EVERYTHING
HAPPENS
SOMEWHERE

The power of place

A sustainable future with geospatial insights

Knowledge Transfer Network

Ordnance Survey

This publication communicates how geospatial intelligence is shaping our world. Experts discuss how we unleash the innovative potential of location and the power of place.

Co-authored by the Knowledge Transfer Network and Ordnance Survey.

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EVERYTHING HAPPENS SOMEWHERE

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Note from the editors

Geospatial is transforming our world.
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Luca Budello

There are billions of sensors collecting data everywhere on Earth, and hundreds of earth observation satellites monitoring the health of the planet. Miniaturisation of electronics enables the production of increasingly smaller payloads for cubesats, drones and ground-based monitoring systems. Meanwhile, cloud-based computing is providing the computational power to experiment with new business models, making geospatial data available via platforms in near real-time.

Geospatial insight is a key piece of information to enable the autonomous and connected world we are building today. It enables cars to drive down a motorway, track assets in large scale civil engineering projects, or reduce city pollution and carbon emissions via better monitoring, for example.

My prediction is that within the next three to five years, companies of any size will make use of geospatial insights to gain a critical advantage. Working with better data will help to identify risks and opportunities faster, exploiting emerging patterns before the competition.

Although, geospatial insights can unlock billions across organisations and global networks, the full economic realisation of this new paradigm is yet to occur and not guaranteed. In this report, industry leaders and emerging thinkers will discuss how cross-sector innovators can derive real-economic value from using geospatial data.

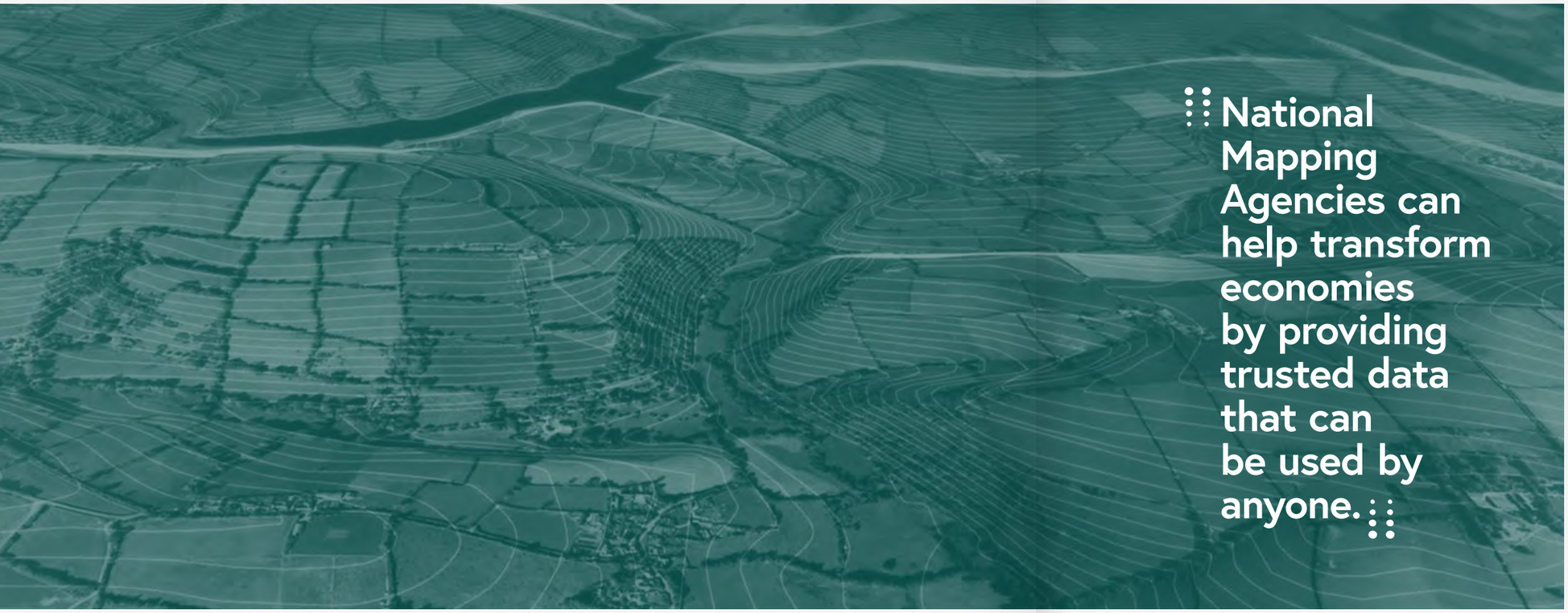
The publication is divided into three sections. In the first part, we bring forward the changing landscape of location intelligence and its implications for business as usual. We then discuss the emergence of a new and powerful data knowledge infrastructure, sitting at the nexus of spatial analysis, artificial intelligence and cloud-based computing, making note of the trends in the geospatial data market.

