THE ECONOMIC IMPACT OF GEOSPATIAL SERVICES:

HOW CONSUMERS, BUSINESSES AND SOCIETY BENEFIT FROM LOCATION-BASED INFORMATION

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The amounts in this report are estimated in both US dollars and local currencies. The conversion is based on the average exchange rate in 2016, sourced from X-Rates.com.

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GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES DURING 2016[1]:

CONSUMER BENEFITS

Consumers value digital maps at up to
US$105 PER USER
resulting in total benefits of
US$347 BILLION PER YEAR.

Digital maps reduce travel time by
12% ON AVERAGE.
The value of time saved is
US$264 BILLION
based on local wage rates.

Consumers save more than
21 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$283 BILLION.

BUSINESS BENEFITS

Geospatial services industry generated revenue of approximately
US$400 BILLION IN 2016.

Geospatial services could have a significant productivity impact in sectors representing approximately
75% OF GLOBAL GDP.

Digital maps have supported over
US$1 TRILLION
of yearly sales for businesses.

SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
1,686 MILLION MT
from more efficient trips and reduced congestions.

Potential employment directly linked to digital maps of over
4 MILLION JOBS GLOBALLY.

Emergency response times
DECREASED BY 20%
resulting in more lives saved. Geo-services also help prepare for a natural disaster (e.g., highlighting flood risk).

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

EXECUTIVE SUMMARY

Geospatial services are now deeply embedded in our everyday life.[1] Satellite-based mapping technology helps commuters bypass rush-hour traffic in London and find their Airbnb apartment in New York. It tracks cyclones in the tropics, can monitor when and where commercial fishing occurs around the world, and can even help improve voter turnout at elections.

But despite the growing use of geospatial technology around the globe, its true economic value remains hidden, as traditional measuring concepts have failed to keep up with the rapid evolution of the industry. Quantifying the extent of geospatial benefits can be difficult given that many geospatial services are provided free of charge and therefore go unmeasured. In addition, it's often impossible to separate geospatial services from the broader product they're embedded in (such as ride-sharing apps). Lastly, it's hard to measure the indirect benefits of geospatial services, which have become indispensable for a wide range of professions—from urban planners to ambulance drivers.

1. See Box 1 at the end of this chapter for a detail definition of geospatial technology and services. When appropriate, the term "digital maps" has been preferred to it, as it is a common geospatial service that consumers are more familiar with.

The goal of this report, which is based on a consumer survey across 22 countries spanning six regions[2] and other innovative estimation approaches (such as big data analysis of online job postings), is to broaden the public knowledge about the many ways in which geospatial services contribute to our society. It provides the most comprehensive economic impact analysis of the geospatial services industry to date and should help inform the actions of investors and decision-makers in government[3].

The study's main finding is that digital maps are playing a significant role in changing our lives for the better. Digital maps have become powerful tools for policymakers to ensure the safety of their citizens and inform urban planning decisions, and for companies and consumers to save time and money when managing their daily affairs. And the benefits of digital maps are far bigger than people may think. As an industry, geospatial services generate US$400 billion in revenue per year. However, their total economic contribution is several times higher, as geospatial services are estimated to:

Generate consumer benefits worth over US$550 billion.

Create approximately 4 million direct jobs, and potentially 8 million indirect ones.

Improve revenues and costs by at least 5% in sectors contributing approximately 75% to global GDP.

Have a myriad of other positive effects for society and the environment, such as reduced air pollution through more efficient transportation because of GPS navigation, which could potentially reduce global CO^2 emissions by 5% per year.

The following sections provide further details on the benefits for consumers, businesses, and the society and environment at large (Exhibit 1).

2. Europe (UK, Germany, Spain, Italy, Russia); Middle East (Saudi Arabia, United Arab Emirates, Turkey); Africa (South Africa, Nigeria); North America (US); Latin America (Mexico, Brazil); Asia Pacific (Australia, India, Japan, New Zealand, Singapore, Korea, Taiwan, Thailand and Indonesia).
3. See Box 5 in Chapter 3 for comparisons with other studies on the industry in terms of scope.

EXHIBIT 1:
THE VALUE OF GEOSPATIAL SERVICES IS EXAMINED IN THREE AREAS

CONSUMER BENEFITS	BUSINESS BENEFITS	SOCIETAL BENEFITS
		
• Commuting efficiency: beating congestion • Fuel efficiency: saving money at the pump • Personal safety: safer routes and driving • Purchasing efficiency: faster shopping	• New products and services • Productivity benefits for other sectors • Sales growth (particularly for small businesses) • Tourism spend	• Job creation • Traffic congestion • Urban planning • Civic engagement • Public Health • Safety & emergency response • Disaster preparation and responsiveness • Environment and wildlife preservation • Knowledge creation and human capital development

CONSUMER BENEFITS

Geospatial services benefit consumers daily, but many of these benefits never show up in our national economic accounts. For example, official statistics don't capture the travel time we save when a digital map helps us reach our destination more quickly. A survey covering over 9,000 internet users across 22 countries was used to find out more about the hidden value of geospatial services for consumers.[4] The responses indicate that modern mapping services have the potential to unleash consumer benefits worth over US$550 billion per year by enabling people to:

- **SPEED UP SHOPPING.**
  Digital maps can make a shopping trip more efficient for consumers. They typically list a store's (or a restaurant's) address, business hours, phone number, email address, directions, and reviews, meaning a consumer doesn't waste time researching these critical details elsewhere. Survey results, paired with further data analysis, indicate that the average shopper saves more than 11 hours per year thanks to these pieces of information found on digital maps. This amounts to a total estimated consumer benefit of around US$280 billion.

- **SAVE FUEL.**
  Commuters who use the live data of modern satellite navigation systems to find the quickest route through traffic are estimated to have saved, on average, an additional $10 per person on fuel per year in 2016.[5] In total, this amounts to around US$22 billion at the fuel pump.

- **TRAVEL EFFICIENTLY.**
  Survey results suggest that, in 2016, digital maps allowed the average commuter to save 6 hours of annual travel time on buses and trains, and 13 hours of annual travel time by car.[6] There is a real monetary value attached to shorter commutes, as workers can do something more productive with their time. The total value of time savings is estimated to have surpassed US$260 billion in 2016.

- **BE SAFER.**
  Many survey respondents said they feel safer when having access to digital maps. Almost a third (32%) use geospatial services to locate police stations and other safe places, while nearly half (46%) like to share their location with friends and family. Digital maps can also improve driver safety. Many now come with road-safety features, such as speed-limit alerts or "lane guidance" to prevent dangerous lane-change maneuvers.

4. This analysis is based on a "willingness-to-pay" methodology, which is described in detail in Box 2 and in the Appendix.
5. Satellite navigation systems refers to standalone systems such as those sold by Garmin or TomTom or navigation apps such as Google Maps, Bing Maps, Yahoo Maps, HERE, etc.
6. Number of commuters is based on data from the AlphaBeta consumer survey. See Box 8 for further information on the approach for estimating time savings from Google Maps.

BUSINESS BENEFITS

Geospatial services don't just benefit those businesses who produce or sell industry-related products, such as satellites or navigation software. For a large number of companies, the benefits are more indirect. They use digital maps for market research and to identify the most profitable locations for their store network. Targeted business listings in digital maps can help them connect directly with customers and ultimately drive growth.

- **NEW PRODUCTS AND SERVICES.**
  The geospatial services industry is estimated to have generated $400 billion of revenue in 2016. Over half of this revenue is driven by businesses selling satellites and other location-based data products. Companies selling geospatial apps and devices generate another 39% of revenue. Services, including consulting and education, contribute to the remaining 4% to total geospatial revenues.

- **SALES GROWTH.**
  Many companies use digital maps as a platform to improve their visibility. Online maps are particularly important for small, lesser-known businesses who and can use "geo-targeting" to acquire new customers. For example, customers are 29% more likely to consider a purchase from a business that has a well-maintained presence on Google My Business (GMB), a free multi-platform service.[7] [8]Results from the consumer survey conducted for this report suggest that online maps facilitated business sales worth more than $1 trillion globally in 2016.

- **PRODUCTIVITY BENEFITS.**
  The indirect benefits for businesses using geospatial services to improve productivity or sales are substantial, with recent research suggesting total geospatial revenues could be worth $1.6 trillion in the US alone.[9] This study confirms that geospatial services have a strong multiplier effect: their use adds value in a range of industries that together drive nearly three-quarters of the world's GDP.

- **TOURISM SPEND.**
  More than two-thirds of all survey respondents use online maps to plan a trip, and locate restaurants, shops and tourist attractions when traveling. Online maps, particularly those that allow users to post reviews and upload pictures of a trip, have become important revenue drivers for the tourism industry. A recent study found that European cities that actively use internet content to promote themselves as travel destinations are more successful in attracting tourist dollars than others.[10]

7. Ipsos MORI (2014), "Impact of Search Listings for Local Businesses" Available at: https://www.gybo.com/downloads/search-listing-research.pdf
8. Google My Business is a free tool that helps small businesses create and manage their Google business listings which appear when customers find businesses on Google Search and Maps.
9. Boston Consulting Group estimates that the revenues driven by geospatial services in the United States were around US$1.6 trillion – more than 20 times the size of the nation's geospatial industry itself. See: Boston Consulting Group (2012), "Geospatial Services: A $1.6 trillion growth engine for the U.S. Economy" Available at: https://www.bcg.com/documents/file109372.pdf
10. Oxford Economics (2013), "The Impact of Online Content on Tourism in Europe" Available at: http://www.oxfordeconomics.com/my-oxford/projects/246666

SOCIAL AND ENVIRONMENTAL BENEFITS

Often, digital maps generate benefits for the wider society that may not attributed directly to a specific company or person. Common economic statistics typically fail to capture these "spillover benefits", which include the following:

- **JOB CREATION.**
  A big data analysis of online job advertisements indicates that geospatial services create more than 4 million direct jobs, and potentially 8 million indirect employment opportunities.[11]

- **REDUCING TRAFFIC JAMS AND EMISSIONS.**
  As the number of cars worldwide is set to double to 2 billion by 2030,[12] traffic would increase urban air pollution, projected to become the top environmental cause of premature mortality by 2050.[13] Geospatial services can mitigate this issue by suggesting alternative routes and by highlighting travel times if commuters were to cycle, walk, or use public transport. 53% of internet users surveyed said digital maps have increased their willingness to use public transport. This could potentially reduce global CO^2 emissions by up to 1,686 million tons, equivalent to 5% of the world's total CO^2 emissions in 2016.[14]

- **URBAN PLANNING.**
  Geospatial services can improve current traffic flows by informing "intelligent" traffic lighting systems. They can play a role in designing more efficient cities: visualizing the 3D model of a building or the impact of an infrastructure network on vehicle circulation can help urban planners to better understand the changing landscape and make more informed decisions on critical planning issues.

- **CIVIC ENGAGEMENT.**
  Geospatial services help governments connect

11. Indirect jobs include both non-geospatial jobs (such as HR, marketing, sales, etc.) within geospatial companies, and jobs created outside of the industry, such as companies' suppliers.
12. Joyce Dargay, Dermot Gatley, and Martin Sommer (2007), "Vehicle ownership and income growth, worldwide: 1960-2030", The Energy Journal, 28(4). 143–170. Available at: https://www.jstor.org/stable/41323125?seq=1#page_scan_tab_contents
13. "World Health Organization (2014), 7 million premature deaths annually linked to air pollution" Available at: http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/
14. British Petroleum (2016), "Energy charting tool" Available at: http://tools.bp.com/energy-charting-tool.aspx

more strongly with their citizens and overcome geographical hurdles during elections. In developing countries, some voters fail to cast a ballot because they struggle to locate polling stations, or have no registered address and never receive ballot papers. Digital maps help solve these issues and allow more voices to get heard.

- **SAFETY AND EMERGENCY RESPONSE.** Thanks to geospatial services, an ambulance can reach a patient faster and firefighters get to a wildfire more quickly. In India, geospatial services could cut response times for ambulances by 3.5 minutes and for fire brigades by 2 minutes.[15] These time savings can save lives: research shows that every 10% reduction in emergency response time lowers the chance of fatalities by 7%.[16]

- **DISASTER PREPARATION AND RESPONSE.** Geospatial technologies can also help save lives when natural disaster strikes. Emergency-response teams already use GIS technology to model high-risk areas that could flood during torrential rains.[17] Digital maps are also being used to prepare for typhoons and other destructive storms, to show residents the best evacuation routes or identify fuel shortages.

- **ENVIRONMENT AND WILDLIFE PRESERVATION.** Geospatial services play a critical role in preserving the environment and wildlife. They allow researchers and government agencies to monitor the health of animal populations, detect illegal poachers, or raise awareness on environmental issues such as deforestation.

- **KNOWLEDGE CREATION AND HUMAN CAPITAL DEVELOPMENT.** Digital maps and imagery services are used as educational tools in many classrooms across the world. Recent research found that the use of digital maps improves students' spatial thinking and geographic knowledge.[18] Partnerships between academia and the geospatial through open source research and education platforms can enhance the quality of teaching materials, inform new research and encourage innovation in geospatial products and services.

15. Dalberg Global Development Advisors and Confederation of Indian Industry (CII) (2015), "Smart Maps for Smart Cities: Urban India's $8 Billion+ Opportunity" Available at: http://www.dalberg.com/wp-content/uploads/2015/07/20150715_Google-Smart-Maps-Report_FINAL.pdf
16. Fire Brigade Union UK (2010), "It's about time: Why emergency response times matter to firefighters and the public" Available at: https://www.fbu.org.uk/publication/its-about-time-why-emergency-response-times-matter-firefighters-and-public
17. ARUP (2017), "River San flood risk assessment" Available at http://www.arup.com/projects/river_san_flood_risk_assessment
18. Oxera (2013), "What is the Economic Impact of Geo Services?" Available at: http://www.oxera.com/Latest-Thinking/Publications/Reports/2013/What-is-the-economic-impact-of-Geo-services.aspx

CONCLUSIONS

Despite the range of benefits geospatial services bring to consumers, businesses and societies, there remains a variance in the impact of geospatial services between different regions. For instance, a disparity in internet penetration rates between developed and developing countries limits the usage of digital maps in the latter. Even when comparing similar countries, there are significant differences in the employment opportunities arising from geospatial services as a proportion of the workforce. Certain features of digital maps – such as those for discovering new businesses and merchants – have varying usage as well. As a consequence, the prevalence of business uses of the technology may be lower too.

This report thus concludes with recommendations to three stakeholder groups that can play a key role in driving the adoption of geospatial solutions and the spread of the associated benefits:

- **Academia, public agencies and civil society organizations** can utilize geospatial technology to improve the efficiency of their major activities. Some applications include city planning, tracking environmental pollution, and maintaining important information on health and diseases. For instance, a study on air pollution variation within a city conducted by the University of Texas at Austin (UT Austin) used the technology to generate practical policy insights and improve air quality.[19] A study at University of California San Francisco used Google Earth Engine to predict the infection risk in certain areas by connecting malaria statistics with information on moisture and other environmental data related to mosquito breeding.[20]

- **Businesses** could increase their investment in and use of geospatial services to enhance the value and productivity of their business, attract new customers and boost sales. A range of studies provide evidence for the positive return of investment in geospatial services. In some cases, the net benefits of geospatial services have proven to exceed investment costs by more than 10 times.[21]

- **Governments** can enable the promotion, adoption and implementation of the emerging applications of geospatial technology and data. Policies should support the collection, sharing, and use of geospatial data and services in order to help ensure data availability, accessibility and quality. It is also imperative for governments to participate in events such as the Geospatial World Forum to understand best practices to facilitate the development of a successful local geospatial industry. These include encouraging the adoption of geospatial data in informing decisions in urban planning, health and emergency services, disaster management and environmental protection; modernizing technical infrastructure required for data collection and dissemination and incentivizing private sector participation.

19. Global News Wire (2017), "Google, Aclima, Environmental Defense Fund, and UT Austin Announce Results of Breakthrough Study Mapping Hyperlocal Air Quality" Available at: https://globenewswire.com/news-release/2017/06/05/1008205/0/en/Google-Aclima-Environmental-Defense-Fund-and-UT-Austin-Announce-Results-of-Breakthrough-Study-Mapping-Hyperlocal-Air-Quality.html
20. University of California San Francisco (2014), "UCSF, Google Earth Engine Making Maps to Predict Malaria" Available at: https://www.ucsf.edu/news/2014/09/116906/ucsf-google-earth-engine-making-maps-predict-malaria
21. See, for example, ESRI (2013), "Return on Investment. Ten GIS case studies" Available at: http://www.esri.com/library/ebooks/return-on-investment.pdf

BOX 1.
WHAT IS GEOSPATIAL?

Geospatial refers to technology used to acquire, manipulate, organize and store data containing some sort of geographic information, such as coordinates, an address, or city zip code. This report focuses on geospatial data sourced from various sources, including satellites, analog and digital maps, and aerial and street imagery.

Examples of geospatial technology include geographic information systems (GIS), global positioning systems (GPS), remote sensing and imagery analysis. Ground-based location technologies—such as "smart" home technology relying on wireless home networks or sensors, or the long-range radio navigation system LORAN—are not considered geospatial for the purpose of this report. While these technologies typically use information on an individual's location and actions to function, they are not powered by GPS technologies.

A common geospatial technology that will often be referenced in this paper is digital map, which leverages geospatial data and formats it into a virtual image, in order to provide accurate representations of a given area. This includes details such as roads, pedestrian paths, buildings, landmarks, and other points of interest. The technology also incorporates GPS satellite networking capabilities and allows for route navigation between two or more designated points. Other features may include information on live traffic, road incident reports, turn-by-turn navigation, and business information (e.g., opening hours, contact details, user reviews, product availability).

CONSUMER BENEFITS

To assess the full economic impact of geospatial services, it is important to look beyond traditional national accounting methods and consider all the benefits—direct and indirect—that digital maps bring to consumers. Modern mapping services make traveling and shopping less time-consuming. They enliven classroom learning, help people save fuel and feel safer. Together, the consumer benefits of geospatial services amount to more than US$550 billion annually.

Consumers are using geospatial services in various ways: to locate restaurants or hospitals, navigate through city traffic, check shop opening hours, or simply to learn about geography and architecture (Exhibit 2).

ESTIMATED CONSUMER BENEFITS LINKED TO GEOSPATIAL SERVICES

DURING 2016[1]:

USAGE AND SELF-PERCEIVED BENEFITS

OVER 90%
of online population in the world use digital maps in a variety of ways. The most popular geo-enabled apps are for
EDUCATION AND SOCIAL NETWORKING.

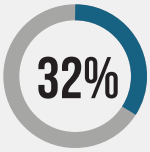
The average user values digital map services at
US$105 PER MONTH,
which translate into
US$347 BILLION PER YEAR FOR ALL USERS.

FUEL SAVINGS

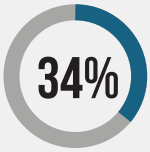
Digital maps reduce travel time by
12% ON AVERAGE,
I.E. 50 HOURS A YEAR,
WORTH US$264 BILLION
based on average local wages.

By reducing travel time and incentivizing efficient travel options (e.g., walking or public transport), digital maps helped save
22 BILLION LITERS OF FUEL.

PERSONAL SAFETY



32 PERCENT
of digital map users state it helps them identify safe places (e.g., police stations) when they feel in danger.



34 PERCENT
of digital map users state that it helps them improve their safety when driving, by avoiding dangerous areas and monitoring speed limits.

MORE EFFICIENT PURCHASING

Survey respondents state that they use digital maps to assist their purchasing decisions
ONCE A WEEK ON AVERAGE.

