

# **The Economic Benefits of Global Navigation Satellite System and its Commercial and Non-Commercial Applications**

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## GLOBAL INDUSTRY OVERVIEW

The applications of Global Navigation Satellite System (GNSS) are rapidly increasing across sectors. As an innovative industry, the GNSS industry directly affects economic activities and economic growth worldwide. During the past several decades, GNSS technology has transformed American businesses and lifestyles with innovative products and services across industries. GNSS applications have improved business operations and best practices in a range of industries from farming, construction, transportation, and aerospace. In addition to creating efficiencies and reducing operating costs, the adoption of GNSS technology has improved safety, environmental quality, and has delivered many other less-readily quantifiable benefits. Furthermore, GNSS applications have entered into our daily life in many ways that we might not think about and be taken them for granted. For example, a person uses GPS-watch for a pleasure run or a mom uses a GPS-navigation device to looking for alternative route to pick up her kid at the daycare. The values of those services are beyond monetary values. Nevertheless, the future potential is still far reaching.

### Market segments

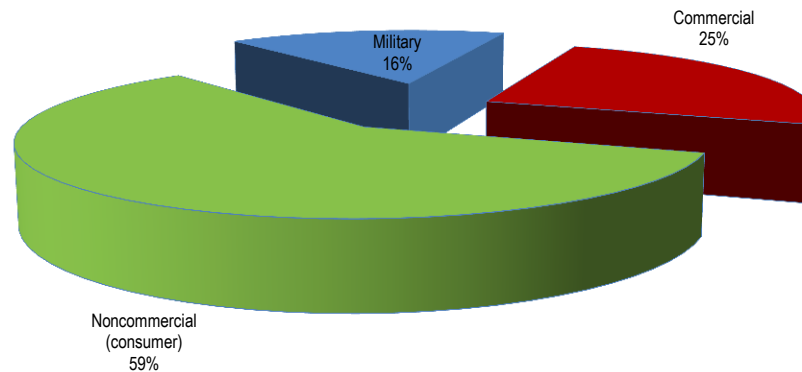
The GPS market can be divided into three broad categories: commercial, noncommercial (consumer), and military. During the period 2005-2010, commercial equipment sales accounted for 25 percent of the total, while noncommercial and military equipment accounted for 59 percent and 16 percent, respectively, in the United States (Figure 1).<sup>2</sup>

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<sup>1</sup> The analysis and views expressed here are solely those of the author.

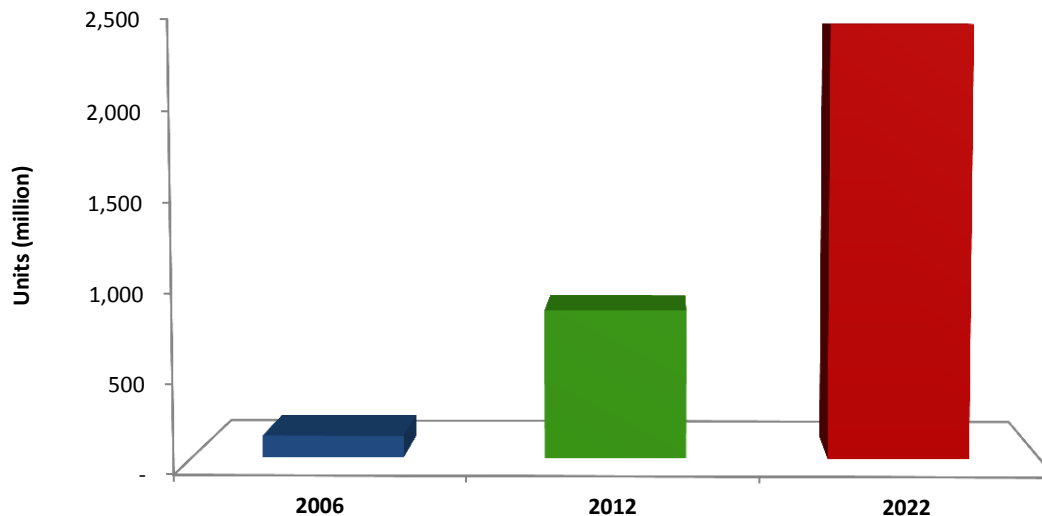
<sup>2</sup> Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and author' estimates. North America consists of the United States, Canada, and Greenland. The U.S. markets are estimated to account for more than 90 of North America. Since disaggregated data is not available, we use North America data for this analysis.

