NETHERLANDS GEOLOCATION ECONOMY

MARKET

ECONOMY

IMPACT

Partnership With

GEONOVUM

Ministry of Interior and Kingdom Relations

Produced By

GEOSPATIAL media + communications

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Note: For the purpose of this report, geolocation and geospatial has been used interchangeably

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Geospatial Media and Communications, through its market research and consulting offerings, delivers high-quality analyses and business intelligence, providing vital information on the geolocation industry, economy dynamics and sectoral opportunities.

Corporate Office: A-145, Sector 63, Noida, Pin code: 201309, India

The Netherlands Office: Geospatial Media and Communications B.V., Business Center, Barchman Wuytierslaan 10, 3818 LH Amersfoort, The Netherlands

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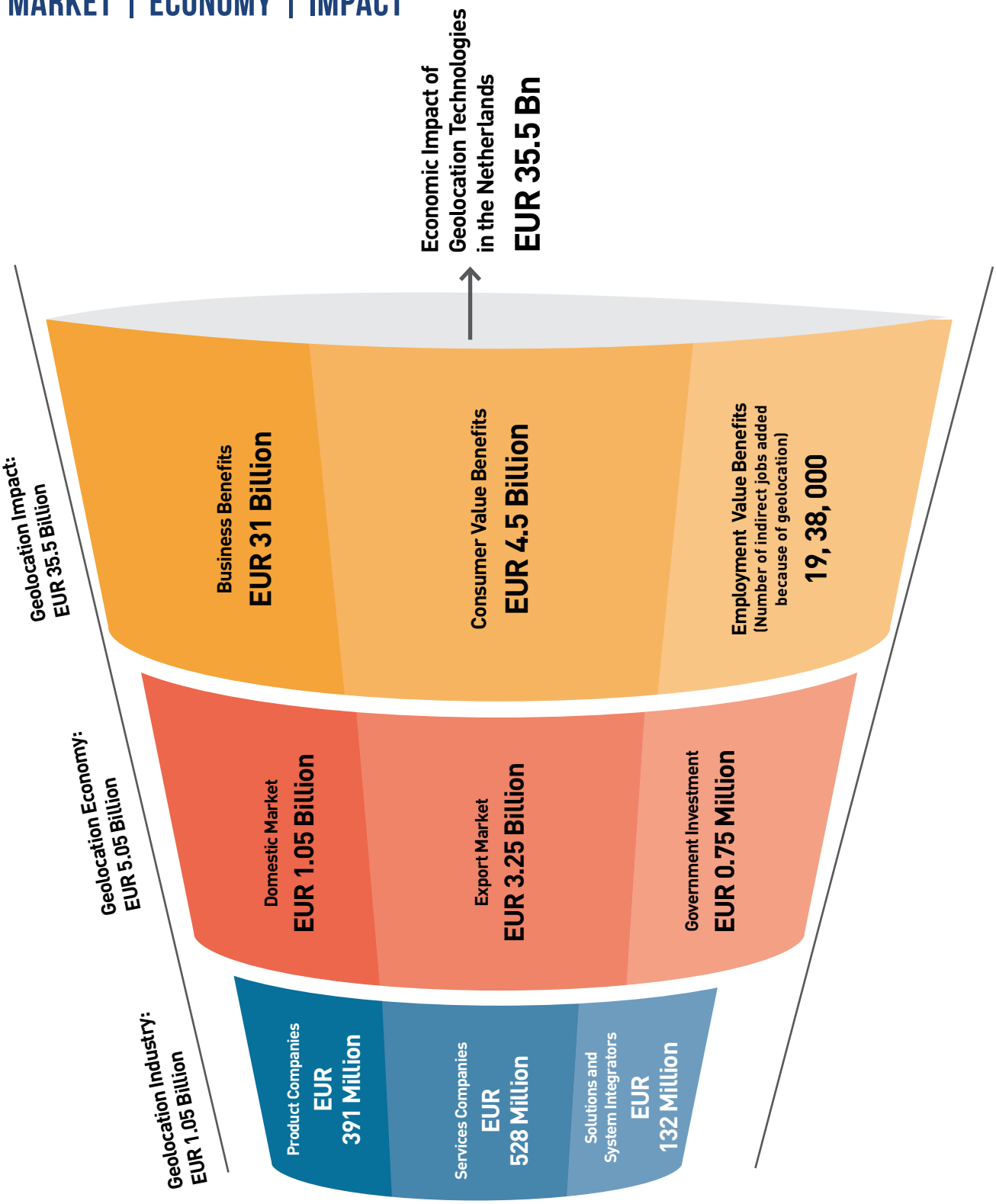
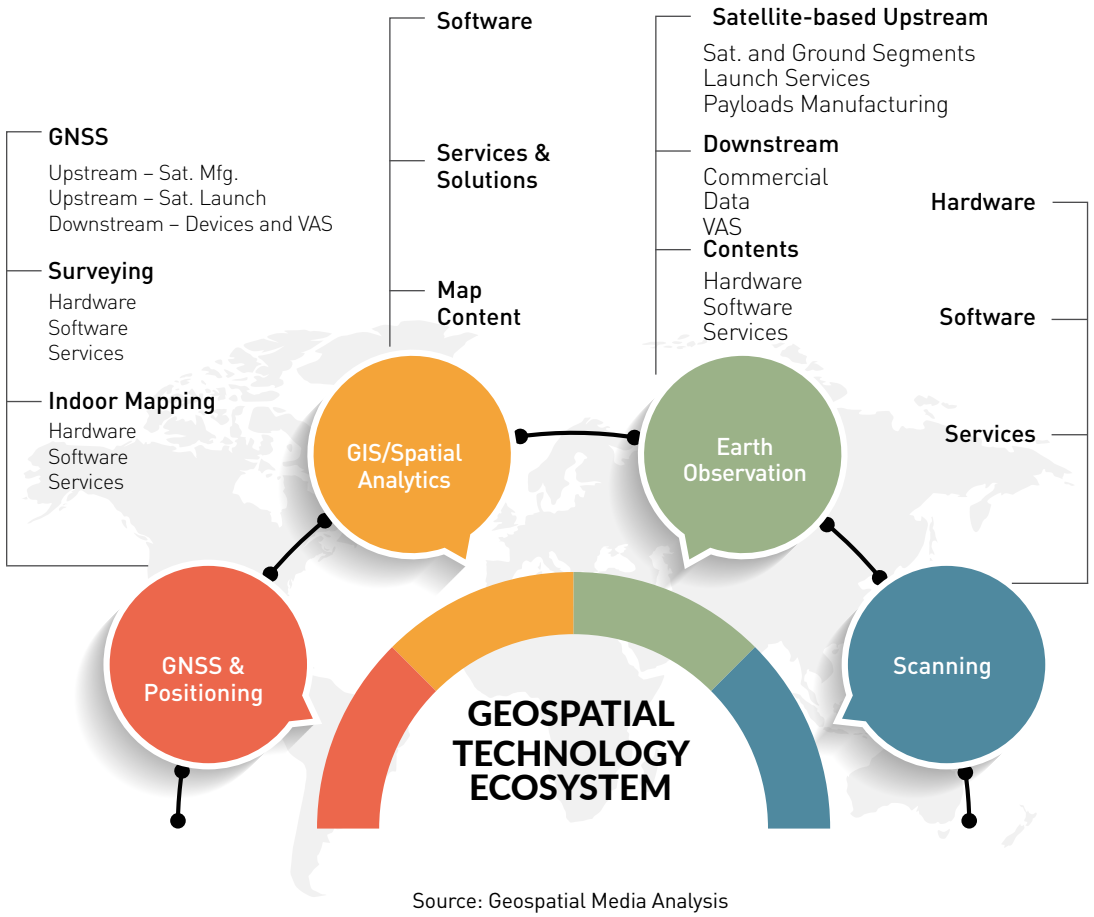


GEOSPATIAL INDUSTRY AND DIGITAL ECONOMY

Geospatial or geolocation technologies are a nation's digital currency for evidence-based decision-making. Geospatial technologies, for the purpose of this report, refers to the varied range of modern tools and technologies that help in the geographic mapping of the earth's surface and provide context to the collected spatial data via intelligence and analytics. In simple words, geospatial technology is defined as any technology that enables the creation, management, analysis, and visualization of geospatial data.

GEOSPATIAL TECHNOLOGY ECOSYSTEM

Today, the geospatial technology ecosystem is a complex entity of multiple interactive components, inclusive of geospatial data sourced from various technologies broadly segmented into four categories – GNSS and positioning systems; Geographic Information Systems (GIS), earth observation (satellite, aerial and street imagery), and scanning tools and technologies (LiDAR, RADAR, and Ground Penetrating Radar). The geospatial information collected from these sources is presented in many forms and mediums, including digital maps, satellite imagery, point clouds, and aerial imagery. The spatial data collected reinforces the importance of 'location' reference frame, which facilitates societal, economic and environmental use across government systems and services, and other national development initiatives.



Source: Geospatial Media Analysis

GEOSPATIAL TECHNOLOGY AND FOURTH INDUSTRIAL REVOLUTION

With the onset of the Fourth Industrial Revolution (4IR), the availability of huge volumes of structured and unstructured data has given rise to the digital economy, which encompasses 4IR technologies, such as, cloud computing, big data, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), automation, robotics, edge computing, Digital Twin, blockchain, and other revolutionary technologies. Today, in the era of digital transformation, the permeation of these digital technologies into countless aspects of the world economy has also impacted the geospatial industry. Since the world is currently deluged with geospatial data, the impact of digital technologies on the geospatial industry is profound and evolving with great velocity, affecting varied sectors and countries across the world.

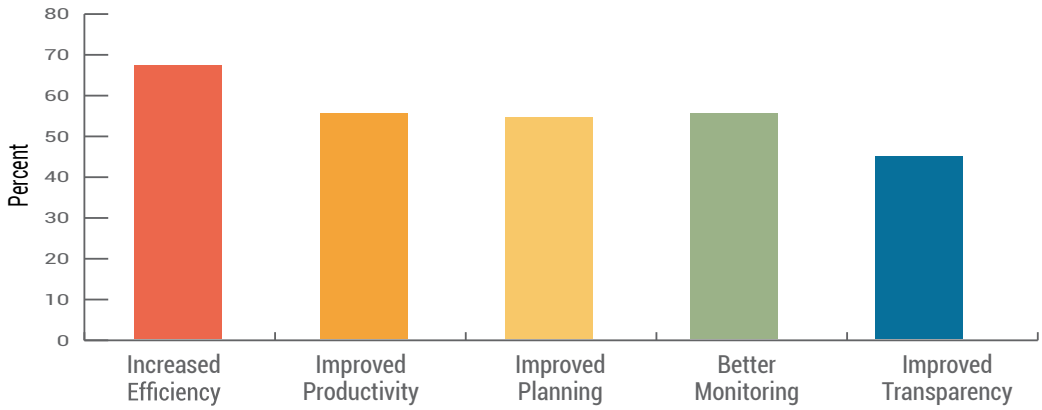
INTEGRATION OF GEOSPATIAL TECHNOLOGIES, DATA AND INFRASTRUCTURE

The pace of the digital economy revolution has thus transformed the geospatial ecosystem in a manner such that the geospatial technologies are now being integrated with Information, Communication and Technologies (ICT), Building Information Modeling (BIM) solutions, Business Intelligence (BI) solutions, and other business processes. In today's digital economy, the integration of geospatial technologies with AI and IoT has prepared the geospatial industry to be agile and flexible and expand the extent of the benefits to both traditional and non-traditional sectors (Fintech, mobility, and environment). Thus, the integration of different technologies, data, and different infrastructure ecosystems accelerates innovations that are particularly focused on delivering consumer-centric services to improve the quality of life of citizens, governments and businesses holistically.

BENEFITS OF GEOSPATIAL TECHNOLOGIES

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. Geospatial technologies ability to integrate databases and visualize the spatial relationships between various components encourages partnerships and data sharing.

Graph 1 - Benefits of Geospatial Technology



Source: Geospatial Media Analysis

DIGITAL READINESS OF THE NETHERLANDS

Today, a country's digital readiness is the single greatest catalyst for its economic and social progress, helping it connect in the best way possible with the world at large. Digital technology opens markets, creates jobs, and better connects citizens and customers. The Economist Intelligence Unit (EIU) of The Economist magazine, recently released the **EIU Technological Readiness Ranking*** which ranks 82 economies across three categories: access to internet, digital economy infrastructure, and openness to innovation. The Netherlands ranks as one of the 'Top 10 Most Technology Ready' countries in the world, an ideal destination for technology companies to consider investing in, thanks to its widespread mobile and broadband connections.

By understanding that there is a strong correlation between a country's digital readiness and other economic performance indicators such as Gross Domestic Product (GDP), the Netherlands government has made strategic efforts to optimally expand its digitalization process. Recently, the Netherlands government released the **Dutch Digitalization Strategy 2.0****, which was initially presented to the House of Representatives in 2018. The Digitalization Strategy emphasizes how the country can optimally and responsibly use digital technologies to address the socio-economic challenges facing the Netherlands. The Netherlands has initiated digital transformation in the country by setting up workplaces where entrepreneurs can innovate and experiment with digital technologies. Also, in this context, the Netherlands' Digitalization Strategy outlines areas for priority actions:

→ Artificial Intelligence
→ Digital Connectivity
→ Using Data (spatial and non-spatial) to tackle social issues and stimulate economic growth
→ Digital Inclusion and Skills
→ Digital Government
→ Digital Resilience

In today's interconnected world, digitalization is at the core of the geospatial ecosystem. The digitalization priorities, as defined by the Netherlands government, are critical for the geospatial readiness of the country.

GEOSPATIAL READINESS

The digital ecosystem integrates data from varied data sources – including real-time data sourced from geospatial technologies. 4IR is changing the world and the geospatial sector needs to change with it as well. The Netherlands is one of the few countries where digital technologies are utilized actively, where geospatial tools are an indispensable part of governance, environmental management, and society and businesses. The country is known to adopt and utilize geospatial information in various aspects of its workflow for informed decision-making, improving efficiency, and enhancing productivity for sustainable development across the economy.

In this context, the Netherlands government has been globally acknowledged for its accomplishments in the ICT, smart city, sub-surface, and digital twin technology domains, and its strong focus on social impact applications. The Netherlands government is known to use an integrated approach that cuts across various technology segments and governance structures to derive maximum benefits from using technology in different areas. The Netherlands' geospatial sector ecosystem, driven by well-recognized national geospatial organizations (Kadaster, Netherlands Space Office, Geonovum, TNO) is almost at par with the leading geospatial organizations of the world with similar or even greater geo-political, economic and demographic heft. Some of the comparative assessments to support the above observation are presented below:

*The Economist Intelligent Unit (2018) Preparing for disruption: Technological Readiness Ranking [Online]. Available at : http://www.eiu.com/public/thankyou_download.aspx?activity=download&campaignid=TechReadiness
**Nederland Digitaal (2019) Dutch Digitalization Strategy 2.0 [Online]. Available at : https://www.nederlanddigitaal.nl/documenten/publicaties/2019/11/13/english-version-of-the-dutch-digitalisation-strategy-2.0

The Countries Geospatial Readiness Index (CGRI) is an assessment of the 'geospatial' readiness of 75 nations, based on the comprehensive evaluation of five core pillars of the geospatial ecosystem, namely, geospatial data infrastructure, policy framework, user adoption, institutional readiness, and the geospatial industry fabric. The Netherlands ranked fourth in CGRI-2019, GeoBuiz-19 report, which highlights the strong stand taken by varied stakeholders to enable and develop the country's data infrastructure, employ facilitative policies and rules and regulations, adopt and apply geospatial solutions in different industry workflows, and create an enabling environment for the geospatial industry to grow. In this respect, the Dutch government and the user sector — inclusive of municipalities, infrastructure and engineering sector, national geospatial organizations, etc. — are working towards developing geospatial knowledge and expertise for long term applications and value-creation.

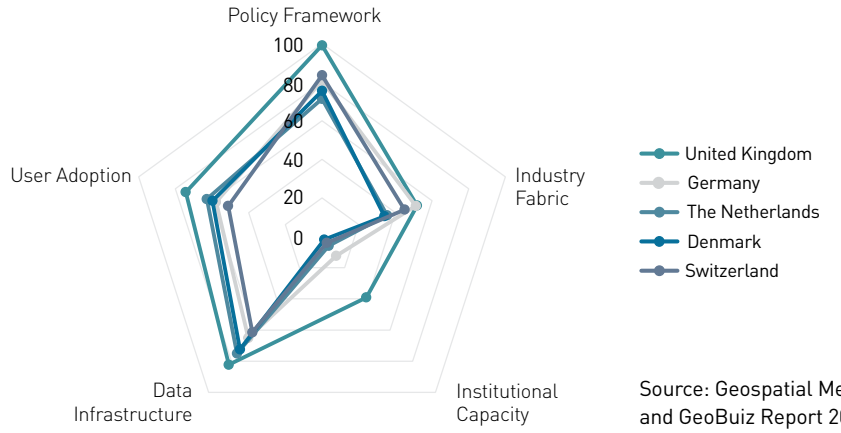
The table below highlights the Netherlands' favorable position across varied indices, ranging from geospatial readiness to the socio-economic indicators of the country (inclusive of UNDP Human Development Index 2018, WEF Competitiveness Index 2018, and UN e-government survey 2018). A correlation can also be drawn among the Netherlands' ranking in the different socio-economic indicators to show that the Netherlands' performance in terms of spatial data infrastructure, spatial data utilization and the industry ecosystem, directly or indirectly contributes to the growth of its GDP, higher standards of living for citizens, and high-quality digital infrastructure.

Country	Geospatial Readiness Rank 2019	UNDP Human Development Index 2018	WEF Global Competitiveness Index 2018	UN e-Government Survey 2018
Top 5 Countries in Geospatial Readiness Index				
USA	1	13	1	11
UK	2	14	8	4
Germany	3	5	3	12
The Netherlands	4	10	6	13
Canada	5	12	12	23

*UNDP's HDI Index ranks 188 countries, UN e-Government Survey ranks 193 countries, and WEF's Global Competitiveness Index ranks 140 countries. GMC's CGRI-2019 is an index of 75 countries selected on the basis of their GDP, population and geographical spread.