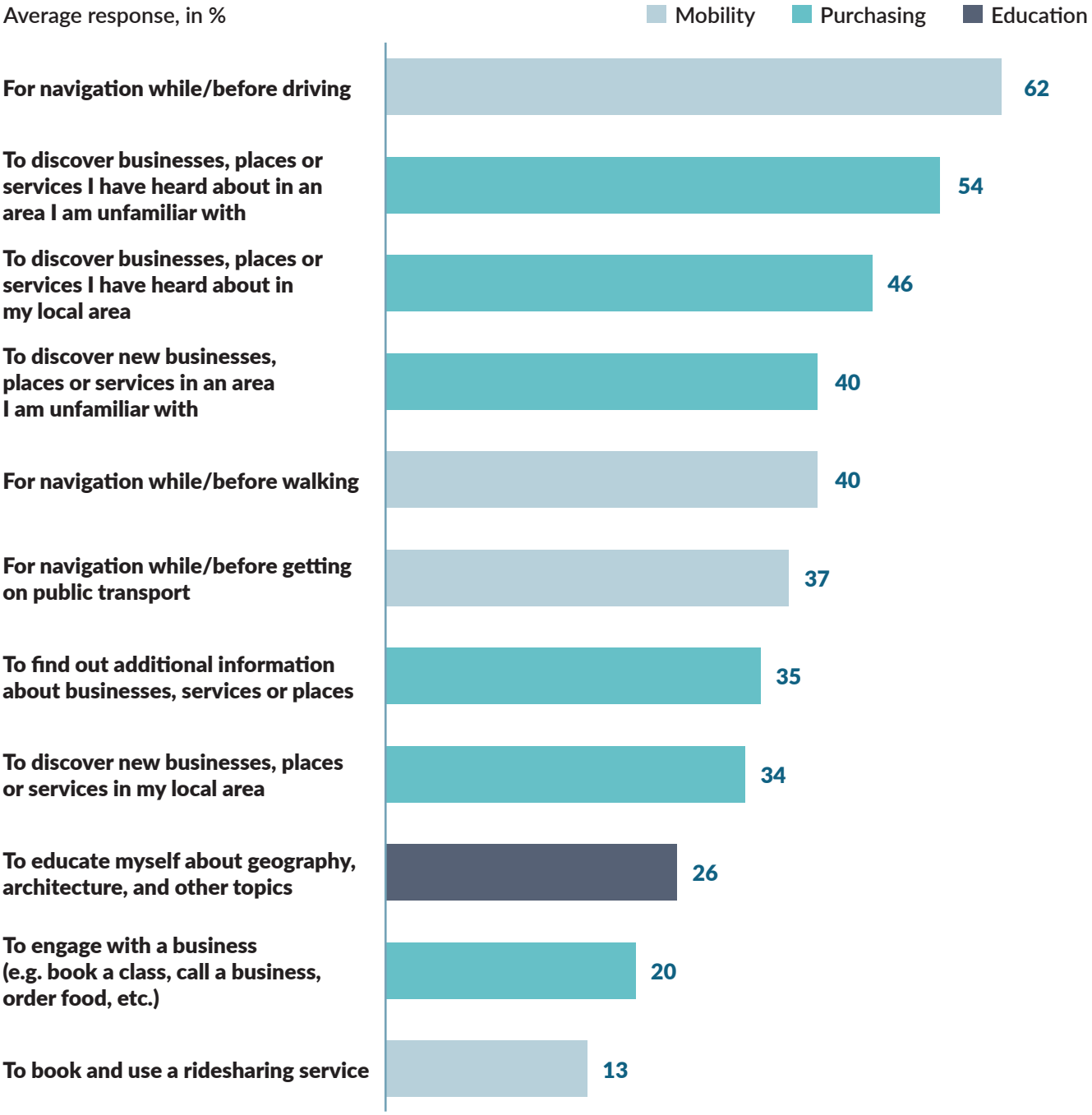
Users save more than
21 BILLION HOURS PER YEAR
from more efficient purchasing decisions,
WORTH US$283 BILLION.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

EXHIBIT 2:

CONSUMERS ARE USING DIGITAL MAPS IN A VARIETY OF WAYS

SHARE OF SURVEY RESPONDENTS WHO OFTEN OR VERY OFTEN USE DIGITAL MAPS FOR THE FOLLOWING ACTIVITIES



Source: Survey of Digital Map users; AlphaBeta analysis

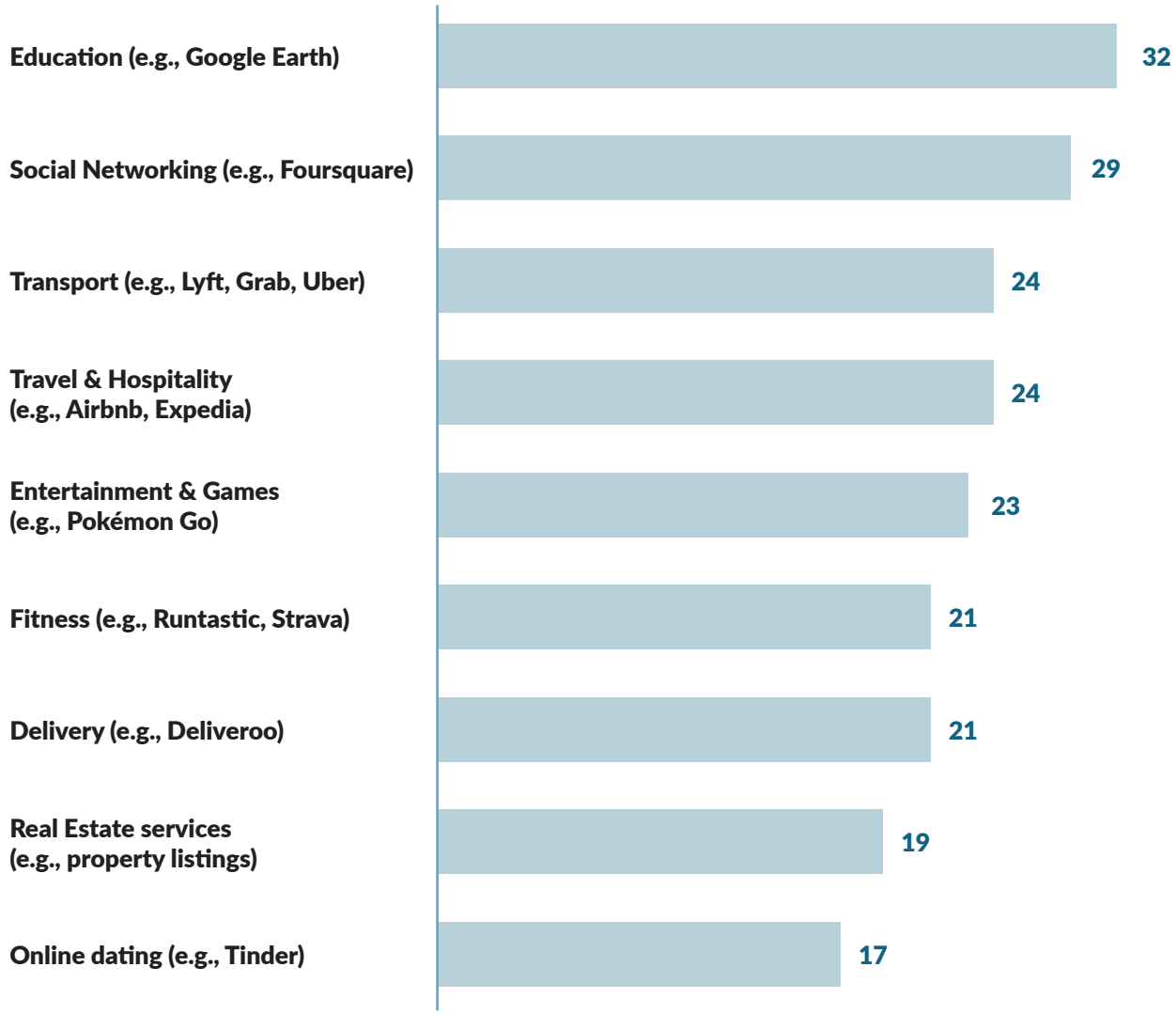
Consumers may be unaware that they are enjoying the benefit of a geospatial service, as digital maps are often embedded in other services. For example, travel platforms (such as Airbnb, Expedia, Jumia, Agoda, Decolar, etc.) use digital maps to help customers find a place to stay, transport platforms (such as Uber, Grab, 99, Citi Bike, Careem, etc.) help customers move around cities, and banking platforms (such as mobile banking apps or internet banking) help people locate ATMs or bank branches.

EXHIBIT 3:

THE MOST POPULAR CONSUMER APPS POWERED BY GEOSPATIAL TECHNOLOGY ARE EDUCATIONAL TOOLS OR SOCIAL NETWORKS

SHARE OF SURVEY RESPONDENTS WHO USE DIGITAL MAPS AS PART OF OTHER APPLICATIONS 3-9 TIMES PER WEEK OR MORE OFTEN

Percent by category of applications



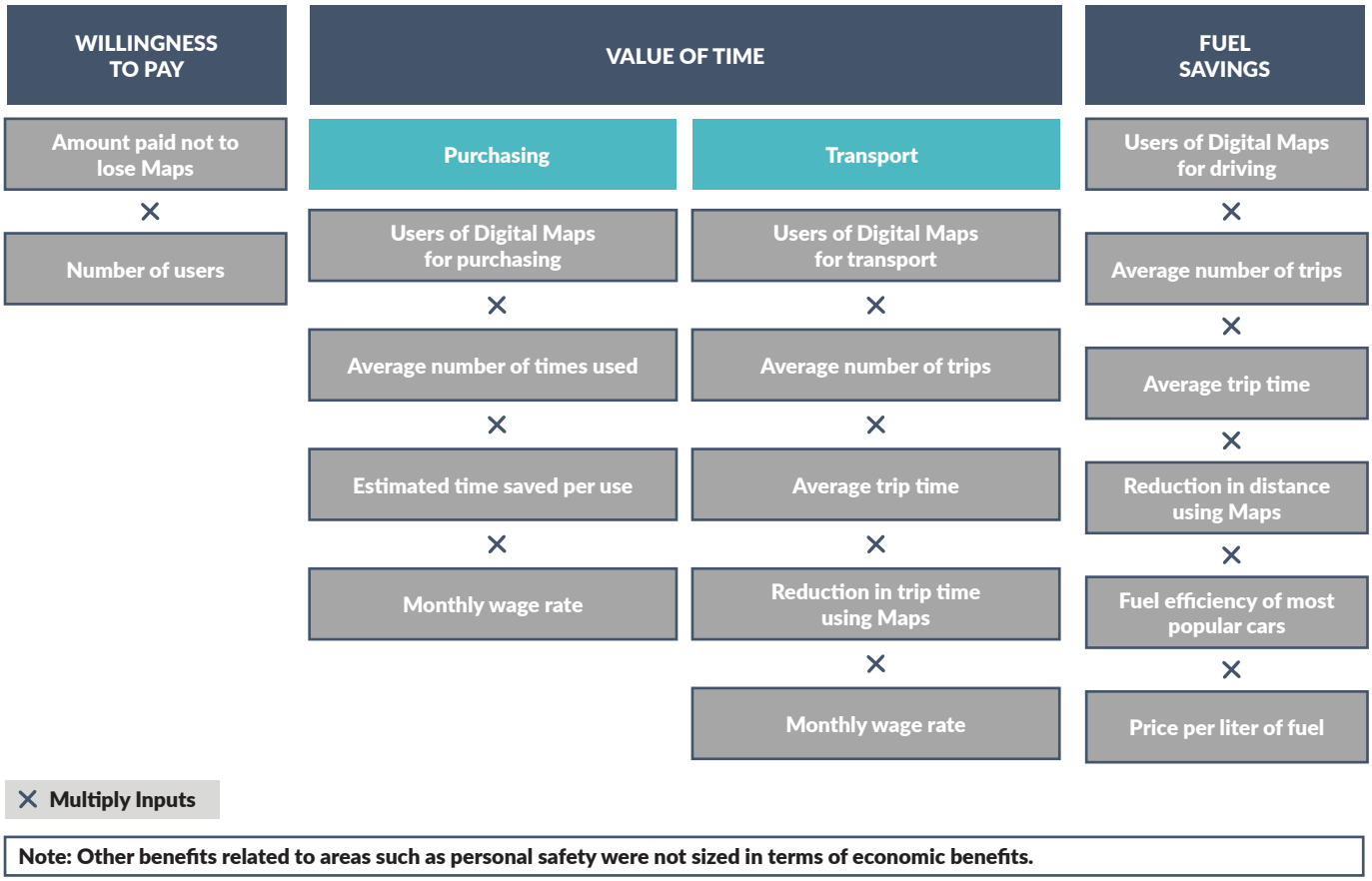
Source: Survey of Digital Map users; AlphaBeta analysis

CALCULATING CONSUMER BENEFITS

Given the variety of different uses of geospatial services, some of which involve direct use, and many involving indirect use (e.g., embedded in popular apps), it is difficult to provide a comprehensive assessment of the potential consumer benefits. This report estimates the consumer benefits of geospatial services using three methodologies: a "willingness-to-pay" (WTP) approach, supported by a "value-of-time" (VOT) approach and a "fuel savings" approach as secondary verifications of the estimates.

The analysis is based on unique and first-of-its-kind data, as well as publicly available data. A survey among 9,000 internet users across 22 countries forms the core of the analysis. In addition, Google Maps was used to simulate thousands of trips by car and public transport. Box 2, Exhibit 4 and the Appendix provide further details on the methodology and specific concepts to measure consumer benefits.

EXHIBIT 4:
METHODOLOGY FOR CALCULATING CONSUMER BENEFITS



Note: Other benefits related to areas such as personal safety were not sized in terms of economic benefits.

BOX 2.
CALCULATING CONSUMER BENEFITS

Traditional economics use the concept of "consumer surplus" to measure the benefits of a product or service. Consumer surplus is usually calculated by observing how customers adjust their consumption when prices change. However, the concept becomes difficult to apply when measuring the benefits of geospatial services. Firstly, geospatial services, such as digital maps mobile applications, are available free of charge—meaning no behavioral changes can be observed in response to changes in price. Secondly, it is hard to measure exactly how often consumers use these services.

There are several alternative methodologies for estimating the consumer benefits of free services. This report employs a "willingness-to-pay" (WTP) approach, supported by a "value-of-time" (VOT) approach and a "fuel savings" approach for secondary verification, to capture the variety of consumer benefits:

- **WILLINGNESS TO PAY (WTP).**
  This method estimates consumer benefits by eliciting how much individuals are prepared to pay for specific products and services. The most straightforward way of obtaining this information is simply to ask consumers. However, this method has drawbacks. For example, individuals often struggle to quantify the value a product or service holds to them. This uncertainty is even higher when a product or service is free. Individuals are prone to overestimate their willingness to pay, and framing can amplify these uncertainties and potential biases. However, there are ways to improve the robustness of estimates. In AlphaBeta's consumer survey, participants were confronted with the following scenarios: they were offered a monthly cash discount on their internet or mobile phone bill if (a) they were willing to permanently forgo their preferred digital maps service; and (b) they were willing to permanently forgo all digital maps services. In other words: the method elicited a willingness to accept, rather than a willingness to pay, which recent research has shown to be less prone to biases induced by framing.[22] To deal with potential uncertainty about the nominal size of their valuations, subjects were provided with a "discount menu" from which they could choose a valuation, as well as an outside option for them to provide their own valuation.

- **VALUE OF TIME (VOT).**
  This method measures consumer benefits by calculating how much time an individual saves by using a good or service—in this case by using digital maps to travel and go shopping. In line with common practice, wages were used to calculate opportunity costs and translate time savings into monetary value. The analysis only calculated the VOT for the share of the population currently employed. This conservative approach, combined with the fact that time savings are only one aspect of the benefits that geospatial services bring to consumers, means that this approach, likely underestimates the value derived by consumers from geospatial services.

- **FUEL SAVINGS.**
  This method only focuses on a subset of the benefits related to fuel savings from improved navigation. It measures how many road miles a traveler saved by using digital maps and then converts this distance into fuel savings (measured in liters and dollar terms). The calculation is based on the fuel efficiency of the most popular vehicles in each country, and the local petrol prices.

22. Yang Yang, Joachim Vosgerau and George Loewenstein (2013), "Framing Influences Willingness to Pay but Not Willingness to Accept", Journal of Marketing Research Vol. L (December 2013), 725-738. Available at: http://www.cmu.edu/dietrich/sds/docs/loewenstein/FramingInfluences.pdf

The estimated consumer benefits (based on a "willingness-to-pay" approach) generated by geospatial services are significant, amounting to a combined US$190 billion per year in the 22 countries examined (Exhibit 5). On a global scale, the total consumer benefits from digital maps likely reach US$347 billion.[23]

EXHIBIT 5:

GLOBAL USERS VALUE DIGITAL MAPS AT US$105 PER PERSON, WHICH RESULTS IN TOTAL CONSUMER BENEFITS OF US$347 BILLION PER YEAR

REGION	ANNUAL VALUATION BY USER[1] Average, US$	TOTAL ESTIMATED CONSUMER BENEFITS BASED ON DIGITAL MAP USAGE[2] Cumulative, US$ billion
ASIA PACIFIC	89	166
EUROPE	127	72
NORTH AMERICA	155	43
LATIN AMERICA	114	42
MIDDLE EAST	85	12
AFRICA	36	12
GLOBAL	**105**	**347**

1 Based on AlphaBeta survey of online population in selected countries, applying a "Willingness to Pay" approach.
2 Regional values were scaled up on the basis of online map users, taking figures from USA for North America; Brazil and Mexico for Latin America; Italy, Germany, Russia, Spain, and UK for Europe; Saudi Arabia, Turkey, and UAE for Middle East; Nigeria and South Africa for Africa; India, Indonesia, Japan, Singapore, South Korea, Taiwan, Thailand, and New Zealand for Asia
Source: Survey of Digital Map users; AlphaBeta analysis

23. Figure derived by extrapolating the results to other countries worldwide, adjusted for share of online population and differences in GDP per capita.

BOX 3.
CALCULATING TIME SAVED FROM USING DIGITAL MAPS

To calculate the time savings from using digital maps, a combination of commuter surveys and an AlphaBeta traffic crawler was used. The surveys provide the digital maps usage habits of a country's population in relation to frequency, purpose and method of trip travel. Trips were broken down by purpose (work commute, personal travel etc.) and mode (personal vehicle, bus, walking).

The AlphaBeta traffic crawler utilized Google Maps application program interface (API) to identify major residential, recreational, and commercial locations within the two largest cities in each of the 22 countries. The crawler then simulated thousands of trips for each mode of transport and journey type in each city at varying times of the day in order to capture peak and off-peak traffic. The time savings were estimated as the difference between the fastest route identified and the average travel time across all routes suggested by the API. The results were finally translated into monetary value using local wage rates.

COMMUTING EFFICIENCY: BEATING CONGESTION

The large-scale consumer survey, undertaken exclusively for this report, indicates that more than 2 billion commuters globally use digital maps when traveling on public transport. 2.5 billion people use digital maps on car trips.[24] Analyzing their trips in detail (see Box 3 for details) reveals that digital maps have likely saved the average commuter 6 hours of annual travel time on buses and trains. Those traveling by car have likely saved more than double as much—13 hours—of annual travel time through digital maps.[25]

How big are these savings in total? Based on the combined annual time saving of 50 billion hours for all travelers and extrapolating the results to the rest of the world, geospatial services have likely created more than US$264 billion in annual time-related savings for commuters in 2016 (Exhibit 6).

FUEL EFFICIENCY: SAVING MONEY AT THE PUMP

Finding the quickest route does not only save drivers and passengers time. It also helps them save money. An analysis of fuel savings reveals that the average person traveling by car and using a digital map in 2016 paid around US$10 less at the petrol pump. In total, this amounts to around US$22 billion of fuel savings.

PERSONAL SAFETY: SAFER ROUTES AND DRIVING

Digital maps can make people feel safer (Exhibit 7). Around a third (32%) of survey respondents said that geospatial services help them identify safe places, such as police stations, when they feel in danger. Almost half (46%) say they share their location with friends and family to let them know where they are. 63% say they use geospatial services to plan safe routes before traveling to an unfamiliar area.

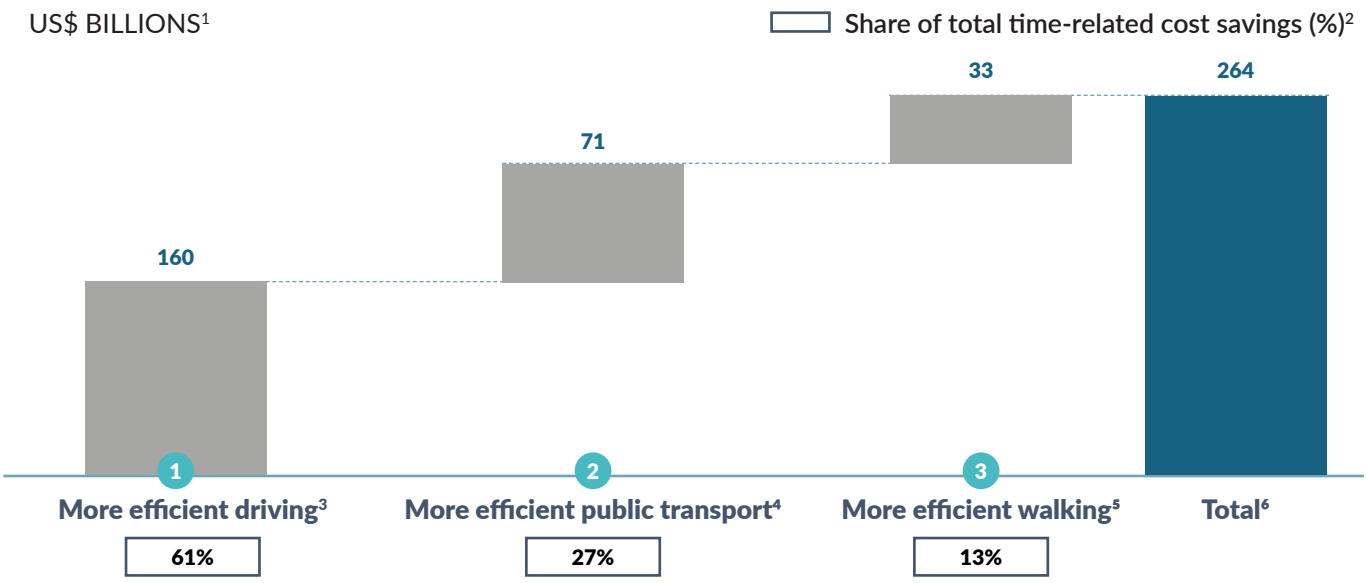
Modern mapping systems, which come with speed limit alerts and similar features, can make traffic safer. For example, live traffic systems (such as HERE, BringGO, Waze, etc.) now offer a speed limit warning, in addition to live reports of accidents, construction works, road closures and suggested routes to avoid these "blackspot" areas.[26] Meanwhile, other navigation platforms (such as Sygic, Google Maps, iGO, etc.) now provide "lane guidance" to prevent dangerous lane-change maneuvers and "turn guidance" to minimize distractions and surprises. Google is also trialing speed limit alerts in select cities.[27] Not surprisingly, more than a third (34%) of survey respondents say geospatial services improve driver safety.

24. To calculate the global estimates, we extrapolate the consumer survey information derived in the 22 countries to form regional estimates based on the size of the online population. The estimates are derived from 6 regions: Asia Pacific (proxied by Australia, India, Japan, New Zealand, Thailand, Indonesia, Singapore, Korea, and Taiwan); North America (proxied by the United States); Latin America (proxied by Mexico and Brazil); Middle East (proxied by Saudi Arabia, the UAE, and Turkey); Africa (proxied by Nigeria and South Africa); and Europe (proxied by the UK, Germany, Spain, Italy, and Russia). See the appendix for further details.
25. Number of commuters is based on data from the AlphaBeta consumer survey. See Box 3 for further information on the approach for estimating time savings from Digital Maps.
26. 9to5 Mac (2016), "Waze app will now alert you when driving over the speed limit", Available at: https://9to5mac.com/2016/03/29/waze-speed-limit-warnings/
27. Android Police (2016), "Google Maps' speed limits start showing up while driving…on Android Auto" Available at: http://www.androidpolice.com/2016/09/13/google-maps-speed-limits-start-showing-driving-android-auto/

EXHIBIT 6:

US$264 BILLION IN TIME-RELATED COST SAVINGS HAVE BEEN REALIZED THROUGH THE SUPPORT OF DIGITAL MAPS

TIME-RELATED TRAVEL COST SAVINGS THROUGH DIGITAL MAPS



1. Rounded to nearest US$ billion.
2. May not sum to 100% due to rounding.
3. Based on time saved for car users from more efficient routes.
4. Based on time saved for public transport users from more efficient routes.
5. Based on time saved for people walking from more efficient routes.
6. Total time-related cost savings are derived from a weighted global estimation based on the 22 in-scope countries
Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources

EXHIBIT 7:

63% OF DIGITAL MAP USERS STATE IT HELPS THEM PLAN SAFE ROUTES BEFORE TRAVELING TO A NEW AREA, 46% SHARE THEIR LOCATION WITH TRUSTED CONTACTS

SHARE OF DIGITAL MAP USERS WHO AGREE WITH FOLLOWING STATEMENTS "I USE DIGITAL MAPS TO..."