Figure 1. Revenue Shares of GPS Equipment, 2005-2010<sup>3</sup>



The applications of GNSS technology are rapidly developing into commercial and noncommercial industries. Global shipments of GNSS devices grew from 125.5 million units in 2006 to more than 850.7 million units in 2012. The European GNSS Agency projects nearly 2.5 billion units of GNSS devices will be sold in 2022. The Agency estimates the number of installed base units of GNSS devices will increase almost four-fold from less than 2 billion units in 2012 to nearly 7 billion units by 2022, almost one GNSS receiver for every person on the planet.<sup>4</sup>

Figure 2. Annual Shipments of GNSS Devices, 2012-2022 (millions of units)<sup>5</sup>



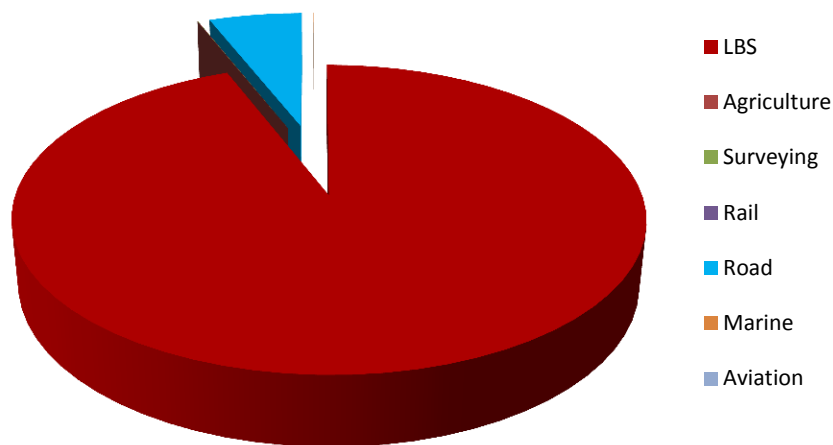
<sup>3</sup> Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and author's estimates.

<sup>4</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3. [http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

<sup>5</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3. [http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

The market segment of location-based services (LBS) that covers smartphones, tablets, digital cameras, laptops, fitness and people tracking devices, and mobile data revenues has been growing exponentially and dominates the GNSS markets. Indeed, the global market of GNSS-enabled location-based services (LBS) devices alone increased more than eight-fold from 100 million devices sold in 2006 to 800 million devices sold in 2012. The European GNSS Agency expects annual sales of LBS devices will increase three-fold to more than 2.3 billion units in 2022. In terms of units, GNSS-enabled devices sold in LBS market account for more than 94% of total GNSS devices sold annually (Figure 3).