The second part looks at the innovation challenges in the sector. We examine the importance of building a collaborative economy that unlocks data from silos and uses collective intelligence tools to harnesses knowledge across sectors. The importance of system thinking and data ethics is also reviewed, illustrating how to build resilient socio-economic infrastructures fit for a connected and autonomous future.

Finally, we reflect on the role that geospatial intelligence plays in supporting the delivery of positive change. From addressing global challenges to delivering a new framework for responsible investment, we showcase how geospatial is at the heart of building a digital ecosystem for planet Earth.

I would like to extend a special 'thank you' to our contributors and guest editors, for their invaluable input and sustained effort over the past few months. I hope you find this publication thought-provoking and I look forward to supporting your company in harnessing the power of location insights.

Luca Budello
Geospatial Insights Lead
at Knowledge Transfer Network



National Mapping Agencies can help transform economies by providing trusted data that can be used by anyone.

There is a structural shift happening in the way we understand, observe and interact with the world around us. A key driver of this shift is an increasing demand for certainty in – and an assurance of the provenance and quality of – the geospatial data that is being used to underpin important decisions.

At the core of the structural shift is demand for intelligence and actionable insight, leading to positive impact, whether that be for policy, service delivery or commercial outcomes. The nations and businesses who successfully provide for their citizens and customers, will do so by making informed decisions from an analysis of trusted data.

Confidence in a trusted analysis comes from high quality geospatial data. Quality data stems from well-defined systems of capture, maintenance and information governance - and is made discoverable, accessible and usable. Quality data that is the foundation on which other datasets can be cross referenced, combined and overlaid, leading to insights that are far greater in value and impact than the sum of their parts.

To achieve this level of success, requires investment. The UK Government, through the Geospatial Commission, has signalled the importance that it places on geospatial data and the opportunities it offers. Since its creation the Geospatial Commission has taken a number of steps towards supporting the realisation of these opportunities including entering into a new 10-year agreement with Ordnance Survey to ensure the UK's geospatial assets continues to be world leading, underpinning the effective and efficient delivery of public services, and supporting our economic recovery.

This is crucial as we manage expanding urbanisation, concerns about food production, climate change, the need for sustainable land management and growing inequality. As the next wave of technology-enabled opportunities present themselves, those who will have greatest advantage are those who have a strong foundational national geospatial data infrastructure in place.

David Henderson

As societies around the world increasingly seek to expand their digital services and data economy, establishing an authoritative national base map to which those records relate is essential. Everything happens somewhere. A high quality trusted and authoritative national base map leads to a geospatially enabled nation; one that shares, integrates, and uses a wide range of data to achieve economic, social and environment benefits.

There are challenges, of course. As the industry goes through this profound structural shift, it will require our collective expertise to consolidate large numbers of data sources, extracting the most valuable insights from ever greater volumes of data from an increasingly and persistently sensed planet. From space, to sensors on buildings, vehicles and assets below ground, and to the multitude of sensors 'in our pockets' we are provided with near real-time insights on how the world is moving, changing and adapting. Ensuring that we make decisions with the right data and in the right context and bringing to the fore organisations that can assure the authority and trust in the services that they provide is paramount.

We will continue to face challenges in determining an appropriate use of data, whether that's at local, national or international scales. As location data professionals, we are at the heart of these discussions; as well as trust in high quality data, we need to assure citizens to have trust in us, protecting their privacy and using data appropriately. Important conversations are being led by the Benchmark Initiative and the establishment of Locus Charter are moving us closer to the crux of how we sustainably work with location from an ethical standpoint.

Our role as geospatial experts should be to guide high quality geospatial data at capture, keep it maintained and updated, to release its connecting and contextualising power, with full consideration of ethical and security considerations. And thereby help us tackle some of the biggest challenges the world faces, today and in the future.

David Henderson

Chief Geospatial Officer
at Ordnance Survey

Part one:

The economic opportunity

01

The era of the data economy

Luca Budello, Geospatial Insights Lead at KTN
Josh Gilbert, CEO at Sust Global

In the same way that technology revolutionised business and transformed all aspects of the economy and society, decision-making without location-based insights will soon become obsolete.

Bomi Okuyiga, Senior Economic Adviser at the Geospatial Commission

Geospatial data is a fundamental enabler of economic growth and technological innovation in the data economy. Businesses and governments have many competing priorities for resource allocation, so representing the value of geospatial data in a way that decision-makers can understand and compare to other investments is essential. Communicating its value first requires a working definition of what comprises geospatial data.