Source: Survey of Digital Map users; AlphaBeta analysis

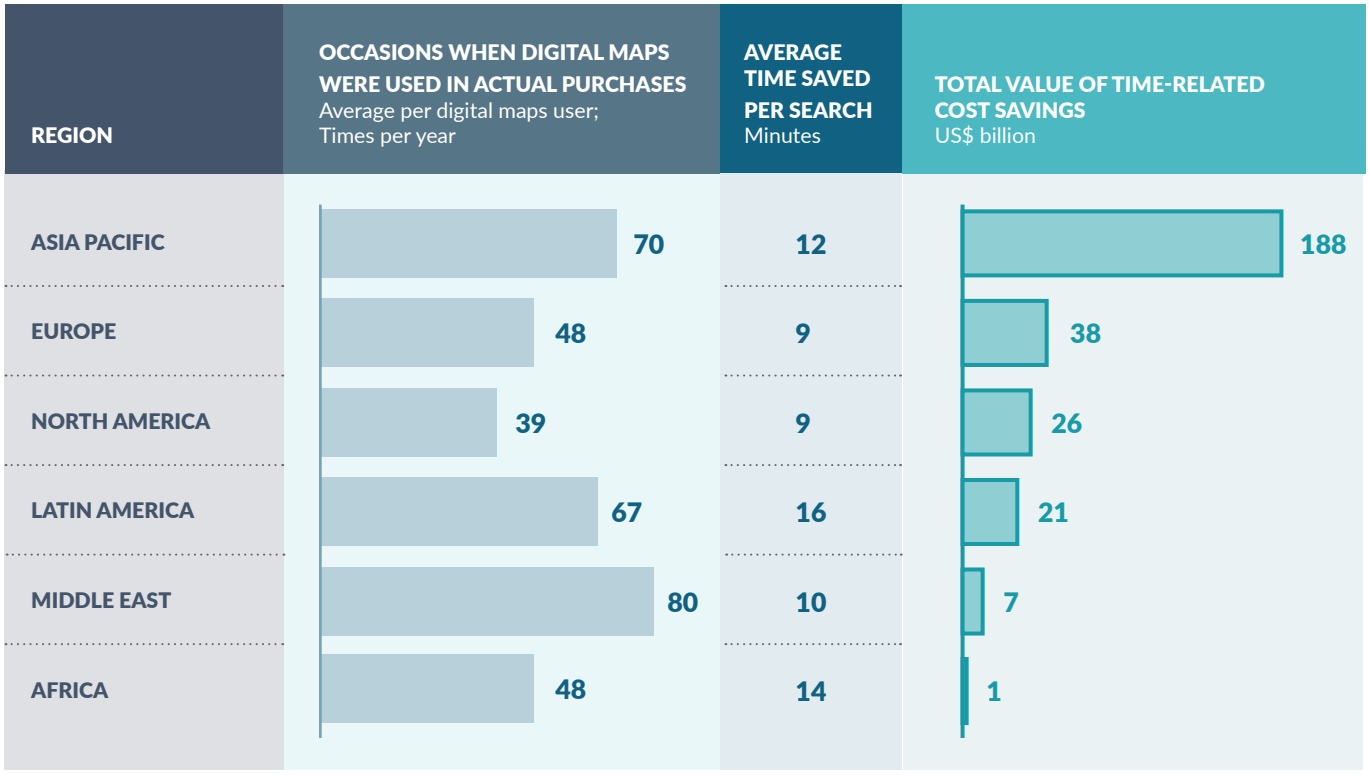
PURCHASING EFFICIENCY: FASTER SHOPPING

Geospatial services can make shopping more efficient. Business entries in digital maps typically includes a store's opening hours, address, telephone number and email, directions and reviews. Consumer survey results show that the average consumer saves 11 minutes per search, thanks to these pieces of information found on digital maps (Exhibit 8).

Combining these savings with other survey results on the frequency of using geospatial services to buy goods reveals that the average person saves around 11 hours per year through more efficient purchasing decisions. On a global scale, the benefits of a more targeted shopping experience are estimated to be worth over US$280 billion.[28]

EXHIBIT 8:

MORE THAN 21 BILLION HOURS, WORTH OVER US$280 BILLION IN TIME-RELATED COSTS ARE SAVED EACH YEAR THROUGH THE USE OF DIGITAL MAP SEARCHES



At global level[1], digital maps users save more than 21 billion hours per year, worth over US$280 billion

1 Global values scaled up on the basis of regional online map users, taking figures from USA for North America; Brazil and Mexico for Latin America; Italy, Germany, Russia, Spain, and UK for Europe; Saudi Arabia, Turkey, and UAE for Middle East; Nigeria and S. Africa for Africa; Thailand for Asia Pacific
Source: Survey of Digital Map users; AlphaBeta analysis

28. The global figure was derived by extrapolating the country results to the urban population in each region and adjusting to local wage rates.

BUSINESS BENEFITS

Geospatial services provide a range of business benefits. The most obvious ones are enjoyed by companies at the core of the industry, who generate direct revenue from selling geospatial products or services, such as satellites or software. However, there is an even bigger number of companies that benefit indirectly from geospatial services. They use digital maps for market research, to improve their public customer profile, to find the best locations for their store network and, simply, to increase sales.

The following section provides an overview on how businesses benefit from geospatial services, and by how much. Details on the methodology of calculating these business benefits can be found in Box 4 and the Appendix.

ESTIMATED BUSINESS BENEFITS LINKED TO GEOSPATIAL SERVICES

DURING 2016[1]:

NEW PRODUCTS AND SERVICES

Geospatial services industry generated revenue of approximately
US$400 BILLION IN 2016.

Location-based data represents
58% OF THE GEOSPATIAL INDUSTRY.

PRODUCTIVITY BENEFITS

75%

Geospatial services have an important strategic role in sectors accounting for approximately
75% OF GLOBAL GDP.

20X

Productivity benefits enabled by geospatial services are more than
20X THE SIZE OF THE GEOSPATIAL INDUSTRY ITSELF.

US$1.2 TRILLION OF SALES
in the world are linked to digital maps, with
52% OF RESPONDENTS
saying that they would not have made the purchase otherwise.

In some cases, "Branded pins" and "takeovers" have found to result in a significant
INCREASE OF OVER 50% IN TRAFFIC FLOWS TO BUSINESS.

TOURISM BENEFITS

70% OF SURVEY RESPONDENTS
state that they use online maps to plan their trips before they travel.

74% OF SURVEY RESPONDENTS
state that they use online maps during their travels to find places to visit.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

BOX 4.
CALCULATING BUSINESS BENEFITS

METHOD:

The benefits of geospatial services for businesses were assessed in three main areas: (1) new products and services directly related to the geospatial industry, such as location-based data, geo apps and devices, (2) the application of these new products and services to improve business productivity, and (3) the use of digital maps to boost sales (particularly for small businesses). As calculation methods differ for each area (for example, calculations for the productivity area comprise both revenue and cost, while those for the other two areas only look at revenue), it is impossible to gauge the total value of business benefits by simply adding up the different results.

SCOPE OF THE ANALYSIS:

It is important to bear in mind that this methodology does not account for activities that may have been made redundant by geospatial services; neither does it attempt to estimate the incremental impact of geospatial services over a case where geospatial services did not exist and an alternative technology was employed to play a similar role in a less efficient way. The hypothetical scenarios required to calculate truly incremental benefits of geospatial services are highly speculative and beyond the scope of this study. The specific methodology for estimating each component of the business benefits are described in the appendix.

NEW PRODUCTS AND SERVICES: A US$400 BILLION INDUSTRY

In 2016, the geospatial industry is estimated to have generated a global revenue of roughly US$400 billion (see Exhibit 9 and Box 4 for details on the calculation). More than half of this revenue was driven by location-based data services, including satellites, environmental, and human data. A further 39% of revenue was linked to geospatial apps and devices. Consulting and education services accounted for only 4% of global geospatial revenues.

North American companies are currently the main beneficiaries in the geospatial industry, with a market share of around 39%. However, businesses in other countries are beginning to overtake their North American counterparts in specific industry sub-segments. For example, India is rapidly emerging as a major player in the satellite industry and recently set a world record for satellite launches.[29]

The impact analysis focused on geospatial apps and devices, as they form one of the most rapidly growing market segments. To calculate the business benefits from using these products, AlphaBeta examined the 100 most popular apps (both free and paid) in select countries with the highest number of smartphone users.[30]

The result: geo-apps offering direct navigation services, such as Google Maps, on average account for around 3% of the most downloaded apps. Meanwhile, apps that draw upon geospatial to enable their service offering (such as Airbnb, Agoda, Moovit, Runtastic, Entertainer, etc.) account for 9% of geospatial apps (Exhibit 10). Many of these geo-apps are produced domestically, allowing local developers and entrepreneurs to reap the benefits of geospatial services.

29. Fortune (2017), "India Just Set a World Record by Launching 104 Satellites at Once", Available at http://fortune.com/2017/02/15/india-world-record-104-satellite-launch/

30. These countries were identified as US for North America, Brazil for Latin America, Russia for Europe, Turkey for Middle East, Nigeria for Africa, and Japan, Australia and India for the Asia Pacific.

BOX 5.
COMPARISON TO OTHER GEOSPATIAL INDUSTRY ESTIMATES

This report estimates that the geospatial industry was worth US$400 billion in 2016. A range of industry reports (including from Frost & Sullivan, Market and Markets, Berg Insight, Global Industry Analysts, and Canadian Geomatics) analyzes sub-segments of the geospatial industry, but only a few reports look at the geospatial industry as a whole. Oxera and the Boston Consulting Group (BCG) have both previously estimated the direct contribution of the geospatial industry. Oxera estimates the global industry to be worth between US$150 and US$270 billion in 2013.[31] BCG estimates that geospatial markets in the US and India were worth US$73 billion and US$3 billion in 2012.[32]

METHOD:

The differences between this report and previous research can be attributed to two main factors: timing and scope. These previous reports were conducted in 2012. However, given its rapid growth (CAGR estimates vary between 7% and even 30% per annum, reflecting the difficulty of measuring its size), the geospatial industry is now significantly more valuable. For example, "connected cars" is now a significant sub-segment that was virtually non-existent in 2012.

SCOPE:

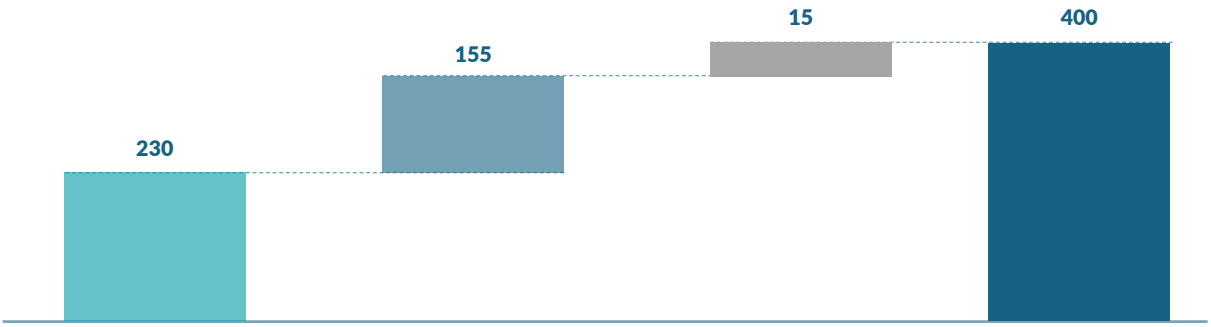
This report focuses on the value of businesses providing satellite constellations, location-based data, geo-enabled devices and applications, and geospatial services. In contrast, Oxera only examined businesses in satellite constellation and associated industries, while BCG did not include the satellite constellation industry. BCG's study also included businesses developing ground-based navigation systems (such as the long-range radio navigation system LORAN), which were omitted in this report, as they have been mostly replaced by GPS systems.

31. Oxera (2013), "What is the Economic Impact of Geo Services?" Available at: http://www.oxera.com/Latest-Thinking/Publications/Reports/2013/What-is-the-economic-impact-of-Geo-services.aspx
32. Boston Consulting Group (2012), "Geospatial Services: A $1.6 trillion growth engine for the U.S. Economy" Available at: https://www.bcg.com/documents/file109372.pdf

EXHIBIT 9:

LOCATION-BASED DATA REPRESENTS MORE THAN HALF OF THE ESTIMATED US$400 BILLION GEOSPATIAL INDUSTRY

MARKET SIZE OF THE GEOSPATIAL INDUSTRY; US$ BILLION; 2016[1]



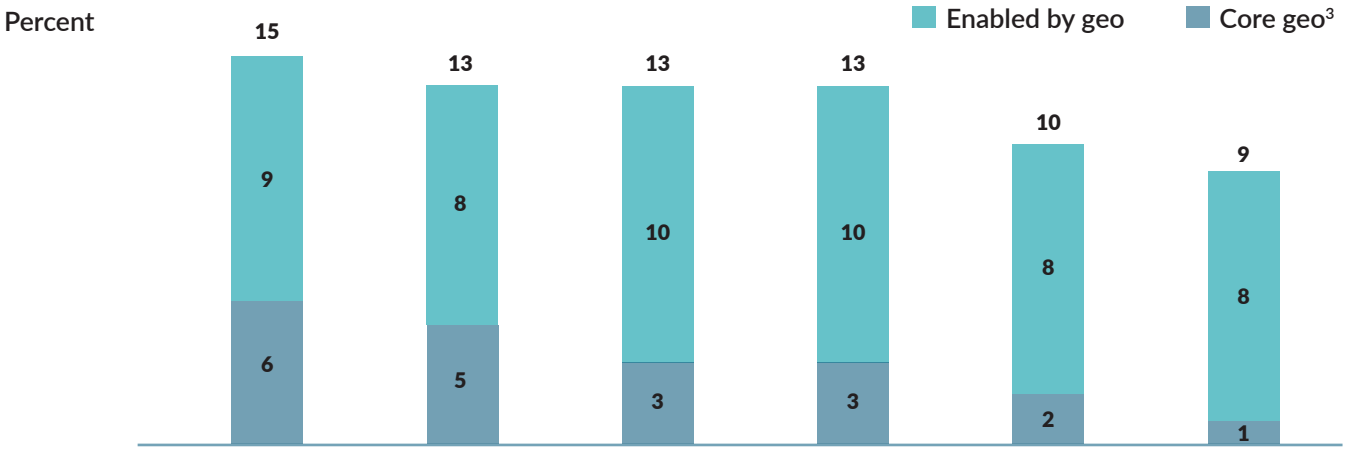
	Location-based data	Geo-Apps and Devices	Geo-expert industries
SHARE OF TOTAL;	58%	39%	4%
SUB-SEGMENTS SIZING; USD BILLIONS	• Position data (175)[2] • Environmental data (45) • Human data (10)	• Geospatial software (70) • Geospatial applications & services (50) • Geo-enabled devices (35)	• Expert industries (10) • Education (5)

1. All figures are in 2016 US dollars. Rounded to nearest US$5 billion.
2. Only 2015 data available, includes infrastructure components necessary to position data
Source: Data in exhibit is estimated by AlphaBeta using a range of original and third party sources

EXHIBIT 10:

AT LEAST 9% OF TOP APPS IN MAJOR MARKETS AROUND THE WORLD ARE DRIVEN OR ENABLED BY GEOSPATIAL TECHNOLOGIES

SHARE OF TOP APPS IN EACH MARKET WHICH ARE GEO-RELATED[1,2]



PERCENT OF GEO APPS WHICH ARE DOMESTIC	Europe	Latin America	North America	Asia Pacific	Africa	Middle East
	69	24	73	48	0	6

1. Based on top 100 apps in both the free and paid charts in the Google Play store.
2. Regions are proxied by the largest smartphone market in the study for each area: Europe (Russia); Latin America (Brazil); North America (USA); Asia Pacific (India; Japan; Australia); Africa (Nigeria); Middle East (Turkey).
3. Core refers to apps (Uber, Waze) that depend on geo-technologies to function, enabled refers to apps (Facebook) where it is complemented by geo
Source: App Annie; AlphaBeta analysis

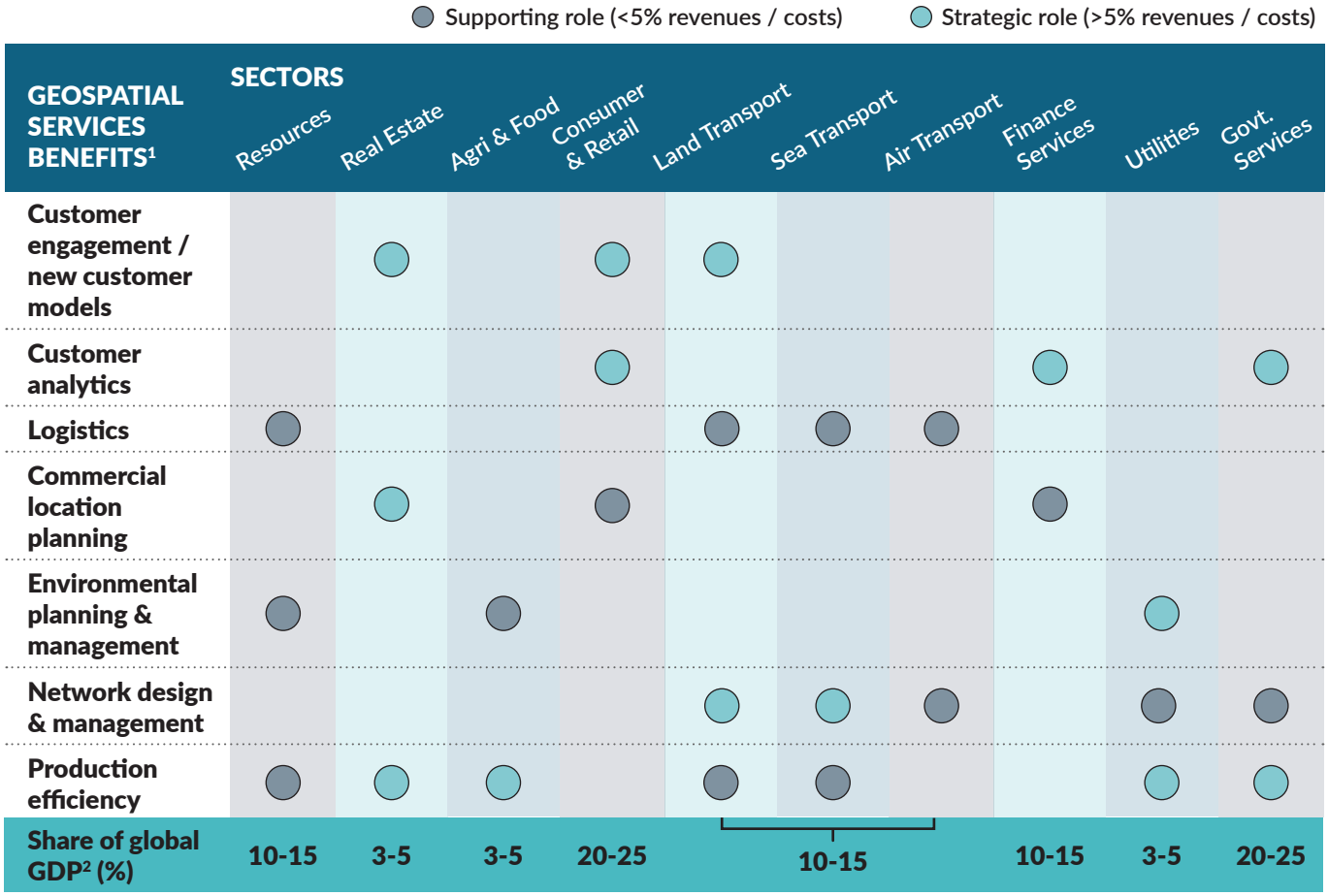
PRODUCTIVITY BENEFITS FOR OTHER SECTORS

The indirect business benefits of geospatial services far outweigh the revenue generated by companies in this industry. A substantial number of companies today use digital maps to improve the productivity of their operations and engage more directly with customers. In a recent study, Boston Consulting Group (BCG) estimated that the revenues driven by geospatial services in the United States were around US$1.6 trillion in 2012, more than 20 times the size of the local geospatial industry itself.[33]

This study confirms the large "multiplier" effect of using geospatial services, which add significant value to other industries. Retailers use digital maps for market research and demographic analysis to find the best locations for their stores, logistics companies rely on navigation systems to work more productively, and farmers use geospatial services to improve their schedule of watering and fertilizing crops. In 2016, geospatial services are estimated to have played a strategic role in sectors contributing approximately 75% to the world's economic output (Exhibit 11).[34]

EXHIBIT 11:

GEOSPATIAL SERVICES COULD HAVE A SIGNIFICANT PRODUCTIVITY IMPACT IN SECTORS REPRESENTING APPROXIMATELY 75 PERCENT OF GLOBAL GDP



1 Based on case studies of impact ; 2 We obtain information from the Groningen Growth and Development Centre 10-Sector Database and the Australian Bureau of Statistics; estimates are extrapolated to find regional and global figures. Numbers might not add up due to rounding. 3 Includes mining, oil, and gas. 4 Government services include public administration, defense, education, health, and social work.

Source: University of Groningen; Australia bureau of Statistics; literature review; expert interviews; AlphaBeta analysis

33. Boston Consulting Group (2012), "Geospatial Services: A $1.6 trillion growth engine for the U.S. Economy" Available at: https://www.bcg.com/documents/file109372.pdf

34. "Strategic role" is defined as influencing a company's cost or revenue by at least 5%.

Below are examples for the benefits of geospatial services in specific sectors:

1. RESOURCES (OIL AND GAS, MINING)

Geospatial services have the potential to improve the logistics, environmental management and production efficiency in the resources sector.

- Some of the **largest benefits are linked to logistics**. At Australian mine sites, autonomous vehicles, using geospatial technology, are now used to transport raw materials. These automated vehicles can be managed remotely by workers, which has allowed companies to lower labor costs by up to 40%.[35]

- Geospatial services can **help companies with their environmental management.** Digital maps can be used to evaluate geological and seismic data to improve resources exploration. They also allow for precision planning of major infrastructure projects, such as the construction of a new pipeline. Mining companies have also begun to use geospatial data for citizen-led exploration efforts, rewarding ordinary people who help identify likely locations of mineral deposits with a prize. In the case of Canadian mining company Goldcorp, this approach yielded 110 potential exploration targets, which ultimately generated US$3 billion worth of gold.[36 37]

- Other benefits are **linked to production efficiency:** GPS devices embedded in "smart" wearable technology provide real-time information on the location of workers. The data has allowed some companies to better plan where to deploy workers during production, which ended up boosting site productivity, reducing operational costs, and improving worker safety. For example, GPS-enabled wearables can help reduce the electricity costs of ventilation (which account for up to 50% of a mine's energy costs) through a ventilation on demand system. This system can help operators identify which sections of the mine are in use and which aren't, thus channeling ventilation only to parts where it is needed.[38]

2. REAL ESTATE

There are a range of potential benefits to the real-estate sector, ranging from better customer engagement and analytics to improved planning of building locations.

- **Customer engagement** can be improved by using geospatial data to determine travel times from properties to key locations. Real-estate firm Windermere, for example, uses a geospatial tool called Drive Time by internet-technology firm INRIX, which allows prospective buyers to set the total amount of time they are willing to travel from a fixed location. The tool then identifies the most suitable property area on a map.[39] Other real-estate websites using mapping technology to showcase properties to potential clients include Redfin, Zillow, PropertyGuru, and MyRealEstate.