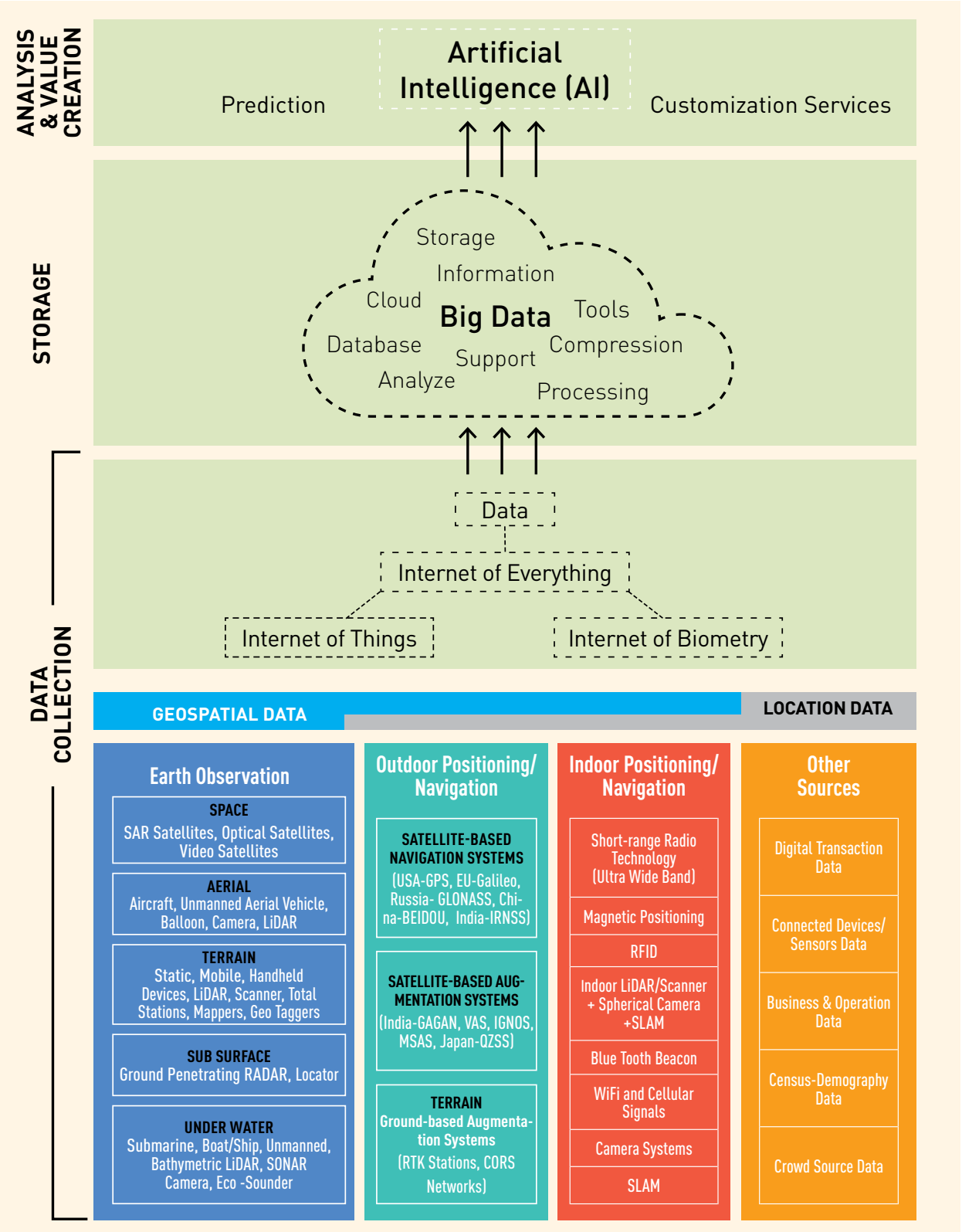
The 'geospatial readiness' of Netherlands vis-a-vis the United Kingdom, Germany, Denmark and Switzerland — a few of the leading European nations that rank high in the CGRI. It shows that while the Netherlands' ranking in the user adoption and the data infrastructure pillar is almost at par with the United Kingdom, Denmark and Germany, it needs to do better with respect to an enabling policy framework, the industry ecosystem, and institutional capabilities. A detailed segment-by-segment analysis is presented in the following chapters.

Graph 2 - The Netherland's Geospatial Preparedness vis-a-vis leading European Countries as per CGRI 2019



Source: Geospatial Media Analysis and GeoBuiz Report 2019

GEOSPATIAL DATA IN INDUSTRY 4.0



Source: National Think Tank (2020) Geospatial Strategy For New India. E-book library [online]. Available at: https://geospatial-media.net/reports/geospatial-strategy-for-new-india-report.html

GEOSPATIAL INFRASTRUCTURE AND DIGITAL ECONOMY

The geospatial infrastructure of a country encompasses data, technology, policy, and people — to ensure smooth provision and use of geospatial data and services. In the present era of the 4th Industrial Revolution, geospatial infrastructure is a foundational and enabling pillar of the data ecosystem. In today's unprecedented times of the COVID pandemic, social unrest, climate crisis, natural disasters, massive unemployment, and economic recession, where there is instability and uncertainty about what lies ahead, the role of geospatial infrastructure is critical in developing a more holistic understanding of the future. Today, geospatial infrastructure brings together data from different solutions to create an understanding of the spatial context, which precedes action for informed decision-making. The role of geospatial infrastructure is, thus, to INTEGRATE – integrate data and information, integrate old and new technologies, integrate people, processes, social, and organizational elements of the much larger digital infrastructure ecosystem with 'location' as a common reference frame. Therefore, geospatial infrastructure, in this context, positions geospatial as a multi-purpose technology at the heart of the digital and knowledge economy.

Traditionally, the national geospatial organizations – including the National Mapping Agencies (NMAs) and Thematic Mapping Agencies – have been the primary custodians of geospatial data. However, with the mainstreaming of geospatial technologies and solutions, the role of the national Geospatial organizations is undergoing a transformation. Today, geospatial infrastructure is not limited to the national geospatial organizations but includes contributions to the sector by the private geospatial industry players, not-for-profits, research and academia institutions, and most importantly, the consumers and citizens themselves. In this context, geospatial infrastructure delivers huge transformational values, basis the principles of geography, on varied applications such as natural resources, urban development, agriculture, disaster management, transparent governance, infrastructure, defense and public security, climate change, and water resources, among many other things.

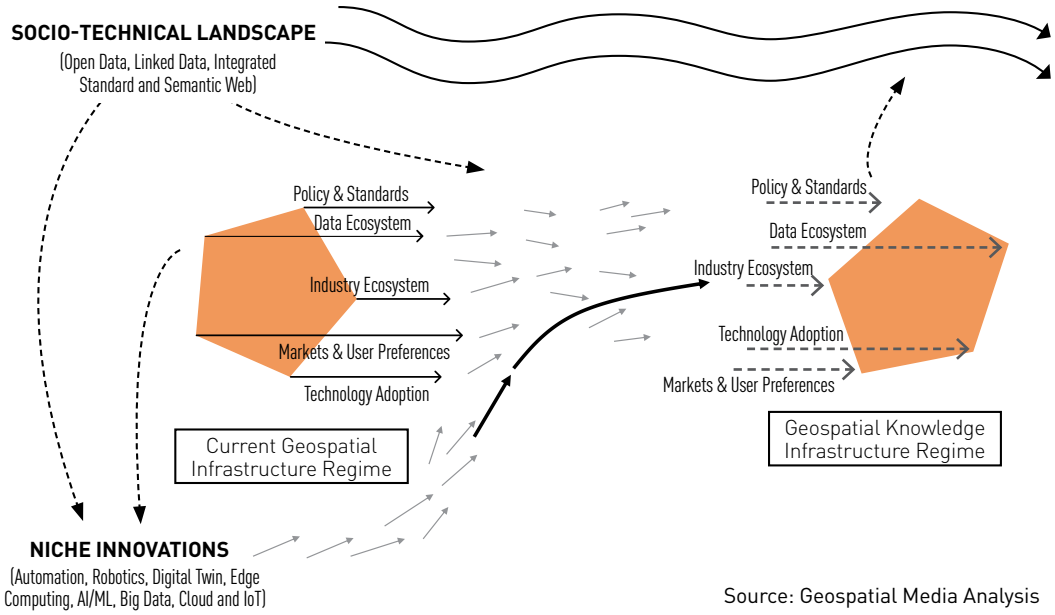
GEOSPATIAL KNOWLEDGE INFRASTRUCTURE (GKI)*

Today, millions of people all over the world are integrating geospatial data and information in their workflows to conduct predictive analyses, simulations, etc., giving geospatial the cognition for knowledge creation and services. In this context, the Geospatial Knowledge Infrastructure (GKI) seeks to add a location dimension to the broader digital ecosystem to mainstream geospatial data and information, expertise, technologies, and analytics. The GKI framework aims to move the geospatial ecosystem closer to the recent but much more widely accepted 4IR digital ecosystem, with the intent of refocusing the geospatial ecosystem on socio-economic decision-making. Thus, the purpose behind GKI in the digital economy is to provide location intelligence and knowledge to the broader ecosystem — inclusive of businesses, societies, governments, consumers and citizens. The availability of real-time geospatial data helps stakeholders solve their problems, exploit opportunities, and deliver strategic value propositions for the development of the national economy and society.

The GKI aims to integrate geospatial information, analytics, and visualization with the wider knowledge and digital ecosystem of our cooperative future, thereby aiding in effective decision-making across all sectors. At the heart of GKI is a broad, collaborative, connected, and innovative geospatial sector that is focused on the present and future needs of users. In order to cater to the demands of diverse user groups, geospatial data needs to be integrated with data from diverse sectors. In addition, the geospatial knowledge products derived from the integration of diverse data have to be made more accessible for wider adoption, even by non-experts in spatial data. The National Spatial Data Infrastructure (NSDI) platform was developed to provide easier access to geospatial data for citizens, government, and businesses. GKI aims to take the objectives of

*Geospatial Media and UNGGIM (2020) Discussion Document on Advancing Role of Geospatial Knowledge Infrastructure in World Economy, Society and Environment [Online]. Available at : https://geospatialmedia.net/gki-campaign.html

Geospatial Knowledge Infrastructure Transition Framework



Source: Geospatial Media Analysis

NSDI forward and advance them by making geospatial knowledge accessible to a wider section of users across sectors through a demand-driven approach.

The transition to GKI requires changes and updates across all the components of the geospatial infrastructure. In addition, this transition is also influenced by external factors like the development priorities of the country; its digital readiness; and local, regional, and global developments happening in the geospatial and allied technology sectors, etc. A multi-level perspective model, as shown in the geospatial knowledge infrastructure transition framework, can be used to demonstrate the landscape and the various components involved in the transition to a GKI. The geospatial infrastructure regime consists of five major components – data ecosystem, policy and standards, technology adoption and integration, industry ecosystem, and markets and user preferences. The transition to a GKI encompasses transition across all these components. In addition, the transition is also influenced by the changes happening outside the regime, like niche innovations in the field of artificial intelligence and machine learning, which can be integrated with geospatial data for enhanced knowledge creation.

The geospatial infrastructure regime is also influenced by the wider socio-technical landscape, which includes the local, regional, and global efforts aimed at enhancing the digital economy, open and linked data, automation, etc. The wider socio-technical landscape exerts pressure on the current geospatial infrastructure regime to adapt to the changes happening around the world, which in turn encourages the current regime to invest further in niche innovations that will aid in the transition to GKI. The data ecosystem forms the most important component in the transition to GKI. The other components of the geospatial regime – policy and standards, technology adoption and integration, industry ecosystem, market and user preferences – interact with and influence the data ecosystem, and aid in the maturity and transformation of the ecosystem.

ASPECTS OF GEOSPATIAL KNOWLEDGE INFRASTRUCTURE

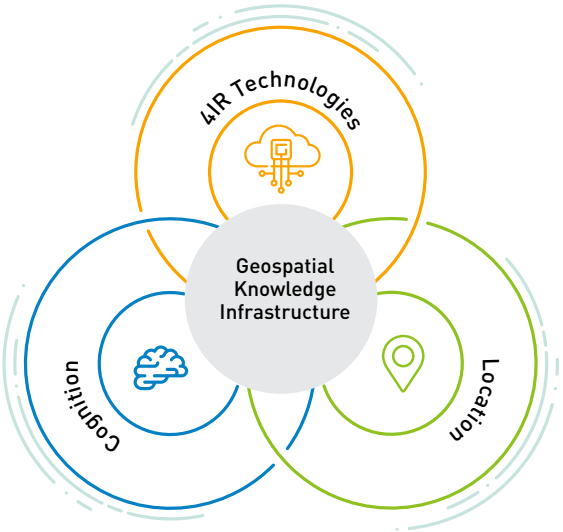
The principal role of geospatial infrastructure is to provide for an interconnected platform, wherein geospatial data from different disciplines, formats, and organizations can be integrated in an organized and usable manner. These datasets include unstructured data, tabular data, LiDAR/ point cloud, terrain, imagery, vector, 3D, CAD/BIM, big data, real-time IoT, multidimensional data and web maps, layers and 3D scenes. When datasets from these diverse sources are connected and integrated through portals in a 4IR world, there is an intersection of

→ the new opportunities enabled by 4IR technologies,
→ cognition as a path to knowledge, and
→ location as a key element of analytics and data.

This helps the world, in general, to maximize social, economic and environmental benefits. One of the best examples that exists at present is of the United Nations, where the reporting of the progress of the sustainable development goals is monitored using geospatial technologies. The GKI aims to create usable intelligence from distributed and integrated data formats, processed and enabled by 4IR technologies and location-referenced using the dynamic nature of the web and modern GIS technologies. As a result, geospatial infrastructure today includes leveraging everything from Software-as-a-Service (SaaS) to open data services, shared services, cloud and edge computing, big data analytics, real-time tracking, AI and ML to help human ingenuity prosper and lead to new avenues of innovation.

GKI sets the groundwork that helps human ingenuity to prosper and lead the geospatial industry, the users and the common citizens to new places. It aims to ensure that Geospatial is everyone's business. It builds on data, GIS, NSDIs, the Integrated Geospatial Information Framework (IGIF) of the UN-GGIM and uses the very same web infrastructure and concepts that are driving knowledge and growth. Centered on users, it helps governments, industry, academia and citizens to build a digital economy and society that can embrace knowledge and automation.

Geospatial Knowledge Infrastructure aims at drawing together 4IR technologies, location and cognition to enable future societies to gain maximum social, economic and environmental value through knowledge and automation.



Source: Geospatial Media and UNGGIM (2020) Discussion Document on Advancing Role of Geospatial Knowledge Infrastructure in World Economy, Society and Environment [Online]. Available at : https://geospatialmedia.net/gki-campaign.html

GLOBAL TRENDS ENABLING THE CREATION OF SUSTAINABLE GEOSPATIAL KNOWLEDGE INFRASTRUCTURE

TRANSFORMATIONAL ROLE OF NATIONAL GEOSPATIAL ORGANIZATIONS

National geospatial organizations (inclusive of NMAs and thematic mapping organizations) are the primary custodians of geospatial data and their key role is to provide accurate, authoritative, interoperable and reusable data, which can be easily leveraged by the industry and user sectors alike. Since the role of the national geospatial organizations is rooted in relevance, it is time now for them to digitally transform themselves to be 'proactive and progressive' in their operations. National geospatial organizations can now shift from their primary role as data collectors to data aggregators and integrators – and (re)focus on making geospatial data and knowledge accessible to wider sections of society, thereby making a significant transition to a demand-driven geospatial infrastructure. National geospatial organizations, therefore, need to be dynamic, interactive and analytical to create and help businesses, governments, consumers and citizens use geospatial data to create impactful stories for data-driven decision-making.

POLICIES AND STANDARDS

Digital policies and standards are optimized to give maximum value to governments, institutions, businesses, and citizens, whilst protecting necessary security and privacy interests. In the world of 4IR, there is a need for integrated policy frameworks to enhance the impact and relevance of geospatial infrastructure for the greater good. Policies and standards – especially pertaining to open data, data security, cybersecurity and data privacy — are critical for the development of geospatial infrastructure. Further, these policies and standards need to also take into account digital technology policies (4IR-related policies), user sector policies, science and technology policies, and education system policies to maximize value across the larger geospatial ecosystem.

Further, as geospatial technology and its services are accelerating at a rapid pace, there is a need for developing a common spatial reference frame or standard today, more than ever to sustain growth. Standards are critical to bridging the gaps created by traditional software and processes and the challenges brought on by rapid advancements and innovations of sensors and data acquisitions.

SECTORAL ENGAGEMENTS

Geospatial underpins much of what happens in our daily lives – from the use of maps for commuting to the use of spatial data to make digital elevation models for infrastructure development, use of ecological data to track hazardous conditions, and the use of foundational data like roads, house parcels, etc., to deliver emergency services effectively and on time. The user sector has warmed up to geospatial-based services, with increasing interest in the digital twin approach to track and monitor ailing structures and utilities, planning and maintenance of transportation projects, disaster response and recovery, and autonomous vehicle and intelligent transportation, among others. Thus, to develop a sustainable geospatial infrastructure, it is imperative for the core geospatial community to broaden and advance sectoral engagement with the user industry sectors for deriving predictive analytics and modelling and drawing simulations to create sectoral applications and value-added services.

COLLABORATION AND PARTNERSHIP BY DESIGN

At the center of the geospatial infrastructure are partnerships and collaboration between cross-sector businesses, consumers and governments to co-create significant value propositions. A surge in private sector innovations and services has heightened the definition of collaboration and partnership – especially public-private partnerships (PPP). There is immense scope among the public and private sectors to collaborate and reap the benefits of cross-fertilization to create uniformity across datasets to extract value for better decision-making. Collaboration between the varied stakeholders of the geospatial infrastructure will play a strategic role in ensuring data interoperability, integrity, and equality. Further, collaboration and partnership ensure the establishment of a common spatial reference frame, which simplifies how different datasets are integrated and used across varied sectors to bring long-term benefits to the economy and society.

TECHNOLOGY INNOVATIONS AND NEW BUSINESS MODELS

With the advent of 4IR technologies and associated technologies, the geospatial ecosystem does not work in silos anymore. The ecosystem now operates within the expansive IT architecture of cloud, edge computing, and big data analytics. To keep up with the pace of digital transformation, especially with the onset of AI, ML, edge computing, automation, etc., both data producers as well as consumers of geospatial data are undergoing significant transformation. In this evolving technology architecture, the focus is on latency, that is, how fast the geospatial infrastructure can respond to the consumers – not with data but with services. This aspect has brought new business models in space and on-ground as well. X-as-a-service, inclusive of data-as-a-service or analytics/intelligence-as-a-service, is the predominant business model towards which the geospatial infrastructure is strategically shifting. The transformation from data to information and analysis is significant and, therefore, service-oriented business models are the future.

