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GLOBAL GEOSPATIAL INDUSTRY OUTLOOK

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FOREWORD

Geospatial industry has been gaining relevance and maturity in today's digital world. Decades of technological innovations and sustained business acumen have made it possible for the geospatial fraternity to a make difference in every walk of life. Currently, most innovative and disruptive business models are principally based on unique capabilities of location-enabled analytics and sensors. The value and utility derived for the economy and society through the geospatial industry is estimated to be over and above $500 billion worldwide. More so, the exponential benefits of geography and spatial dimension are being realized by citizens globally in some form or the other.

What is more exciting is the limitless opportunities the future holds for the geospatial industry. Drivers of the digital world, including Cloud, IoT, Robotics and Automation, Deep Learning and Artificial Intelligence, Mesh Reality are equally driving geospatial industry, expanding its horizons and opportunities manifold. However, it does pose humongous responsibility on our community to change, adapt, collaborate, put forward collective efforts, resources, energy, and capabilities to harness these opportunities and continue to make our mark and relevance in global industry and business leadership. As we move forward, several new players would share our vision and stake, opening new avenues while closing some existing ones. Solution-centric and system integration-oriented character of the industry would determine successes, making it imperative to have a better understanding of the digital ecosystem and agility to collaborate, while maintaining unique business propositions. Therefore revenue models too would require adaptability, refinement and alignment.

Digital revolution is bringing in a lot of excitement; but for the industry to grow, the focus ought to be on the Geospatial Readiness of countries. Fundamental geospatial information, positioning infrastructure, policy frameworks, institutional capacity, industrial development, constantly moving up the value chain in terms of user adoption are essential for transforming and converging opportunities. The need of the hour is to assess and understand the fundamental tenets and consistent investments in preparing the nations' readiness in leveraging the digital revolution. International organizations have a greater role to play in raising the profile of geospatial industry and building in the geospatial elements within the framework of respective development programs. The responsibility of readiness is not limited to the public authorities and academic institutions, but is shared by industry and the user stakeholders.

Geospatial Media and Communications undertook the initiative to publish the **'Global Geospatial Industry Outlook'** in partnership with leading geospatial companies worldwide. While it took almost a year of consistent effort to collect information and perspectives through primary and secondary sources, we have also integrated knowledge and learnings of our research and documentation of the past five years to provide an insight duly supplemented with facts and figures.

I would like to acknowledge the support extended by several professionals and leaders who we have interacted with in the last few years to capture their mindshare. These leaders have been associated with various segments of geospatial industry, including technology, business, academia, national governments, multilateral agencies, professional societies, and user industries globally. I express my gratitude towards Karthik Ramamurthy, Aswani Akela, Manoj Misra and Saurabh Rai, who participated actively in rounds of discussions with our team and offered their guidance and supervision. I also appreciate the gigantic efforts put in by the Market Intelligence and Business Consulting division of Geospatial Media and Communications.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AI	Artificial Intelligence
AR	Augmented Reality
BI	Business Intelligence
BIM	Building Information Modelling
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAGR	Compound Annual Growth Rate
CEN	The European Committee for Standardization
CRM	Customer Relationship Management
EGNOS	European Geostationary Navigation Overlay Service
EO	Earth Observation
ERP	Enterprise Resource Planning
ESA	European Space Agency
EU	European Union
FAO	Food and Agriculture Organization
GAGAN	GPS Aided GEO Augmented System
GALILEO	Europe's Global Navigation Satellite System
GCPs	Ground Control Points
GEO	The Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information System
GLONASS	Russian Global Navigation Satellite System
GPS	Global Positioning Systems
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite Systems
HDI	Human Development Index
ICT	Information and Communication Technology
IoT	Internet of Things
INSPIRE	Infrastructure for Spatial Information in the European Community
IPS	Indoor Positioning System

IRNSS	Indian Regional Navigation Satellite System
ISO	The International Organization for Standardization
IT	Information Technology
LBS	Location Based Services
LED	Light Emitting Diode
LiDAR	Light Information Detection and Ranging
M2M	Machine to Machine
MR	Reality Mesh or Mixed Reality
Navstar	Navigation Satellite Timing and Ranging System
NFC	Near Field Communication
OGC	Open Geospatial Consortium
PUMA	Platform for Urban Management and Analysis
QZSS	Japanese Quasi Zenith Satellite System
R&D	Research and Development
RFID	Radio Frequency Identification
RTK Base Stations	Real-time Kinematic Base Stations
SBAS	Satellite Based Augmentation System
SCADA	Supervisory Control and Data Acquisition
SDI	Spatial Data Infrastructure
SDN	The Sustainable Development Network
SDK	Software Development Kit
UAVs	Unmanned Aerial Vehicles
UAS	Unmanned Aircraft Systems
UN-GGIM	The United Nations initiative on Global Geospatial Information Management (UN-GGIM)
UN-GGIM PSN	The United Nations initiative on Global Geospatial Information Management (UN-GGIM), Private Sector Network
UNOOSA	The UN Office for Outer Space Affairs
UNSDI	United Nations Spatial Data Infrastructure
VR	Virtual Reality
WAAS	Wide Area Augmentation System

1. INTRODUCTION

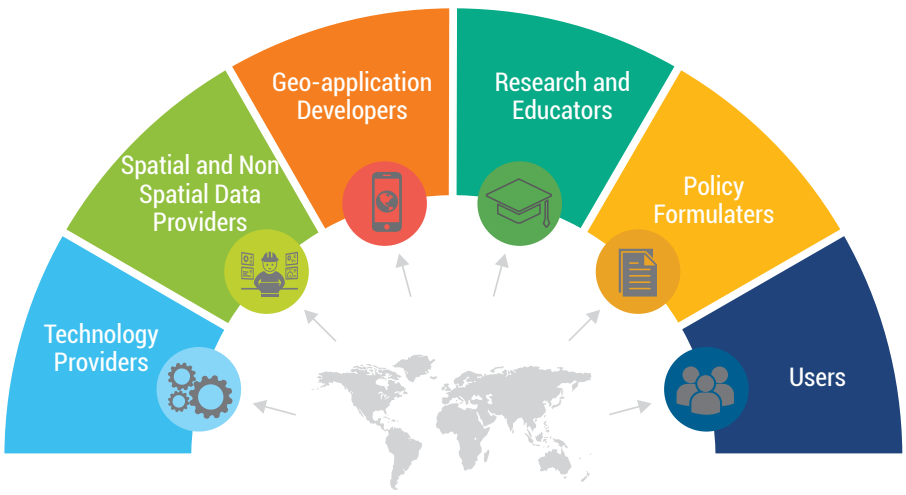
Geospatial technologies have become all-pervasive, driving major disruptions across industry segments. The economic value of the sector is more than $500 billion

In this progressively complex and interconnected world, issues that impact our everyday lives are often analogous. One of the most powerful and astute ways of exploring the physical and digital landscapes for individuals, businesses and governments today is through the 'where' dimension. Geographic information and intelligence not only underpins all decision-making, it improves efficiency and productivity leading to sustainable development. No wonder then geospatial technologies have become all-pervasive, driving to major disruptions across industry segments.

The burgeoning adoption of location analytics and Big Data among enterprises, the ubiquity of everyday geo-enabled mobile applications like Facebook and Google Maps, the decreasing cost and increasing accuracy of all sorts of sensors, and surging reliance on the Cloud have ensured that geospatial becomes a core enabling technology for even those who find it hard to define the term.

Every field that is fuelled by spatial information is a part of the geospatial industry. The economic value of the sector today forms a handful of long-established geo-services like digital maps, satellite navigation, satellite imagery, location-based search, and satellite receivers and manufacturing. The size of the industry accounts for today ranges more than $500 billion[1]. Add to this the fiscal potential of emerging sectors like autonomous

Figure 1.1 Stakeholders of the Geospatial Industry Ecosystem



1 https://www.geospatialworld.net/article/where-is-the-money/

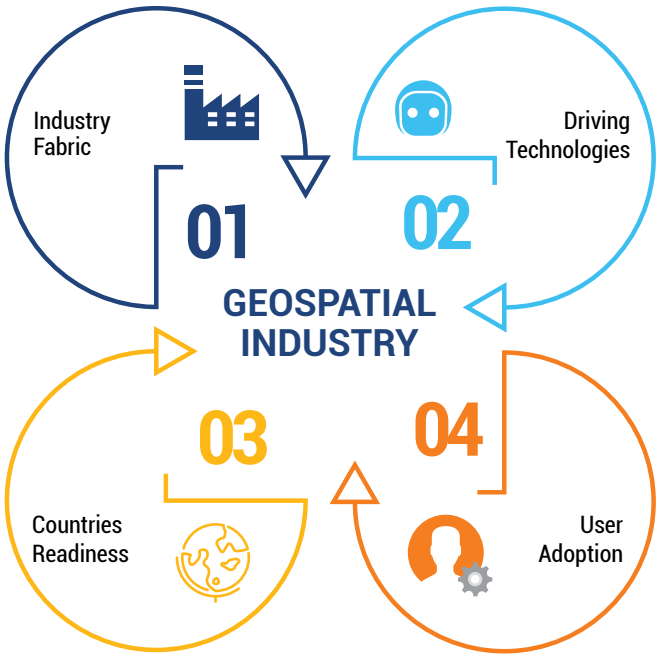


Figure 1.2 Key Influencers of Geospatial Industry

vehicles, unmanned aerial systems, wearables and augmented reality, and sky is the limit.

Governments today realize that access to reliable and adequate geospatial information is crucial for any nation vying for real economic growth, wealth creation, better quality of life and transformation in the society.

This process of transformation includes deep-seated business transformations as well, which are stimulated by innovation. In the information age, innovation plays a key role in national competitiveness and provides industries with a sustainable edge over rivals.

The geospatial industry is no exception, where rapidly changing technology trends are leading to diminished innovation lifecycle and shrinking gestation periods. This has resulted in raised profit vulnerability for the industry.

In such a scenario, it is imperative to understand the key factors influencing the geospatial industry (Figure 1.2). These include users, private companies, non-profit organizations, research and academic institutions, and government agencies who research, develop, manufacture, implement, and employ geospatial technologies (Figure 1.1). The industry is also affected by the prevailing trends in IT technologies.

Another leading factor that provides guidance for businesses and governments by underlining the realities and opportunities of the ecosystem is the

Rapidly changing geospatial technology trends are leading to diminished innovation lifecycle, resulting in heightened profit vulnerability for the industry

Geospatial readiness of a nation lays the foundation for businesses and governments by underlining the realities and opportunities as a whole

geospatial readiness of a nation. Readiness is dependent on the institutions, policies and factors driving the level of productivity in a country. This productivity level, in turn, will determine the rate of return on investment in any economy.

It is an established fact that geoinformation plays a conspicuous role in a nation's development, accelerating the global development agenda. An innovation-driven and efficiency-centric economy can be achieved only through the growth of the entire fabric of the geospatial ecosystem for decision support in the public sector, and market development in the private sector.

This study investigates the interaction between the two inter-reliant pillars of **industry trends** and **geospatial readiness** to determine the success of the global geospatial industry.

But, how do you find out the trends and direction of the global geospatial industry? How do you ascertain the geospatial readiness of a country? How do you get an accurate picture of the drivers influencing the geospatial industry in a nation? The Global Geospatial Industry Outlook strives to succinctly answer these questions in a clear, coherent manner.

The Global Geospatial Industry Outlook is presented in two parts:

Global Geospatial Industry Trends and Business Models:
This section presents a transparent picture of the global geospatial industry fabric by scrutinizing trend in technology, product, drivers of geospatial business and transforming business ecosystem.

Geospatial Readiness Index of Countries:
In a first-ever study of the geospatial readiness of any nation, the Global Geospatial Readiness Index ranks more than 50 countries across the globe on their readiness for this industry.

Objectives

- Assess the current prevailing global geospatial technology trends
- Identify and appraise the additional factors influencing these trends
- Establish a trend in innovation of geospatial products over the years
- Ascertain the business trends reigning the global geospatial industry and their correlations
- Access the readiness of a country on parameters affecting geospatial industry by unveiling 50 countries' geospatial readiness index
- Understand whether a country possesses the drivers necessary for geospatial technologies to meet their potential
- Get an accurate picture of all the drivers of the geospatial industry to flourish at the country level

Global Geospatial Industry Trends and Business Models

This part of the study is the global evaluation of geospatial industry. To highlight the industry trends, firstly, the objective of the study was defined. An analysis of the industry trends sheds light on the economic health of the industry globally, highlighting the following key factors:

- The types of the geospatial companies
- Driving technologies of the geospatial industry
- Top industry sectors that use geospatial technologies
- Business process embedment
- Spatial embedment
- Benefits and challenges of geospatial technology
- Product trends
- Acquisitions and partnerships
- Revenue model in geospatial industry

To analyze the above key factors globally, the basis is both primary and secondary research (Figure 1.4). Primarily, Geospatial Media and Communications is a domain expert on the Geospatial Industry having considerable in-house information available and therefore this has been collated together to begin modelling the study. The benchmarking analysis is from a survey of 500+ companies which has led us to draw some eye-opening conclusions (Figure 1.3).

Field Research

Field Research is an important component to conduct any analysis. To understand the industry trends in the geospatial industry, one-to-one interactions supplemented with secondary data sources (case studies, company websites, press releases, magazine articles, etc.) have been conducted with 500+ companies globally.

500+ companies surveyed, 1500 press releases mapped that had shed light on the economic health of the industry

Figure 1.3 Global Distribution of Companies Surveyed to Analyze Global Geospatial Industry Trends & Business Models

The sample has been chosen strategically to define accurate representation of the geospatial industry dynamics globally

20% of these companies are leading players in the geospatial industry. Questionnaires were generated which were shared with the stakeholders of the geospatial industry and analysis has been done from their perspective. The sample of the study has been chosen strategically to define the universe of the study to give an accurate representation of the geospatial industry dynamics. The intelligence has been drawn from one-to-one interactions with the leading industry players of:

- Product companies (hardware, software and data)
- Solution providers
- System integrators
- Service providers
- Consultants

500+ companies have been analyzed and studied to understand the regions they operate in, the type of industry offerings they have and the driving technologies like Cloud, IoT, etc., that drive the geospatial industry and define the revenue model within the industry.

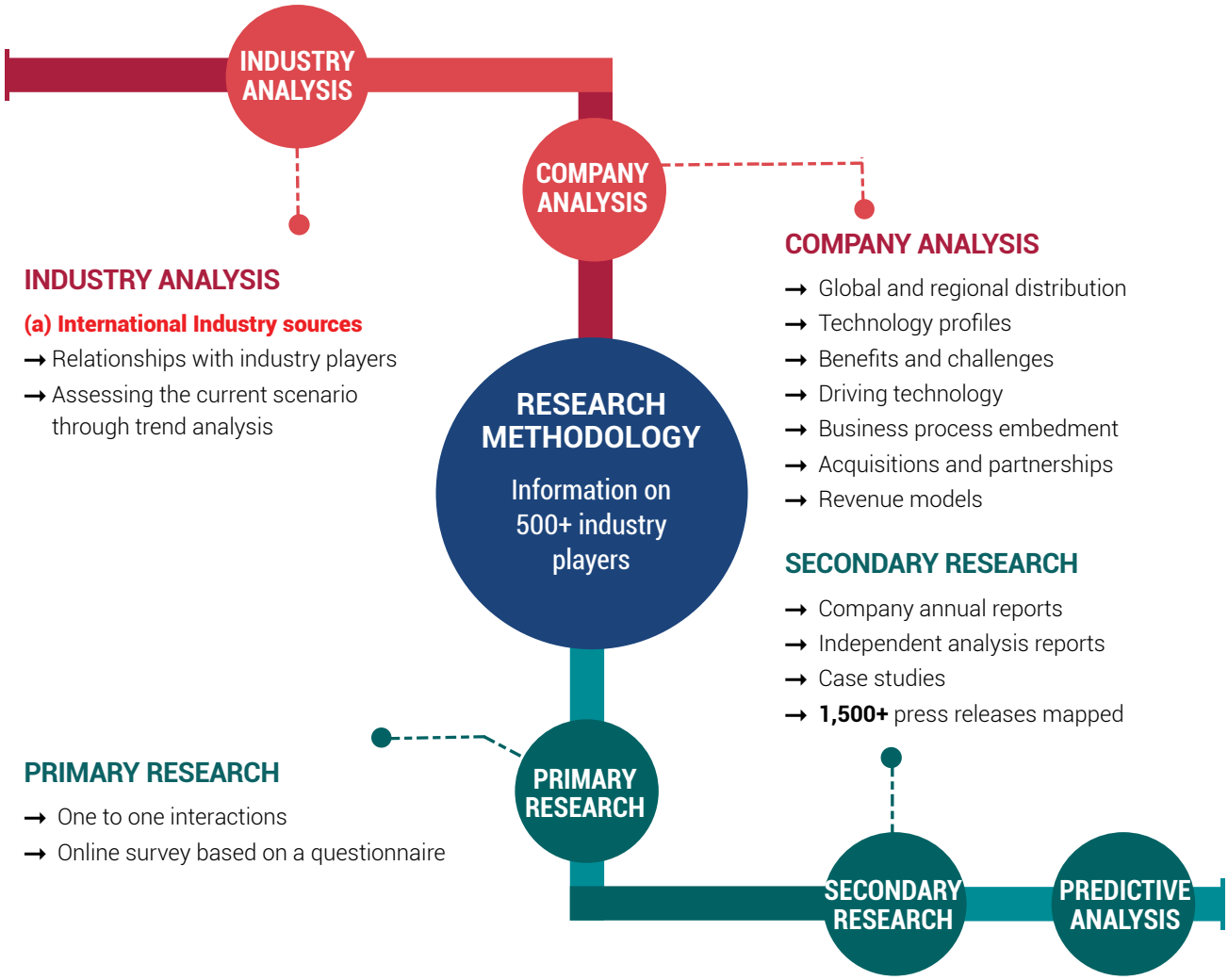


Figure 1.4 Research Methodology to Analyze Global Geospatial Industry Trends & Business Models

The analysis has been done on the basis of interviews conducted with top management officials, technology practitioners, product managers and industry stakeholders.

The industry has therefore been assessed to define the technology ecosystem, the enabling technologies, the technologies offered and the industry types to draw final inferences on the basis of the sorted sample size using factor analysis (Figure 1.4).

Secondary Study

The field research or the primary research is validated and supplemented by the review and analysis of extensive secondary information. Intelligence is drawn from the study of:

- Company annual reports
- Independent analysis reports
- Press coverage
- Case studies

1,500+ press releases and other secondary information collected, have been studied through the years 2012-2016 to define the trends in technology, revenue models, acquisitions and partnerships and others so that a rational analysis of development patterns can be carried out.

Detailed secondary study has also been conducted to evaluate the recent trend of spatial embedment in the non-geospatial companies and mainstream consultants. Such companies include, Facebook, Twitter, LinkedIn, IBM, Flipkart, etc.

Predictive Analysis

Future outlook is very important for any industry and therefore is a key element of the global industry market intelligence. The objective of the study is also to highlight the futuristic trends in the geospatial industry. Predictions are drawn from the already available knowledge and the analysis conducted. Correlation has been drawn from the previous and the current industry standing to define the future trends in the geospatial industry domain.

Countries' Geospatial Readiness Index

The Geospatial Readiness Index of 50 countries reflects an assessment of four primary pillars driving the readiness of a country's geospatial ability.

To create a Countries' Geospatial Readiness Index, it was first necessary to identify the wide spectrum of factors that define the geospatial readiness in a country. The methodology defines and prioritizes the parameters impacting and influencing the geospatial industry as a critical factor.

The methodology used in this study consists of the following steps:

- Identify 50 countries for the readiness index
- Determine the pillars, sub-pillars and sub themes to model the study
- Assigning weights to each pillar and sub-pillars
- Determine and conduct the survey strategy (primary & secondary) to encompass the pillars holistically
- Formulate the Readiness Score

Correlation has been drawn from previous and current industry standing to forecast the future trends in the geospatial industry domain

50 economies selected for readiness index represents 75% of the world's population and 89% of the world's GDP

Identifying 50 countries for Geospatial Readiness Index

The Geospatial Readiness Index assesses the readiness of 50 countries. It provides a key tool of detailed metrics for 50 economies representing 75% of the world's population and 89% of the world's total GDP. The countries have been chosen keeping two considerations:

- Geographic representation
- Economic representation

Also, it is to be noted that the countries have been chosen by leveraging the 20+ years of global geospatial knowledge of professionals of Geospatial Media and Communications. It has helped to identify an almost equal distribution of the above two factors – geographically and economically. Only after careful assessment of the geospatial industry on a whole, 50 countries have been shortlisted (Figure 1.5) .

Identifying the Pillars, Sub-Pillars and the Sub-themes to model the study

The index pillars put a great emphasis on the fundamentals imperative to the global geospatial industry. As a result, the following four pillars are identified:

- Geospatial infrastructure and policy framework
- Institutional capacity
- Users adoption level
- Industrial capacity

These pillars are not independent of each other and reinforce each other constantly. To model the readiness index, the four pillars have been sub divided into several decision criteria such that each decision attribute is defined. These pillars and sub-pillars are defined as follows (Figures 1.6 & 1.7):

Figure 1.5 Geographical Distribution of Selected Countries for Assessing Geospatial Readiness Index

Geospatial Infrastructure and Policy Framework

For any country to flourish in the Geospatial domain, it is important that the country has an efficient and extensive geospatial infrastructure and policy framework. This pillar has been further divided into the following sub-pillars which have been analyzed for each of the 50 countries to reach a score:

- Data Infrastructure (Topographic & Earth Observation): Layer, scale, characteristics of data, type of imagery, resolution, etc.
- Positioning Infrastructure: Positioning system, augmentation system and geodetic infrastructure
- Platforms and Portals: Geoportal, characteristics, functionality and architecture
- Open and Linked Data: Data dissemination mode, inter-intra data linkages, and standards
- Policy framework: National-level policies, tech-specific and data related

Institutional Capacity

It is a well-known fact that quality education institutions and training institutes are crucial for economies to move up the value chain. It is imperative that in today's global economy, countries have well established institutions to nurture pools of well-educated workers who are able to adapt to the changing environment.

For any country to flourish in geospatial domain, it is important that the country has an efficient & extensive geospatial infrastructure and policy framework

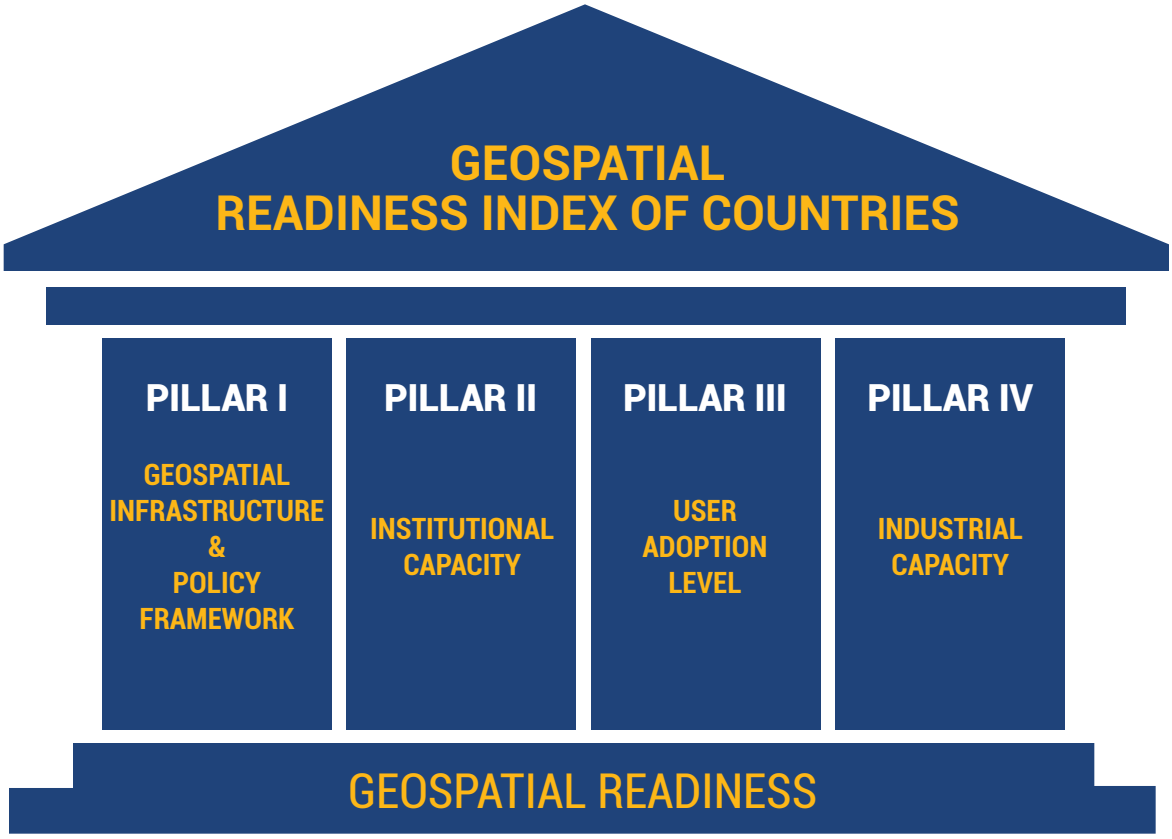


Figure 1.6 Identified Pillars for Accessing Countries' Geospatial Readiness

The user adoption level measures the agility and extent to which the economy is adapting the geospatial technologies

Similarly, we have studied the institutional capacities specific to geospatial knowledge dissemination (courses) in each of the 50 countries with respect to the following criterions:

- Fundamental Science
- Professional Education
- Interdisciplinary Application Courses
- Vocational Training
- Business Incubation

User Adoption Level

The user adoption level measures the agility with which an economy is adapting the Geospatial technologies to enhance the productivity of its industries. It also measures the capacity to fully leverage ICTs and Geospatial knowledge together in everyday activities of the major industries.

This pillar is analyzed using the following sub-pillars:

- Mapping Services
- Business Process Modeling
- Analytics and Workflows
- System Integration Level
- Enterprise Level

Industrial Capacity

Industry plays an important role in the economic development of the country and therefore it is important to assess the role of geospatial industry in each of the 50 economies to elucidate the readiness of the index. The Industry fabric has been sub-divided into the following sub-parameters:

- Product companies (hardware, software and data)
- Service providers
- Solution and system integrators

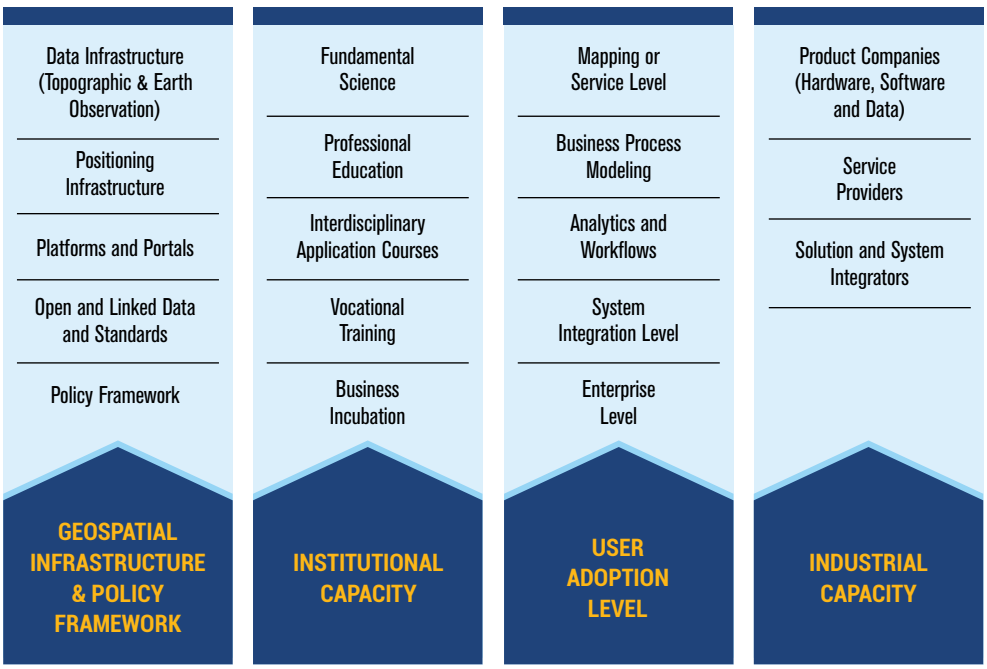


Figure 1.7 Pillars and Sub-pillars for Accessing Geospatial Readiness Index of a Country

As discussed, each parameter within the four pillars comprises a series of five sub-pillars that are each converted to a score of 0-5 and weighted summed to generate the pillar scores to 25% each (Table 1.1). Once the scores of the four pillars are derived, they are summed to map the overall readiness of the ranking. It is to be noted that the weights are based on our assessment of the relative

PILLARS FOR GEOSPATIAL READINESS INDEX		TOTAL WEIGHTS
PILLAR I: Geospatial Infrastructure & Policy Framework		**25%**
Data Infrastructure (Topographic and Earth Observation)	5%	
Positioning Infrastructure	5%	
Platforms and Portals	5%	
Open & Linked Data Standards	5%	
Policy Framework	5%	
PILLAR II: Institutional Capacity		**25%**
Fundamental Sciences	5%	
Professional Education	5%	
Interdisciplinary Application Courses	5%	
Vocational Training	5%	
Business Incubation	5%	
PILLAR III: User Adoption Level		**25%**
Mapping or Service Level	5%	
Business Process Modelling	5%	
Analytics and Workflows	5%	
System Integration Level	5%	
Enterprise Level	5%	
PILLAR IV: Industry Capacity		**25%**
Product Companies (Hardware, Software & Data)	8.33%	
Service Providers	8.33%	
Solution and System Integrators	8.33%	
TOTAL		**100%**

Table 1.1 Assigned Weights to Pillars & Sub-Pillars for Accessing Geospatial Readiness Index of a Country

Interactions with stakeholders of the geospatial ecosystem have been conducted and supplemented & validated through secondary sources

importance of each dataset, parameters and pillars to determine the readiness index.

Research Methodology

The methodology for the study includes extensive quantitative analysis using both primary and secondary survey strategies. For the global geospatial readiness index, interactions with stakeholders of the geospatial ecosystem have been conducted which is further supplemented and validated through secondary sources. The study has been conducted to identify the status of the geospatial data infrastructure, policy framework, image resolutions, etc. Similarly, primary interactions and secondary research have been conducted with various institutions in the top 50 countries to identify the numerous course offerings in each country.

Primary and secondary research have also been conducted on the basis of a specially designed questionnaire to evaluate and elucidate the user level adoption of geospatial technologies and the geospatial industry fabric in the 50 countries.

Data sets henceforth are available through field research and extensively available public data. The primary research data has also been authenticated for each country through exhaustive cross referencing with secondary research. These data sets aim to capture the multi-dimensional facets of geospatial innovation in geospatial industry and therefore are tailored to map the readiness index accordingly.

Formulate the Readiness Score

After thorough analysis has been conducted through primary and secondary means, the data sets have been analyzed according to the four pillars, their sub pillars and further sub-themes on an equal weightage of 25% and then aggregated to arrive at the final score for the country. On the basis of the final score, the countries have been ranked to arrive at the Global Geospatial Readiness Index.

GLOBAL GEOSPATIAL INDUSTRY TRENDS AND BUSINESS MODELS

Core geospatial technologies has evolved exponentially. They have rallied with a potpourri of information technology disciplines to complete the digital puzzle. There has been a constant transformation in the geospatial landscape and business environment is simultaneously giving birth to exciting opportunities and formidable challenges. Information, communication, and other driving technologies have been steadily disrupting the industry's fabric and adding new dimensions to the value and utility of geo-information and practices. This has enabled, reorganized and redefined the composition, character and the business models of the industry. We did a deep dive into some of the key forces influencing the geospatial community and put them into a comprehensive framework to make sense of them all. More than 500 companies were surveyed to gauge the landscape of the industry and understand where it is heading.

This part of the study is the global evaluation of geospatial industry. It highlights the:

→ Geospatial industry fabric
→ Product trends
→ Driving technologies of the geospatial industry
→ Business process embedment
→ Acquisitions and partnerships
→ Revenue model

A detailed analysis of these is presented in the following pages

2. GEOSPATIAL TECHNOLOGY IN DIGITAL ECOSYSTEM

It could be stunning satellite imagery from space, or detailed surveying data gathered by total stations, or even beautifully layered maps on mobiles. The truth of the matter is the key to solving many of our problems today lies in unlocking the potential of these data, and turning it into meaningful information that enables the decision-making process.

Today, billions of people are aware of and use spatial technologies and products daily — especially online maps and GPS-based car navigation — but very few understand the range and complexity of the technologies involved and how they interact.

The global GIS market is expected to touch $14.62 billion by 2020 from $7.61 billion in 2014, growing at a CAGR of 11.4%[3]

The first known use of the term 'Geographic Information System' can be traced back to Dr Roger Tomlinson's research paper *A Geographic Information System for Regional Planning in 1968*[1]. Since then, GIS has evolved from being a niche scientific tool to a mass-market technology.

Today, while GIS is being used in different industries and applications, the industry itself has evolved into what has come to be known as geospatial, encompassing all forms of technologies that are involved in collection and processing of spatial data. Regardless of whether the famous quote "80% of all data in the world has a spatial relation" — attributed to various sources — is accurate or not, it is true that by the end of this year, there will be 5.72 billion smartphones[2] with GNSS capabilities, up from 3.1 billion in 2014.

What Does the Geospatial Industry Encompass?

The geospatial industry comprises of government organizations, private companies, non-profit organizations, and academic and research institutions that develop, manufacture, research and employ geospatial technology. They are involved in gathering, storing, processing, integrating, managing, mapping, analyzing and distributing data tied to a particular location on Earth.

Geospatial technologies include Geographic Information System (GIS)/Spatial Analytics, Global Navigation Satellite System (GNSS) & Positioning, Earth Observation and Scanning (Figure 2.1).

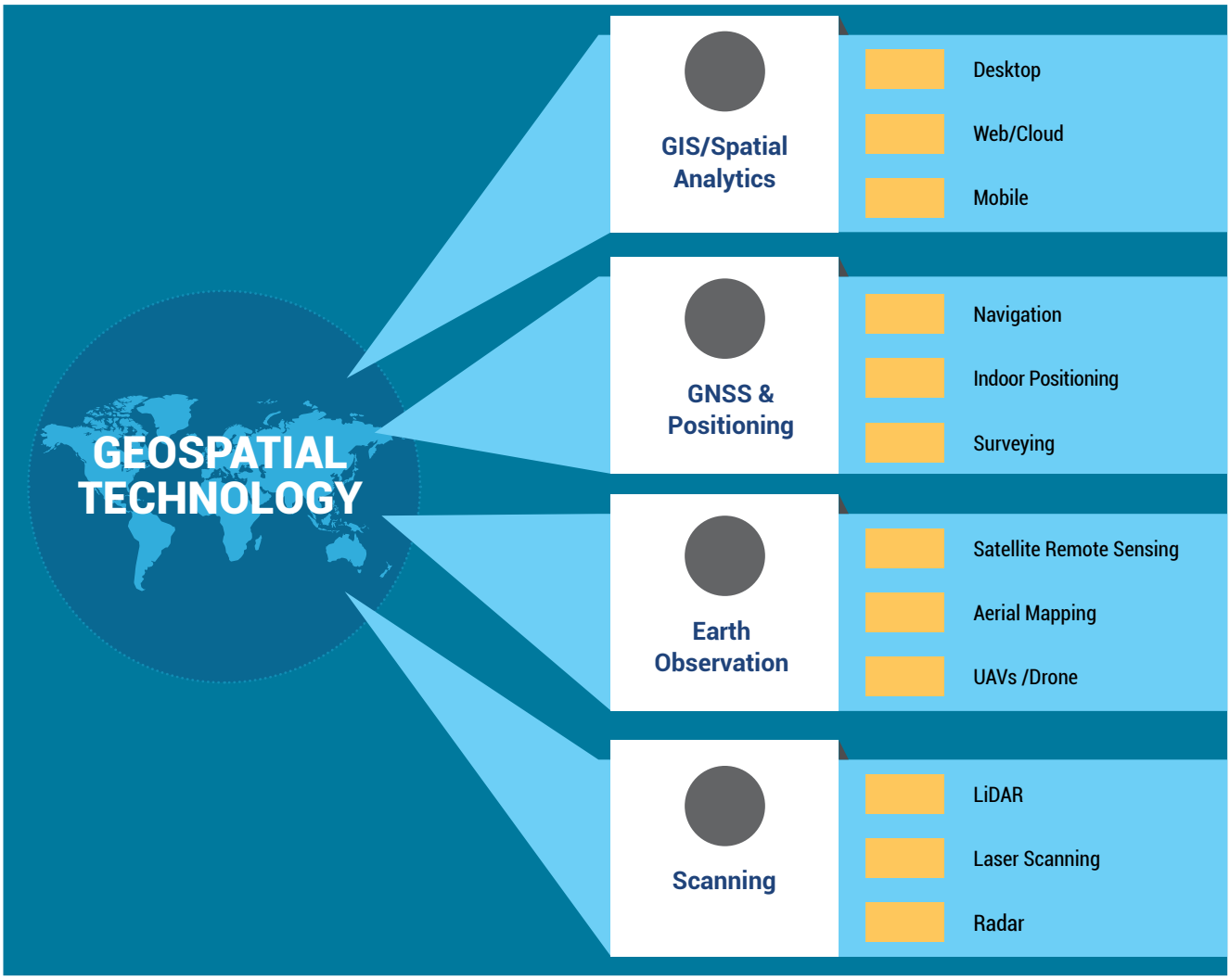


Figure 2.1 Components of Geospatial Technology

GIS /Spatial Analytics

The use of GIS/Spatial Analytics by various industries is only expected to go up in a market driven by increasing global demand for geographically correlated information. GIS can primarily be categorized into three types:

- **Desktop GIS:** Software is installed onto and runs on a personal computer
- **Web/Cloud GIS:** A desktop or mobile application allows the user to connect with the GIS server on the Internet. Running GIS software on Cloud allows a user to leverage the flexibility of the Cloud environment for data capture, visualization, analysis and sharing
- **Mobile GIS:** Takes GIS technology out of the office and into the field on a mobile device like a smartphone or a tablet

GNSS & Positioning

GNSS or Global Navigation Satellite Systems has become such an integral part of our daily lives that it is almost impossible to do without them. Be it surveying, navigation or indoor positioning, GNSS is the backbone of it all. Everything from businesses and banking, to defense and aviation is heavily dependent on GNSS and positioning services.

As many as 3.6 billion GNSS devices were in use in 2014 and by 2019, this number is expected to cross 7 billion, or an average of one device per person on the planet[5]

Regional systems operate on the same technology as GNSS, but instead of being global, their coverage is limited to a certain region. Satellite Based Augmented System (SBAS) is an improvement of the positioning service of the satellite navigation system and is primarily meant for aircraft navigation. Meanwhile, major synergies are also developing in terms of wireless mobile terminals with a navigation capability.

The newest kid on the geospatial block, indoor positioning, is a still evolving field. It combines the power of GPS and precise mapping to the place where human beings spend 70% of their time – indoors. Indoor Positioning can be broadly classified into: magnetic positioning, radio waves, mobile sensors, RFID. However, it must be mentioned that there is no standard way to build an IPS. A company may use WiFi triangulation, bluetooth, beacons, Near Field Communication (NFC), infrared, indoor mapping, sensors or even acoustic analysis LED lighting, and 'pedestrian dead reckoning,' among others to determine a person's position in a building.

Earth Observation

Earth Observation, or remote sensing from space to surface, includes technologies like satellites in space, aerial photography (manned as well as unmanned flying vehicles). Over the next decade, 419 satellites are expected to be launched generating $35.5 billion in manufacturing revenues[5]. In the meantime, small, mini and nano satellites have shaken up the traditional earth observation market.

And while aerial remote sensing, which involves flying a piloted plane to collect data, has been widely used in areas like land surveying, mining and agriculture, it was always regarded as an expensive task. Enter unmanned aerial vehicles, or drones, which are expected to boost the aerial photography industry by 12.9% over the next six years[6].

Scanning

The scanning market comprises of Laser, LiDAR, Radar and Point Cloud from images – non-contact technologies that can digitally capture the shape of physical objects. 3D laser scanners create "point clouds" of data from the surface of an object or data about the surroundings.

While the government sector will continue to lead the demands in scanning technology, increased penetration across areas like wind energy, transportation, urban data acquisition are expected to be big growth drivers. Meanwhile, factors such as technological superiority, encouragement from government, and various applications of LiDAR, such as, engineering projects and large magnitude set are key drivers for the growth of LiDAR market.

Further, the radar sensor ecosystem, made up of of chip designer companies, component manufacturers, technology

providers and system integrators, is expected to touch $30.67 billion by 2022 from $19.29 billion in 2015 growing at a CAGR of 6.94% between 2016 and 2022[7].

Geospatial and its Linkage with Others

We need to remember that definitions can be a tricky thing. If one were to define geospatial technology with the typical dictionary definition of "any technology that enables the creation, management, analysis and visualisation of geospatial data", then would it be correct to identify that any field/domain that uses spatial information and maps, as part of the geospatial industry? And as a natural extension, would it be accurate to identify anyone who works with spatial data as a geospatial professional?

Most applications and technologies today use location data for some purpose or the other. Self-driving cars, UAVs, wearables, augmented reality, Internet of Things, all use spatial data and maps for a wide variety of purposes and applications. This is where the line starts blurring and geospatial either gets integrated or rides on other platforms to produce knowledge or deliver complicated solutions to human problems.

Figure 2.2 explains the geospatial ecosystem in a digital environment.