**Figure 3. Annual Shipments of GNSS Devices by Market Segment, 2012 (millions of units)<sup>6</sup>**

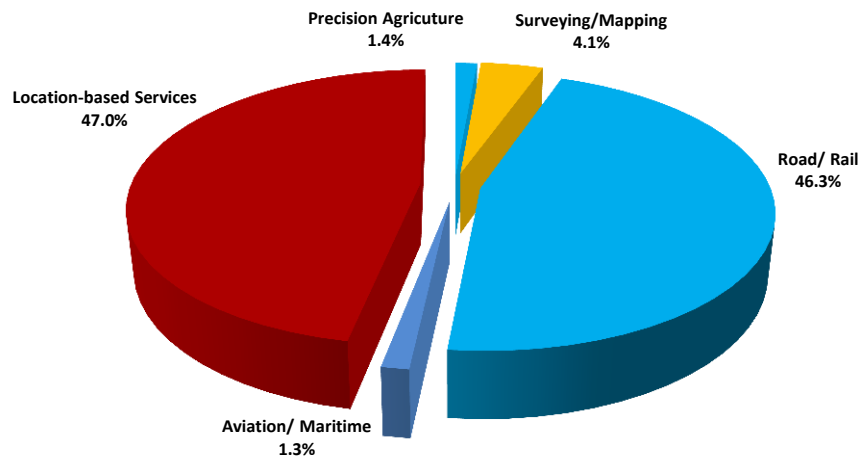


In its Market Report 2013, the European GNSS Agency estimates global revenues of the GNSS enabled market (accounting for the full retail price of the GNSS enabled devices) will grow from €150 billion (approximately \$204 billion) in 2012 to approximately €250 billion (approximately \$340 billion) in 2022. During the same period, global revenues of the GNSS core market that include only the part of the retail value attributable to GNSS (e.g., chipsets) is expected to double from €50 billion (approximately \$68 billion) to €100 billion (approximately \$136 billion). According to the report, the average cumulative revenues of LBS is expected to account for nearly half of total GNSS revenues in the next two decades. Note that the estimates above include only the value of GNSS functionality (rather than the full device price) and service revenues directly attributable to GNSS functionality (data downloaded by smartphones to use LBS) (Figure 4).<sup>7</sup>

<sup>6</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3. [http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

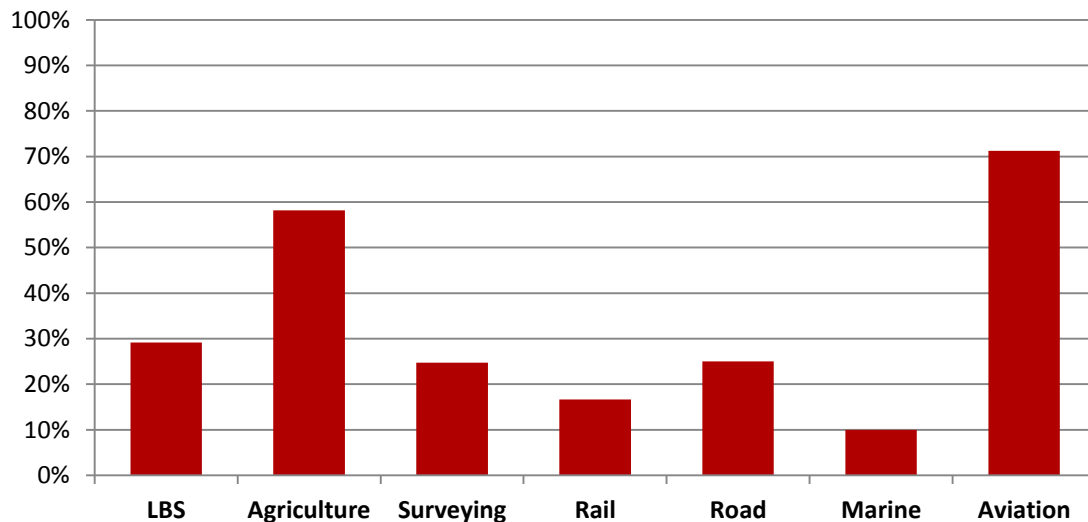
<sup>7</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3. [http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

**Figure 4. Cumulative Global GNSS Core Revenues, 2012-2022<sup>8</sup>**



The revenue share to North America markets were approximately 30% of total global revenues in 2012. North America markets account for about 70% and nearly 60% of GNSS device sales of the aviation market segment and agriculture segment, respectively (Figure 5).

**Figure 5. Revenue Shares of GNSS Devices in North America by Market Segment, 2012 (%)<sup>9</sup>**



<sup>8</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3.  
[http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

<sup>9</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3.  
[http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

## ECONOMIC IMPACTS OF THE GNSS APPLICATIONS ON COMMERCIAL AND NONCOMMERCIAL USERS

The economic benefits of GNSS to society are substantial. Like other innovative products, the economic benefits of the GNSS technology on the economy and society are generated from the value added of GNSS manufacturers and the benefits of the GNSS technology to consumers. GNSS manufacturers create employment, provide earnings, and generate tax revenues for governments. Far more important, GNSS technology produces cost-savings for end-users, improves productivity, and provides nonmonetary values for users. In addition, the spillover effects from the GNSS technology to other sectors otherwise unavailable.

### Impacts on GNSS Manufacturers

The Europe GNSS Agency estimates there are 1.8 billion GNSS devices currently installed globally and are expecting the number of installed units to grow by nearly four-fold to reach nearly 7 billion units by 2022. The number of GNSS devices sold in 2012 was over 850,000 units and is estimated to be nearly 2.5 million units by 2022. Total revenues of GNSS devices sold in 2012 were nearly \$60 billion and are estimated to be nearly \$144 billion by 2022. The estimated revenues include only the value of GNSS functionality and service revenues directly attributed to GNSS functionality. For example, only the value of GNSS chipsets in smartphones is counted and only the value of the GNSS receiver inside the Flight Management System is included (Table 1).