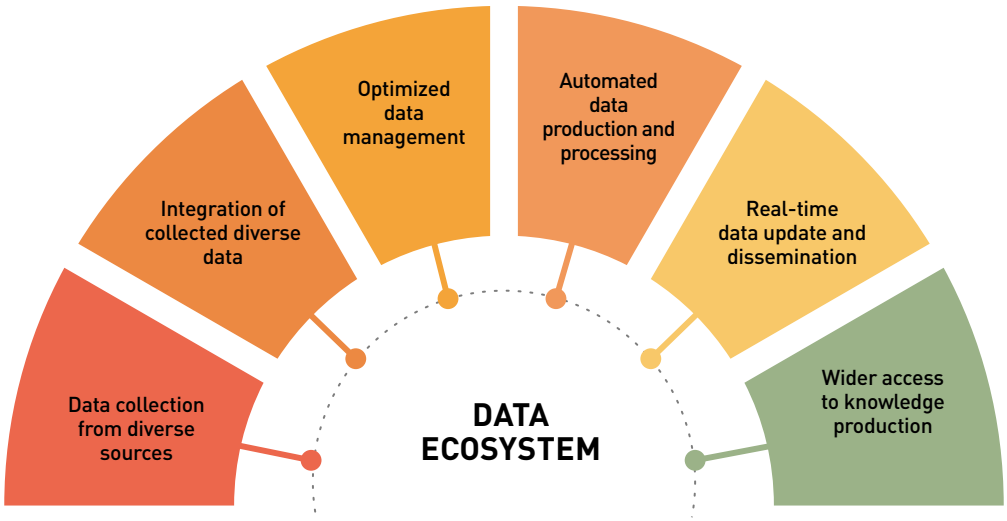
GEOSPATIAL-BASED HIGHLY DERIVATIVE PRODUCTS

Geospatial data underpins decision-making across all user segments. With the advent of 4IR technologies and associated technologies like IoT, 5G, edge computing, etc., the availability of geospatial data from non-traditional diverse sources has increased significantly. However, the responsibility of a geospatial infrastructure' is not to collect data but to provide the derivative products from the data so collected — such as, location-based services and applications, and space and big-data based value-added services and applications — that are attracting the majority of investments. The increasing demand of intelligent analytics spatial solutions to meet the specific demands of the citizens and the user industries is key for an evolving geospatial infrastructure. These users do not consume 'data' or 'technology' but are relevant to the geospatial infrastructure because they demand derivative products, which are primarily data-driven intelligent applications and software. The success of the geospatial infrastructure, thus, depends on providing easy access to the available geospatial datasets. These datasets help the industry and the broader stakeholders to create interactive and analytical applications and value-added services.

STATE OF PLAY OF GEOSPATIAL KNOWLEDGE INFRASTRUCTURE IN THE NETHERLANDS

DATA ECOSYSTEM

A mature geospatial data ecosystem caters to users from multiple sectors by providing continuously updated fundamental geospatial data themes and knowledge at community, national, and global levels for efficient decision-making. The integration of geospatial data with diverse datasets, and the associated benefits, can be observed across multiple sectors in the Netherlands.



Source: Geospatial Media Analysis

A few examples of the social and economic benefits of integration of geospatial data with other datasets are given below:

→ In the Netherlands, anyone getting excavation work done has to register with the Land Registry to source information on cables and pipelines. The land registry provides both spatial and non-spatial data, which is further integrated to understand the subsurface infrastructure. The availability of accurate and authoritative information regarding cables and pipelines helps to avoid any breakages, thereby leading to cost savings.

→ The Netherlands Fire Service portal links nation-wide registries for address and buildings, which is inclusive of location information. This data is provided to firemen in the form of navigation directions to reach emergency locations on time, thereby saving many lives. The service can be further enhanced with the increased adoption and integration of indoor mapping data.

The transition to GKI will enhance adoption and integration of geospatial data across diverse sectors, leading to wide-ranging social and economic benefits. There are multiple sub-components within the data ecosystem that need to be streamlined in order to make geospatial data more accessible and beneficial for the users.

Data Collection and Integration

→ The Netherlands has taken significant steps to develop a mature data ecosystem. PDOK (Public Services on Maps), the National Spatial Data Infrastructure of the Netherlands, aggregates data from different government departments links them using globally accepted standards, and makes them, available for re-users. By following the 'build once-use multiple' approach, PDOK helps avoid data redundancy and reduces data collection costs.

→ The Netherlands ranks 5th in the Open Data Maturity Report of 2019, published by the European Data Portal, which assesses the level of open data maturity in the EU28 Member States. Geodata comprises the majority of the open data available on data portals in the Netherlands. Ninety percent of the data in these portals have open licenses and are available in structured machine-readable formats, whereas 50% to 60% of available data use Uniform Resource Identifiers (URI). Efforts are being made to link open and closed data using globally accepted standards.

→ In the first two decades of the 21st century, the focus of the Netherlands was on consolidating geospatial data and integrating it with non-spatial data, to make it available for use by public and private stakeholders. In the third decade of the 21st century, the focus of the government needs to be on realizing the potential of utilizing the widely available public and private geospatial data for the benefit of society. This will involve a transformation of the National Spatial Data Infrastructure platform from a public platform to a public-private platform, re-inventing the Spatial Data Infrastructure as a public-private platform, which facilitates easy exchange, integration, and analysis of data from diverse sources.

INTERNATIONAL CASE STUDY I

United States Geological Survey (USGS): Integration of Volunteered Geographic Information – Center of Excellence for Geospatial Information Science (CEGIS)

→ Research by CEGIS proves that participatory mapping projects produced data that are as accurate as those produced by national geospatial organizations.

→ There is added advantage over expensive accuracy testing by official agencies, in some instances because of unique local knowledge.

→ The National Map Corps is an online crowdsourcing mapping project with volunteers editing structures like schools, hospitals etc. across 50 states. Data contributed by volunteers was found to be sufficiently accurate to be integrated with the official national spatial databases.

→ CEGIS developed a crowdsourcing framework to guide the development of future crowdsourcing projects specifically for use in disaster management.

→ Research is being done to explore user motivations, changes to business models and institutional cultures, online community formation, policy barriers, etc.

Data Management

The national geospatial organizations in the Netherlands are also transitioning from being traditional data centers to cloud-based storage for the management of large amounts of Geospatial data. With the integration of geodata from businesses and citizens, the national geospatial organizations should expend more efforts in integrating blockchain technology for data storage in order to address privacy concerns arising from integration of diverse datasets.

INTERNATIONAL CASE STUDY II

Ordnance Survey: Streamlined Data Collection and Enhanced Data Management

- → Integration of Microsoft Azure cloud computing and ArcGIS Enterprise for process improvements.
- → Turned accurate record of change into meaningful information – predictive analysis to identify potential areas of change and allocation of data collection efforts (surveyors and aircrafts) accordingly.
- → Shifting to cloud storage enabled development of a new job management portal for sharing tools and capabilities with business partners to streamline and accelerate data editing, quality control and validation.
- → Forty percent cost reduction in end-to-end supply chain, from capturing data to making it available to customers.

Data Production and Processing

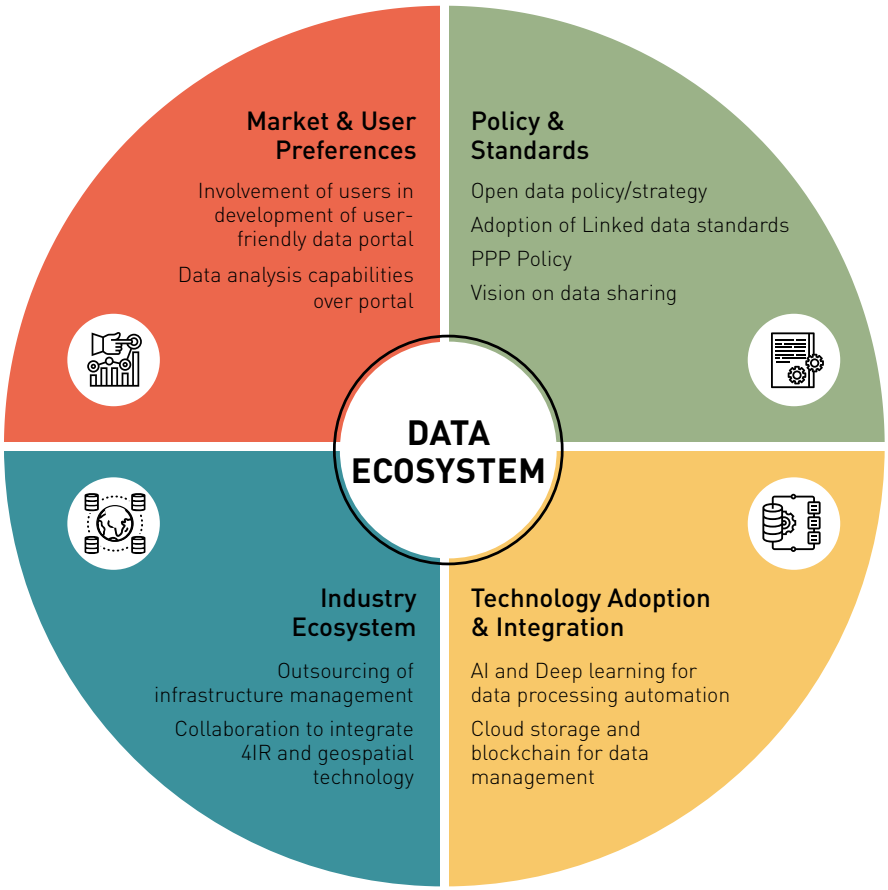
The Kadaster in the Netherlands was the first mapping authority in the world to fully automate the production of multi-scale maps using AI and deep learning, which in turn led to 5000% time savings compared to traditional cartographic methods for map production. The geodata available on PDOK and other portals are updated very frequently, but with the adoption of change detection using GeoAI and deep learning, real-time data update and dissemination can be made possible, and will also aid in integrating disparate datasets. The Kadaster, in collaboration with the Ministry of Interior and Kingdom Relations and SVB-BGT, is organizing a working group to act as a testing ground for change-detection of geospatial datasets.

Data Dissemination and Knowledge Creation

With the adoption of geospatial data across the wider digital ecosystem, it is ever more important to make Geospatial information accessible to non-experts. Efforts have to be made to offer sector-specific geospatial knowledge products, and to provide analytics capability over the PDOK portal. Geonovum has conducted a test bed to test the GeoDCAT-AP standards, which will help in making finding, accessing, and using Geospatial data easier for non-experts; such efforts have to be accelerated to enhance the adoption of geodata across the digital ecosystem. The re-invention of the Spatial Data Infrastructure as a public-private platform should also encompass supporting and incentivizing creation of knowledge (instead of just provision of data), thereby enhancing value addition to society.

POLICY AND STANDARDS: The integration of diverse geospatial data from different sources is aided by the implementation of the open data strategy and the adoption of globally accepted linked data standards. The vision of the Netherlands with respect to data sharing between businesses will further aid in the integration of geodata from businesses with the traditional data sources.

Allied Parameters of Geospatial Knowledge Infrastructure



Source: Geospatial Media Analysis

TECHNOLOGY ADOPTION AND INTEGRATION: The integration of diverse datasets is made easier with the use of AI and deep learning for automated processing of the datasets, which will in turn be updated on cloud-based servers to accommodate the large amount of data.

INDUSTRY ECOSYSTEM: The National Geospatial Organizations collaborate with private technology providers for the integration of Geospatial technology with 4IR technology. Kadaster collaborated with ESRI to integrate multi-scale mapping into its workflow, which in turn led to substantial time-savings. Kadaster is also collaborating with IT companies to outsource the management of geographic applications and IT infrastructure, so they can divert their focus to more pressing matters like increasing the accessibility of Geospatial information.

MARKETS AND USER PREFERENCES: A study by TU Delft shows re-users of Geospatial data would like to be involved in the development of data portals in order to make them more user-friendly. Efforts are also underway to convert Geospatial data into formats that can be picked up by search engines over the web, thereby making geodata more accessible to non-experts.

INTERNATIONAL CASE STUDY III

Swedish National Center for Applied Artificial Intelligence: AI Sweden

- → Accelerate use of AI for the benefit of society by running projects of national interest in areas like information-driven healthcare, autonomous vehicles, climate change, etc.
- → Foster a culture of sharing, cooperation, and action in the Swedish AI ecosystem through collaborative projects with 80 partners.
- → Data Factory – set up by AI Sweden to provide technological infrastructure, datasets, legal framework, user interface, etc., to enable partners to share datasets, conduct research and develop solutions, run pilot projects, etc.
- → Validation of Mapping and Localization of Autonomous Vehicles (VAMLAV) to collect map data using dashcams, LiDAR and RADAR, and update HD maps.
- → Space Data Lab – regularly updated satellite imagery for developing applications like removal of clouds from satellite images, use in thematic areas like spatial planning, forest and vegetation monitoring, water monitoring, etc.

INTERNATIONAL CASE STUDY IV

Singapore Land Authority: GeoWorks

- → Southeast Asia's first geospatial industry center to foster a vibrant geospatial ecosystem.
- → Bring together geospatial businesses to promote business growth, drive innovation, and build a diverse well-connected geospatial community.
- → Under GeoWorks' GeoInnovation Program, house over 25 local and international geospatial startups and scale-ups from different industry segments.
- → GeoChallenges – key initiative that matches solution providers with sectoral users looking to solve their geospatial issues through joint innovation projects.

The changes across all these parameters have to be held together by a common vision of innovation of the geospatial and integrated digital ecosystems. The geospatial industry needs to ride the wave of the 4th Industrial Revolution (4IR) and integrate the developments in 4IR technology. In order to transition to a demand-driven approach, it is important to change the geo-centric point of view and identify ways in which an integrated geospatial digital ecosystem can solve current socio-economic challenges. The national geospatial organizations play an important role in fostering innovation by promoting protected spaces and providing financial incentives. They also enhance adoption of geospatial solutions by developing a platform for linking solution providers to prospective users across sectors.

DIGITAL TWIN AND GEOSPATIAL INFRASTRUCTURE

DIGITAL TWIN: THE DEFINITION

The 4th Industrial Age embraces automation, data interoperability, data exchange, and manufacturing technologies. Digital Twin technology lies at the core of this new industrial revolution. A Digital Twin is a virtual replica of a physical asset, process or service. The pairing of the digital and physical entities allows for easy analysis of data and simulations that can help ward off problems even before they occur and allow for future planning. The Digital Twin concept cuts across various economic sectors, changing traditional approaches to design in the industrial world and bringing in a more virtual system-based design process. The implementation of Digital Twin helps organizations derive better insights, improve product performance, and enhance operational and strategic decisions.

DIGITAL TWIN: APPLICATION AND PURPOSE

Digital Twinning is used across various sectors — ranging from manufacturing, healthcare, automobile, retail, public safety, digital cities (smart cities), architecture, engineering and construction to Industrial IoT, among many others. Using varied sensors (internet of everything), cognitive tools and technologies, artificial intelligence, and analytics, digital twin solutions make digital simulations or twins to improve product design and services. In addition, Digital Twin models across these sectors remove uncertainties, errors, silos, and inefficiencies.

PURPOSE AND GEOSPATIAL DATA USE FOR DIGITAL TWIN IN VARIOUS ECONOMIC SECTORS

MANUFACTURING AND INDUSTRIAL FIRMS

Purpose

- Optimizes manufacturing and makes it more efficient, while reducing the throughput times. Also reduces maintenance issues and ensures optimal production output.
- Industrial firms with Digital Twin implementation can now monitor, track and control industrial systems digitally. Digital Twin in industrial firms help predict future operations and reveal anomalies.

Geospatial technology use: BIM, Drones, Indoor Positioning Systems, IoT Sensors, Robotics, and Scanners

Example: General Electric Co. (GE) was an early adopter of this technology. GE was able to improve one customer's reliability from 93% to 99.49% in less than two years and cut reactive maintenance by 40% in just one year. A Digital Twin also saved another customer USD 360,000 by accurately predicting a power outage.

SMART CITIES

Purpose

- Enhances economic development, efficient management of resources, reduction of ecological footprint, and increases the overall quality of a citizen's life.
- Helps city planners and policymakers involved in smart city planning to gain insights from various sensor networks and intelligent systems.

Geospatial technology use: : BIM, Drones, GIS and Spatial Analytics, GNSS and Positioning Systems, Indoor Positioning Systems, LiDAR, IoT Sensors, Robotics, Scanners, Immersive Solutions, Artificial Intelligence, and Location Technology.

Example: As part of its Digital City mission, the Dutch city of Rotterdam created a Digital Twin by using existing city maps, structured and textured 3D data from LiDAR, blueprints of buildings and transport networks, and real-time sensors. Using Digital Twin technology, the team was able to capture models for 205,000 buildings in one-fifth the time compared to traditional methods.

PUBLIC SAFETY AND CITIZEN SERVICES

Purpose

- Helps provide real-time information to safety organizations and professionals to address challenges and use predictive analysis to develop unsafe scenario simulations and plan accordingly.
- Helps citizens and decision-makers take decisions on the basis of 3D models and virtual experiences for smart decision-making

Geospatial technology use: Indoor Positioning Systems, IoT Sensors, GIS, Location Intelligence, and Spatial Data.

Examples: Rennes Metropole in France has developed a digital 3D model covering the city's entire territory. This online model is used in various ways for collaborative urban planning, by including citizens in the process, and for urban development purposes such as sunshine simulation, noise modeling, tree shadow impact on buildings, and for developing applications to be used by frontline emergency and safety workers - including police, service, and healthcare professionals.

RETAIL

Purpose

- Enables customer experience in the retail sector by creating 'store' virtual twins for customers, providing them with in-store experience digitally and in real-time.
- Enables better in-store planning, security implementation, and energy management in an optimized manner.

Geospatial technology use: BIM, Drones, Indoor Positioning Systems, IoT Sensors, Robotics and Scanners, Augmented Reality and Virtual Reality, and Artificial Intelligence.

Example: Dematic has recently released a product that lets users explore a distribution centre environment before it is built, to look at factors such as labor productivity, inventory movement and the effectiveness of material handling.

HEALTHCARE

Purpose

- Plays a key role in the health sector — from cost savings to patient monitoring, and preventive maintenance to providing personalized health care services.
- Allows surgeons and health professionals to practice procedures in a simulated environment rather than on a real patient.

Geospatial technology used: IoT, AI, and Digital Data

Example: Hamilton Health Sciences measured a 900% improvement in cost savings after implementing Digital Twin technology to remove problems in patient flow.

AUTOMOBILE

Purpose

- Can be used in the automobile sector for creating the virtual model of a connected vehicle — one that is equipped with internet connectivity and can communicate with other devices and systems outside and inside the vehicle.
- Captures the behavioral and operational data of the vehicle and helps analyze the overall vehicle performance as well as connected features.

Geospatial technology use: IoT Sensors, Spatial Data (of street view), Aerial Imagery, Drones, and GNSS and Positioning Systems

Example: Nokia has developed state-of-the-art innovations – Nokia Wing and IMPACT Auto — aimed at helping automobile organizations use 5G, IoT Sensors and Digital Twin solutions to develop the connected car of tomorrow.