35. McKinsey Global Institute (June 2015), "The Internet of Things: Mapping The Value Beyond The Hype" Available at: http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx

36. Fast Company (2002), "He struck gold on the Net (really)," Available at: https://www.fastcompany.com/44917/he-struck-gold-net-really

37. McKinsey Global Institute (2013), "Open data: Unlocking innovation and performance with liquid information" Available at: http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Open%20data%20Unlocking%20innovation%20and%20performance%20with%20liquid%20information/MGI_Open_data_FullReport_Oct2013.ashx

38. Ramjack Technology Solutions (2015), "How Ventilation on Demand (VOD) Can Reduce Mine Operating Costs" Available at: https://ramjack.co.za/mining-resources-articles/ventilation-demand-vod-reduce-operating-costs/

39. Geekwire (2013), "Windermere partners with INRIX to provide drive-time recommendations for homebuyers" Available at: http://www.geekwire.com/2013/windermere-partners-inrix-provide-drive-time-recommendations-homebuyers/

- **Customer analytics** can also be improved through geospatial services. Some local governments have begun to overlay digital maps with data on resident demographics and average house prices to better understand the socio-economic status and housing needs in a neighborhood. For example, Texas-based Fort Bend Economic Development Council used this method to plan property developments.[33] Forest City Enterprises, a US real-estate developer, has used similar information to help retailers find the most suitable building location.[40]

- Geospatial services can also be used to **improve commercial planning decisions** where right-of-way (meaning legal rights to pass along a specific route through grounds or property belonging to another) may be required, or where land could be sold or leased. For example, the Union Pacific Railroad used their GIS maps to identify areas where they could sell or lease land to companies building cellular communication towers or installing communication cabling.[33]

- The **building efficiency can increase** when developers use geospatial services to make better use of power, gas and water. Digital maps can be modified with thermal mapping to track energy efficiency. The University of Calgary, for example, created a software tool that allows people to see a building through a thermal spectrum provided by a Geographic Information System (GIS). This thermal viewer enabled people to spot where heat was escaping from their residence or another building and then take the necessary steps to cut energy use.[41]

- Geospatial technology can also **help towards the goal of affordable housing** through tools such as the Housing Suitability Model developed by the University of Florida, which assesses the suitability of potential affordable housing developments beyond the land price, through factors such as proximity to transport networks, job hubs, and educational institutions.[42]

3. AGRICULTURE AND FOOD

Geospatial information has transformed the agriculture and food sectors, with benefits ranging from improved crop monitoring (part of environmental management) and production efficiency, to new consumer business models.

- In **environmental management,** traditional methods for monitoring crop health include hiring a pilot to fly over a field to take photographs or ordering satellite imagery. These methods have limitations in either availability or cost, since satellites only pass over a field once a week or more rarely; and hiring a manned plane can cost up to $1000 an hour.[43] On the other hand, GPS-enabled drones provide a more cost-effective solution (prices start at US$1,000 and are only paid once) for farmers to actively monitor crops in real time. This real-time data can include spectral imaging to assess field irrigation issues; and early detection of pest infestation through infrared scanning.[44]

- Geospatial data has also **triggered new business models:** food-on-demand services, such as UberEats, Deliveroo, Abrafood, Subdelivery, and Foodpanda, enabled by geospatial data, have also transformed the food supply chain.

40. ESRI (2007), "GIS Best Practices: GIS for Real Estate" Available at: http://www.esri.com/library/bestpractices/real-estate.pdf
41. University of Calgary (2011), "Geospatial Technologies to Improve Urban Energy Efficiency", Remote Sens. 2011, 3 1380-1405. Available at: www.mdpi.com/2072-4292/3/7/1380/pdf
42. University of Florida (2013), "Housing Suitability Model" Available at: http://www.shimberg.ufl.edu/fl_housingSuitableModel.html
43. MIT Technology Review (2017), "Relatively cheap drones with advanced sensors and imaging capabilities are giving farmers new ways to increase yields and reduce crop damage" Available at: https://www.technologyreview.com/s/526491/agricultural-drones/
44. MIT Technology Review (2017), "Six Ways Drones Are Revolutionizing Agriculture" Available at: https://www.technologyreview.com/s/601935/six-ways-drones-are-revolutionizing-agriculture/

- There are also **large benefits for production efficiency**. McKinsey Global Institute estimates that geospatial technology can increase farmers' yields by up to 25% when using GPS-supported seed-planting machines.[45]

4. CONSUMER AND RETAIL

There are numerous geospatial benefits available to the consumer and retail sector:

- Retailers can use digital maps to provide useful business information, from opening hours to product availability, to **increase their customer engagement** (see Box 9 on The Value of GMB listing).

- Digital maps can help manage inventories in different locations, which **improves logistics**.

- **Customer analytics:** Retailers can overlay digital map with income data in a certain neighborhood and their own sales records to gauge potential market demand or improve their sales performance. Intermarche, a French supermarket company, combined geospatial data with demographic information to simulate sales strategies in individual stores and improve its sales performance.[46]

- Geospatial data can also be used for **store planning**. For example, Environmental Systems Research Institute (ESRI), a global supplier of geographic information system software, worked with American retailer Federated Department Stores to identify new store locations.[47]

- On-demand delivery services (such as Amazon Prime Now, Go-Jek, Postmates, etc.) **rely heavily on mobile navigation apps** which direct delivery staff from the item pickup point to the recipients' destination.

5. LAND TRANSPORTATION

Geospatial services can enhance land transportation through consumer engagement and new business models, route planning, commercial planning (building warehouses), network management (reducing fraud), and production efficiency (through higher utilization).

- For **logistics optimization**, Indian startup AIRPIX lets drones equipped with remote sensing technology fly over construction sites to track the progress of works and identify issues that could become bottlenecks, such as material shortages.[48] Using drones, rather than workers, planes or satellites to inspect a construction site, can reduce costs and time by as much as 50%.

- **Commercial planning** can be improved when using geospatial services to optimize the location of warehouses and monitor the handling of goods, thus reducing the cost of cargo theft.[49]

45. McKinsey Global Institute (June 2015), "The Internet of Things: Mapping The Value Beyond The Hype" Available at: http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx

46. Innovative Retail Technologies (2017), "GIS' Multidiscipline Retail Value Proposition" Available at: https://www.innovativeretailtechnologies.com/doc/gis-multidiscipline-retail-value-proposition-0003

47. Federated Department Stores, Inc. is the parent company of department stores such as Macy's and Bloomingdale's.

48. Federation of Indian Chambers of Commerce & Industry (2017), "Geospatial Technologies in India – Select Success Stories" Available at: http://ficci.in/spdocument/20873/Geospatial%20Technologies%20in%20India%20-%20Success%20Stories.pdf

49. DHL and Cisco (2015), "Internet of things in logistics" Available at: http://www.dhl.com/en/about_us/logistics_insights/dhl_trend_research/internet_of_things.html#.WW2tS4iGNEY

- **Network management**: Route planning for logistics companies has also been enhanced through geospatial services. "Real-time smart routing" has helped drivers identify the best routes to accommodate last-minute changes and avoid traffic congestion, which is estimated to have improved operating efficiency (measured in terms of delivery times) by 17%. Other fleet management applications include monitoring fleet efficiency and ensuring safety protocols are observed. For example, consumer-goods company Nestlé uses wireless vehicle management systems on more than 2,000 industrial trucks to encourage safe driving habits and to shut down idle equipment to cut fuel consumption.

- Geospatial services can also **increase the production efficiency** of freight companies. Coyote, a Chicago-based freight broker and logistics services provider, helps firms book space in returning freight trains that would otherwise travel empty. A smartphone app provides shippers and carriers with real-time information on prices, load details and delivery routes. According to a report by the World Economic Forum, shared transport capabilities could allow the logistics industry to save up to US$30 billion and reduce CO^2 emissions by 700 million metric ton or 2% of the global carbon emissions in 2016.[50]

6. SEA TRANSPORTATION

Connected networks enabled by GPS satellites can increase the passage of ships through crowded straits and track shipping containers as they crisscross the world.

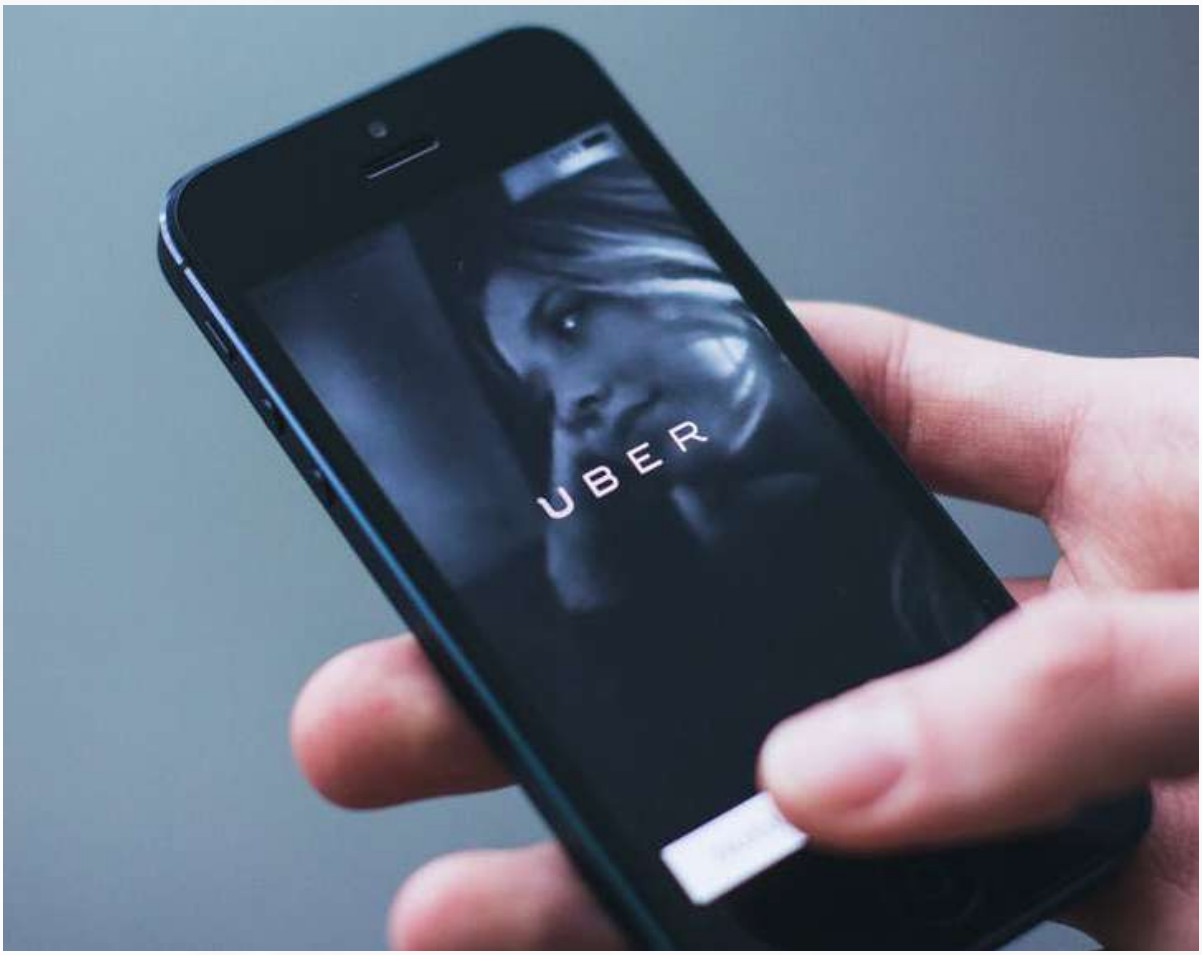
- Employing GPS technologies to track containers can allow merchant lines to **improve network management** by keeping a record of where inventory is stored. Often, empty containers are stored in unknown locations or small ports, making retrieval and re-use inefficient. Tracking container inventory can increase utilization rates (the amount of times a container is loaded) by up to a quarter.[51]

- Better navigation can also **improve logistics**. Maritime traffic on the world's oceans has increased 300% over the past 20 years, according to a study by the American Geophysical Union (AGU).[52] Congested waters have become more perilous and ships have to slow down in order to avoid collisions. Maritime safety improves, as GPS networks replace old-fashioned radar-driven systems, allowing captains to receive real-time traffic information on board. The added benefit: overall transportation costs could fall by up to 13%.[53]

- **Production efficiency** can also be improved using geospatial services. Ports can use geospatial services to automate the movement of containers within a port. Tianjin Container Terminals in China, for example, reported that it was able to lower costs by 4% to 8% and increase efficiency by 5% to 10% thanks to a new automation system powered by GPS technology.[54]

50. World Economic Forum (2016), "How can digital help logistics be more sharing?" Available at: http://reports.weforum.org/digital-transformation/cutting-costs-through-sharing-logistics-assets/
51. McKinsey Global Institute (June 2015), "The Internet of Things: Mapping The Value Beyond The Hype" Available at: http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx
52. J. Tournadre (2014), "Anthropogenic pressure on the open ocean: The growth of ship traffic revealed by altimeter data analysis", Geophysical Research Letters, Volume 41, Issue 22, 28 November 2014 Pages 7924–7932. Available at: http://onlinelibrary.wiley.com/doi/10.1002/2014GL061786/abstract
53. McKinsey Global Institute (June 2015), "The Internet of Things: Mapping The Value Beyond The Hype" Available at: http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx
54. GPS.gov (US) (2014), "Marine" Available at: http://www.gps.gov/applications/marine/

BOX 6.
SHARED MOBILITY



Geospatial services have led to the creation of an entire new market worth US$40 billion: shared mobility. Using GPS chips embedded in smartphones, shared mobility companies such as Uber, Lyft, Cabify, Grab, Ola, EasyTaxi, and Go-Jek, have developed technologies that have revolutionized the private hire car market.[55]

The same technology that powers shared mobility companies is also used by carpooling providers, including Waze Carpool and Scoop. Their smartphone apps allow friends, family and neighbors to identify travel routes they have in common. This facilitates the logistics of sharing a carpool ride.

55. Reuters (2016), "Economists see ride-hailing industry as ripe for competition" Available at: http://www.reuters.com/article/us-uber-ridesharing-analysis-idUSKCN1110B2

7. AIR TRANSPORTATION

Geospatial technology does not only guide aircraft. Airports have also turned to geospatial services in various areas, from air traffic control to facility management. GPS technology has become an integral part of general aviation, with roughly 80% of US planes using it.

- **Logistics**: using GPS data, rather than ground-based radio navigation between airports, can shorten the duration of flights, thus helping airlines save fuel, one of the largest cost drivers.

- There are also large benefits **linked to network design**. For example, McCarran International Airport in Las Vegas has used geospatial solutions to meet business needs ranging from planning to engineering to information systems, enabling them to conduct analysis, track complaints, and manage flights.[56]

- **Safety and production efficiency**: GPS technology is now an integral part of so-called Terrain Awareness and Warning Systems, which has lowered the amount of fatal accidents related to controlled-flight-in-terrain[57] by 44% over the five years through 2011, according to the US Federal Aviation Administration (FAA). The FAA is also in the process of implementing NextGen, a new GPS-supported air-traffic control system that is expected to reduce flight delays by 35%, generating estimated benefits worth US$23 billion by 2018.[58]

8. FINANCIAL SERVICES

Geospatial services can be used in financial services in a range of areas, for example:

- They can have **an impact on commercial planning decisions** by determining where to locate a new retail banking outlet or ATM. JPMorgan Chase, for example, is among the banks that combine GPS technology with data on customers and employees (where they live and like to shop) to improve the location of branch offices and ATMs.[59]

- When overlaid with other demographic and economic data geospatial services can **aid a bank's customer analytics** to improve the assessment of loan applications, better match products and customer needs, and refine marketing campaigns.[60] Geospatial data, for example on car theft, can also improve the pricing of insurance products.

56. ESRI (2016), "Location Strategy Gets First Class Seating at Las Vegas McCarran International Airport" Available at: http://www.esri.com/News/2016/Transportation/las-vegas-mccarran-airport
57. A controlled flight into terrain is an accident in which an aircraft is unintentionally flown into the ground, a mountain, a body of water or an obstacle.
58. Federal Aviation Administration (2017), "NextGen" Available at: https://www.faa.gov/nextgen/
59. Fintech – News and Analysis (2015), "JPMorgan Chase Uses Esri Mapping For Branch Plans, Resilience And Marketing" Available at: https://techandfinance.com/2015/10/25/jpmorgan-chase-uses-esri-mapping-for-branch-plans-resilience-and-marketing/
60. Geospatial World (2009), "An Integrated approach for Banking GIS" Available at: https://www.geospatialworld.net/article/an-integrated-approach-for-banking-gis/

BOX 7.
CLASSIFYING PRODUCTIVITY BENEFITS

Given their broad impact on a vast array of business activities, there are various ways to classify productivity benefits of geospatial services on the economy. This research takes a "vertical" perspective, mapping the use of this technology by sectors, such as agriculture and food, consumer and retail, or land transportation.

An alternative approach, which this research did not apply but is useful to keep in mind when sizing the impact of geospatial technology, would have been to adopt a horizontal perspective and measure these benefits by the activities that drive impact in these sectors. For example, a key activity area that provides benefits to multiple sectors is in logistics. In resource extraction, geospatial technologies applied to autonomous vehicles help reduce the cost of labor being deployed in remote locations. In sea transportation, GPS technology helps vessels navigate congested waters.

Another set of activities related to geospatial services is in construction and engineering services. For example, geospatial services are being used to re-design airports to improve security and traffic management. Some global engineering players are also using geospatial technologies to carry out specific projects related to environmental impact assessment and design. For example, ARUP has used GIS (Geographic Information System) technology in their Flood Hazard Assessment and Adaptation Toolkits to install innovative moveable weirs in Leeds (UK) as part of the city's Flood Alleviation Scheme.[61] AECOM has applied GIS technology to build an evaluation model for sustainability improvements to Singapore's Jurong Lake District development. A unique addition to this project was the creation of tools to measure the accessibility of vertical components (such as elevated parks, skyways, and trams) to speed up evaluation of sustainable design options, allowing participants to immediately see the impact of different options.[62]

61. Arup (n.d.), "Climate change, resilience and adaptability" Available at: http://www.arup.com/climate_change_resilience_and_adaptability
62. ESRI (2012), "Singapore's Sustainable Development of Jurong Lake District" Available at: http://www.esri.com/news/arcnews/spring12articles/singapores-sustainable-development-of-jurong-lake-district.html

9. UTILITIES

Geospatial technology allows utility companies to better engage with customers, streamline the planning phase of infrastructure projects and manage their networks more efficiently. Geospatial data can also provide insights into how much customers use services, such as energy and water.

- **Customer engagement**: Geospatial services educate consumers about the potential benefits of installing solar panels on their homes' rooftops. Google's "Project Sunroof", for example, is a simple online tool powered with Google's mapping and imagery technology that estimates how much lower a household's electricity bill would be if solar panels were installed. The calculator draws on a range of data, from solar panel costs to local weather patterns, and informs about local providers of solar equipment. The initiative covers more than 50% of households in the US and recently expanded into Europe.[63]

- **Customer analytics**: Software companies such as Opower use geospatial information to inform household about their energy use compared to their neighbors, which can motivate them to be more energy efficient.

- **Environmental planning & management**: Utility companies also use geospatial modelling software to minimize negative environmental impacts when building new infrastructure. Tools such as the "Infrastructure Placement Analysis System" designed by the University of Arkansas' Center for Advanced Spatial Technologies can simulate how the construction of oil, gas and water pipelines affects water sources. Such simulations can save companies time when seeking regulatory approval for infrastructure projects. Another example of geospatial technology applied to environmental planning is the "Google Air View" program, which uses cars equipped with cameras and methane sensors to detect gas leaks in municipal pipelines.[64] The data, used in conjunction with digital maps, has allowed governments to identify gas mains that most urgently need replacement.[65]

- Geospatial technology also **facilitates the planning of networks**, including where to place mobile phone towers, power lines and water piping. German utility company Lechwerke, for example, uses geospatial data to merge new sources of residential solar power into an existing energy grid.[66]

- **Production efficiency**: Geospatial technology can make maintenance jobs more efficient. For example, US company Austin Water Utility (AWU) uses geospatial software to help inspection teams report water violations in real time. AWU found that this saved $400,000 in payroll costs in a drought situation.[67]

63. Google (2017), "Project Sunroof" Available at: https://www.google.com/get/sunroof
64. Google Environment (2016), "Mapping the invisible: Street View cars add air pollution sensors" Available at: https://environment.google/projects/airview/
65. American Chemical Society (2017), "Scientists partner with Google Earth Outreach to analyze methane leaks in U.S. cities" Available at: https://www.acs.org/content/acs/en/pressroom/presspacs/2017/acs-presspac-march-22-2017/scientists-partner-with-google-earth-outreach-to-analyze-methane-leaks-in-us-cities.html
66. ESRI (2014), "Esri News for Electric & Gas Utilities" Available at: http://www.esri.com/~/media/Files/Pdfs/library/newsletters/electric-gas/electric-gas-2014.pdf
67. ESRI (2015), "Austin Water Utility Cuts Labor Costs by $400,000" Available at: http://www.esri.com/library/casestudies/austin-water-company.pdf

10. GOVERNMENT SERVICES

Government agencies use geospatial technology to better manage their resources and provide key services more efficiently, and engage with citizens in new ways.

- **Customer analytics**: Geospatial services can make government services more effective. For example, digital maps helped the Arizona Department of Health Services created a "Community Profiles Dashboard" spend money on health initiatives more efficiently by allowing officials to assess the health of citizens in different areas and then design a targeted response.[68] [69]Towns can also use geospatial technology to analyze crime patterns and develop a policy response based on that data.

- Geospatial technology can **improve public transport** when used to analyze traffic flow and accident "blackspots". Policymakers can use the data to make more informed decisions on road construction and traffic management.[70]

- **Network management**: Geospatial services can significantly improve public works, which can be lengthy and cumbersome when multiple work crews at various locations have to be coordinated. The City of Memphis overcame this challenge by using a geospatial database to prop up its Customer Relationship Management software, so that construction workers could be deployed more efficiently across different sites.[71] India uses geospatial technology to improve engineering and construction works along a road network spanning 15,000 kilometers—for example by using 180-degree geo-imagery or GPS-powered laser tools to assess road damage.[72]

- **Productivity improvement**: Geospatial technology allows government to complete major public tasks more efficiently. For example, Cape Verde switched from paper maps to digital maps for conducting their census exercises, equipping field staff with geospatial software tools. This technological shift proved to be 40% faster than the previous methods.[59]

- Public services that use digital maps can **generate broader benefits for society and the environment**, ranging from faster emergency response to livelier classroom education. Chapter 4 discusses these benefits in detail.