Location-based services (LBS), which include smartphones, tablets, digital cameras, laptops, fitness and people tracking devices, accounted for nearly 90% of number of GNSS installed-base devices. Since the price per unit is relatively inexpensive (approximately \$20 per unit in 2012), revenues of LBS accounted for less than 30% of total revenues in 2012. However, revenues of LBS are expected to rise up to nearly two-thirds of total revenues by 2022 (Table 1).

**Table 1. Global GNSS Markets, 2012--2022<sup>10</sup>**

Market Segment	Installed Base (units; million)		Shipments (units; million)		Revenues (\$; billion)	
	2012	2022	2012	2022	2012	2022
<b>LBS</b>	1,600.0	6,300.0	800.0	2,350.0	16.3	93.8
<b>Agriculture</b>	0.5	3.6	0.2	0.8	0.8	2.4
<b>Survey</b>	0.3	1.3	0.1	0.3	2.9	5.0
<b>Rail</b>	0.1	0.4	0.1	0.1	0.1	0.1
<b>Road</b>	200.0	500.0	50.0	120.0	38.0	41.0
<b>Marine</b>	0.5	1.0	0.1	0.2	0.2	0.4
<b>Aviation</b>	0.8	1.5	0.3	0.4	1.1	1.2
<b>Total</b>	1,802.2	6,870.8	850.8	2,471.8	59.4	143.9

<sup>10</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3. [http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf); rounding figures.

North America markets account for approximately one-third of total global GNSS markets, the equivalent of \$16 billion in 2012. Again, this revenue figure only accounts for GNSS chipsets and direct services attributed to GNSS functionality. Aviation markets in North America are about 70% of global markets, agriculture markets are 50% of global markets, LBS markets are 30% of global markets, and surveying and road markets are about 25% of global markets.

GNSS manufacturers are spreading in several industries in the U.S. including radio, TV broadcasting, wireless communications equipment (NAICS 334220), search, detection, navigation, guidance, aeronautical and nautical systems, instrument manufacturing (NAICS 334511), and other measuring and controlling device manufacturing (NAICS 334519). According to the U.S. Census data, there are 2,206 establishments in these three industries. These establishments employed 241,964 workers in 2011 and paid nearly \$20.4 billion in wages. Value of shipments and value added in 2011 were approximately \$91.9 billion and \$54.3 billion, respectively. Annual payroll per employee averaged \$81,969. Value of shipments and value added per employee in 2011 averaged \$379,809 and \$216,202, respectively (Table 2).

**Table 2. GNSS-related Manufacturing Industries in the United States, 2011<sup>11</sup>**

	NAICS 334220	NAICS 334511	NAICS 334519
Number of Establishments	809	592	805
Employees	68,643	145,288	28,033
Annual Payrolls (\$ million)	6,192.3	12,186.8	2,013.3
Value of Shipments (\$ million)	30,231.6	52,145.8	9,533.9
Value Added (\$ million)	13,708.0	34,683.0	5,892.2
<i>Per employee</i>			
Annual Payroll (\$)	90,210	83,880	71,818
Total of Shipments (\$)	440,418	358,913	340,096
Value Added (\$)	199,700	238,719	210,187

We use the GNSS revenues in 2012 (estimated by the European GNSS Agency) and the manufacturing industry averages (estimated by the U.S. Census) to estimate the economic impacts of GNSS manufacturing companies on the U.S. economy. As shown earlier, the European GNSS Agency estimated GNSS revenues in 2012 were approximately \$16 billion in North America, which are mostly in the United States. Using averages of three GNSS-related manufacturing industries, we estimate GNSS manufacturers employed 42,126 workers in 2012, paid nearly \$3.5 billion in wages, and contributed over \$9.1 billion to the U.S. GDP (Table 3).