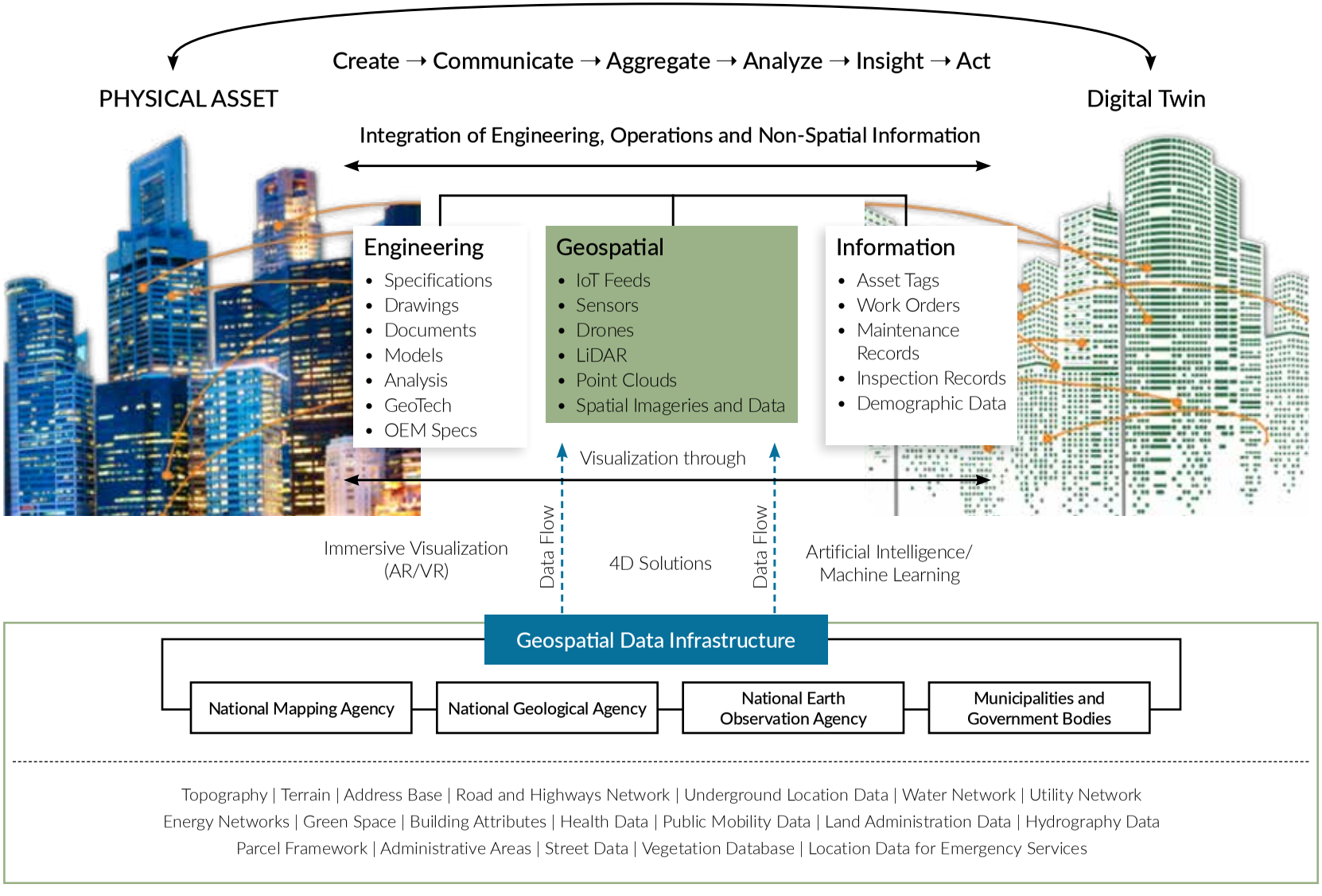
GEOSPATIAL INFRASTRUCTURE FOR BUILDING DIGITAL TWIN OF A CITY

Geospatial infrastructure serves as the foundation of the digital infrastructure and Digital Twin leading to greater demand for authoritative, accurate, updated and accessible data platforms. Geospatial infrastructure is primarily the responsibility of national geospatial organizations (national mapping agencies, survey organizations, geological agencies, earth observation agencies, etc.) who in the 4th industrial age have a critical role to play in reinforcing Digital Twin in varied economic sectors. Geospatial data inclusive of both above and below surface facilitated and provided in real-time by national geospatial organizations, results in a continuously updated Digital Twin i.e., a systems-of-systems unit which is accessible anytime from anywhere by all stakeholders involved in the twin ecosystem.

To build a Digital Twin of a city, a large-scale base map, topography and terrain data, a complete map of underground networks of cables and pipes, map of transport networks and buildings, precise positioning data from GNSS systems and IoT sensors (for health and emergency services), spatial data maintained by municipalities and city departments along with non-spatial content such as zoning regulations and laws, emergency services contact information, etc., needs to be available and usable. Additionally, the Digital Twin is often produced by latest modelling technologies and applications such as standard-based semantic city information model and a reality mesh model. Thus, to build a viable Digital Twin, a geospatial data infrastructure is responsible to provide the following:

→ Reliable, continuously updated, and maintained datasets for both above-the-surface and sub-surface infrastructure as per attributes mentioned above,
→ Database have to be easily accessible and usable; data interoperability and data standards have to be maintained,
→ Spatial datasets should be present as intelligent and semantic-rich data based on open standards, and
→ Datasets should be centralized as per the requirement of the Digital Twin – presenting all information in 3D.

ROLE OF GEOSPATIAL DATA INFRASTRUCTURE IN DIGITAL TWIN



To build a Digital Twin of the various economic sectors, cities, and even nationally, a strong geospatial data infrastructure is of importance. Subsequent investments have to be made particularly in building, strengthening the geospatial data infrastructure including organizations who are responsible for managing, processing, and automating the core geospatial data for both above and below the surface infrastructure assets. Thus, without authenticated data from geospatial data infrastructure, building a digital twin of cities for public safety and citizen services, for health and governance, for transport infrastructure networks, among many other things, is an incomplete process.

RETURN ON INVESTMENTS ON GEOSPATIAL INFRASTRUCTURE AND ITS IMPACT ON DIGITAL TWIN

To understand the present use of geospatial technologies in Digital Twin ecosystem globally, Geospatial Media studied the best Digital Twin case studies from different regions of the world. At present, most of the Digital Twin models are focussed on city development & infrastructure management including, traffic management, urban planning, environmental planning, resilient infrastructure development etc., It is noteworthy, that the foundational data for all the many Digital Twin of cities such as Singapore, Helsinki, Palo Alto, among others has been provided by national geospatial data infrastructure of each country.

3D SMART NATION PROGRAM – SINGAPORE
GEOSPATIAL ORGANIZATION: SINGAPORE LAND AUTHORITY
INVESTMENT: SGD 73 MILLION

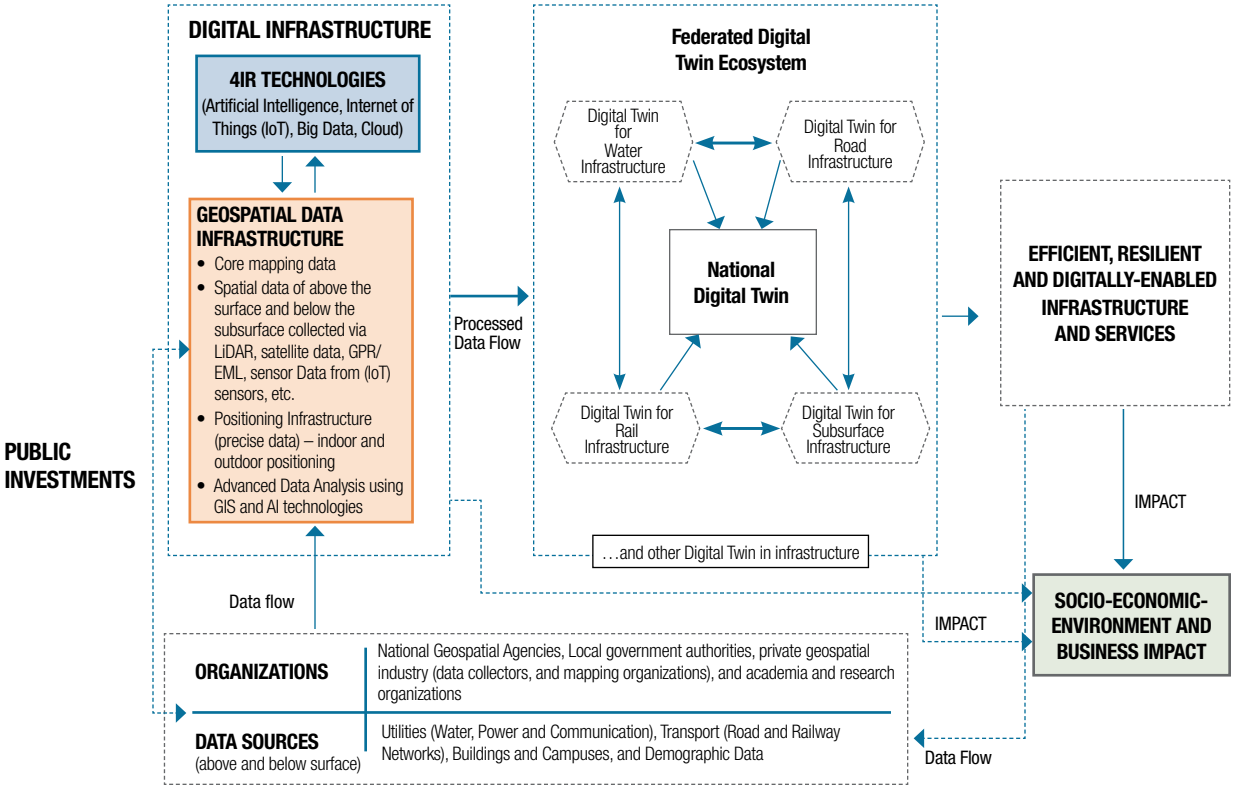
Singapore launched the Virtual Singapore (or Singapore's Digital Twin) project to develop a data-rich, a live digital replica of the actual city. Established under the Smart Nation initiative, the National Research Foundation provided funding of **SGD 73 million to Singapore Land Authority for data and to GovTech for technology development**. SLA provided geospatial, topographical, topological, analytical, semantic, real-time and legacy data for the project. Qualitatively, the investments in spatial data for building the Digtial Twin model – the 3D Smart Nation, enabled the citizens of Singapore to leverage advanced digital technologies to deliver seamless and secure citizen-centric services efficiently. **The investment in SLA's data hub resulted in net benefits of over SGD 550 million and saved approximately SGD 20 million in costs in operations and maintenance**. Qualitatively, the new investments also:

- → Enabled users and city leaders to run simulations of everything from population growth to public events to natural disasters to determine the best response
- → Enhanced the creation of digital twin models to capture the impact of infrastructure changes on traffic, pollution, population density, and more.

DIGITAL CITY HELSINKI (HELSINKI 3D+)
CLIENT: MUNICIPALITY OF HELSINKI
GEOSPATIAL ORGANIZATION: NATIONAL LAND SURVEY OF FINLAND

The National Land Survey of Finland provided vector data of city attributes; and aerial imageries to help create Digital Twin for the city of Helsinki and to provide a virtual platform for the experiments that are part of the future development. Considerable investments were made to strengthen the geospatial data infrastructure of Finland to build the 3D model of the built environment, the **benefits of which included a 10% monetary savings on the total cost of the operations**. Impact of investing in geospatial infrastructure for Digital Twin resulted in collaboration across all multiple functions of the city providing strategic value to decision making, for development of regulation compliance and municipal asset management.

BUILDING A NATIONAL DIGITAL TWIN



A federated and connected ecosystem of multiple Digital Twin forms a National Digital Twin of a county. As geospatial data is critical for building Digital Twin of cities, and infrastructure assets (as established above), the role of geospatial data in building a National Digital Twin is even more crucial. In this context, the role of geospatial infrastructure organizations in the country is very important because they are the sole custodians of high-resolution, accurate, reliable, secure, continuously updated spatial information which is necessary to create a dynamic National Digital Twin. New public investments in geospatial data infrastructure – particularly in adopting innovative ways to collect the data; and in 4IR technologies is the need of the hour.

One of the best examples is that of the United Kingdom (UK), wherein the Cambridge Centre for Digital Built Britain is running a program called the National Digital Built Britain Programme. **The programme is aimed at building a National Digital Twin of the UK, expected to generate benefits worth GBP 7 billion per year for the country, improving day-to-day life, the economy, the business world, and the environment**. Thus, the use of real-time geospatial data supported by 4IR technologies in the National Digital Twin ecosystem increases efficiency, generates high economic values, and facilitates better decision making for maintaining the social-economic-and environment continuum.

THE NETHERLANDS GEOSPATIAL INDUSTRY ECOSYSTEM

KEY HIGHLIGHTS

EUR 1.05B
Domestic Geospatial Market of the Netherlands

Services
Dominating the Netherlands Geospatial Industry

Artificial Intelligence
Technologies Driving Geospatial Industry

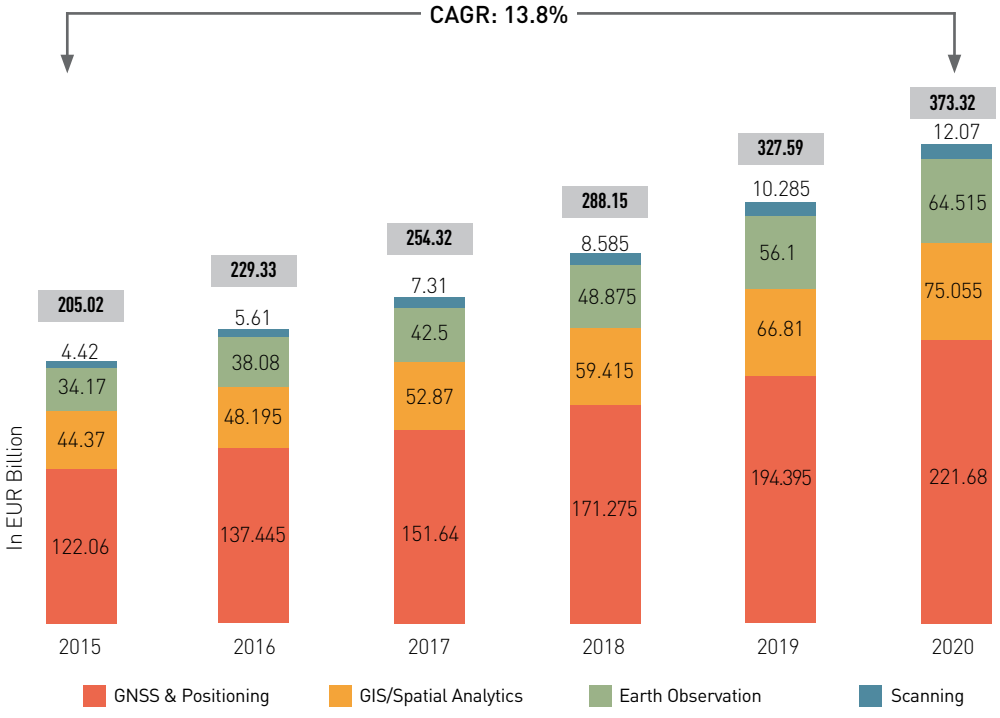
Infrastructure
Highest sectoral focus for Domestic Technology providers

X-As- A-Service
The most preferred revenue model

OVERVIEW

The geospatial industry has grown over the years to keep pace with other developments in the digital era, evolving from analog models to the digital models of today. The geospatial industry is among one of the fastest growing industries globally and is at the forefront in bringing about major socio-economic transformation across all user sectors such as infrastructure and engineering, utilities, and agriculture. Worldwide, the geospatial market is growing at an exponential rate due to increasing integration with other allied technologies (BIM, CAD, sensors, etc.). This has raised the demand for geospatial-based derivative products (value-added services), accelerated technology innovation, created new business models and increased sectoral engagements. In this context, the cumulative global geospatial industry in 2019 was worth EUR 327.5 billion and was estimated to grow at a CAGR of 13.8% to EUR 373.32 billion in 2020 (pre-COVID).

Graph 3 - Geospatial Technologies: Global Market Size



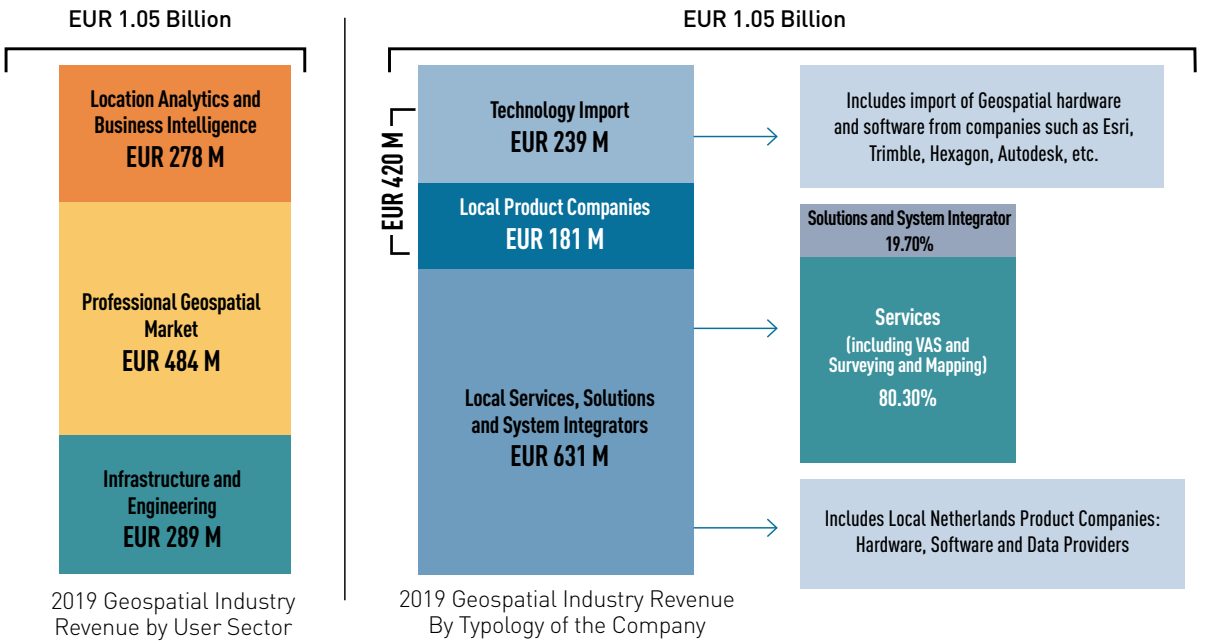
Source: Geospatial Media Analysis; Geobuiz Report-2018

In 2019, the European region's geospatial market was worth EUR 76.32 billion, that is, nearly 23.3% of the total global geospatial market. The key drivers for the market in the region are the accelerating use of integrated geospatial technologies for workflow management, strategic investments in new technology infrastructure for Digital Twin and automation, and the transformational shift of the geospatial ecosystem towards innovating, developing and utilizing geospatial-based derivative products (value-added services) across different sectors.

GEOSPATIAL TECHNOLOGIES MARKET

The cumulative market size of the Netherlands' geospatial commercial industry market in 2019 was estimated to be EUR 1.05 billion. Of the total revenue, the geospatial market for the professional geospatial or traditional user sectors (inclusive of agriculture, natural resources, forestry, oil, gas and energy) was found to be the highest, that is, EUR 484 million. This was followed by the infrastructure and engineering sector; the geospatial market for this was estimated to be EUR 289 million. The infrastructure and engineering sector, which is otherwise known to be a laggard in digitalization, has a significantly higher percentage share (27.5%) of the total geospatial market. This is because of the innovative and collaborative approach taken by many municipalities in the country to adopt the 'digital twin' approach in their workflows for urban development and infrastructure planning. A case in point is the city of Rotterdam, which is developing a 'Digital City Rotterdam' using 3D geospatial solutions and integrating them with BIM and IoT sensors to improve the efficiency of urban planning and management. The municipalities of Amsterdam, Utrecht, Hague, and Delft in the Netherlands are also increasingly adopting geospatial technologies to streamline their workflows for efficient management of their cities.

