

Economic Benefits of the Second Civilian GPS Signal (L2C)

*Civil GPS Service Interface Committee
Fort Worth, TX
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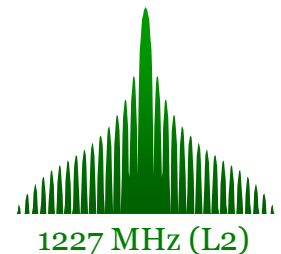
Overview

➤ **Background**

- Approach
- Findings
- Conclusion

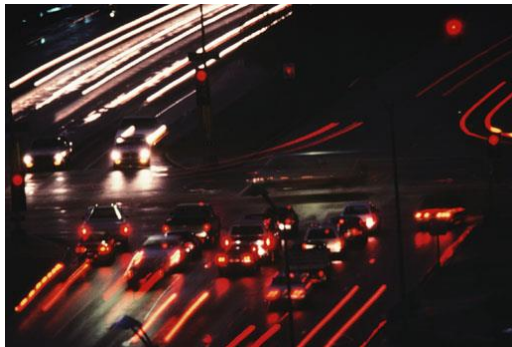
Second Civilian GPS Signal (L2C)

- Announced by White House in 1998
- Designed to meet commercial needs
 - Benefits thousands of existing high-end receivers
 - Increases accuracy for lower-end users
 - Improves availability in challenged environments
- Implemented on eight GPS IIR-M satellites
 - First one declared operational in Dec 2005
 - Second launch: Sep 2006
- Included on all future GPS satellites
- Free signal and technical documentation





Example Applications That L2C Will Benefit

- Agriculture
- Construction
- Intelligent Transportation Systems
- Wireless Telecommunications
- Structural Monitoring
- Natural Resource Conservation



U.S. Industry Celebration of L2C





The U.S. Department of Commerce
The Space Enterprise Council of the U.S. Chamber of Commerce
The National Space-Based Positioning, Navigation, and Timing Coordination Office

are pleased to host

Next Generation GPS for Enhanced Business Productivity

Because Time is Money, and Location is Everything

Wednesday, January 25, 2006
U.S. Chamber of Commerce
Washington, D.C.



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L2C Study

- Initiated in late 2004 with funding from DOC/NOAA, DOT, and IGEB
 - Project Director: Rodney Weiher, NOAA Chief Economist
 - Principal Investigator: Irving Leveson
- Objective: Quantify economic benefits of the new L2C signal through the year 2030

Approach to Benefit Measurement

- Benefits measured according to the **economic productivity approach** which includes productivity gains and cost savings
 - Vs. the typical economic impact approach
- Incremental benefits and user costs defined as the differences from what would be expected in the absence of L2C
- Benefits may be attributable to specific users or spread over a large population
- Market and non-market benefits included

Elements of the Analysis

- Examining potential applications and their benefits to users and the public
- Constructing alternative context scenarios that incorporate developments in signal availability, markets and competing and complementary systems
- Projecting numbers of users, benefits, and user costs for each scenario
- Computing present discounted values and benefit/cost ratios
- Risk/sensitivity analysis

Context Scenarios

High Opportunity

- Timely signal availability
- Larger than expected markets
- High complementarity with L5
- Success of High Accuracy NDGPS
- Full Galileo deployment in 2012 with less than complete technical performance

Moderate Benefits

- Timely L2C availability
- Large potential markets
- Benefits moderated by competition from other signals and augmentations
- Full Galileo deployment in 2011

Diluted Benefits

- Large potential markets
- Gradual L2C deployment and uncertainty about schedules slows investment in innovation and market development
- Improvements in public and private augmentations make single signal use more attractive