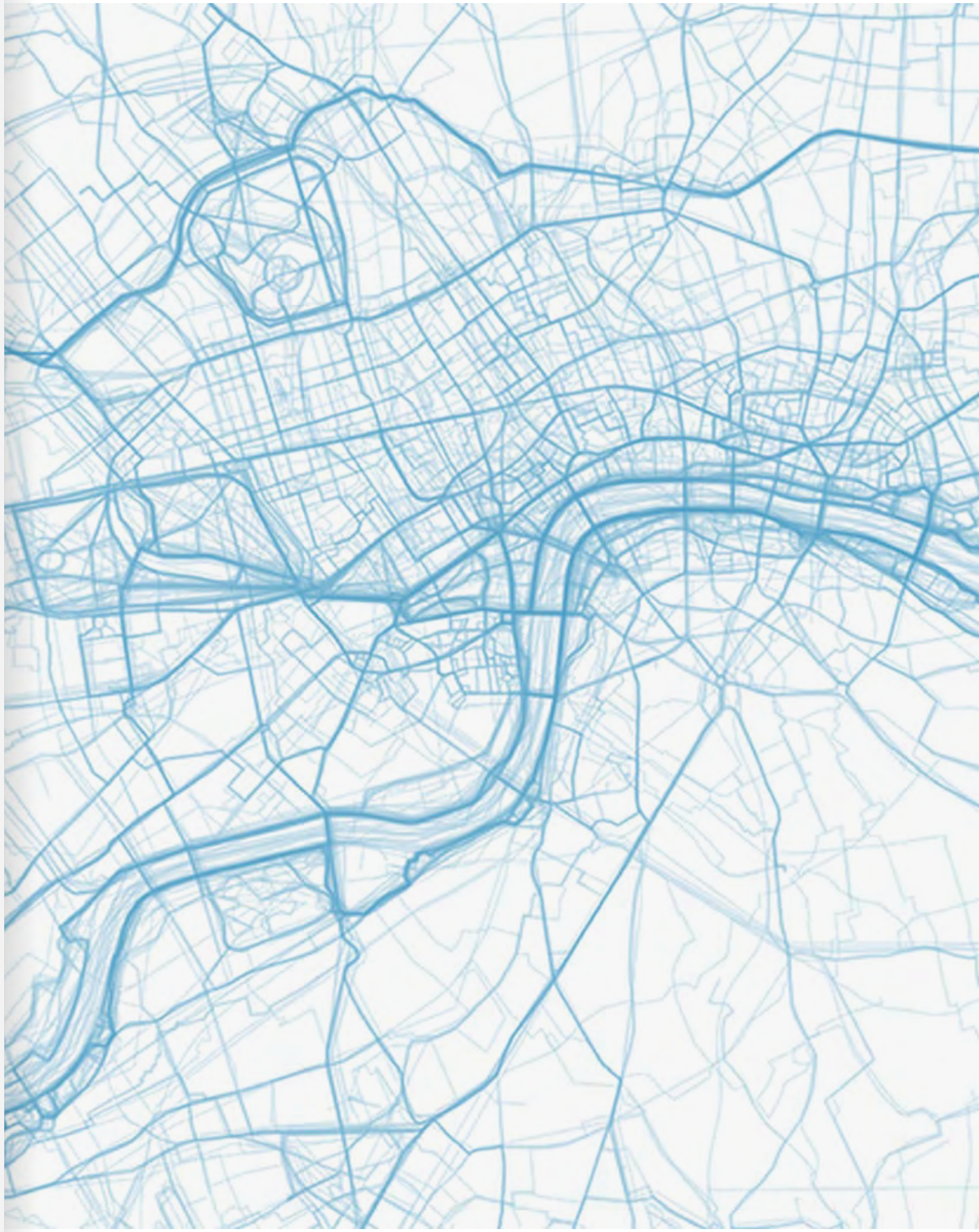
Geospatial refers to a type of dataset that defines a location. This encompasses GPS coordinates and post codes, but also information about geography, including the path of a river or size of a city. It can refer to elevation, geology or land cover, and it describes both the built and the natural environment. It can be collected via land-based sensors or satellite sensors. Often, different types of geospatial data are combined to provide information on a geographic area, which are then visualised in the form of maps, represented in geographic information systems (GIS), or used for spatial planning or navigation[1].

The emergence of Geospatial 2.0

In the digital era, geospatial technologies are revolutionising the economy. From navigating public transport to monitoring supply chains and designing efficient distribution paths, location-based digital services, Earth Observation (EO) data and geospatial analytics and insights have seen an exponential growth[2]. Machine learning and other developments in data science are facilitating much more sophisticated analysis of geospatial data than was previously possible. Some refer to this development as Geospatial 2.0.

In Geospatial 2.0, the sector is transitioning from a vertical industry to a horizontal enabler where the value of geospatial intelligence is captured across many industries. There is now a need for establishing the knowledge-base to support geospatial innovators.