Graph 4 - Geospatial Technologies: The Netherlands Market Size 2019



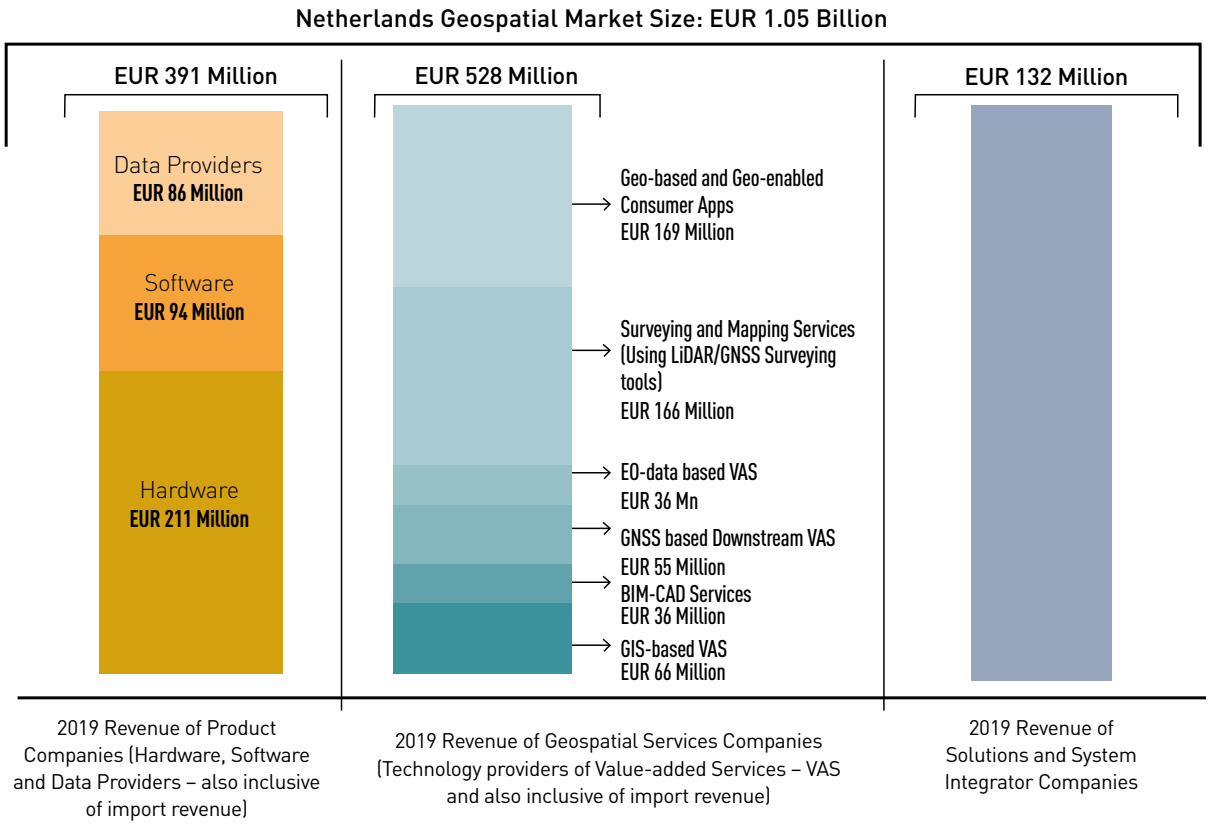
Professional Geospatial Market: Agriculture, Forestry, Natural Resources, Forestry and Oil, Gas and Energy
Product Companies: Hardware, Software and Data Providers

Source: Geospatial Media Analysis; Market Analysis Methodology available in the Appendix

The location analytics and business intelligence sectors, largely driven by consumer digital maps and real-time 'location intelligence', encompass all non-traditional sectors such as banking, finance and insurance, retail, supply chain and logistics, healthcare, and marketing and advertising; they have a market share of EUR 278 million. It is in these segments, particularly, that the majority of the revenue, that is, up to 60.6% of the revenue, is generated from geo-based and geo-enabled applications such as Uber, Deliveroo.nl, DigiD, Thuisbezord.nl, Marktplaats – koop en verkoop, etc. Furthermore, the Netherlands is the innovation ground for two of the leading location technology and consumer service providers, namely TomTom and HERE; the sum of the domestic revenue for both was estimated to be approximately EUR 40 million in 2019 for the location analytics and business intelligence sector; and EUR 20 million for the professional geospatial user sector.

Furthermore, of the total domestic revenue of EUR 1.05 billion in 2019, up to EUR 239 million is estimated to be import revenue. The import revenue comes in from the subsidiaries, resellers, suppliers and distributors of the leading global geospatial technology providers such as Trimble, Esri, Autodesk, Hexagon, Nvidia, Oracle Spatial, Bentley Systems, among others. On the other hand, EUR 181 million of the revenue comes from domestic technology product companies, that is, companies that innovate, develop and produce hardware, software and data domestically. In this context, while the total market for the product companies (inclusive of the import sector) is EUR 391 million, the actual import revenue is EUR 209.5 million.

Graph 5 - Geospatial Technologies: The Netherlands Market Size by Service Offerings 2019



Source: Geospatial Media Analysis; Market Analysis Methodology available in the Appendix

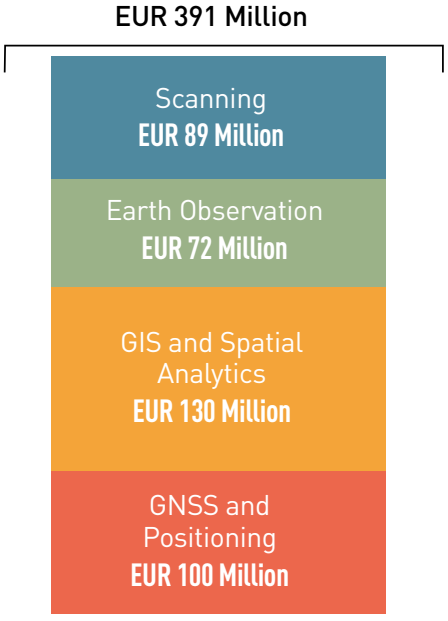
In the Netherlands the market for geospatial hardware is found to be the highest, at EUR 211 million. The reason for this is that the geospatial industry in the Netherlands is service-oriented, especially since many sole proprietorship and micro companies offer surveying and mapping services to the domestic market. To provide these services, the companies require geospatial hardware equipment, which results in an increase in the total market share in the technology product category (hardware, software and data providers). The domestic market of hardware solutions includes drone/UAV hardware manufactures, satellite payload manufacturers, and GNSS chipset and GNSS receivers' manufacturers. Most of this hardware is imported from leading Geospatial technology providers who are leaders in the field, such as, Leica Geosystems (Hexagon), FARO, Trimble, and Topcon Positioning Inc, thus, ensuring that the hardware segment has the largest share of the geospatial market. Strategically, the geospatial hardware market is a B2B market.

Further, the Netherlands' market for geospatial software is estimated to be EUR 94 million and for data providers it is estimated to be EUR 86 million. There are not many geospatial software companies in the Netherlands – most, including the likes of Esri, Oracle Spatial, Autodesk, Bentley Systems, Nvidia, SuperMap GIS, etc., are from outside the country. Also, there are not many domestic innovations happening in the software domain and most of the software revenue is import revenue.

The technology and market growth trends of the Netherlands' Geospatial industry ecosystem are in line with the global geospatial industry trends. With a market share of almost 50.2%, that is, EUR 528 million, most of the domestic companies are focused on providing geospatial services as derivative products/ applications, surveying and mapping services, or geo-based and geo-enabled consumer applications. In this context, the cumulative market share of geo-based and geo-enabled consumer services is the highest, with EUR 169 million, followed by the geospatial market of service companies providing surveying and mapping facilities to the larger user ecosystem, that is, EUR 166 million.

Mostly, these service companies are either sole proprietorships or micro companies, employing two to ten people. However, since the Netherlands' economy is heavy on construction, urban planning, infrastructure development (transport and water), and oil, gas and energy, the services companies play a critical role in streamlining the surveying processes.

There are many other small companies that provide value-added services (or derivative products). Many sole proprietors and MSME's leverage the available spatial data and solutions to create value-added services upon existing geospatial software and tools . The total market of these value-added services for 2019 was estimated to be EUR 193 million, with GIS-based value-added services having the highest market share of approx. 34%, that is, EUR 66 million as many of the small companies and sometimes even government users utilize Esri's software, or SuperMap GIS's software to create value-added services respectively. The geospatial market of solutions and system integrator companies such as Arcadis, Royal HaskoningDHV, Antea Group, etc., was estimated to be EUR 132 million in 2019.



2019 Revenue by Geospatial Technology Segment (inclusive of Import Revenue)

Source: Geospatial Media Analysis; Market Analysis Methodology available in the Appendix

Lastly, the geospatial market for product companies (including import) is estimated to be EUR 391 million. The largest market revenues come from the GIS and Spatial Analytics segment, to the tune of EUR 130 million. This is followed by GNSS and Positioning, at EUR 100 million.

The geospatial market in the Netherlands is thus significant, even though it is service-oriented instead of being product (hardware, software and data providers) oriented. In this context, the market for geospatial technology and solutions also have a critical role to play in the economy – especially when the contribution of geospatial companies to the country's export revenues is taken into consideration, along with the potential employment opportunities provided by geospatial industry in the Netherlands.

The Netherlands Geospatial Industry: Trends And Directions

The 4th Industrial Age has brought with it constant disruptions. The geospatial industry is at a critical point as the 'where' dimension has become fundamental to numerous industries in both the traditional and non-traditional sectors of the economy. From Digital Twin to automation, artificial intelligence, machine learning, edge computing, immersive solutions, and customized geo-based and geo-enabled applications – the speed with which these new technologies are emerging is making traditional business practices irrelevant. These constant disruptions in the geospatial technology ecosystem bring opportunities as well as challenges, making it necessary for countries such as the Netherlands to create geospatial infrastructure and put together an enabling policy framework that will organize, manage and adapt to these disruptions.

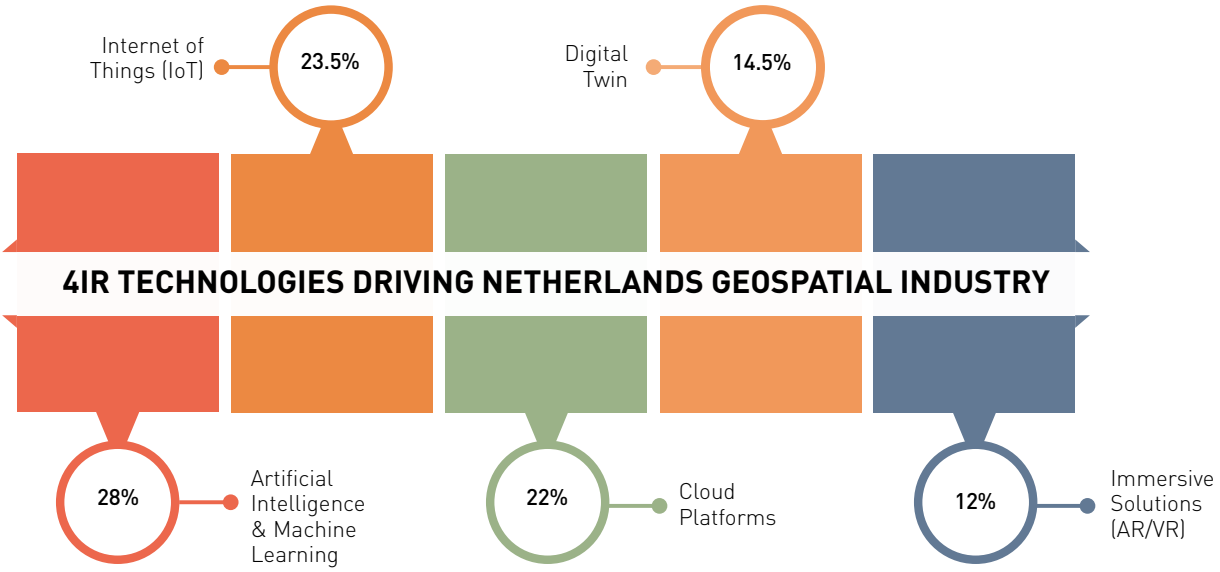
To understand the direction in which the Netherlands' heospatial industry is moving, Geospatial Media conducted a survey based on one-on-one interviews with senior officials representing almost forty companies operating in the country. The results of the survey are presented below:

TECHNOLOGY DISRUPTION:

The geospatial industry's reach and contribution to the overall economy is significantly rising due to the growing digital infrastructure ecosystem. In the Netherlands, just like in any other country, the future of the geospatial industry is largely dependent on how geospatial and frontier technologies such as Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT), among others, are able to enable and augment each other. Approximately 28% of the stakeholders who responded to the survey from the Netherlands are of the opinion that AI and ML, followed by IoT, is going to be the big game changer for the Netherlands geospatial industry going forward. Since, the geospatial industry primarily deals with huge volumes of data, AI and ML are critical tools to process and derive insights from the huge repositories of structured and unstructured data.

Furthermore, IoT sensors create a network of GPS receivers, making it possible to share and distribute accurate positioning in real-time. The data collected by IoT sensors, when used in conjunction with GIS, provides analytical insights for diverse sectors, such as, urban planning, smart vehicle and traffic management, infrastructure development (inclusive of smart cities), among others. With the Netherlands' government aiming to become a smart nation soon, the disruptions brought by IoT are critical for the growth of the geospatial industry ecosystem. IoT also lies at the heart of the digital twin's technology, which is globally recognized as one of the dominant technologies of the future.

Graph 6 - Technology Trends Driving the Netherlands Geospatial Industry



Source: Geospatial Media Analysis; User Survey Results

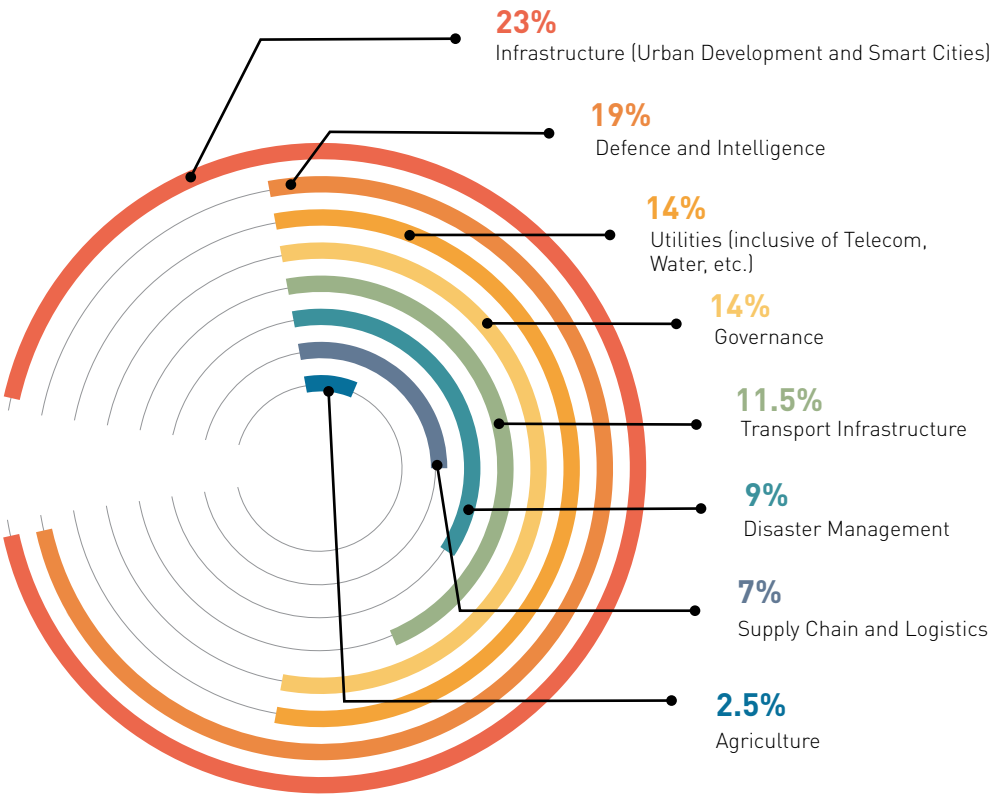
PRIORITY USER SECTORS

In the Netherlands, the use of geospatial information and technology is still highly driven by archetypal sectors like defense and internal security, urban development, infrastructure, disaster management, governance, among others. While the penetration of geospatial technologies and solutions in sectors such as media and advertising, retail, supply chain and logistics, and travel and tourism is expanding, the infrastructure sector is still a priority for the domestic geospatial industry.

With the strategic focus of the Netherlands government on urban development, smart cities initiatives and transport infrastructure projects, the infrastructure sector as a whole is the priority for most of the domestic technology providers. With smart cities projects worth EUR 125+ million (NEXT-Buildings, Triangulum, E2REBUILD, City-Zen, Amsterdam Smart City, etc.) and transport infrastructure projects worth EUR 2.9 billion (ARCADE, InterCor, Connekt-ITS, Delta Programme, and Trans-European Transport Network (Ten-T)) emphasizing the use of geospatial technology and solutions, the geospatial industry finds the infrastructure sector to be of topmost priority. In this sector, the government is focusing extensively on the use of digital technologies, along with geospatial technologies, to create more effective collaboration models that will help accelerate the development of infrastructure projects.

The Netherlands infrastructure sector is, thus, investing heavily in IoT solutions, sensor technologies, integrated geospatial and BIM (GEOBIM) solutions, and AI. Furthermore, since the majority of the geospatial companies in the Netherlands are service-oriented, the percentage of companies providing surveying and mapping facilities (using LiDAR and RADAR solutions) for the infrastructure sector is significantly higher.

Graph 7 - Priority User Sectors for the Netherlands Geospatial Industry



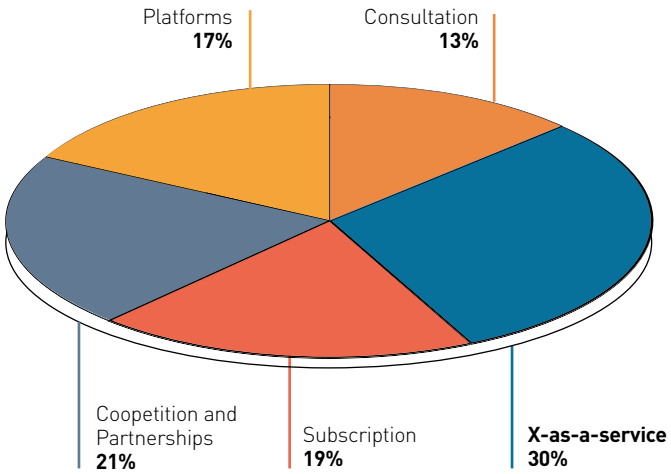
Source: Geospatial Media Analysis; User Survey Results

Apart from infrastructure, and defense and intelligence, the other critical sector that continues to be of importance to the Netherlands government and national geospatial organizations is the utilities sector. To accommodate the rapidly increasing numbers of utility networks both above and mostly underground (buried utilities), the infrastructure in various cities needs to use space efficiently to plan the development of public utility networks, especially in densely populated areas. The use of geospatial technologies, particularly ground penetrating radars (GPR), electro-magnetic locators (EML), LiDAR and other surveying tools is found to be critical for the utilities sector. Apart from small companies providing services to the utility sector, Fugro, one of the leading geotechnical service providers in the Netherlands, provides a comprehensive range of survey options to map utilities (above and below the ground), helping stakeholders plan their projects with ease and reduced risk.