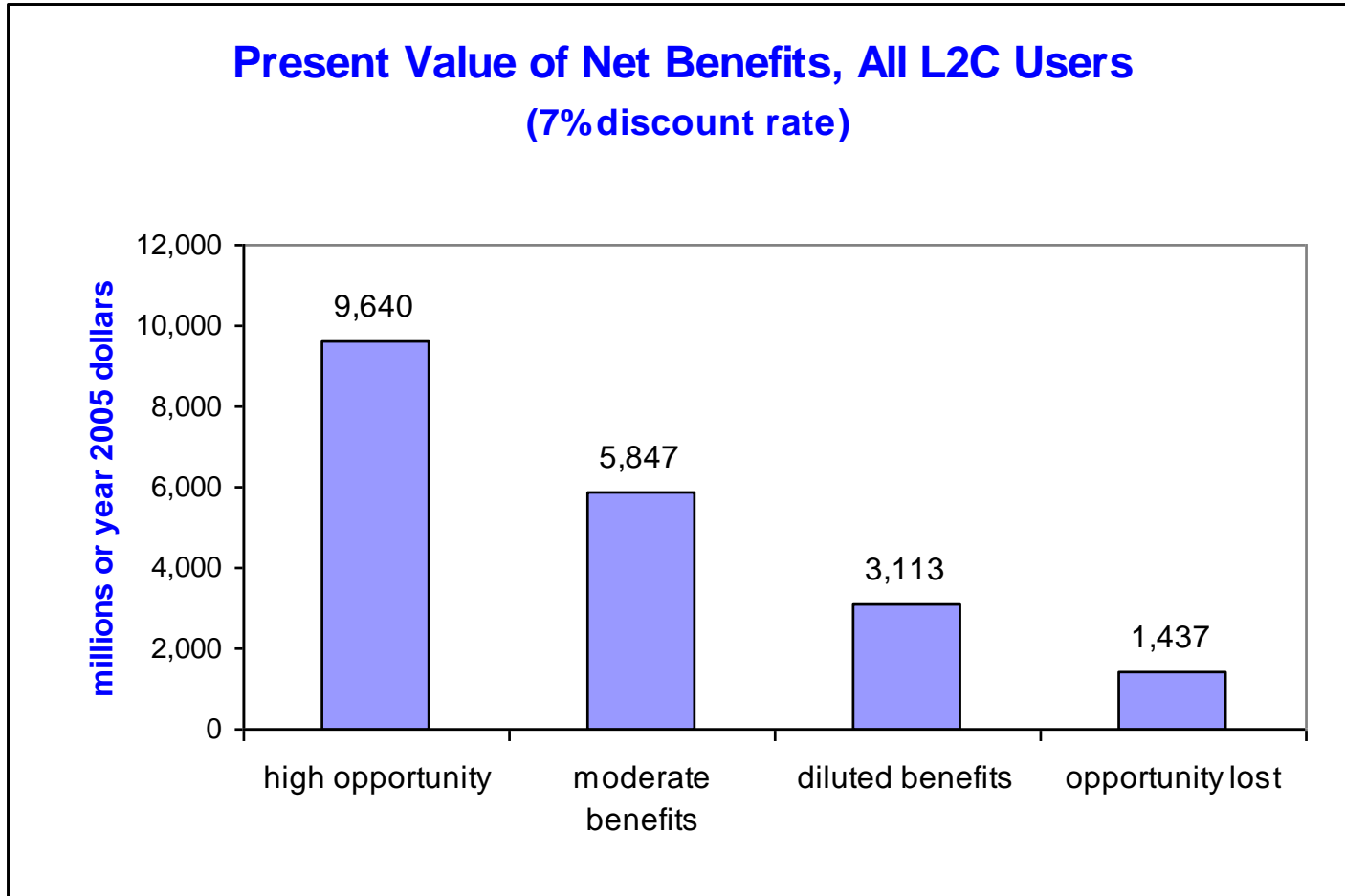
Opportunity Lost

- Late signal initiation and protracted pace of L2C deployment
- Moderately large potential market size, moderate effects of availability of other signals and delay in Galileo FOC to 2011
- Attractiveness of augmentations