The 3D scanner market is expected to grow from $3.41 billion in 2015 to $5.90 billion by 2022, at a CAGR of 9.6% between 2016 and 2022[8]

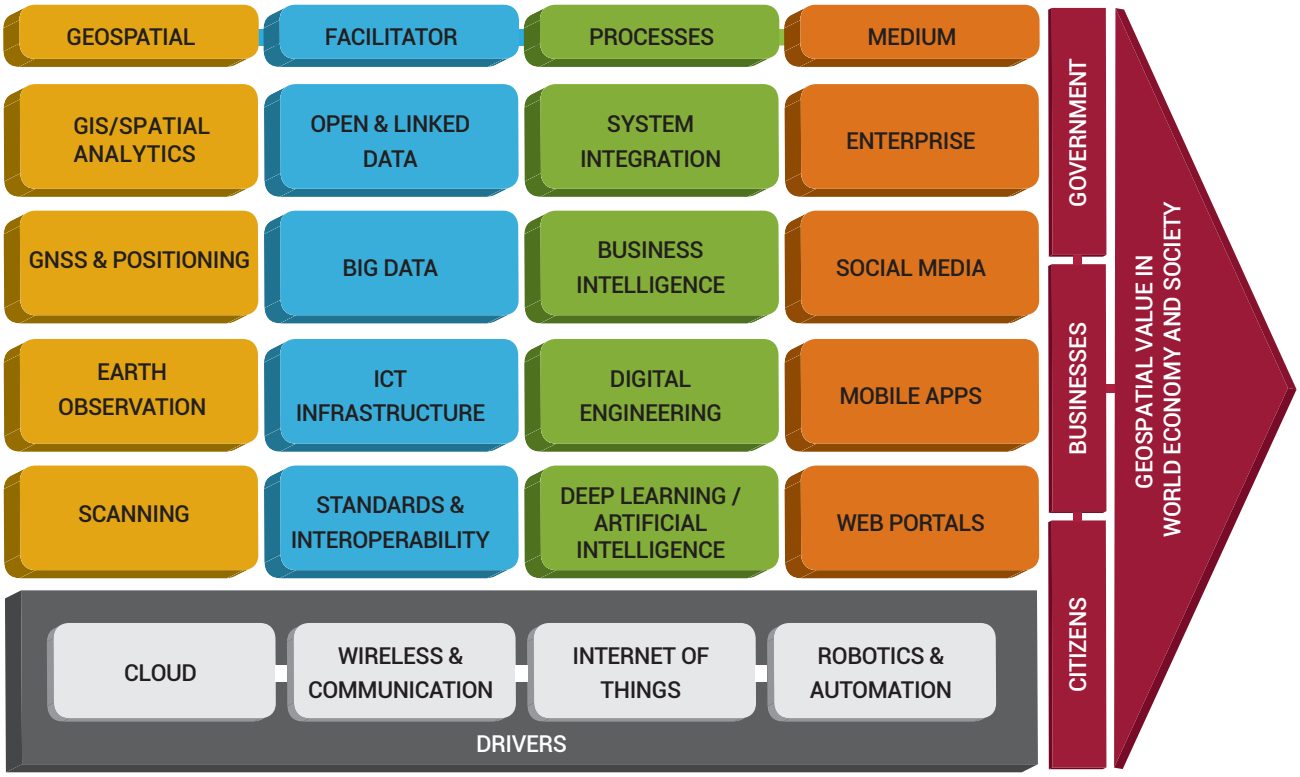
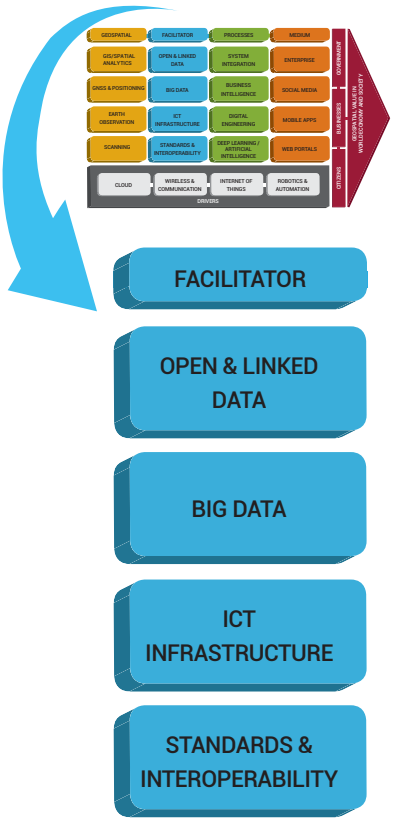


Figure 2.2 Geospatial Technology & Digital Ecosystem Yielding Value to Economy & Society



The first column lists out the main pillars of the core geospatial industry that are involved in data collection. The second column lists out various platforms that facilitate the outreach of geospatial technologies in their process of reaching out to users – open and linked data, Big Data, ICT infrastructure, and standards and operability. The third column stands for the processes on which geospatial rides – system integration, business intelligence, digital engineering. Finally, we come to the mediums that are used – enterprise technologies, social media, mobile apps and Web portals. The common drivers in this entire process are platforms like Cloud, wireless and communication technologies, Internet of Things and robotics and automation. The users could be citizens, governments or private enterprises, who all can be clubbed together as Geo Users.

The Facilitators

Open and Linked Data: The value of open data is well established now and ranges from improved efficiency of public administrations and economic growth in the private sector to wider social welfare. Governments across the world are moving toward opening their datasets. While the US government launched an open data initiative in 2011, the European Union is working on regulations to unlock the data held by European institutions. Between 2016 and 2020, the market size of open data for the EU 28+ is expected to increase 36.9% from €55.3 billion to €75.7 billion[9].

When 2.5 quintillion bytes of data are being created every day, the geospatial industry's ability to link information on the Web becomes extremely important. Linked data offers the opportunity to connect data to other pieces of data on the Web, contextualizing and adding value to the information that already exists. To this end, we may see data increasingly being distributed as 'linked data' in the coming decade.

Big Data: As location intelligence becomes more and more relevant across industries, Big Data and its analytics are what the future depends on. Big Data is characterized by five Vs — Volume, Velocity, Variety, Veracity and Value. While Volume is easily understood, Velocity, Variety, Veracity and Value lie in our ability to take fast-moving data and convert it into something meaningful through analytics.

Traditional geospatial data, which includes remotely sensed data, is structured and stored for analysis post facto in analytical systems like GIS. However, modern data with useful geospatial content like photos, social media chats, video, voice and messages now constitutes almost 80% of the total data. In its unstructured form, it cannot be used in conventional analytic systems like GIS because the sheer volume far exceeds the data storage capacity available. It also has a high velocity, but its veracity may require curation. Big Data improves innovation, sustainability and translates into billions in savings. Globally, the Big Data technology and services markets is expected to touch $48.6 billion by 2019, growing at a CAGR of 23.1% between 2014 and 2019[10].

ICT Infrastructure: Information and Communication Technology (ICT) Infrastructure encompasses all the devices, networks, protocols and procedures that are employed in the communications or information technology fields to foster interaction amongst different stakeholders. And geospatial is no exception here. ICT infrastructure includes computer hardware (servers and related workstations), network connectivity with accessories, and all the necessary equipment. It is a necessary condition for the deployment of digital services. ICT infrastructure is most fundamental to the most recent technological wave — the Third Wave — that uses information and knowledge as the prime factors in production. The Internet is the most influential category of ICT, making significant economic and social impact, especially in developed countries.

Standards and Interoperability: One interesting aspect of the recent technology advancements is the ability of interoperability, or the capacity of different and diverse systems, data, platforms, processes and services to efficiently and effectively work together.

Geospatial technologies are a pivotal part of this convergence. Interoperability between heterogeneous computer systems is essential for providing geospatial data, maps, cartographic and decision support services, as well as analytical functions. Geospatial interoperability is dependent on standards, which are essential to advancing data access and collaborations in e-Government, natural hazards, weather and climate, exploration, and global earth observation.

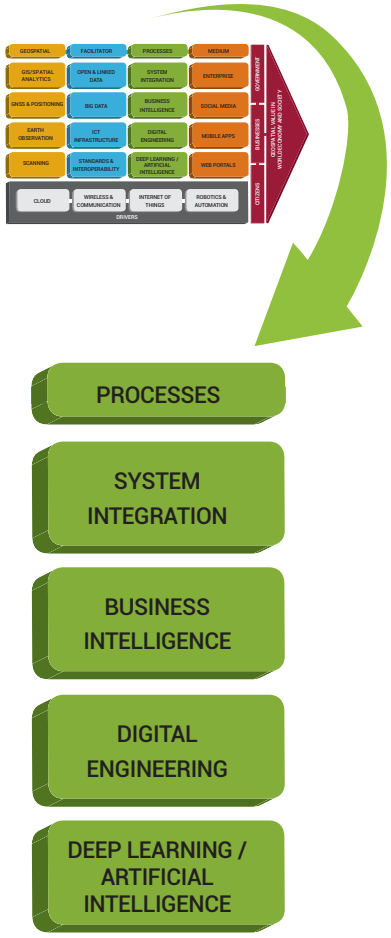
The Processes

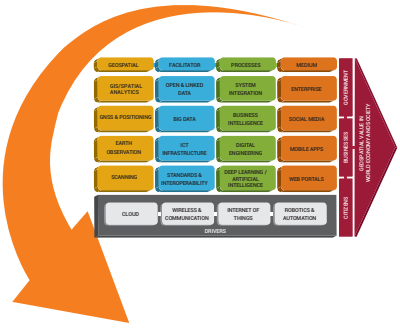
System Integration: As the world is beginning to reject systems that create silos or force inefficient workflows, system integration is the key to making disparate solutions fit the customer workflow rather than the other way around. Since there are too many permutations to simply make everything 'plug and play', systems integration will be the dominating trend across the industry for the next five years.

Further, geospatial capabilities are being integrated into all kinds of systems wherein they don't exist as separate industries. Geospatial content is being driven by tremendous innovation in the technologies used to generate it or the ones it rides on — faster processors, better displays, wireless networks, online databases, fixed and mobile sensors, etc. These disparate technologies are growing new branches and spawning new hybrids as inventive minds seek new solutions.

Business Intelligence (BI): About 80% of all data stored in corporate databases has a spatial component. Traditionally, such data would be presented to the user in the form of long reports, either with graphs and pie charts, or in a spreadsheet format. Now, given the complex interrelationships of multidimensional data, integrating spatial data and visualization technology has become ineluctable for offering an accurate, high impact insight to business intelligence users.

Humans think visually. Therefore, BI environments must provide visualization techniques based on spatial





relationships. In this background, spatial data is becoming a boon to analysts, wherein the definition of a modern warehouse needs to include 'space-centric' aspects along with traditional characteristics, such as, 'integrated' and 'time-variant'.

Digital Engineering: The key to successful digital engineering (aka Building Information Modelling or BIM) lies in proper management of data. Aligning that data across multiple project stakeholders and project lifecycle phases provides a platform on which the model can be built. That said, digital engineering is not limited to just creating models. Unlocking knowledge and insight, and creating the platform for true collaboration are its mainstays.

Efficient management of geospatial information is fundamental to the success of engineering projects across the private and public sectors, underpinning a wide range of activities — from sustainable development, conservation and environmental monitoring to infrastructure planning, implementation and asset management.

Artificial Intelligence (AI): AI encompasses many technologies like cognitive computing, machine learning, language processing, neural networks, data analysis, information retrieval, genetic and evolutionary computation, knowledge discovery, machine vision, and, of course, the latest catch word, deep learning. All these techniques have one common thread: how to mimic human faculties like vision, thought processes and reasoning using computers.

In geospatial systems, for example, one of the accepted methods of classification of remotely sensed data for thematic mapping is using AI software called Neural Networks. Companies like DigitalGlobe and Airbus Defence & Space are already taking help of artificial intelligence and deep learning to process large volumes of satellite imagery to identify objects and patterns automatically in huge volumes of satellite imagery. The next step will be the ability to handle information in a manner that enables a personalized experience, as is illustrated by Apple's Siri or the Google Assistant.

Artificial intelligence could dramatically boost economic growth and productivity by up to 40% in 2035, while the economic growth in the US could increase from 2.6% to 4.6 % over the same period with the adoption of AI technologies[11]. Among the countries that stand to make the largest gains in productivity from AI in 2035 are Sweden, Finland, the US and Japan.

The Mediums

Enterprise Systems: Like all other enterprise systems — essentially large-scale application software packages that support information flows, business processes and data analytics — enterprise GIS is a system that is integrated for the entire organization to enable all its employees to manage, share, use, create, visualize, analyze and disseminate spatial data. GIS-based data service levels may be formal or informal agreements between departments, divisions, or external agencies such that the enterprise GIS is the application system that holds a process together.

Social Media: Ubiquity of location and smartphones in every hand has led to an ever-increasing amount of spatially located information on social media — in most cases, without it even being a conscious decision of the user. In addition to an exponential increase in the availability of geo-referenced information, as the use of social media for providing realtime information and expanded functionality increases, it offers newer opportunities for location-based service providers to further detect patterns and behavior prediction.

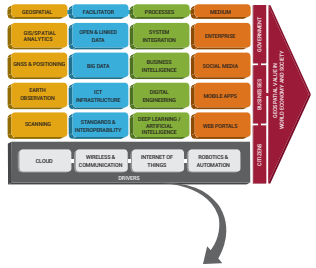
Mobile Apps: The growth of apps has been driven by the evolution of mobile devices like tablets and smartphones. What's new in this segment are the professional apps that cater to users from the fields of science, engineering, defense, homeland security, administration and business. Today, soldiers, police personnel, firefighters and rescue teams require apps to navigate areas under threat or damage. Professionals do not have to go back to their desktops for analysis. This has made in-situ decision-making and viewing the results in real-time or near-real-time possible. Apps are platform and software neutral, and have to follow open standards to be acceptable in the marketplace, which makes this medium a gold mine for independent developers.

Web Portals: Geospatial Web portals, often referred to as geoportals, are a popular way of delivering geographic information and associated services, such as, updates, analysis, etc., via the Internet. Geoportals are important for effective use of GIS and are a key element of Spatial Data Infrastructure (SDI) for any nation. Geographic information providers, including government agencies and commercial sources, use geoportals to publish geospatial metadata of their geographic information. Geoportals can help avoid duplicated efforts, inconsistencies, delays, confusion, and wasted resources.

The Drivers

Cloud: Geospatial systems are solutions always in search of innovative technologies. The emergence of Cloud computing has provided a platform for the evolution in Big Data Analytics with an elastic, on-demand computing platform to integrate the essential elements of the geospatial sciences — observation systems, parameter extracting algorithms, phenomena simulations, analytical visualization and decision support. Public cloud services are expected to cross $195 billion in 2020, more than doubling the $96.5 billion in revenues forecast for 2016 and representing a compound annual growth rate (CAGR) of 20.4% over 2015-2020[11]. While these figures are for the total Cloud computing market, geospatial Cloud services are also forethought to grow at similar rates.

Wireless and Communication Technologies: A seamless and robust spatial decision support system relies on three major components — Internet GIS, Mobile GIS and broadband wireless communication networks. Each component needs to be customized in order to provide real-time or near-real-time GIS functions.



Further, location-based services depend on two cutting-edge technologies — wireless location and mobile Internet. Recent developments in the processing capabilities of smartphones and other mobile computing devices have contributed to making LBS much more accessible to many users. Persistent efforts by IT majors have led to location information being shared much more freely globally, and LBS being buttressed in many parts of the world where comprehensive spatial databases are either still being developed or are too expensive to access.

Internet of Things (IoT): Fundamentally, IoT is about devices connected to the Internet or Machine-to-Machine (M2M) communications. But, the real value of this technology is not based on the tons of data these sensors and devices are gathering every second. Its true potential depends on that data's analysis, and on how Cloud-based applications leverage that information. Currently, the Internet is human-orientated. The change toward machine learning or IoT will need to take into account devices which are, for all intents and purposes, autonomous and act independently.

2020 will be a big year to watch out for while talking about the Internet of Things. As many as 50 billion devices[12] will be connected to the Internet by that time, making the IoT industry $1.9 trillion in size[13]. IoT will start to impact close to 6% of the global economy in the next four years[14].

Robotics and Automation: Even as the debate rages over robotics and automation taking away jobs, Oxford University researchers have estimated that 47% of US jobs could be automated within the next two decades[15]. In the geospatial space too, unmanned and remote autonomous systems and interactive robots are boldly going where no one has gone before.

The growing adoption of unmanned platforms such as UAVs and robotics has taken hold in the public safety and security space. From tactical military situations to routine security patrolling, these platforms have the potential to transform traditional security and public safety processes. Robotics and automation are already addressing challenges in risky or complicated operations where continuous human presence is either undesirable or impossible, such as such as mining, engineering systems or utility maintenance.

Geospatial Industry in Economy and Society

If growth drivers are to be considered, the geospatial industry couldn't have had it better. The continuing global economic uncertainty has brought increased focus on productivity. While companies and government are battening down the hatches, dramatically reducing staff and spending, there are others looking at how they can use the time of uncertain to advance their business.

Geospatial technologies provide not only the ability to manage and integrate data, but also the analytical tools that sharpen decision making and, ultimately, save time and money (Figure 2.3)**.** Using data in new ways counteracts the forces of a sluggish economy. It helps make organizations efficient and

resilient during economic downturns. A Google-commissioned report prepared by Oxera in 2013 found that the global geo services generate $150-$270 billion in revenues.

No wonder then most developed countries and forward-looking governments are turning geo evangelists by encouraging uptake of spatial technologies in work processes. Certain countries have adopted the technology more quickly than others. The legislative approach of governments of these countries in bringing market-oriented policies and enabling the users to capitalise on such a versatile technology is the major reason for the growth.

Global Geospatial Initiatives

Geospatial technology and information has great potential to be a public commodity and a panacea to the larger challenges facing global economic and social well-being. However, this requires the right policy framework, such as the promotion of other technologies, including telecommunication, broadband and the Internet, to unlock its potential.

In addition to governments and government agencies, many international organizations have been working on issues related to geospatial information. A big boost to the sector when in 2015, the United Nations Sustainable Development Agenda recognized the importance of

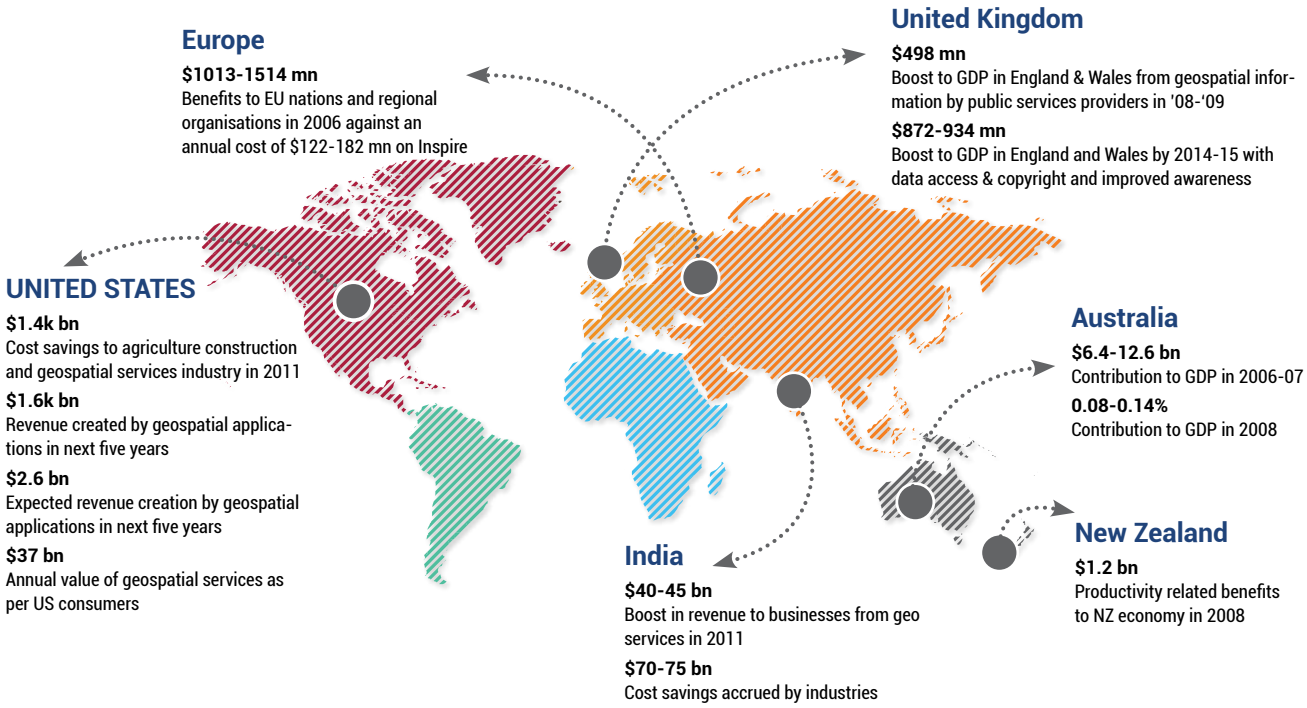


Figure 2.3 Geospatial Technology Bringing Benefits to the Economy & Society

space-technology-based data, in situ monitoring and reliable geospatial information for sustainable development policymaking, programming and project operations[16]. This was a formal recognition of declaration in the Rio+20 Outcome Document, *The Future we Want* in 2012: "... the importance of space-technology-based data, in situ monitoring and reliable geospatial information for sustainable development policymaking, programming and project operations" and noted "the efforts in developing global environmental observing systems, including .... the Global Earth Observation System of Systems (GEOSS)[17].

UN-GGIM: The United Nations initiative on Global Geospatial Information Management **(UN-GGIM)** aims at playing a leading role in setting the agenda for the development of global geospatial information and to promote its use to address key global challenges.

UN-GGIM-Private Sector Network: The UN-GGIM PSN was established during the sixth session in New York in August 2016 to work in a mutually beneficial collaboration with Members for development of global geospatial information to address key global challenges; enable citizen services; support the initiatives of United Nations; facilitate direct connection and communication for the private sector with member states; and facilitate an ongoing dialogue for collaboration between and amongst members of UN-GGIM and participants of PSN.

GEO: The Group on Earth Observations (GEO) is a partnership of around 100 national governments and more than 100 participating organizations that envisions a future where decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained earth observations.

G8: As part of an Open Data Charter signed in 2013 at the G8 summit in Northern Ireland, the Group of Eight economic powerhouses have put geospatial information firmly at the forefront of international efforts to drive economic growth and use transparency to improve accountability. The G8 members identified 14 high-value sectors including geospatial data and infrastructure from which they will release data.

World Bank: For international development organizations and professionals at institutions like the World Bank, every project and initiative has geospatial data. The World Bank uses geospatial data and owns a huge amount of it. The Sustainable Development Network (SDN), a vice-presidential unit of World Bank, has launched the tool GeoSDN, which is a repository for geospatial data and a Web interface that offers a new capability to leverage development datasets and to analyze them in the context of an online mapping tool. The Platform for Urban Management and Analysis (PUMA) is another geospatial tool from World Bank that allows users with no prior GIS experience to access, analyze and share urban spatial data in an interactive and customizable way.

Asian Development Bank: ADB recognizes that space technology and geographic information can be applied to various development works. Based on this understanding, ADB has implemented many projects applying space technology and GIS since the 1990s.

Food and Agriculture Organization: The United Nation's FAO uses satellite remote sensing, GIS and global positioning systems for comprehensive worldwide assessment and monitoring of environmental conditions related to sustainable agriculture development and food security. FAO's interactive visualization Geonetwork - is built upon a host of datasets - is an open source platform that allows enables sharing of geographically referenced thematic information between different organizations to improve access to and integrated use of spatial data and information.

COP21: The COP21 Climate change agreement doesn't mention the role of geospatial or space technologies explicitly in the official draft. This despite the fact that spatial data and technologies have become fundamental to environment monitoring and protection. Further, the the UN Office for Outer Space Affairs (UNOOSA) focuses on space technology and sustainable development in a major way.

Global Direction: Where Is It All Heading?

Position to Precision

A decade ago, geospatial as a domain was still evolving. And everybody felt that GIS could be used only for decision-making. This thought was being

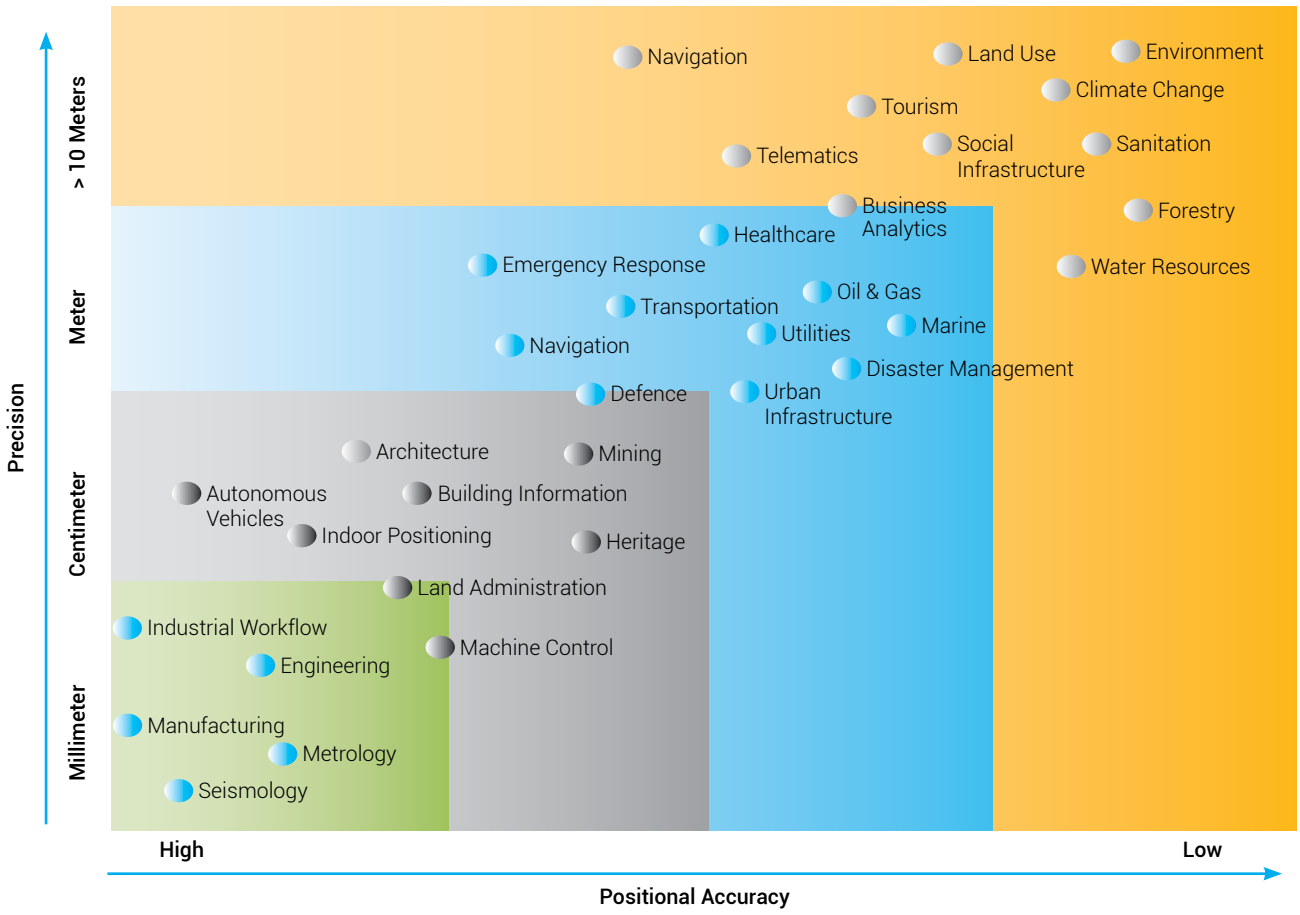


Figure 2.4 Geospatial Industry Applications Moving from Position to Precision

broadcasted in colleges and universities too. Recent technological advancements have changed the state of affairs. Geospatial technology today uses modern software and hardware to store, access, visualize, map, analyze, and disseminate geographic data. And it is permeating into all kinds of processes. Geospatial data can now be referenced to a globally defined coordinate system. An integrated analysis of these combined data can provide new insights into the geographic phenomena.

The market for geomatics products can be broken down into three segments by the level of accuracy: consumer grade, resource grade, and survey grade

The most important benefit that geospatial technology offers today is efficiency, followed by precision, monitoring, analytics and productivity. As is with all technologies, the value from increase in productivity will become much higher in the coming times.

Today, the industry includes basic and applied research, technology development, and applications to address all types of planning, decision-making, and operational needs of the government, the private sector, science, and individuals. Today, as the industry moves from position to precision (Figure 2.4), the market for geomatics products can be broken down into three segments by the level of accuracy: consumer grade, resource grade, and survey grade.

Everything Happens Somewhere: Consumerization of Geospatial

As is the norm of the technology landscape, the most significant changes in the world of geospatial will not come from a singular technology, but from a combination of multiple technologies. The geospatial community itself is one of the best examples of this principle — the now-ubiquitous nature of mapping is only possible from the universal availability of global positioning, the increased reduction in the size of computers and the ability to store and distribute large volumes of data over different technologies. The globe is in our pocket now. Geospatial is in the process of becoming a toothbrush technology — something you use every day!

Sensors are not just processing the location and the properties of that location, but also the time that the information was collected, providing an important and foundation variable for so many applications and services. This is an important and growing trend.

In the past, technology or products from the professional world would get migrated to the consumer space. Today, that trend has shifted with the consumers driving and seeding the development in the professional ecosystem. The rise of social media and Internet has also added on to this interest in location from the consumer side.

There are different tiers of what is required to support the geospatial initiatives — the consumer tier, the professional tier, and then something in the middle — the 'prosumer' market, which sort of dabbles with some professional requirements, but also needs basic mapping capabilities.

As location becomes mainstream, the line between geo and non-geo is fast getting blurred. Today, geospatial industry is not comprised of only a handful of 20-30 core geo companies that deal with location. It is about every industry that deals in location and builds on top of it. And then there are the startups — a growing ecosystem of new ventures that has the blessings of the investor community.

The geospatial industry is the prime example of a highly dynamic market whose members may be able to benefit from ecosystem mapping — particularly as older, high-investment incumbents struggle with new innovative disruptors.

Technology is enabling better business models. For the geospatial industry, it is an opportunity to connect it with sensors, real-time data, and Cloud computing to deliver smarter solutions.

Ten years ago, geospatial was all about visualization. Today, it is more prevalent at the enterprise level. The GIS silos are breaking. They are becoming a part of a larger picture. Business processes are being integrated. This is the future direction — a representation of *tomorrow*.

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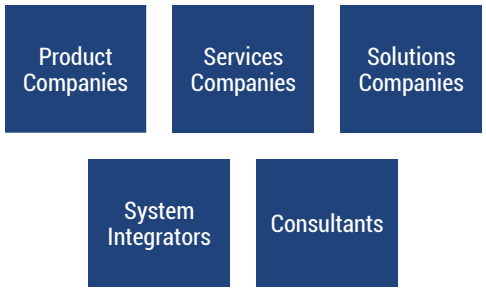
3. LANDSCAPE OF GEOSPATIAL INDUSTRY

In the last decade, core geospatial technologies have not only evolved exponentially, they have rallied with a potpourri of information technology disciplines to complete the digital puzzle. The discrete, arcane quests known to the world as GIS, earth observation, GPS, location-based services and navigation systems are no longer obscure. Fast becoming routine, spatial technologies today interact freely through a network of enablers like the Internet, wearables, sensors, and wireless and portable computers. Geo-information today underpins the digital world, and has wide-ranging implications on both, the emerging technologies and our society.

Driving technologies have been disrupting the geospatial industry fabric and adding new dimensions to the value of geoinformation creating a geographical language of communication between policies, processes and practices

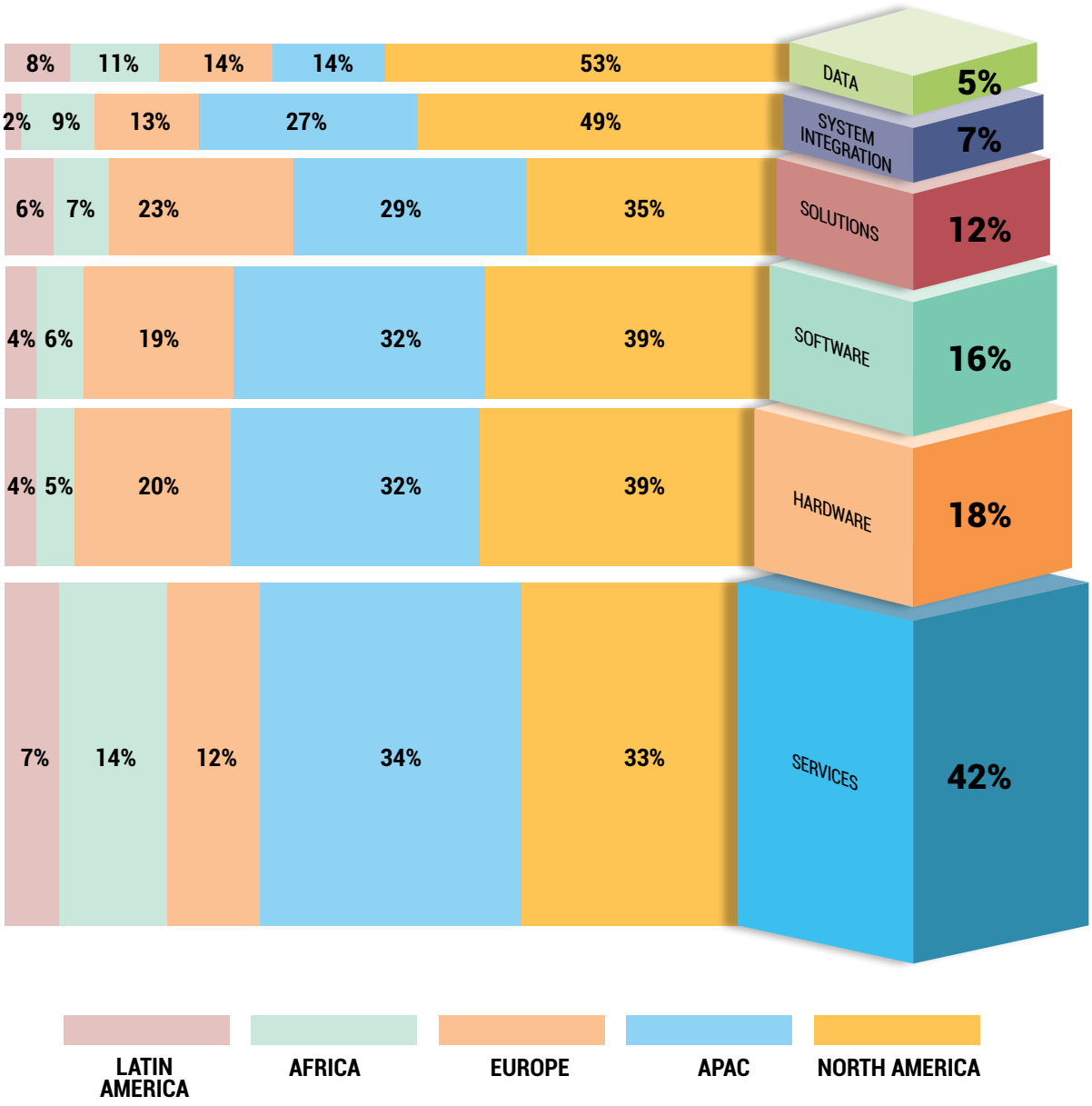
The constant transformation in the geospatial landscape and business environment is simultaneously giving birth to exciting opportunities and formidable challenges. Information, communication, and other driving technologies have been steadily disrupting the industry's fabric and adding new dimensions to the value and utility of geo-information and practices. In a way, all this developments have created a geographical language of communication between policies, processes and practices. This, in turn, has enabled, reorganized and redefined the composition, character and the business models of the industry.

When seeking to extend the use of information about our changing earth to over a billion people, we need to understand and map the dynamics, behavior and the trends prevailing in the geospatial industry. This will help us to understand the direction of the industry as a whole. Geospatial Media & Communications recently dived deep into some of the key forces influencing the geospatial community and put them into a comprehensive framework to make sense of them all. More than 500 companies were surveyed to gauge the landscape of the industry and understand where it is heading.



Geospatial Technology Providers Footprint

Even though the transformation is evident, the largest representation comes from the services sector. This is, in fact, expected to continue in the near future. A representation of the global geospatial industry shown in Graph 3.1 clearly indicates this. Moving forward, and adding a regional dimension to the picture, the graph clearly indicates the distribution in different regions, namely, North America, Latin America, Europe, Africa and Asia Pacific.



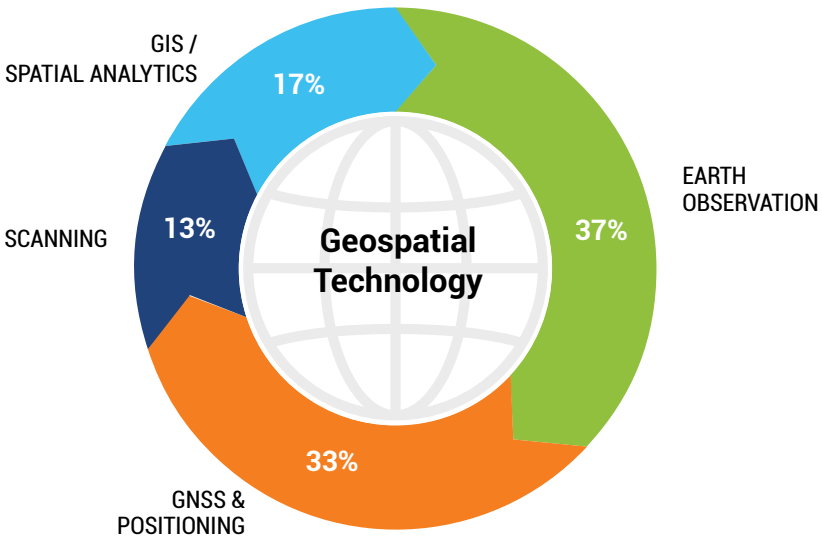
Graph 3.1 Percentage Share of the Technology Providers in the Geospatial Industry Ecosystem and their Regional Distribution

We are at the threshold of a new era in earth science analytics, where everything is about how we gather and process information from satellites, aerial devices, UAVs and video data

- It is observed that more than 40% of the global industry players are oriented to offer services in the geospatial market. Next in the line are product companies which include the hardware and software providers, followed by data products and solutions, and lastly the system integrators.
- North America dominates the market with a formidable presence in all the major segments.
- Asia Pacific is the region with the largest percentage of service providers, followed by North America. While Africa is also striving to make its presence felt with several companies offering services to the geospatial industry, Latin America shares a small percentage of the global service market.
- North America takes over the market with the largest percentage of hardware, software and solution providers, followed closely by Europe. With a major presence of the data companies in North America, the region stands out as the largest economy covering almost 50% of the global system integrator companies.

Technology Landscape

From a technological perspective, the industry can broadly be divided into four categories, wherein companies working in the earth observation space are leading. The earth observation segment comprises of satellite, aerial devices, and in-situ systems which are well-recognized as critical for monitoring the planet (Graph 3.2). This indicates that we are at the threshold of a new era in earth science analytics, where everything is about how we gather and process information from satellites, aerial devices, UAVs and full-motion video data. This segment of the industry has seen a proliferation of new players in the past few years,



Graph 3.2 Percentage Share of the Components of Geospatial Technology

such as, small satellites and swarms of nanosatellites.

Meanwhile, there is a buzz in the air. And it is being created by unmanned aircraft systems (UAS)! The industry is excited about the endless data collection and analysis possibilities all these platforms enable. This is what is making earth observation companies dominate the ecosystem.

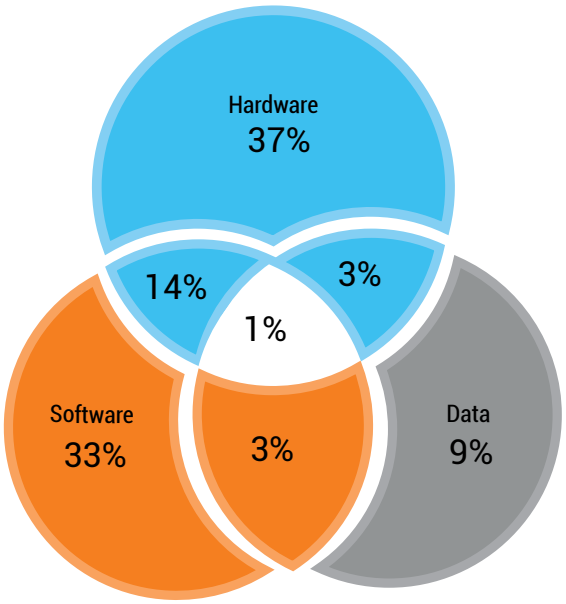
When it comes to surveying, GNSS is ubiquitous. Followed by the advancement in real-time network capability and permanent base stations to modern communication methods of radio or cellular transmission, GNSS instruments have become one of the most valuable tools in the professional surveyor's kitty. Moreover, an enhanced role for GNSS in both consumer and professional markets is evident from the fact that more than 40% of the players of this ecosystem are working in the GNSS space.

We are at a technological tipping point in geospatial analysis. As the tools of the profession continue to evolve, more surveyors are venturing into 3D technology. Not so long ago, scanning technology like LiDAR was considered specialized and quite niche. Recently, it made a dominant place for itself in the entire ecosystem. And today, it has become completely democratized. We are even talking about putting LiDAR on phones. From a technology's standpoint, LiDAR is all set to become a 'commodity'.

Industry is witnessing a fusion of hardware, software and data to create, manage and deliver seamless solutions.