Geospatial 2.0 places an emphasis on contextualising the challenges that the world is facing today. It combines location-based data and non-geographic data to provide a rich layer of information that creates value for businesses and consumers.



1 ODI (2018): The UK's geospatial data infrastructure: challenges and opportunities. Available at www.theodi.org/article/geospatial-data-infrastructure-report
2 www.ktn-uk.co.uk/perspectives/the-growing-importance-of-geospatial-insights

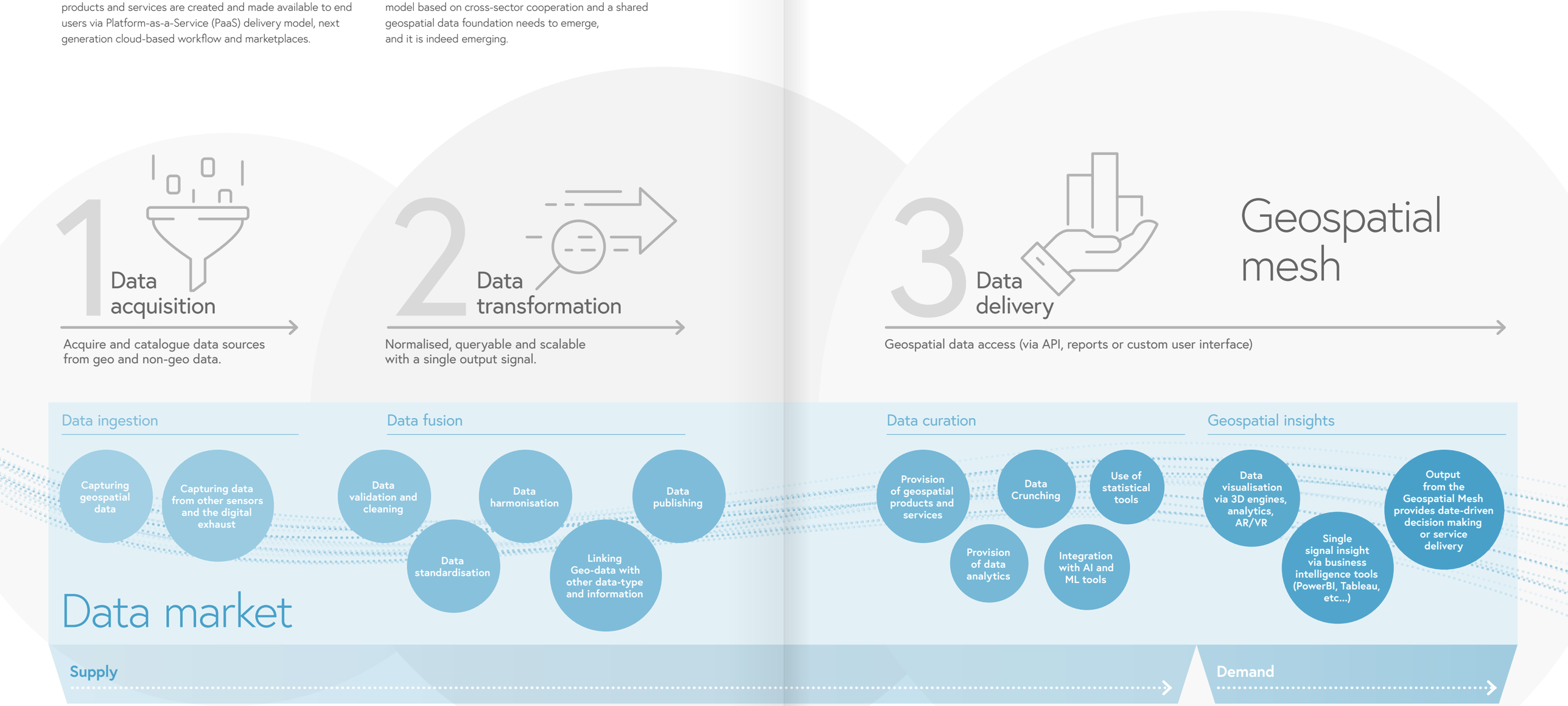
The data life cycle

At the core of Geospatial 2.0 is the Geospatial Mesh, a data and knowledge infrastructure where geo- and non geo-data is acquired, transformed and delivered into the emerging geospatial data market. Here, data is published in vertically focused smart aggregators for B2B operation where new products and services are created and made available to end users via Platform-as-a-Service (PaaS) delivery model, next generation cloud-based workflow and marketplaces.

Building this geospatial value chain and supporting solutions to reach technological and commercial maturity, requires a step-change not only in the way we handle data, data standards and data integration, but also in way we support a paradigm shift from business, licensing and regulatory models. A new economic model based on cross-sector cooperation and a shared geospatial data foundation needs to emerge, and it is indeed emerging.