BUSINESS MODEL TRANSFORMATION

The stakeholders operating in the domestic geospatial industry ecosystem have transitioned from preferring the coopetition and partnership business model to the X-as-a-service business model. Since the domestic geospatial industry is service-oriented, with a market share of EUR 528 million, the majority of the companies offer value-added services to the end consumers. Most of the MSMEs understand that the consumers do not require 'raw data' but a complete consumer-centric service. In this context, up to 30% of the companies responding to the survey prefer X-as-a-Service business model for the future. Most of the domestic companies in the Netherlands are including data-as-a-service, analytics-as-a-service, and cloud-as-a-service, to their portfolios to reach out to newer segments.

Graph 8 - Preferred Business Model by the Netherlands Geospatial Industry



Source: Geospatial Media Analysis; User Survey Results

The second business model that is most preferred by the Netherlands geospatial industries is coopetition and partnerships. Increasingly large numbers of companies are looking at entering into strategic partnerships to deliver customized solutions to their customers and to enter new markets, customer segments and regions. Approximately 21% of the companies that responded to the survey in the Netherlands prefer the coopetition and partnerships business model in comparison to others.

Finally, approximately 19% of the respondent companies still prefer the traditional business model of subscription/ pay per use, which has been prevalent in the industry for the past few years. This business model enables users to 'subscribe' to or 'pay-per-use' for software, hardware, data or analysis, by essentially paying a small subscription fee. This business model does not require huge investments from the businesses and can be upgraded at a low cost. Therefore, it is still preferred by a significant number of stakeholders to capture new consumer segments.

GEOSPATIAL - HUMAN RESOURCE LANDSCAPE

KEY HIGHLIGHTS

80,700
Number of people employed

Engineering
Core education background

Survey Engineering
Specialization of employees

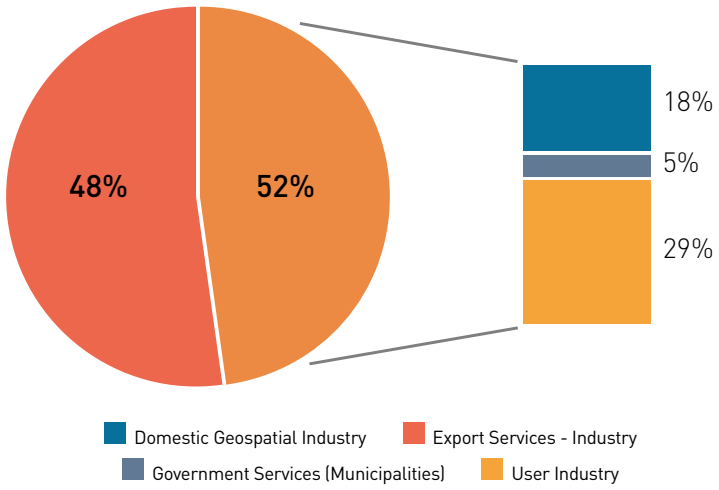
TU Delft
University from where maximum number of employees are educated

GIS and Spatial Analytics
Expertise of Employees

Overview

The Netherlands geospatial industry employs about 80,000 people across the country who specialize in geospatial and geospatial associated technologies. Of these, 14,520 people or approximately 18% of the people are employed in the domestic geospatial industry (product, service, and solution and system integrator companies); 4,030 people or approximately 5% are employed across 355 municipalities; 23,550 people or 29.2% are employed in the user sectors (construction, agriculture, banking, finance and insurance, oil, gas and energy, supply chain and logistics, etc.); and 38,600 people or approximately 48% are appointed outside by the subsidiaries of the companies originating from the Netherlands (inclusive of service companies like Fugro and data provider companies like TomTom and HERE).

Graph 9 - Human Resource Landscape in the Netherlands Geospatial Economy



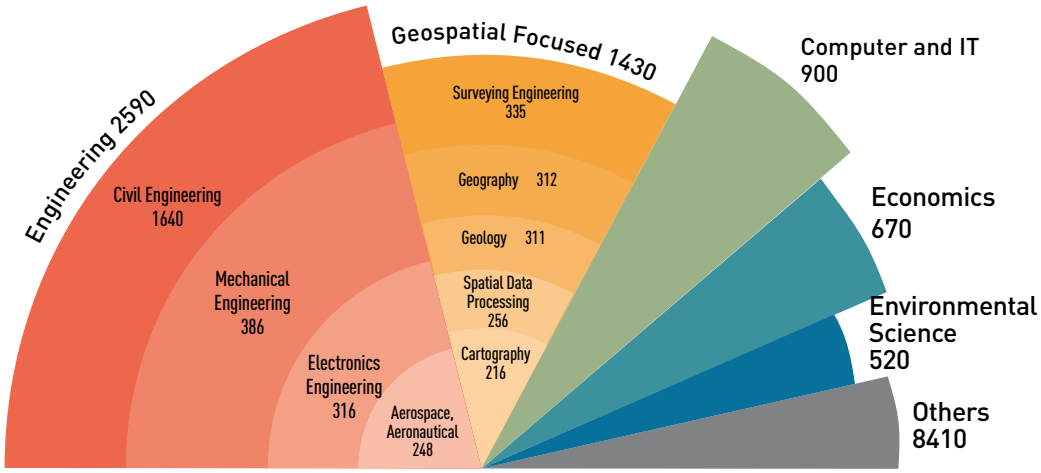
Source: Geospatial Media Analysis; Linkedin Employee Data Analysis

EMPLOYEE EDUCATION

An assessment of the domestic geospatial industry (14,520 employees) from the human resources point of view revealed that about 18% of the employees or 2,590 people, had an educational background in engineering. Another 9.99% or 1,430 people had done geospatial and related courses, while 6.2% or 900 people came with a computer and information technology background.

In terms of education in different disciplines related to geospatial, it was found that of the 1,430 employees who had done geospatial related courses, 335 people had studied surveying and engineering while 623 had

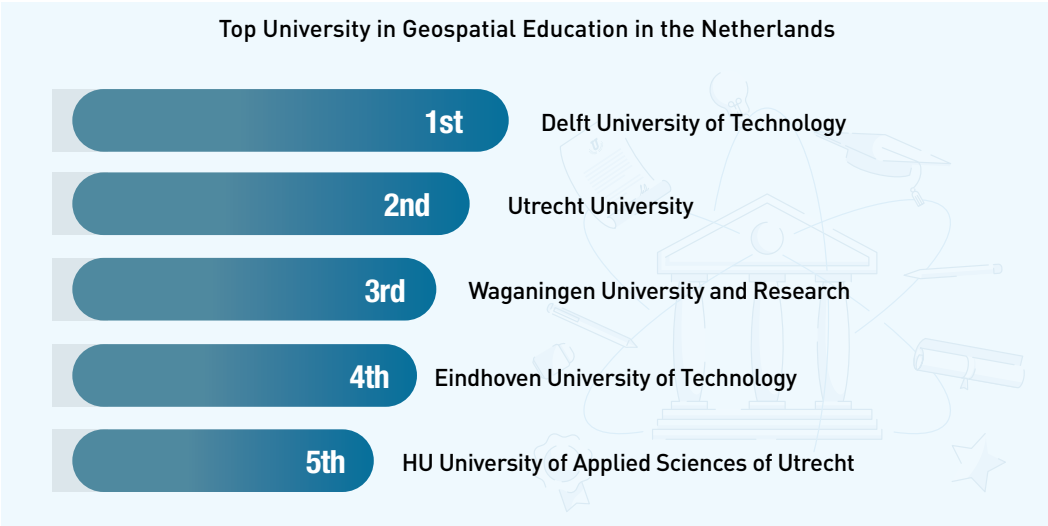
Graph 10 - Education Background of Geospatial Professionals in the Netherlands



Source: Geospatial Media Analysis/Linkedin Employee Data Analysis

received an education in geology/earth sciences and geography. Of the 2590 who had studied engineering, the majority had opted for civil engineering and are employed in the domestic services market.

In addition to understanding the education background of the geospatial industry employees, Geospatial Media also conducted an analysis of the top universities in Netherlands from where geospatial professionals are hired within the industry ecosystem. The assessment of the employee education profile showed that a majority of the geospatial professionals studied at the Technische Universiteit Delft (TU Delft) or the Delft University of Technology based in Delft. TU Delft offers core courses in the geospatial sector focused around fundamental geospatial themes – locational awareness, sensing technologies, GIS and cartography and 3D modeling, Digital Terrain Modeling (DTM), photogrammetry and 3D computer vision, geomatics, geoscience and remote sensing, and geo-datasets and database management, among many others. Furthermore, TU Delft offers geospatial diploma and certificates in application-oriented courses such as urban planning and management, city planning, disaster management, etc.



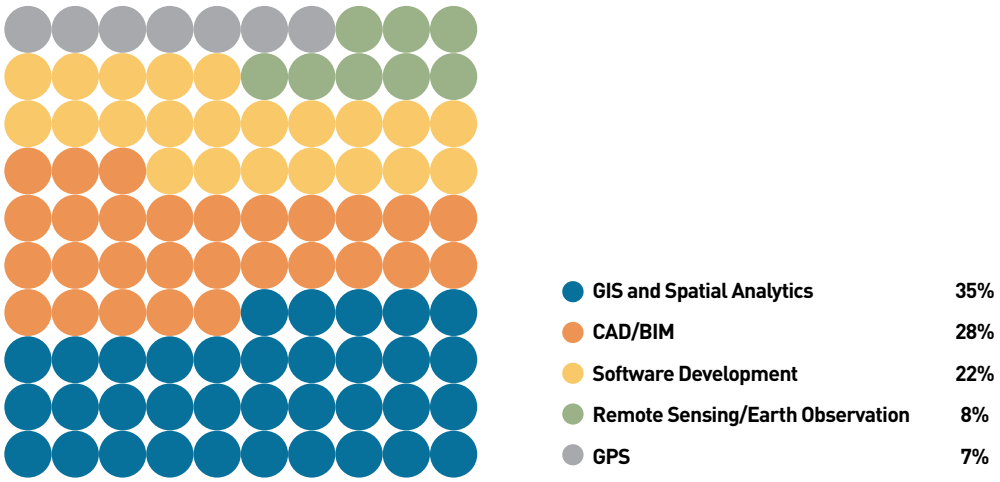
Source: Geospatial Media Analysis; Linkedin Employee Data Analysis

The other universities from where geospatial professionals are mostly hired from include Utrecht University, Wageningen University and Research, Eindhoven University of Technology, HU University of Applied Sciences of Utrecht, and University of Twente (ITC).

EMPLOYEE SKILLS

Whilst the majority of geospatial professionals have a background in engineering, geospatial, IT and other vertical studies such as urban planning, water resource management, transport infrastructure, aeronautical engineering, etc., up to 52% of the total employees in the industry ecosystem, that is, 7,550 people, have geospatial skills and capabilities. These skills were enhanced and developed either as part of the graduate and master programs, via diploma or certificate courses, or through on-the-job learning. Of these 7,550 employees, approximately 2,180 were found to be skilled in GIS tools and software, specifically in ArcGIS, ERDAS, etc. Further, since significant number of employees are educated in civil engineering – up to 1,790 employees are skilled in CAD/BIM software, which is today integrated heavily with GIS tools and geospatial data to add location context to 3D built environments. Also, knowledge of CAD/BIM is also useful for employees working in the Digital Twin ecosystem.

Graph 11 - Geospatial and Related Skills of Geospatial Professionals in the Nethelands



Source: Geospatial Media Analysis; Linkedin Employee Data Analysis

Additionally, software development is critical for developing geo-enabled and geo-based applications that have an approximate market share of EUR 169 million; approximately 1,450 employees were found to be skilled in this discipline. The remaining people are skilled in other key geospatial technologies such as remote sensing, GPS, geodesy, spatial database management, 3D scanning, and photogrammetry.

In terms of knowledge of cutting-edge technologies that are in line with 4IR technology revolution, it was found that approximately 225 employees were specially trained in AI and ML. These people are primarily employees of those domestic geospatial companies where big data analysis requires state-of-the-art technology knowhow. Fugro, TomTom, HERE, e-Leaf, Arcadis, Antea Group, Royal HaskoningDHV are some of the companies where the critical role of AI and ML experts is realized.

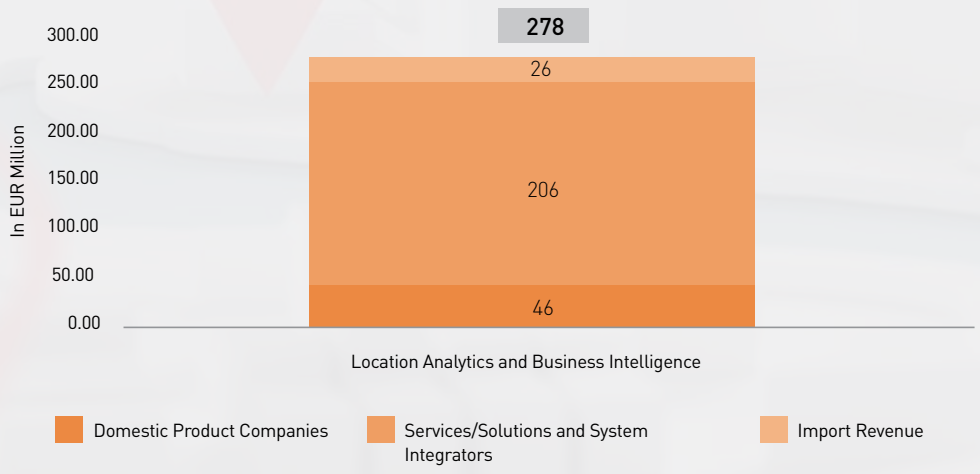
LOCATION ANALYTICS AND BUSINESS INTELLIGENCE

Location Analytics and Business Intelligence is a relatively new sector within the geospatial industry. Under this broad category, location data is usually combined with business data/processes in order to draw meaningful insights, discover relationships between spatial and non-spatial datasets, and identify trends. In order to conduct location analytics and gain useful intelligence from the process, a business needs to either capture/ curate location data related to its operations or procure location data from a third-party.

Next-generation users of location-based solutions are of key importance in this sector as it is largely driven by digital maps and location-data enabled applications. The majority of the solutions in this sector are developed using high-quality, comprehensive location data on MapAPI suites and map content that can be easily sourced (for example, Google maps). The users are primarily ordinary people and all non-traditional sectors that require navigation and location intelligence in real-time, such as, banking, finance and insurance, retail, supply chain and logistics, healthcare, and marketing and advertising.

The Netherlands is home to two of the leading geospatial companies catering to the location analytics and business intelligence market – TomTom and HERE. Both TomTom and HERE contributed approximately EUR 40 million to the domestic geospatial market from the location analytics and business intelligence segment in 2019. In the Netherlands, their location technology business grew at a CAGR of 14% in 2019, with nearly 60% of their revenues coming from location-based data, software, and services. These companies (along with few smaller companies) are at the forefront of providing accurate location data to the domestic market. The data so provided is being used by application developers and large business houses to create highly accurate or high-definition (HD) maps, develop navigation systems, provide traffic information services, and enable autonomous driving.

Graph 12 - Geospatial Technology Market for Location Analytics and Business Intelligence Sector in 2019



Source: Geospatial Media Analysis

The share of geospatial in the location analytics and business intelligence segment is approximately EUR 278 million. Of this total market, the revenue that actually comes from the domestic product companies (including TomTom and Here) is approximately EUR 46 million, while the data, software and services imported from companies outside the Netherlands – such as Nvidia, Esri, and Pitney Bowes — is EUR 25.50 million.

The total market share of the location analytics and business intelligence services in 2019 was estimated to be about EUR 206 million. Of this total share, the market size of consumer based geo-enabled and geo-based applications was EUR 169 million, while the remaining EUR 37 million came from business users. The EUR 169 million market for consumer-based geo-based and geo-enabled applications included all those applications that are built on the central premise of location-based services.

Some of the domestic applications that are built using location-based services and are being used by citizens readily are:

deliveroo	Deliveroo, a well-recognized food-delivery application based in the Netherlands
IMAGEM	Leegstand Bedrijvenmonitor, a location intelligence enabled dashboard developed by ImageM of the Netherlands to locate commercial real-estate properties in the country
9 2 9 2	9292.nl, a location-based travel planner application for train, bus, metro, and tram in the Netherlands
	OVinfo, a location-based app to plan travel when using the bus in the Netherlands
Buienradar	Buienradar, a location-based weather app that lets you know when the next rain shower is going to come along, by tracking your current location

Source: Analysis of Top 100 applications in Google playstore

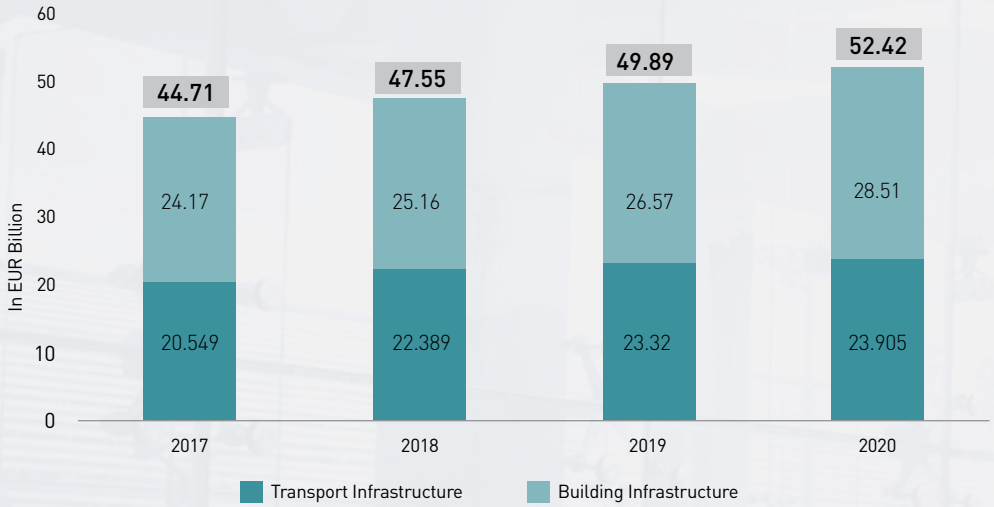
GROWTH OPPORTUNITIES

- → High-Definition Maps
- → Connected In-vehicle Navigation (Traffic Information Services, Speed Camera, Fuel Locator)
- → Autonomous Driving
- → Maps APIs and SDKs
- → Electric Mobility (route planners, charging station locator apps, and reachable range calculators)

INFRASTRUCTURE AND ENGINEERING

The Netherlands infrastructure and engineering market in 2020 was estimated to be EUR 52.4 billion, highlighting a year-on-year growth of 5.2% from 2019. For 2020, the building infrastructure market (inclusive of residential, commercial, and utility infrastructure) is estimated to be EUR 28.5 billion, and the transport infrastructure market is estimated to be EUR 23.9 billion.