Product Companies Landscape

The trend is toward diversification and branching out into multiple lines of businesses that may include hardware, software and data. This is in order to



Graph 3.3 Percentage Share of the Product Companies in the Geospatial Industry

Geospatial technologies are taking quick strides into various sectors across the world

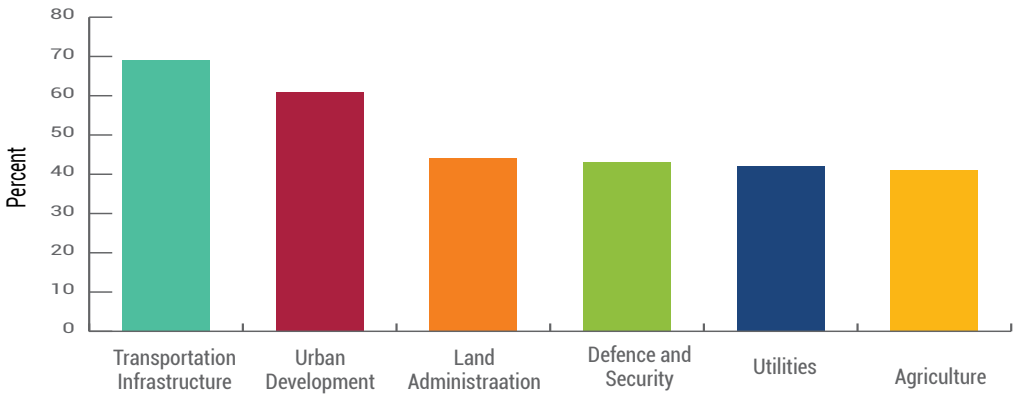
meet the customer's requirements, which is no longer one-dimensional. The industry is witnessing a fusion of hardware, software and data to create, manage and deliver seamless solutions. Instead of proprietary hardware and software packages, the industry today is doling out software-ready hardware. So much so, 14% of hardware companies today make software as well (Graph 3.3).

All this leads us to the solution-centric approach the industry has adopted. The realization of the value of content and up-to-date location information is compelling companies to move to the intersection of hardware, software and product. Today, 1% of the companies are in this zone. Data automation is also the raison d'être for this.

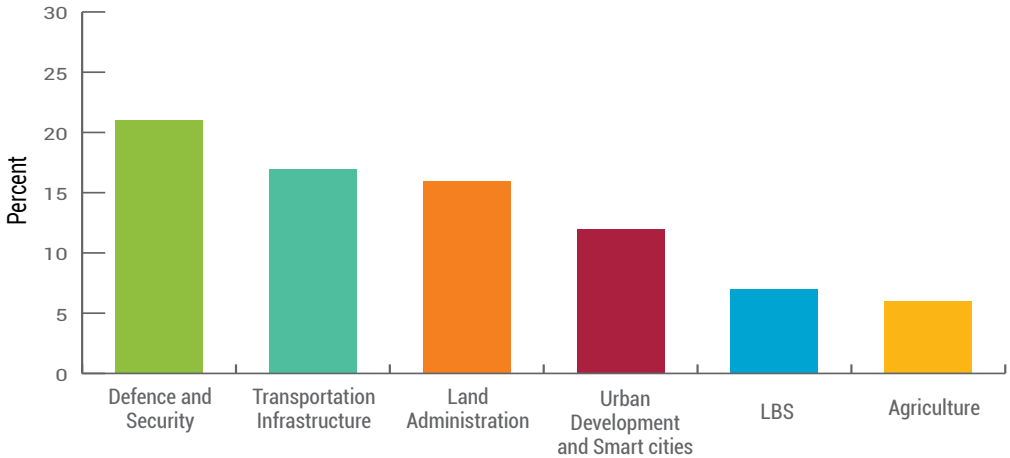
Industry Segments and Geospatial Technology Providers

Geospatial technologies are taking quick strides into various sectors globally. Though not in very advanced stages in most of the sectors, their applications have surely found new avenues of implementation in the last few years.

Transport infrastructure is a major focus segment for the technology providers.



Graph 3.4 Industry Segments where Geospatial Technology Provider are Focusing



Graph 3.5 Industry Segments Contributing to Business Volume of Geospatial Technology Providers

Nearly 69% of them are focusing on providing technology solutions in this sector (Graph 3.4). Other segments on the priority list include urban development, land administration, defense security, utilities and agriculture.

Looking at the aggregate volume of business coming from industry segment, defense and security contribute the most with a massive 21% share in the total business of different technology providers. This is followed by transport infrastructure (17%), land administration (16%), urban development and smart cities (12%), utilities (7%) and agriculture (16%) (Graph 3.5).

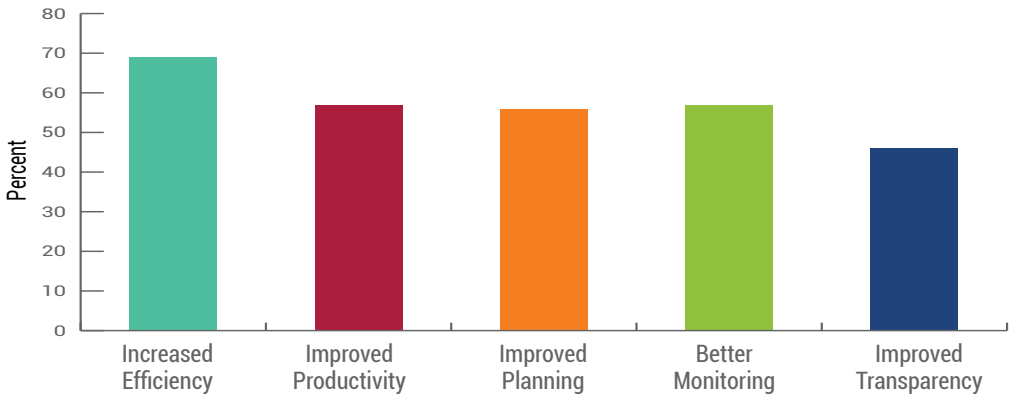
It can be seen that, overall, 80% of the business comes from these sectors.

Benefits of Geospatial Technology

- Nearly 70% of the users feel that increase in efficiency is one of the most critical benefits. These are associated either with carrying out the project or improvements in the project efficiency itself. Geospatial technologies considerably reduce the time it takes to complete the project and improve the customer service.
- For long, businesses have viewed the improvement in productivity that comes from implementing geospatial technology as a way to beat the competition and increase bottom line. Governments have also adopted geospatial technologies in projects that require accountability. Both public and private sector see improved productivity as a factor critical to the management of time, labor and cost (Graph 3.6).
- Geospatial's ability to integrate databases and visualize the spatial relationships between various components encourages partnerships and data sharing. Users find the technology helpful in identifying potential problems early in the planning process.

Challenges in Implemention of Geospatial Technologies

Adoption of any new technology comes with several challenges attached to it. It has been observed that geospatial technologies have also be constrained by certain factors during the various stages of implementation.



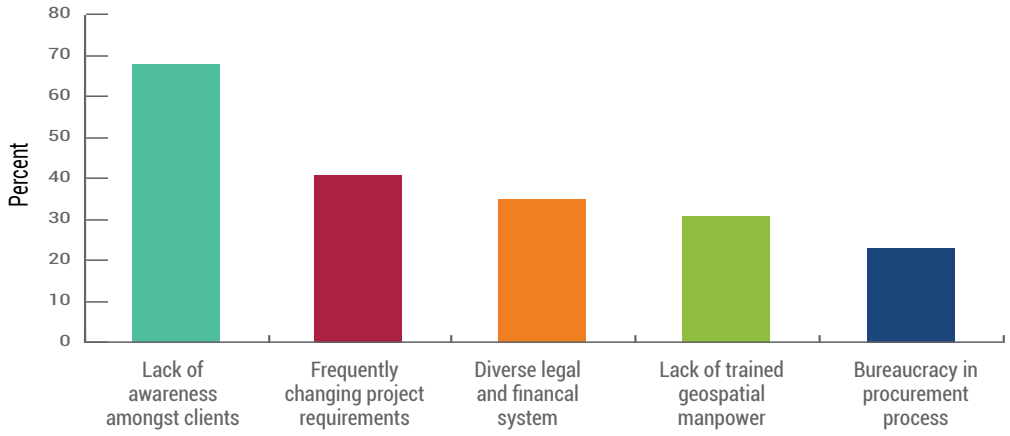
Graph 3.6 Benefits Derived by Adoption of Geospatial Technologies

Adoption of technology comes with several challenges attached to it. It has been observed that geospatial adoption is also constrained by certain factors during the various stages of implementation

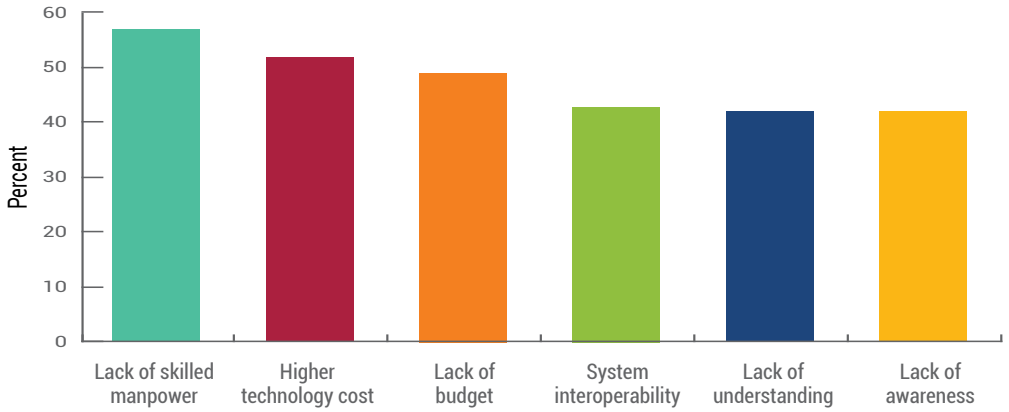
Of these, the most worrisome factor is the lack of skilled manpower. Non-availability of the skilled and trained professionals has an adverse effect on the quality of the project. Hence, it is imperative to increase awareness, training and mentoring to develop the requisite skillsets in the professional community (Graph 3.7 A).

Higher technology cost and lack of budget are among other major challenges. Cost of technology (i.e. hardware, software, training, etc.) was identified by practitioners as both the biggest challenge for the use of geospatial technology, and a major factor that hinders the use of said technology (Graph 3.7 B).

Geospatial technology requires specialized knowledge. About 40% of the users consulted, identified the lack of knowledge about the technology or low-level of knowledge as a hindrance to its use. Contrary to the users, the technology providers see this as the biggest challenge. The other major challenge from the perspective of technology providers is the frequently changing project requirements and bureaucracy in the procurement process.



(A) From the Perspective of Users



(B) Perspective of Technology Providers

Graph 3.7 Challenges of Implementing Geospatial Technologies

4. EVER-EVOLVING GEOSPATIAL PRODUCTS

Steve Jobs, co-founder of Apple and a model of innovation, once said, "Innovation distinguishes between a leader and a follower." Like in several other domains, things are moving pretty fast in the geospatial sector as well. To sustain in this field, businesses constantly need to come up with a 'creation', not a 'reaction'.

Ever-increasing data sources, analytics and processing capabilities are revolutionizing the geospatial community's ability to map and monitor our changing planet. The cutting-edge competition in the geospatial technology and services is not only resulting in the rapid growth of the industry; it is also shaping our future.

The industry is coming up with products having enhanced capabilities, multiple applications, and improved features, resulting in making products ready for integrated solutions

The quest for the industry to offer complete solutions in the market is resulting in more acquisitions, collaborations and partnerships between the hardware, software, data producers and service providers for different products. The innovations happening in the segment are making products ready for integrated solutions.

Unsurprisingly, the industry is coming up with products with enhanced capabilities, multiple applications, and improved features, resulting in easy and efficient work. Some of the key trends observed are:

Earth Observation

Nanosatellites and Small Satellites for High-Definition Imaging and Videography

Microsatellites have invaded space with developmental and commercial intents, offering high-definition pictures and videos. This trend has been driven by a number of important converging factors, of which the most significant is ultrafast space-qualifiable micro-electronics that help in reducing the cost of this satellites. Smallsats have democratized EO data, with a huge impact upon areas as diverse as deforestation, disaster relief, agriculture, desertification, security, water management, and more. It is safe to say that nanosatellites are changing the economics of space (Figure 4.1).

Light-Weight Sensors and Satellites

The continuing trend toward miniature imaging sensors has resulted in creating a new generation of light-weight airborne remote-sensing platforms, offering very high spatial resolution

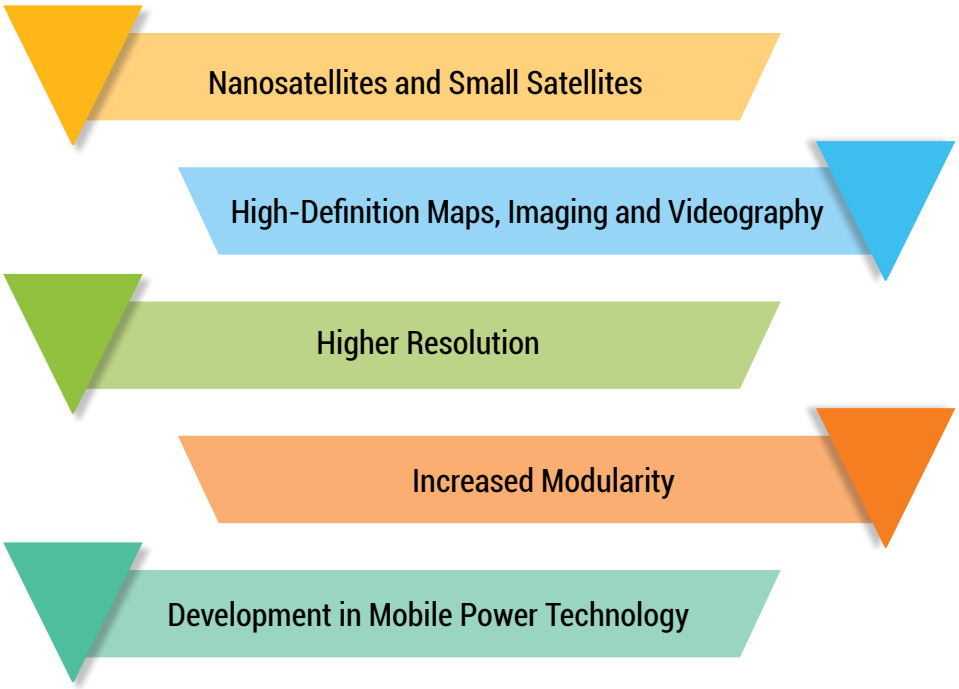


Figure 4.1 Current Trends in Products Pertaining to Earth Observation

and an unparalleled operational flexibility. The advancement of small satellites in the 1–500 kg range is being supported in the satellite space as well in technology spheres. Both commercial and space industries are enabled by advances in low power, highly-integrated, miniaturized (low volume), light-weight, and reliable real time embedded systems.

Higher Resolution

Many users who previously relied on aerial imagery now benefit from the improved economics, global availability, and faster refresh rate of satellite imagery, which is available at a resolution as high as 30 cm. Previously, to get imagery of this resolution, one had to depend on aerial platforms, which often proved to be costly and even impossible to access in many parts of the world. Today, the new 30 cm imagery products are a rapid and affordable alternative for all. New imagery orders can be delivered on timescales of weeks or even a few days in many cases, as opposed to months earlier. Customers can also leverage from a rapidly-growing volume of available 30 cm archive imagery.

Increased Modularity

In the space of aerial photography, advancements have happened in terms of more modularity, increased processing power and real-time air-to-ground transfer capabilities, as well as increasing

proliferation of engine, aircraft system and airframe component sensors.

Mobile Power Technology

It has revolutionized the unmanned vehicle segment. Thin and light-weight solar panels, that do not significantly impact the weight or aerodynamics of the aircraft, are ideal for unmanned systems. This is especially true in the case of aerial vehicles that require power for long endurance missions without returning to ground.

GNSS and Positioning

Increased Accuracy

The trend in the last decade has been toward decimeter- to centimeter-level accuracy. This has been possible not only as a result of reduced pricing, but also because of higher accuracy in correction services. This trend is quickly gaining importance because businesses want to reach their customers on time, and at the right place by using contextually relevant, personalized, and multi-dimensional products (Figure 4.2).

Compactness and Light-Weight

Light and compact products are top trends for new-generation surveying instruments.

Multi-sensor System

The development of multi-sensors has greatly accelerated in the recent years.

Microsatellites have invaded space with developmental and commercial intents, offering high-definition pictures and videos

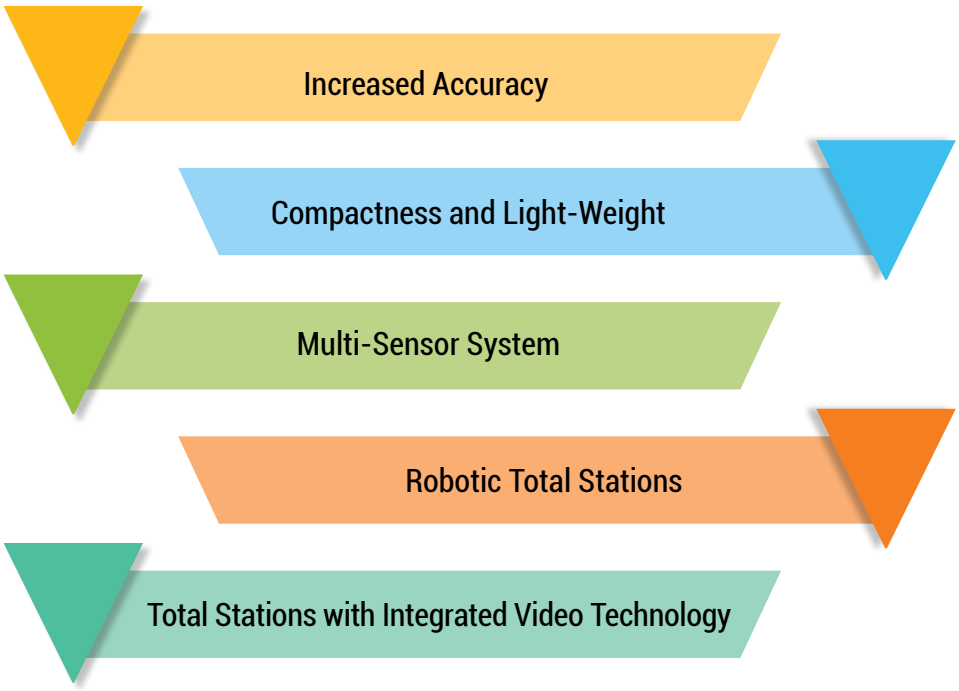


Figure 4.2 Current Trends in Products Pertaining to GNSS and Positioning

Technology development driving a paradigm shift in surveying. We are seeing the emergence of total stations with integrated video technology

One of the latest application trends is to deploy such systems in indoor environments. If mapping systems are used in buildings, GNSS measurements will no longer be required. This platform serves not only as a means to explore new sensors for indoor applications, but also to ensure that a system is suitable for outdoor use — which is the current state of affairs.

Robotic Total Stations

Over time, and keeping pace with the microelectronics revolution, the primal design of the total station has been extended with features that have made surveying faster and more convenient. A piece of technology that has changed the profession is robotic total stations. These remote control devices allow surveyors to measure angles, distances, and more without traveling to each point themselves. This can save time and money, and also cuts down on the amount of workers needed and the manual labor that the job typically requires.

Total Stations with Integrated Video Technology

New technologies and changing demands are driving a paradigm shift in modern surveying. Rapid technological development now extends beyond measurement to include computing, communications and geospatial data mapping. The integration of surveying technologies will continue. Integrated survey rovers, which combine GNSS and total station target on a single pole, are already available. Now, we are seeing the emergence of total stations with integrated video technology that enables surveyors to see exactly what the instrument sees and to capture geo-referenced images for use in photogrammetry and 'in-office surveys'.

GIS/Spatial Analytics

From Cloud to Mobile

Today's mobile devices provide far more than communications on-the-go. Mobile apps are also revolutionizing the potential for rapid information dissemination and access. With this, the trend is moving from webification to appification for the consumers of location. This trend has democratized the location component in every sphere (Figure 4.3).

Software Integrated in Hardware

Hardware and software sub-systems have joined forces in the current environment. This integration is one of the most rapidly growing trends in the geospatial domain. The complexity of today's systems, especially the embedded ones, has increased the demand for the know-how in hardware issues as well as advanced software with real-time operating and processing systems. We see an integrated way at system level, as well as the use of unified tools and techniques for system design enhancing the entire workflow.

Platform for Comprehensive Delivery

There has been an increasing attention toward designing a dynamic experience that provides an ongoing information service. This has been effective in moving beyond maps to fuse the art of design

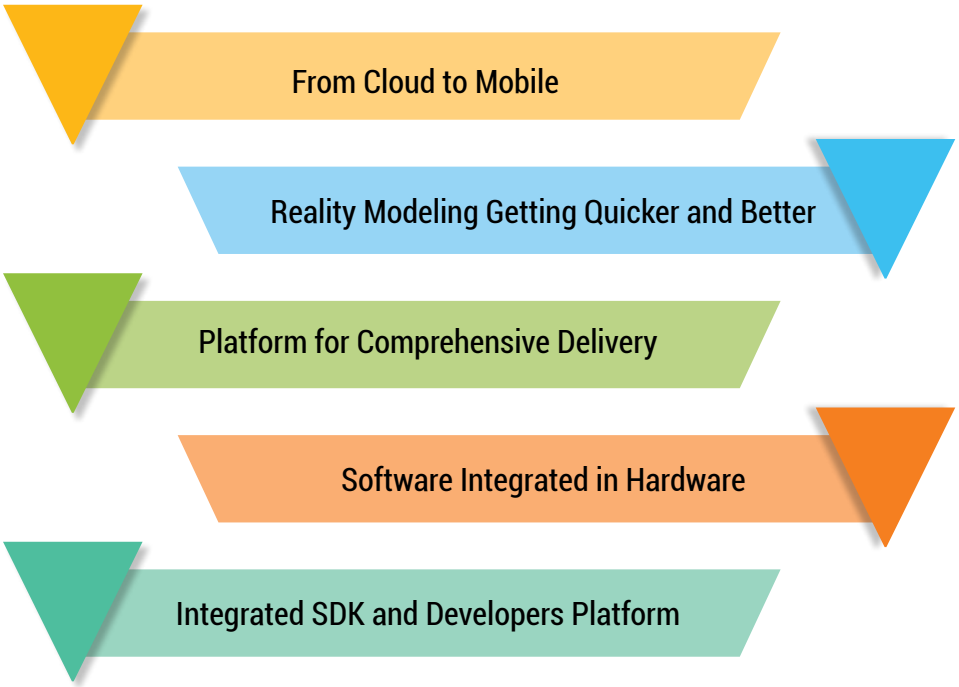


Figure 4.3 Current Trends in Products Pertaining to GIS/Spatial Analytics

> **Integrating the latest laser-scanner hardware and software makes it possible to speed up the documentation process**

and communication with mapping. The technology is moving toward empowering experts to build Cloud-based applications that harness fresh content, and analytics to provide a dynamic information experience. This trend not only empowers spatial experts, it also encourages non-geospatial business experts to tap into the power of geospatial content to answer their own, focused, specific business questions and problems.

Reality Modeling Getting Quicker and Better

Geospatial professionals today have an end-to-end solution for converting reality captured with photos or scans into high-definition 3D meshes. What is known to us all as mesh reality, helps make the matrix quicker and less tedious. This trend highlights the benefit of having a single platform through which a vast array of applications can access common data-types. It is actually an incredibly powerful hybrid environment, as models may be derived from data sourced from a wide variety of inputs and can benefit a range of existing vertical applications.

Integrated SDK and Developers Platform

SDK support (developers' platform) with sensors, drone applications, software, etc. helps developers to create customized applications and expand

the use of sensors to suit any need in the field. Embedded analytics is a result of this accelerated business process.

Scanning

Portability

From a system that was known to be bulky and expensive, to a handheld system that is not only affordable, but also easy to operate and highly accurate, laser scanners have come a long way. The latest models are portable, highly intuitive to their surroundings, and can be used in a variety of environments (Figure 4.4).

Increased Effectiveness in Documentation Process

Integrating the latest laser-scanner hardware and software not only provides the said effectiveness and required robustness, but makes it possible to speed up the documentation process as well.

Multi-Sensor Vehicle-Borne Laser Mapping System

We are witnessing a rise in multi-sensor integration that intelligently integrates data from multiple sources to derive synthesized information to facilitate decision-making. Fusing data from multiple sensors involves a formal framework that expresses the necessary means and tools for fusing the data, and exploiting the synergy of this fusion to generate information. Bundled to this is the software integrated in the system. This multi-sensor integration applies detection, pre-processing, fusion, and data interpretation to derive the precise, sought-after information.

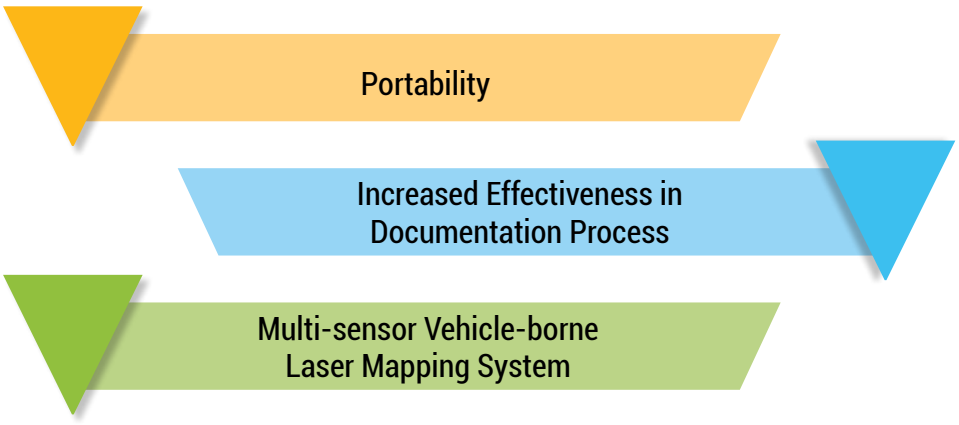


Figure 4.4 Current Trends Pertaining to Scanning

5. TECHNOLOGIES DRIVING GEOSPATIAL INDUSTRY

Technology never stands still. Never. And this fact has become more evident as we enter deeper and deeper into the information age. The many advances that have burst onto the scene in the geospatial industry during the last few years herald that innovation makes the world go round. Innovations, like increasingly sophisticated systems and web-enabled devices embedded with location technology have catapulted the industry to the forefront of business and application development.

One of the reasons why geospatial is always on the forefront of the things is because the industry readily adapts to new technologies, applications and business models. These advances in convergence have, in turn, made geospatial more user-friendly, synergistic and compelling.

Though geospatial technologies has never been standoffish, it has come a long way from the time when the process of geospatial analyzes and processing was considered highly complex. A part of our daily existence today, geospatial technologies are associated with several IT and other enabling elements. And geospatial drives these technologies just as these drive geospatial. Let's have a look at some of these upcoming and enabling technologies (Figure 5.1):

Convergence of Geospatial technologies with mainstream IT and Engineering has resulted in more user-friendly, synergistic and compelling technologies

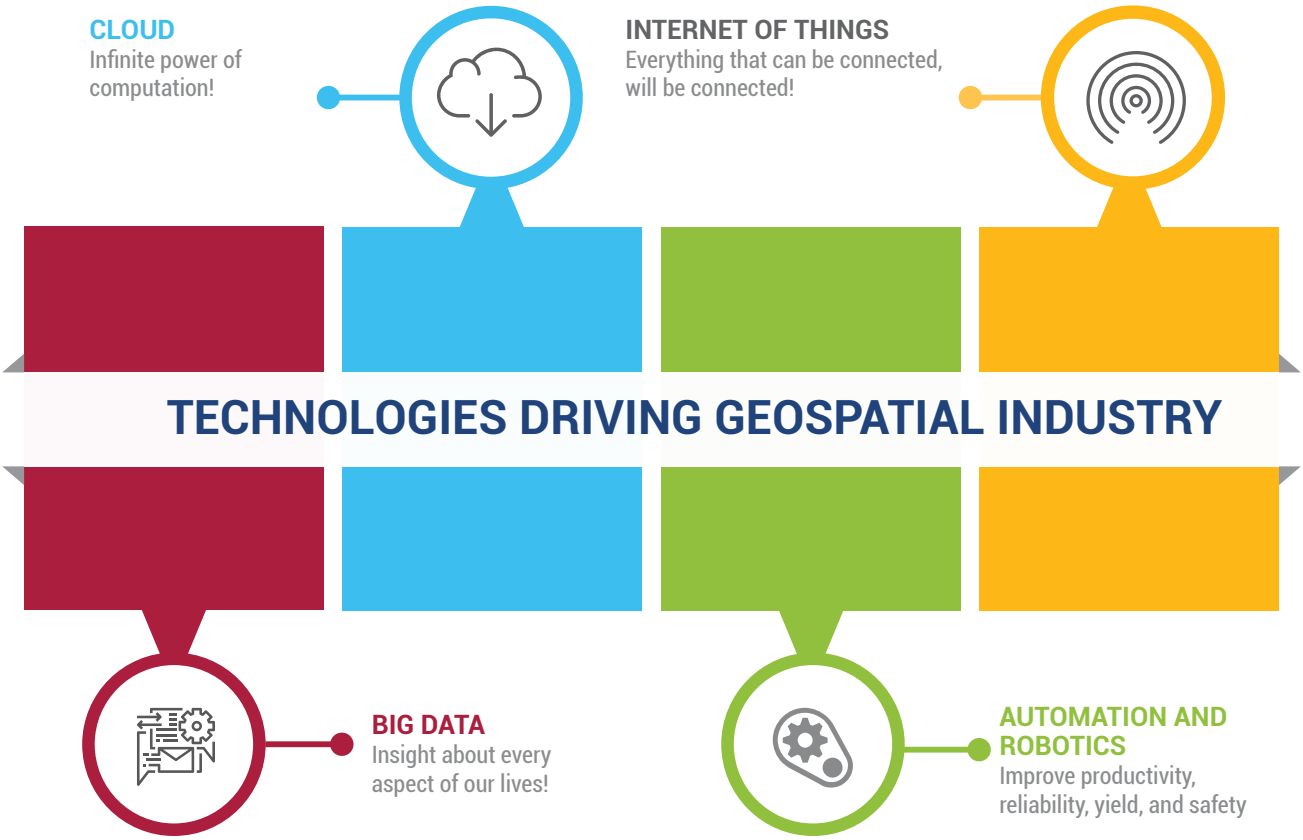


Figure 5.1 Technologies Driving Geospatial Industry

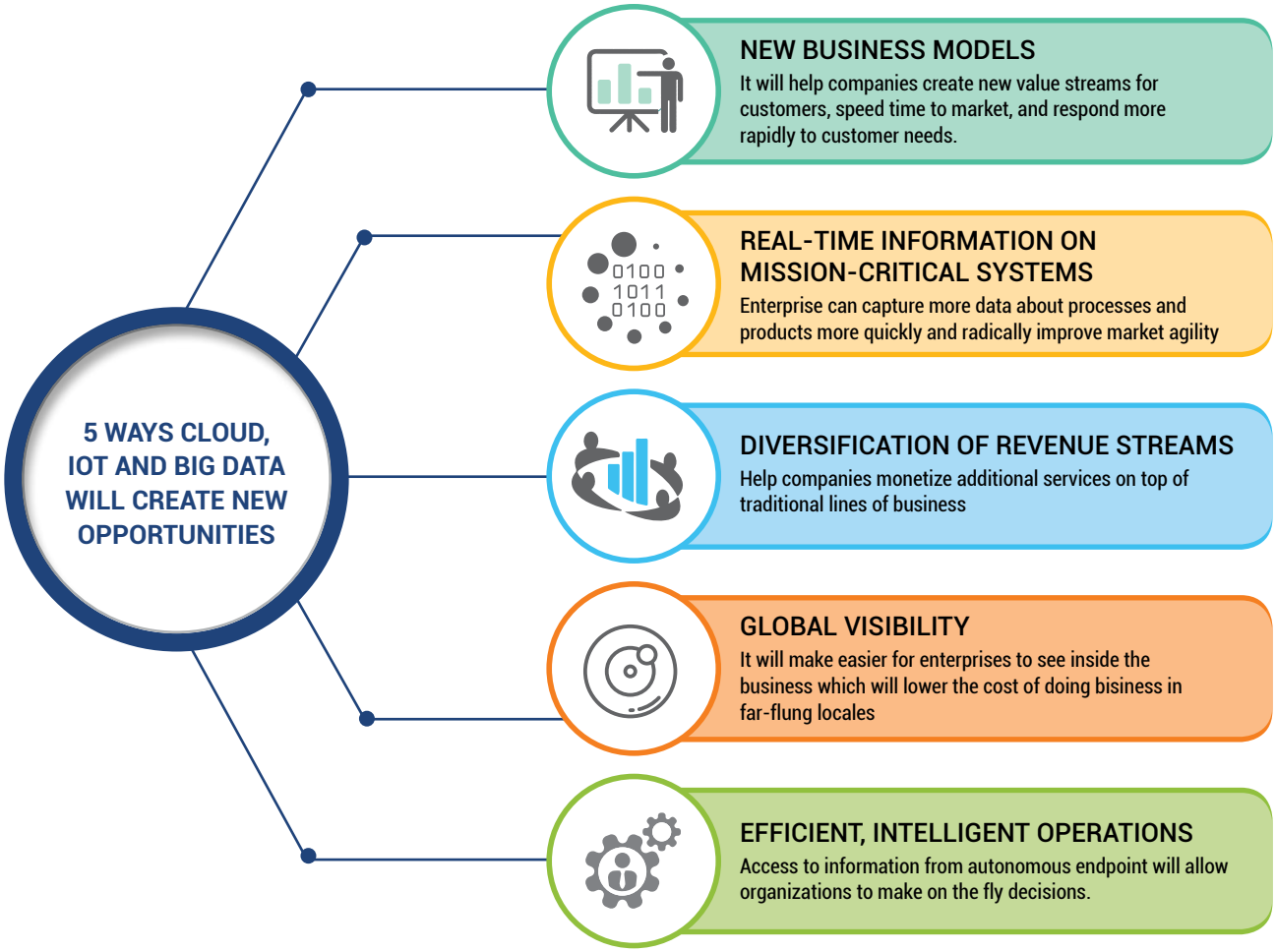
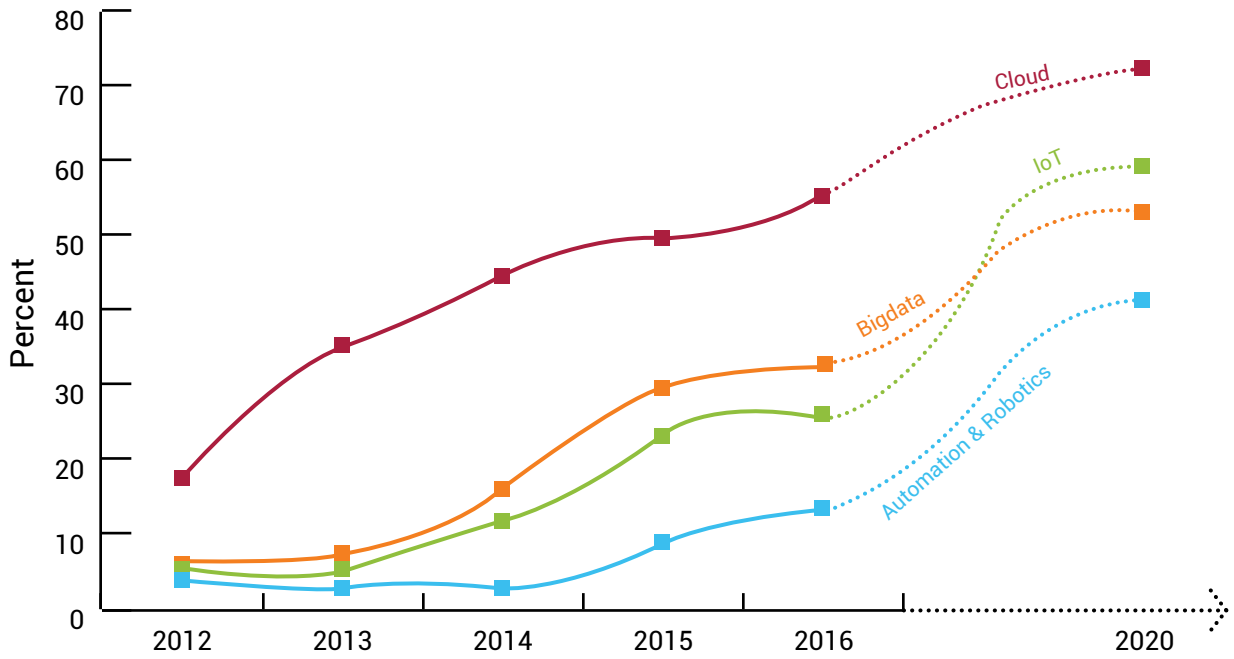


Figure 5.2 Geospatial Industry Trends : A Function of other Driving Technologies

As technologies like Cloud, Internet of Things (IoT), Big Data and automation flourish, the audience for geospatial technology is also growing as they also create new opportunities (Figure 5.2). Big Data, Cloud and IoT are all parts of a continuum. It is hard to think about the Internet of Things without thinking about the Cloud, and it is hard to think about the Cloud without factoring in the analytics. It goes without saying that if you are going to have lots and lots of devices creating data, the said data is going to exist in the Cloud. And because you have got large volumes of data, the only way to analyze that is to use analytical models, identifying the current state of the world.

Augmented reality (AR) and virtual reality (VR) are two technologies that have popped out of sci-fi books and movies to become a part of the real world. Countless possibilities wait in both the enterprise and the consumer domains as AR and VR power automation and robotics. Now, it might take some time for dominant players to emerge in the consumer space, but enterprises can become early adopters to fundamentally metamorphose how they get their work done.



Graph 5.1 Trends in Driving Technology Influencing Geospatial Industry (2012 - 2020)

Unlocking the potential of such technology is not a process confined to 'today'. It goes straight to the heart of the business strategy, spawning the need to understand the trend it will adopt in the coming future.

Cloud computing is increasingly becoming the preferred platform for product delivery. It allows users to avoid the expense of technology and focus more on its ability to manage and process data into actionable information. Being able to manipulate and process data in a high-performance computing environment allows a user to access data from any location, whenever necessary.

It is often seen that when a large organization has made a huge investment in a platform, they become reluctant to change. Cloud gives them the freedom to change. Meanwhile, for small to mid-size businesses, the Cloud proves cost-efficient and secure — at least as secure as possible with the current commercial encryption technologies. Moving to the Cloud allows smaller businesses to act faster than big, established competitors, and gives them the power to disrupt the market. All these capabilities have given a boost to the adoption of this technology in the geospatial arena and will dominate in the future for product delivery.

The ability of Big Data Analytics to utilize the exponentially increasing streams of data with the goal of bringing enterprise-wide visibility and insights to make critical decisions rapidly has been widely acknowledged by the industry (Graph 5.1) .

Cloud allows smaller business to act faster than big, established competitors, and gives them the power to disrupt the market

Given the massive amounts of data available to an enterprise today, high speed analytics leveraging advanced Cloud services will gradually become the norm. This Big Data as a Service, or BDaaS, scenario will soon become a trend the industry will not be able to ignore.

With machine-to-machine communications plumbing the growing network of the Internet of Things with the capabilities of sharing real-time data and making decisions based on artificial intelligence, companies are focusing their energies on formulating new opportunities in automation and robotics — which will finally become a reality thanks to better sensors and critical advancements in processing power and bandwidth.

Are these the only game-changing technology-driven trends you need to know? Of course, not! Like we said, the technological landscape is ever-evolving, creating new trends and new products every day. That is why smart organizations stay ahead of the curve by anticipating trends, rather than adapting them. So, watch out for the following technologies as well (Figure 5.3):

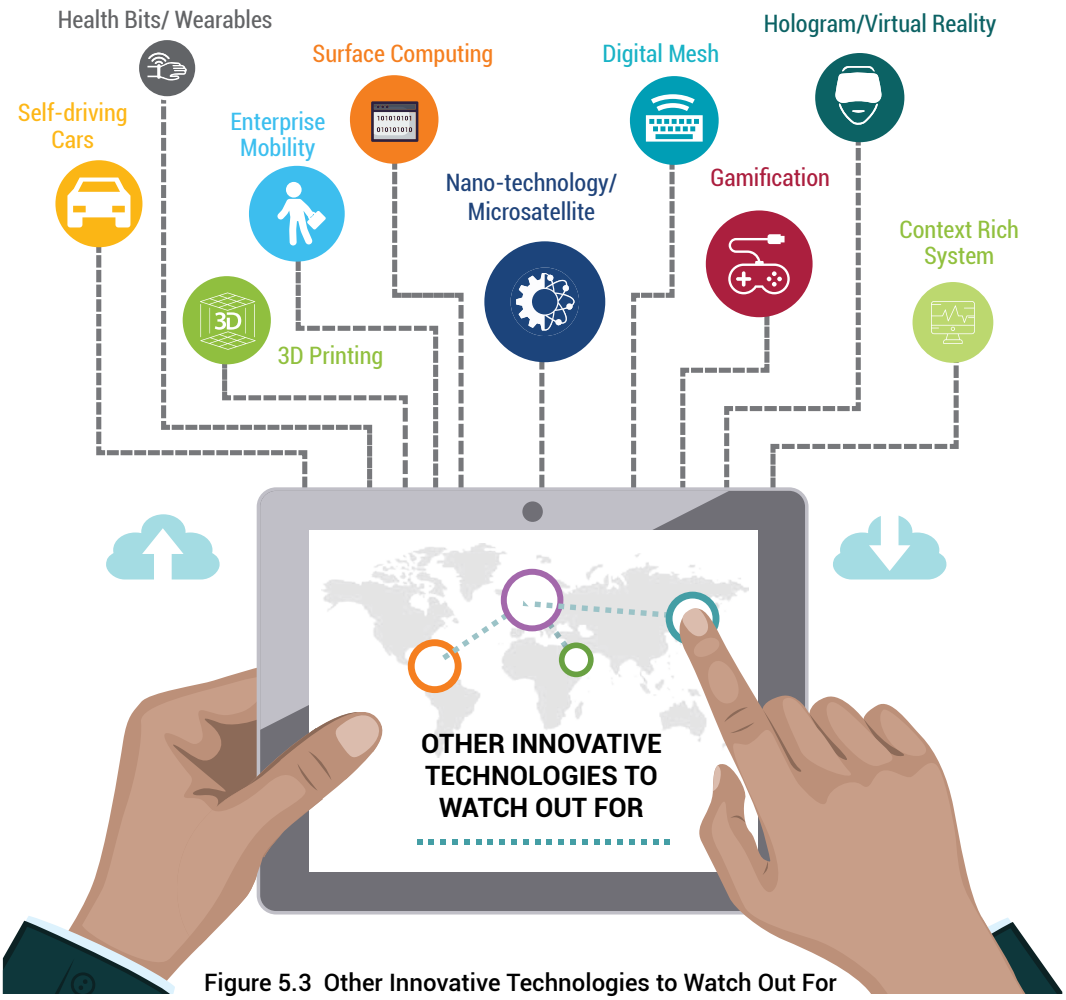


Figure 5.3 Other Innovative Technologies to Watch Out For

6. GEOSPATIAL IN BUSINESS PROCESSES

In 2010, Google added a function called 'Map This' to its webmail client. The tool automatically produced a hyperlink when the Gmail application recognized an address or a package shipping number. This is just one example of how Google embedded geospatial technology into its mainstream application several years ago. Today, spatial information has become an integral part of businesses as diverse as automobiles, utilities, telecommunications, construction, engineering, defence and security in both public and private sector.