Furthermore, we applied the BEA economic multipliers to estimate total direct, indirect, and induced effects of GNSS manufacturers on jobs, earnings, and outputs. The Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce produces job, wage, value-added, and output multipliers to estimate the indirect and induced effects of U.S. industries. The BEA estimates the job multiplier of the related-GNSS manufacturing industries ranges between 2.3 and 3.1 and the wage and output multipliers range between \$1.8 and \$2.2.<sup>12</sup> Direct effects are the dollar amount of inputs required by an industry to produce a dollar of the industry's output, while indirect effects are the dollar amount of inputs required by all other industries in

<sup>11</sup> U.S. Census Bureau. 2011 Annual Survey of Manufacturers; U.S. Census Bureau. 2011. County Business Patterns. Web.

<sup>12</sup> Regional Input-Output Modeling System (RIMS II); <http://www.bea.gov/regional/rims/index.cfm>

the supply chain to meet the industry's initial demand for the dollar of its output. Mary Streitwieser at the BEA illustrates by using the example of motor vehicles to demonstrate the direct and indirect effects associated with the final outputs. The direct effects are the input production requirements such as the paint, steel, and plastic for the motor vehicles industry to provide additional motor vehicle outputs. The indirect effects are those "trickle down" production requirements for all other industries necessary in the supply chain to support the additional demand for intermediate inputs from the motor vehicles industry, such as the additional requirement for tire cord and synthetic rubber by the plastics and rubber industry to provide the additional tires required by the motor vehicles industry. The induced effects are the impacts of household expenditures on goods and services from the income earned by all direct and indirect employees.<sup>13</sup>

We estimate the GNSS manufacturing companies supported 105,315 workers (including direct jobs) with \$6.8 billion in earnings and \$32 billion in outputs (Table 3).

**Table 3. Economic Contributions of GNSS Manufacturing Companies**

Economic Benefits	Total
<i>Direct Economic Impacts</i>	
Total Revenues	\$16.000 billion
Total Value Added	\$9.107 billion
Total Payrolls	\$3.453 billion
Number of Employees	42,126
Payroll per Employee	\$81,969
<i>Direct and Indirect Economic Impacts</i>	
Output	\$32.0 billion
Earnings	\$6.8 billion
Employment	105,315

Like all other manufacturers, GNSS manufacturers create additional economic activities for upstream and downstream business entities. While GNSS manufactures purchase intermediate goods and services from upstream vendors to produce chipsets, the GNSS technology creates additional economic activities for downstream companies who rely on the technology to create other products and services. The downstream business entities include GNSS device vendors, service and content providers, original equipment manufacturers, application developers, and retailers. In its 2013 report, the European GNSS Agency provides examples of key companies in the value chain of GNSS commercial and noncommercial applications (Table 4).<sup>14</sup>

<sup>13</sup> Streitwieser, Mary L. 2010, "Measuring the Nation's Economy: An Industry Perspective – A Primer on BEA's Industry Accounts," Bureau of Economic Analysis.

<sup>14</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3.  
[http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)



**Table 4. Examples of GNSS Manufacturers and Downstream Companies of the Value Chain<sup>15</sup>**

Value Chain	Examples of Key Companies
Chipset manufacturers	<ul style="list-style-type: none"> <li>• Broadcom</li> <li>• Intel</li> <li>• Qualcomm</li> <li>• Texas Instruments</li> </ul>
Device Manufacturers	<ul style="list-style-type: none"> <li>• Honeywell</li> <li>• Rockwell Collins</li> <li>• Universal</li> <li>• Garmin</li> <li>• Trimble</li> </ul>
Device Vendors	<ul style="list-style-type: none"> <li>• Apple</li> <li>• Dell</li> <li>• HP</li> <li>• Garmin</li> <li>• Trimble</li> <li>• TomTom</li> <li>• John Deere</li> </ul>
Service & Content Providers	<ul style="list-style-type: none"> <li>• Apple</li> <li>• Garmin</li> <li>• Google</li> <li>• Nokia</li> <li>• TomTom</li> </ul>
Original Equipment Manufacturers	<ul style="list-style-type: none"> <li>• Ford</li> <li>• General Motors</li> <li>• Daimler</li> </ul>
Application Developers	<ul style="list-style-type: none"> <li>• Apple</li> <li>• Microsoft</li> <li>• TripAdvisor</li> </ul>
Application Stores	<ul style="list-style-type: none"> <li>• Apple App Store</li> <li>• Amazon App Store</li> <li>• Google Play</li> <li>• Windows Phone Store</li> </ul>

Oxera Consulting Group estimates that the direct economic effects of the downstream location-based service companies (Geo services) to be around \$150-\$270 billion in revenues per year globally. These companies contribute around \$113 billion value added to GDP per year, accounting for 0.2% of global GDP.<sup>16</sup> The Boston Consulting Group (BCG) estimates the geospatial services industry employs the GPS

<sup>15</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3.