Graph 13 - Infrastructure and Engineering Market in the Netherlands



Source: Geospatial Media Analysis; GEOBIM Market in AEC Industry Report

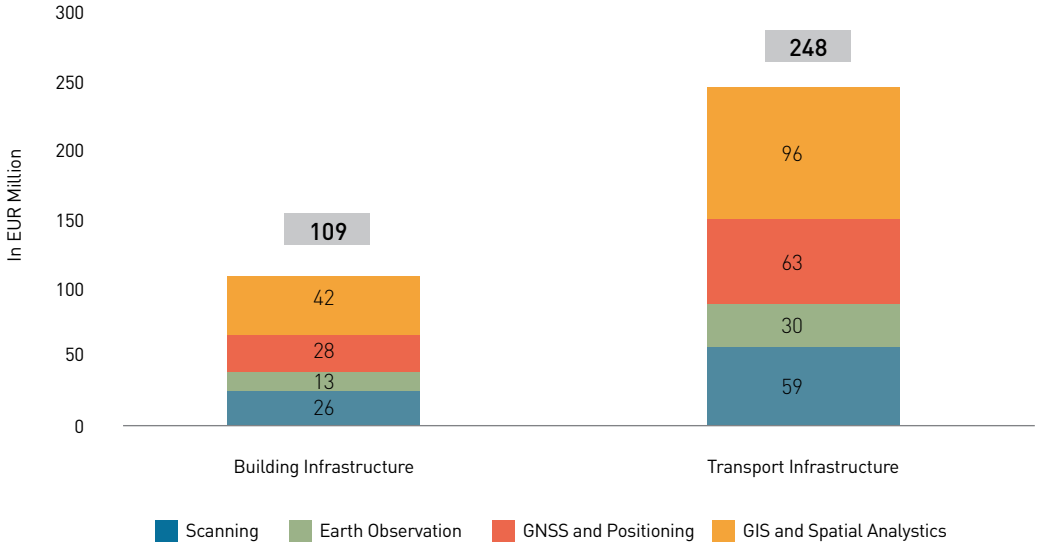
The Netherlands government has also laid a lot of emphasis on the national smart city initiative that began in 2015. For this purpose, the government has released the Netherlands smart city strategy, which aims to address the problem of rapid urbanization and its expanding pressure on public amenities and existing infrastructure. The strategy takes into purview cross-sector partnerships – inviting participation from both residents and businesses. Other key elements of the strategy include cybersecurity, open source digital infrastructure, standards, interoperability of data, privacy and finance.

As part of the smart city initiative, the G5 (Group 5) five large cities in the Netherlands — namely Amsterdam, Rotterdam, the Hague, Utrecht and Eindhoven – along with the G32 (Group 32) of middle to large cities will lead the implementation. Rotterdam and Amsterdam, in this regard, are already way ahead on the curve, having created 3D digital twin models for smart city implementation.

The geospatial technology demand by the infrastructure and engineering sector for 2019 was estimated at EUR 357 million in 2019, almost EUR 68 million more than the geospatial industry's market share. **This means that the demand for geospatial technology by the infrastructure and engineering sector is much more than what is currently supplied by the industry.**

Of the two core sub-sectors of the infrastructure and engineering sector, the Netherlands transport infrastructure sector demands more geospatial technology solutions and therefore, its demand is presently

Graph 14 - Geospatial Technology Demand from the Infrastructure and Engineering Sector in 2019



Source: Geospatial Media Analysis; Market Analysis Methodology available in Appendix

valued at EUR 248 million. On the other hand, geospatial technology demand by the building infrastructure sector is comparatively low, valued at EUR 109 million. The transport infrastructure demand is higher since the potential of utilization of geospatial technology in this sector is much more. From LiDAR to GPR, UAVs, and GIS and Spatial Analytics, the transport infrastructure sector utilizes almost all geospatial technologies in its construction and operational workflows. In contrast, the building infrastructure sector primarily uses GIS and Spatial Analytics as an important tool with the intent to integrate it with CAD or BIM. The use of geospatial technologies is, thus, not as extensive in the building infrastructure sector as it is in the transport sector.

Overall, the demand for GIS and Spatial Analytics is the highest in the infrastructure and engineering sector, with the total market demand standing at EUR 112 million. The infrastructure and engineering stakeholders of the Netherlands are also recognized as leaders in utilizing integrated BIM and GIS tools, and Digital Twin solutions (inclusive of BIM+GIS+IoT), which also contribute to the growing market of GIS and Spatial Analytics.

GEOSPATIAL ADVANTAGE

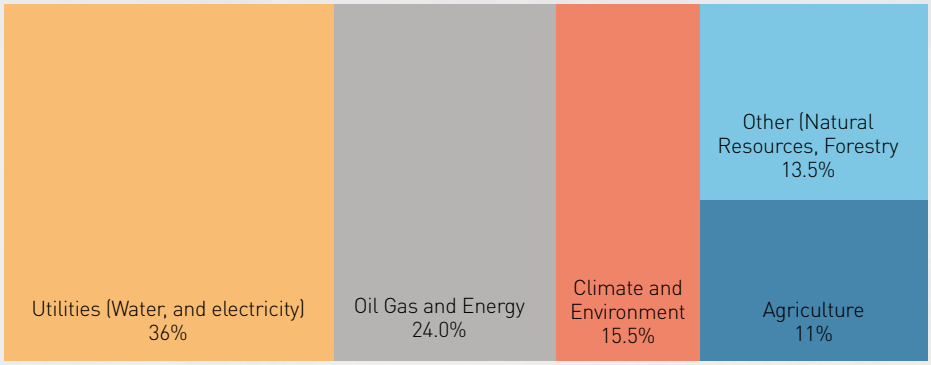
- → Better planning and improved decision-making
- → Efficient project execution, monitoring and maintenance
- → Improved cost and time efficiency
- → Real-time tracking of assets
- → Informed city planning and inclusive growth
- → Clash detection and risk mitigation
- → Better coordination and collaboration
- → Better-designed projects

PROFESSIONAL GEOSPATIAL USER SECTOR

The professional geospatial user sector encompasses the traditional user sectors — utilities (water, electricity), oil, gas and energy, climate and environment, agriculture, natural resources and forestry sectors. For the purpose of this report, the professional geospatial sector does not include defence and intelligence, public security, and the national geospatial organizations.

Traditionally, the professional geospatial user sector comes under the purview of the national government and therefore the utilization of geospatial technologies and solutions for this sector is largely defined by governing bodies and agencies. In this context, the supply side of geospatial technologies and solutions, the cumulative market of geospatial technologies for the professional geospatial user sector in 2019, was estimated to be EUR 484 million.

Graph 15 - Geospatial Technology Market for the Professional Geospatial User Sector in 2019



Source: Geospatial Media Analysis; Market Analysis Methodology available in Appendix

In 2019, the geospatial market in utilities (water and electricity) was found to be the highest, valued at EUR 174.25 million, that is, 36% of the cumulative professional geospatial user market. Water management in the Netherlands comes under the purview of Rijkswaterstaat (RWS), the executive branch of the Ministry of Infrastructure and Water Management, and the district water (control) boards. RWS is one of the few government bodies that utilizes geospatial solutions effectively and efficiently. It is known to use GIS and Spatial Analytics Solutions in the operational workflows to ensure government authorities are alerted in time about any impending floods. In addition, RWS is also one of the leading users of integrated GIS and BIM solutions to construct and maintain dykes, dams, weirs, and storm surge barriers around the country.

GEOSPATIAL ADVANTAGE IN UTILITIES (WATER AND ELECTRICITY)

- → Informed planning and policy formulation
- → Real-time monitoring of water storage
- → Identification of location of drinking water
- → Site-suitability for rainwater harvesting
- → Providing decision support systems
- → Integrated Water Resource Management
- → Improved predictive analysis of water resources

The energy sector contributes substantially to the national income, exports and employment of the Netherlands. The oil, gas and energy sector thus has the second highest market share of geospatial solutions in 2019, that is, an estimated value of EUR 116 million. This large market share can be attributed to the privatization of the energy sector, which took place in 2004. The privatization of the energy sector resulted in many new energy companies foraying into the Netherlands energy market. Today, most of these energy companies – such as Vattenfall, Energiedirect, and Engie — use GIS and Spatial Analytics to streamline outage management, comply with regulations, analyze risks, and deliver customer service. Also, the Netherlands government is investing heavily in Smart Grids. The city of Groningen has the first 'live' smart grid community in Europe called PowerMatching City, which connects households with smart appliances that match their energy use in real time, depending on the available (renewable) generation.

GEOSPATIAL ADVANTAGE IN OIL, GAS AND ENERGY

→ Better management of assets and complex operations
→ Effective planning of transmission and distribution requirements
→ Transmission line route alignment
→ Efficient project management
→ Higher transparency
→ Better network monitoring
→ Reduced network time
→ Improved customer services

With respect to agriculture, the Netherlands is the world's second-largest exporter of food and agricultural products. Approximately 50-65% of the farmers based in the Netherlands are using GPS in combination with map and sensor-based data for precise land management, and GIS and Spatial Analytics solutions for improving communication and decision-making among stakeholders. The geospatial market for agriculture in the Netherlands is only 11%, that is, EUR 53.25, since approximately 5% of the total population is employed in the sector (however, the benefits of geospatial solutions continue to be realized).

Geospatial solutions are used effectively to practise agriculture in a sustainable way, to manage logistics (seed and animal), and plan pesticide usage, among other things. Also, to increase the use of geospatial in agriculture, the Dutch Ministry of Foreign Affairs has commissioned a program called geospatial for Agriculture and Water (G4AW), executed by the Netherlands Space Office (NSO), to help improve food security in developing countries such as India, Indonesia, and Kenya by using satellite data.

GEOSPATIAL ADVANTAGE IN AGRICULTURE

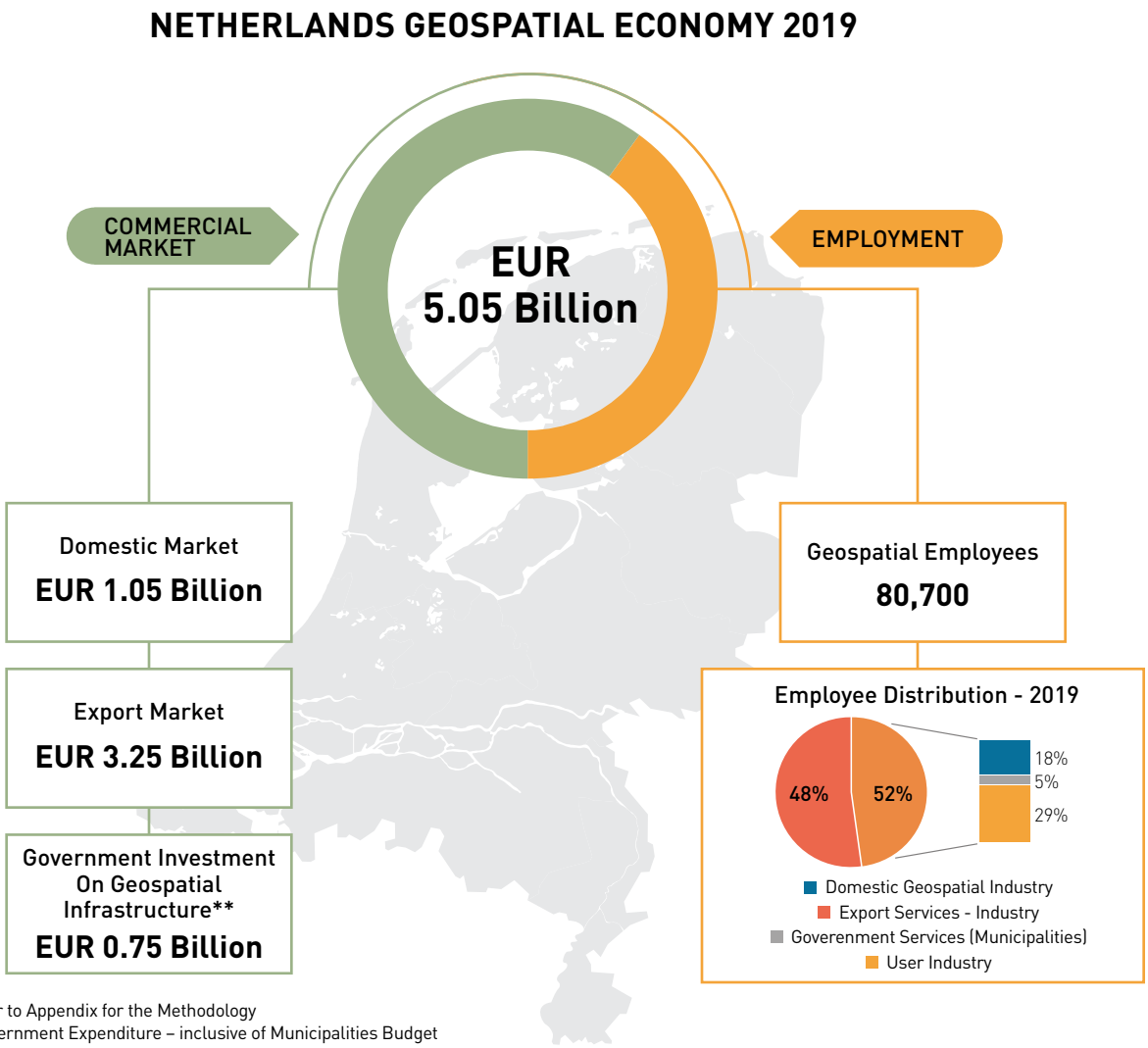
→ Efficient resource utilization
→ Informed decision-making for better policies
→ Higher yield
→ Increased efficiency of the agricultural chain
→ Increased food security
→ Monitoring and managing of farm operations

THE NETHERLANDS GEOSPATIAL ECONOMY

The Netherlands geospatial economy comprises the following key components:

- → The domestic market size through commercial procurement of hardware, software, data and services (inclusive of import value of geospatial hardware, software, data and services)
- → Export value of geospatial hardware, software, data and services.
- → Government investment on creation and maintenance of geospatial data, infrastructure and institutions, that is, government expenditure on national geospatial organizations and associated government departments, such as, municipalities, provinces, etc.

In 2019, the Netherlands geospatial economy was valued at EUR 5.05 billion and employed over 80,000 people from across the country. In 2025, the geospatial economy is estimated to be valued at EUR 7.25 billion with employment in the sector rising to over 100,000 people*.



* Refer to Appendix for the Methodology
** Government Expenditure – inclusive of Municipalities Budget

Source: Geospatial Media Analysis; Market Analysis Methodology available in Appendix

KEY HIGHLIGHTS:

DOMESTIC MARKET

- → The Netherlands' domestic geospatial market was valued at 1.05 billion in 2019 and estimated to grow at a CAGR of 5.05% by 2025 to EUR 1.34 billion*.
- → Sectorally, the traditional sectors (inclusive of agriculture, forestry, natural resources, oil, gas and energy, etc.) account for the maximum share of the geospatial market in the Netherlands, that is, up to 46% of the total Netherland's geospatial market. Infrastructure and engineering have an approximate share of EUR 289 million, that is, 27.5% of the country's domestic geospatial market.
- → Non-traditional users of geospatial technology and solutions, such as banking, finance and insurance, retail, supply chain and logistics, etc., are all included in the location analytics and business intelligence sector where the approximate market share is valued at EUR 278 million, that is, 26.5% of the Netherlands' domestic geospatial market.

INTERNATIONAL TRADE

- → The Netherlands relies heavily on geospatial hardware and software imports for its geospatial technology requirements. For 2019, the amount spent was estimated to be EUR 239 million.
- → The export of geospatial data and services from the Netherlands has been rising steadily, with major companies such as TomTom, HERE, Fugro, Arcadis, etc., exporting data and services worth EUR 3.25 billion.
- → As the use of geospatial, driven by innovations in 4IR technologies, becomes more pervasive and there is an increase in the consumption of geospatial data and intelligence via digital maps and applications, the export market for geospatial solutions is estimated to increase by 9.23% to EUR 5.03 billion by 2025.

GOVERNMENT INVESTMENT

- → During 2019, the government invested nearly EUR 0.75 billion on multiple national geospatial agencies and municipalities through revenue and capital expenditure.
- → Assuming a conservative CAGR of 3.34%, the government investment on national geospatial agencies and municipalities is estimated to be EUR 0.88 million by 2025.
- → The government, especially the municipalities, spend heavily on in-house GIS data integration and development of solutions for improving productivity and efficiency in workflows.

EMPLOYMENT

- → In 2019, the Netherlands geospatial industry employed 80,700 people.
- → Of these 80,700, about 18% were employed in the geospatial industry ecosystem, that is, approximately 14,520 people were employed by the domestic geospatial companies.
- → Further, of the total employees, nearly 38,000 people were engaged in exports related services.
- → Up to 34% of the total number employed in the Netherlands geospatial ecosystem, are employed in the user sectors such as municipalities, construction, agriculture, oil, gas and energy, retail and logistics, etc.

GEOSPATIAL ECONOMIC IMPACT IN NETHERLANDS:

EUR 35.5 BN

BUSINESS BENEFITS

EUR 1.05 Bn
Approximate Market of Commercial Geospatial Industry in Netherlands

60% of Netherlands GVA
Geospatial industry could have a productivity impact on sectors representing approximately

EUR 31 Bn
Total Business Impact of Netherlands' Geospatial Industry

CONSUMER BENEFITS

EUR 2.55 Billion
Value of travel time saved by consumers by using digital maps effectively

EUR 1.95 Billion
Value of fuel savings by consumers by using digital maps for navigation

EUR 4.5 Billion
Total Consumer Value Benefits of using digital maps

SOCIETAL BENEFITS

19,38,000
Potential Employment Directly Linked To Geospatial Industry that is inclusive of non-Geospatial jobs across the value chain is

18.5%
(in comparison to 2010)
CO2 emissions from vehicles has reduced from the use of digital maps leading to efficient trips and reduced congestions

Source: Geospatial Media Analysis

ECONOMIC IMPACT OF GEOSPATIAL TECHNOLOGIES AND SOLUTIONS

Geospatial technology and solutions are deeply embedded in our everyday life. The use of geospatial technologies and solutions does not just underpin one sector, but cuts across the entire spectrum of the socio-economic-and environment sectors of a country. 'Geospatial' is a powerful force that helps to (re)solve the complexities of geography to deliver huge transformational values to varied sectors and industries making communities smarter, improving productivity and efficiency, managing sustainable development goals (SDGs), engaging consumers and citizens, protecting biodiversity, integrating environmental thinking, and designing a collaborative workflow to create holistic solutions to address all challenges the world economy and society faces today.

However, despite the many benefits of the growing use of geospatial technologies and solutions, its true economic value remains hidden. Quantifying the extent of geospatial benefits is often difficult because many benefits are derived from the embedded services (such as navigation tools, ride-sharing apps, delivery apps, communication tools, etc.). It is often impossible to present a true understanding of the economic impact of geospatial technologies and solutions. For the purpose of this study, the economic impact of geospatial technologies and solutions is calculated by taking into consideration the factors that advance economic development – employment, benefits derived from the value-added-services, and by examining the consumer and societal benefits which lead to an incremental value impact.

Business Benefits

Geospatial technologies and solutions benefit not just the geospatial product companies but also create indirect benefits for the larger business ecosystem. Using geospatial technologies and solutions, businesses are able to improve productivity, connect directly with consumers and ultimately drive business growth.