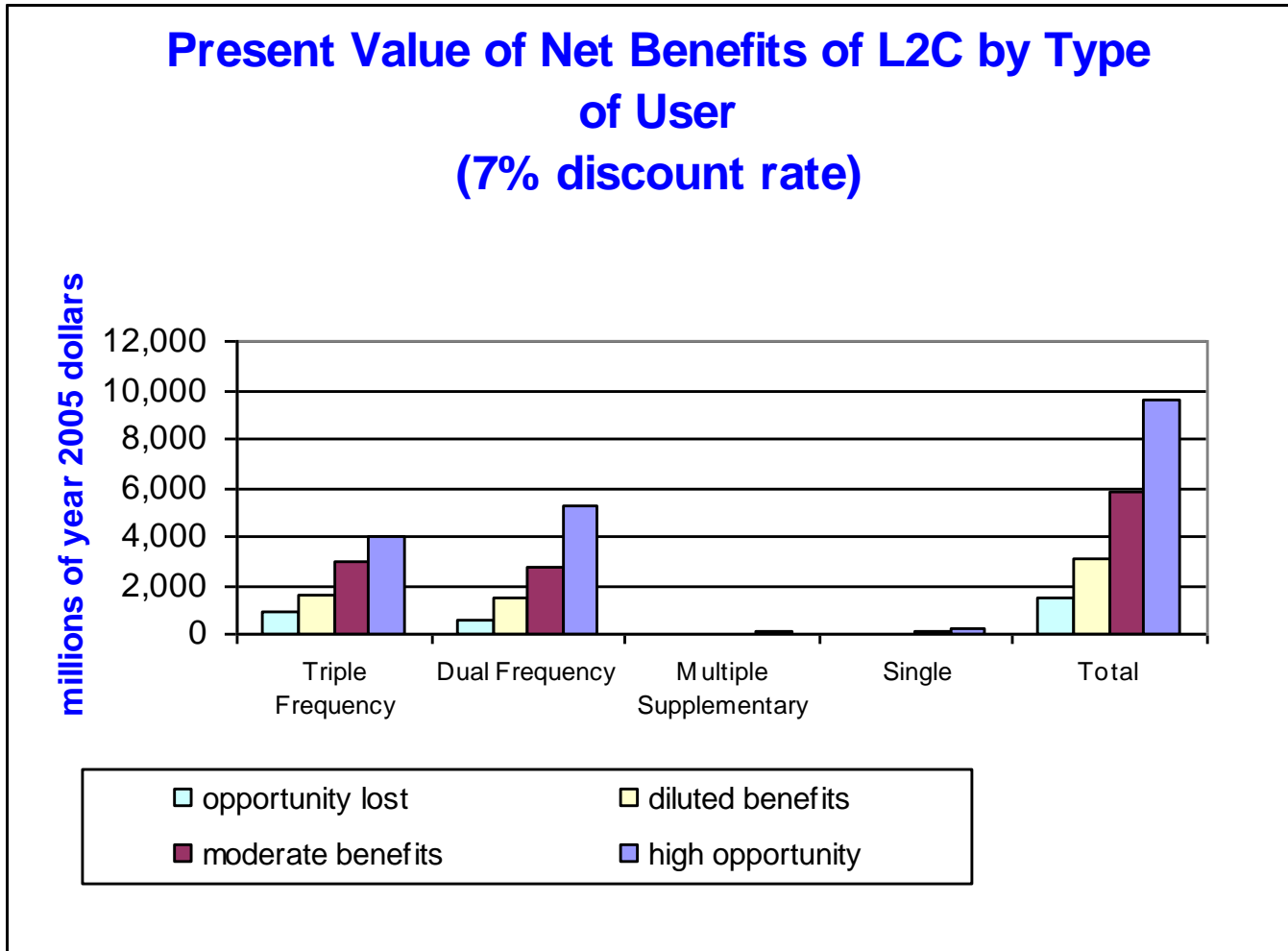
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