[http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

<sup>16</sup> Oxera Consulting. 2013. “What is the economic impact of Geo services?” <http://www.oxera.com/Latest-Thinking/Publications/Reports/2013/What-is-the-economic-impact-of-Geo-services.aspx>

technology to generate about \$75 billion revenues and provides more than 500,000 workers in the U.S. to support consumers, businesses, and government agencies. The downstream effects are expected to continue growing to reach \$100 billion in annual revenues between 2012 and 2017 in the United States.<sup>17</sup>

Another major commercial market of GNSS applications is ground transportation that applies intelligent transportation system (ITS) technology. According to an IBM report, the ITS industry markets in North America were \$52 billion in 2009 and is expected to grow to \$73 billion by 2015. The industry employed over 513,000 workers and is expected to expand to 564,000 employees by 2015.<sup>18</sup>

Clearly, the impacts of GNSS technology on economies and societies are large. However, there are at least three technical challenges to quantify the exact direct economic activities of GNSS manufacturers and their upstream and downstream vendors. The first challenge is related to the industry classification system. As shown earlier, GNSS manufacturers are among 2,206 establishments in three industries. However, not all of these companies produce GNSS-related products and government statistics do not have exclusive data for GNSS companies. The second technical challenge is to estimate the portion of GNSS-related activities in each company. As seen in the examples of GNSS companies and their downstream vendors above, these companies have multiple lines of business. For example, key chipset manufacturers like Broadcom, Intel, Qualcomm, and Texas Instruments produce many other products. Similarly, device vendors and application developers and stores have other products and services as well. The third technical challenge is the rapid development of the GNSS applications that affect downstream vendors. As shown in the 2013 European GNSS Market Report, the location-based services market alone increased by eight-fold in the past seven years. The number of mobile applications increased more than ten-fold within one year. As results, data becomes outdated quickly.

## Impacts on Major Markets

The GNSS technology creates valuable applications to both commercial and noncommercial users. Commercial users apply GNSS technology to increase productivity which in turn have positive impacts on cost-savings. Direct economic impacts include savings on inputs of labor, capital, and time. Noncommercial users enjoy GNSS technology for their daily life activities. In addition to monetary measures, GNSS technology creates nonmonetary benefits for noncommercial users. Altogether, GNSS technology creates values for personal and business consumers.

*Location-based Service (LBS) Market.* LBS is increasingly integrated into our daily lives. The LBS market segment applications include personal navigation, point of interest search, LBS advertising, person and objects tracking, emergency caller location, location based gaming, sport and entertainment, weather information, and social networking. The number of applications is estimated to be around 775,000 in Apple App Store in 2013 and the number of Android Apps increased from 88,000 in 2011 to 700,000 in 2013. Various positioning technologies are integrated into one device such as cameras, watches, and binoculars. Location information sent from devices to application layers to enable sharing and tracking.<sup>19</sup>

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<sup>17</sup> Henttu, Heikki, Jean-Manuel Izaret, and David Potere. 2012. "Geospatial Services: A \$1.6 Trillion Growth Engine for the U.S. Economy." Boston Consulting.

<sup>18</sup> Keeling, Mary and Gerard M. Mooney. 2011. "Transportation and economic Development." IBM Global Business Services.

<sup>19</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3.