As businesses readily embrace geographic data, the geospatial industry is also actively responding with cutting-edge tools, applications and solutions that allow the integration of spatial data into enterprise systems

The applications for which geoinformation is being used are just as disparate. From infrastructure management and vehicle routing to site selection and research and analysis, the value of location as contextual information is one of the most effective filters for the huge amounts of data available to any organization around the globe. With location awareness becoming a key component for many businesses, it is also well-realized that spatial analysis is an important factor to make effective decisions within any business process.

As businesses readily embrace geographic data, the geospatial industry is also actively responding with cutting-edge tools, applications and solutions that allow the integration of spatial data into enterprise systems. This has enabled better optimization of resources, effective planning of operations and a more efficient and streamlined business processes for enterprises, allowing them to respond better to customer requirements and market forces.

In order to understand the current trend in geospatial industry with respect to business process embedment, we need to delve into the various popular business processes.[1] These processes span industries, both vertical and horizontal and can include any type of business operations.

1 http://www.pnmsoft.com/resources/bpm-tutorial/business-process/

BUILDING INFORMATION MODELLING (BIM): A COLLABORATION PROCESS IN THE CONSTRUCTION INDUSTRY

BIM enables organizations to improve the quality of building design, reduce costs and achieve the collaborative workflows required to drive true innovation. It is more of a business process than a technology and is firmly inter-linked to geospatial ecosystem. Advancement of BIM relies on integrating geospatial skills and technologies into BIM solutions.

- → Converged solutions using existing BIM, geospatial and 3D visualization technology are being applied to intelligently model urban infrastructure and entire urban environments.
- → Current applications include planning, emergency management, sustainability analysis, and facilities management, but it is not hard to imagine many other areas where these digital urban models will play an important role in the future.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA): MANAGING FACILITIES BETTER IN THE UTILITIES SECTOR

Traditional SCADA functionality has evolved dramatically over the years enabling it to be tightly integrated to the domain of business processes, creating an improved value proposition for its usage. SCADA systems bring improved performance to geographically dispersed assets and provide a framework for real-time performance management on a global basis.

- → In the utilities sector, embedment or integration of geospatial with SCADA, enables, real-time data management from distribution systems on a geographical view of the electrical network.
- → SCADA and geospatial are key operational tools in electricity distribution, and integration between the two results in increased efficiency.

C4ISR: COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS, INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE

C4ISR in the military arena combines all the systems that allow military commanders to understand their operational environment, identify mission critical factors, and control their assets. C4ISR systems make extensive use of geospatial technologies. C4ISR relies upon a distributed set of spatial data resources, spread across multiple agencies, services, commands and theatres. C4ISR solutions, leveraging the latest in geospatial technologies, promise and deliver significant improvements in the operational environment of the defense forces.

- → The past decade has seen the convergence of imaging and geospatial communities within defence organizations around the world.
- → C4ISR and geospatial intelligence inherently require spatial data infrastructures that are interoperable, distributed, secure, temporally-enabled and enterprise-class. It is expected that in the future, geospatial intelligence and C4ISR will be more ubiquitous.

ENTERPRISE RESOURCE PLANNING (ERP) AND CUSTOMER RELATIONSHIP MANAGEMENT (CRM): INCREASED BUSINESS PROFITABILITY

CRM is used to organize, automate and synchronize sales, marketing and customer service, and has developed to include all areas of the customer experience. Where CRM manages the customer, ERP is used to manage the business. ERP is a system for improving the efficiency of business processes and provides a method for streamlining business processes across the board.

- ERP/CRM and geospatial applications can be connected together to take advantage of the key strengths of each other and yield a stronger, integrated result for the user. Spatial analysis assists customers as part of CRM by modeling optimal siting of business facilities,
- The geospatial industry is moving toward providing solutions, which integrates extensive spatial capabilities into the existing workflow and logics to deliver perceptible process improvements and real value gained from this spatial capacity.

ANALYTICS: LIFELINE OF BUSINESSES

Business process analytics enables organizations to gain real-time, end-to-end visibility into complex business processes. Analyzing large volumes of data from disparate systems in real-time is arduous. Business analytics exists to bridge this gap between the glut of unusable data and the unsatisfied appetite for insights that can inform decisions.

- Today, it is possible for organizations to add the context of timing and location to traditional data, creating maps that show changes over a period of time. Maps make it easier for the eye to recognize patterns that were previously buried in spreadsheets, such as, distance proximity, contiguity, and affiliation.
- Geospatial analysis uses this data to build maps, graphs, statistics, and cartograms to make complex relationships clear. Representations like these can reveal historical shifts, as well as those underway today. They can even point to those that are likely to occur in the future.

REALITY MESH: AMALGAMATION OF REAL AND VIRTUAL WORLDS

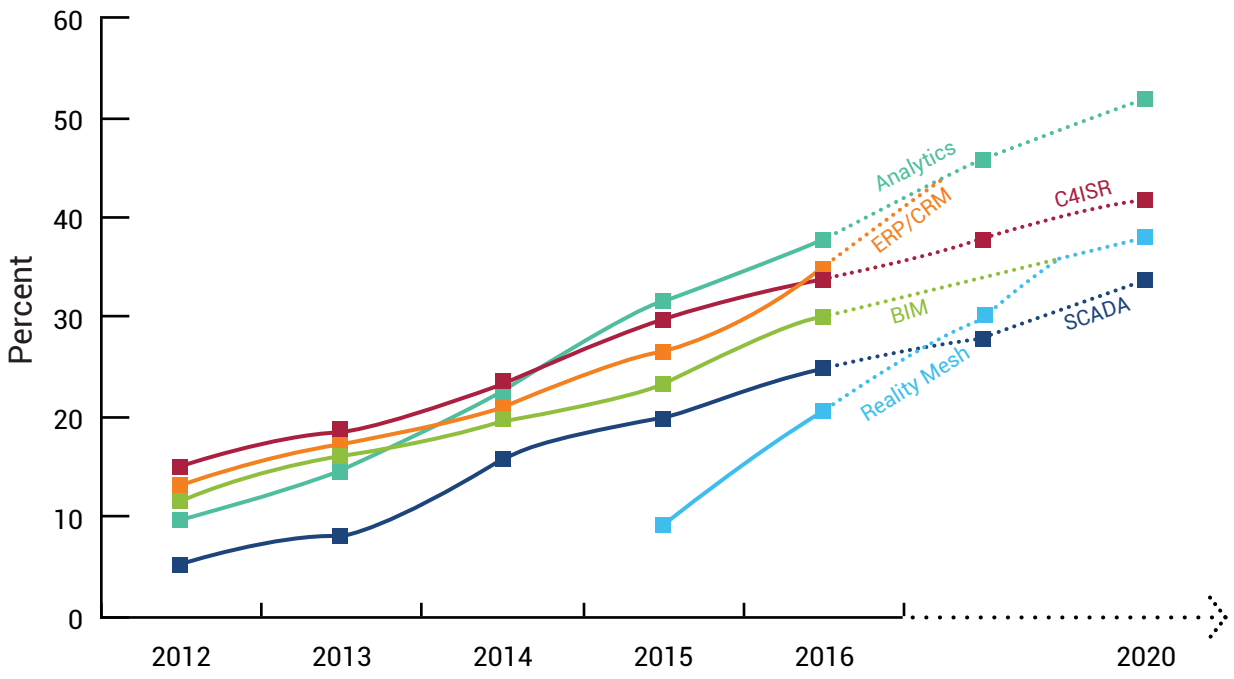
Reality Mesh or Mixed reality (MR), also referred to as hybrid reality, is the amalgamation of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real-time. This is fast becoming an integral part of digital engineering as well. In today's practice, the interpretation of digital content and its translation to real world objects is heavily dependent on the user's spatial understanding, even if advanced 3D modelling tools are used.

- When used to classify the larger scope of reality technologies, it refers to the coverage of all possible variations and compositions of real and virtual objects.
- Together with holographic technology, it brings the models out of the screen and helps people efficiently interpret physical and digital information, and the spatial relations between them.

Prevailing business process embedment trends in the geospatial industry have been mapped. As is evident from Graph 6.1, over the years (2012-2016) integration of geospatial with popular mainstream business processes has witnessed a gradual increment. It indicates that the industry is continuing to invest in a more efficient and productive future by embracing technologies and processes of BIM. The study also establishes the fact that BIM and geospatial are firmly inter-linked, with the advancement of BIM relying, in part, on the integration of geospatial tools and technologies into BIM solutions. The industry is moving exactly in this direction.

Over the past year, reality mesh/digital engineering has come up as an emerging business process in the construction industry. Though the adoption level is yet to catch up with other business processes, it is expected to see a sharp boost in the next 5 years. One of driving factors behind this is that every construction project has a decisive process in which design is transformed into reality and abstract ideas translated into physical objects.

Mixed reality is an emerging technology which is taking BIM a step further. Amalgamating the real and digital worlds to provide the user with an immersive virtual experience, this hybrid reality can very well be conceded as the future of BIM.



Graph 6.1 Trends in Business Process Embedment of Geospatial Technology (2012 - 2020)

This indicates that the industry is moving toward integrating workflows and improving communications wherein a disruptive technology like mixed reality has the potential to make a lasting change, predominantly in the construction industry.

Similarly, when we plot the trend of ERP/CRM embedment, the study indicates that it is one of the most popular business processes in terms of integration with geospatial technologies. The reason may be accounted to the fact that when ERP/CRM and geospatial applications are connected together, they leverage each other's key strengths to yield a stronger, integrated result for the user. The ERP/CRM is enriched by map displays and spatial analysis, while geospatial benefits by access to deeper and broader attribute data. This integration is already well-established and is expected to see a steep rise in the near future.

Analytics has been a part of the geospatial industry for long, but it has never been as relevant as it is today. Analytics is no longer only about helping organizations make better decisions; it is the foundation on which businesses of the future will flourish on. Analytics is essential not only for decision makers, but also for customers. A precipitous increase in its adoption in the years to come is inevitable.

Also, a very interesting prophecy could be that the ever-growing ERP/CRM is moving towards being subsumed into analytics, with geospatial integration going to increase the value proposition manifold.

C4ISR, despite being exclusive to the defence and security sector, has always been prevalent in geospatial technology integration. It has also shown a gradual increase in embedment over the last few years. The current study indicates a particularly high phase around 2013 to 2015, when several geospatial companies seem to have offered solutions pertaining to this sector. Of late, the geospatial industry's engagement in this has increased and a lot of companies are offering geospatial solutions on C4ISR framework. It is expected that in the future, geospatial intelligence and C4ISR will be more ubiquitous as the industry is moving towards customized solutions for the defense sector.

A precipitous increase in adoption of analytics is inevitable and ERP/CRM is moving towards being subsumed into analytics

7. TRANSFORMATION THROUGH COLLABORATION

Acquisition and partnership are two pillars of growth strategy for businesses. The landscape of geospatial industry is evolving through the flurry of partnerships and acquisitions

The technology industry is always in flux. Frequent new products and category innovation define and redefine the sector's constantly shifting landscape, affecting the makeup of hardware, software and data companies themselves. This volatility is manifested by massive shifts in relationships and sudden clash of cultures courtesy mergers, acquisitions, partnerships and divestitures.

Acquisitions and partnerships are two pillars of the growth strategy of a business. These two important organizational activities give a company access to external resources. But, the two strategies differ in many ways. Acquisition deals are competitive, based on market prices but are risky. Partnership and alliances are cooperative, negotiated and not so risky. Companies habitually deploy acquisitions to increase scale or cut costs, and use partnerships to enter new markets, customer segments and regions.

That the value of the geospatial business is growing is clearly evidenced by the flurry of mergers and acquisitions happening in the domain. Year 2013 was the peak year for partnerships and acquisitions. This can be viewed as the after-effect of Hexagon-Intergraph deal which is considered as the most significant acquisition ever in the geospatial domain. This event had tremendous impact on the existing alignment and the prevailing partnership networks of the industry. Everybody in the geospatial technology business was affected in one way or another. Eventually, many of the geospatial players aligned with other large players, amalgamating their distinct spheres of influence and expanding their product portfolio.

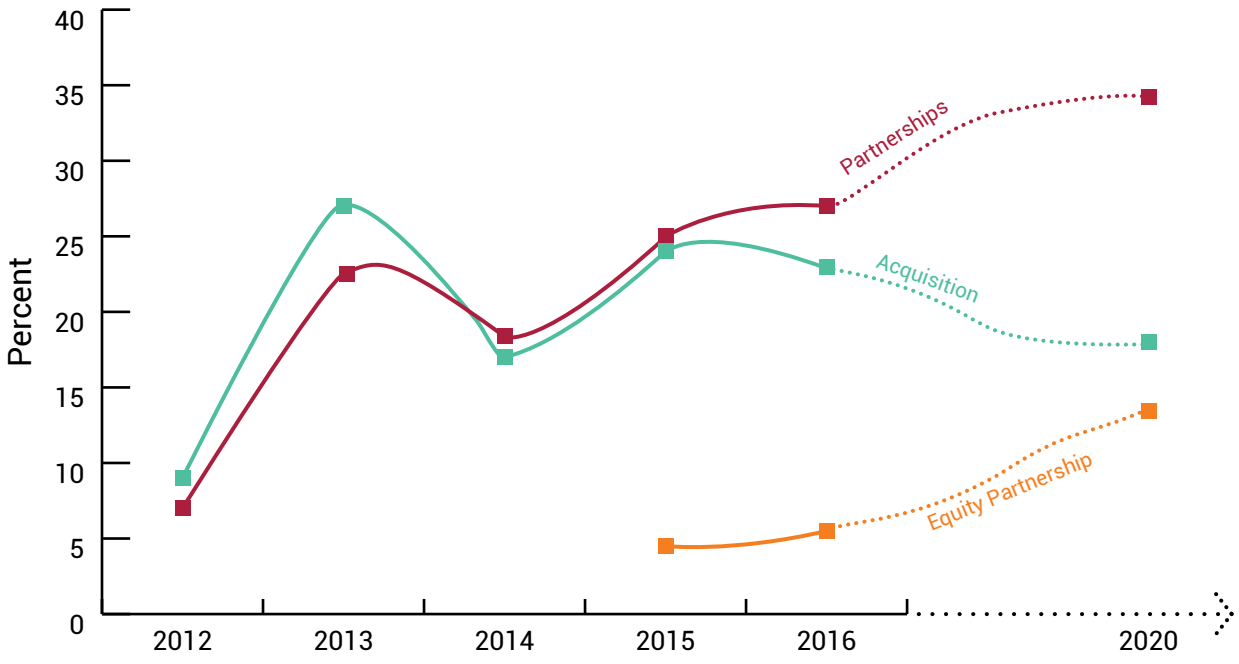
Also, around this time, the companies started talking in a big way about comprehensive and integrated solutions for end users. Year 2013 was when 'one-stop-shop solution' was the driver. Many companies were actively either partnering with or acquiring another to move toward that goal. Meanwhile, large enterprise users were also motivating geospatial and IT companies to get together and integrate their offerings

from data acquisition and data management to IT integration and, finally, delivering valuable solutions. All these factors coalesced to gear the industry for various inward and outward acquisitions and partnerships.

Post 2013, the partnership strategy took a lead over acquisitions (Graph 7.1). This happened because acquisitions were a costly affair and only a few can sustain it for long. A bulk of companies started working toward strategic partnerships. The trend in partnerships also increased because it delivers access to new markets or customers, accelerates new product development cycles, and improves a company's competitive positioning in cost-effective manner. Partnerships help companies expand their capabilities without the added step of creating those capabilities in-house or increasing business risks by carrying extra costs/assets on the balance sheet. Companies, therefore, perform more efficiently and adapt more quickly than they could have on their own.

A new trend that has started of late in the partnership arena is what can be termed as equity partnership that reflects partners' ownership interest in the business. The deal between Siemens and Bentley Systems, wherein the former acquired secondary shares of the latter common stock to advance infrastructure project delivery is a case in point. Similarly, Flipkart acquired a stake in MapMyIndia to sharpen its logistics capabilities. These kinds of partnerships are going to see the north direction in the coming years.

Equity Partnership, a new trend, started off-late, is going to see the north direction in the coming years



Graph 7.1 Trends in Acquisitions and Partnerships in the Geospatial Industry (2012 - 2020)

SIEMENS AND BENTLEY SYSTEMS' STRATEGIC ALLIANCE

Conglomerate Company & Software Company

→ To realize new growth opportunities in industry and infrastructure through integration of complementary digital engineering models.

TOPCON-SOKKIA MERGER

Surveying Company to Surveying Company

→ The market environment for the two companies is highly competitive. The merger of two companies is to maintain an edge in the increasingly competitive worldwide surveying instruments market.

→ Together they are to compete on an equal basis into the future with the two leading US and European manufacturers, as well as with emerging Asian manufacturers that can produce on a low-cost basis.

DIEMOS IMAGING ACQUIRED BY URTHECAST

Satellite Imaging Company to 'A New Kind' of Earth Observation Company

→ A growth opportunity that will help to accelerate UrtheCast Constellation plans, while populating the platform with powerful content

→ Expected to significantly accelerate UrtheCast's strategies related to distribution, web platform development, and the building out of the UrtheCast Constellation

GEOEYE MERGER WITH DIGITALGLOBE

Satellite Imagery Company to Satellite Imagery Company

→ Both companies capture photos and other imagery from satellites that orbit the Earth, then sell them to government and enterprises.

→ The merger increases the flexibility by reducing risk and optimizing capital expenditures. The companies are positioned better to meet the customer needs and create value for share owners.

PARTNERSHIPS THROUGH 2012

UBER AND TOMTOM PARTNERSHIP

Ride Hailing Company with Navigation Company

- Teamed up with TomTom to provide navigation map on the driver's side.
- Though Uber isn't cutting ties with current providers like Apple and Google Maps, this latest move does suggest a more concerted effort from the ridesharing app to develop native navigation, mapping, and location services.

GOOGLE ACQUIRES WAZE

Mapping Service to Information Company

- Waze has created a culture of user engagement. Google to spread this culture of user engagement to its other services and competitors would not have access to this technology and users.
- Google Maps lacks key features that are useful to Waze users. Waze has options to report accidents, police presence, speed cameras and blocked roads, all things that Google does not have.

HERE ACQUIRED BY AUDI, BMW AND DAIMLER CONSORTIUM

Digital Mapping and Location Business by Consortium of Car Makers

- The acquisition is intended to secure the long-term availability of HERE's products and services as an open, independent and value creating platform for Cloud-based maps and other mobility services accessible to all customers from the automotive industry and other sectors.
- Real-time maps and location-based services will be the basis for the mobility of tomorrow. HERE is laying the foundations for the next generation of mobility and location based services. For the automotive industry this is the basis for new assistance systems and ultimately fully autonomous driving.

FINANCIAL TIMES ACQUIRED GIS PLANNING, A FAST GROWING SILICON VALLEY COMPANY

GIS Company to Media Company

- The acquisition is for location analytics for business Intelligence and marketing opportunities
- While this is likely to disrupt many industries in the future - including the geospatial industry itself - it should also serve as a wakeup call to the vast potential for innovation which GIS presents.

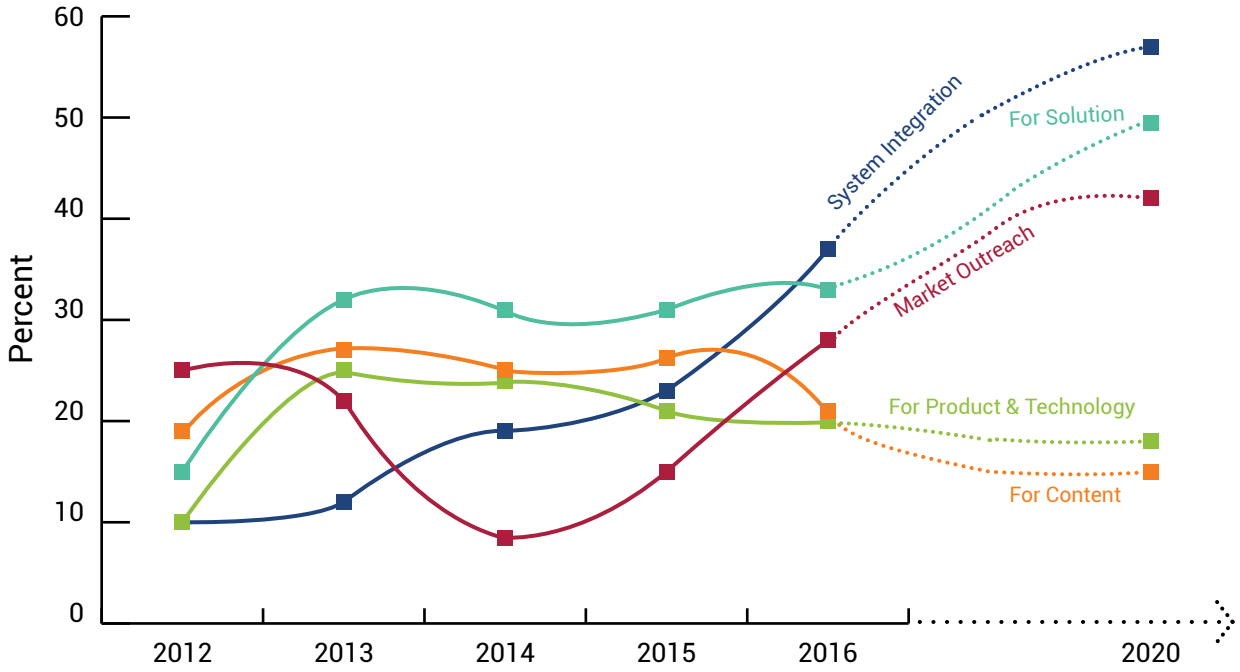
Reasons for Partnerships and Acquisitions

Partnerships and acquisitions are significant aspects of a modern business strategy. From deriving competitive advantages, economies of scale, economies of scope, international expansion, vertical integration and access to unique assets, the reasons behind partnerships and acquisitions could be many. Of these, the most common today is perhaps the drive to deliver a complete solution.

Over time, we can see acquisitions and partnerships moving through a number of 'waves' from a strategy point of view in order to pursue 'system integration and solutions' (Figure 7.1).

	DOMINANT PARTNERSHIP AND ACQUISITIONS	PURPOSE	CHARACTERISTICS
FIRST WAVE	Horizontal partnerships and mergers	For technology portfolio	Between firms that operate in the same space producing ideal products by coming together
SECOND WAVE	Vertical partnerships and mergers	For content	Where separate stages of the production process are aligned for a specific finished product
THIRD WAVE	Concentric partnership and mergers	For market consolidation	Between firms that are involved in totally or partially unrelated business activities. Here, firms are looking for product extensions or market extensions
FOURTH WAVE	Co-generic partnerships & mergers	Direct engagement and outreach	Two companies are in the same or related industries, but do not offer the same products. In a congeneric merger, the companies may share similar channels for outreach
FIFTH WAVE	Cross-sector partnerships and mergers	For solutions and system integration	Where two different sets of companies come together to provide a particular solution

Figure 7.1 Waves in Value-Added Collaborative Business



Graph 7.2 Determinants of Partnerships in Geospatial Industry (2012-2020)

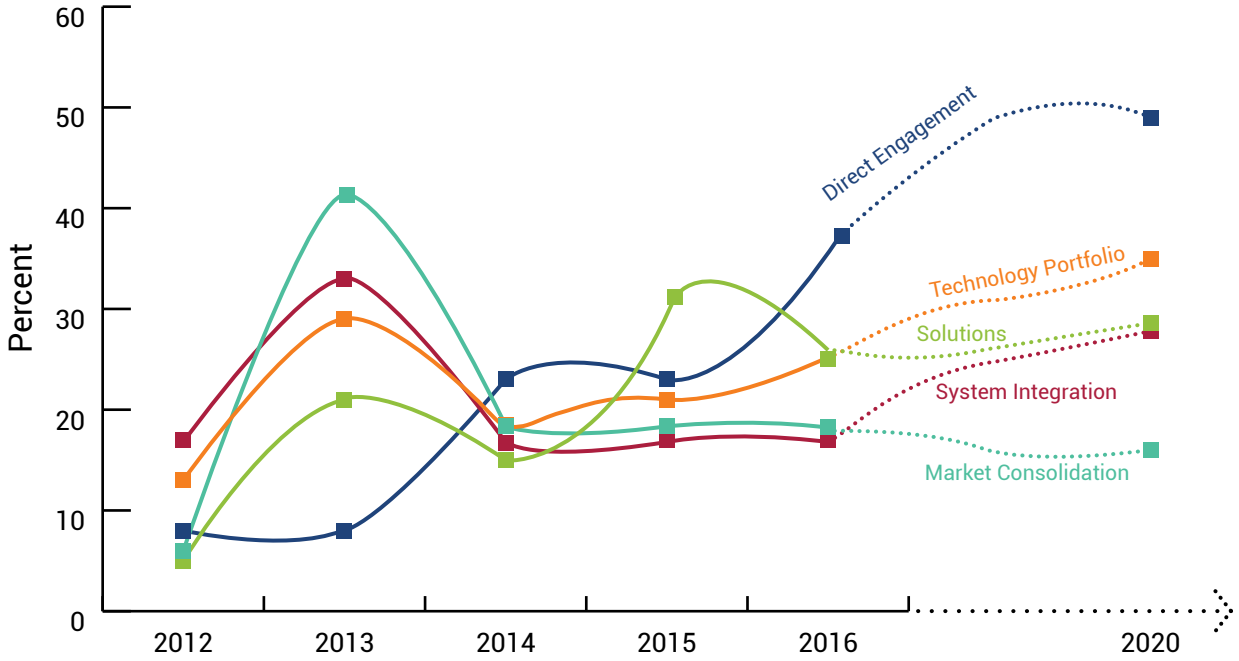
Content is the king in the geospatial space. Various partnerships and acquisitions have taken place for delivering applications and solutions with usable insights and information. All these require content (Graph 7.2, 7.3).

Hexagon Geospatial partnered with content providers like Airbus Defence and Space and HERE. This enabled the company to find and access geospatial content that drives the applications on Cloud-based M.App exchange platform. Esri's partnership with MapmyIndia gave its users an interface for collaboration and sharing with a complete geospatial content management experience. DigitalGlobe's partnership with Trimble provided users the power of mapping and location intelligence even in the most remote location.

These kinds of partnerships are expected to stabilize as most of the product companies have now started creating their own content, i.e., they now own the content. Product and content are converging because the software and hardware today are coming content-ready. This trend has also enabled companies to make use of the same content n-number of times, depending upon the requirement.

The emerging trends of the solution-centric approach and enterprise orientation have triggered a change in the existing business practices and policies of geospatial companies.

The industry has realized that the required degree of integration/ convergence for integrating systems



Graph 7.3 Driving Factors of Acquisition in Geospatial Industry (2012-2020)

Direct engagement has been one of the reasons behind acquisitions. By buying out its distributors, a business eliminates certain level of expenses

and developing a solution-centric workflow environment was an option to sail through by partnerships and collaborations. It requires acquisition of technologies, integration of processes, and embedding of workflows, which was possible with a structural re-organization of the existing ecosystem.

Acquiring Telog enabled Trimble to expand its portfolio for extending monitoring solutions. Bentley's partnership with Microsoft played a strategic role in the advancement of infrastructure project delivery and asset performance.

Partnerships for system integration or solutions are growing, though at a differential rate compared to acquisitions, wherein they are almost stabilizing. Companies are finding it more cost competitive to partner for extending integrating systems and providing solutions to the users, rather than amalgamating the entire new technology portfolio in their systems. This system integration and solution-oriented collaboration is driven by an established geospatial player who wants to venture into a specific market, but doesn't have the domain knowledge. And finally, there are partnerships between equals for competitive advantage.

Direct engagement has been one of the chief reasons behind acquisitions. By buying out one of its suppliers or distributors, a business can eliminate a certain level of cost. When Topcon acquired one of its significant European dealers GEOTOP, the move not only enabled Topcon to save on margins that the supplier was previously adding to

its costs, but also enabled the parent company to have direct engagements with the market. In the software space, emergence of the Cloud has enabled companies to reach directly to the customer. This has affected the revenue model of distributors, who now need to move up the value chain to survive.

The acquisition of GeoEye by DigitalGlobe or that of Sokkia by Topcon was for market consolidation, wherein the acquirer aimed to eliminate future competition and gain a larger market share in its products market. The downside of this is that a large premium is usually required to convince the target company's shareholders to accept the offer. These kinds of acquisitions will see a downside in the future (Figure 7.2).

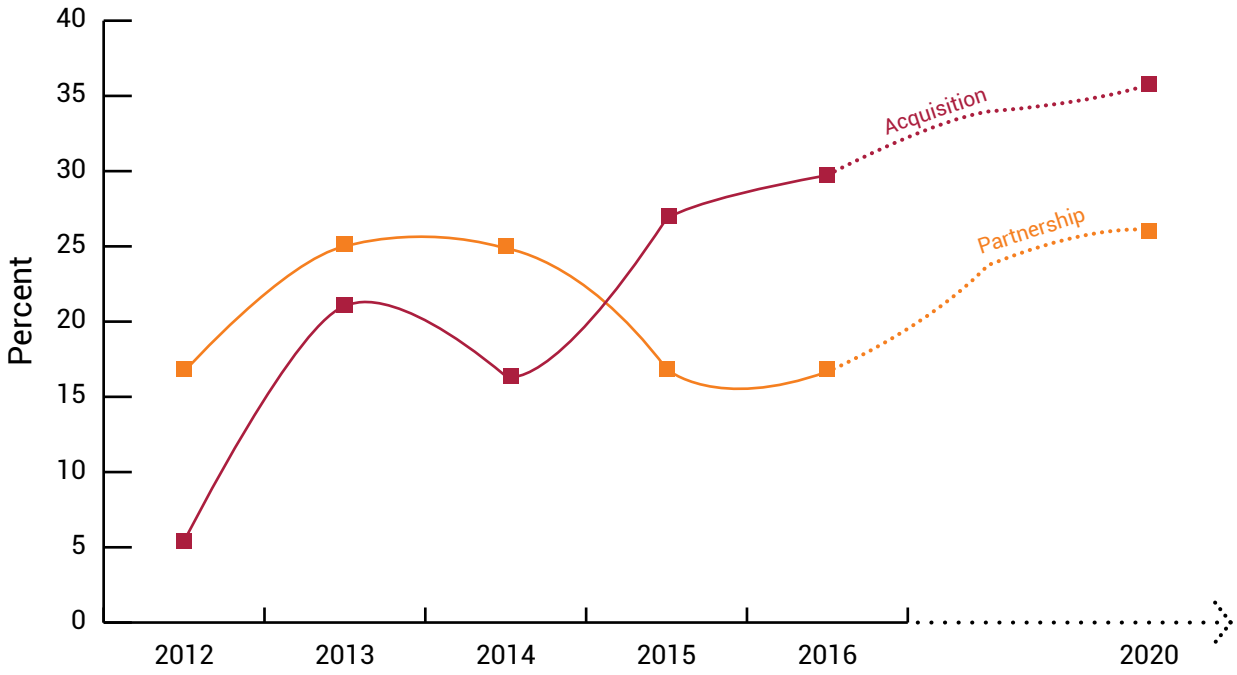
Increased capabilities may come from expanded research and development opportunities, or from acquiring a unique technology platform rather than trying to build it from scratch. Market outreach has been an influencing factor for partnerships. The company planning to expand into different markets joins hand with the company already operating in that segment. The network gives both companies a wider customer base practically overnight.

Spatial Enablement: Beyond Moor's Law

Objects that know where they are can capitalize on their locational knowledge. Spatially-enabled entities have the potential for financial and functional utility. Spatial enablement has a deep influence on further disruption to the disruptive agents. Over the past decade, there has been a phenomenal expansion of applications and enterprises that have been labeled disruptive

> **Across the commercial world, the idea of location intelligence gains currency in leading business management circles, resulting in spatial enablement in their offerings, and enhancing competitiveness**

Figure 7.2 Companies Mapped for Spatial Enablement



Graph 7.4 Trends in Acquisitions & Partnerships for Spatial Enablement (2012-2020)

(Graph 7.4). Uber and Airbnb are classic examples. Myriad other examples are evident across the commercial world as the idea of business intelligence and locational intelligence gains currency in leading business management circles. Empowering clients with purchasing knowledge at the front door of commercial shops and sharing price comparisons on customers' smartphones is also feeding the retail industry's individual and aggregate customer profiles for increased sales efficiencies through big data analytics.

Location-driven trends have given way to new businesses and use cases, creating even more demand. This has been the driving factor for companies who are embedding spatial component in their offerings, thus complementing and enhancing the current services.

8. EVOLVING BUSINESS MODELS

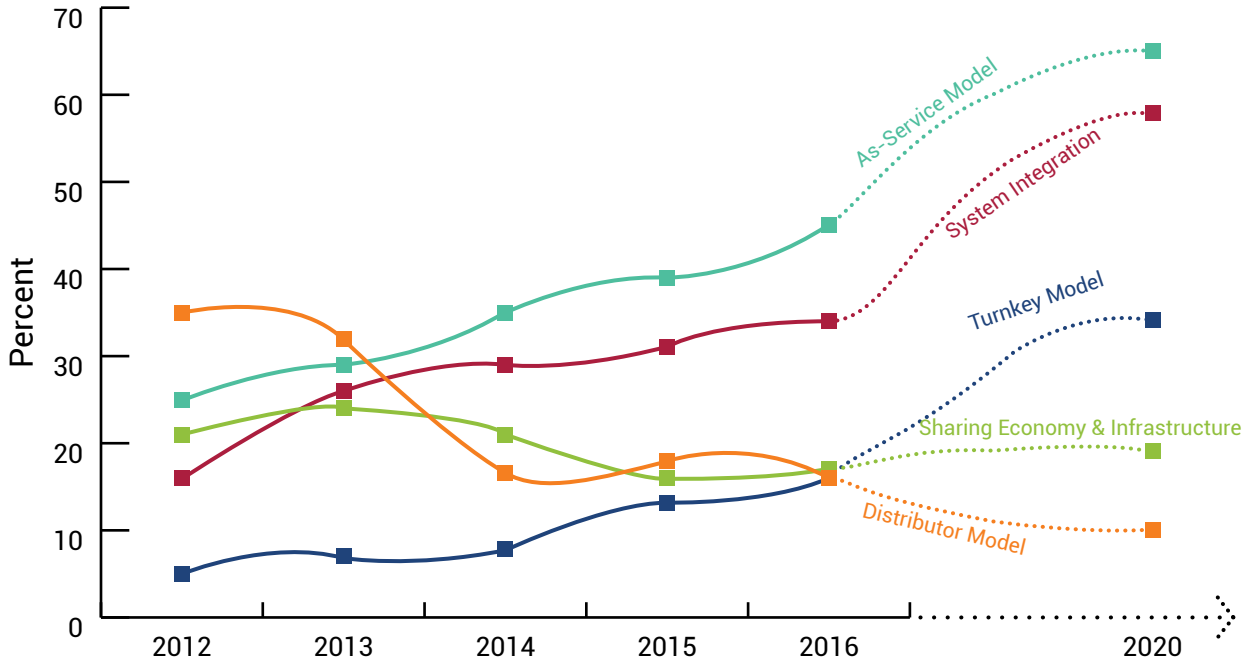
The technology industry is being remodeled in several ways. Disruption is evident in delivery, business models, entrepreneurialism and constant innovation. In such a scenario, companies can no longer rely on one-note value strategies. Immediate path holds the maximum chance for short-term success, but, over time, both improving margins and finding new revenue streams are critical for success.

With the maturity of the user community, business models are moving toward a new paradigm. The key to stand out in a crowded marketplace lies in delivering a complete suite with innovation. The direction is to provide a true business solution versus platform solutions. Technology providers are moving toward providing end-to-end solutions to clients and staying connected to deliver a greater impact. These factors have given rise to the system integrator business model, which will not only create an ongoing recurring revenue stream, but drive the future as well (Graph 8.1).

The turnkey model has the potential to positively diversify and significantly alter the existing business and revenue model by 2020

The revenue model from Cloud-based delivery, known as XaaS, is expected to grow at a compound rate throughout this decade. Outpacing traditional license delivery, XaaS is not only driven by competition; but also triggered in part by customers' increasing demand for flexibility that will allow them to take advantage of new technologies. With an XaaS model, customers are not burdened by significant upgrade costs and can more accurately estimate the total cost of ownership of product, content and infrastructure. As a result, corporate and individual attitudes about the Cloud are beginning to change. Rather than licensing software or services, XaaS options have become much more acceptable.

As a revenue growth strategy, XaaS can be extremely beneficial for the companies that provide it, but they will need to adjust their financial expectations. For example, in the traditional software model, five years or more could pass after a sale before the customer agrees to buy another version of the program. As a result, after the initial bulk up-front payment, all that a technology provider can count on was an annual service fee, usually about 20% of the purchase price. In contrast, XaaS is a slow-flowing revenue stream. Which is why, legacy license software companies that shift even a small portion of their business to XaaS, must be prepared for a sharp loss in item sales revenue. Nonetheless, in view of the increasing allure of XaaS for many customers, a good deal of licensing revenue is going to disappear organically. So, adopting XaaS in the product portfolio will become a necessity, not a choice.



Graph 8.1: Trends in Revenue Models of Geospatial Industry

One of the special modes of carrying out international business is a turnkey project. The turnkey model has the potential to positively diversify and significantly alter the existing business and revenue models. In this model, a firm agrees to fully design, construct and equip a manufacturing/business/service facility, and turn over the project to the buyer when it is ready for operations and revenue-generation. This revenue model will head north as most of the big fish are looking for one-stop-solution approach for customers. It will be an effective way to increase sales revenue and ensure prolonged success through more diverse product offerings.

With these models coming up strongly and the 'end user' outsourcing contracts to solution providers and systems integrators, buying through distributors is not obligatory. Another significant factor is the relentless adoption of annuity sales models. This trend is most visible in as-a-service model or a Cloud model which is enabling companies directly reaching out to the customers. All this, along with the company's strategy to have direct engagement with the market, is pulling down the distributor model of revenue generation. Distributors have to review their strategy and move up the value chain for sustained existence.

We started the decade in the midst of a seismic shift in business models, fuelled by the Internet and a generation of connected users. Market upstarts were displacing market leaders faster than ever before as entire industries transformed toward shared infrastructure and content. But to succeed in this model, reliable, timely content in the right format and the right price was a prerequisite. This model is expected to stabilize as shared economy and infrastructure are chiefly created through integration with partners.

COUNTRIES' GEOSPATIAL READINESS INDEX

In a first-ever study of the geospatial readiness of nations, 50 countries have been ranked for their geospatial readiness. The countries index is an initiative to integrate several new approaches to assess the geospatial readiness of a country for evaluation. The Geospatial Readiness Index is, therefore, a comprehensive framework for analyzing the preparedness of 50 selected countries — their strengths and weakness in the geospatial domain. The index has been calculated on the basis of the following defined pillars:

→ Geospatial Infrastructure and Policy Framework
→ Institutional Capacity
→ User Adoption Level
→ Industry Fabric

A detailed analysis of the four pillars along with their sub-determinants is presented for each of the selected 50 countries in the following pages

9. GEOSPATIAL INFRASTRUCTURE & POLICY FRAMEWORK

Geospatial infrastructure and an enabling policy framework are fundamental to determine the geospatial readiness of any economy. Geospatial data plays a crucial role in the decision making process and planning efforts across a broad range of industry segments, ultimately leading to the growth of the economy. Ease of accessing, sharing and using the data form the core of geospatial infrastructure. This is dependent on the available datasets, thematic layers, data dissemination channels, platforms and portals.

Geospatial data plays a crucial role in the decision-making process and planning efforts across a broad range of industry segments, ultimately leading to the growth of the economy

Similarly, a progressive policy framework for the industry not only facilitates easy adoption and use of geospatial technologies, it also supports the development of an efficient geospatial data infrastructure. A dynamic policy framework, through the establishment of common protocols, policies, standards, etc., serves as a driving force for geospatial infrastructure.

Naturally, these two factors have been considered as the first of the four pillars of the Geospatial Readiness Index. The research methodology undertaken to identify the readiness of 50 countries with respect to this pillar is as follows:

- One-to-one interaction with the representatives of national mapping agencies, space agencies (earth observation) and other stakeholders on the basis of a specially designed questionnaire
- Validation and supplementation of data through secondary research
- Secondary study of policy documents for 50 countries to identify the geospatial policy framework and its specifics

To evaluate the readiness of the 50 countries, it is important to scale them on the determinants (data infrastructure, positioning infrastructure, platforms and portals, open and linked data and standards and policy framework) in Figure 9.1 that encompass the entire geospatial infrastructure and policy framework.

Data Infrastructure (Topographic & Earth Observation)

Geospatial data infrastructure is an important institution which enhances the integration of the geographic information/data to provide easy access, sharing, and use of spatial data. An enabling geospatial data infrastructure consists of two important factors: topographic and earth observation.

Topographic data, mostly managed by country's national mapping agency, is of great importance to any country. It is available in different scales and different layers specific to each country. Topographic datasets are imperative for geographical and geological engineers for planning, evaluating and identifying trends with respect to cadastre, utilities, infrastructure, agriculture, soil cover, hydrology, defence and security, forests and environment, etc.