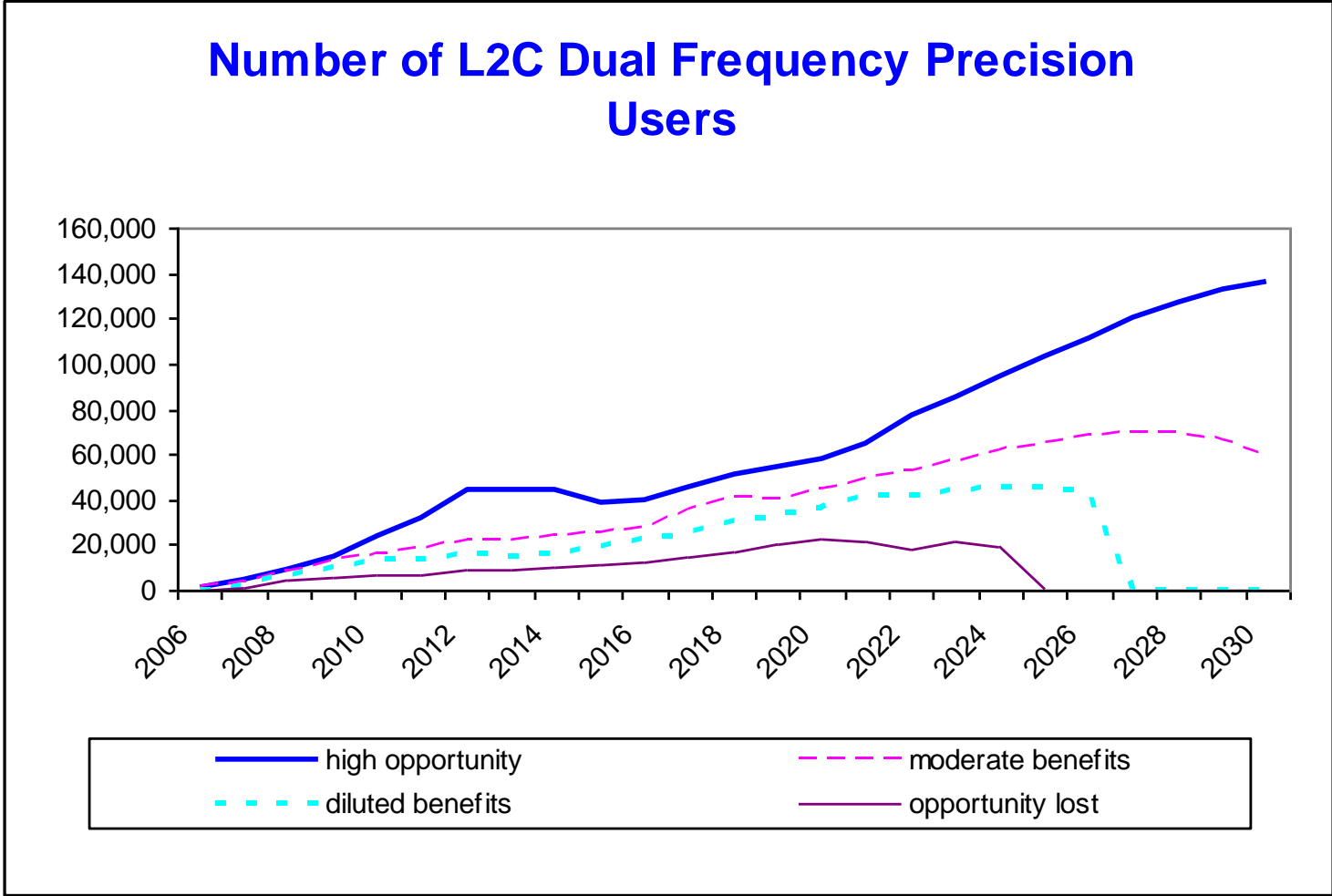
Productivity Benefits of L2C Are Likely to Exceed \$5 Billion