[http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

The first LBS services were launched in 2001 by TeliaSonera in Sweden and by EMT in Estonia, relying on the Ericsson mobile positioning system. The first advertisement for iPhone was in 2007 and the mobile apps were launched in 2008 at the App Store. Global shipments of GNSS-enabled LBS devices have grown from 100 million units in 2006 to 800 million units in 2012. North America and Europe account for half of the shipments in 2012. About 90% of LBS devices are in smartphones and other platforms such as tablets, digital cameras, laptops, fitness devices, and people tracking.<sup>20</sup> According to CTIA Wireless Association, around 74% of consumers largely benefit from an expanded smartphone ownership that helps to get real-time location-based information. The overall proportion of U.S. adults who get location-based information has almost doubled from 23% in May 2011 to 41% in February 2012.<sup>21</sup> The Mobile technology industry is also estimated to provide around 519,000 application jobs as of 2012. Lower costs of data connectivity and consumer electronics drive the development of new applications.<sup>22</sup>

The economic benefits of location-based services span across personal and business consumers as well as governments. In addition to national security and defense, the GNSS applications enable law enforcement to improve the efficiency of disaster response, people tracking, and community safety. Geospatial services become an essential element in our daily life to access information on computers, mobile phones, tablets, and GPS devices. On the commercial side, companies have integrated geospatial services into their core business operations, sales, and marketing. In its 2012 report, the Boston Consulting Group estimates that the multiple effects of the \$75 billion geospatial services industry range between 15 and 20 times. The report estimates that the overall impacts of geospatial services in the U.S. economy are 1.6 trillion in economic activities and an additional \$1.4 trillion in cost savings a year. The report also projects the overall impacts to reach \$2.6 trillion per year by 2017.<sup>23</sup>

Studies have shown geospatial services create benefits via many channels including time savings, fuel savings, emergency response, and education. The GNSS applications help drivers to get to their destinations faster and in shorter routes which in turn save fuel consumption. In addition to personal trips, time savings add the substantial benefits for emergency services to locate and reach the scene quickly. The GNSS applications provide educational tools for students to gain information and knowledge and to sharpen their skills to enter the workforce. For example, Oxera Consulting estimates the consumer benefits from geospatial services are nearly \$50 billion per year globally (\$22 billion in journey time and fuel savings, \$12 billion in educational benefits, and up to \$13 billion in emergency responses). The study estimates about one-third of the global benefits are allocated to the United States.

Civil Aviation Markets. The GNSS applications cover all commercial and noncommercial aviation to provide the accuracy and integrity of the position of aircrafts. Application of GNSS in aviation sector helps comprise various socio-economic benefits and helps to increase safety, reduce congestion, save fuel, protect the

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<sup>20</sup> The European GNSS Agency. 2013. GNSS Market Report 2013 – Issue 3.

[http://www.gsa.europa.eu/sites/default/files/GNSS\\_Market%20Report\\_2013\\_web.pdf](http://www.gsa.europa.eu/sites/default/files/GNSS_Market%20Report_2013_web.pdf)

<sup>21</sup> Pew Internet. 2012. "Three-quarters of smartphone owners use location-based services." Press Release;

<http://www.pewinternet.org/Press-Releases/2012/Location-based-services.aspx>

<sup>22</sup> Mandel, Michael and Judith Scherer. 2012. "The Geography of the App Economy." TIA Wireless Association,

[http://files.ctia.org/pdf/The\\_Geography\\_of\\_the\\_App\\_Economy.pdf](http://files.ctia.org/pdf/The_Geography_of_the_App_Economy.pdf)

<sup>23</sup> Henttu, Heikki, Jean-Manuel Izaret, and David Potere. 2012. "Geospatial Services: A \$1.6 Trillion Growth Engine for the U.S. Economy." Boston Consulting.

environment, reduce infrastructure operating costs, and maintain reliable all weather operations, even at the most challenging airports. The U.S. economy relies on aviation.

Indeed, the Federal Aviation Administration (FAA) projects daily flights in the U.S. will increase by 40% from 43,000 in 2010 to 60,000 in 2030. The number of passengers will increase by more than 68% from 712 million in 2010 to 1.2 billion in 2030. Thus, operational efficiency and passenger safety are essential for the future of the aviation industry.