Earth observation data of a country presents unprecedented levels of information and a holistic view of the environment and resources. Satellite-derived data is becoming critical in economies worldwide, and satellite ownership is taken as an important factor for analysis because it affects economic growth and national security. Also crucial is the spatial resolution available in each country because a high spatial resolution means increased image detail, which in turn, positively affects the geospatial readiness of a country.

The data infrastructure pillar is therefore scored on the basis of weights assigned to each of these characteristic of topographic and earth observation data, namely thematic layers, characteristics (consistency, timeliness, accuracy, interoperability, etc.), spatial data type, spatial resolution, etc. The scores of the

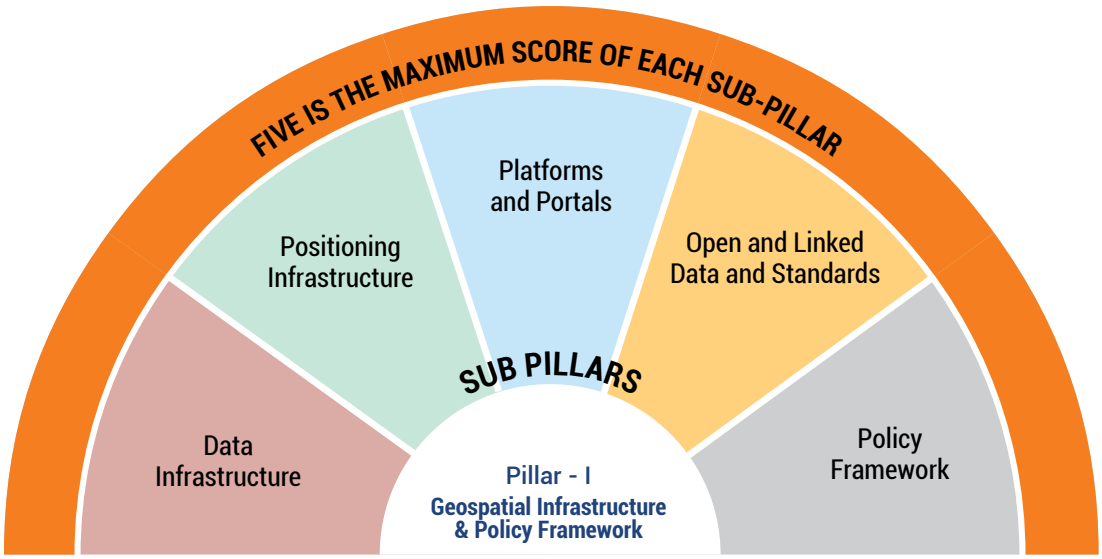


Figure 9.1 Determinants of Pillar I: Geospatial Infrastructure & Policy Framework

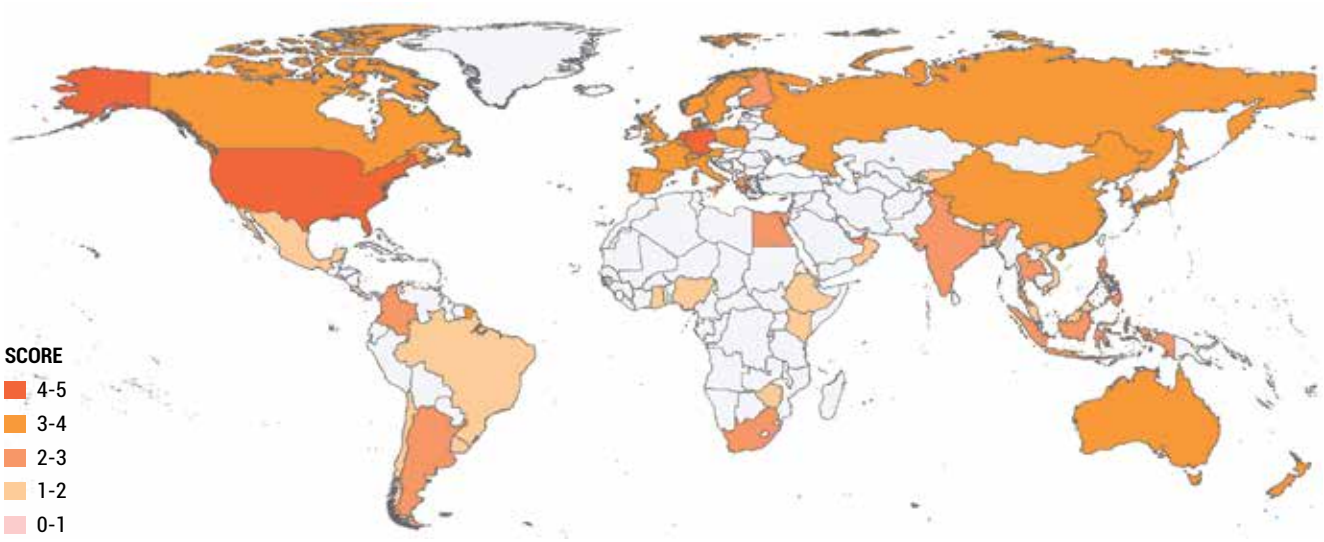


Figure 9.2 Frequency Score Representation of Data Infrastructure of 50 Countries

said characteristics are then summed to achieve the score of the sub-pillar.

In Figure 9.2, the world map shows a frequency score for the selected 50 countries based on the weights assigned to the topographic and earth observation infrastructure which have been further normalized and scaled from 0-5. As can be inferred from the graph, the United States, the Netherlands, Germany, Switzerland and Russia (developed countries) are the top 5 leading countries with respect to geospatial data infrastructure. These countries have a well-established, operational national spatial data infrastructure and all the major thematic layers — cadastre, infrastructure, utilities, defence and security, water resources, forest and environment, geomorphology, etc. — available at very high scales. Similarly, most of these countries have their own satellites that provide high spatial resolution data, directly contributing to the economic growth. The data in these countries is accurate, interoperable, consistent and timely, thereby making the geospatial infrastructure effective and efficient.

Countries that rank the lowest and are at the beginner's level of setting up their geospatial infrastructure are mostly emerging economies. The reason these countries rank low is because the national data infrastructure in these countries is still at the initial stage of planning. Even though the datasets in these countries are available through the national mapping agencies, the scales at which they are available are quite low. Their maps cater to only the very basic level of thematic layers, thereby affecting their rank in the overall data infrastructure sub-pillar.

Most of the developing countries, like India, Thailand, South Africa, etc., are in the middle rank as the data infrastructure of these countries is either at the implementation stage or at the initial stage of being operational. The

scale of map available for the thematic layers is mid-scale when compared to the underdeveloped nations, and low when compared to the scales offered by the developed nations. Some of these countries also have their own earth observation capacity (like India) which highlights that the data infrastructure in the developing countries is expanding at a fast pace.

Positioning Infrastructure

To understand the geospatial infrastructure it is essential to study the positioning infrastructure, which is dependent on the following determinants or sub-pillars:

- Positioning Systems
- Augmentation Systems
- Geodetic Infrastructure

A powerful tool, a positioning system provides real-time positioning on or near the earth surface, to provide crucial capabilities to military, civil and commercial users globally. For instance, Navstar (Navigation Satellite Timing and Ranging System) is a network of United States satellites that provides GPS services. Similarly, the Russian Global Navigation Satellite System aka GLONASS was developed alongside GPS and has been providing global coverage since 2002. The other positioning systems are the European Union's Galileo, China's BeiDou, the Japanese Quasi Zenith Satellite System and India's Indian Regional Navigation Satellite system (IRNSS). Countries with their own positioning systems are given a score on the basis of their precision accuracy, positioning accuracy and timing velocity.

The second determinant is the augmentation of global navigation satellite system (GNSS), which improves the navigation system's attributes, such as, accuracy, reliability and availability. For example, Wide Area Augmentation System (WAAS) of the United States follows a precision approach, addressing all navigation problems to provide easy to use, highly-accurate positioning. The benefits of WAAS are not limited to only causing convenience, but also to generating significant cost savings. Similarly, EGNOS (European Geostationary Navigation Overlay Service) and the European Operational SBAS, and MTSAT Satellite Augmentation System (MSAS) exist for Europe and Japan respectively. India too has a satellite based augmentation system called GAGAN under implementation

The third determinant, the geodetic infrastructure, provides accurate information about fundamental properties of the earth as they change over time leading to many scientific, civil, military and commercial applications. The geodetic infrastructure comprises of the Ground Control Points (GCPs) and the RTK Base Stations. Ground control points are important to understand the geodetic infrastructure because they are used to geo-reference data used in conjunction with GPS to increase the accuracy of the area being surveyed. The more the number of the ground control points in a country, the more precise and accurate will be the maps so derived. Similarly RTK base stations, i.e., real-time kinematic stations enhance the precision and accuracy of location data that is derived from the satellite based positioning systems,

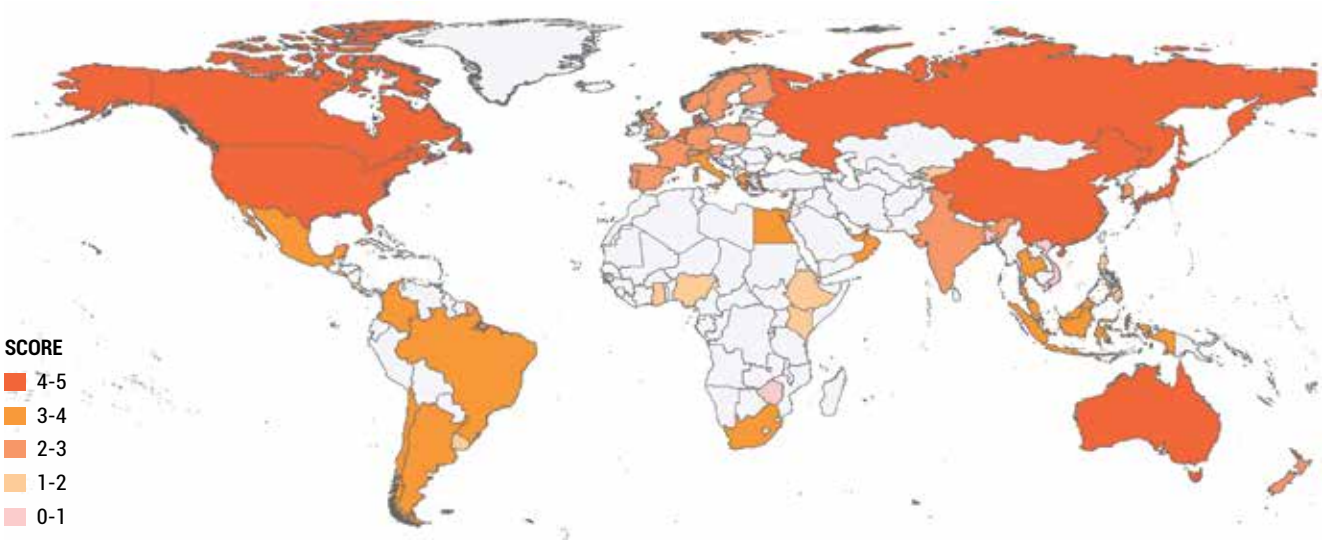


Figure 9.3 Frequency Score Representation of Positioning Infrastructure of 50 Countries

The geodetic infrastructure, provides accurate information about fundamental properties of the earth as they change over time leading to many scientific, civil, military and commercial applications

such as, GPS, GLONASS, Galileo and BeiDou. The larger the number of RTK base stations, greater the surety of correct geo-positioning.

In Figure 9.3, the world map shows the frequency score for the selected 50 countries based on the weights assigned to the three determinants of the positioning infrastructure, which have been further normalized and scaled from 0-5. It can be inferred that the leading countries in terms of positioning infrastructure are the United States, Russia, Japan, Singapore, Denmark, China, Canada and the Netherlands. As discussed, these countries are rich in positioning infrastructure with their own positioning systems, augmentation systems and a high number of ground control points and a widely established RTK network for higher precision and accuracy.

In contrast, it can be seen, that the countries lagging behind are the emerging economies because they do not have augmentation systems of their own. The number of ground control points is also not as high as compared to those of the developing and developed nations. Also, the establishment of the RTK networks is still not adequate and is at the planning stage in most of these countries

Platforms & Portals

The third sub-pillar of the geospatial infrastructure and policy framework is an understanding of the platforms and portals. Geoportals and other data dissemination platforms play a crucial role in the sharing of geographic information. They provide a direct access to raw data in various formats, metadata, online visualization tools, datasets, maps, etc. Their key benefits include:

- Accuracy, timeliness, correctness and consistency of data being used in planning and development, while simultaneously eliminating the possibility of duplicity of data
- Enhancing the utilization and awareness of geospatial data because of easy consumption of data and services
- Data transparency and consistent supply of information for decision makers

As of today, there has been an explosion of geoportals for sharing geographic information based on region or theme. For example, INSPIRE (Infrastructure for Spatial Information in the European Community), UNSDI (United Nations Spatial Data Infrastructure) and the NatCarb geoportal, which provides geographic information concerning carbon sequestration in the United States. Geoportals are being widely used for water and marine environment, transport, land use planning, biodiversity and nature protection, tourism, climate change, etc.

While portals are of utmost importance, their optimal function depends on the support of geospatial technology architecture. In the study, we have taken into consideration five major technology architecture formats:

- View-only Web Portals
- Catalogue and Metadata
- Functional Clearing House
- Integrated Data Centre
- Centralized Analytical Platform

The geospatial technology architecture has been weighted according to the level of functionality. So, the centralized analytical platform is ranked highest because this platform not only allows access and viewing of spatial datasets, but also provides users with facilities to analyze the data on the platform itself to get the desired results. At present, the centralized analytical platform is at the development stage in most of the developed nations and will soon be a functioning platform in these countries.

Meanwhile, an integrated data centre and a functional clearing house are the two most commonly found technology architecture platforms in almost all the developed nations. An integrated data centre provides a homogenous approach to national data infrastructure to improve workflow management, while a functional clearing house provides access to digital spatial data infrastructure and related online services for data access, visualization, etc. Therefore, these technology platforms facilitate access to spatial metadata, data and services on the internet, and are crucial to map the geospatial infrastructure of a country.

While assessing the portal and platforms of the countries (Figure 9.4), it is found that developed countries like the United Kingdom, the Netherlands, United States, Canada, Germany, Singapore and Russia are the leading countries to have an operational geoportal, and an effective and efficient technology architecture that facilitates the growth of geospatial data access and sharing. In the United Kingdom, it is the location infrastructure portal that enables the share and reuse of spatial data. With respect to technology architecture, the United Kingdom is much closer

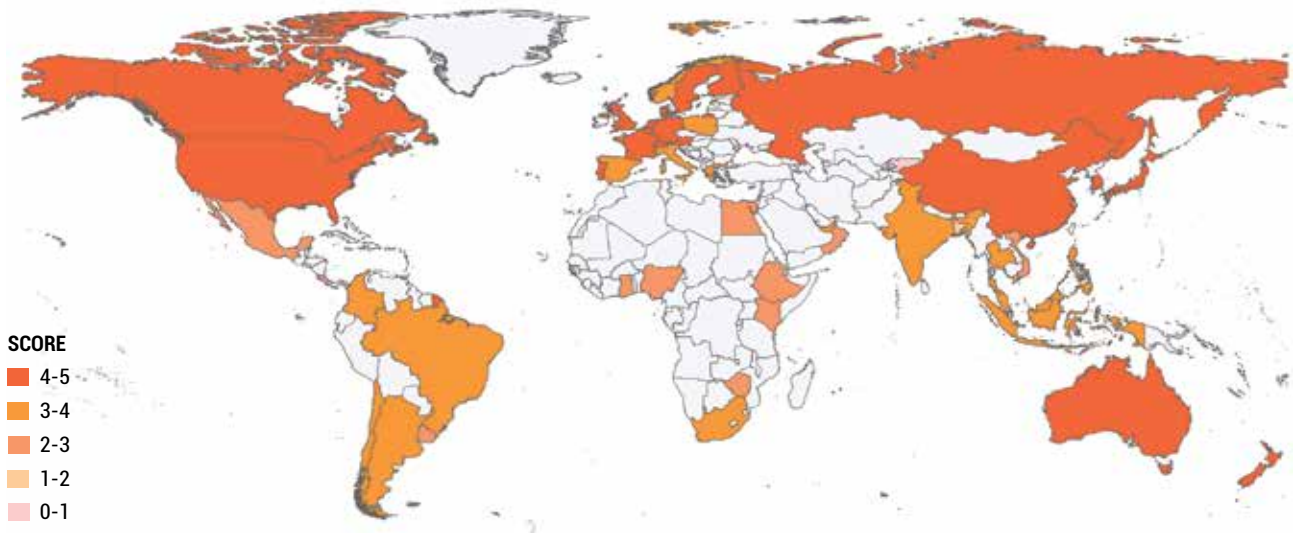


Figure 9.4 Frequency Score Representation of Platforms and Portals of 50 Countries

Technology platforms facilitate access to spatial metadata, data and services on the internet, and are crucial to map the geospatial infrastructure of a country

than most countries in establishing its centralized analytical platform to provide analyzed data, and has an integrated data centre as well as a sound, functioning clearing house.

Similarly, the Netherlands ranks higher for the topographic and the earth observation (or satellite) data portal, which provides access to both raw and processed data for free. The Netherlands also ranks higher because the country is one of the firsts to establish a Cloud-based Web portal for real-time satellite data access.

The runner-up countries, such as India, UAE, and Indonesia, etc., also have their own portals and platforms. It is observed that new geospatial technology architecture in these economies is being implemented, and the existing one being modified constantly to match the advanced architecture of the developed nations. At present, technology innovation in these countries is at a high; technology enthusiasts, users and the geospatial industry, with firm support from policy makers, are pushing for the establishment of platforms and portals on an urgent basis.

Most of the underdeveloped or emerging countries are at the beginner stage for this determinant. At present, on an average, the low-ranked countries do not have a proper platform and portal for spatial data yet. Countries like Ghana and Kyrgyz Republic have already realized the need for platforms and portals for geospatial use, and have taken initiatives toward establishing a comprehensive technology architecture.

Open and Linked Data and Standards

Freely available open data is important to build accountable and effective institutions. Majority of the countries in

the study have an open data initiative and a national data catalogue providing access to datasets available for reuse. It is a well-recognized fact that open data enhances the ability of policy-makers, decision makers and geospatial engineers to find solutions to complex development problems — even though concerns with respect to privacy and security are increasing. Seen as a driver of innovation, free availability of spatial data remains heavily concentrated in the developed countries.

To assess the open and linked data pillar, inter-data and intra-data linkages are also assessed. In many countries, data is collected by the government departments of various industries separately. In such a scenario, data is shared within the same department (inter-department), while simultaneously the data is also shared within two departments to create an intra-department linkage. In some cases the data is shared openly within and among the departments, while in others, the datasets are restricted.

Data dissemination methods are important to understand the ease with which data is disseminated in any country. Traditional data dissemination methods include CD/DVD and FTP, though now the movement is toward Web portals and Cloud. As such, the countries moving toward Cloud- and Web-portal based dissemination have been given higher weightages.

In the field of geographic information, standardization began 25 years ago, thereby establishing the importance of data standards. Geospatial data standards allow diverse data sources, applications and systems to operate with each other. Harmonization of standards is important for facilitating robust open transfer of spatial data, to encourage innovation, improve efficiency and increase transparency. Standards, such as ISO, CEN, OGC, data and metadata standard, etc. are needed to be implemented for economic and strategic reasons, and therefore, also need to be assessed for readiness purpose.

As can be inferred from the world map in Figure 9.5, European countries like Denmark, France and Germany lead the linked and open data standards readiness sub-pillar. European countries follow the INSPIRE directive, which clearly defines the open data policies and data standards.

These countries are followed closely by the United States, Canada, Japan, the Netherlands, Switzerland and Sweden. It is again not surprising to note that the developed nations lead the readiness for this sub-pillar. In these countries, the importance of spatial data and its openness is well understood. These countries have flexible open data policies, with no inter-department or intra-department restriction on the use of spatial data.

Spatial data sharing in emerging economies is conservative and restricted. Thus, inter- and intra-data linkages are not encouraged. The use of spatial data is still at an embryonic stage. Data dissemination is limited to mostly traditional methods, and the importance of data standards is yet to be realized.

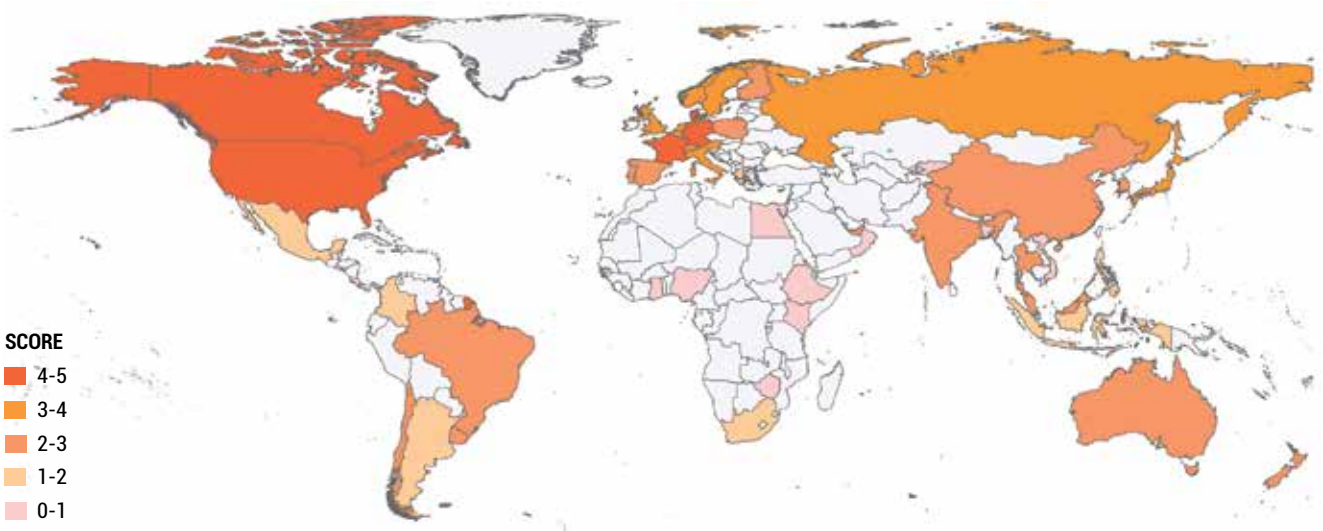


Figure 9.5 Frequency Score Representation of Open and Linked Data and Standards of 50 Countries

Policy makers have begun to show a deep interest in connecting space and location technologies to match up to the paradigm shift happening in the geospatial industry

Policy Framework

A well-regulated policy framework acts as a binding and a guiding force for the adoption of geospatial technologies in a country. Today, geospatial policies are seen as a national priority, essential to eliminate barriers and to promote data exchange and integration. In various countries, a broad range of guidelines, rules and regulations, law and legislations and directives have been issued to facilitate the development, sharing and use of geospatial data. It is vital that a policy framework exists to govern the lifecycle of geospatial information, i.e., data acquisition, data dissemination, data management, data use, etc.

To assess the policy framework of 50 countries, apart from primary research, extensive secondary study has been done of the policy documents for geospatial related policies for the chosen countries. The policies that have been taken into detailed consideration are:

- National Geospatial Policy
- Surveying and Mapping Policy
- Remote Sensing and Earth Observation Related Policies
- Unmanned Aerial Vehicle (UAVs) and Drone Policies
- Data Policies (open data, data standards, data acquisition, data dissemination, data security, etc.)

Decision makers all over the world have realized the value of flexible policies for the adoption and use of geospatial technology in various projects. Policy makers have begun to show a deep interest in connecting space and location technologies to match up to the paradigm shift happening in the geospatial industry. The value of spatial technologies is being increasingly recognized and, therefore, a national geospatial policy/law plays a crucial role in defining the mandate of use. Moreover, a national geospatial policy is needed to regulate the acquisition, dissemination, publication, sharing

and distribution of geospatial information so as to not compromise on national security, but simultaneously develop a level-playing field to mature the various spheres of geospatial domain in an economy. In our study, a country that has a viable national geospatial policy has been given a higher weightage than its contemporaries.

The surveying and mapping policy plays a pivotal role in defining the geospatial readiness of a country. Invariably, every country has a basic surveying and mapping policy in place. Maps form the core of geospatial domain, and policies are needed to define a set of rules that determine the regions that can be mapped, accessibility of survey maps and the usage of these maps. Land surveying and mapping activities need to be regulated by legal and administrative framework to provide spatial data and information to a broad spectrum of users to establish a proper decision support system. In our study, a detailed evaluation has been done of policy documents of 50 countries with respect to their surveying and mapping policy, and weights have been assigned accordingly.

Progressive remote sensing and earth observation (EO) policies are a must for a healthy and thriving geospatial industry. The data acquired from EO satellites has a large number of users — both within a country and outside. While not every country has an EO satellite of its own, high-resolution EO imagery is being used widely by all. Therefore, it is imperative to have policy guidelines and framework to establish the rules for the adoption and use of remote sensing and earth observation data.

The use of unmanned aerial vehicles (UAVs) or drones has become much more commonplace in the past few years for academic, commercial and recreational purposes. Therefore, UAV/drone laws are crucial for every economy so that these vehicles do not toy with the national security and privacy of the citizens. Many European countries and American states have already implemented drone laws and legislations and are actively seeking to issue further guidelines to restrict UAV/drone use in sensitive areas.

In Figure 9.6, the world map represents the scores for the 50 countries normalized in the scale 0-5. It can be seen that most of the developed countries, such as, the United States, Canada, the Netherlands, Singapore, Denmark, Japan, Australia and China have a well-formulated policy framework for the use and adoption of geospatial technologies. It is to be noted that all these countries have adopted a national geospatial policy and have flexible regulations with respect to open data, data standards, data acquisition, data dissemination, etc. Governments in these countries have an explicit commitment toward the geospatial industry.

A fascinating fact here is that Indonesia was the first country to pass and implement the Geospatial Information Act in 2011. However, the reason that the country ranks lower in the policy framework is because of low adaptability and knowledge of the Act among the users and the industry.

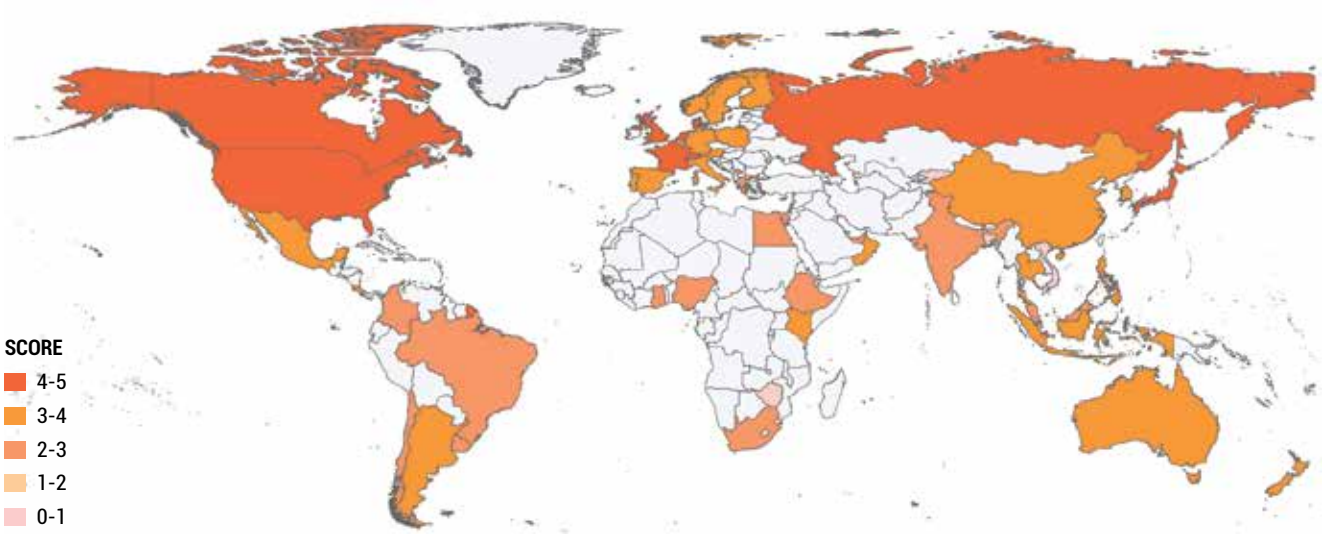


Figure 9.6 Frequency Score Representation of the Policy Framework of 50 Countries

Emerging countries are at an initial stage of planning for the national infrastructure and policies supporting geospatial technologies need to be developed in parallel

Developing countries like India, Malaysia, Colombia and Brazil feature in the middle range of the policy readiness sub-index. Countries at this level have formulated geospatial policies and are at the implementation stage of the policies. Existing policies in these countries are enabling and encouraging as the policy makers and decision makers have begun to adapt and understand the need for extensive use of geospatial in their respective countries. However, it is important to note that while the existing policies promote and encourage geospatial, there is a lag in the implementation of specific laws/legislations and rules and regulations. The absence of clear processes, timeliness, resources and delegated responsibilities creates a problem with respect to the actual implementation. Also most of the policies formulated in developing nations are not legally binding, which further creates problem during implementation.

Lastly, the emerging economies are learning from their counterparts in the developed world and are formulating policies for each level. It should be noted that these are the countries that are at the initial stage of planning for the national infrastructure, and therefore, policies supporting geospatial need to be developed in parallel. At present, these countries do not have their own remote sensing capabilities, so they do not have any remote sensing/earth observation and UAV/drone policies also. Surveying and mapping policies do exist in these countries, but no proper legislations are defined with respect to data. Policy makers and decision makers in these countries have only recently begun to understand the benefits and advantages derived from geospatial use, investments have just started pouring in and, therefore, the development of policy framework in these countries is at an initial, but promising stage

Final Ranking

It can be inferred from the analysis that the United States, the Netherlands, Denmark, Canada, Russia, Germany, Singapore, France, United Kingdom and Japan are the top 10 countries with efficient geospatial data infrastructure and an enabling policy framework. From the detailed analysis conducted for each sub-pillar, it is not a surprise that the top 10 leading countries and even the ones that closely follow these countries are all developed nations that rank highly in the sub-pillar indices as well. Almost all of these countries are pioneers in the use of geospatial technology, are self-sufficient with respect to their own satellite capabilities, and have their own augmentation systems, access to an efficient geoportal and a strong policy framework.

For instance, the United States ranks number one in this pillar because the country is rich in both topographic data sets (with respect to scale and thematic layers available) and has its own earth observation capabilities (satellites) making imagery available in high resolutions. The United States also has a wide RTK network and its own augmentation system (WAAS) that enhances its positioning infrastructure capabilities. Even with respect to policy framework and standards, the country has a clearly defined framework for the growth of the geospatial industry and geospatial standards such as the Open Geospatial Consortium (OGC) and International Organization for Standardization (ISO). Overall, the country ranks at number one because it leads in all attributes of the geospatial infrastructure and policy framework pillar.

Similarly, the European countries that feature in the top — Denmark, the Netherlands, Germany, France — rank so because the EU follows the INSPIRE Directive that aims to establish a common platform for spatial information in Europe since 2007. Even though most of these countries have their own geospatial data infrastructure, they are governed by the guidelines issued in the INSPIRE Directive, and therefore, an enabling policy framework is followed. Copernicus, previously known as GMES (Global Monitoring for Environment and Security), is the European program for the establishment of European capacity for EO, of which all European countries are members. Also, Europe has the European Geostationary Navigation Overlay Service (EGNOS) which covers the whole of Europe and, thus, showcases a strong positioning infrastructure.

It is no surprise that the emerging nations rank the lowest in infrastructure and policy readiness. As discussed, these nations are still setting up their own spatial data infrastructure and have no satellite capabilities of their own. With respect to policy framework and standards, these countries lack in an adequate legal framework at present and would need considerable time to develop and implement relevant policies. However, these economies are quite proactive in establishing the geospatial infrastructure and policy framework in parallel to each other, which is a promising start.

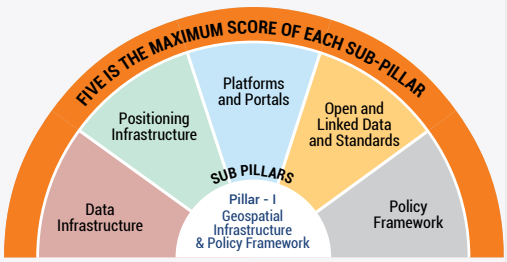
Harmonization of standards is important for facilitating robust open transfer of spatial data, to encourage innovation, improve efficiency and increase transparency

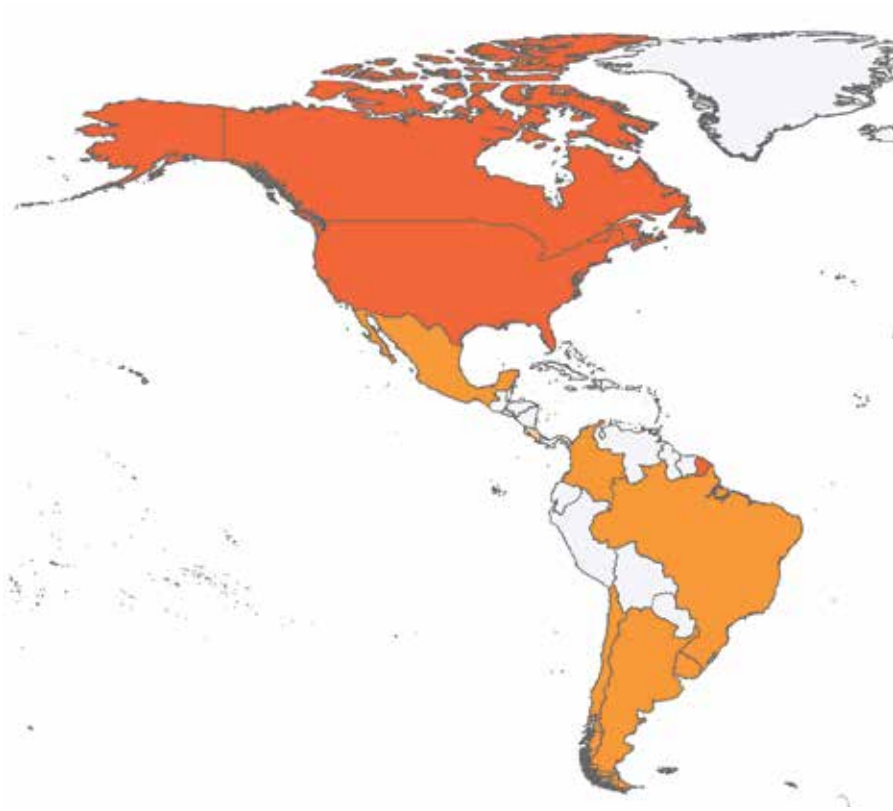
PILLAR I: GEOSPATIAL INFRASTRUCTURE & POLICY FRAMEWORK

OVERVIEW

This pillar showcases the geospatial readiness with regards to g eospatial infrastructure and policy framework of the selected 50 countries.

DETERMINANTS





0-5

Beginners

Countries at this level are at the beginners stage i.e. at the planning stage of creating a geospatial infrastructure and policy framework

5-10

Basic

Countries at this level are focusing on implementation of the geospatial Infrastructure and policy framework

10-15

Intermediate

Countries who have an operational but expanding geospatial infrastructure with a supporting policy framework

15-20

Advanced

Advanced nations having a competent geospatial infrastructure and an adequate policy framework in place

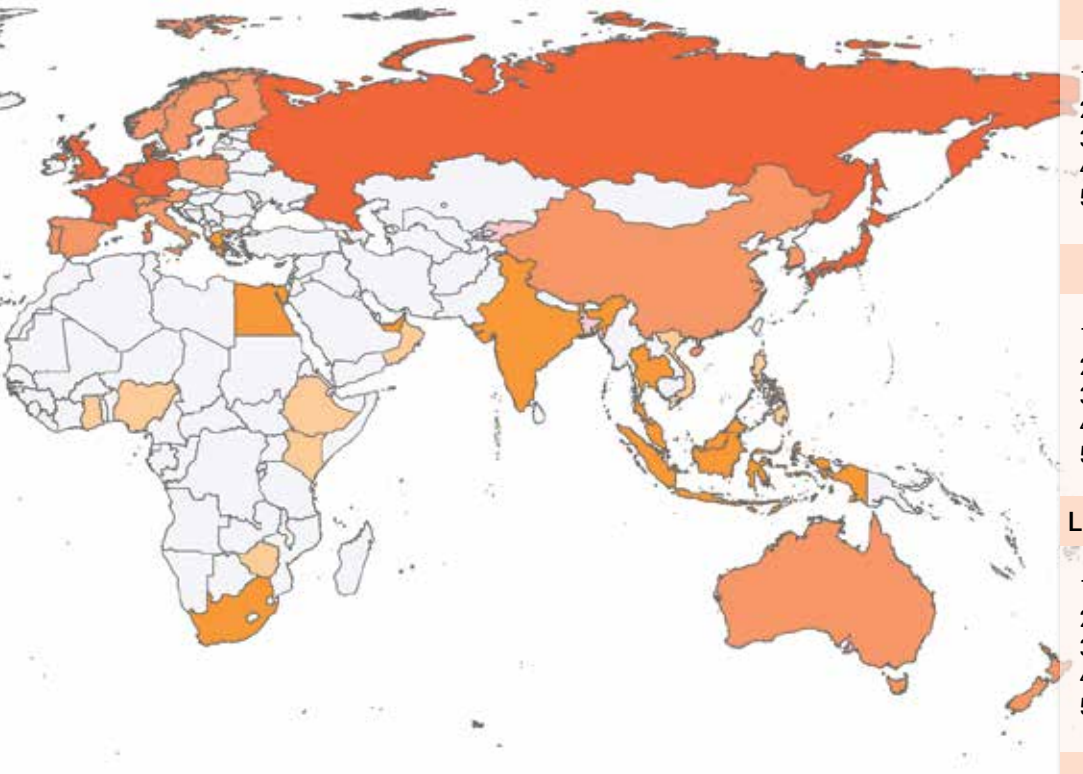
20-25

Highly Advanced

Highly advanced countries having a highly efficient geospatial infrastructure and an enabling policy framework

50 Countries Indexed as per Geospatial Infrastructure & Policy Framework

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
United States	The Netherlands	Denmark	China	Singapore	Switzerland	United Kingdom	Australia	France	Belgium	South Korea	Germany	Russia	Poland	Spain	Italy	Austria	Canada	Japan	New Zealand	Sweden	Greece	Portugal	Norway	UAE



Sub-Pillar Leaders

DATA INFRASTRUCTURE AND POLICY FRAMEWORK

1 United States
2 Netherlands
3 Germany
4 Switzerland
5 Singapore

PLATFORM AND PORTALS

1 Denmark
2 The Netherlands
3 United States
4 Switzerland
5 South Korea

LINKED DATA AND STANDARDS

1 United States
2 China
3 Singapore
4 Denmark
5 Switzerland

POLICY FRAMEWORK

1 United States
2 Denmark
3 China
4 The Netherlands
5 Singapore

GEODETIC INFRASTRUCTURE

1 United States
2 Singapore
3 China
4 Australia
5 United Kingdom

Overall Takeaway

LEADERS

1 United States
2 The Netherlands
3 Denmark
4 Canada
5 Russia

BEGINNERS

46 Vietnam
47 Kenya
48 Zimbabwe
49 Krygyz Republic
50 El Salvador

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Egypt	Indonesia	Thailand	Brazil	Colombia	Finland	Argentina	Philippines	South Africa	Nigeria	India	Ethiopia	Malaysia	Uruguay	Ghana	Mexico	Chile	Costa Rica	Oman	Bangladesh	Vietnam	Kenya	Zimbabwe	Kyrgyz Republic	El Salvador

10. INSTITUTIONAL CAPACITY

Capacity can be defined as, 'the ability to perform functions, solve problems and set and achieve objectives[1]. Capacity building is central to the development of an industry and the same holds true for the geospatial industry. The geospatial industry needs a 'geo-intelligent' workforce, who are well-versed with the geospatial domain, and related concepts like crowdsourcing, human geography, visual analytics and forecasting. These requisite skills are computationally-oriented and supported by degree programs and academic institutions and infrastructure.

The geospatial industry needs a 'geo-intelligent' workforce, who are well-versed with the geospatial domain, and related concepts like crowdsourcing, human geography, visual analytics and forecasting

It is, therefore, essential for each country to have a sustainable supporting institutional platform for the geospatial industry to encourage technology innovation and incubation in the country. There is an increasing realization, especially in the developed countries, of the benefits and advantages of a thriving geospatial industry and, therefore, a country must have strong institutions that can enhance the geospatial knowledge base in the country.

Institutional capacity is systematic. Increasing the number of institutions that provide geospatial knowledge (courses), and promoting geospatial specific incubation centers is relevant to the overall level of institutional capacity. At present, the need to develop human capabilities to harness geospatial knowledge is being recognized globally. The drivers of geospatial institutional capacity are:

- **Increase in active geospatial projects and investment:** There has been a huge push in investment to enhance geospatial projects for economic growth. The enormous growth in investments for geospatial projects requires human capacity with a strong geospatial knowledge base.
- **Embedment of geospatial in overall business processes:** There is a growing requirement of embedding geospatial in the everyday processes of various industry verticals. The use of geospatial technology in inter-disciplinary platforms has created a 'pull effect' for inter-department skilled workforce in the current education system.

1 Fukuda-Parr & al., 2002

Institutional capacity ranking of the selected 50 countries based on the set determinants (Business Incubation, Fundamental Sciences, Professional Education, Interdisciplinary Application and Vocational Training) as seen in Figure 10.1; follows a statistical approach to understand the level of advancement and comparative stand of each country. Various statistical indexing studies have proved that a nation's human skill and capacity put to productivity is an important determinant of the country's economic growth. The World Bank's Human-Development Index — which maps correlation between educational capabilities to the overall development of the country — is one of the most recognizable examples. This chapter maps and showcases the geospatial institutional capacity of selected 50 countries in terms of geospatial courses provided in each country.

Business Incubation

Entrepreneurship and incubation, a recent trend in the technology landscape is predominant in countries with an inherent quest for innovation. An incubation centre aims to encourage students with entrepreneurial mindsets to innovate and channelize their efforts to develop new geospatial ventures. Incubation centers bring together the academia and the industry with global partners to empower technology entrepreneurship. Incubation in geospatial industry has started growing consistently in the last decade.

