publications.aspx					

European Studies

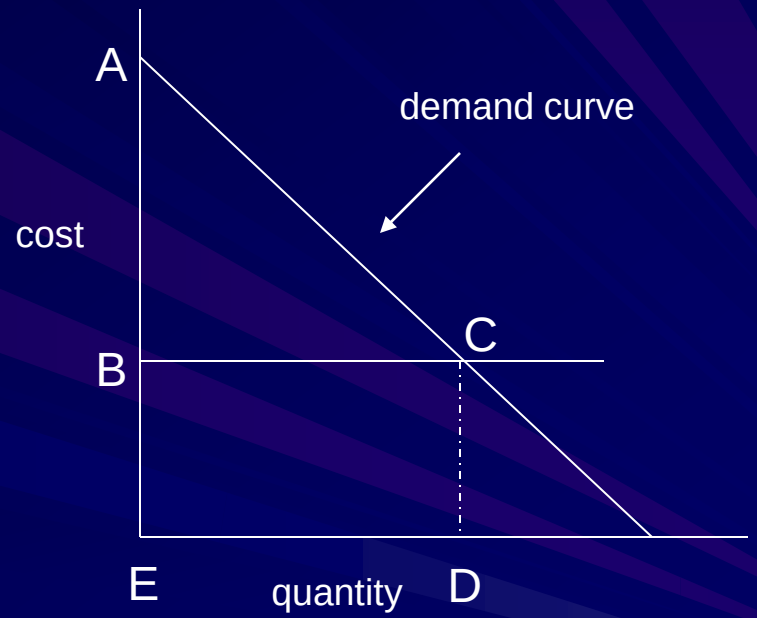
- Galileo studies have not considered its benefits as incremental to those from GPS
- The January 2005 Galileo brochure states:
  - "The equipment and services market resulting from the programme is estimated at around €10 billion per annum, with the creation of more than 100,000 highly skilled jobs."
  - "PricewaterhouseCoopers, based on updated projections over a period of 20 years, indicates a cost/benefit ratio of 4.6, higher than for any other infrastructure project in Europe."
- The European Commission January 2011 review cited an EU estimate that Galileo and EGNOS would generate about €60-€90 billion in economic and social benefits over 2010-2027 if the full Galileo infrastructure were completed

The L2C Study

- The “L2C Study” examined the benefits of the new civilian L2C signal for several scenarios of usage and signal availability based primarily on contributions to productivity of multiple frequency users
  - Benefits included broader impacts on society such as reduced loss of life and injury
- Civilian benefits net of user costs were estimated from 2006 to 2030
- The underlying calculations in the study were used in:
  - The Aerospace flexpower study, which provided the estimate of loss of benefits from ending the P(Y) signal
  - The Aerospace study of financing alternatives for civil-unique GPS capabilities

Consumer Surplus

- Organizations or individuals will purchase a good or service if they perceive the benefits to be at least as great as their cost, where cost includes both what they have to pay for the service and the incremental cost of using it (such as downloading and processing data and the value of their time). Potential users will differ in what they are willing to pay
- A demand curve is a schedule of what customers are willing to pay, with those with the highest benefit buying when costs are higher. The area under the demand curve AC and above the purchase price B, that is, the area of the triangle ABC, is the consumer surplus. The area ACDE is the total value to consumers



Productivity largely measures consumer surplus for GPS since obtaining productivity gains is the major reason for its use.

Indirect and Induced Economic Benefits

- Indirect benefits are benefits from increased activity in supporting industries
- Induced benefits result from productivity, cost and output influences on the rest of the economy
- A multiplier, which is the ratio:

$$\frac{\text{direct + indirect + induced benefits}}{\text{direct benefits}}$$

can be based on findings of available econometric models or inputting the direct benefit results into a national econometric model

Induced benefits can come about in a number of ways:

- Advances in GPS and its use can facilitate or stimulate creation of new or improved production processes or products and development of new or expanded markets
- Changes in attitudes can occur when innovation is evident, causing people to innovate and invest more and/or resulting in increased customer acceptance of new technology
- Exports of equipment and services incorporating GPS can be stimulated by inclusion of GPS capabilities in exported products