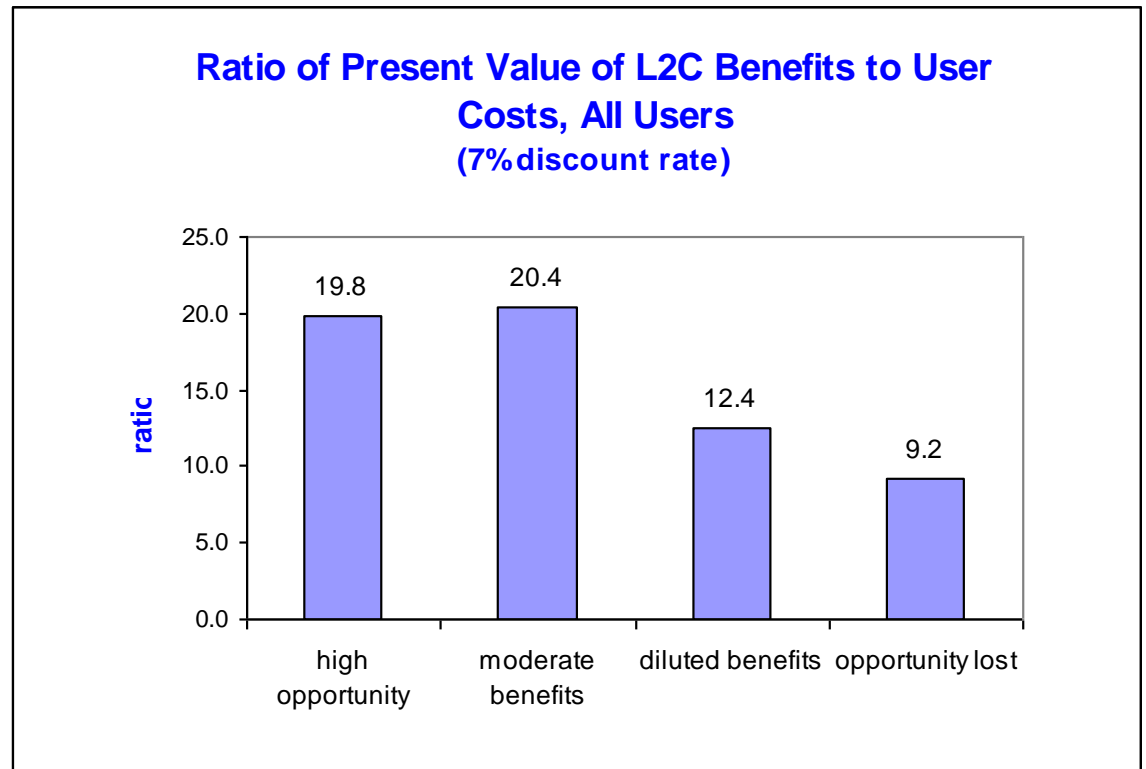
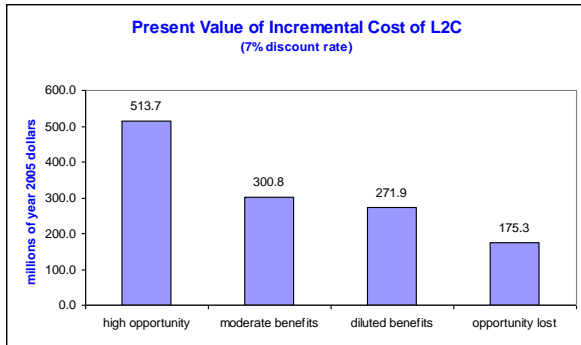
Most Benefits Will Result from Combining L2C with Other Signals