At present, there are a large number of research labs and incubation centres that are giving rise to geospatial entrepreneur ventures across the globe. Incubators are also crucial for creating synergies. Thus, they are considered as an important factor for studying the geospatial institutional capacity and get

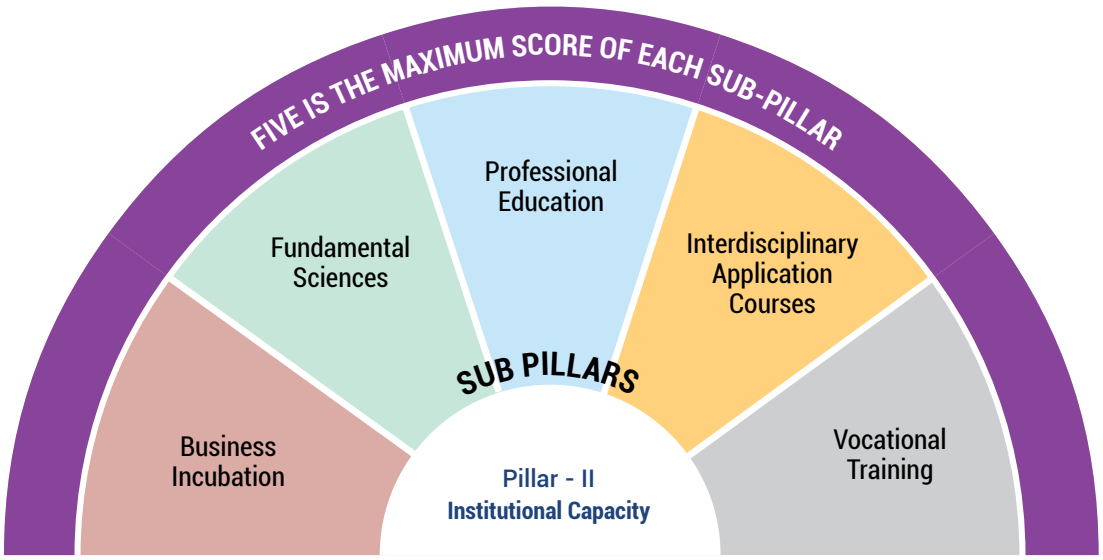


Figure 10.1 Determinants of Pillar II: Institutional Capacity

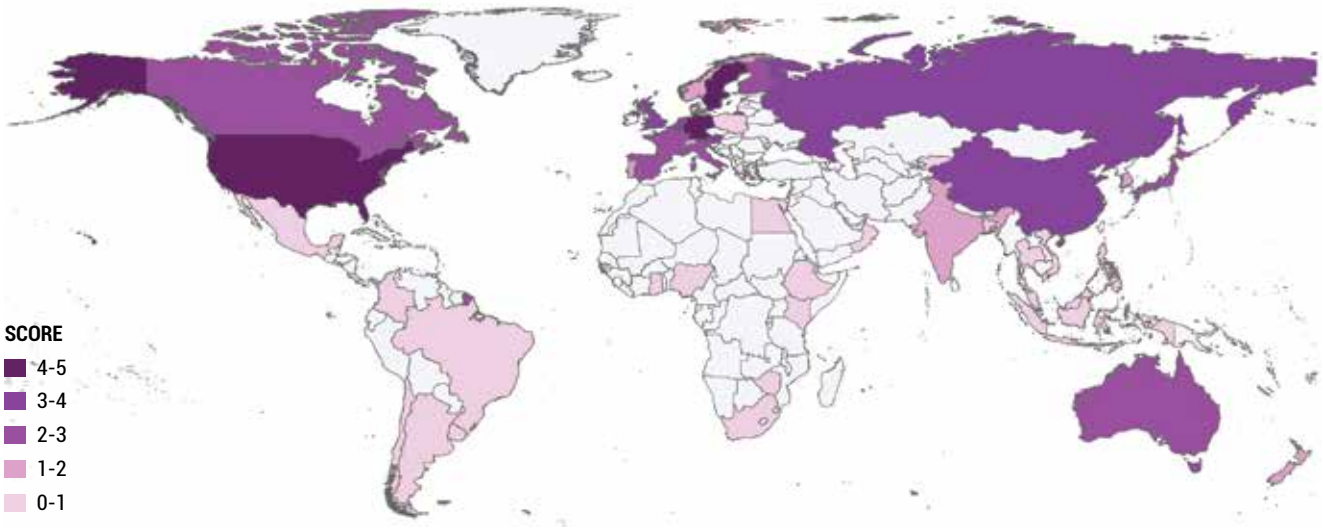


Figure 10.2 Frequency Score Representation of Business Incubation in 50 Countries

a clear picture of the overall geospatial readiness index.

In Figure10.2, the world map gives frequency score of the number of incubator programs in the selected 50 countries which have then been weighted and scaled from 0-5. The United States, Germany, Sweden, the Netherlands, Austria, Belgium, Singapore and the United Kingdom are the countries that are at advanced levels for the incubation capability and entrepreneurship. In these developed countries, both government and the private sector encourage incubation in the geospatial industry for increasing technological advancement.

For instance, in Europe, the European Space Agency (ESA) has set up its own incubation centers in the Netherlands, Germany, Belgium, Austria, Spain, Sweden and France to support technical ventures that apply space technology to non-space industry fields. This way, the ESA helps to create viable spatial businesses and new employment opportunities.

In the United States, the University of California for example, has a geospatial innovation facility. Similarly, University of Illinois, University of Akron and Boston University also have incubation centers that support entrepreneurship for geospatial advancement.

Countries such as India, Portugal, Switzerland, New Zealand and Denmark have received a low score for incubation and entrepreneurship. However, these countries have recognized the strategic importance of geospatial innovation for competitiveness and economic development, and are expected to increase their incubation capacity in the years to come.

The incubation capacity of Latin America, South Africa and most of the southern nations is also low because these countries are still at the beginners' stage for the use and adoption of geospatial technologies.

Fundamental Sciences

For a country to have sound geospatial human resource, strong institutions for fundamental studies in geodesy and geomatics is a must. These studies strengthen the core knowledge needed in the geospatial domain and give rise to a number of research and development (R&D) projects. For the scope of this study, fundamental studies are defined as the advanced applied science courses and postgraduate research degrees (Ph.D.) in core geospatial technologies. These include post-doctorate degrees in geomatics and geographic information science (GIS), M. Phil., etc.

Geospatial applied science courses harness the existing geospatial technical knowledge to develop more practical applications and bring in innovations. Countries that provide a large number of applied science courses tend to progress faster and register more patents than others. The human capital from this segment mostly caters to the upper middle level of the pyramid.

In Figure 10.3, the world map showcases the frequency scores of the selected 50 countries based on the number of fundamental courses available in each country, which has been further scaled from 0-5. It is again no surprise that the United States, Canada, Australia, Germany, Japan, Russia and France rank higher in the pyramid for providing fundamental courses.

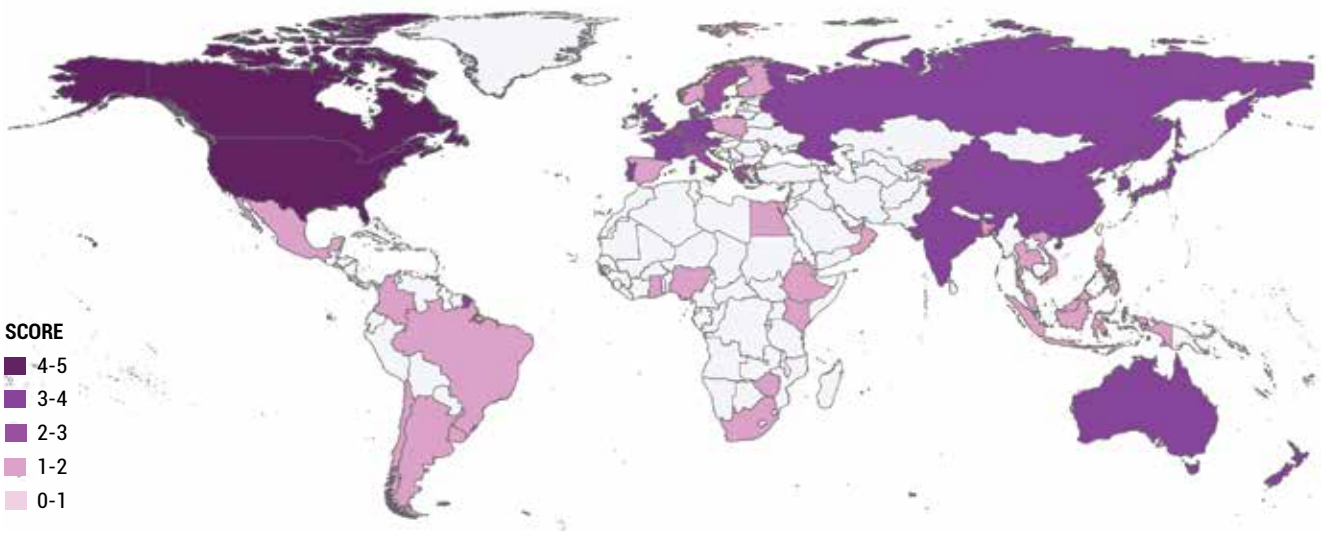


Figure 10.3 Frequency Score Representation of Fundamental Science in 50 Countries

Most of the emerging economies have a beginner's level score due to the very low focus of geospatial fundamental studies in their universities. These countries currently are not adequately equipped for geospatial fundamental research and applied science courses, but they do have exchange programs to develop the human capacity in these domains.

Professional Education

Professional geospatial courses are a precondition to equip human capacity for meeting the growing demand for expertise in spatial analytics, spatial data management, cartography, positioning and remote sensing, both nationally and internationally. Students or executives who undertake these professional courses rigorously learn the fundamental theories, concepts, quantitative tools and analytical research methods. Geospatial professionals trained in such a manner are project leaders with the necessary understanding of project management and geospatial technical skills.

Professional courses are a significant determinant to evaluate a country's capacity for harnessing talent that can cater to the geospatial industry. The professional degrees considered in this study are provided at graduation and post-graduation level, depending on the profession concerned and are classified as bachelor's and master's degrees.

The world map, in Figure 10.4 gives frequency score of the number of professional courses in the 50 countries weighted and further ranked from 0-5. The United States leads in providing the highest number of geospatial professional courses, and that too in a large number of universities. It is closely followed by Germany, Russia, United Kingdom and China.

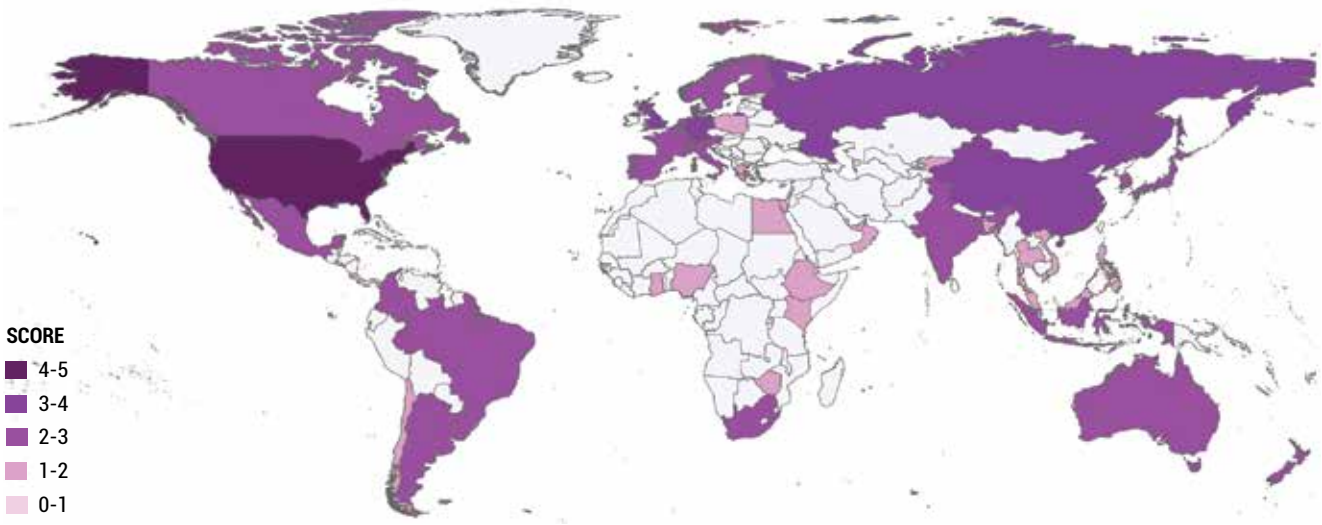


Figure 10.4 Frequency Score Representation of Professional Education in 50 Countries

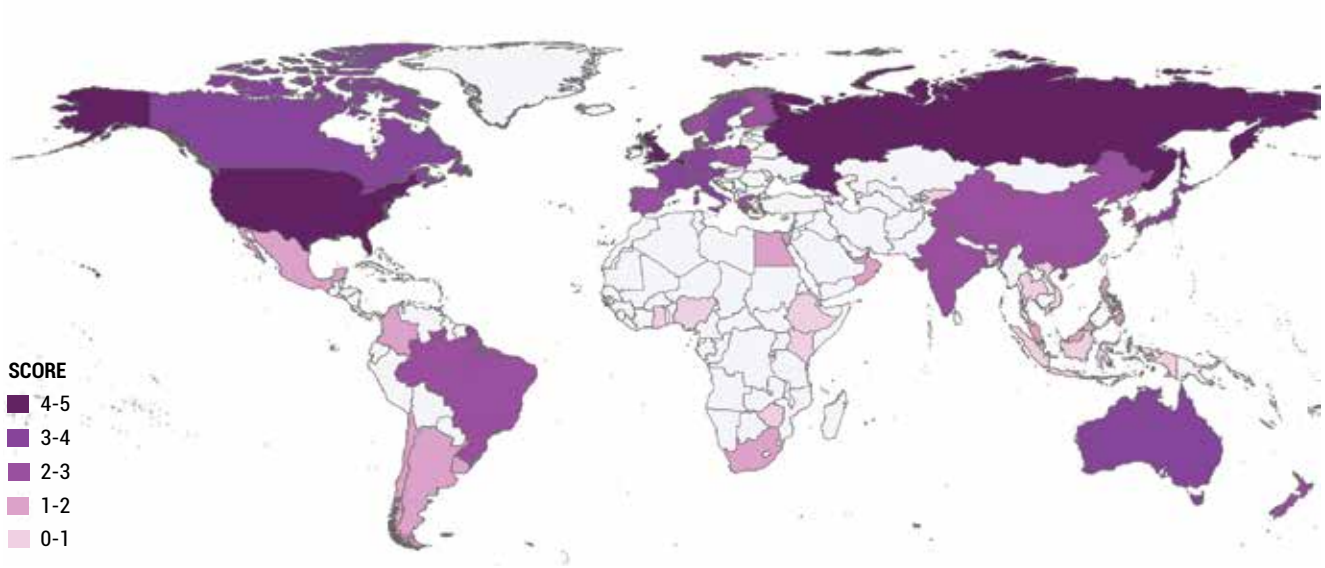


Figure 10.5 Frequency Score Representation of Interdisciplinary Applications in 50 Countries

Not surprisingly, emerging economies like Oman, Costa Rica, Zimbabwe, and Bangladesh do not have as many institutions that provide geospatial professional courses, when compared to those provided by developed countries. The number of professional courses provided in the emerging economies fails in comparison to those of developed countries. Therefore, these countries have scored low as compared to their developed counterparts.

Interdisciplinary Applications Courses

Interdisciplinary courses are defined as education programs that are combined with a specific industry vertical for accurate application knowledge, etc. A geospatial interdisciplinary course can be defined as an academic program that provides specialized knowledge in key areas that complement geospatial science for environmental science, natural resource management, computer science business, architecture, urban planning, infrastructure, forest and environment, etc. In such a scenario, the students get a chance to understand the application of geospatial technologies in their disciplines. These programs are much more widely found across the globe to have cross border discipline experiences. The study, therefore evaluates the number of cross disciplinary programs in the selected 50 countries as a factor to evaluate institutional capacity.

In Figure 10.5, the world map shows the frequency score of the 50 countries based on the number of interdisciplinary courses which was weighted and normalized on scaled from 0 to 5. It is observed that the number of interdisciplinary programs are more in the United States, Russia, Belgium, the United Kingdom, Germany, Australia, the Netherlands, France and Canada. Some of the courses provided in these

countries include degrees in Civil Engineering with GIS/Cartography concentration, geography major with a track in geospatial science, building engineering, remote sensing and security or a masters degree in industry ecology with environmental informatics, etc.

Emerging economies have less number of geospatial inter-disciplinary courses available in their universities and, therefore, these countries rank lower in this sub-pillar.

Vocational Training

Vocational courses are short-term certification courses pertinent to a certain field of study. Geospatial vocational courses provide students with practical skills, as well as an understanding of how to use these skills. Vocational courses can be seen as a stepping stone for a student to professional courses for continued personal development.

This study has considered short-term diploma courses, certifications and other training courses under vocational courses and has mapped this factor to evaluate the concentration of vocational courses in the universities.

The world map in Figure 10.6 gives frequency score for the number of vocational courses in the selected 50 countries weighted and normalized on scale from 0 to 5. The United States has the maximum number of vocational courses in its universities, followed closely by Canada, India, Australia and United Kingdom. India, for instance, has a lot of government and private universities that offer certification and diploma courses in the geospatial domain.

From certificate courses on surveying and mapping to remote sensing, geomatics and GIS, there is no dearth of vocational courses in these coun-

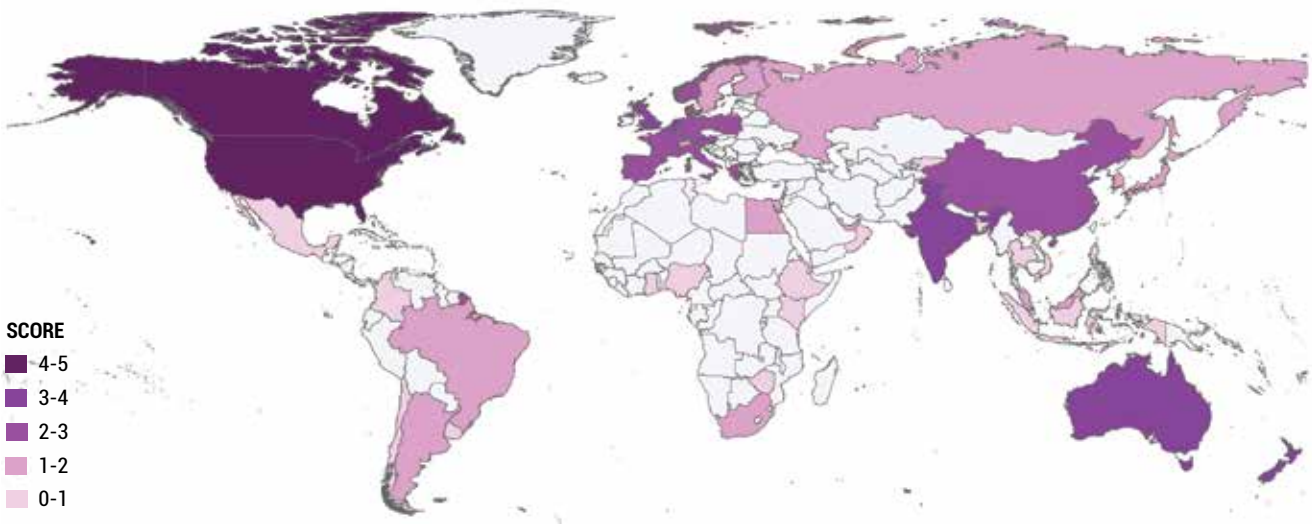


Figure 10.6 Frequency Score Representation of Vocational Training in 50 Countries

tries. Which is why, these countries rank higher in the sub-pillar. Also these countries are pioneers in offering a large number of geospatial certificate and diploma courses through online education for which there is a growing demand nowadays.

Very few regions underperform in this sub-pillar because almost all universities globally have a huge number of geospatial certificate courses and programs. Emerging economies also have a good number of such courses, though that number pales in comparison to developed nations.

Final Ranking

The final ranking for Pillar II: Institutional Capacity has been calculated for the 50 countries. This has been done on the cumulative number of different types of courses available at universities of each country. This has been further weighted based on the availability of skilled manpower at various stakeholder organizations, such as, national mapping agencies, earth observation agencies, etc.

From the detailed analysis of the sub-pillars and their cumulative scores, it can be inferred that the United States leads in the overall institutional capacity, followed closely by the United Kingdom, Germany, Canada, Russia, Australia and the Netherlands.

The reason why the geospatial industry is growing predominantly in the developed countries is because it is being supported by the strong institutional capacity in these regions. These countries also prove to be a fertile ground for start-ups and, therefore, business incubation is also high in a number in these countries, leading to their high score for institutional capacity.

Further, the study finds that the institutional capacity in the emerging economies is at a developing stage. The courses offered for the geospatial domain are few, and as such, it is difficult to find skilled manpower in these countries.

The contrast, however, is interesting. While in developed nations, the number of fundamental science courses, professional courses and incubation centers are on the rise, it is the vocational training/certificate courses that are predominant in the developing countries. Most of the emerging economies also offer geospatial vocational courses in abundance. This is because these economies have begun to adopt geospatial technology only recently, and their universities are more focussed on providing courses that make individuals job-ready quickly. So, even though these countries rank lower in the overall geospatial readiness of the institutional capacity, we cannot ignore the fact that these countries are willing and eager to grow.

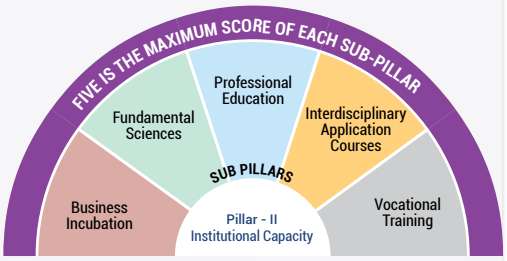
Geospatial industry is growing predominantly in the developed countries because it is backed by strong institutional capacity in these regions

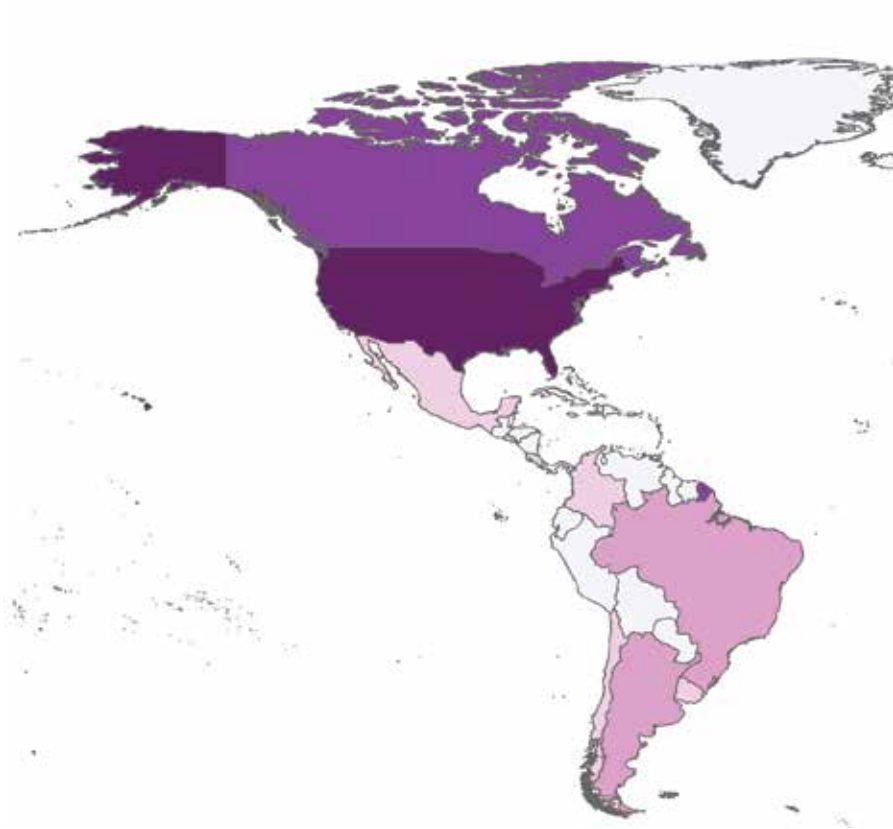
PILLAR -II: INSTITUTIONAL CAPACITY

OVERVIEW

This pillar showcases the geospatial institutional capacity of the 50 countries in terms of their geospatial courses and available skilled manpower.

DETERMINANTS





0-5

Beginners

Countries have low geospatial institutional capacity with presence of only vocational & interdisciplinary courses.

5-10

Basic

Countries have high focus on improving vocational & interdisciplinary courses; but are lagging at incubation and fundamental studies.

10-15

Intermediate

Countries having moderate focus in fundamental and professional studies but have abundant interdisciplinary and vocational courses.

15-20

Proficient

Proficient in geospatial institutional capacity with moderate focus on incubation and fundamental studies and abundant professional studies.

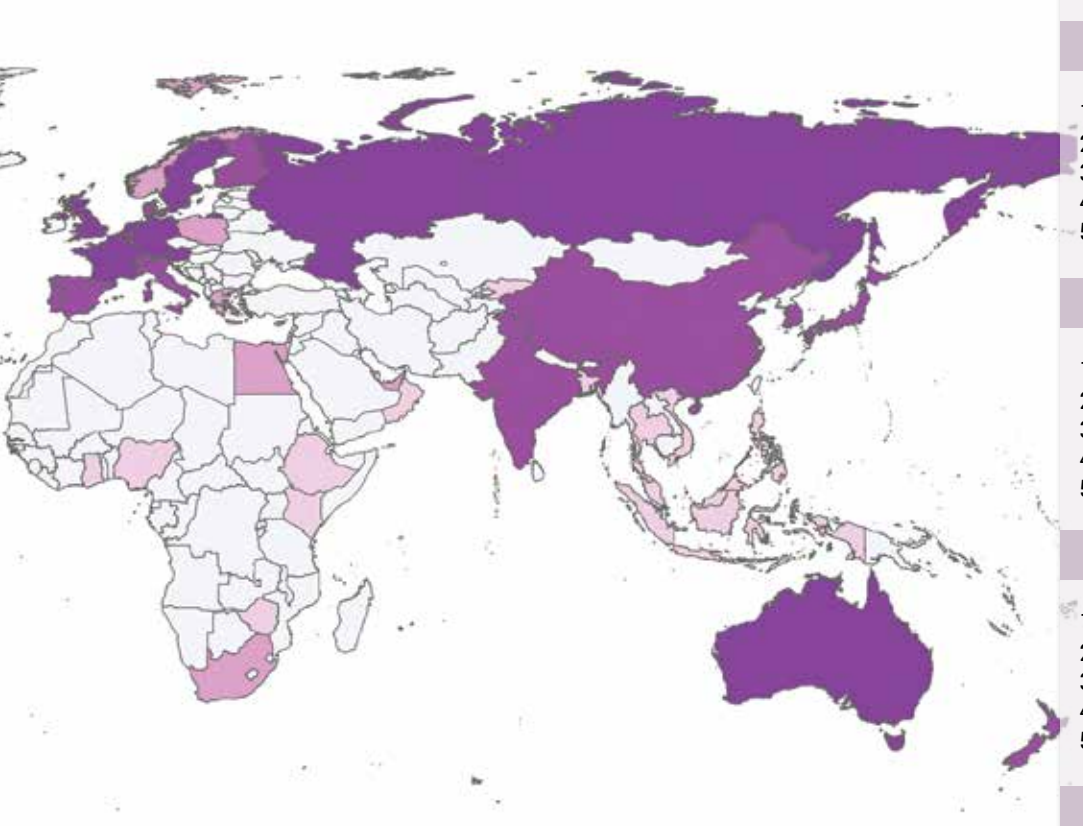
20-25

Advanced

Highly advanced countries in geospatial institutional capacity that are providing professional, fundamental and incubation studies in abundance.

50 Countries Indexed as per Geospatial Institutional Capacity

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
United States	United Kingdom	Germany	Canada	Russia	Australia	The Netherlands	Belgium	Austria	France	Singapore	Sweden	China	Japan	India	New Zealand	Italy	Switzerland	Spain	South Korea	Denmark	Finland	Portugal	Norway	Poland



Sub-Pillar Leaders

BUSINESS INCUBATION

1 United States
2 Germany
3 Sweden
4 The Netherlands
5 Russia

FUNDAMENTAL SCIENCES

1 United States
2 Canada
3 United Kingdom
4 Australia
5 Germany

PROFESSIONAL EDUCATION

1 United States
2 Germany
3 Russia
4 United Kingdom
5 China

INTERDISCIPLINARY APPLICATION

1 United States
2 Russia
3 Belgium
4 United Kingdom
5 Germany

VOCATIONAL TRAINING

1 United States
2 Canada
3 Australia
4 United Kingdom
5 The Netherlands

Overall Takeaway

LEADERS

1 United States
2 United Kingdom
3 Germany
4 Canada
5 Russia

BEGINNERS

46 El Salvador
47 Bangladesh
48 Vietnam
49 Kyrgyz Republic
50 Zimbabwe

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Greece	Brazil	Egypt	South Africa	Argentina	Malaysia	Mexico	UAE	Colombia	Chile	Indonesia	Uruguay	Thailand	Nigeria	Philippines	Costa Rica	Ghana	Kenya	Ethiopia	Oman	El Salvador	Bangladesh	Vietnam	Kyrgyz Republic	Zimbabwe

11. USER ADOPTION LEVEL

> When users adopt geospatial as a part of their workflow management, they enrich a country's technology, economic and cultural growth

The adoption level of any technology is dependent on how the user base responds to that innovation. A successful industry ecosystem cannot flourish without a thriving user base. The users are at the forefront of the geospatial ecosystem as well. If the users benefit from geospatial technologies, and are able to channelize those gains into the revenue stream, the user adoption level will continue to rise at an increasing pace. The user level adoption of geospatial pertains to:

- Automating the process of spatial data collection
- Carrying real-time observations and measurements
- Enhancing innovation, etc.
- Integration geospatial into the entire enterprise system

Geospatial data is used to add value to businesses and quicken the decision-making process. When users adopt geospatial as a part of their workflow management, they enrich a country's technology, economic and cultural growth.

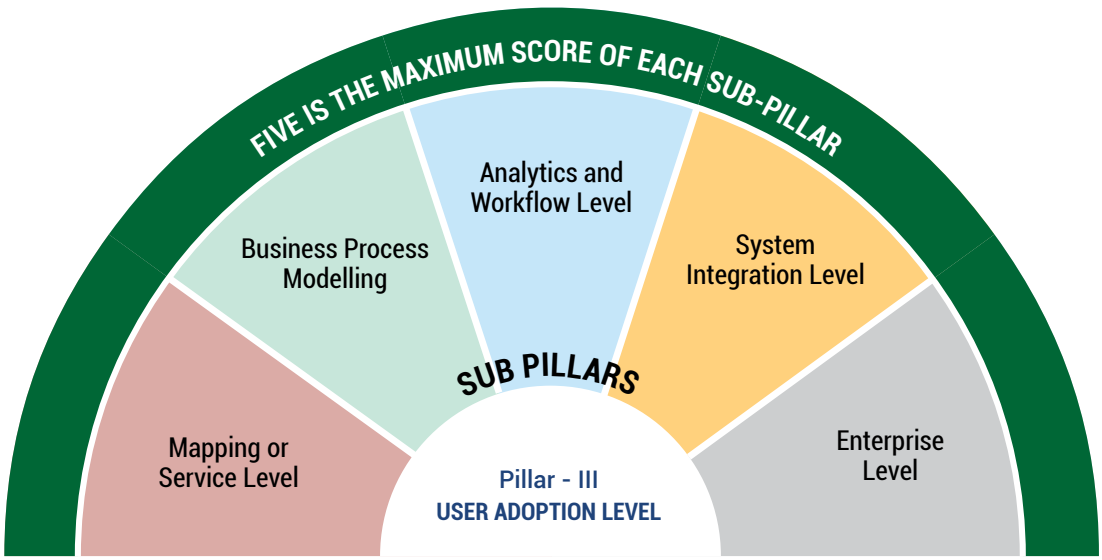


Figure 11.1 Determinants of Pillar III: User Adoption Level

To assess the level of user adoption in the selected 50 countries, 500+ users have been mapped and surveyed. This has been done on the basis of the determinants for this sub-pillar (Mapping or Service Level, Business Process Modelling, Analytics and Workflow Level, System Integration Level and Enterprise Level) as shown in Figure 11.1.

Mapping or Service Level

Adoption of geospatial at the mapping level is the most basic, yet important level of adoption. Geospatial technologies, such as, satellite remote sensing, sensors, UAVs, etc., are all being used for mapping and monitoring. The users that deploy geospatial technologies for mapping have been growing at a rapid pace in sectors like industrial engineering, construction, infrastructure, defence and security, agriculture, forestry and environment, etc. This level of adoption entails that intelligence is drawn from geo-referenced maps — finding patterns and assessing trends to make decisions. An important aspect of GIS is its ability to assemble a range of geospatial data into a layered set of maps that allow complex themes to be analyzed.

At the mapping level as seen in the Figure 11.2, the user adoption is highest in the United States, the United Kingdom, Germany, Switzerland, Japan, the Netherlands, Austria, Canada, Australia and Singapore. Users of maps are finding, querying, reading and applying maps in different ways. Maps are digital and interactive in these nations, which helps in effective visualization and communication of results in an engaging way. Geospatial is being used at the mapping level for making better decisions about location with respect to real estate site selection, agriculture site selection, evacuation

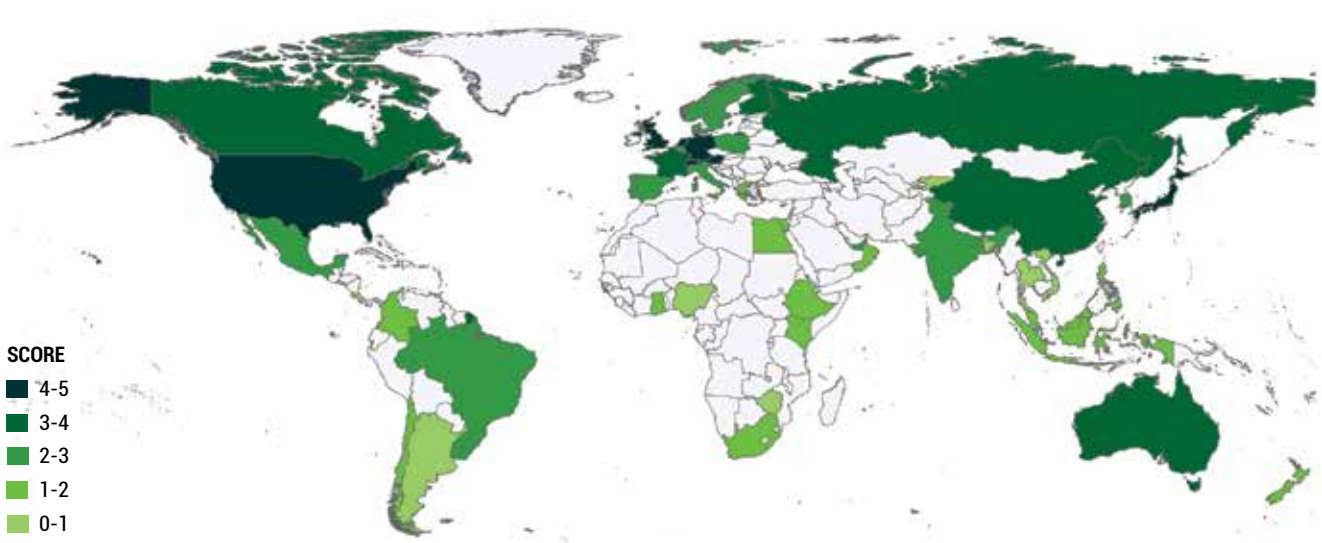


Figure 11.2 Frequency Score Representation of Mapping or Service Level User Adoption in 50 Countries

planning, natural resource extraction, etc. This has contributed extensively to the development of these economies.

The gap between the developed economies and the emerging economies persists. The importance of using geospatial at the mapping level is being recognized in the emerging economies, but it will take time before it reaches the progressive levels of the developed economies.

Asset Management/ Business Process Modelling

Asset management is a systematic process of maintaining, upgrading and operating physical assets effectively and efficiently. Asset management systems combine powerful mapping and spatial analysis with a comprehensive system for organizing information on strategic assets like utilities, infrastructure, energy, water, etc. Asset management is pivotal to the growth of any economy because it enables the government to increase information accessibility and use, make more effective investments and improve infrastructure quality.

Fundamental to asset management is the ability to easily and accurately report work activities to locate assets. Users need to determine the geographical context of an asset and find other assets location close by. Geospatial technologies efficiently manage inspections and inventory of critical assets both above and under the ground level, such as, roads, sewers, hydrants, sidewalks, etc. This timely evaluation helps in reducing inefficiencies, errors and risks.

The user adoption at this level is increasing at a rapid pace in both developed and developing economies. This could be because governments

Figure 11.3 Frequency Score Representation of Business Process Modelling Level User Adoption in 50 Countries

across the globe encourage asset management, for it provides them with the ability to visualize geographic information, improve the longevity and efficient execution of public works, and enables efficient decision-making.

As can be inferred from the world map, shown in Figure 11.3; the United States, Singapore, the United Kingdom, the Netherlands and Canada are the top 5 countries that are leading the user level adoption of geospatial asset management. Most of the European countries follow closely. And the same scenario exists in developing economies as well.

For instance, India ranks high in the readiness index for the adoption of geospatial at the asset management level because it uses it for applications like disaster management, utilities or at the enterprise level. Comparatively, geospatial adoption for asset management is higher in the emerging economies but falls when compared to the advanced level of adoption in the developed and developing economies.

Analytics and Workflow

From marketing to disaster management, geospatial analytics is finding its way into day-to-day activities. It is being used to add geographic context to data and uncovering patterns that are otherwise invisible. The geospatial component in analytics allows the user to overlay business data on maps for convergence and integration to generate insights.

Workflows connect various components and initiate processes to enable smooth data from source to delivery of the final actionable information. Integrating geoinformation or spatial data for workflow management to deal with all aspects of planning, management and monitoring helps them to achieve higher levels of productivity and efficiency.

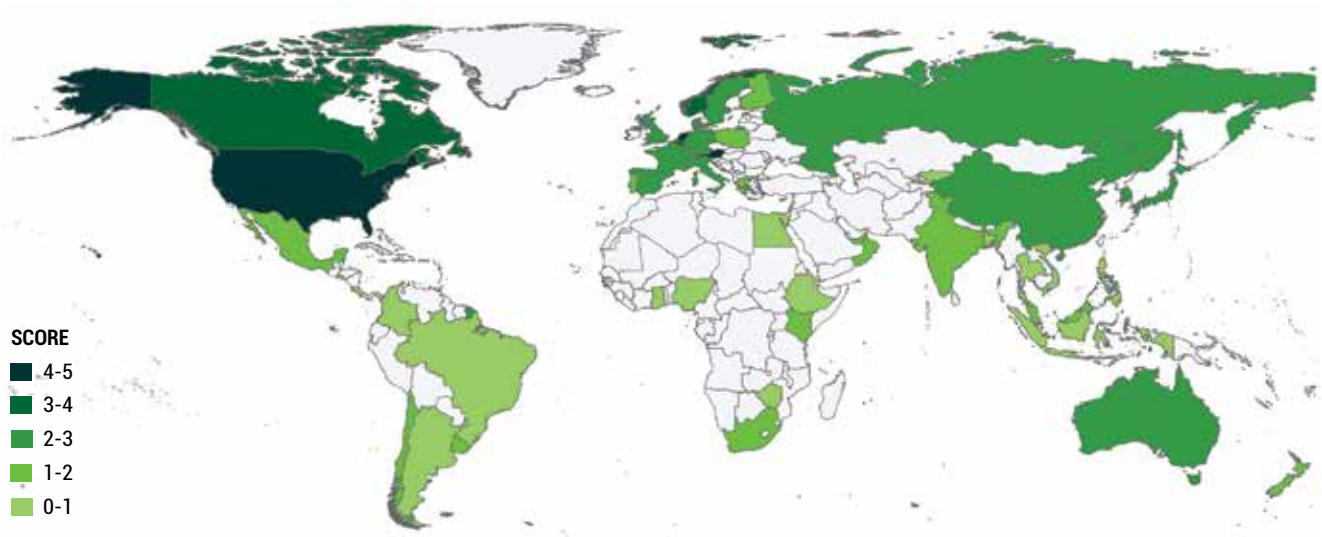


Figure 11.4 Frequency Score Representation of Analytics and Workflow Level User Adoption in 50 Countries

An integrated geospatial solution enables the user to derive enormous value from the application of these robust solutions

Organizations adopt and continue to use geospatial components in their workflow management to produce a better product or to perform a service quickly and economically. These workflows include business intelligence, supply chain management, customer relationship management, customer applications, etc.

In Figure 11.4, the world map shows Singapore leading in the adoption level of geospatial for analytics and workflow. The study reveals that there are more users in Singapore who use geospatial technology for high quality analytics and productive workflow management. Singapore is closely followed by the United States, the Netherlands, Austria, Norway, Canada, Belgium and Germany in the user adoption at the analytics and workflow level. These countries are using geospatial analytics to build maps, graphs and statistics, and making complex relationships understandable to reveal historical shifts as well as to predict the future.

The scenario, however, is different in the emerging economies where the adoption level of geospatial is low for analytics and workflow management. These economies are at the beginner's level for the adoption of the geospatial component in workflow management.