→ The Netherlands geospatial industry is estimated to have generated a total revenue of EUR 1.05 billion in 2019, wherein the maximum share of the revenue, that is, approximately EUR 528 billion was generated from geospatial services (inclusive of value-added services and surveying and mapping capabilities).

→ The study shows that the use of geospatial technology and solutions has a strong multiplier effect and could result in a productivity impact on sectors representing 60% of the Netherlands Gross Value Added (GVA).

→ Taking into account the direct and indirect economic benefits of the Netherlands geospatial industry, the total business impact of the geospatial industry in the country is presently valued at EUR 31 billion.

Consumer Benefits

The estimated consumer benefits basis a "willingness-to-pay" approach in the Netherlands amounts to a combined EUR 4.5 billion per year.

- → Using the Value of Time (VOT) approach, time benefits associated with the use of digital maps have been calculated using publicly available indicators for efficient driving, efficient use of public transport and efficient walking. Analyzing the public indicators with the number of cars using digital maps, a real monetary value is attached to shorter commutes, as people can use their time efficiently and productively. In this context, it is estimated that the value of time saved by commuters by using digital maps is approximately EUR 2.5 billion for the Netherlands.
- → The benefits of fuel saving from improved navigation are calculated by taking into account the total number of registered passenger and commercial vehicles in the Netherlands and the total vehicle movement between 2014 and 2017; the same has been calculated for 2018 and 2019 using trend analysis. Using the available data of the vehicular traffic movement, and the measure of how much the cars have traveled using digital navigation systems, a value has been assigned to the fuel savings basis the domestic petrol price in the Netherlands. Fuel savings due to improved navigation is estimated to be around EUR 1.95 billion per year.

Societal Benefits

The benefits of geospatial technology and solutions are not limited to businesses and consumers alone but spill over to the society and environment sectors at large. While common economic derivatives are often unable to capture the accurate benefits, in our study we have examined the impact of geospatial technology and solutions on boosting direct and indirect employment and its potential benefit in carbon reduction.

- → A big data analysis of employee profiles of 125 geospatial companies, 355 municipalities and six critical user sectors of the economy suggests that more than 80,000 people work directly in a technical geospatial role, inclusive of GIS advisors, GIS technicians, software programmers and developers, surveyors, cartographers, geologists, among many others.
- → To calculate the potential employment indirectly linked to the geospatial industry (inclusive of non-geospatial jobs such as HR, Finance, etc.), a multiple effect was derived from secondary literature, from analysis of consumer surveys, and big data analysis of company profiles. The analysis conducted using the multiplier effect showed that the potential employment indirectly linked to geospatial industry value-chain is over 1.9 million jobs.
- → Basis the carbon emission (CO2) trends in the Netherlands from the overload transport and the total number of registered passenger and commercial vehicles, the efficient commuting metrics were calculated with the assumption that at least one commuter per vehicle in the Netherlands is using digital maps for navigation, saving significant travel in kilometers. The kilometer figure was then converted into savings by using average emissions output by vehicles in the Netherlands. Thus, in comparison to 2010, the CO2 emission from vehicular traffic had reduced by 18.5% with the use of digital maps.

RECOMMENDATIONS

The Netherlands is a sophisticated and innovative economy, staying ahead in terms of adoption and efficient use of digital technologies for governance, environmental management, and societal and business objectives. Innovation and sustainable development have been at the core of the country's socio-economic fabric. Even in these uncertain times, the Netherlands's economy appears to be stable, primarily due to its efficient infrastructure, industrial capacity and competent workforce. Because of these advantages, the Netherlands has immense potential to grow its geospatial economy and become a world leader in the global geospatial market.

DEVELOPING NATIONAL STRATEGY FOR GEOSPATIAL INFRASTRUCTURE AND KNOWLEDGE PLATFORM

The Fourth Industrial Revolution (4IR) is defined by digitalization, connectivity and convergence. It is characterized by advancements in automation and the Digital Twin, which is a digital representation of the physical world in real time. Today, geospatial infrastructure and knowledge platforms serve as the foundation of the digital infrastructure (and Digital Twin), leading to greater demand for authoritative, accurate, updated and accessible data platforms. In this context, there needs to be a strategic plan to provide geospatial infrastructure as a service to a whole range of stakeholders, including citizens and businesses, to secure national sovereignty and security, ensure good governance, efficient infrastructure and utilities, protect environment, and above all, support the national objective of sustainable development. The strategic plan can look to:

- → **Strengthen National Geospatial Data Infrastructure:** Netherlands should strengthen it already strong National Geospatial Data Infrastructure will help in effectively addressing socio-economic and environmental challenges. A robust real-time geospatial infrastructure will provide accurate and authoritative geospatial data, and analytics and intelligence at community, national and global levels, to support a wide range of initiatives from Digital Twin to automation. With Netherland aiming to build a National Digital Twin, the role and value proposition of the National Geospatial Data Infrastructure is critical.
- → **Develop Augmented Positioning Infrastructure:** Augmented Positioning Infrastructure is key to ensuring reliable and non-disruptive Positioning, Navigation and Timing (PNT) as a service nationwide. With the advent of 5G, IoT, autonomous and Indoor Positioning technologies, there is a definite need to improve consistency and accuracy of the positioning infrastructure. Given that more than 80% of human activities have a location element, an open and robust PNT service will enable uniform, equitable and coordinated access to locational information. In today's unprecedented time having a national augmented positioning infrastructure is the need of the hour.
- → **Ensure Establishment of Geospatial Knowledge Platform and Services:** Since geospatial data is at the core of digital data infrastructure and can help in driving the economy through data-driven workflows and business processes, there is greater need to develop dynamic Cloud-based geospatial platforms which will have the ability to access different kinds of datasets (both static and real-time) and integrate and process the same through the power of Artificial Intelligence and Spatial Analytics, to deliver different products in the form of actionable information for different stakeholders. This will pave the way for scalability of applications and extend the socioeconomic benefits of geospatial knowledge.
- → **Build National Geospatial Policy and Regulatory Framework:** As we live in the age of data economy, it is natural that geospatial data and its transactions require a comprehensive geospatial data policy and a regulatory framework. While open data and linked data initiatives are an integral part of the existing policies, what's needed is a National Geospatial Policy and Regulatory Framework that can define the scope of geospatial data and positioning infrastructure covering the entire spectrum of the geospatial data ecosystem. There is need to further have a regulatory framework that will incorporate and align with other policies covering autonomous vehicles, data privacy, data sovereignty, intellectual property, AI and ICT.

→ **Set Up Standards and Interoperability Frameworks:** Since geospatial data comes from varied sources and is used across different ecosystems, there is a need to strategically focus on continuously developing standards and supporting interoperable frameworks to ensure that the data collected is (re)usable seamlessly, without losing its attribute of knowledge. The standards have to be optimized to maximize value to governments, businesses, institutions and citizens, while protecting security and privacy interests.

GEOSPATIAL INDUSTRIAL DEVELOPMENT STRATEGY

The geospatial industry in the Netherlands is currently a solutions and service-oriented industry. Given the increasing role of geospatial knowledge in the digital age, there is need to add technology and product portfolios to the industry fabric. Therefore, **geospatial industrial development will be an integral part of the National Geospatial Strategy, to** strengthen the domestic industry and expand the overall size of the country's geospatial economy (inclusive of exports), and ultimately add to incremental socioeconomic value and benefits.

The national geospatial industry development strategy should aim to:

→ **Develop an enabling environment** for the domestic geospatial companies and encourage them to innovate with 4IR technologies; nurture the domestic geospatial industry to move up the value chain and support the national digitalization mission. At present, the Netherlands' geospatial industry is service-oriented and generates an economic impact of EUR 31 Billion. An enabling environment for the domestic geospatial companies will help the Netherlands to nurture more product companies which will quadruple its economic impact in the long run.
→ **Facilitate long-term contract R&D** to enable the geospatial industry to build next-generation geospatial technology, which will also strengthen the geospatial infrastructure in the country.
→ **Accelerate investments** in the geospatial industry to encourage small and medium companies to scale their business operations within and outside the country. It has been observed that most Dutch geospatial companies are very small, and service oriented because of which, the geospatial import value is much higher. In this case, it is important to empower these small companies to grow in terms of their size, product portfolio and business outreach. Since, at present, very few domestic geospatial companies export their technologies and services, it is important to uplift the profile of these companies and expand their product portfolios to cater to both domestic and international markets.

EMPOWER RESEARCH AND EDUCATION INSTITUTIONS AND ENGAGEMENT WITH INDUSTRY

The digital age is driven by science and knowledge and their productization. The National Geospatial Strategy should aim to do the following:

→ **Strengthen Geography and Geospatial Education at Middle-School and High-School Level:** To enable new professionals in the geospatial sector, it is imperative to impart the importance of geography and geospatial in the middle and high school students of Netherlands. Measures need to be taken to ensure that maximum numbers of students are encouraged to take geography and geospatial education at an early stage in their career planning.
→ **Strengthen Fundamental Science and Applied Education:** Given the fact that geospatial infrastructure and knowledge serve as the foundation of the next-generation knowledge economy, it is recommended that geospatial institutions be empowered to undertake research in the field of fundamentals of geospatial science, applied education and interdisciplinary programs.
→ **Establish Centers of Excellence:** There must be specific focus on engaging with industry and establishing centers of excellence in partnership with global companies. Specific focus must be laid on

technology innovation and domain-specific knowledge, with emphasis on fundamental user sectors, public policy and sustainable development.

→ **Enhance Academia-Industry Engagement:** There is need to facilitate interactions between the academia and the industry to nurture entrepreneurial spirit among students and establish a thriving startup ecosystem in the country.

INTERNATIONAL COOPERATION AND GLOBAL GEOSPATIAL HUB

International cooperation is gaining momentum in the geospatial industry. There have been several initiatives in the past few years at regional and global levels to facilitate engagement, exchange of knowledge, develop common frameworks and support capacity building and sustainable development. The Netherlands has been has been one of the pioneers by setting ITC (Faculty of Geo-Information Science and Earth Observation) which has been imparting education, undertaking research and supporting capacity development since 1950. Additionally, the Kadaster International continues to play an active role across several international collaborative platforms. It may be worthwhile to develop a network of professionals who have been educated and trained through Dutch programs and leverage their understanding and contacts to accelerate a collaborative network towards serving the goals of sustainable development.

The Netherlands is considered as a global business hub and offers ease of doing business. The mainstream global business community finds it very attractive to set up operations in the country — global headquarters of many companies are located in the Netherlands. This is because of the leadership of the Dutch business community in several fields. A high-quality infrastructure and service industry acts as the backbone of international business. The Geospatial Industrial Strategy may be based on a futuristic approach through:

→ **Global Geospatial Hub:** Given the growing relevance of geospatial knowledge worldwide, there is need to develop a global geospatial hub which can serve as the nodal body working towards building an environment of collaboration, innovation/incubation, knowledge management and best practices. As part of the strategy, the government may consider setting up a Global Geospatial Hub and the same may serve as an institution to showcase the Dutch geospatial capacity and engage with the global geospatial industry. Hosting a Global Geospatial Hub can be instrumental in:

  → Establishing a leadership role for the host country, with the government being at the cutting edge of innovation and knowledge;
  → Enabling a healthy and open business environment, so that global companies are encouraged to set up operations in the host country — creating fresh opportunities and markets for the local geospatial community;
  → Boosting research and education in a collaborative environment, commercialization of research, and enhanced awareness leading to investments in education, jobs and capacity building; and
  → Enjoying the first-mover advantage in terms of adoption of technologies, given the increasing role of geospatial in the digital economy and society.

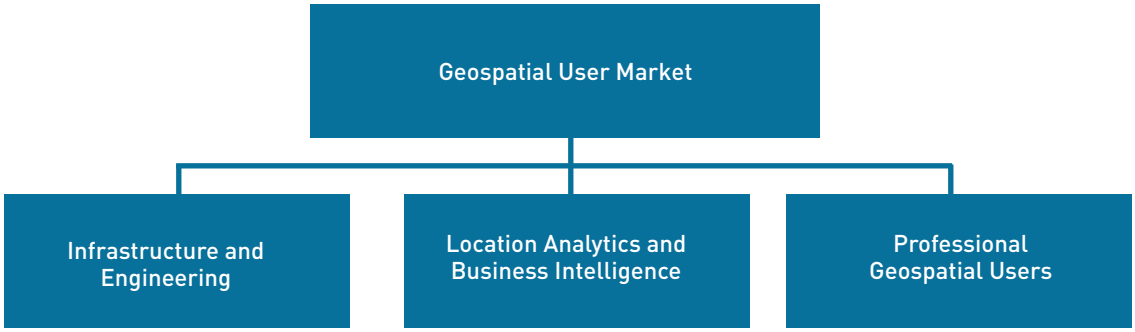
ANNEXURE

REPORT BRIEF:

The Netherlands Geospatial Economy Report has been developed by Geospatial Media, in partnership with the Ministry of Interior and Kingdom Relations, the Netherlands; and Geonovum. The report presents takes cognizance of the:

- → Geospatial infrastructure in digital economy
- → Role and impact of geospatial solutions in Netherlands' economy and its business, consumer, and societal
- → Geospatial industry market (both import and export) across critical sectors of the economy inclusive of infrastructure and engineering, professional geospatial market and location analytics and business intelligence.
- → Technology trends and directions of the geospatial industry of Netherlands

Research Methodology



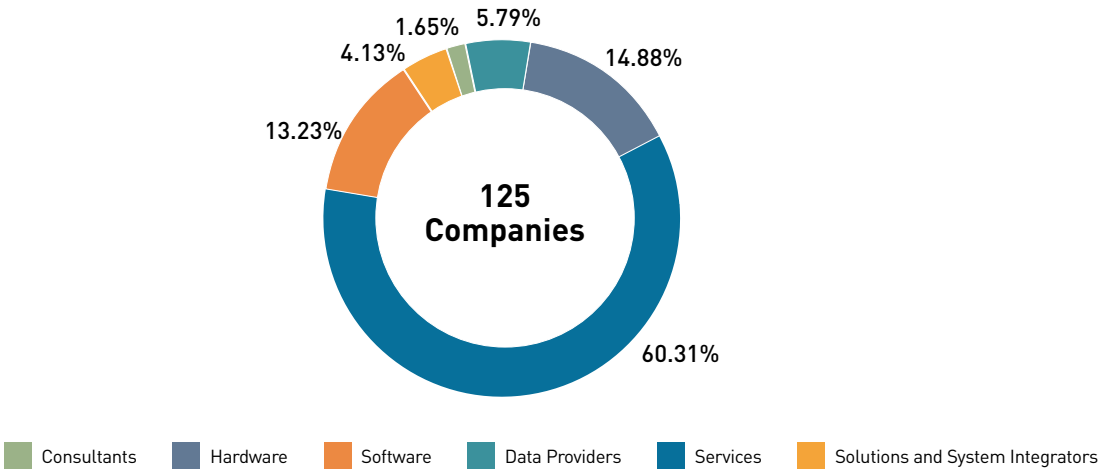
For the purpose of this study, the geospatial user market has been divided as follows:

The analysis presented in the Netherlands Geospatial Economy Report has been collected and calculated using both primary and secondary research collected by the Market Research and Consultancy division of Geospatial Media.

Primary Research: Several one-on-one interviews were conducted with key stakeholders from the Geospatial infrastructure and industry of the Netherlands. Basis the interactions and also a survey questionnaire, the trends and directions for the Netherlands Geospatial industry was established. Further, primary research was also used to define the **multiplier effect** which has been used to derive the direct, indirect and induced economic impact of geospatial technologies and solutions.

Secondary Research: The secondary research includes deep dive into available literature on Geospatial infrastructure, industry and institutions. It also includes literature review of renowned consultancy reports, whitepapers, and peer-reviewed journals in the geospatial domain. Also, to calculate the market size of the geospatial industry of the Netherlands, an extensive industry profiling of 125 domestic companies was conducted. For these companies, human resource profile, revenue for 2019, and export value was collected

Graph 16 - Geospatial Industry Profile by Service Offerings



Source: Geospatial Media Analysis; Company profiling by Geospatial Media

using primary interactions and data scrapping from annual reports, company databases, and LinkedIn.

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ABBREVIATIONS

3D	Three Dimensional
4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
B2B	Business-to-Business
BIM	Building Information Modelling
CAD	Computer-Aided Design
CAGR	Compound Annual Growth Rate
CO2	Carbon Dioxide
COVID	Coronavirus Disease
DTM	Digital Terrain Modelling
EML	Electro-Magnetic Locators
EO	Earth Observation
EUR	Euro
Fig.	Figure
GEOBIM	Integrated Geospatial & BIM Solutions
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPR	Ground-Penetrating Radar
GPS	Global Positioning System
GVA	Gross Value Added
HD	High Definition
HR	Human Resources
IoT	Internet of Things
LiDAR	Light Detection and Ranging
ML	Machine Learning
MSME	Micro, Small & Medium Enterprises
RADAR	Radio Detection and Ranging
SDG's	Sustainable Development Goals
SDK's	Software Development Kit
UAV	Unmanned Aerial Vehicle
VAS	Value-Added Service
VOT	Value of Time
VR	Virtual Reality
G5	Group 5
G32	Group 32
ICT	Information and Communication Technologies
5G	Fifth-Generation Wireless
Sat.	Satellite
BI	Business Intelligence
NMAs	National Mapping Agencies
GKI	Geospatial Knowledge Infrastructure
NSDI	National Spatial Data Infrastructure
IGIF	Integrated Geospatial Information Framework
UN-GGIM	United Nations Committee of Experts on Global Geospatial Information Management
SaaS	Software-as-a-Service
PDOK	Public Services on Maps
URI	Uniform Resource Identifiers
CEGIS	Center of Excellence for Geospatial Information Science
USGS	United States Geological Survey
IT	Information Technology
VAMLAV	Validation of Mapping and Localization of Autonomous Vehicles
RWS	Rijkswaterstaat
G4AW	Geospatial for Agriculture and Water
NSO	Netherlands Space Office

ABOUT MINISTRY OF THE INTERIOR AND KINGDOM RELATIONS (BZK)

The Ministry of the Interior and Kingdom Relations (BZK) is one of the eleven ministries of Dutch central government. The ministers and civil servants formulate policy, prepare legislation and regulations, and are also responsible for coordination, supervision and policy implementation.

The Ministry safeguards the core values of democracy. BZK stands for effective public administration and public authorities that the public can trust. BZK helps people live in affordable, safe, energy-efficient homes in pleasant neighbourhoods where everyone counts and everyone takes part. The Ministry deals with the following isues:

→ democracy and the rule of law;
→ public administration;
→ the quality of personnel and management within central government;
→ the Dutch constitution and the system of constitutional government;
→ the partnership with Curaçao, St Maarten and Aruba;
→ public housing and government buildings;

ABOUT GEONOVUM

Geonovum is the National Spatial Data Infrastructure (NSDI) executive committee in the Netherlands. The organization devotes itself to making the government perform better with spatial data, by developing and managing spatial data standards. Geonovum is a public organization, supported by the Ministry of Interior, the Ministry of Agriculture, Nature and Food Safety, Rijkswaterstaat, Cadastre and the Geological Survey of the Netherlands.

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. 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.