Economic Benefits Accrue Early for Dual Frequency Users



Benefit/Cost Ratio Is High Under All Scenarios



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Conclusions

- Economic benefits of L2C were estimated in terms of productivity gains minus equipage costs
 - Non-monetary benefits to society were also included
- Net benefits range between \$1.6B and \$9.6B through 2030, depending on scenarios
 - Most likely scenario: \$5.8B
- The bulk of economic benefits will result from combining L2C with other signals
- Benefits may be up to 20× equipage costs


Read the Complete Article

- Published in July/August 2006 issue of *Inside GNSS*
- Link to free electronic version available at PNT.gov

Benefits of the New GPS Civil Signal

The L2C Study

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Power grids could be one of the infrastructures benefitting from a second civil GPS signal

How much will civilians benefit from further GPS modernization efforts? A recent study conducted on behalf of the U.S. departments of commerce and transportation focused on L2C applications other than those of aviation and military users. The analysts concluded that L2C will substantially benefit dual-frequency applications until alternative signals are widely used and could be a long-term boon for applications requiring three or more frequencies.

GPS has had enormous benefits to the economy and society that go well beyond military and civil aviation applications – that is becoming ever more widely understood. What has been more open to discussion are the civilian non-aviation benefits of further U.S. efforts at GPS modernization, particularly the introduction of additional signals.

In an effort to define and measure civilian benefits, the U.S. departments of commerce and transportation commissioned some economic analyses of civil signal modernization. Particular emphasis was placed on the value of the L2C signal centered at 1227.60 MHz, which recently began broadcasting from the first modernized GPS Block IIR-M satellite. This article is an outgrowth of that effort.

The analysis focused on the value of signals at more than one frequency for precision non-aviation use by business and government. It considered how utilization of the second civilian signal and its benefits would evolve in the coming

decades as the L2C constellation expands and as additional signals become available from GPS and other GNSSs.

In the study, projections were developed under four scenarios – with the “moderate benefit” scenario seeming most likely – that reflect combinations of developments, including the strength of markets, the timing of L2C signal availability, the timing of Galileo availability, and complementary and competitive relationships with augmentations.

The main findings of the study are:

- The projected number of U.S. high precision users of any signal nearly doubles from 39,000 to 75,000 from 2004 to 2008, and reaches 146,000 in 2012 and 333,000 in 2017.
- Under a “moderate benefit” scenario, the number of L2C users reaches 64,000 by 2017, of which 35,000 are dual-frequency users and 29,000 use three or more frequencies.
- Civilian benefits of L2C net of user costs range from \$1.4–\$9.6 billion under alternative scenarios and civilian net benefits are about \$5.8 billion under the moderate benefit scenario.

- Results are robust.
- Positive present values of benefits net of user costs are obtained in all tests.
- The ratio of benefits to user costs ranges from 8 to 20 in all tests.

In addition to the domestic benefits examined, L2C will undoubtedly have important international benefits.

This article presents in more detail how we defined the problem, approached the study, and arrived at these conclusions.

The L2C Evolution

L2C, together with the present L1 C/A-code signal and the future modernized civil signal L1C, will provide an alternative to augmented single frequency GPS for precision users. Separate investigations have outlined the incremental benefits of L1C (See sidebar, “The L1C Studies.”)

L2C signals can be used for both horizontal and vertical measurement and positioning along with L1 C/A as satellites become available over more areas and in more times of the day. The first satellite can be used for improved timing. L2C also can be used in configurations of three or more frequencies in combination with the forthcoming GPS L5 signal and with signals from Galileo and GLONASS.

At various times in each signal’s deployment and development of markets, other signals will, to varying degrees, provide complements to L2C and competitors to it. L2C has its greatest potential to generate benefits for dual frequency applications until alternative signals are widely utilized, and for long-term use in applications taking advantage of three or more frequencies.