System Integration Level

Extracting maximum value from spatial datasets requires more than just map layers. The maximum value can only be derived when the geographic information available is integrated with the data and applications from a completely different ecosystem. System integration means assimilation of two different ecosystems to provide a unique solution for the purpose of solving a problem. In such a case,

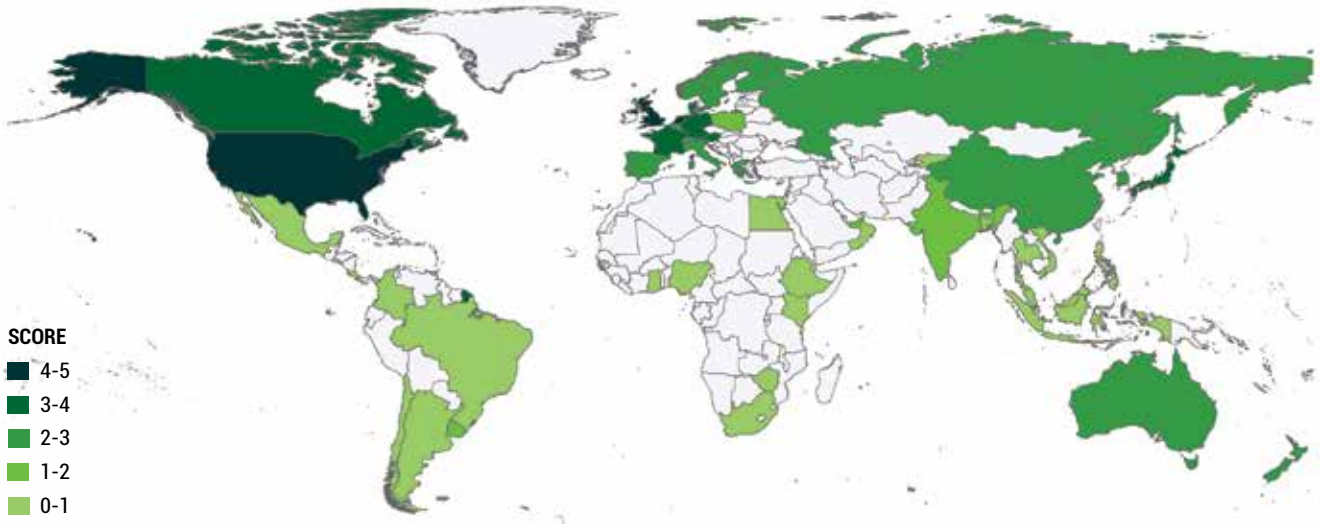


Figure 11.5 Frequency Score Representation of System Integration Level User Adoption in 50 Countries

geoinformation integration can happen with customer information systems, work management systems, mobile systems, compliance systems and asset management systems to provide solutions to various industry verticals. System Integration brings about solutions that are further used by the users to bring the fabricated geospatial ecosystem together.

System integrators utilize a wide range of software and hardware to develop customized solutions for the users. An integrated geospatial solution enables the user to derive enormous value from the application of these robust solutions. Since system integration engineers need a broad range of skills with generally high level of problem solving skills, its user adoption is high in developed countries like the United States and the European Union.

As can be concluded from Figure 11.5, the United States, the United Kingdom, the Netherlands, Canada, Austria, Germany, Singapore, Denmark, Japan and France are deriving maximum value from spatial information through system integration. Given that all these countries are developed economies, integration of two different ecosystems is quite prevalent there to provide reliable and affordable geospatial solutions to governments and citizens. For instance, the integration with BIM workflows to support the important aspects of construction, transportation, urban planning, etc., happens actively in the developed nations. Similarly, these countries are proficient in seamlessly integrating spatial data with mobile and Web technologies for project.

While the developed economies are at a very advanced level with respect to the adoption of geospatial at system integration level, the developing economies are at the basic level of adoption. And the emerging economies are at the beginner's level for the adoption of geospatial at system integration.

Enterprise Level

Given their many benefits, geospatial technologies are fast graduating to the enterprise level in most of the countries surveyed. Enterprise-level adoption means that geospatial is inculcated at all levels of the organization for better or more informed decision-making to increase the return on investment from planning, implementation, delivery or monitoring. Successful adoption of geospatial component at the enterprise level requires scaling, innovation, increased efficiency, structural changes, etc.

As can be inferred from the world map in Figure 11.6, developed countries like the United States, the United Kingdom and the Netherlands, the adoption level of geospatial component at the enterprise level is much higher. This is because the users in these economies put great emphasis on becoming lean and meeting customer expectations adequately. Adopting the geospatial ecosystem at the enterprise level is a disruptive process that requires seamless integration of businesses and technology systems to deliver innovative solutions efficiently. It can only be undertaken by countries that are at the top of the frequency score.

Adopting the geospatial ecosystem at the enterprise level is a disruptive process that requires seamless integration of businesses and technology systems to deliver innovative solutions efficiently

Figure 11.6 Frequency Score Representation of Enterprise Level User Adoption in 50 Countries

In the emerging economies, the transformation and level of adoption is pretty slow. Challenges in the adoption of the geospatial ecosystem at the enterprise level have stemmed from the lack of knowledge, investment and clarity on how to proceed when it comes to imbibing geospatial at every level of the enterprise. At present, the emerging economies are struggling to reach the advanced levels of adoption similar to that of the developed nations. So, the divide that can be seen in Figure 11.6 is not a surprising scenario. Countries like Bangladesh, Zimbabwe, Costa Rica and Kyrgyz Republic score the lowest with respect to enterprise level adoption. These countries are at the initial stage of understanding the role that geospatial technology can play in the growth of an industry or an economy. Which is why, they will take time to adopt geospatial at the enterprise level.

Final Ranking

An analysis of the final pillar shows that top countries where geospatial use and adoption is high are the United States, the United Kingdom, the Netherlands, Singapore, Austria, Germany, Canada, Switzerland, France and Japan. It is no surprise that the top 10 countries that rank high on adoption of geospatial use are developed countries. These countries are frontrunners in the use of geospatial data, innovating new technologies and driving geospatial application and solutions in almost every industry vertical.

For instance, the United States and the United Kingdom rank number one and number two, respectively, because the enterprise users in these countries have been using geospatial data for more than two decades now. Users of these countries have imbibed geospatial into their workflow management and

consider geoportals as an important catalyst in their growth story.

The use of geospatial information in these countries is not limited to only defence and security or disaster management, as is the case in most of the underdeveloped and a few developing nations. Here, geospatial encompasses all industry segments, such as, infrastructure, urban planning, forest and environment, agriculture, climate change management, marine life conservation, transportation and logistics, location applications, etc.

The predominant use of maps, solutions, business processes, system integrators, etc., has brought about revolutionary growth in these countries. For example, at the Los Angeles Airport in the United States, integrated solutions for indoor mapping have provided significant savings in time and cost. This has been achieved by combining on-site data collection with GIS and CAD to deliver accurate, high-quality information on airport assets.

Similarly, in the United Kingdom, Centre for Smart Infrastructure and Construction (CSIC) uses geospatial data to map the current condition of the roads which are derived using highly accurate and cost-effective sensing technologies. This helps the engineers and asset managers to formulate effective maintenance and repair programs to maintain the transport infrastructure.

The other important factor here is that the user segment in these countries is not defined by the government alone, but also by the private sector. Both sectors use geospatial as an important component — be it in the form of maps, analytics, workflow management or business processes — to extend the capabilities of employed assets and services. Also, it is in these developed countries that the geospatial ecosystem is being integrated with the other industry ecosystems, such as, digital, communications, wireless, etc., or is being adopted for use in the entire enterprise.

Countries like the UAE, India and Malaysia rank at the runners-up level, as can be seen from the pillar index. The use and adoption of geospatial in these countries is high, but is restricted to the government. The adoption of geospatial is widely happening at the federal level. However, when it comes to adoption in the private sector, it is still at a nascent stage. While the value of spatial data is realized in these countries, achieving user adoption goals is quite challenging. In these countries, enterprise level of adoption is almost in significant.

The countries that are lagging far behind in the user level adoption of geospatial are Costa Rica, Kyrgyz Republic, Zimbabwe, Bangladesh and El Salvador. These countries lack in skilled manpower and financial resources, and as such the user adoption there is at the beginner's level.

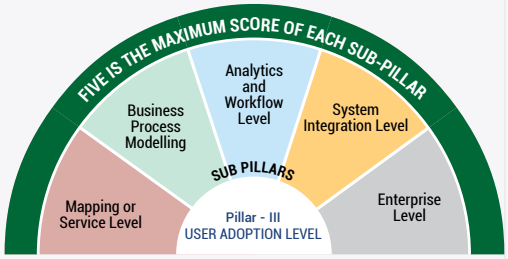
Integrating geoinformation or spatial data for workflow management to deal with all aspects of planning and management, helps users to achieve higher levels of productivity and efficiency

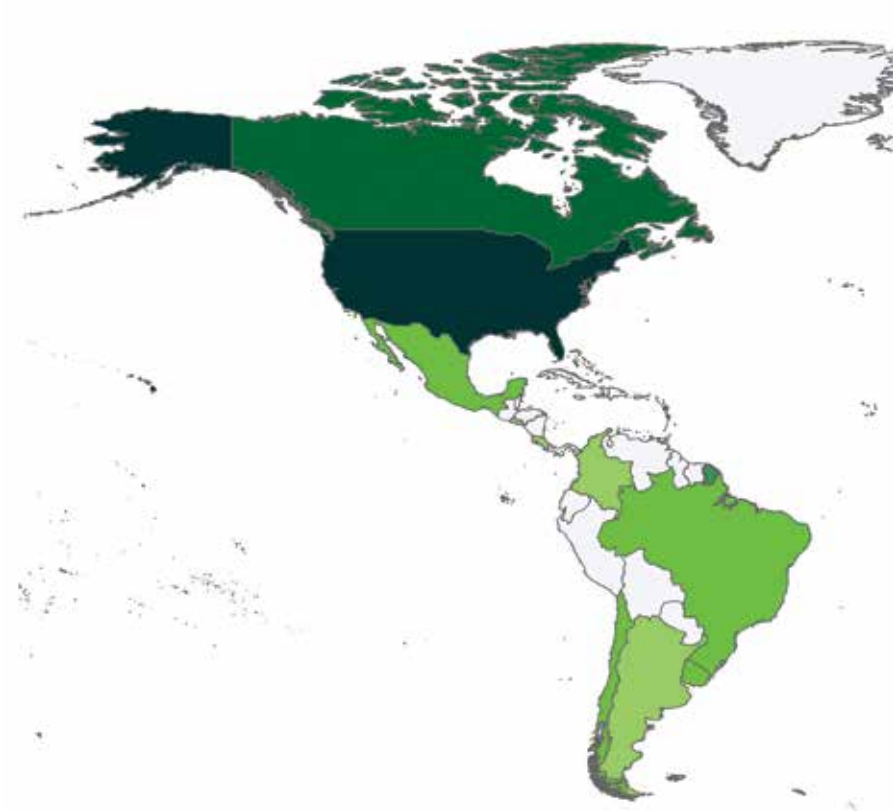
PILLAR - III
USER ADOPTION LEVEL

OVERVIEW

This pillar showcases the readiness with respect to the level of user adoption of geospatial technology in the selected 50 countries.

DETERMINANTS





0-5

Low

Countries where the user adoption of geospatial technologies is low and is at the basic level of mapping or services

5-10

Below A verage

Countries where the user adoption of geospatial technologies is focussed on mapping, moving towards asset management level

10-15

Average

Countries where the user adoption of geospatial technologies is at mid-scale with high focus at the asset management level and in analytics and workflow level

15-20

Above Average

Countries where the user adoption of geospatial technologies is above the moderate level with focus on system integration and analytics and workflow level

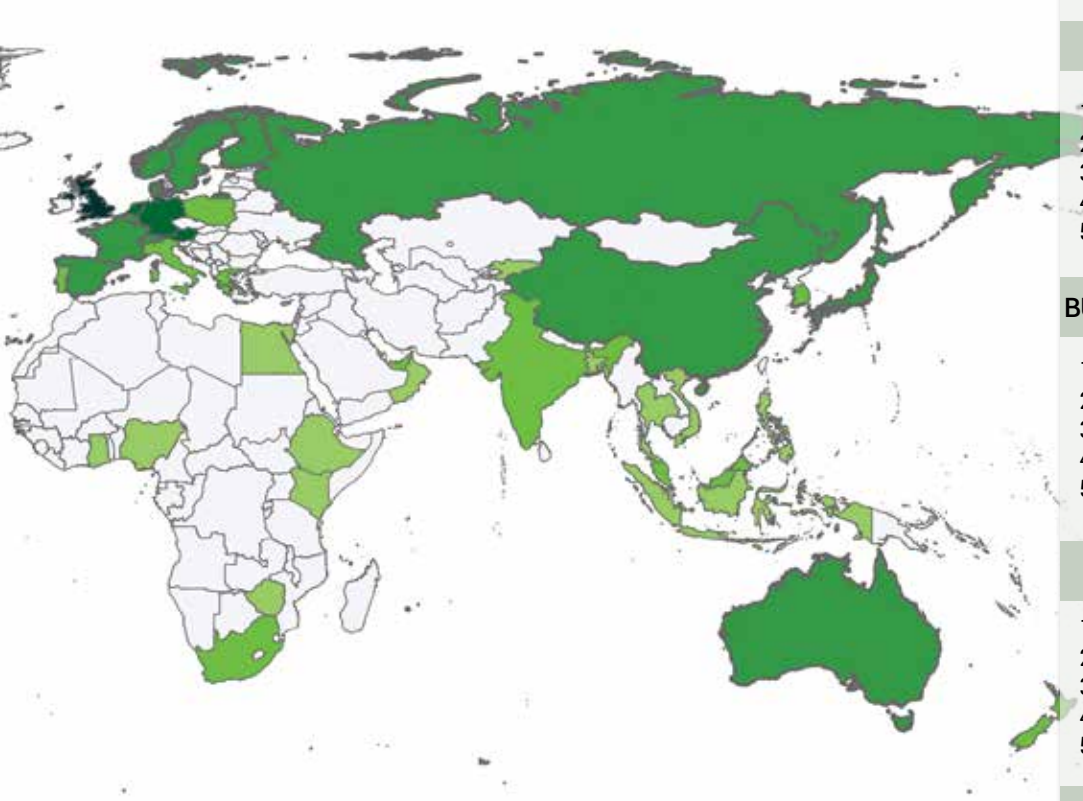
20-25

High

Countries that are frontrunners in the user adoption level of geospatial technologies, especially at the enterprise and system integration level

50 Countries Indexed as per Geospatial User Adoption Level

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
United States	United Kingdom	The Netherlands	Singapore	Austria	Germany	Canada	Switzerland	France	Japan	Russia	China	Norway	Australia	Belgium	Spain	Denmark	Finland	Sweden	Italy	South Korea	Portugal	New Zealand	India	Poland



Sub-Pillar Leaders

MAPPING / SERVICES LEVEL

1 United States
2 United Kingdom
3 Germany
4 Switzerland
5 Japan

BUSINESS PROCESS MODELING

1 United States
2 Singapore
3 United Kingdom
4 The Netherlands
5 Canada

ANALYTICS AND WORKFLOW

1 Singapore
2 United States
3 The Netherlands
4 Austria
5 Norway

SYSTEM INTEGRATION LEVEL

1 United States
2 United Kingdom
3 The Netherlands
4 Canada
5 Austria

ENTERPRISE LEVEL

1 United States
2 United Kingdom
3 The Netherlands
4 France
5 Norway

Overall Takeaway

LEADERS

1 United States
2 United Kingdom
3 The Netherlands
4 Singapore
5 Austria

BEGINNERS

46 El Salvador
47 Bangladesh
48 Zimbabwe
49 Costa Rica
50 Kyrgyz Republic

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Uruguay	Greece	UAE	Mexico	Malaysia	Brazil	Chile	South Africa	Oman	Colombia	Egypt	Ethiopia	Kenya	Ghana	Argentina	Indonesia	Philippines	Nigeria	Thailand	Vietnam	El Salvador	Bangladesh	Zimbabwe	Costa Rica	Kyrgyz Republic

12. INDUSTRIAL CAPACITY

The geospatial industry is moving from position to precision while acquiring a more solution-centric role

Rapid changes in the technology landscape have ensured that the global geospatial industry surges toward innovation, convergence and integration, and brings about a significant value proposition to several vertical industries by offering diverse products (hardware, software and data), services and solutions. As the industry moves from position to precision, and acquires a more solution-centric role, the need to have a pulse on the user segment becomes all the more important. This will translate into efficiency and an increase in the adoption of geospatial technologies across all sectors, leading to a more holistic growth of the entire industry.

The market drivers of the geospatial Industry are:

- Increasing geospatial awareness
- Business process embedment
- Enterprise level adoption
- ROI orientation
- Convergence of industry with the technology ecosystem

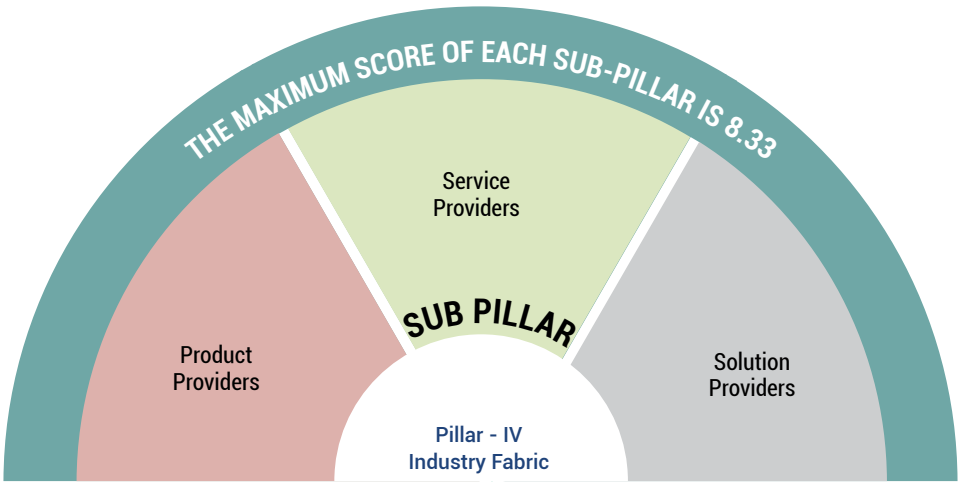


Figure 12.1 Determinants of Pillar IV: Industry Fabric

Technology drivers of the geospatial Industry:

- Integrated processing visualization
- System integration and solution Orientation
- Integrated sensors network
- Analytics and intelligence platform
- Multiple platform sensors

As 'geo' gets embedded in a majority of applications and services today, the industry is in for an exciting time. This chapter will map and showcase the geospatial industry capability in each of the 50 countries with respect to the chosen determinants (Product providers, service providers and the solution and system integration providers) as shown in Figure 12.1.

Product Providers (Hardware, Software and Data)

Any industry ecosystem is incomplete without the presence of product companies. The geospatial industry is no exception. From infrastructure to environment, the ability of geospatial products to provide valuable insights to optimize the investments and planning in an economy is of paramount importance.

The geospatial product portfolio consists of three sub components, namely, hardware, software and data. Hardware provides include the companies that provide the hardware component needed for geospatial activities, like satellites, drones, sensors, etc.

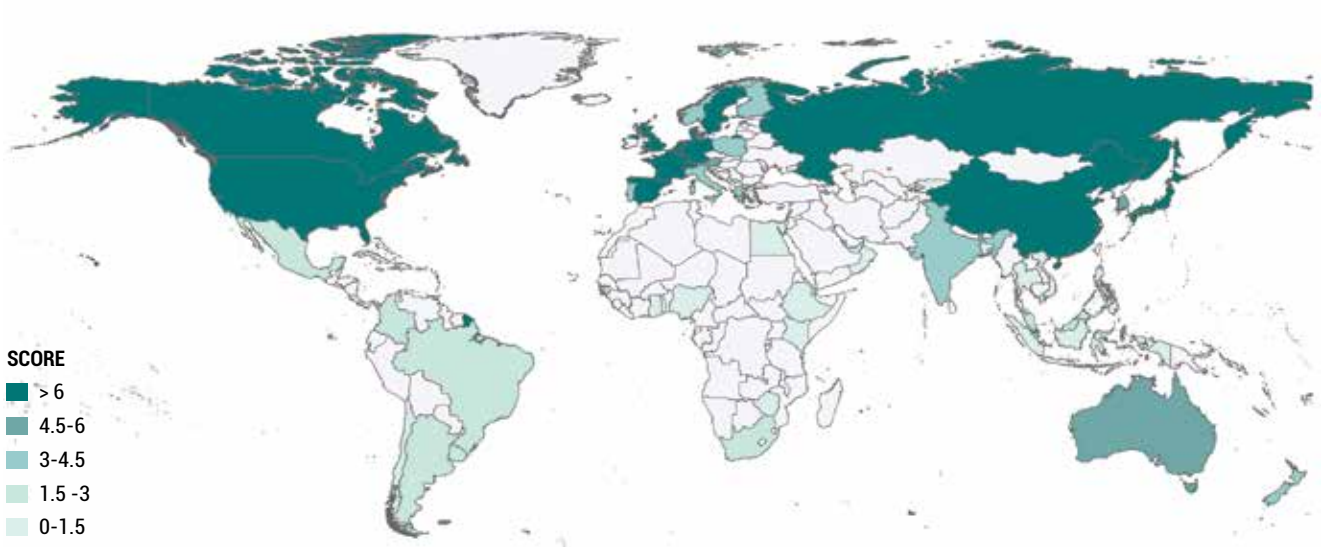


Figure 12.2 Frequency Score Representation of Product Providers in 50 Countries

The software providers offer the IT expertise that encompasses a broad range of applications for various industry verticals. Geospatial software integrates digital maps and geo-referenced data to create business-to-business visualization and analysis tools.

At the core of the products is content, i.e., the data. The role of geospatial data as a product is increasingly becoming critical to further the economic development of a country. This also explains why the data providers are increasing in numbers, because the providers of data are also leaning towards becoming the users of the geospatial data.

Recent innovations in the geospatial industry is moving the industry towards integration of all product categories (hardware, software and data)

The key to the development of any product category is innovation. And the innovations happening in geospatial in the recent times are moving the industry towards an integration of all the product categories.

The world map in Figure 12.2 highlights the footprint of the product companies in the geospatial domain in the selected 50 countries. It can be inferred that the United States, Germany, the United Kingdom, the Netherlands, Canada, Belgium and Japan are the economies with the highest ranks in the product index. These countries have an enormous penetration in hardware, software and data, chiefly because geospatial innovation is primarily happening in these countries. Also, let's not forget that the use of geospatial technologies and data is also higher in these countries. So, the demand for an efficient geospatial product industry is higher there.

Compared to the developed countries, the emerging economies are at a nascent stage of product development. The bottom 10 countries, including Oman, Kenya, Bangladesh, Zimbabwe and Vietnam still need to facilitate the development of product companies. These countries are still developing their geospatial industry fabric, and will take quite some time to reach the capabilities of the developed countries.

Service Providers

Geospatial services involve collection, analysis, presentation and delivery of information. Using the resources available through the geospatial product segment, services includes a wide range of technologies, such as, analytical methodologies, data and database management, spatial analysis, enterprise software application development, etc. Services like Big Data, for instance, create considerable opportunities for users across the spectrum of the community. Navigation and location-based services also cater to geospatial and have started playing an important role in the growth of the economy.

Over the years, the geospatial industry has gradually been moving from being a product-oriented industry to a product-cum-services industry. The industry verticals love geospatial services because their data-rich and detailed visual representations enable quick decision-making. Geospatial services change the way an industry functions. The key services in this segment include geo-referencing, spatial data creation, spatial modelling, network analysis, satellite image analysis, photo-

Figure 12.3 Frequency Score Representation of Service Providers in 50 Countries

grammetry services, data and image processing services, LiDAR services, Web GIS applications, etc.

The world map in Figure 12.3 represents the footprint of the geospatial service providers in the 50 selected countries. The study finds that the United States and Spain are the leaders in this segment, followed closely by Austria, China, Switzerland, India, Belgium, Canada, Russia, Germany and Japan. As can be seen from the graph, there is not much difference in the impression of the developed and developing countries with respect to geospatial service providers.

Geospatial services are being used actively in all developed and developing countries and, therefore, the demand for geospatial service providers is also high. Geospatial professionals in these countries are actively providing 3D maps, remote sensing services (capturing, storing, integrating, manipulating and analysing), image processing services, etc., to adequately satiate the users in these countries.

An interesting observation in the above map is that both India and China — two of the biggest Asian economies — score high on the readiness pillar for geospatial service providers. This could be because both these markets have the human resource required to cater to the services industry.

Also, not surprisingly, the massive divide between the developed and emerging economies is clearly visibly. While many of the emerging economies may be using geospatial services for their day-to-day activities, they are mostly outsourced from the developed countries. An emerging economy's industry fabric with respect to the geospatial services is quite limited, which is why these countries score poorly and are ranked at the beginner's level.

Figure 12.4 Frequency Score Representation of Solution Providers and System Integrators in 50 Countries

Solution Provider and System Integrators

Till a few years ago, the geospatial product industry used to offer stand-alone products only. Slowly, that focus shifted to providing services along with products. And now, with the user segment demanding unique fixes for their quandaries, solutions have been added to the mix. Geospatial solutions are information/data-rich and enable real-time business decisions. Consequently, through strategic alliances and with an eye toward the future, the geospatial ecosystem has widened and the industry has successively become solution-centric. Companies that have made a smooth transition from services to solutions and system integration by integrating geospatial with different ecosystems to deliver content and information have a competitive edge over others. Seamless delivery of industry-specific solutions is the key to success in this industry now.

Geospatial solutions provide high business value to an organization and its customers. There is a higher return on investment and a guarantee towards efficient regulatory compliance as the operational cost decreases. To facilitate high quality workflow and data management which would drive efficiency, effectiveness and productivity, a number of small geospatial solutions are being integrated together to offer customized package to the industry verticals. Today, comprehensive geospatial solutions are available for land administration, mapping and GIS, forestry, infrastructure, transportation, etc. Industries that offer geospatial

solutions operate at a very advanced level because they integrate myriad technologies into one system.

The world map in Figure 12.4 presents a footprint of the solution providers in the geospatial industry in the 50 countries. As expected, the developed nations of the United States, Canada, the United Kingdom, Japan, the Netherlands, Russia, China and Germany have quite a large number of companies providing integrated and comprehensive geospatial solutions. These countries are pioneers in technology innovation, convergence and integration, and have been able to create geo-information solutions that can be used by all industries.

In developed countries, the demand for geospatial solutions is also on a very large scale because these solutions need to be imbibed into business processes of various industry verticals like land administration, precision agriculture, climate change management, etc.

A careful study of the map also reveals that solution providers are also dominant in some developing countries where innovation is high. But, in the emerging economies, like Ghana, Oman, Philippines, Ethiopia and Bangladesh, solution providers are few and far between. Most of these economies are at the initial growth stage of the geospatial industry. Their industry fabric with respect to solution providers has not yet developed.

Final Ranking

In the final analysis of the Pillar IV: Industry Fabric, a complete picture of 50 countries with respect to their geosaptial industry footprint is established. Again, the United States is leading the geospatial readiness for the industry fabric because of its vast geospatial ecosystem that provides comprehensive products, services and solutions through continuous innovation.

The United States is closely followed by Canada, the United Kingdom, Germany and the Netherlands — countries that are rich in industry advancement as well. Since these countries are quick to adapt to the fast-changing technologies, their industries also adopt the changing trends needed for growth just as swiftly.

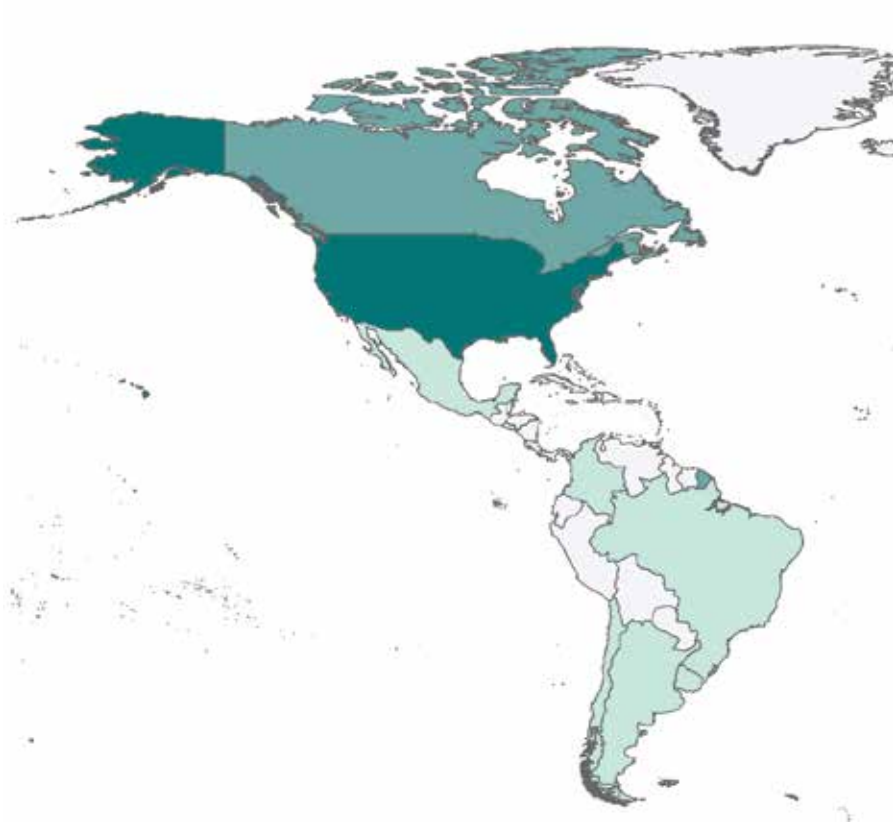
The trend of a visibly huge divide between the developed countries and the emerging economies continues with the final pillar of geospatial readiness index. Zimbabwe, Costa Rica, Bangladesh, and Kyrgyz Republic are some of the countries that are still exploring the opportunities in the geospatial domain, and do not have a well-established industry fabric. Lately, these countries have begun to use geospatial actively in their workflows, but, majorly they outsource the products (mostly data/content) and services from developed nations. These economies are still struggling to establish a well-functioning geospatial industry ecosystem.

Developed countries are pioneers in technology innovation, convergence and integration, and have been able to create geoinformation solutions that can be used by all industries

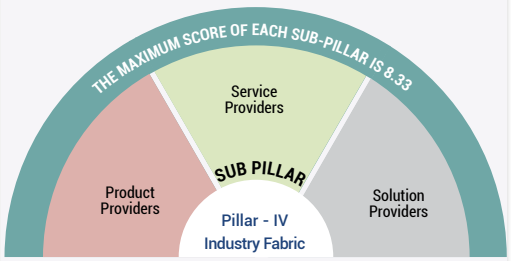
PILLAR - IV: INDUSTRIAL CAPACITY

OVERVIEW

This pillar showcases the readiness with respect to the level of geospatial industry penetration



DETERMINANTS



0-5

Low Penetration

Countries that have minimal geospatial industry penetration with presence of very few product and service companies.

5-10

Below Average Penetration

Countries with a basic level of industry penetration with a high focus on services industry and average focus on only product companies

10-15

Average Penetration

Countries having deep geospatial industry penetration with a moderate focus on services and product industries and having minimal number of solutions and system integration companies

15-20

Above Average Penetration

Above average industry penetration with abundant number of geospatial industries in services & products and adequate number in solutions and system integration companies

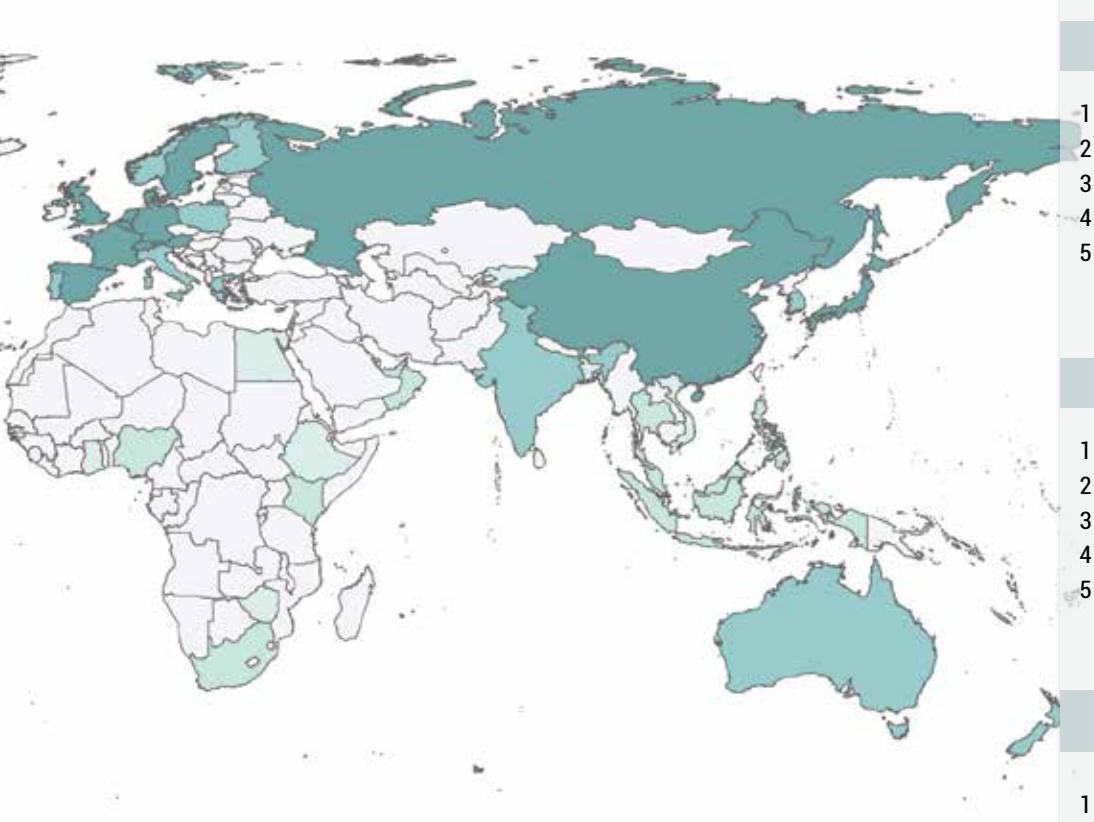
20-25

High Penetration

Highly advanced countries in industry penetration with abundant industries in products (hardware, software, and data), services and solutions and system integration comapnies

50 Countries Indexed as per Geospatial Industrial Capacity

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
United States	Canada	United Kingdom	Germany	The Netherlands	Japan	Spain	China	Belgium	Russia	Switzerland	France	Sweden	Denmark	Austria	South Korea	Australia	Finland	India	Norway	Portugal	Italy	Singapore	Greece	New Zealand



Sub-Pillar Leaders

PRODUCT PROVIDERS

1 United States
2 Germany
3 United Kingdom
4 The Netherlands
5 Canada

SERVICE PROVIDERS

1 United States
2 Spain
3 Austria
4 China
5 Switzerland

SOLUTION & SYSTEM INTEGRATION PROVIDERS

1 United States
2 Canada
3 United Kingdom
4 Japan
5 The Netherlands

Overall Takeaway

LEADERS

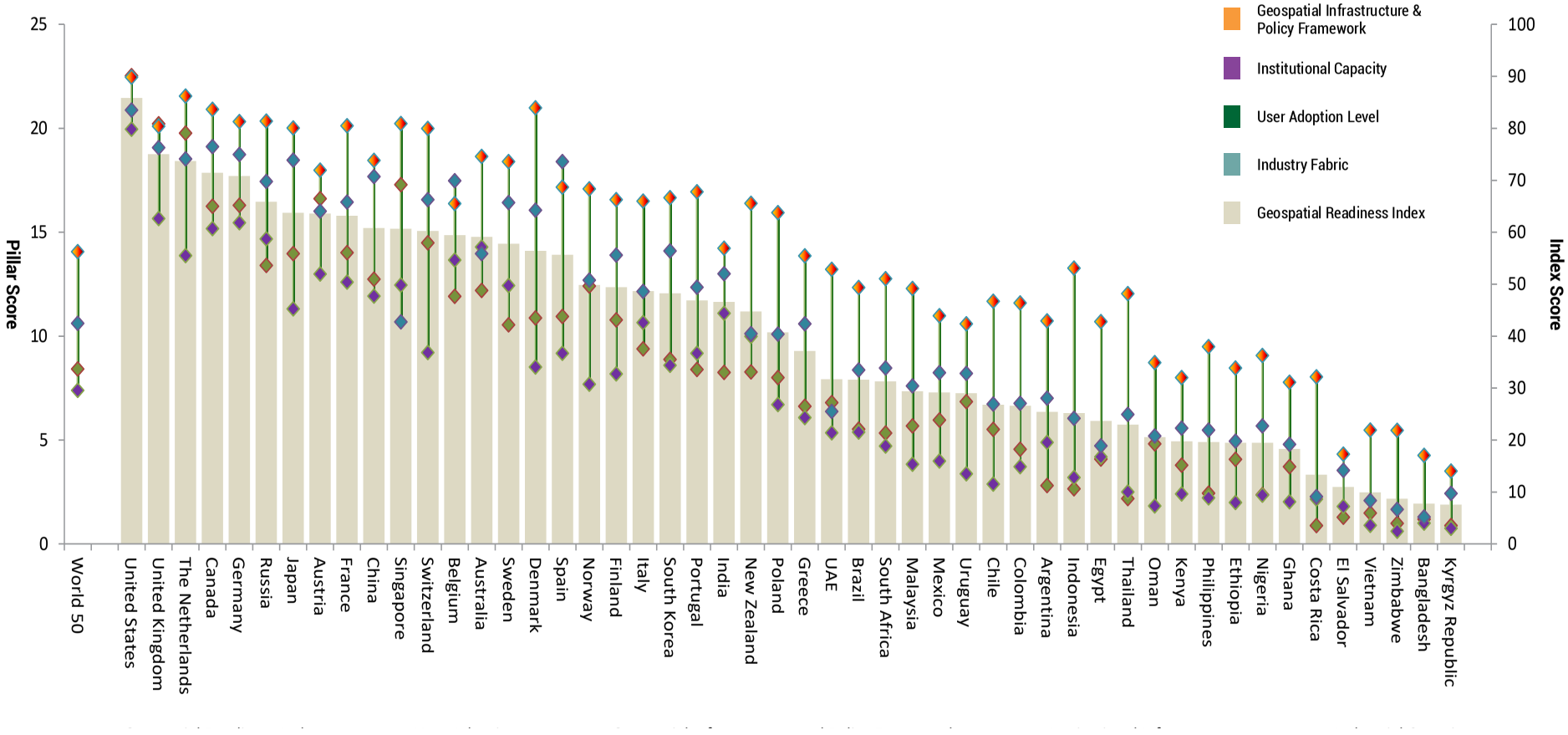
1 United States
2 Canada
3 United Kingdom
4 Germany
5 The Netherlands

BEGINNERS

46 Kyrgyz Republic
47 Costa Rica
48 Vietnam
49 Zimbabwe
50 Bangladesh

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Poland	South Africa	Brazil	Mexico	Uruguay	Malaysia	Argentina	Colombia	Chile	UAE	Thailand	Indonesia	Nigeria	Kenya	Philippines	Oman	Ethiopia	Ghana	Egypt	El Salvador	Kyrgyz Republic	Costa Rica	Vietnam	Zimbabwe	Bangladesh

Geospatial Readiness Index of Countries — Pillar Comparison



INFERENCES

GEOSPATIAL INFRASTRUCTURE AND POLICY FRAMEWORK

- United States of America, The Netherlands, Denmark, Canada, Russia, Germany, Singapore, France and United Kingdom are the leading countries the overall geospatial readiness of the Geospatial Infrastructure and Policy Framework.
- The geospatial infrastructure in terms of national geospatial infrastructure, geoportal and platforms and positioning infrastructure in the developed countries are well established and operational; underdeveloped countries are still at the planning stage.
- The legal framework is more open and flexible in nature in the developed nations, the developing countries and the underdeveloped nations have conservative frameworks to support the Geospatial industry.

INSTITUTIONAL CAPACITY

- United States of America, Germany, Canada, United Kingdom and Australia are the leading countries in overall geospatial readiness of the institutional capacity
- Enormous gaps is visible in geospatial human capacity of developed and developing countries
- Russia and the Eastern European region have scored higher in incubation centers and fundamental research courses but rank lower in vocational courses because these countries are focussing more on higher level of education and to produce highly capable human resource for the geospatial industry.

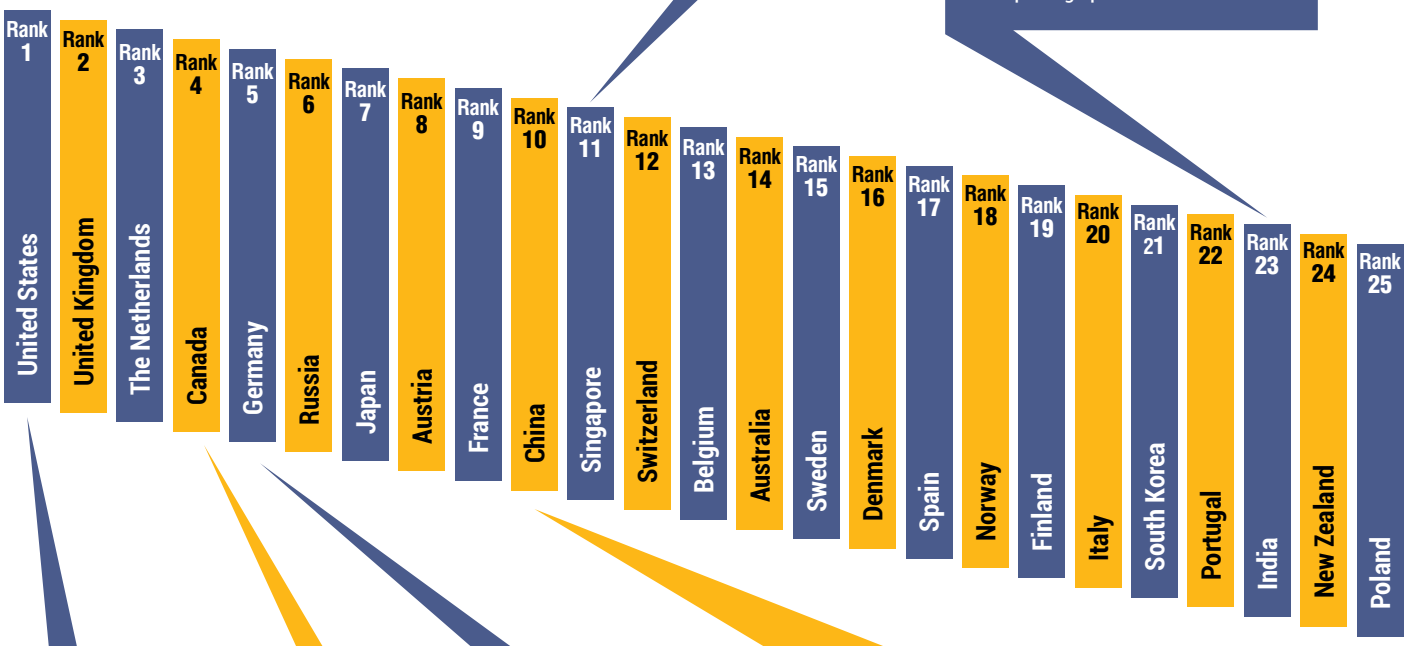
USER ADOPTION LEVEL

- United States of America, United Kingdom, the Netherlands, Singapore, Austria, Germany are the leaders in the user level adoption of geospatial technology and thereby lead the geospatial readiness index for the user adoption among the 50 selected countries.
- There is an enormous gap in the usability of geospatial technology between developed and emerging economies.
- Most emerging economies are at the beginner's stage of use of geospatial adoption
- System integration level of adoption and enterprise level of adoption, both are significantly prominent in the developed countries while the emerging economies catch up to their advanced status.