68. ESRI (2015), "Esri News for State & Local Government", Winter 2014/2015. Available at: http://www.esri.com/library/newsletters/state-local/winter-2014-2015.pdf#page=6
69. Healthcare Tech Outlook (2017), "Location, Location, Location: The Geospatial Imperative for Better Health Care" Available at http://www.healthcaretechoutlook.com/cxoinsights/location-location-location-the-geospatial-imperative-for-better-health-care-nid-284.html
70. McKinsey Global Institute (June 2015), "The Internet of Things: Mapping The Value Beyond The Hype" Available at: http://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/Unlocking_the_potential_of_the_Internet_of_Things_Executive_summary.ashx .
71. ESRI (2016), "City of Memphis Public Works Reduces Response Time by 33 percent" Available at: http://www.esri.com/News/2016/public-works/full-article/city-of-memphis-public-works
72. International Road Assessment Programme (2012), "India Four States Road Safety Report" Available at: http://www.irap.net/about-irap-3/assessment-reports?download=54:india-four-states-report

BOX 8.
THE IMPACT OF GEOSPATIAL TECHNOLOGY IN THE GAMING INDUSTRY – INGRESS

Despite not having yet reached strategic levels, Geospatial technology is also starting to having an impact on the gaming industry as well. Smartphone games such as "Ingress", "Magical Park" and "Pokemon Go", have developed interactive gaming set in player's local environments.[73]

Ingress was launched in February 2012, racking up over 8 million downloads through 2015 on various app stores.[74] The game is played in a continuous open narrative, with a science-fiction themed storyline. The game makes innovative use of GPS data, smartphone cameras and augmented reality (AR) to provide a novel, interactive gaming experience to users.

In Ingress, players are presented with live 3D-maps of their surrounding areas. Most of the gameplay occurs at "portals", or places such as museums, sculptures, historic landmarks, parks and other public spaces.[75] These portals are made visible by the "scanner" – enabled by smartphone cameras – and gameplay elements are overlaid using AR technology over the landmarks. As the game is GPS-enabled, players are required to physically move to the portals, meeting fellow players and discovering locations within their city.[76]

Games such as Ingress have spill-over health benefits generated by the incentivized walking and physical activity. Ingress players had covered over 127 million kilometers while playing the game by January 2015. The game also encourages social interaction as teamplay is an essential component of the experience. Ingress players have revealed that the interaction is not limited to the game alone; community members meet outside of team activities, and have helped each other find employment as well.[77]

73. Fulcrum (2016), "What's new in the world of geospatial gaming 2016" Available at: http://www.fulcrumapp.com/blog/more-geospatial-fun/
74. Motherboard (2016), "The king of augmented reality street fighting" Available at: https://motherboard.vice.com/en_us/article/z4mgzy/the-king-of-augmented-street-fighting-the-worlds-best-ingress-player
75. Lifehacker (2015), "How Ingress, Google's real-world smartphone game, got me out of my shell" Available at: http://lifehacker.com/how-ingress-googles-real-world-smartphone-game-got-me-1710320867
76. Quartz (2016), "Forget Pokemon Go, there's another augmented reality game that's way better" Available at: https://qz.com/732809/forget-pokemon-go-theres-another-augmented-reality-game-thats-way-better/
77. Motherboard (2016), "The king of augmented reality street fighting" Available at: https://motherboard.vice.com/en_us/article/z4mgzy/the-king-of-augmented-street-fighting-the-worlds-best-ingress-player

BOOSTING GROWTH: HELPING SMALL BUSINESSES FIND NEW CUSTOMERS

Many businesses use digital maps through "Google My Business", a free service that lists firms within a search category together with information on how to get to the business, when it is open, and which products it currently stocks. These listings have been found to increase customer visits online and in the brick-and-mortar shops (see Box 9).

Online maps are particularly important for small businesses, who often lose customers to larger retailers due to the challenges faced by customers in finding them. The consumer survey undertaken for this report shows that 94% of people use digital maps to search local businesses or services.

Based on the consumer survey, we estimate that businesses are reaping over US$1 trillion of sales globally from purchases linked to online maps (Exhibit 12). In 52% of the cases, consumers surveyed said they would have not been able to make the purchase, suggesting that digital maps offer a genuinely new marketing channel to firms.

EXHIBIT 12:
OVER US$1 TRILLION OF YEARLY SALES IN THE WORLD ARE LINKED TO DIGITAL MAPS

REGION	OCCASIONS WHEN DIGITAL MAPS WERE USED IN ACTUAL PURCHASES Average per digital maps user; Times per year	CONSERVATIVE VALUE OF PURCHASE US$	TOTAL VALUE OF ANNUAL PURCHASES USING DIGITAL MAPS US$ billion
ASIA PACIFIC	59	7	600
EUROPE	42	22	300
NORTH AMERICA	32	35	200
LATIN AMERICA	52	6	100
MIDDLE EAST	59	5	31
AFRICA	29	5	31

At global level[1], over US$1 trillion of sales are linked to digital maps

1. Global values were scaled up on the basis of regional online map users, taking figures from United States for North America; Brazil and Mexico for Latin America; Italy, Germany, Russia, Spain, and UK for Europe; Saudi Arabia, Turkey, and UAE for Middle East; Nigeria and South Africa for Africa; Thailand for Asia Pacific
Source: Survey of Digital Map users; AlphaBeta analysis

BOX 9.
THE VALUE OF GMB LISTINGS

Google My Business (GMB) is a free tool that helps small businesses create and manage their Google business listings which appear when customers find businesses on Google Search and Maps. It makes their business stand out with pictures, opening hours, and web address and helps them attract new customers. Recent research found that these entries were positively correlated with consumer intentions of visits or purchase, concluding that "firm-specific benefits for small to medium-sized businesses could be between $212 and $250 per year".[78] Internal Google data reveal that "well maintained" listings get three times more clicks than others. Meanwhile, a 2014 survey revealed that customers are 38% more likely to visit a location and 29% more likely to consider a purchase when exposed to these detailed map listings.[79]

Other research suggests that additional features using location data can have a very significant impact of consumer behavior: business listings which include virtual tours, for example, are found to be twice as likely to get consumers interested in making a reservation than more basic listings.

78. Oxera (2014), "The Benefits of Complete Business Listings" Available at: https://www.gybo.com/downloads/verification-benefits.pdf
79. Ipsos MORI (2014), "Impact of Search Listings for Local Businesses" Available at: https://www.gybo.com/downloads/search-listing-research.pdf

SUPPORTING TOURISM SPEND: HELPING TRAVELERS PLAN AND FIND PLACES

Online maps can encourage tourists to come to a city and increase their spending during their visit. 70% of consumers surveyed for this report say they use online maps to plan their trips before they travel; 68% use it when traveling to find places to eat; 64% to find shops; and 74% to find places to visit (Exhibit 13). Tourism businesses particularly benefit from additional map features that allow users to post reviews and pictures of restaurants, sites and attractions. By doing so, they increase the amount of information available online—which is increasingly driving success in the tourism industry. Recent research shows that European travel destinations with well-managed online presence (also beyond GMB) attract more visitors and gain more market share than their peers.[80]

Digital-map providers (such as Bing, Apple, Google, Yandex, etc.) have also designed specific programs to help businesses attract more tourist dollars (see Box 10 for further details).

EXHIBIT 13:

74% OF RESPONDENTS STATE THEY USE DIGITAL MAPS TO LOCATE PLACES TO VISIT WHEN TRAVELING, AND 70% TO PLAN THEIR TRIP BEFORE TRAVELING

SHARE OF DIGITAL MAP USERS WHO AGREE WITH FOLLOWING STATEMENTS "I USE DIGITAL MAPS TO..."

Source: Survey of Digital Map users; AlphaBeta analysis

80. The study estimates, for example, that improved online content in Spain would increase tourism demand by 3%, with a 0.4% boost to national GDP and over 50,000 new jobs created. See Oxford Economics (2013), "The Impact of Online Content on Tourism in Europe" Available at: http://www.oxfordeconomics.com/my-oxford/projects/246666

BOX 10.
TOURISM BENEFITS IN NEW ZEALAND

New Zealand boasts amazing natural landscapes, with native forests and valleys that are ideal for hiking and camping in the great outdoors. New Zealand has nine walking tracks across the country called the "Great Walks", ranging from the Kepler Track in the Fiordland region to the Tongariro Northern Circuit in the Central North Island.[81] To allow a greater audience to view the spectacular views from these tracks, Google has worked with the Department of Conservation from 2012 to equip hikers with the Google Trekker (a backpack with 15 cameras), allowing them to capture 360-degree panoramic images.[82] Images are now also available for seven of the "Great Walks", thanks to a partnership between Google, Air New Zealand and the Department of Conservation. The imagery allows internet users to virtually step on these trails or prepare for the actual hike.[83] This provides a boost to the country's tourism industry: being able to experience the stunning landscapes and vast open spaces online likely entices more people to travel to New Zealand.

Christopher Luxon, Air New Zealand's chief executive, says that New Zealand has "seen a big increase in visitor numbers on the 'Great Walks'. The introduction of the Google Trekker imagery is another way to further this momentum using new technology to inspire and give visitors a preview of what it's like to walk on the 'Great Walks'"[84]. The Fiordland Regional Tourism Organization estimates that the Fiordland, home to several famous tracks, has seen an increase of over 25% in international visitors between September 2015 and March 2016.[85] As more visitors come to visit the "Great Walks", local businesses will also benefit as these tourists spend on accommodation, gifts, and food. While further analysis would be required to assess the impact of digital map imagery on New Zealand's tourism industry, it has certainly expanded the online reach of these tourist attractions to potential visitors around the world.

81. Information obtained from the Department of Conservation - http://www.doc.govt.nz/parks-and-recreation/things-to-do/walking-and-tramping/great-walks/map/
82. Google Maps - https://maps.googleblog.com/2015/11/take-walk-on-wild-side-with-street-view.html
83. Reported by Stuff, November 5, 2015 - http://www.stuff.co.nz/travel/destinations/nz/73503987/new-zealands-great-walks-launch-on-google-maps
84. Reported by Stuff, November 5, 2015 - http://www.stuff.co.nz/travel/destinations/nz/73503987/new-zealands-great-walks-launch-on-google-maps
85. Information from Statistics New Zealand, International Visitor Survey: Place visited (RTO) - http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7573#

SOCIAL AND ENVIRONMENT BENEFITS

Geospatial services accrue benefits not just for individual consumers and businesses, but for the society at large. In economics, these types of benefits are called “spillover benefits”. Common economic statistics typically fail to capture these benefits. A more creative approach is needed to measure the impact of digital maps on the wider economy where they create value in many areas, from easing road congestion to boosting employment in the startup sector.

ESTIMATED SOCIETAL BENEFITS LINKED TO GEOSPATIAL SERVICES

DURING 2016 (OR AS INDICATED)[1]:

CREATING JOBS

Potential employment directly linked to geospatial services of over
4 MILLION JOBS
such as GIS technicians, geographical surveyors, and satellite engineers.

Potential employment indirectly linked to geospatial services of over
8 MILLION JOBS
i.e. non-geospatial jobs (such as HR) within geospatial companies, and jobs outside the industry, such as companies' suppliers.

TACKLING CONGESTION

Carpooling services (enabled by geospatial services) could potentially
REDUCE THE NUMBER OF CAR TRIPS ON ROADS BY 73 BILLION
if all regions could match San Francisco penetration.

The reduction in car travel (through better navigation and increased use of public transport) can potentially
REDUCE CARBON EMISSIONS BY 1,686 MTCO$_2$E
(equivalent to 5% of 2016 emissions).

DISASTER PREPARATION AND EMERGENCY RESPONSE

It is estimated in some countries that digital maps could reduce response times by
3.5 MINUTES PER CALL FOR AMBULANCES AND 2 MINUTES FOR FIRE BRIGADES.

KNOWLEDGE CREATION AND CIVIC ENGAGEMENT

MORE THAN 1 MILLION STUDENTS ACROSS 11 COUNTRIES
have embarked on a Google Expedition. The programme allows students to go on a virtual reality trip to over 200 destinations.

Geospatial services can help monitor and prevent overfishing, which is estimated to create
US$50 BILLION OF ECONOMIC LOSSES PER YEAR.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

JOB CREATION

Geospatial services can create significant direct and indirect employment opportunities:

- **DIRECT EMPLOYMENT.**
  A big data analysis of online job advertisements (see Appendix for details) suggests that more than 2 million jobs in the 22 countries surveyed work directly in a technical geospatial role, including software programmers, app developers, GIS technicians, geographical surveyors, and satellite engineers (Exhibit 14). Scaling this figure up to global levels, results in over 4 million jobs directly linked to geospatial technology
- **INDIRECT EMPLOYMENT.**
  An analysis of the consumer survey results and other labor-market data suggests that geospatial technology indirectly create at least an additional 8 million jobs in the broader geospatial sector.[86]

TRAFFIC CONGESTION

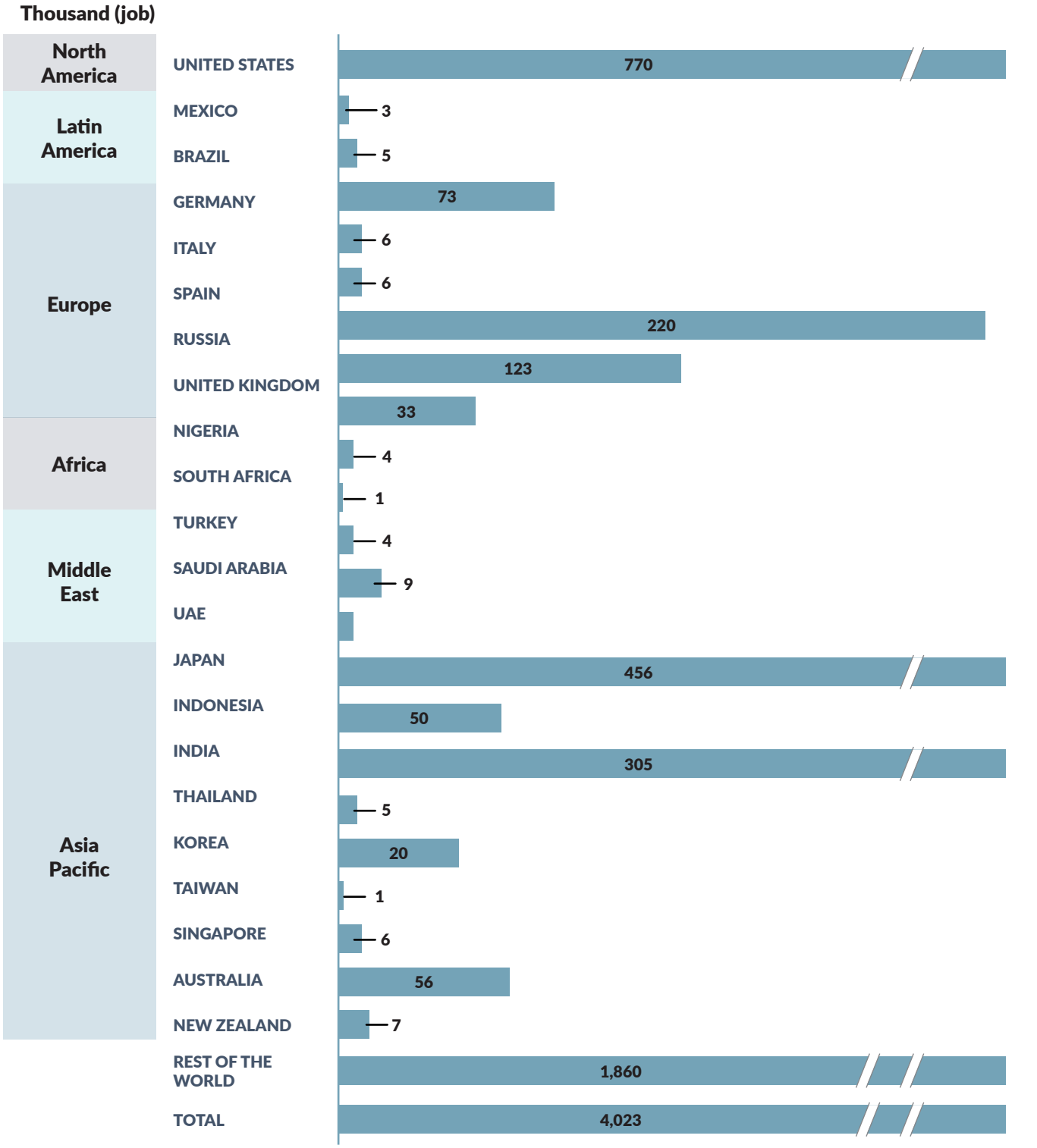
As the number of cars worldwide is projected to double to two billion cars by 2030, the pressure on urban infrastructure grows.[87] Geospatial technology can be a powerful tool to ease road congestion. Digital maps can improve traffic flows by guiding drivers over less-traveled roads or encouraging them to use alternative means of transport, including ride-sharing services such as Waze Carpool.[88] While the benefits of geo-navigation systems for drivers can already be felt today, other benefits—such as structural improvements to a transport network—will only show over time.

Digital maps can also help reduce health and environmental issues related to traffic congestion. It is estimated that over seven million premature deaths are attributable to air pollution each year.[10] Urban air pollution is projected to become the top environmental cause of premature mortality by 2050. The reduction in car travel (through better navigation, carpooling, and increased use of public transport) can also reduce carbon emissions. Recent research suggests that reduced traffic has lowered CO^2 emissions in Indian cities by 1 million metric tons annually (equivalent to afforestation worth 1.2x the size of Mumbai).[89] Globally, this report estimates that less traffic could reduce carbon emissions by 1,686 million tons in 2016 – representing 5% of total global emissions (see Appendix for further details on the calculation).

86. In line with expert interviews, survey results and academic literature, we apply a conservative ratio of 1:2 between direct and indirect jobs. The definition of indirect jobs includes both "non geo-related" jobs (such as HR, marketing, and sales) within the geospatial sector, and jobs created outside of the industry due to spillover effects such as companies' suppliers
87. Joyce Dargay, Dermot Gatley, and Martin Sommer (2007), "Vehicle ownership and income growth, worldwide: 1960-2030", The Energy Journal, 28(4). 143–170. Available at: https://www.jstor.org/stable/41323125?seq=1#page_scan_tab_contents
88. Waze (n.d.), "Waze Carpool" Available at: https://www.waze.com/carpool
89. Dalberg Global Development Advisors and Confederation of Indian Industry (CII) (2015), "Smart Maps for Smart Cities: Urban India's $8 Billion+ Opportunity" Available at: http://www.dalberg.com/wp-content/uploads/2015/07/20150715_Google-Smart-Maps-Report_FINAL.pdf

EXHIBIT 14:
OVER 4 MILLION JOBS ARE DIRECTLY LINKED TO GEOSPATIAL SERVICES

GEOSPATIAL DIRECTLY IMPACTED JOBS[1]



At global level[2], over 8 billion indirect jobs are created through geospatial services

1 Direct jobs refer to those jobs directly related to the provision of geospatial services or technologies in the geospatial sector

2 In line with expert interviews, survey results and academic literature, we apply a conservative ratio of 1:2 between direct and indirect jobs. The definition of indirect jobs includes both "non geo-related" jobs (such as HR, marketing, and sales) within the geospatial sector, and jobs created outside of the industry due to spillover effects such as companies' suppliers

Source: Online job ad boards; literature review; AlphaBeta analysis

- **TRANSPORT NETWORK.**

  1. The Waze Connected Citizens Program allows town planners from more than 250 municipalities to receive direct information from drivers on road closures, accidents and other traffic issues.[90] They can use this information to improve traffic management. For example, new traffic signaling—supported by Waze's geospatial technology—helped ease traffic jams at key intersections in Boston, by 18% in a month. Meanwhile, morning commuters in Rio de Janeiro benefitted from a decrease in morning congestion by 24% to 27% during the Olympic Games, thanks to a new traffic alert system developed by Waze, which includes live traffic updates.[91]

  2. INRIX supplies the United States Federal Highway Administration (FHWA) and other local agencies with traffic data to assist in the assessment of travel reliability, congestion, and emissions on the United States' roadways.[92]

- **ALTERNATIVE MODES OF TRANSPORTATION.** If 20% of drivers were to use carpooling instead of using their own vehicle, 41 billion car vehicle trips could be taken off the road in 2016.[93] This would imply a reduction of 73 billion car vehicle trips globally—a number likely to increase in coming years, especially as more consumers in the fast-rising middle class of emerging countries will recognize the value of carpooling (Exhibit 16).[94] Google's digital maps already provide the option to book ridesharing services, such as Uber, Cabify, Ola and Grab, while allowing users to directly compare the cost and travel time of shared rides with other transport options.[95] In addition, online maps have also begun to encourage people to use buses and trains instead of cars. 53% of internet users surveyed for this report say they are more inclined to use public transport since they started using online maps.

URBAN PLANNING

Geospatial technology has already improved urban planning in Japan and India:

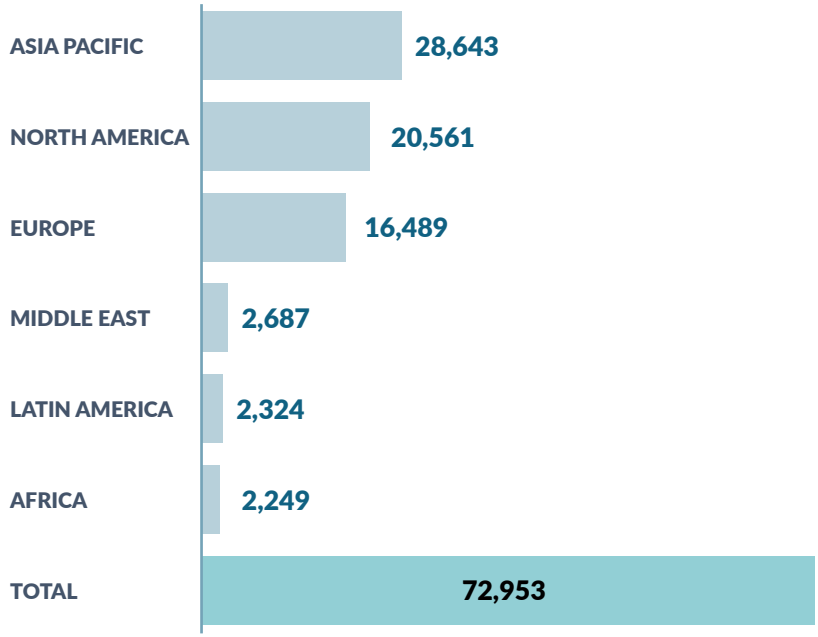
- The Indian government is pursuing a masterplan to develop smart cities through initiatives where geospatial technology is the keystone element of the plan. For example, to facilitate the development and growth of cities, the Odisha state government in India digitized all land within the state into a web-based GIS land bank to allow state officials, industry, academia, and public members find suitable locations for their proposed business activities.[96]

90. The Wall Street Journal (2017), "Navigation App Joins With Port Authority to Help Ease Congestion" Available at: https://www.wsj.com/articles/navigation-app-joins-with-port-authority-to-help-ease-congestion-1490261400
91. Waze (n.d.), "Connected Citizens Program" Available at: https://s3-eu-west-1.amazonaws.com/waze-partner-assets/CCPCaseStudies.pdf
92. Automotive World (2017), "INRIX Selected by The U.S. Federal Highway Administration for National Traffic Data Set" Available at: http://www.automotiveworld.com/news-releases/inrix-selected-u-s-federal-highway-administration-national-traffic-data-set/
93. Refers to any trip the vehicle (car) makes.
94. 20% carpooling penetration extrapolated to the entire global population, accounting for regional travel habits in terms of trip propensity and vehicle modal shares. See Appendix for details on the methodology.
95. TechCrunch (2017), "Google Maps' redesigned ridesharing feature lets you hail an Uber without ever leaving the app" Available at: https://techcrunch.com/2017/01/12/google-maps-redesigned-ridesharing-feature-lets-you-hail-an-uber-without-ever-leaving-the-appp/
96. The Hans India (2017), "Centre Govt to utilise geospatial technology for Smart Cities" Available at: http://www.thehansindia.com/posts/index/Telangana/2017-01-24/Centre-Govt-to-utilise-geospatial-technology-for-Smart-Cities/275425

EXHIBIT 15:

CARPOOLING SERVICES ENABLED BY DIGITAL MAPS COULD POTENTIALLY REDUCE THE NUMBER OF CAR VEHICLE TRIPS ON ROADS BY UP TO 73 BILLION

REDUCTION IN DAILY CAR TRIPS (MILLION); 2016[1]



- Carpooling has reached 20% of shared mobility rides in many regions in the US and in Singapore.
- **If carpooling represented 20% of all private car trips in the world**, there would be a significant reduction in car trips all over the world[2].