The L3 signal is currently being widely used for augmentations, and the new signals can be used in that way along with the existing constellation. However, L5x use as a competitor to L2C and as a partner to L2C in multiple frequency implementations primarily depends on the launch timeline for satellites carrying the L5 signal since L5, centered at the 1176.45 MHz frequency, is not currently in service. Plans call for its implementation on the GPS Block IIF satellites, with the first IIF now expected to be launched in 2008.

L2C deployment requires a commitment to operational capability. Decisions will be required as to launch dates and signal activation for each successive satellite containing the signal. The L2C benefits study is intended to contribute to decisions about L2C deployment with consideration of alternative scenarios informed by quantitative and qualitative analysis.

To explore the implications of L2C evolution, we make projections about the numbers of U.S. precision users, incremental benefits, and user costs, based on examination of applications and available evidence on value of benefits, and consider how these can unfold over the period 2006–2030.

The analysis focuses on precision users of L2C who use two or more frequencies, although we do include estimates for supplementary multiple-frequency users and single-frequency users. However, the estimates of these types of use are more conjectural and do not contribute much to the overall value of benefits.

Benefits net of user costs are measured according to the widely accepted economic productivity approach, which includes productivity gains and cost savings. This comprehensive approach is more appropriate than one that measures benefits simply by expenditures on equipment and services.

Incremental benefits and user costs are defined to include all differences in outcomes from what would be expected in the absence of L2C.

Signal Advantages and Availability

The L2C signal, scheduled to be the first of the modernized civil GPS signals, is intended for civilian purposes other than aviation and safety-of-life. It will provide greater accuracy and robustness and faster signal acquisition than the current L1 C/A-code signal. Higher signal power and forward error correction will improve GPS mobile, indoor, and other uses.

The L5 signal that will arrive within a few years will be in a protected aeronautical radiolocation system (ARNS) band intended for aviation and other safety-of-life uses and will have broader applications.

Multiple signals will allow many users to obtain greater precision and availability at lower cost than achievable with proprietary augmentation systems. However, signal combinations combined with public and private augmentations for even greater precision and reliability will support applications with some of the greatest potential benefits. Combined use of L2C with L1 C/A and L5 will also enable some precision users to achieve even greater reliability and accuracy.

Although available simulations differ on the size of benefits of three signals over two, many professionals expect important advantages from such “tri-laning” techniques.

The L1C Studies

Before the L2C study, important progress had already been made in understanding the benefits of additional GPS signals. These activities included the discussion of civilian applications in the report of the Defense Science Board Task Force on GPS, released last December, and the L1C study undertaken by the Interagency GPS Executive Board in 2004. (See the “Additional Resources” section at the end of this article to find out how to obtain these studies on-line.)

Upper limits of total benefits of L1C for the single year 2005 – including those obtained by single- and multiple-frequency users in private households, businesses, governments – were estimated at approximately \$2 billion, \$140 million for mobile and wireless location services, \$62.5 million for information/data services, \$390 million for “commercial GPS” and \$490 million for in-vehicle information and navigation services (telematics).

The L1C study approximated a “rough order of magnitude” dollar value of L1C applications based on 2005 spending by applying a “beam consensus” for an assumed incremental benefit as a percentage of market value (revenue) for each of 12 user categories. Spending in user group categories was based on a compilation of trade estimates.

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Backup

Study Assumptions

- L2C + L1 C/A will provide an alternative to augmented single frequency GPS
- L2C will be used in multi-frequency applications with L5 and/or Galileo signals
- L2C has its greatest potential to generate benefits:
 - For dual frequency applications until alternative signals are widely utilized
 - For long term use as a third frequency
- Dates of GPS signal availability
 - Dates of 24 and 18 satellites for each signal based on best information available during the study year 2005
 - To enable analysis, assumes approximately straight line of deployment
- Assumed Galileo FOC dates as indicated in each of the context scenarios
- Capabilities of public and private augmentations will continue to improve