INDUSTRY FABRIC

- United States of America, Canada, United Kingdom, Germany and the Netherlands are the top 5 countries with an adequate Industry fabric that caters to the product, service and solutions segment.
- The gap between the industry – ecosystem of developed countries and under-developed or emerging nations is visible.
- India makes an entry into the top 10 countries for geospatial readiness for service providers because of strong imprint of service companies in the region.

COUNTRIES GEOSPATIAL READINESS INDEX



Singapore has broadened its technological capacities viz-à-viz the geospatial area and has embarked on several geospatial initiatives to increase efficiency and productivity through seamless workflows

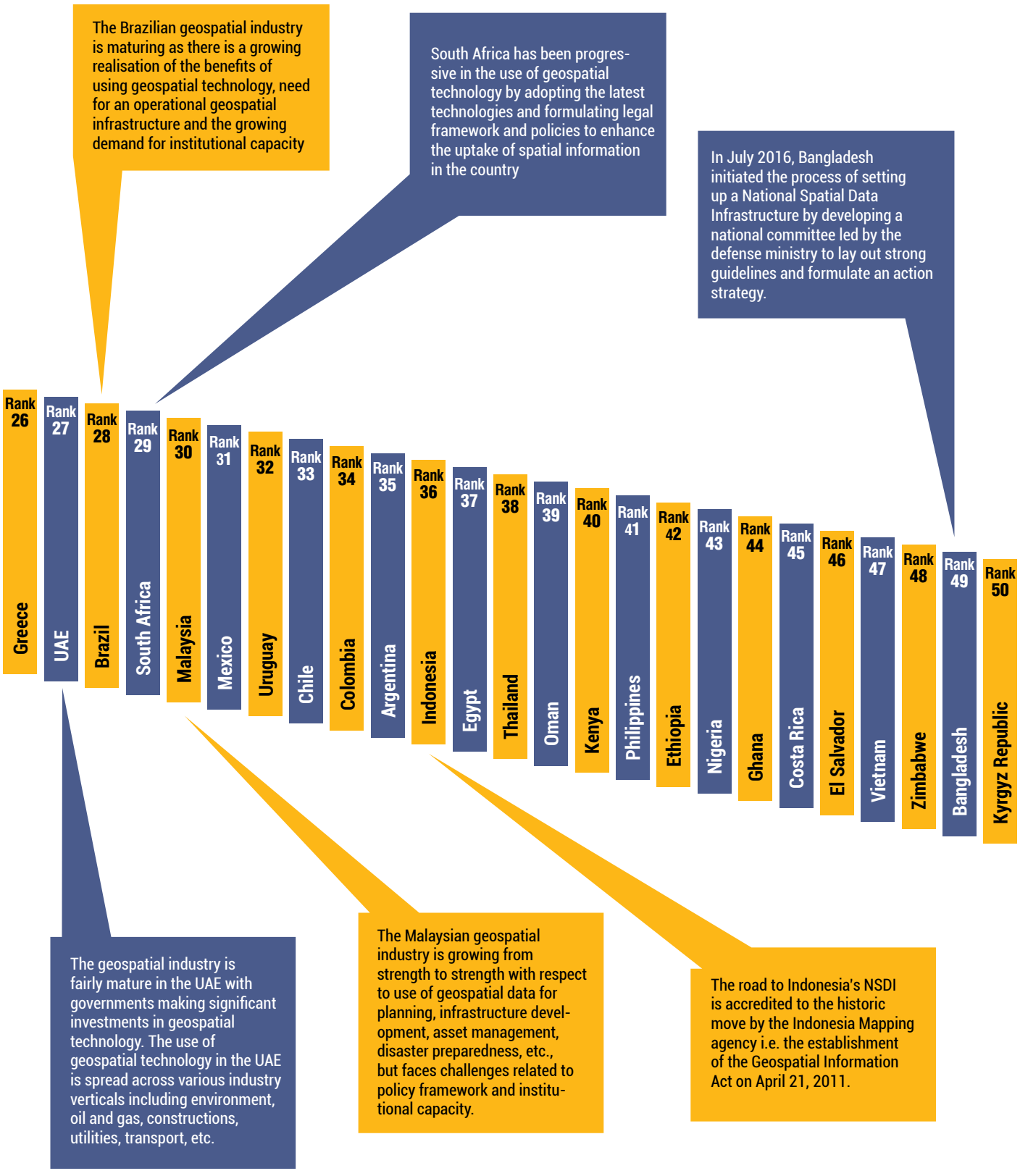
The Indian geospatial industry is witnessing tremendous opportunity and is on the threshold of a major transformation. The geospatial industry is striding ahead with its enterprising spirit

Geospatial Industry has been part of the Chinese government agenda in the current 12th Year Plan (2011-2016), with an average annual increase of 25% in investment

United States of America holds the top position in the global geospatial readiness index for the country has it all – an efficient geospatial infrastructure, an enabling policy framework, an excellent institutional capacity, the strongest industry capacity and an in-depth user adoption across all industry verticals

Canada is one of the most sophisticated and geospatial innovative society riding on open data policies, institutions to promote strong geospatial uptake at national, regional and local levels

Driven by the geospatial hardware industry, strong institutional capacity, consistent government policies and investments and integration of geospatial technologies to serve horizontal applications in vertical industries; the German geospatial industry has been growing continuously over the years – showing no signs of slow down.


The Brazilian geospatial industry is maturing as there is a growing realisation of the benefits of using geospatial technology, need for an operational geospatial infrastructure and the growing demand for institutional capacity
South Africa has been progressive in the use of geospatial technology by adopting the latest technologies and formulating legal framework and policies to enhance the uptake of spatial information in the country
In July 2016, Bangladesh initiated the process of setting up a National Spatial Data Infrastructure by developing a national committee led by the defense ministry to lay out strong guidelines and formulate an action strategy.
Rank 26 Greece
Rank 27 UAE
Rank 28 Brazil
Rank 29 South Africa
Rank 30 Malaysia
Rank 31 Mexico
Rank 32 Uruguay
Rank 33 Chile
Rank 34 Colombia
Rank 35 Argentina
Rank 36 Indonesia
Rank 37 Egypt
Rank 38 Thailand
Rank 39 Oman
Rank 40 Kenya
Rank 41 Philippines
Rank 42 Ethiopia
Rank 43 Nigeria
Rank 44 Ghana
Rank 45 Costa Rica
Rank 46 El Salvador
Rank 47 Vietnam
Rank 48 Zimbabwe
Rank 49 Bangladesh
Rank 50 Kyrgyz Republic
The geospatial industry is fairly mature in the UAE with governments making significant investments in geospatial technology. The use of geospatial technology in the UAE is spread across various industry verticals including environment, oil and gas, constructions, utilities, transport, etc.
The Malaysian geospatial industry is growing from strength to strength with respect to use of geospatial data for planning, infrastructure development, asset management, disaster preparedness, etc., but faces challenges related to policy framework and institutional capacity.
The road to Indonesia's NSDI is accredited to the historic move by the Indonesia Mapping agency i.e. the establishment of the Geospatial Information Act on April 21, 2011.

PARTNERS PROFILE

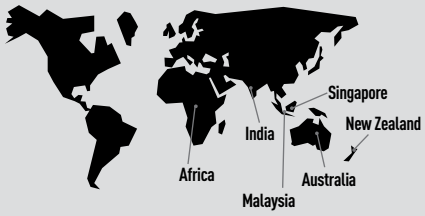
MARK FREEBURN
CEO

START OF OPERATIONS
1952

HEADQUARTERS
Australia

EMPLOYEES
500

OFFICE LOCATIONS



CONTACT

Level 1 Leichhardt Court
55 Little Edward Street
Spring Hill QLD 4000

Phone: +61 (0)7 3620 3111
Website: www.aamgroup.com

ABOUT US

AAM's GeoSolutions enable the Digital Revolution

Smart Cities, Big Data, Internet of Things, Artificial Intelligence, the Cloud. These technologies are changing the way in which we live and interact with the world. Driverless cars, augmented reality and on-demand-services powered by Smart Apps are set to further transform our lives. The Digital Revolution is truly upon us.

AAM's **'GEOCIRRUS Cities'** 3D City Models provide the building blocks for Smart City applications. No matter what the Smart City Application, detailed 3D models provide a framework for, and give context to, all manner of intelligent 'apps', from smart street lighting to green rooftops and community engaged urban planning.

AAM's **Mobile Mapping technology** underpins intelligent transport systems, from monitoring road traffic flows through to planning new road and rail corridors or enabling driverless vehicle precincts, rich detailed models provide the base for informed analysis and decision making.

AAM continue to provide world leading solutions in **surveying, airborne mapping and remote sensing**. Our tools range from our fleet of nimble drones, perfect for small areas, corridor and linear inspection, through to traditional aircraft mounted LiDAR systems, capable of mapping an entire continent. No matter what the application, from national mapping, to agriculture, natural resource management or monitoring power transmission lines, AAM solutions underpin intelligent analysis, applications and solutions.

GEOCIRRUS is AAM's cloud based platform providing content, infrastructure and geospatial applications as a service. GEOCIRRUS enables data discovery, system integration along with a raft of web based geospatial applications and analysis.

For decades, AAM's Geo-Solutions have enabled our clients to measure, monitor and visualise the natural and built environment. Today, as the world changes at an ever increasing pace, AAM's GeoSolutions are truly providing the framework to enable the digital and virtual revolution in which we are living.

CYIENT

Designing Tomorrow Together

BVR MOHAN REDDY
Founder & Executive Chairman

START OF OPERATIONS
1991

HEADQUARTERS
India

TURNOVER
$472 mn

EMPLOYEES
13,800

OFFICE LOCATIONS

CONTACT

Cyient Limited
Software Units Layout
Infocity, Madhapur
Hyderabad - 500081, India

Phone: +91 40 6764 1000
Fax: +91 40 2311 0352
Email: connect@cyient.com
Website: www.cyient.com

ABOUT US

Cyient is a global provider of engineering, manufacturing, geospatial, data analytics, networks and operations solutions. With robust and automated systems that have evolved over the past 25 years in data acquisition, processing, mapping, modelling and application development, Cyient offers end-to-end geospatial and data solutions.

Recognized as a trusted technology partner with global delivery models and processes, Cyient can leverage the full potential of geospatial technology. Our services focus on systems' development for visualization and editing of geographic data, analysis of spatial relationships, and efficient spatial data management. At Cyient, we can also help clients' business needs by designing, building, implementing bespoke geospatial applications and integrating them with their business processes.

We collaborate with our clients to help them achieve more and shape a better future together. We call it "Designing Tomorrow Together".

DESIGNING	TOMORROW	TOGETHER
Leveraging our design engineering and technology expertise we deliver practical solutions that make things better, every day	Our work is future facing, solving problems large and small that can make a positive difference to everyone's tomorrow	By doing more and working closely with our associates, clients and partners, we build a virtuous circle of collaboration and trust

SERVICES & SOLUTIONS PORTFOLIO

DATA ACQUISITION & PROCESSING

- → LiDAR capture & processing
- → Aerial imagery capture & processing
- → Oblique imagery capture & processing
- → UAV data capture & processing
- → Mobile mapping

MAPPING & MODELING

- → 2D feature extraction & mapping
- → 3D feature extraction & mapping
- → 3D modeling
- → Ground survey support
- → Data management & maintenance

SOFTWARE & SOLUTIONS

- → Application development
- → Automated data classification & capture
- → Enterprise GIS
- → 3D web GIS
- → Analytics solutions
- → Mobile & cross platform solutions
- → Integration with business processes

FOCUS INDUSTRIES

Aerospace & Defence I Rail Transportation I Communications I Utilities I Navigation I Oil & Gas I Medical Technology I Power Generation I Semiconductor I Off-Highway & Industrial

COLLABORATION AND PARTNERSHIPS

Cyient's growth story has been an ambitious blend of organic investments, technology and business acquisitions, and steady partnerships. The first phase of its 25-year journey saw the acquisition of Dataview Solutions Ltd., Cartographic Sciences Ltd., Advanced Graphics Software Gmbh, and Map Centric, which enabled it to move up the geospatial value chain. The recent acquisition of Blom Aerofilms Ltd progressed Cyient into a truly complete data solutions provider. Strong long-term partnerships with technology companies such as Esri, GE, Autodesk and Hexagon have successfully enabled Cyient transform into a name to reckon with in the global geospatial industry.

VALUE TO USER

- — Strong capabilities combined with a network of more than 13,800 associates across 38 global locations enable us to deliver measurable and substantial benefits to organizations.
- — Twenty-five years of global industry experience, domain expertise and innovation
- — Investments in virtuous circle of value-creating and sustainable partnerships
- — Strong expertise in working with all industry-standard data models across all phases including design, development, customization, and implementation
- — End-to-end GIS solutions
- — Proven in-house data migration, productivity, and quality tools for deploying validated solutions rapidly
- — Focused technology practices with a flexible global delivery model and complete project life cycle ownership

AWARDS & ACCOLADES

- — Recipient of "Solutions Company of the Year 2016" awarded by Geospatial Media & Communications.
- — Itron Ignite Innovation Challenge Winners 2016
- — Asian Utility Week 2016 - Best Customer Value AMI

JEFFREY R. TARR
CEO

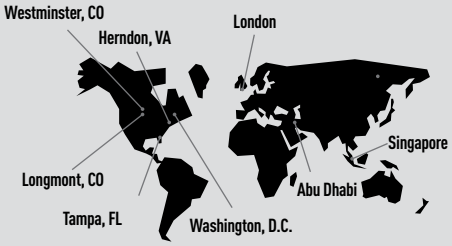
START OF OPERATIONS
1992

HEADQUARTERS
USA

TURNOVER
$700 mn

EMPLOYEES
2,000

OFFICE LOCATIONS



CONTACT

1300 W. 120th Ave
Westminster, CO, 80234

Toll Free: 800.655.7929
Phone: 303.684.4000
Website: digitalglobe.com

ABOUT US

DigitalGlobe is the world's leading provider of high-resolution Earth imagery, data, and analysis. With the most sophisticated commercial satellite constellation on orbit, we create the world's smartest images, to give customers confidence when making decisions that matter most. Customers everywhere rely on our best-in-class technology, global coverage, and 16-year time-lapse image library for the most exacting, mission-critical information available about our changing planet. By helping customers solve their most difficult challenges, DigitalGlobe has become the trusted partner for dozens of industries worldwide, from environmental monitoring to mapmaking, from defense to public safety.

INDUSTRY LEADER	HIGHEST QUALITY	FLEXIBLE PLATFORMS
DigitalGlobe is a trusted and experienced partner to governments and businesses around the globe.	With unsurpassed native resolution and locational accuracy, DigitalGlobe images contain more information than resampled lower resolution alternatives.	Our powerful cloud-based platforms enable information extraction and machine learning on a global scale.

PRODUCT PORTFOLIO

DigitalGlobe offers Earth imagery from our constellation of high-resolution satellites, as well as geospatial platforms and services that combine our Earth imagery, analytic expertise and innovative technology to deliver integrated solutions. The result is a comprehensive product suite that meets needs of advanced imagery users, developers, business professionals, and more.

CONTENT	ACCESS	EXPERTISE
For satellite imagery and geospatial information users across all industries. Select the exact image, elevation model or dataset you need from anywhere in the world. Download it. Own it. Add it to your workflow in the way that works best.	For all producers and users of geospatial data as well as app developers and programmers. Use our imagery and data platforms to unlock critical information about our changing planet at any scale to create actionable, world-changing solutions.	For decision makers across a wide range of commercial, security and humanitarian applications who can benefit from our unsurpassed insight and deep analytic capabilities. Leverage our experience to confidently solve your most difficult challenges.

FOCUS INDUSTRIES

Location-Based Services & Navigation | Civil Government | Oil & Gas| Defense & Intelligence | Telecommunications | Global Development Organizations | Mining | Public Safety | Insurance & Finance | Forestry & Environment

COLLABORATION AND PARTNERSHIPS

Our robust partner community is an important ingredient in solving our customers' geospatial challenges. DigitalGlobe certified resellers specialize in many types of geospatial industries and applications that help customers effectively meet business needs.

In 2014, DigitalGlobe acquired Spatial Energy and gained more robust, multi-source geospatial solutions for energy companies. In 2016, DigitalGlobe acquired The Radiant Group in an important step in deriving new insights for customers from our imagery and other geospatial information sources.

VALUE TO USER

- Sharpest resolution - The first and only company to deliver true 30 cm resolution imagery. Clearer images empower better decisions.
- Unsurpassed haze penetration - Our technology can see through smoke and haze so you can clearly detect objects on the other side.
- Broadest spectral diversity - Our multispectral capabilities give you the most feature identification opportunities.
- Frequent revisit rate - Our satellites revisit at a high rate, so you can detect changes over extremely short periods of time.
- Best locational accuracy - Industry-leading accuracy standards help create maps that inspire confidence.

The Science of Where

JACK DANGERMOND
President/Founder

START OF OPERATIONS
1969

HEADQUARTERS
USA

EMPLOYEES
3800

OFFICE LOCATIONS

CONTACT

Esri
380 New York St.
Redlands California

Phone: (909) 793-2853
Website: www.esri.com

ABOUT US

Esri, the global market leader in geographic information systems (GIS) technology, offers the most powerful mapping and spatial analytics tools available. Since 1969, Esri has helped customers unlock the full potential of data to improve operational and business results. Today, Esri software is deployed in more than 350,000 organizations including the world's largest cities, most national governments, more than 75% of the Fortune 500, and more than 7,000 colleges and universities. Esri designs and engineers the most advanced solutions for today's distributed computing platforms to create the maps that run the world. Visit us at esri.com.

BUSINESS SENSE	FOCUS ON USER EXPERIENCE	FUTURE READY TECHNOLOGY
We help people efficiently manage, use, and serve geographic information to make sense of the world around them.	Our direct work with users helps us to evolve and improve our software to better meet the needs of every industry.	GIS is capable of managing and modeling big data to create accurate spatial predictions that will help shape the future of our planet.

PRODUCT PORTFOLIO

ArcGIS provides contextual tools for mapping and spatial reasoning so you can explore data and share location-based insights. ArcGIS creates a deeper understanding, allowing you to quickly see where things are happening and how information is connected.

CONTENT
- → Data Collection
- → Data Management
- → Authoritative Contributions
- → Sensor
- → Imagery

MAPPING
- → Base Maps
- → Data Layers
- → Web
- → 2 and 3D
- → Real Time

ANALYSIS
- → Contextual
- → Patterns
- → Relationships
- → Temporal
- → Predictive

FOCUS INDUSTRIES

Government| Business| Utilities and Communications| Natural Resources| Defense and Intelligence| Education and Training| Health and Human Services| Transportation| Public Safety

COLLABORATION AND PARTNERSHIPS

More than 350,000 organization rely on Esri software. Esri's 2,200+ global partners provide customer-focused, geographically-enabled solutions that span dozens of industries. Products and services range from configured apps and custom-built solutions to complete ArcGIS system implementations and content. Hundreds of organizations in Esri's user community contribute their authoritative content which Esri builds into its platform as part of the user experience.

VALUE TO USER

- — Transform data into valuable information to drive decision making, design, and collaboration.
- — Improve business practices by applying location-based analysis.
- — Share insights and collaborate with others via apps, maps, and reports.
- — Develop web products that increase efficiency, engagement, increase enterprise intelligence.

AWARDS & ACCOLADES

2016 TM Forum Live! Award for Internet of Things; 2016 Microsoft Azure Certified ISV Solution Partner of the Year Award; PwC Recognized Esri as one of the 25 fastest growing cloud companies in 2016.

JOE AREZONE
Chief Commercial Officer

START OF OPERATIONS
1982

GLOBAL HEADQUARTERS
USA

EMPLOYEES
1000+

OFFICE LOCATIONS

CONTACT

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No. 3 Changi South Street 2
#01-01 Xilin Districentre Building B
Singapore 486548

Phone: +65.65111350
Fax: +65.65430111
Website: www.faro.com
Email: asia@faro.com

ABOUT US

FARO is the world's most trusted source for 3D measurement, imaging, and realization technology. The Company develops and markets computer-aided measurement and imaging devices and software. Technology from FARO permits high-precision 3D measurement, imaging and comparison of parts and complex structures within production and quality assurance processes. The devices are used for inspecting components and assemblies, rapid prototyping, documenting large volume spaces or structures in 3D, surveying and construction, as well as for investigation and reconstruction of accident sites or crime scenes.

FARO's business is mainly segmented into 5 vertically focused teams – namely, factory metrology, product design, construction BIM-CIM, public safety forensics, and 3D solutions and services applications. This purpose of this segmentation is to develop and deliver industry and application specific solutions to our customers.

PRODUCT PORTFOLIO

FOCUS^{S}
Key Features

Accuracy ± 1mm
Scanning range from 0.6m to 150m and 350m, IP 54, Extended temperature range

Focus^{S} combines hallmark features of the FARO® Focus^{3D} product line with significant technological innovations such as Ingress Protection Rating (IP54), increased scanning accuracy, internal accessory bay & built-in compensation routine.

- Capture outdoors with the certified industry standard Ingress Protection (IP) Rating, IP54
- Scan with improved accuracy and distance via dual-axis compensator and angular measurement
- Conduct on-site compensation routines for confident high data quality
- Operate the scanner in temperatures as low as -4°F (-20°C) and upto 131°F (55°C)

FOCUS^{3D} X HDR
Key Features

Accuracy ± 2mm
Scanning range from 0.6m-130m & 330m
HDR delivers authentic color imagery

The Focus^{3D} X HDR is a high-speed 3D laser scanner with mid to long range options. Scan in varying lighting conditions to deliver realistic results. With its integrated GPS receiver, the laser scanner correlates individual scans in post-processing.

- Scan precisely with authentic color imagery even under challenging lighting conditions
- Conduct fast and high-precision scanning in direct sunlight
- Use the GPS receiver to correlate individual scans and simply workflows during processing
- Survey with fewer scans with extended ranges, thus resulting in faster project completion

FREESTYLE^{3D} X
Key Features

Accuracy of ± 1mm
Scanning range from 0.5m to 3m
Intuitive plug and play system

The FARO Freestyle^{3D} X is a top-quality, durable, industrial-grade and high-precision handheld scanner for AEC professionals. It quickly and reliably documents rooms, structures and objects in 3D and creates high-definition point clouds.

- Scan around corners where visibility and lighting conditions is limited
- Capture many surfaces in a wide range of environments with or without artificial targets
- Calibrate on-site, ensuring consistent and high quality data
- Combine results from Focus Laser Scanners and the Freestyle^{3D} X, even in gray scale

FOCUS INDUSTRIES

Manufacturing, Construction, Public Safety and Historical Preservation

A HISTORY OF INNOVATION

1994: Evolves from medical 3D component construction to manufacturing
1995: Introduces FaroArm®
1996: FARO Arm Platinum becomes world's best selling measurement arm
2004: Introduces Xtreme ADM Technology
2009: Introduces world's most accurate laser tracker - ION® Laser Tracker
2010: Introduces world's smallest and lightest 3D laser scanner Focus^{3D}
2014: Introduces new blue laser technology for high definition

AWARDS & ACCOLADES

2012 | FOCUS^{3D} S
- Red dot design award "Best of Best"
- IF Design Gold Award
- "Hardware Product of the Year" Construction Computing Award 2012
- Innovation Prize for Architecture and Construction

2014 | FOCUS^{3D} X 330
- Geospatial Technology Innovation Award 2014

2015 | FREESTYLE^{3D}
- Red dot design award 2015
- "Hardware Product of 2015 " Construction Computing Award

IIC TECHNOLOGIES

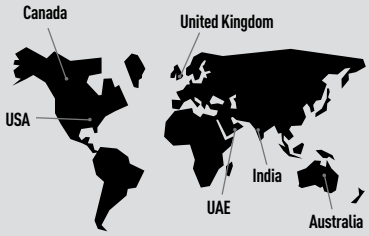
RAJESH ALLA
Chairman & Managing Director

START OF OPERATIONS
1993

HEADQUARTERS
India

EMPLOYEES
1000+

OFFICE LOCATIONS



CONTACT

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Hyderabad, Telangana, India 500 034

Phone: +91 (40) 3914 4444
Fax: +91 (40) 3914 4455
Website: www.iictechnologies.com
Email: info@iictechnologies.com

ABOUT US

IIC Technologies provides geospatial engineering solutions to organizations across aerospace, defense, government, infrastructure, natural resources, transportation, and utility sectors. Armed with state-of the-art geospatial technology, rich domain experience, and system integration expertise we collaborate closely with our clients, to address their unique challenges and opportunities. Operating from our offices across four continents, we deliver on the entire geospatial value chain from surveys to end-user products and software applications for decision makers.

SURVEYS AND DATA ACQUISITION

- → Topographic, Hydrographic and Geophysical Surveys
- → Airborne, terrestrial, and marine surveys
- → LiDAR, Photogrammetric, Bathymetric, and Geotechnical Surveys
- → Cadastral mapping, Engineering and Geodetic surveys

DATA CONVERSION AND MODELING SOLUTIONS

- → Marine and Aeronautical Navigation Products
- → Geospatial database services
- → Photogrammetric services
- → Land information systems
- → 3D Modeling
- → Heritage mapping

ENGINEERING AND CONSULTING SERVICES

- → Conceptual plans and feasibility studies
- → Detailed surveys and investigations
- → Detailed Project Reports (DPR)
- → Pre-tender engineering
- → BIM and digital engineering

SOFTWARE SOLUTIONS AND SYSTEMS INTEGRATION

- → Geoportals
- → e-Commerce extensions to geospatial applications
- → Integration of GIS solutions with ERP applications
- → Embedded systems
- → Systems integration

TRAINING

- → Ensuring successful deployment and transfer of technology
- → Skill development
- → Capacity building in industry

FOCUS INDUSTRIES

We deliver solutions to address unique opportunities and challenges for our client's, across many industries including:

| Aeronautics | Defense | Government | Heritage| Irrigation |Marine | Mining and Minerals | Railways | Roads & Highways | Water Resources

ASSOCIATIONS

We collaborate very closely with leading industry and government bodies to help define, develop and propagate standards in the geospatial arena. The International Hydrographic Organization (IHO), Open Geospatial Consortium (OGC), Association of Geospatial Industries (AGI), International Airborne Geophysics Safety Association (IAGSA), various national hydrographic agencies, etc., are some of our key partners in the industry.

LUCIAD

MARC MELVIEZ
CEO

ABOUT US

Luciad delivers geospatial software solutions that power the world's mission critical operations. Our APIs provide developers with advanced visual analytics that allow them to unlock the potential of real time location intelligence and create the foundations for next generation geospatial systems.

"Connect, visualize, analyze, act" is both our method and our motto.

PERFORMANCE AS FLUID AS DATA	GEOSPATIAL ANALYTICS FOR THE FUTURE	CRUCIAL INSIGHTS IN REAL TIME
The human eye is a highly developed tool for picking up movement, but works best with seamless movement. Systems built with Luciad technology provide a performance at 60FPS even when managing complex and continuous moving data.	The volume of data we produce is growing at an exponential rate. Luciad provides the building blocks which enable users to develop 2D, 3D and 4D visualization solutions which can scale to meet future challenges.	Luciad provides the foundations for truly interactive solutions capable of analyzing and visualizing real-time data. Whether in the control room or the board room, our advanced geospatial analytics enable split-second decision making.

START OF OPERATIONS
1999

HEADQUARTERS
Belgium

EMPLOYEES
100

OFFICE LOCATIONS

CONTACT

Luciad
Gaston Geenslaan 11
B-3001 Leuven, Belgium

Phone: +32 16 23 95 91
Website: www.luciad.com
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PRODUCT PORTFOLIO

Our software components empower users to unlock the power of advanced geospatial analytics, providing real-time situational awareness that the modern world demands.

LUCIADRIA Key Features	LUCIADLIGHTSPEED Key Features	LUCIADFUSION Key Features
Full browser-based platform Seamless 2D & 3D views HTML5, Java & WebGL powered No plug-ins	High performance and precision Easy-to-use API Modular, open architecture Flexible deployment	Powerful server solution Handle multi-layered & multi-dimensional data Central management and quick access to data

FOCUS INDUSTRIES

Aviation, Defense, Homeland Security, Logistics, Maritime, Public Safety, Utilities

COLLABORATION AND PARTNERSHIPS

In addition to developing high performance geospatial software solutions, Luciad contributes to open geospatial standards development as a long-term member of the Open Geospatial Consortium (OGC). Luciad also works with many technology partners including AFCEA, Barco, Cloudalize, DigitalGlobe, exactEarth, Hortonworks, Open Design Alliance, Oracle and Nvidia.

VALUE TO USER

From safeguarding critical assets to creating the digital infrastructure for smart cities, we help users implement intuitive command and control systems for leading organizations such as Airbus Defence and Space, Lufthansa Systems, NATO, Lockheed Martin and Thales. Our customers depend on Luciad for high performance visualization that allows them to implement scalable solutions. We provide users:

- Accurate, high performance visualization of their datasets
- Advanced visual analytics to make sense of big data
- Powerful, flexible API to handle the most complex data

AWARDS & ACCOLADES

2015 Geospatial Excellence Award: "LuciadRIA – 3D Situational Awareness in the Browser" (Geospatial World Awards)
Best in Class Solution: "CAPS (Collaborative Airspace Provision Service)" (2014 SWIM Master Class, Single European Sky ATM Research (SESAR))
Best in Class Runner-Up Solution: "Remotely-Piloted Aircraft Systems Very Low Level Operation Coordination (RPAS VLLOC)" (2014 SWIM Master Class, Single European Sky ATM Research (SESAR))

RIEGL®

Innovation in 3D

DR. JOHANNES RIEGL
CEO

ABOUT US

With almost 40 years experience in the research, development & production of laser rangefinders, distance meters, scanners and scanning systems, *RIEGL* delivers proven innovation in 3D.

The *RIEGL* headquarters are located in Austria, with international main offices in the USA, China, and Japan. *RIEGL* employs roughly 200 highly skilled and motivated staff members in research, development, production, marketing, sales, training and administration worldwide who deliver highest quality LiDAR products and outstanding customer service to the marketplace.

RIEGL is renowned for its constant efforts in LiDAR technology development and innovations like echo digitization, online waveform processing, full waveform analysis, and multiple-time-around processing which have left an significant imprint in the whole industry.

BUSINESS SENSE	USER-FRIENDLINESS	FOCUS ON TECHNOLOGY
Highest accuracy and reliabilty to satisfy customers' expactations - that's our ambition, not only for our products but also for partnership.	Providing devices and systems that are tailored for the special requirements of our customers result in user-friendly solutions for every unique business.	Current R&D efforts are the basis for providing latest waveform LiDAR technology resulting in the best possible value for our customers and their business.

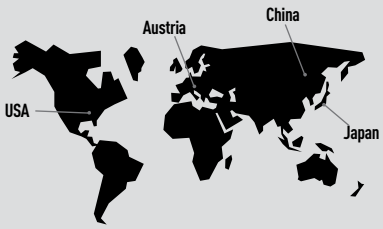
START OF OPERATIONS
1978

HEADQUARTERS
Austria

TURNOVER
$50 mn

EMPLOYEES
200

OFFICE LOCATIONS



CONTACT

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Fax: +43 2982 4210
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PRODUCT PORTFOLIO

The broad *RIEGL* portfolio comprises various laser scanners and laser scanning systems for terrestrial, industrial, mobile, bathymetric, airborne and UAS-based applications.
The sophisticated hardware is complemented by innovative software resulting in powerful solutions for nearly all imaginable fields in surveying. Some of our current key products are:

RIEGL VZ-400i	*RIEGL* VQ-1560i	RiCOPTER
Extremely Fast 3D Terrestrial Laser Scanner System	**Dual Channel Waveform Processing Airborne LiDAR Scanning System**	**Remotely piloted aircraft system for UAV-based surveying**
innovative new processing architecture and latest waveform processing technology	for ultra wide area / high altitude mapping	with fully integrated *RIEGL* VUX-SYS LiDAR system

FOCUS INDUSTRIES

Mining I Mapping I Monitoring I Civil Engineering I Archaeology & Cultural Heritage I City Modeling I Agriculture & Forestry I Hydrography I Investigation I Emergency Management

COLLABORATION AND PARTNERSHIPS

Worldwide sales, training, support and services are delivered from *RIEGL*'s Austrian headquarters and its offices in Vienna, Salzburg, and Styria, main offices in the USA, China, and in Japan, and by a worldwide network of representatives covering Europe, North and South America, Asia, Australia and Africa.
Current cooperations with numerous universities and technical institutions worldwide as provide a sound basis for developing and testing new technologies and equipments.

VALUE TO USER

According to the slogan "Innovation in 3D" *RIEGL* provides:

- sophisticated state-of-the-art Waveform LiDAR processing technology
- highest performance, quality, reliability, and longevity of all products and services
- strict adherence to applicable international standards
- perfect fullfilment of measurement requirements and customers' expectations

AWARDS & ACCOLADES

among many others *RIEGL* was awarded with the Geospatial Innovation Award in 2013 and 2014

ROLTA

KK SINGH
Chairman & CEO

START OF OPERATIONS
1989

HEADQUARTERS
India

TURNOVER
$584 mn

EMPLOYEES
2500

OFFICE LOCATIONS

CONTACT

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Rolta Technology Park
MIDC, Andheri (East)
Mumbai 400 093, India

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Fax: +91 (22) 2836 5992
Website: www.rolta.com

ABOUT US

Rolta is a leading provider of innovative IP-led IT solutions for many vertical segments, including Federal and State Governments, Utilities, Oil & Gas, Petrochemicals, Financial Services, Manufacturing, Retail, and Healthcare. Rolta is recognized for its extensive portfolio of solutions based on field-proven Rolta IP tailored for Indian Defence and Homeland Security. By uniquely combining its expertise in the IT, Engineering and Geospatial domains, Rolta develops State-of-the-Art Digital Solutions incorporating rich Rolta IP in the areas of Cloud, Mobility, IoT, BI and Big Data Analytics.

PRODUCT PORTFOLIO

Rolta has consciously made efforts to remain at the forefront as a solutions provider with a sharp focus on the Digital revolution. Rolta's relentless focus on R & D has undoubtedly been a strong differentiator in its global go to market initiatives as a result of its rich and growing IP. Rolta has about 250 copyrights and several patents filed in the US.

BI & BIG DATA ANALYTICS

Organisations require effective Asset Lifecycle Management for both strategic planning as well as tactical maintenance where seamless integration and access to asset design data is vital for effective Management of Change processes. Rolta's flagship Rolta OneView™ Enterprise Suite was therefore designed from the grounds up with Rolta OT/IT Fusion™ incorporating Rolta's patented Rolta iPerspective™ technology for secure real-time ingestion of IoT and OT data together with Rolta Engineering and Geospatial Fusion to populate its rich industry specific Knowledge Model.

SMART AND SAFE CITIES

Rolta is perhaps one of the few companies globally capable of undertaking the end-to-end requirements of Smart City projects. The company has built its own domain expertise which translate into 100+ proven IP solutions that are rapidly deployable. A pioneer in the fields of Geospatial, Engineering and ICT, Rolta has been working for more than two decades with governments across the globe to provide better services to citizens. Rolta has successfully implemented hundreds of sophisticated solutions globally and now has a formidable array of Smart City solutions.

DEFENCE

Rolta has long been a prominent member of Indian Defence & Security industry by investing years in pioneering new technologies for providing state-of-the-art solutions. The combination of Rolta IPs, track record of 20+ years, has led to Rolta gaining a dominant share of the C2ISR market. Recently the exclusive consortium of Bharat Electronics Limited (BEL) and Rolta were selected as a Design Agency for the prestigious and large value Battlefield Management System.

FOCUS INDUSTRIES

Defence, Homeland and Maritime Security, Federal & State Governments, Oil & Gas, Petrochemicals, Chemicals, Utilities, Manufacturing, Financial Services, Retail, and Healthcare

COLLABORATION AND PARTNERSHIPS

Rolta has forged strategic partnerships with world leaders to exploit cutting-edge technology and penetrate newer markets. Besides Rolta's own expertise and IP, the company appreciates the value of partnerships with industry technology leaders. Some of our strategic partnerships that have been a source of strength to the company are - Bharat Electronics Ltd., Oracle, SAP, Microsoft, IBM, ESRI, HP, EMC, VMWare, Danphone, Ness Technologies, Controp, Konsberg, Airbus Defence & Space amongst others.

VALUABLE FEATURES AND BENEFITS

Rolta combines the domains of IT, Business Intelligence & Big Data, Geospatial & Engineering and Defence & Security to provide unique and highly differentiated IP led solutions to its customers. Rolta has developed some very powerful software suites capable of seamlessly integrating IT, OT, geospatial and engineering data from disparate sources in an enterprise and present unified Business Analytics in real-time. This differentiated and unique combination has given Rolta a significant competitive edge and permitted the company to establish itself as a mature global IT provider. Rolta's holistic approach, innovative IP and domain expertise to help customers to traverse through their Digital Transformation.

Trimble

TRANSFORMING THE WAY THE WORLD WORKS

STEVE W. BERGLUND
CEO

START OF OPERATIONS
1978

HEADQUARTERS
America

EMPLOYEES
8600

OFFICE LOCATIONS

CONTACT

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ABOUT US

Trimble is transforming the way the world works.

Trimble is transforming the way the world works by delivering products and services that connect the physical and digital worlds. Core technologies in positioning, modeling, connectivity and data analytics enable customers to improve productivity, quality, safety, and sustainability. from purpose built products to enterprise lifecycle solutions, Trimble software, hardware and services are transforming a broad range of industries such as agriculture, construction, geospatial and transportation and logistics.

OUR HISTORY

From Silicon Valley to a global presence. In a few short decades.

Every brand has history. Ours starts with Charlie Trimble and two others from Hewlett-Packard. They didn't know they were creating an entire industry when they founded Trimble in 1978. But that's just what they did.

OUR PURPOSE

Our place in the world. Our reason for being.

At Trimble, we keep our feet on the ground and our eyes on the horizon. Because we believe it isn't enough just to keep pace. We're intent on leading the way by creating breakthrough solutions that solve customers' problems so they can be more productive and more profitable.

OUR FOCUS

Our focus revolves around building lasting relationships with each and every customer. By providing positioning solutions, we are able to help our customers make intelligent decisions, solve complex problems, optimize productivity, improve operating results and safety.

PRODUCT PORTFOLIO

Trimble operates through four segments: Engineering and Construction, Field Solutions, Mobile Solutions and Advanced Devices.

Positioning

Wide range of positioning technologies including GPS, laser, optical and inertial technologies with application software, wireless communications, and services to provide complete commercial solutions. Its integrated solutions allow customers to collect, manage and analyze complex information faster and easier, making them more productive, efficient and profitable.

Automation

Products include equipment that automates large industrial equipment, such as tractors and bulldozers; integrated systems that track fleets of vehicles and workers and provide information and analytics to the back-office; data collection systems that enable the management of geo-referenced information; software solutions that connect all aspects of a construction site or a farm, and building information modeling (BIM) software that is used throughout the design, build and operation of buildings.

FOCUS INDUSTRIES

Professionals worldwide across numerous diverse markets including Agriculture, Civil Construction, Buildings, Land Information, and Transportation and Logistics use our intuitive products, reliable data, advanced modeling, professional services and powerful visualization tools.

VALUE TO USER

For over 35 years, supported by a global employee base and distributor network, Trimble has delivered accurate information that our customers in over 150 countries can act upon with the confidence. Whether we are providing high accuracy technology, a unique answer to a business challenge or a product that is simple and easy to use, our solutions transform the way our customers work. Bringing together the right resources and technologies provide our customers with the experience they deserve.

ABOUT GEOSPATIAL MEDIA AND COMMUNICATIONS

Geospatial Media and Communications, with its vision of Making a Difference through Geospatial Knowledge in World Economy and Society, works to build the geospatial industry in all its facets. It is a catalyst organisation pursuing business objectives towards promotion and facilitation of growth of Geospatial Industry through creating awareness, policy advocacy, business development and by connecting stakeholders and communities worldwide. Since 1997, Geospatial Media has invested its energies and resources in developing geospatial market globally and has provided a leadership role in promoting geospatial tools to several stakeholders with a thrust on prospective industries. Headquartered in India, it has regional offices in USA, UAE, Brazil, South Africa, Malaysia and The Netherlands.

Geospatial Media achieves its objectives by publishing content on geospatial technologies, trends, policies and applications. It also undertakes policy advocacy, business consulting and produces industry reports on market behaviour, requirements, challenges and prospects of geospatial information and applications for society and economy. In addition, it is one of the few professional organisations that organises many national, regional and international conferences on the domain.

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GEOSPATIAL media + communications

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media + communications