Geospatial mesh

Knowledge infrastructure where geo- and non geodata is acquired, transformed and delivered into the emerging geospatial data market.



The geospatial data market

To realise the promise of Geospatial 2.0, businesses, organisations and governments need to start considering geospatial data as a strategic asset, much like market and sales data, and develop a common geospatial framework that breaks down 'data silos' and opens up access to analytical tools and skills. Building Geospatial 2.0 requires agreeing on a common geospatial data framework to support a business environment that increasingly requires collaboration across enterprise.

The vision of the Government of the United Kingdom's Geospatial Strategy[3] addresses this issue; supporting the creation of a common data framework that underpins the geospatial data market. Furthermore, by choosing to align the strategy with the Integrated Geospatial Information Framework[4] (IGIF), and the government's national data strategy, the UK's Geospatial Strategy recognises the need for a common location data framework that is compatible with international policy, champion the achievement of the Sustainable Development Goals (SDG) and supports the UK ambition to meet the goals set out in the Industrial Strategy; growing the economy and addressing societal challenges such as climate change, emergency planning, an ageing society, clean growth and urbanisation.

The innovation challenge

In this paper, four non-technical trends, expanded upon in part two of this paper, are examined to provide an overview of the opportunity ahead of us. These core principles are central to maximising the benefits and utility of the opportunity that location data may offer. These are:

The collaborative economy

To create new value in the economy, geospatial analytics must become more interdisciplinary and move from a commercially competitive model to a collaborative one.

The geospatial community must utilise skills from across society, with a range of experiences – many of which will not come immediately from the GIS, space, or corporate worlds. It is only through a deep understanding of the specific needs and problems of users that technology-driven innovation can transition from R&D into the real economy.

In order to tackle global challenges and capitalise on market opportunities, we must also incentivise the sharing of data and collaboration. Building trust is crucial to breaking down data silos, and deliver new insights and shared value.

Thinking in systems

Our planet is a system-of-systems, and yet we often take a siloed approach to planning our built environment that hampers progress towards wider economic, social and environmental goals. There is a need for greater exchange between organisations to understand the impacts of their work beyond their system boundaries, to harness synergies and mitigate trade-offs, and to work together for the larger objective of further human well-being on Earth.

Let's imagine a UK smart city, powered by technology solutions providers – smart street lights from Cambridge-based *Telensa*, ride-hailing technology from London-based *Xooox*, traffic data and analytics from Leeds-based *Tracsis*, and (recently UK-approved) electric scooter software provided by Sweden-based *JoyRide*. Individually, these technology providers can all offer UK residents an improvement in quality of life on their own, but it is the integration of these activities as a holistic and interconnected suite of solutions that can create a positive impact greater than the sum of its parts.

3 Geospatial Commission (2020). The UK's Geospatial Strategy, 2020 to 2025. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/893455/Geospatial_Strategy_1920x1080.pdf

4 https://ggim.un.org/IGIF/overview

Collective Intelligence

To create new value in the economy, geospatial analytics must become more interdisciplinary. Technological advances have created a market opportunity, but we require a solution that is both qualitative and quantitative, drawing on a range of skills and experiences to unlock value.

To date, the geospatial industry has suffered from a technocentric and homogeneous approach. Technology experts are crucial in developing the innovative solutions that power our shift towards Geospatial 2.0 – from R&D, to launching start-up companies which utilise new cutting-edge technologies, but technology is not a magic bullet, and horizontally embedded solutions across multiple industries can easily become 'masters of none'.

The collective geospatial community must employ skills from across society, with a range of experiences – many of which will not come immediately from the GIS, space, or corporate worlds. It is only through a deep understanding of the specific needs and problems of users that technology-driven innovation can transition from R&D into the real economy.

Public trust

In business, the mining and monetisation of private data has increasingly been challenged by regulators, the media and the public. The Cambridge Analytica data scandal is an example of the dangers to businesses that work with data when ethics take a back seat to profits.

As we move into a new decade, there is an opportunity to redefine the relationship that we have with the data economy. Areas of innovation which are crucial to our collective future are already starting to see the benefits of geospatially-derived data – including spatial finance, electric and multi-modal mobility, smart cities, climate risk analytics and pandemics response.

Case study:

Singapore's transformation

Geospatial information has played an important role in Singapore's journey to becoming a smart nation. An area of focus in Singapore today is that of environmental sustainability. Increased vegetation can help to tackle air pollution and climate change, i.e. through carbon capture processes.