The economic impacts of the GNSS application on the aviation industry are significant. The FAA's initiative of NextGen is to create satellite-based procedures to transform the national airspace system. NextGen flight tracks will relieve bottlenecks and improve safety and efficiency to deliver more on-time and fuel-efficient flights. The FAA estimates the benefits of NextGen to reach \$123 billion through 2030. Consumers will benefit from better travel experiences through the reduction in delays resulting from on-time performance by controllers and operators. The FAA expects that NextGen improvements will reduce overall flight delays in the U.S. by 41% between 2013 and 2020. The application of NextGen in aviation industry also helps consumers to indirectly benefit from a reduced adverse impact on the environment through the reduction of carbon dioxide emissions.<sup>24</sup>

Ground Transportation Markets. The role of transport is crucial in creating jobs and sustaining economic growth in growing urban areas. The ground transportation systems of cars, buses, metros, and rails are required to be efficient and safe to move workers and goods around the city smoothly. Approximately 82% of total population in the U.S. is working and living in urban areas and the urbanization rate is expected to reach over 90% by 2050.<sup>25</sup> Therefore, it is more important for cities and communities to ensure to implement and maintain suitable transportation systems to support the increasing demand.

The development of the intelligent technology systems (ITS) provides cities with cost-effective solutions to maximize the economic returns of the city infrastructure to build safe, smart, and efficient transportation systems. The benefits of ITS application in the transportation segment are tremendous, by reducing congestion while enhancing mobility. In fact, the U.S. Government Accountability Office (GAO) conducted a literature review to identify cost-and-benefit studies of real-time traffic and information systems and technologies. The GAO report concludes that the benefits are greater than the costs of the real-time information systems. The report emphasizes an important finding from the Department of Transportation (DOT) that the benefit-to-cost ratio of real-time information systems is over 25, compared to the ratio of 2.7 for conventional highway projects. The DOT study found that the present value of total cost savings are about \$30.2 billion (generating from the benefits to mobility, the environment, and safety) compared to the present value of the costs of \$1.2 billion of the program.<sup>26</sup>

Other Markets. The GNSS technology is also popular in agriculture and engineering construction industries. The GNSS technology helps farmers to match production techniques including farm planning, field mapping, soil sampling, tractor guidance, and crop scouting. In addition, the technology enables more precise application of pesticides, fertilizers, and better control of the dispersion of those chemicals. Thus,

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<sup>24</sup> U.S. Federal Aviation Agency. NextGen. <http://www.faa.gov/nextgen/slides/?slide=2>

<sup>25</sup> Keeling, Mary and Gerard M. Mooney. 2011. "Transportation and economic Development." IBM Global Business Services.

<sup>26</sup> U.S. Government Accountability Office. 2009. "Surface Transportation: Efforts to Address Highway Congestion through Real-Time Traffic Information Systems Are Expanding but Face Implementation Challenges." Report to Congressional Requesters.

farmers are able to reduce input costs and to increase yields. In our previous report, we estimate the economic benefits of GPS on agriculture are between \$19.9 billion to \$33.2 billion per year. Our findings are based on 10% yield gain and savings of 10% in labor wages, 15% in capital, and 15% in inputs.

Another market that receives significant contribution of GNSS application is engineering construction. The GNSS equipment increases productivity in the construction industries by providing accurate machine guidance and measurement technology. The technology improves accuracy and increases efficiency in many related functions such as surveying, excavating, grading, sub-grading, transportation management, facility delivery, urban planning, and jobsite safety monitoring. The benefits of GPS to the industry can be measured in terms of savings of labor, capital, and materials. In our previous report, we estimate the economic benefits of GPS technology on the industry are between \$9.2 billion and \$23 billion per year.

Table 5 summarizes economic benefits of GNSS applications on selected industries in the United States.

**Table 5. Economic Benefits of Major Market Segments in the United States**

Markets	Economic Benefits
Location-based Services	\$1.6 trillion in economic activities \$1.4 trillion in cost savings
Civil Aviation -- NextGen	\$123 billion cumulative money saved through 2030
Ground Transportation – ITS	\$30.2 billion cumulative cost savings through 2018
Precision Agriculture	\$19.9 ~ \$33.2 billion per year
Engineering Construction/Survey	\$9.2 ~ \$23 billion per year

## CONCLUSIONS

The application of GNSS technology in a number of market segments has delivered enormous benefits to both global and the U.S. economy. The GNSS-enabled products and services create values for commercial and noncommercial users. For commercial users, the GNSS technology has made the production processes and operations to be easier, safer, and cost-effective. For noncommercial users, the GNSS technology creates monetary values of time and cost savings as well as nonmonetary values of safety and lifestyles. Like other innovative products and services, the GNSS industry directly creates jobs and economic activities to support the economic growth.

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