Leveson GPS and Related Studies

- *Current U.S. Economic Benefits of the Global Positioning System*, Interim Report to the National Coordination Office for Space-Based Positioning, Navigation and Timing, The Aerospace Corporation, March 16, 2010 (unofficial internal report).
- "GNSS in the Global Economyy," *GPS World* (September 2012), forthcoming.
- Turner, D. A., and Irving Leveson, *Financing Alternatives for Civil-Unique GPS Capabilities*, Task Group 2 Final Report to the Alternative Financing Working Group Co-Chairs, prepared for U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Space Commercialization, The Aerospace Corporation, January, 2007 (FOUO).
- *A Strategic Cost-Benefit Analysis of GPS Civil Signal Modernization*, report to the National Space-Based PNT Executive Committee, March 4, 2006 . Full report prepared under the auspices of the IGEB. Adaptation of public version available as: "Benefits of the New GPS Signal: The L2C Study," *Inside GNSS* (July/August 2006), pp.42-47, 56 http://insidegnss.com/pdf/08-leveson-v5Web.pdf
- *Socio-Economic Benefits Study: Scoping the Value of CORS and GRAV-D*, prepared for the National Geodetic Survey, National Oceanic and Atmospheric Administration, January 2009 http://www.ngs.noaa.gov/PUBS_LIB/Socio-EconomicBenefitsofCORSandGRAV-D.pdf
- *Socio-Economic Study: Scoping the Value of NOAA's Coastal Mapping Program, report to the Remote Sensing Division, National Geodetic Survey, National Oceanic and Atmospheric Administration, March 8, 2012 http://geodesy.noaa.gov/PUBS_LIB/CMP_Socio-Economic_Scoping_Study_Final.pdf*
- *Preparing for GPS Modernization in NOAA*, report to the NOAA Office of Program Planning and Integration, December 18, 2005.

Other GPS and Related Studies

- ACIL Tasman, *The Value of Spatial Information*, prepared for the Cooperative Research Centre for Spatial Information and ANZLIC – The Spatial Information Council, March 2008.
- Allen Consulting Group, *Economic Benefits of High Resolution Positioning Services*, prepared for the Victorian Department of Sustainability and Environment and the Cooperative Research Centre for Spatial Information, Australia, November 2008.
- Arthur, Daniel, *et. al*., "The Macroeconomic Impacts of Galileo," *Proceedings of the ION GNSS International Technical Meeting of the Satellite Division, Long Beach, CA, September 13-15, 2005*, pp.381-389.
- European Commission, *Mid-term Review of the European Satellite Radio Navigation Programme*, Brussels: European Commission, January 18, 2011.
- GPS World, "Leadership Talks – Cost of New Tech," interview with Jason Kim on phasing out use of the P(Y) signal, *GPS World* (July 1, 2008) http://www.gpsworld.com/survey/news/leadership-talks-costs-new-tech-4499
- GSA, *GSA GNSS Market Report*, issue 2, May 2012 http://www.gsa.europa.eu/sites/default/files/MarketReportMEP72012WEB.PDF
- Hudnut, Kenneth W., and Bryan Titus, *GPS L1 Civil Signal Modernization* (The L1C Study), Interagency GPS Executive Board, July 30, 2004.
- Nam D. Pham, *The Economic Benefits of Commercial GPS Use and the Costs of Potential Disruption*, NDP Consulting, June 2011 http://www.saveourgps.org/pdf/GPS-Report-June-22-2011.pdf
- PricewaterhouseCoopers, *Galileo Study, Phase II. Executive Summary*, January 17, 2003.

Biography

Irving Leveson is an expert in economic and strategic analysis and public policy, combining an understanding of critical issues and trends with experience dealing with practical problems. He has worked for both business and government and addressed complex social and technological, as well as economic and industry issues. He has been working on GPS markets, benefits and related issues since 2004.

Dr. Leveson has been providing research and consulting services through Leveson Consulting since 1990. He has served as a consultant to the Aerospace Corporation and is an Adjunct Fellow at the Hudson Institute.

From 1984 to 1990 he was Senior Vice President and Director of Research of Hudson Strategy Group, a consulting firm that was part of Marsh & McLennan. He served as Director of Economic Studies of Hudson Institute from 1977-84. He received his PhD from Columbia University.

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

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