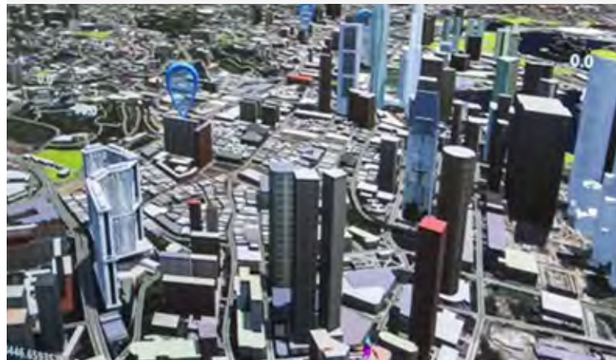
Using 3D mapping data including point cloud and images collected by the Singapore Land Authority (SLA)[5], and the National Parks Board (NParks), greenery planning and management has been taken to a new level. NParks, Singapore's lead agency for greenery, is now using geospatial data not only to locate, identify and earmark trees, but also to undertake predictive analytics for tree maintenance and inspection, park planning, tree banks and nursery management. These geo-enabled initiatives are contributing to their work towards realising their City in Nature vision, where greenery becomes an integral part of the country's urban environment.

Through GeoWorks[6], an industry centre established by SLA, Singapore will foster a vibrant geospatial community. GeoWorks aims to bring together different players and facets of the geospatial community in Singapore and beyond, to promote business growth and drive geospatial innovation. By the end of 2020, SLA will also be releasing its first public 3D city map, OneMap[7], a 3D-upgraded version of its existing OneMap platform, containing details such as government services and information.

5 www.sla.gov.sg

6 www.geoworks.sg

7 www.onemap.sg/home



02

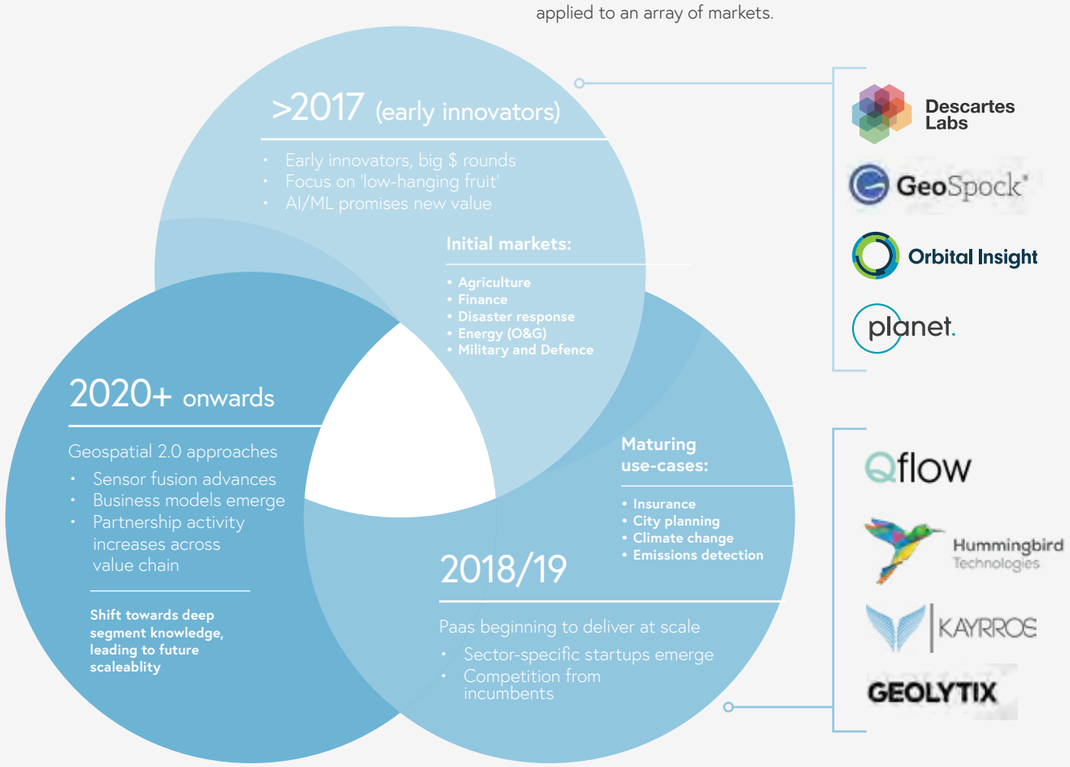
Building the geospatial value chain

Josh Gilbert, CEO at Sust Global

Geospatial is on the cusp of unlocking significant value across multiple industries. Advances in sensor fusion capability and emerging business models will soon lead to scalable, tailored geospatial products that can be applied to an array of markets.

In recent years, the field of geospatial analytics has emerged at the intersection of GIS, artificial intelligence (AI), and cloud-based computing. We have seen an evolution from a collection of tools for analysts to download, view and analyse, towards a scalable collection of cloud native capabilities that promise to deliver action-oriented insights to decision-makers across multiple industries.