1 Based on an assumption of 20% of total car trips shifting to carpooling.
2 Assuming current carpooling penetration is 0%; analysis based on average vehicle occupancy today in each region (versus average carpool occupancy)
Source: AlphaBeta Analysis

BOX 11.
DIGITAL MAPS FOR URBAN PLANNING IN JAPAN

Japan's ageing and shrinking population has led to a surge in urban revitalization projects in recent years. This has led the Japanese Fukuoka Prefecture to launch the "Urban Structure Visualization Project", which leverages the Google Maps Application Programming Interface (API) and Google Earth.

Traditionally, urban planning relies on national census data and commercial statistics. However, it is often impossible to bring piles of numbers in tables and spreadsheets to life, making it difficult for both government officials and citizens to understand the full impact of urban planning decisions.

The "Urban Structure Visualization Project" overcomes this challenge. Using Google Maps and Google Earth, planners can now combine traditional data on population, retail sales and transport with geographical maps to create a 3D display of their urban-planning ideas. The new visualization tool has allowed citizens and urban planners to better understand the changing urban structure and make more informed decisions on critical planning issues.

Kentaro Akahoshi, a section chief in the Fukuoka Prefecture's Architecture and Urban Design Department, praises the new technology: "After the website opened, we received comments from all parties that it was 'easy to understand' and 'easy to use'. We have also received inquiries from private companies. Initiatives to use this tool to revitalize housing complexes in the suburbs where the population continues to decrease have also started in coordination with the regional residents."[97] [98]

97. Information gathered from Google Maps for Work case study. See Google (2015), "Google Maps for Work" Available at: http://services.google.com/fh/files/blogs/geo-fukuoka-pref-2015-0928.pdf
98. Information gathered from the Urban Structure Visualization Project. See: National Research and Development Corporation Architectural Research Institute, "Difference in population between day and night" Available at: https://mieruka.city/

CIVIC ENGAGEMENT

Geospatial technology has also been widely applied to enhance civic engagement, for example to help citizens exercise their voting rights or gain access to basic services.

- **VOTING RIGHTS.**
  Digital Maps can help citizens exercise their voting rights by improving the delivery of ballot papers to residents or help them locate polling booths.

  1. In 2013, the Election Commission of India plotted polling booths on Google maps, and created a website for citizens to search and locate them in their constituencies. Voters were able to see the satellite image of the building and roads leading to them.[99]

  2. A survey in India found that 10% of residents in Kaula Bandar, Mumbai, said they had difficulties to cast their vote in at least one of the past four elections because election scripts could not be delivered to their houses.[100]

  3. In the 2016 US Presidential election, Google played an important role in promoting voter resources and improving turnout, helping users to find the polling place closest to them upon opening the app, both the day before and on election day.[101]

- **ACCESS TO SERVICES.**
  Gaining a trackable address can also allow people to gain bank accounts, electricity connections. Digital maps can also increase public infrastructure by helping identify shortcomings of drainage pipes, sewerage systems or garbage collection.

  1. When "Outline India", a local startup committed to "Social impact through data", set out to improve the quality of maps in rural India, it discovered that some villages were insufficiently equipped with basic infrastructure, such as drainage systems, piped water connections, toilets, and accessible healthcare. While these villages had always reported those specific problems, the lack of quality maps (now available thanks to GIS technology) used to prevent them from seeking funding from the government to rectify the problems.[102]

  2. The Grameen Foundation App-Lab "Community Knowledge Worker" (CKW) initiative used mobile technology to facilitate a two-way exchange of agricultural information with grassroots farmers in Uganda – often those off the power grid. Grameen Foundation utilized the increased use of mobile phones to establish demographic information and consumption patterns from those in extreme rural poverty. Using a range of Google Map services, Grameen Foundation was then able to map out and disseminate important information on crop disease outbreaks, impact

99. Technology for Today (2013), "Locate your Polling booth using Google Map: Election Commission of India" Available at: https://techupdate4today.wordpress.com/2013/10/23/locate-your-polling-booth-using-google-map-election-commission-of-india/
100. Dalberg Global Development Advisors and Confederation of Indian Industry (CII) (2015), "Smart Maps for Smart Cities: Urban India's $8 Billion+ Opportunity" Available at: http://www.dalberg.com/wp-content/uploads/2015/07/20150715_Google-Smart-Maps-Report_FINAL.pdf
101. Tech Crunch (2016), "Google Maps urges users to vote with its new polling place finder" Available at: https://techcrunch.com/2016/11/08/google-maps-urges-users-to-vote-with-its-new-polling-place-finder/
102. Outline India (2016), "A Third Person Perspective" Available at: http://blog.outlineindia.com/?p=568

of farmers using best practice disease control methods, and other data useful to farmers, scientists and policymakers.[103]

3. Also in India, the Urban Development Ministry recently launched an application, powered by geospatial technology, that allows citizens to lodge complaints related to local infrastructure services (lack of water supply or uncollected garbage). The app, which encourages citizens to upload photos of the affected area, allows government officials to pinpoint the exact location of the infrastructure issue, using geospatial technology.[104]

PUBLIC HEALTH

Geospatial services are frequently used to improve public health services.

- **RISK MAPPING.**

1. Maps were first used to fight epidemics as early as 1854 during a cholera outbreak in London.[105] Today, digital risk maps manage global health threats. The Global Health Group - a team of global experts affiliated with the University of California, San Francisco - has developed DiSARM (Disease and Risk Mapping), an analytical risk-mapping platform to help fight malaria. DiSARM uses the Google Earth Engine, a cloud computing platform for processing satellite imagery and other Earth observation data, to predict the infection risk in certain areas by connecting malaria statistics with information on moisture and other environmental data related to mosquito breeding. The database, which is supporting malaria control programs in 34 countries, helps decision-makers improve their policy response.[106]

2. Geospatial services are also supporting planning, delivery and tracking activities to eradicate polio. A team of geospatial-tech experts of "eHealth Africa" (eHA), an NGO, in partnership with the Gates Foundation, for example is using digital mapping software to collect demographic information and improve polio-immunization outcomes in Nigeria. During recent immunization campaigns, GPS-enabled mobile phones tracked the movement of health workers and helped identify missed settlements. Through eHA's work, 782 previously undocumented hamlet settlements were identified, allowing more settlements to be visited during future vaccination campaigns.[107]

3. Geospatial services enable efficient monitoring of environmental pollution through complementary solutions. Google partnered with the Environmental Defense Fund (EDF) in the US on a project called "Airview", which attached an environment sensing mechanism to Google's Street View fleet of vehicles. Airview's sensing mechanism measures greenhouse gas concentration in the air from the moving vehicle, taking a minimum of two trips in a particular location to capture good quality data. Presently, Airview-powered maps in 11 cities have helped to

103. Google Earth Outreach (n.d.), "Grameen Foundation AppLab" Available at: https://www.google.com/earth/outreach/success-stories/grameen-foundation-applab/
104. Hindustan Times (2016), "Govt launches Swachhata App for addressing civic issues" Available at: http://www.hindustantimes.com/india-news/govt-launches-swachhata-app-for-addressing-civic-issues/story-I4vLkKxexgZb4HsFHRHW9K.html
105. University of Delaware (2006), "Dr. John Snow's map of the 1854 London cholera outbreak" Available at: https://www1.udel.edu/johnmack/frec682/cholera/
106. University of California San Francisco (2014), "UCSF, Google Earth Engine Making Maps to Predict Malaria" Available at: https://www.ucsf.edu/news/2014/09/116906/ucsf-google-earth-engine-making-maps-predict-malaria
107. eHealth Africa (2017), "Polio Program" Available at: https://www.ehealthafrica.org/polio-program/

spot over 5,500 methane leaks in natural gas distribution pipelines.[108]

- **RESOURCE ALLOCATION.**
  A well-designed GIS database can have a substantial impact on the work of government agencies, as demonstrated by the Arizona Department of Health Services: charged with the task of setting health policies in its state, the department created a "Community Profiles Dashboards" to get an accurate picture of the population demographics across counties. These dashboards allow the agency to obtain detailed population data, for example on the rates of diabetes, heart disease, hypertension, and age. Officials also learn whether an observed area fares above or below the state average, allowing them to allocate resources more effectively to areas where support is most needed.[59]

- **SANITATION SERVICES.**
  The Indian government has started using digital maps to help citizens find public toilets, in an effort to improve hygiene conditions across the country.[109] The new service contains information, such as operating hours and addresses of public restrooms, and also provides a feedback mechanism to rate public toilets.

SAFETY AND EMERGENCY RESPONSE

Geospatial technology has proven to increase public safety. Governments rely on digital maps to improve the structure of emergency networks and make them more responsive. Modern mapping systems have also become a tool for citizens to indicate whether they are safe or in danger during natural disasters or terrorist attacks.

- **EMERGENCY RESPONSE.**
  Emergency services can use digital maps to arrive at a location sooner, potentially saving crucial minutes in attending patients, fires and crime victims.

1. In Lucknow City (India), the local police use a GIS system to obtain real-time information when alerted of an emergency.[48] For example, police cars are now fitted with GPS transponders that continuously transmit the location of the cars. The system automatically highlights the location of an emergency call on a digital map, selects the nearest vehicle and plots the most efficient route to the caller's location. All data is also saved in a database, allowing police to identify emergency hotspots and, drawing on the other socio-economic data on the surroundings, improve area patrols.

2. Research suggests that each 10% reduction in emergency response time lowers the likelihood of fatalities by around 7%.[110] In India, it is estimated that digital maps could reduce the response times of ambulances and fire brigades by 20%.[111] Geospatial technology can also shorten the time it takes people to alert emergency crews of an incident. In the US, for example, Waze has partnered with local governments to speed up traffic accident

108. Google (2017), "Mapping the invisible: Street View cars add air pollution sensors" Available at: https://environment.google/projects/airview/
109. The Hindu (2016), "Now, find your way to public toilets with Google Maps" Available at: http://www.thehindu.com/sci-tech/technology/Now-find-your-way-to-public-toilets-with-Google-Maps/article16926570.ece
110. Fire Brigade Union UK (2010), "It's about time: Why emergency response times matter to firefighters and the public" Available at: https://www.fbu.org.uk/publication/its-about-time-why-emergency-response-times-matter-firefighters-and-public
111. In India, it is estimated that ambulances could attend patients on average 3.5 minutes faster and firemen reach a fire on average 2 minutes faster when using geospatial services. See Dalberg Global Development Advisors and Confederation of Indian Industry (CII) (2015), "Smart Maps for Smart Cities: Urban India's $8 Billion+ Opportunity" Available at: http://www.dalberg.com/wp-content/uploads/2015/07/20150715_Google-Smart-Maps-Report_FINAL.pdf

alerts. The firm found that in more than half of the cases (62%) the Waze notification reached emergency services up to 4.5 minutes before a traditional 911-call.[112]

3. In New Zealand, a new system to track the origin of emergency call through GPS receivers built into mobile phones was implemented after discovering that 80% of such calls originate from these devices. Knowing the location where an emergency call is made could potentially reduce response time by crucial minutes.[113]

- **NETWORK DESIGN.**
  India's government is using geospatial technology to identify flaws in its existing fire service system and understand where taxpayer money is most wisely spent. For that purpose, it has created a new database, fed by geospatial data, covering fire stations, road infrastructure, administrative boundaries, demographic trends, and land use.[53]

- **SITUATIONAL AWARENESS.**
  Telecommunication companies (such as AT&T, Sprint, Verizon) are beginning to offer various geospatial services, including "Trusted Contacts" services or the location-sharing feature that allow users to share their location via GPS with selected contacts, even when their phone is not connected to the internet. Selected contacts can also ping a phone to check that user is safe. Other companies which offer similar services include Google, Glympse, and Life360.

DISASTER PREPARATION AND RESPONSE

Geospatial technologies can have a crucial role in saving lives when natural disaster strikes.

- **DISASTER PREVENTION.**
  GIS technologies can assist with disaster prevention. For example, ARUP, an engineering services group, recently led a consortium to define areas at risk of flooding along Poland's river San. GIS technology was employed to create a model of the zones that will most likely require a disaster response.[14]

- **DISASTER PREPARATION.**
  Digital maps support authorities to prepare for destructive storms and other natural disasters, ranging from providing evacuation information for residents to supplying critical disaster information to emergency services.

  1. In Japan, digital map providers, such as, Zenrin, display detailed information on the locations of evacuation centers, including the contact details of the crisis management divisions overseeing each area.[114]

  2. In Taiwan, Google has partnered with government agencies to supply critical disaster information during natural disasters (see Box 12).

- **DISASTER RESPONSE.**
  Geospatial services have helped improve disaster response around the world by showing residents evacuation routes or by allowing local "first responder" teams to reach an emergency area:

  1. In 2005, satellite imagery was used in the aftermath of Hurricane Katrina to identify the most heavily flooded areas. People could track

112. Genesis Pulse (2016), "Waze Partnership Helping to Reduce Response Times for Emergency Personnel" Available at: http://genesispulse.com/2016/08/16/waze-genesis-partnership/
113. Beehive (2017), "New caller location system for mobile 111 calls". Available at: https://www.beehive.govt.nz/release/new-caller-location-system-mobile-111-calls
114. Yonago City Hall (n.d.), "Disaster evacuation center map" Available at: http://www.city.yonago.lg.jp/6998.htm

physical damage to houses and infrastructure, but also leave markers on the map to provide local contextual information, for example on working transport routes and the health of loved ones.[115]

2. When a major earthquake and tsunami struck Japan in 2011, nearly sparking a nuclear catastrophe at its Fukushima power reactor, numerous geospatial companies granted emergency teams and government officials access to their mapping resources. The geospatial data included information on flooded coastal areas, on the status of the nuclear power plant, and on damage to public infrastructure.[116] In addition, automotive manufactures were providing access to the driving records of their customers to allow emergency teams to know which roads were passible.[117]

3. In 2012, after Hurricane Sandy struck the U.S. eastern seaboard, the Federal Emergency Management Administration partnered with geospatial services firm Waze to identify fuel shortages across the region.

4. When the New Zealand city of Christchurch was hit by a major earthquake in the same year, authorities quickly set up a geospatial map linked to social media. The map allowed residents to post location-based information ranging from news on infrastructure damage to alerts on people trapped under debris.[118] Nepal replicated the system in 2015 when it suffered an equally devastating earthquake.[119]

5. Pakistan benefited from Google's geospatial technology in 2012, when heavy monsoon rains flooded swathes of the country. Processing large quantities of current and historical satellite imagery, Google Earth Engine played a crucial role in helping authorities quickly analyze the severity of situation and develop a crisis-management plan.[120]

6. In 2016, when snow from a severe winter storm blanketed large parts of the United States East Coast, Google crisis maps also ensured that information on local weather conditions, shelters and evacuation routes was readily available.[121]

115. Forbes (2005), "Google Is Everywhere" Available at: https://www.forbes.com/2005/09/02/hurricane-google-map-rescue-cx_de_0902google.html
116. Earth Imaging Journal (2011), "Disaster Response in JAPAN" Available at: http://eijournal.com/print/articles/disaster-response-in-japan-2
117. Honda (2015), "To be widely known and used, traffic results information at the time of the Great East Japan Earthquake" Available at http://www.honda.co.jp/safety/hearts/feature/2015/10/page3.html#saigai-link
118. The Sydney Morning Herald (2011), "Web acts as virtual crisis centre for Christchurch quake victims" Available at: http://www.smh.com.au/technology/technology-news/web-acts-as-virtual-crisis-centre-for-christchurch-quake-victims-20110222-1b4iq
119. GIS Lounge (2015), "How Crowdsourced Mapping is Supporting Relief Efforts in Nepal" Available at: https://www.gislounge.com/how-crowdsourced-mapping-is-supporting-relief-efforts-in-nepal/
120. Earthenable (2015), "Processing Terabytes of Satellite Imagery in Google Earth Engine: Crisis Response for 2015 Flood Season in Pakistan" Available at: https://earthenable.wordpress.com/2015/09/01/processing-terabytes-of-satellite-imagery-in-google-earth-engine-crisis-response-for-2015-flood-season-in-pakistan/
121. The Next Web (2016), "Google.org's crisis map will tell you everything you need to know about winter storm Jonas" Available at: https://thenextweb.com/google/2016/01/23/google-orgs-crisis-map-will-tell-you-everything-you-need-to-know-about-winter-storm-jonas/#.tnw_nIaU3wWV

BOX 12.
DISASTER PREPARATION IN TAIWAN

Taipei has been identified as the city with the highest risk globally of being hit by natural disasters, from windstorms to earthquakes.[122] Around 360 typhoons have struck Taiwan over the past 100 years alone.[123] To help rescue teams and others swiftly access critical disaster information, Google.org is partnering with government agencies in Taiwan (Central Weather Bureau, Water Resource Agency, Soil and Water Conservation Bureau, the Directorate General of Highways and the Natural Science and Technology Center for Disaster Reduction) to compile essential environmental data and circulate them via Google's platforms (Google Now, Google Maps and Google Search). Services such as Google Public Alerts and Google Crisis Map now send out timely alerts on Google Now, Android and iOS devices about approaching typhoons or possible earthquakes. They also list other critical information, such as evacuation routes and shelter locations.[124] The result: information can spread rapidly, allowing for speedy crisis coordination and evacuation.[125] [126]

122. The Actuary (2015), "Taipei at highest risk from major disasters" Available at: http://www.theactuary.com/news/2015/09/taipei-at-highest-risk-from-major-disasters/
123. Central Weather Bureau (n.d.), "Typhoon's impact on Taiwan" Available at: http://www.cwb.gov.tw/V7e/knowledge/encyclopedia/ty014.htm
124. ICTDEV.org (2013), "Public alerts for natural disasters now available in Taiwan" Available at: http://www.ictdev.org/pulse/20130710/crisis-response/public-alerts-natural-disasters-now-available-taiwan
125. Information obtained from Google and National Science and Technology Center for Diaster Reduction (n.d.), "Google & CAP in Taiwan: Progress and Learnings" Available at: http://ncdr.nat.gov.tw/Files/Game/Google%E8%87%BA%E7%81%A3%E7%81%BD%E5%AE%B3%E6%87%89%E8%AE%8A%E8%B3%87%E8%A8%8A%E5%B9%B3%E5%8F%B0.pdf and
126. Information obtained from Google (2017), "Google Crisis Map for Taiwan" Available at: http://www.google.org/crisismap/taiwan?hl=zh-TW

ENVIRONMENT AND WILDLIFE PRESERVATION

Geospatial services play a critical role in preserving the environment and wildlife.

- **WILDLIFE MONITORING.**
  Some commercial applications of geospatial technologies, such as Geofencing and GPS for marine vessels, can also be used for wildlife monitoring:

  1. In Kenya, GSM elephant collars allow local animal reserve staff and farmers to safely monitor and redirect elephants which stray outside the wildlife zones.[127]

  2. In Indonesia, the "Global Fishing Watch", an alliance of SkyTruth, Oceana and Google Earth Outreach, is collaborating with the Ministry of Marine Affairs and Fisheries to better manage Indonesia's fish populations. It uses GPS-equipped vessels, big data analysis, machine learning, cloud computing and visualization techniques to spot illegal fishing activities (See Box 13).

- **STAKEHOLDER AWARENESS & ENGAGEMENT.**
  Geospatial data can also raise awareness about global issues like deforestation and enable change. The Google initiative Earth outreach team helps community groups and others harness the power of digital maps to highlight social and environmental issues.[128]

  1. The Global Forest Change Explorer website contains maps that are available for interactive analysis, enabling students to quickly visualize the loss of forests, compare deforestation trends in different countries and ecoregions, and identify the potential reasons for significant changes in forest density.[129] The program is also supporting efforts to reduce emissions from deforestation and forest degradation.[130]

  2. Not-for-profit organization "The Keystone Foundation" specializes in protecting access to water and biodiversity in the Nilgiris, a region in the Indian state of Tamil Nadu. Its environmental protection efforts are supported by maps using satellite images, mobile GPS data, and other information, including about water resources, land use, biodiversity, and the movements and interactions of humans and wildlife.[53]

127. Save the Elephants (2017), "Geo-Fencing" Available at: http://www.savetheelephants.org/project/geo-fencing/
128. Google Earth Outreach (2017), "Google Earth Outreach empowers you to create positive change for people and the planet with Geo tools" Available at: https://www.google.com/earth/outreach/index.html
129. Google (2016), "Bring the world's changing forests inside the classroom" Available at: https://blog.google/products/earth/bring-worlds-changing-forests-inside/
130. Forest Trends (2016), "Good News for Forests: REDD+ Money Going to the Right Places" Available at: http://forest-trends.org/blog/2016/08/18/redd-money-going-to-the-right-places/

BOX 13.
GLOBAL FISHING WATCH

The global economic losses in marine fisheries resulting from poor management, inefficiencies, and overfishing add up to US$50 billion per year. It is estimated that sustainable fisheries approaches are estimated to yield an annual economic benefit of US$51 billion.[131] But the tide may be turning in Indonesia where "Global Fishing Watch", a partnership between SkyTruth, Oceana and Google Earth Outreach, is collaborating with the Indonesian Ministry of Marine Affairs and Fisheries to protect the country's waters from overfishing.

The alliance has developed an interactive web tool based on satellite data received by GPS systems on fishing vessels. It also uses big data analysis, machine learning, cloud computing and visualization techniques to help citizens, governments, and the industry's businesses and fishermen track potentially illegal fishing activity.[132]

Illegal, unreported and unregulated fishing is a shadow sector of the global economy generating an estimated revenue of up to US$23.5 billion each year.[133] Curbing illegal fishing activity is likely to improve the health of Indonesian fish stocks and protect the livelihoods of local fishermen. Global Fishing Watch can play a significant part in this struggle.