To date, innovators in this emerging Geospatial 2.0 environment have focused on delivering a 'one-size-fits-all' platform-as-a-service (PaaS) for analytics, which are yet to provide consistent business value at scale. We posit that with recent advances in sensor fusion capability and emerging business models, we will soon have scalable, tailored geospatial products which can be applied to an array of markets.

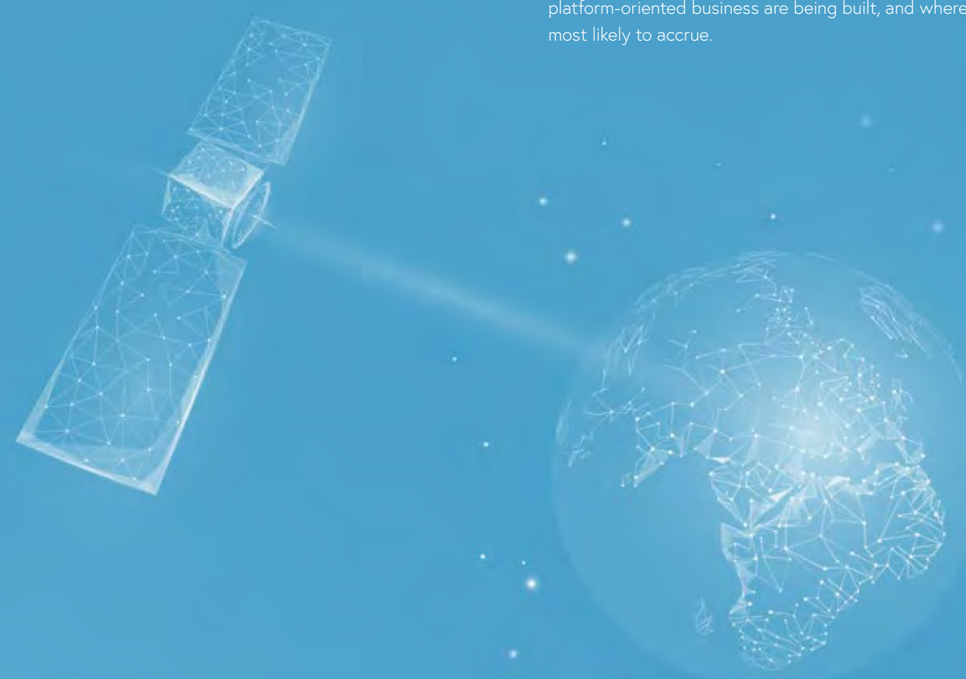


Technological enablers

High-quality, high-frequency EO data has historically been expensive and hard to analyse, with most demand coming from government and military analysts. This scenario has been changing over the past five years — smaller, smarter and cheaper satellites are being launched in greater numbers, greatly expanding access to data. Advances in AI and computational capabilities have led to software-based, cloud-enabled platform start-ups which process petabytes of imagery data to deliver business insights. Cloud-native processing and spatio-temporal analytics are key technical capabilities that enable this evolution.

A survey of market forecasts indicates the current size of the geospatial analytics market is somewhere between $35 billion[8] and $40 billion[9], with forward looking 5-year CAGR of 14–17 percent — and a market projected to hit $86 billion by 2023. While there has been an initial focus on 'low-hanging fruit' applications, such as precision agriculture, finance and defence, there are huge markets where uptake of geospatial products will drive billions of dollars in value, ranging from insurance, climate change, supply chain management and intelligent city management.

Looking at the value-chain, from geospatial sensors to end-users, we can identify the focal points where data-driven and platform-oriented business are being built, and where value is most likely to accrue.



8 www.marketsandmarkets.com/Market-Reports/geospatial-analytics-market-198354497.html

9 www.prnewswire.com/news-releases/geospatial-analytics-market-2018---global-forecast-to-2023-300637220.html

User personas

To unlock the value across the Geospatial value chain, it is crucial to understand the three user personas in Geospatial 2.0: The Developer, the Analyst and the Executive.

Traditionally, geospatial solutions providers have focused upon the Analyst and Developer personas, which have more often than not had previous experience with geospatial/GIS systems. But to unlock future value, the Executive business user must be understood.

Below is an outline of these three personas, and their differing usage and needs for geospatial data solutions:

Characterising geospatial analytics user personas

The Developer
We see the developer persona consuming geo-data inputs and building on them to deliver geo-aware and location-dependent applications and interfaces. The primary medium of delivery is via APIs often compliant with open geo-aware standards. These enterprise-facing APIs act as gateways to the cloud-native geospatial platforms being developed by Geospatial 2.0 entities.