131. Environmental Defense Fund and Bren School of Environmental Science and Management (2015), "Unlocking the potential of global fisheries" Available at: https://www.edf.org/oceans/report-unlocking-potential-global-fisheries

132. The Ministry of Marine Affairs and Fisheries of the Republic of Indonesia and Global Fishing Watch (2015), "Indonesia & Global Fishing Watch Announce Collaboration to Make Nation's Commercial Fishing Data More Transparent" Available at: http://kkp.go.id/assets/uploads/2015/11/PRESS-RELEASE-Indonesia-Global-Fishing-Watch-Announce-Collaboration-to-Make-Nation%E2%80%99s-Commercial-Fishing-Data-More-Transparent.pdf

133. Global Ocean Commission (2014), "From Decline to Recovery: A Rescue Package for the Global Ocean" Available at: https://www.mpaaction.org/sites/default/files/Global%20Ocean%20Commission_2014_From%20Decline%20to%20Recovery.pdf

KNOWLEDGE CREATION AND HUMAN CAPITAL DEVELOPMENT

Research indicates that the use of digital maps and satellite images in both high schools and universities helps improve spatial thinking and geographic knowledge of students.[134] However, the benefits of geospatial education for society can be felt beyond classrooms: today, training programs teach digital mapping skills to adults in various roles, from data journalists to research scientists and workers in the nonprofit sector.

- **STUDENT LEARNING.**
  Programs such as "Google Expeditions" help teachers make classroom learning a more memorable experience by allowing students worldwide to go on a virtual-reality trip to hundreds of travel destinations—from the Great Barrier Reef in Australia to the Grand Canyon in the United States. Since its launch in 2015, more than 1 million students across 11 countries have taken part in such a Google Expedition, enhancing their learning experience.

- **INDUSTRY-ACADEMIA COLLABORATION.**
  Open access teaching and research infrastructure can provide platforms for joint projects. Collaboration with academia on high-potential satellite observation products that are not yet commercialized can create a well-funded and focused innovation ecosystem. Companies such as OSGeo have reached out to universities in this vein through their "Geo for All" initiative, which has set up 114 global labs for open geospatial education.[135]

- **GENERAL WORKFORCE UPSKILLING.**
  A dedicated team of Google specialists teaches not-for-profit workers, research scientists, academics, and government officials how to make best use of digital mapping tools and other geospatial technology.

- **ENHANCING QUALITY OF TRAINING.**
  Experts in the geospatial industry can help significantly strengthen existing teaching material in geospatial courses to develop industry-ready graduates. A recent AlphaBeta report on the competitiveness of digital sectors across the Asia Pacific found that the "lack of talent" is one of the biggest concerns among the region's entrepreneurs and investors in the digital economy.[136]

134. Oxera (2013), "What is the Economic Impact of Geo Services?" Available at: http://www.oxera.com/Latest-Thinking/Publications/Reports/2013/What-is-the-economic-impact-of-Geo-services.aspx
135. AlphaBeta (2017), "Digital Nation: Policy Levers for Investment and Growth" Available at: http://www.alphabeta.com/digital-nation-policy-levers-investment-growth/
136. Geospatial World (2017), "Wanted: A sustainable, collaborative academia-industry engagement model for geospatial community" Available at: https://www.geospatialworld.net/blogs/geospatial-academia-industry-collaboration/

CONCLUSIONS

This report demonstrates that geospatial services create significant value for consumers, businesses, and societies all over the world.

Modern mapping services make traveling and shopping less time-consuming. They enliven classroom learning and help people save fuel and feel safer. Together, the global consumer benefits of geospatial services are estimated to amount to more than US$550 billion annually.

Businesses selling geospatial products and services are estimated to generate a combined revenue of US$400 billion per year. However, the indirect benefits of geospatial technology to businesses are assumed to be even larger. A substantial number of companies use geospatial technology to improve their public customer profile, find optimal store locations and ultimately increase sales. This indirect sales boost is likely worth more than US$1 trillion annually. It is enjoyed by companies operating in sectors estimated to generate approximately 75% of the world's GDP.

Geospatial services create a significant number of jobs worldwide. The industry employs more than 4 million people directly, including software programmers, app developers, GIS technicians, geographical surveyors, and satellite engineers. It is estimated to support at least another 8 million non-technical jobs—in areas such as human resources and marketing, as well as in secondary industries that indirectly depend on geospatial services.

In addition, online maps have also begun to encourage people to use shared mobility solutions such as ridesharing and carpooling services, buses and trains instead of cars, which have the potential to take billions of cars off roads around the world and save tons of climate-damaging emissions. This report estimates that the potential traffic improvements from wider use of geospatial services could lower global carbon emissions by 5% per year. Geospatial services have also proven to reduce the emergency response time of police, ambulances and firefighters, allowing them to reach patients, fires or crime scenes minutes faster. However, the positive impact from geospatial services is found to be greater in some parts of the world compared to others.

- **USE OF GEOSPATIAL SERVICES:**
  In some countries, almost everyone with access to the internet uses geospatial services. In other countries, however, their use remains more limited. In Taiwan, as much as 99% of the online population uses digital maps, compared to 82% in Saudi Arabia. The disparity becomes more obvious when relating the use of digital map to a country's total population. In this case, only 34.5% of India's citizens use digital maps, compared to 90.5% of citizens in the United Arab Emirates.

- **EMPLOYMENT OPPORTUNITIES:**
  While geospatial jobs create direct and indirect job opportunities around the world, there are substantial differences in how much different countries benefit from them. For example, geospatial jobs constitute 1% of the total workforce in Russia and 0.5% in Germany.

- **SALES GROWTH:**
  In some countries, digital maps are found to boost business sales more strongly than in others. For example, consumers in the United States on average spend 2% of their annual income to purchase goods or services with the help of digital maps. The same figure is 7% in the United Arab Emirates.

- **INNOVATIVE BUSINESS MODELS:**
  As the mobile economy becomes a larger part of global economic output, it is interesting to note regional differences in penetration of geospatial technology among the top listed mobile applications. For instance, geospatial technology powers or enables 15% of the top 100 applications in Europe, versus 9% in the emerging Middle East; the former, more mature app market generates approximately US$1.5 billion more than the latter, emerging one.

These large variations show that there is still scope to make better use of geospatial services in some countries to maximize the technology's benefits for consumers, businesses, and society at large. While quantifying the size of these opportunities is beyond the scope of this paper, it is important to offer some reflections on what

various stakeholder groups could do to make the most of them.

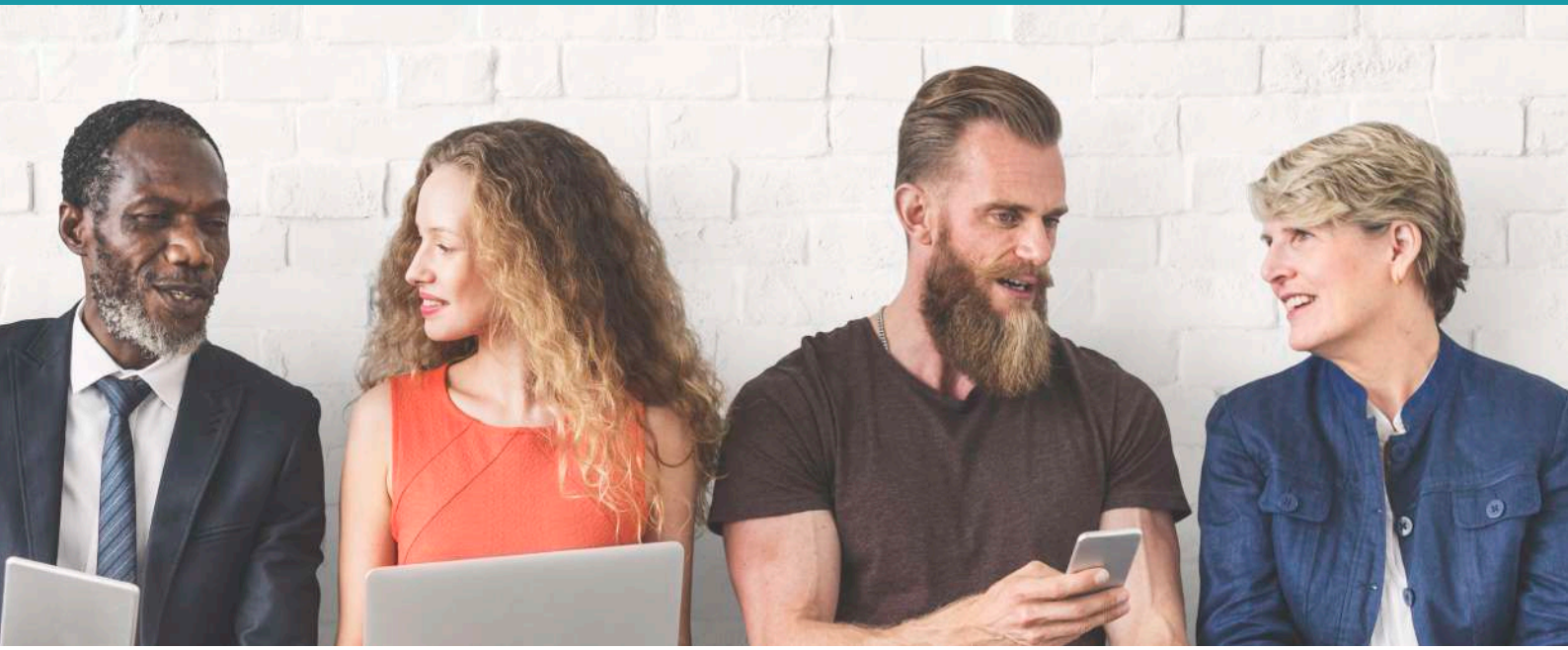
- **Academia, public agencies and civil society organizations** could increase the use of geospatial technology to improve the efficiency of their research and achieve a greater impact on the communities. For example, a research partnership between the University of Texas at Austin (UT Austin), environmental intelligence firm Aclima, Google Earth Outreach, and the Environmental Defense Fund led to improved ways of measuring air pollution in cities. The researchers used geospatial technology for their joint study to measure and map how air pollution varies between city blocks, something that had been impossible to measure with previous technology.[137] Geospatial data has also been used to track and prevent disease outbreaks, providing important first response information to emergency services. For example, University of California San Francisco has used Google Earth Engine, to predict the infection risk in certain areas by connecting malaria statistics with information on moisture and other environmental data related to mosquito breeding.[138]

- **Businesses** could increase their investment in and use of geospatial services to enhance the value and productivity of their business, attract new customers and boost sales. A range of studies provide evidence for the positive return of investment in geospatial services. In some cases, the net benefits of geospatial services have proven to exceed investment costs by more than 10 times.[139]

- **Governments** can enable promotion, adoption and implementation of emerging applications of geospatial technology and data, by doing at least three things:

  1. Support policies that enable the development, sharing, and use of geospatial data in order to help ensure data availability, accessibility and quality. This could include updating legislation to support the collection, storage and visualization of geospatial data and user-generated content. Policies should also promote the broader use of geospatial technology in business, academic and non-profit applications. Events such as the Geospatial World Forum offer a unique

137. Global News Wire (2017), "Google, Aclima, Environmental Defense Fund, and UT Austin Announce Results of Breakthrough Study Mapping Hyperlocal Air Quality" Available at: https://globenewswire.com/news-release/2017/06/05/1008205/0/en/Google-Aclima-Environmental-Defense-Fund-and-UT-Austin-Announce-Results-of-Breakthrough-Study-Mapping-Hyperlocal-Air-Quality.html
138. University of California San Francisco (2014), "UCSF, Google Earth Engine Making Maps to Predict Malaria" Available at: https://www.ucsf.edu/news/2014/09/116906/ucsf-google-earth-engine-making-maps-predict-malaria
139. See, for example, ESRI (2013), "Return on Investment. Ten GIS case studies" Available at: http://www.esri.com/library/ebooks/return-on-investment.pdf



opportunity for government and industry leaders to discuss how to design policies that make better use of geospatial technology to tackle economic and social issues.[140]

2. Encourage development of the industry by leveraging existing geospatial technology and exploring emerging applications of geospatial data. Support agencies that can use this data in innovative and effective ways through urban planning, education, health and emergency services, disaster management and environmental protection. Governments have the opportunity to modernize the technical infrastructure to enable geospatial services and support private sector collaboration; for instance:

    - In 2010 the government of the United Arab Emirates (UAE) made the geospatial industry one of the pillars of its future, establishing Spatial Data Infrastructure (SDI) initiative. SDI standardizes and brings together all local geospatial players under one umbrella, allowing the country to coordinate and scale its efforts in the industry.[141]

    - The European Space Agency also set a good example for encouraging private-sector uptake of geospatial technology, by establishing incubators that provide technical support to geospatial startups.[142]

3. Enable access to geospatial data that can be used by both the public and private sectors, with open source licensing. The Australian government, for instance, has launched a Locational Information Knowledge (theLINK) platform under the Foundation Spatial Data Framework to consolidate Australia's "common asset" of geospatial information. Datasets on theLINK are grouped by ten themes, including administrative boundaries, land cover and land use, and positioning data. National data is compiled using jurisdictional information.[143] Increasing the number of sources of such data can improve end-user's trust and accuracy in use of the information, spurring innovation within and beyond the geospatial industry.[144]

140. Geospatial World Forum (2017), Accessible at http://geospatialworldforum.org/
141. Geospatial World (2010), "The UAE Spatial Data Infrastructure: Initiatives and issues" Available at: https://www.geospatialworld.net/article/the-uae-spatial-data-infrastructure-initiatives-and-issues/
142. European Space Agency (2017), "European Space Agency Incubation Centres" Available at: http://www.esa.int/Our_Activities/Space_Engineering_Technology/Business_Incubation/ESA_Business_Incubation_Centres12
143. ANZLIC (2017), "FSDF: Location Information Knowledge Platform" Available at: http://link.fsdf.org.au/
144. ANZLIC (2015), "Foundation Spatial Data Framework" Available at: http://www.anzlic.gov.au/foundation-spatial-data-framework

APPENDIX A: REGION-SPECIFIC BENEFITS

GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES IN ASIA PACIFIC DURING 2016[1]:

CONSUMER BENEFITS

Users value digital maps at up to
US$89 PER USER
resulting in total benefits of
US$166 BILLION PER YEAR.

Digital maps reduce travel time by
6% ON AVERAGE.
The value of time saved is
US$60 BILLION
based on local wage rates.

Users save more than
11 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$188 BILLION.
based on local wage rates.

BUSINESS BENEFITS

Geospatial industry generated revenue of approximately
US$73 BILLION IN 2016.

UP TO US$554 BILLION
of sales are linked to digital maps.

51% OF USERS
declared that without consulting digital maps, they would not have made the purchase.

SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
1,686 MILLION MT
from digital maps, through more efficient trips and reduced congestions.

Potential employment directly and indirectly linked to digital maps of
6 MILLION JOBS.

Carpooling services (enabled by digital maps) could reduce the number of car trips by
28 MILLION
If all nations match San Francisco penetration.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES IN LATIN AMERICA DURING 2016[1]:

CONSUMER BENEFITS

Users value digital maps at up to
US$114 PER USER
resulting in total benefits of
US$42 BILLION PER YEAR.

Digital maps reduce travel time by
9% ON AVERAGE.
The value of time saved is
US$31 BILLION
based on local wage rates.

Users save more than
4 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$21 BILLION.
based on local wage rates.

BUSINESS BENEFITS

Geospatial industry generated revenue of approximately
US$18 BILLION IN 2016.

UP TO US$100 BILLION
of sales are linked to digital maps.

54% OF USERS
declared that without consulting digital maps, they would not have made the purchase.

SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
301 MILLION MT
from digital maps, through more efficient trips and reduced congestions.

Potential employment directly and indirectly linked to digital maps of
36,000 JOBS.

Carpooling services (enabled by digital maps) could reduce the number of car trips by
2 BILLION
If all nations match San Francisco penetration.

1. *Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.*

GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES IN EUROPE DURING 2016[1]:

CONSUMER BENEFITS

Users value digital maps at up to
US$127 PER USER
resulting in total benefits of
US$72 BILLION PER YEAR.

Digital maps reduce travel time by
10% ON AVERAGE.
The value of time saved is
US$87 BILLION
based on local wage rates.

Users save more than
3 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$39 BILLION.
based on local wage rates.

BUSINESS BENEFITS

Geospatial industry generated revenue of approximately
US$131 BILLION IN 2016.

UP TO US$130 BILLION
of sales are linked to digital maps.

48% OF USERS
declared that without consulting digital maps, they would not have made the purchase.

SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
227 MILLION MT
from digital maps, through more efficient trips and reduced congestions.

Potential employment directly and indirectly linked to digital maps of
900,000 JOBS.

Carpooling services (enabled by digital maps) could reduce the number of car trips by
17 BILLION
If all nations match San Francisco penetration.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES IN MIDDLE EAST DURING 2016[1]:

CONSUMER BENEFITS

Users value digital maps at up to
US$85 PER USER
resulting in total benefits of
US$12 BILLION PER YEAR.

Digital maps reduce travel time by
12% ON AVERAGE.
The value of time saved is
US$17 BILLION
based on local wage rates.

Users save more than
1 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$8 BILLION.
based on local wage rates.

BUSINESS BENEFITS

Geospatial industry generated revenue of approximately
US$9 BILLION IN 2016.

UP TO US$37 BILLION
of sales are linked to digital maps.

44% OF USERS
declared that without consulting digital maps, they would not have made the purchase.

SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
127 MILLION MT
from digital maps, through more efficient trips and reduced congestions.

Potential employment directly and indirectly linked to digital maps of
20,000 JOBS.

Carpooling services (enabled by digital maps) could reduce the number of car trips by
2.5 BILLION
If all nations match San Francisco penetration.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES IN AFRICA DURING 2016[1]:

CONSUMER BENEFITS

Users value digital maps at up to
US$36 PER USER
resulting in total benefits of
US$12 BILLION PER YEAR.

Digital maps reduce travel time by
8% ON AVERAGE.
The value of time saved is
US$1.7 BILLION
based on local wage rates.

Users save more than
2 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$1.2 BILLION.
based on local wage rates.

BUSINESS BENEFITS

Geospatial industry generated revenue of approximately
US$11 BILLION IN 2016.

UP TO US$31 BILLION
of sales are linked to digital maps.

53% OF USERS
declared that without consulting digital maps, they would not have made the purchase.

SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
138 MILLION MT
from digital maps, through more efficient trips and reduced congestions.

Potential employment directly and indirectly linked to digital maps of
70,000 JOBS.

Carpooling services (enabled by digital maps) could reduce the number of car trips by
2 BILLION
If all nations match San Francisco penetration.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.

GLOBAL ECONOMIC IMPACT OF GEOSPATIAL SERVICES IN NORTH AMERICA DURING 2016[1]:

CONSUMER BENEFITS

Users value digital maps at up to
US$155 PER USER
resulting in total benefits of
US$43 BILLION PER YEAR.

Digital maps reduce travel time by
11% ON AVERAGE.
The value of time saved is
US$67 BILLION
based on local wage rates.

Users save more than
1 BILLION HOURS
per year from more efficient purchasing descisions.
The value of time saved is
US$26 BILLION.
based on local wage rates.

BUSINESS BENEFITS

Geospatial industry generated revenue of approximately
US$160 BILLION IN 2016.

UP TO US$188 BILLION
of sales are linked to digital maps.

59% OF USERS
declared that without consulting digital maps, they would not have made the purchase.

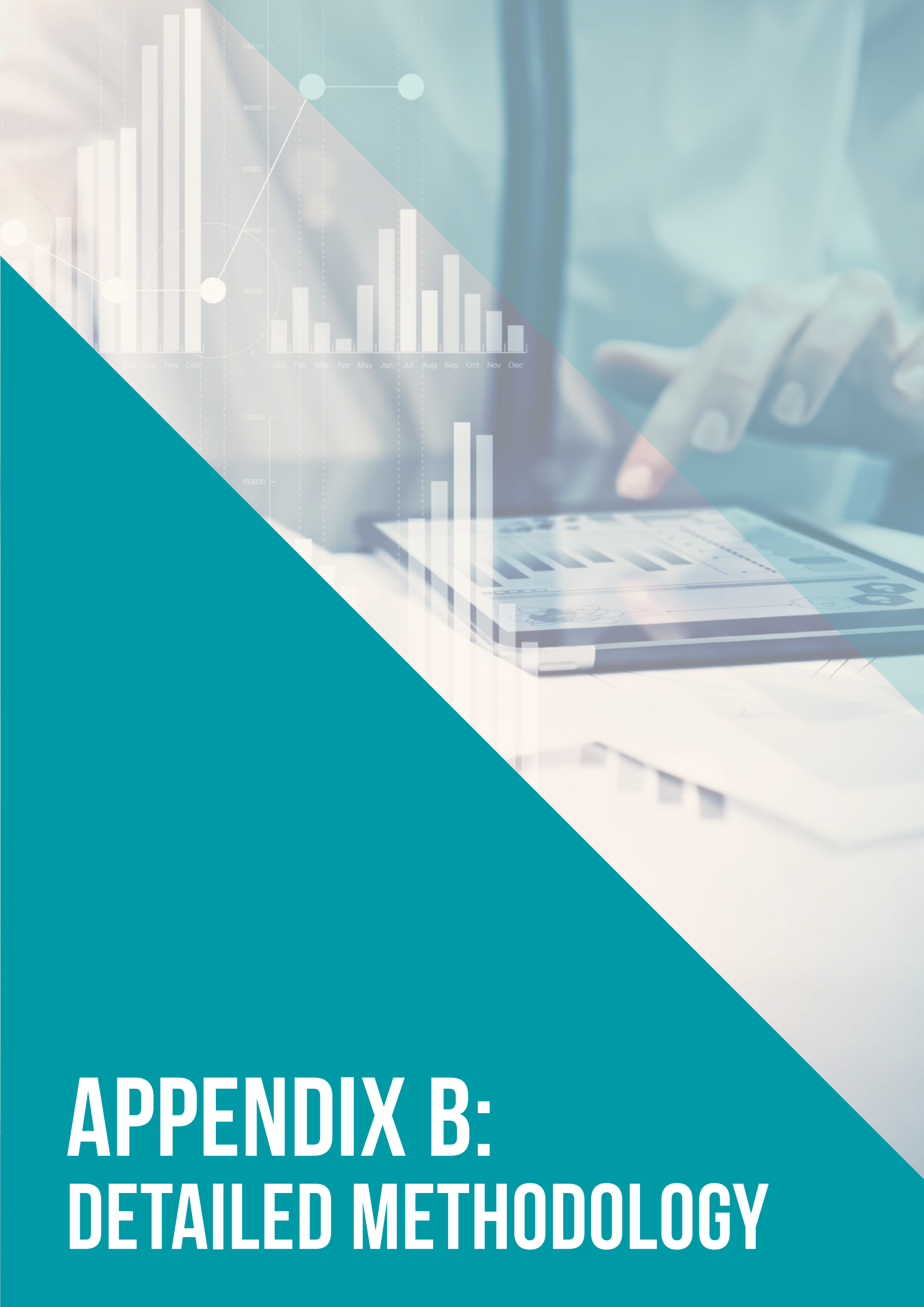
SOCIETAL BENEFITS

CO^2 emissions from vehicles could be reduced by
135 MILLION MT
from digital maps, through more efficient trips and reduced congestions.

Potential employment directly and indirectly linked to digital maps of
800,000 JOBS.

Carpooling services (enabled by digital maps) could reduce the number of car trips by
21 BILLION
If all nations match San Francisco penetration.

1. Data in exhibit is estimated by AlphaBeta using a rangge of original and third party sources. See Appendix for detailed methodology.



APPENDIX B: DETAILED METHODOLOGY

This report attempts to assess the true global economic value of geospatial services in 2016 by measuring both their direct and indirect benefits for consumers, businesses and society at large. Unlike traditional concepts to determine an industry's value–which tend to focus solely on immediately measurable data, such as revenue figures or employment numbers–this report pursues a more holistic approach: it uses several alternative analytical tools, including a large qualitative survey, to capture the total economic benefits of digital maps.

The analysis draws on a range of proprietary consumer data, third-party estimates, and AlphaBeta's algorithms related to commuting and jobs data. The countries included in the consumer survey are, by region:

- **NORTH AMERICA:** United States
- **LATIN AMERICA:** Brazil, Mexico
- **EUROPE:** Germany, Italy, Russia, Spain, United Kingdom
- **AFRICA:** Nigeria, South Africa
- **ASIA PACIFIC:** Australia, India, Indonesia, Japan, New Zealand, Singapore, South Korea, Taiwan, Thailand

The survey draws on a statistically significant sample size of over 400 participants per country to provide estimates with a 95% probability of being no more than 5% away from the true value. Country-specific responses were aggregated and adjusted for the size of national online populations to produce regional and global estimates. The consumer survey was supported by further analysis using AlphaBeta algorithms to estimate the impact of geospatial services on commuting behavior and employment.

Also, local wage data was used in conjunction with the survey to assess business benefits and a big data approach (i.e., a traffic crawler) was used to examine the wider impact of geospatial services on public health and the environment.

It is important to bear in mind that the resulting figures represent the gross benefits of geospatial services, which means some of the figures overlap with each other (for example, consumers' "willingness to pay" may take into account fuel and time savings). In addition, some of these gross benefits are quantifiable, while others can only be described in qualitative terms. All results have been converted into US dollars based on average local exchange rates for 2016.[145]

145. Exchange rates are sourced from www.x-rates.com

METHODOLOGY AND DATA: CONSUMER BENEFITS

The consumer benefits are calculated using both a "top-down" and a "bottom-up" approach. The analysis from the top down uses the extensive survey data to calculate the consumer surplus, an economic concept to measure what consumers are willing to pay for an activity or service. Meanwhile, the "bottom-up" approach focuses on calculating the time and fuel savings that occur when consumers use digital maps.

CONSUMER SURPLUS

The consumer surplus is usually calculated by observing how customers respond to price changes. For example, a rapid fall in demand for a good or service in response to a higher price may signal that consumers are not willing to pay more for the benefit they get from this product. Economists can use this consumer reaction to make conclusions about the value of this product.

However, measuring the consumer surplus of geospatial services is more challenging because individuals typically don't pay for services such as Google Maps or Waze. In the absence of price indicators, a "willingness-to-pay" approach can be used to estimate how much value consumers attach to geospatial services. Consumers would then indicate themselves how much they would pay for a good or service.

This report uses an even more robust concept to estimate the value consumers attach to digital maps. As part of the consumer survey, internet users could choose between two options to receive a monthly cash discount on their internet or mobile phone bill. Survey participants could decide to (a) permanently forgo their preferred digital maps service; or (b) permanently forgo all digital maps services.

Rather than testing a consumer's willingness to pay, this approach elicits a willingness to accept, which research has found to be less prone to biases.[146] To help survey participants attach a specific value to the digital maps on their devices, they could pick a dollar figure from a "discount menu" or come up with their own amount.

The resulting consumer surplus figures for each of the 22 countries surveyed were then extrapolated to other countries across the six regions. The data was adjusted for differences in the size of national online populations and local wage levels.

MORE EFFICIENT PURCHASING DECISIONS

Data from the consumer survey were also used to calculate how much time consumers save when using digital maps in relation to shopping. During the survey, internet users were asked to estimate how much faster they think they can complete their shopping when a digital map provides them with core business information, such as a store's address and opening hours. The responses were translated from minutes into dollars with the help of local wage levels and the share of the working population in each country. Results for sample countries were then extrapolated to other countries across the six regions, adjusted for national differences in wages and the size of the online population.

MORE EFFICIENT COMMUTING

A combination of commuter surveys and a "traffic crawler" as used to calculate how much time people save when using geospatial services to navigate traffic.[147] The surveys provided insights into the traveling habits of internet users in a country. They included data on how frequently people use digital maps when traveling. Data was further broken down into trip purpose (work commute, personal travel, etc.) and mode (car, bus, bicycle, etc.).

A traffic crawler, designed by AlphaBeta, was then used

146. Yang et al. (2013) Framing Influences Willingness to Pay but Not Willingness to Accept, Journal of Marketing Research.
147. "Traffic Crawler" refers to a web algorithm which simulates thousands of trips within a fixed location for a range of times, distances, semi-randomized locations, etc.

to simulate thousands of trips and their duration, relative to the mode of transport, in each of the 22 countries' two largest cities. The traffic crawler used the application program interfaces of Google Maps to identify major residential, recreational, and commercial city locations in the 22 countries. Trips were simulated for varying times of the day to capture peak and off-peak traffic. Time savings were estimated as the difference between the fastest route identified and the average travel time across all available routes. Data on wages and the size of the workforce in each country were used to translate the resulting figures into monetary values and, in a last step, extrapolated to other countries across the six regions. The results were adjusted for national differences in wages and the size of the online population.

CO^2 EMISSIONS & FUEL COST SAVINGS

A shorter travel time has a knock-on benefit for consumers and the environment, as it reduces petrol consumption and the harmful climate gases related to burning fossil fuels.

- **CO^2 EMISSIONS:** To estimate how much pollution is avoided when people get to their destination faster, it was first calculated how many kilometers can be saved through more efficient commuting. The kilometer figure was then converted into CO^2 savings based on the average emissions output of a 2017 Toyota Corolla (which was used as a car proxy, given its wide use around the world).[148]

- **FUEL COSTS:** To estimate how much money an average commuter saves at the petrol pump when using a faster route to get to a destination, the kilometers saved through more efficient travel are converted into fuel savings. This calculation was based on the fuel efficiency of a 2017 Toyota Corolla, with savings measured in dollars per liter (considering local fuel prices).

The results for each of the 22 countries were then extrapolated to other countries across the six regions, relative to the size of their online population. The benefits per person were further adjusted for national differences in travel habits and petrol prices.

More efficient travel entails further benefits for society at large, for example, by reducing traffic congestion and improving air quality. These benefits are explained in greater detail later in the Appendix in the section on societal benefits.

CARPOOLING SAVINGS

Geospatial services can encourage commuters to use alternative and more environmentally-friendly means of transport. The potential benefits of carpooling were calculated for a scenario in which the share of motorists using carpooling rises from zero to a mature penetration rate of 20%. Benefits were calculated relative to the size, trip propensity, and vehicle modal share of a country's population.[149] The result mirrors the number of car trips that would occur less, as carpooling becomes more popular.

TRIP SAVINGS FROM SWITCHING TO PUBLIC TRANSIT

The commuter surveys were used to estimate the benefits of switching from private to public transport. They provided insights into how often digital map users would switch modes of transport because of improved navigation. Results were combined with data from the AlphaBeta traffic crawler to estimate average benefits per person. Table 1 provides further details on the metrics and sources used in estimating the consumer benefits linked to geospatial services.

148. Toyota Corolla Altis specification sheet, Toyota. Accessible at http://www.toyotasingapore.com.sg/showroom/corolla-altis/
149. A modal share (also called mode split, mode-share, or modal split) is the percentage of travellers using a particular type of transportation or number of trips using said type.

TABLE 1: INPUTS AND SOURCES FOR CALCULATING CONSUMER BENEFITS OF GEOSPATIAL SERVICES

ESTIMATION	METRIC	SOURCE
Consumer benefit realized through "willingness to accept"	Discount required on monthly phone plan to forgo access to any digital map provider	AlphaBeta Consumer Survey
Value of time saved through digital map searches for business information	Number of digital-map users	AlphaBeta Consumer Survey
	Percentage of adult working population	• OECD • Trading Economics
	Average time saved per search	AlphaBeta Consumer Survey
Value of time saved through more efficient driving	Share of adult working population	• OECD • Trading Economics
	Percentage of people using digital maps for driving	AlphaBeta Consumer Survey
	Average number of digital-map-assisted drives per year and person	AlphaBeta Consumer Survey
	Average amount of time saved per year, per person	AlphaBeta traffic crawler
Value of time saved through more efficient public transit	Percentage of adult working population	• OECD • Trading Economics
	Percentage of people using digital maps for public transit	AlphaBeta Consumer Survey
	Average number of digital-map-assisted public transit trips per year and person	AlphaBeta Consumer Survey
	Average amount of travel time saved per year and person	AlphaBeta traffic crawler
Value of time saved through more efficient walking	Percentage of adult working population	• OECD • Trading Economics
	Percentage of people using digital maps for public transit	AlphaBeta Consumer Survey
	Average number of digital-map-assisted public transit trips per year and person	AlphaBeta Consumer Survey
	Average amount of travel time saved per year and person	AlphaBeta traffic crawler
CO^2 emission savings	Percentage of people using digital maps for driving	AlphaBeta Consumer Survey
	Average number of digital-map-assisted drives per year and person	AlphaBeta Consumer Survey
	Average distance saved per year and person	AlphaBeta traffic crawler
	Average distance saved per year and person	National transportation authorities

ESTIMATION	METRIC	SOURCE
Fuel savings	Percentage of people using digital maps for driving	AlphaBeta Consumer Survey
	Average number of digital-map-assisted drives per year and person	AlphaBeta Consumer Survey
	Average distance saved per year and person	AlphaBeta traffic crawler
	Number of registered light passenger vehicles	National transportation authorities
	Price per liter of petrol	Numbeo
Trip savings from carpooling	Total Population	World Bank
	Trip propensity	• 2014 US household survey • 2009 JICA Surabaya commuter trips survey
	Transportation modal share	• National household surveys • City transportation surveys
Trip savings from switching to public transport	Percentage of people using digital maps for driving	AlphaBeta Consumer Survey
	Percentage of digital-map users who switch to public transport from driving	AlphaBeta Consumer Survey
	Average number of switched trips per year and person	AlphaBeta Consumer Survey
Cross-cutting assumptions	Number of digital-map users	AlphaBeta Consumer Survey
	Average hourly wage	• ILO Global Wage Report 2016/2017 • UAE National Bureau of Statistics • Turkish Statistical Institute
	CO^2 emissions per kilometer	• Toyota • De Lijn CO^2 emissions of vehicles[150]
	Fuel consumption per kilometer	• Toyota • US Department of Energy
	Vehicle occupancy (cars/buses)	AlphaBeta analysis

150. CO^2 emissions of vehicles, De Lijn. Accessible at https://www.delijn.be/en/overdelijn/organisatie/zorgzaam-ondernemen/milieu/co2-uitstoot-voertuigen.html

METHODOLOGY AND DATA: BUSINESS BENEFITS

The impact of geospatial services on businesses was calculated separately for three different types of benefits:

- **Direct revenue** from new products and services related to the geospatial industry.
- **Productivity improvements** that occur when businesses use these new geospatial products and services in a range of sectors.
- The potential **sales boost** that businesses, particularly small and medium-sized firms, can achieve when using geospatial products and services.

NEW PRODUCTS AND SERVICES

The analysis measures the direct benefits (revenue) for businesses in the geospatial industry, which operate in three major segments: location-based data, geo-apps and devices, and geo-expert services.[151]

- **Location-based data** (collection, management, and distribution of spatial information and imagery)
    1. *Human geo-data*: relates to gathering of data related to business and building locations, consumer and census data, street views, and transport (for example, to measure traffic volume).
    2. *Environmental geo-data*: relates to surveying and mapping of geophysical data (from elevations to watersheds) and environmental data (such as crop health, crop wealth, and land cover).
    3. *Satellite positioning data*: includes space-based positional systems and satellite constellations, such as GPS, GLONASS, Galileo and Compass .
- **Geo-apps and devices** (development and manufacturing of devices, applications, and software for creating, visualizing, sharing and analyzing geographic information)
    1. *Online geo-apps and services*: relates to applications for creating, visualizing, sharing, and analyzing geographic information. Examples include smartphone apps, "traditional" websites, Google Maps APIs, location-based digital advertising, etc.
    2. *Location-enabled devices*: relates to devices for creating, visualizing, sharing, and analyzing geographic information. Includes smart devices, other mobile devices (such as surveying equipment), in-vehicle devices and analytics devices.
    3. *Geospatial services, software and platforms*: relates to development and manufacturing of software for creating, visualizing, sharing and analyzing geographic information. Examples include geographic information systems and spatial relational databases.

151. India geospatial services industry study, Boston Consulting Group, May 2012.

- **Geo-expert industries** (transformation of location-based information into insights for commercial and government organizations; training and education of geospatial professionals)
    1. *Education services*: train and educates geospatial professionals.
    2. *Consulting services*: turn location-based information into insights for commercial and government organizations.

In each of these areas, a range of third-party estimates were used to calculate the benefits for businesses. Table 2 provides a detailed list of sources.

TABLE 2: INPUTS AND SOURCES FOR CALCULATING NEW PRODUCTS AND SERVICES

ESTIMATION	METRIC	SOURCE
Human geo-data	2012 US data value	Boston Consulting Group
Environmental geo-data	2012 US data value	Boston Consulting Group
Satellite positioning data	Active satellite numbers	Industry sources including Air Force Magazine Space Almanac
	Global revenue	2016 State of the Satellite Industry report
Online geo-apps and services	Online geospatial services	• Statista Digital Advertising Outlook • Boston Consulting Group
	Geo-app revenue	AppAnnie
Location-enabled devices	Stand-alone navigation units & land transport in-vehicle navigation systems revenues	2016 State of the Satellite Industry report
	Avionics	• European Global Navigation Satellite Systems Agency • Boeing
	Maritime devices	European Global Navigation Satellite Systems Agency
Geospatial services, software and platforms	2012 US-based revenue	Boston Consulting Group
Education	2012 India-based revenue	Boston Consulting Group
Consulting	2012 US-based revenue	Boston Consulting Group
Cross-cutting assumptions	Industry growth rates	European Global Navigation Satellite Systems Agency
	Geospatial market share	European Global Navigation Satellite Systems Agency

PRODUCTIVITY BENEFITS FOR OTHER SECTORS

A range of case studies derived from various sources (see footnotes throughout the report for further details) were used to calculate the productivity benefits for businesses in different sectors. The productivity impact (through lower cost or higher revenue) was measured in seven typical business areas:

- **Customer engagement / new business models.** Geospatial data can help sharpen the public profile of a business when a firm uses it to inform customers about essential store data, such as opening hours or whether a product is currently in stock.
- **Customer analytics.** Companies use geospatial services to analyze customer behavior. Some stores link demographic data and information on customer shopping behavior with geographic mapping data to improve their sales strategies. In real estate, it could help firms understand land-purchasing patterns and regulations.
- **Logistics.** Geospatial services can help businesses save fuel. They can also reduce pilferage in warehouses and improve inventory management. For example, the use of GPS in plane and maritime navigation, similar to land-based traffic shown in this report, can lead to fuel cost savings due to more efficient navigation.
- **Commercial location planning.** Geospatial data in conjunction with demographic data can facilitate strategic decisions regarding the location of facilities, such as warehouses and retail stores.
- **Environmental planning & management.** Geospatial services can help mining companies identify potential areas for resources exploration.
- **Network design & management.** Geospatial data help telecoms, utilities and other companies plan and design infrastructure networks.
- **Production efficiency.** Geospatial data can also support modern agriculture, known as precision farming. They can help farmers fertilize their crops in a highly targeted way or identify where maintenance and repair is needed.

SALES IMPACT

The consumer survey served as the basis for calculations on the estimated sales benefits of geospatial services. Survey participants were asked how frequently they use digital maps for shopping, and how much they typically buy when using digital maps. To assess whether digital maps actually increase the number of purchases or whether they do not change buying behavior, survey respondents were asked whether they would have completed the purchase regardless of the digital mapping service. The results for sample countries were then extrapolated to other countries in each of the six regions, adjusted for each country's online population, wage levels and average purchase values per user.

TABLE 3: INPUTS AND SOURCES FOR CALCULATING SALES IMPACT

ESTIMATION	METRIC	SOURCE
Sales Impact	Number of times digital maps are used for purchasing decisions	AlphaBeta consumer survey
	Number of those times that resulted in purchase	AlphaBeta consumer survey
	Average size of purchase	AlphaBeta consumer survey

METHODOLOGY AND DATA: SOCIAL AND ENVIRONMENTAL BENEFITS

Social and environmental benefits are more difficult to calculate than benefits to business or consumers. Those wider benefits to society are often not immediately visible in traditional economic metrics because the impact can only be measured over the longer term. Some, such as charitable activity or innovation, are also difficult to quantify.

This report analyzes the wider social and environmental benefits that come from a stronger job creation, less traffic congestion, more efficient urban planning, improved public health, faster safety and emergency response, better wildlife and environment protection and enhanced classroom education.

JOB CREATION

To calculate the impact of geospatial services on employment, both direct and indirect jobs have to be considered. While the geospatial services industry employs a large number of people directly, it also creates employment in other industries that depend on input from geospatial firms.

To calculate the direct employment impact, we analyzed online job advertisements in each of the 22 countries surveyed. This approach built upon the work done by Dr. Michael Mandel at the US-based Progressive Policy Institute.[152] The process involved four steps:

- **Identification of geospatial job postings.**
  Using summary statistics generated by searches on national websites of online job-search platforms, we identified job postings containing one of the following key words: GIS, Geography, Geographic, Geographer, Geographical, Map, Observation, Satellite, Photogrammetrist, Stereo-Plotter, Imagery, Aerial photographs, Spatial, Cartographer, Cartography, Cartographic, Sensing, Surveyor, Information Scientist.

  An AlphaBeta web crawler was used to "scrape" all relevant job postings from online job search platforms. The translation program Google Translate was used to allow the web crawler to search websites in languages other than English.

- **Validation.**
  Any keyword search typically generates a certain amount of irrelevant results. For example, the word "geospatial" may appear in a job posting for a salesperson who needs to use geospatial services as part of their job, but isn't directly employed in the geospatial industry.

  To identify and eliminate irrelevant search results, any postings that did not fit the criteria of an immediate geospatial job description were deleted manually.

- **Benchmarking ICT job postings against official ICT employment statistics**.
  Advertized jobs in the information and communications technology (ICT) industry were benchmarked against official government statistics to reduce any data bias. A country-specific keyword list containing common search terms was created to identify ICT job postings. These were then compared with figures on the number of ICT

152. The App Economy in Europe: Leading Countries and Cities, Progressive Policy Institute 2016

professionals per country, as declared by national statistic bureaus. Results had to be adjusted to match the varying definition of "ICT worker" used in each country.

The number of ICT professionals was then compared to the size of the whole ICT workforce in each country and validated. This approach allowed us to calculate the ratio of ICT job postings to overall ICT employment in each country.

Indonesian authorities did not have any statistics on the number of ICT workers in 2015 readily available. To overcome this hurdle, the analysis used the ICT employment figure for 2005 and estimated the corresponding figure for 2015 using the industry's compound annual growth rate (CAGR). The CAGR was obtained from a research paper written by the International Labour Office on employment in Indonesia, supported by data from the EU-Indonesia Business Network.[153] [154]

- **Estimation of geospatial core jobs for sample countries.**
  Previous work by the Progressive Policy Institute was expanded to estimate the number of geospatial core jobs. It was assumed that the ratio of online ICT job postings to overall ICT employment is the same for core geospatial jobs.

  We multiplied the ratio generated in step 3 and the validated number of geospatial job postings generated in step 2. The result gave us the estimate of core geospatial jobs.

  The validity of this number was tested by comparing it with expert interviews as well as existing estimates for the number of jobs in the geospatial industry in the US and India.[155] The job estimates were then scaled to regions outside the sample group of 22 countries with the help of data on the size of online populations across the world.

To estimate the indirect of jobs related to geospatial services, i.e. the ratio of workers employed in admin, sales and market functions and suppliers to the number of core geospatial workers (i.e., engineers), we used a mix of consumer survey, desk research and interviews with industry experts, applying a conservative ratio of 2:1.

TRAFFIC CONGESTION

Beyond improved navigation, digital maps can improve traffic congestion through two main channels: by encouraging carpooling (e.g. through services such as Waze carpool), and through encouraging higher usage of public transport through better knowledge of available routes. To size the former, a hypothetical case was created (informed by current shared-mobility rates) assuming that 20 % of total car trips could shift to carpooling.[156] The impact of this shift on traffic volume was then calculated based on the average occupancy of vehicles in each country. It was assumed that an average carpooling vehicle carries four people. Data on the total number of daily car trips in each country was used to calculate how many individual car trips could be replaced by carpooling. This analysis assumes that carpooling users have previously used their own car for a trip, rather than other means of transport such as trains.

The impact on public transport was based on the AlphaBeta consumer survey where consumers were asked how many car trips they have likely already substituted for public transport and/or cycling/walking because of digital maps. The results were extrapolated to the rest of the online population.

The reduction in car trips due to carpooling and a shift to public-transport use lowers CO^2 emissions and fuel costs. This impact was calculated using the methodology discussed in the consumer benefits section of this report.

153. International Labour Office (2012), Trade and Employment in Services: The Case of Indonesia. See also:
154. EU-Indonesia Business Network (2015), Indonesian ICT Market.
155. India geospatial services industry study, Boston Consulting Group, May 2012.
156. Rethinking urban mobility in Indonesia: The role of shared mobility services, AlphaBeta, 2017.

URBAN PLANNING AND CIVIC ENGAGEMENT

The impact was not quantified in this report. Instead, case studies were used to describe how geospatial services generate benefits in this area.

SAFETY AND EMERGENCY RESPONSE

The impact was not quantified in this report. Instead, case studies were used to describe how geospatial services generate benefits in this area.

KNOWLEDGE CREATION AND HUMAN CAPITAL DEVELOPMENT

The impact was not quantified in this report. Instead, case studies were used to describe how geospatial services generate benefits in this area.

PUBLIC HEALTH

The impact was not quantified in this report. Instead, case studies were used to describe how geospatial services generate benefits in this area.

ENVIRONMENT AND WILDLIFE PRESERVATION

The impact was not quantified in this report. Instead, case studies were used to describe how geospatial services generate benefits in this area.

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