The Analyst
The second persona is that of an analyst, looking at imagery and other sources of data in integration platforms like Earth Engine from Google, ENVI from Harris and ArcGIS from Esri. At times, analysts also use custom visualisation interfaces. Analytics can be served to these platforms through open geospatial standard interfaces too like WebTile Mapping Service (WTMS), Web Map Service (WMS) and Web Feature Service (WFS). This cohort is well versed in SQL and familiar with writing queries and creating reports for the purposes of business intelligence. They bring together different sources of imagery to create static maps or serve up intelligence reports.

The Executive
The third persona is one of an executive decision-maker. These users expect clear, refined signals often communicated through dashboards and time series. These users use business intelligence platforms like Tableau, Microsoft PowerBI or Google BI Engine.

In the Geospatial 2.0 landscape, technological and computational advances allow automated delivery of business insights directly to the executive persona. This new paradigm is a significant lever for the creation of business value, where previously hours of analyst work would be needed to provide this actionable data.

Evolution of geospatial platforms

The simplest form of platform-as-a-system (PaaS) is one that enables data for a small collection of data sources serving a specific set of use-cases targeting a single vertical. We see early examples of such PaaS solutions in precision Agriculture and disaster analytics.

The next order of complexity is using a small collection of data sources to serve insights in multiple verticals. Geospatial 2.0 PaaS would use a large collection of data sources to serve insights in multiple verticals.

The challenge for PaaS providers to date has been that in order to serve a wide collection of use cases, there exists a technical gap for harmonising data from multiple sensors together (a sensor fusion problem) and a solutions gap to address different forms in which insights can be consumed (an integration problem). These two issues can be broadly characterised as a technological problem, and a business model problem, respectively.

The solutions gap is the last-mile link, and final piece in the Geospatial 2.0 puzzle. By connecting geospatial PaaS with vertical-specific end-users, we will unlock scalable platform products that provide capabilities across verticals, and solutions engineering that tailor those capabilities to vertical-specific use cases. Herein lie the big opportunities, and winning strategies in Geospatial 2.0. We expect the rapid iteration and evolution of geospatial solutions to continue throughout 2020 and beyond, with unified platform solutions reaching technological and commercial maturity in the near future.

Challenges and opportunities

Despite a huge market and large war-chests of capital being raised, there is yet to be a breakout success in the cohort of Geospatial 2.0 companies.

The one-size-fits-all platform-based model of geospatial analytics tends to have been created by space-sector executives (for example, long-term employees of NASA, national research labs, and incumbent aerospace operators). These early-movers recognised the emerging technological trends, and raised venture-funding to scale rapidly.

However, in the rush for rapid scaling, Geospatial 2.0 products have been developed by tech-savvy developers and executives from government agencies. This has led to a technology-driven approach aimed at horizontal growth across verticals via a supply-side push of technology.

At the other end of the spectrum, niche application GIS consultancies have tended to be led by geographers/GIS experts, with a focus on analysts utilising point-and-click tools (e.g. Esri ArcGIS). Although these organisations are looking to integrate emerging geospatial technology (moving to the cloud, automation using AI), the innovator's dilemma means that there is a path dependency in place which inhibits real innovation.

Case study:

The Geospatial 2.0 value chain

A sample of the geospatial 2.0 value chain

Data sources

Data as a Service (DaaS)

These are data providers with source specific interfaces serving raw, semi-processed and processed geospatial data for search and download through simple APIs. These DaaS players mostly represent incumbent market leaders with lineage in hardware such as satellites and different types of onboard sensors. We are also seeing some early multi-source data aggregators for sector-specific applications and location-based services.

Solutions and services

Smart aggregators (vertical focused)

These are vertical focused aggregators of relevant data, applying geospatial solutions to a specific market use-case. Today, most of these aggregators have vertical specific expertise and vertical focused partnerships to source the right data for the analytics problem to be solved from upstream DaaS providers. We are seeing some very potent smart aggregators bringing together data operations expertise and machine learning prowess to solve unique challenges in specific verticals like precision agriculture, energy and utilities and mapping.

Platforms

Platform as a service (vertical agnostic)

Platforms charge for using hard coded pre-developed features. Platforms are paid (gated) or freemium to enable subscription businesses. Like preconfigured basemaps, specific radiometrics and geometric collections, etc. Platforms serve users in many different verticals. They help partners and customers build solutions. We are seeing traditional desktop tools like ArcGIS and ENVI create bigger platform plays with cloud native processing and next generation cloud-based workflows.

Market places

Multi-source / multi-vertical

Marketplaces make it easy for users to engage with their platforms, and aim to reduce the friction to discover new capabilities and experiment with them. Marketplaces bring together datasets, processing chains and expertise to enable creation of third-party applications.

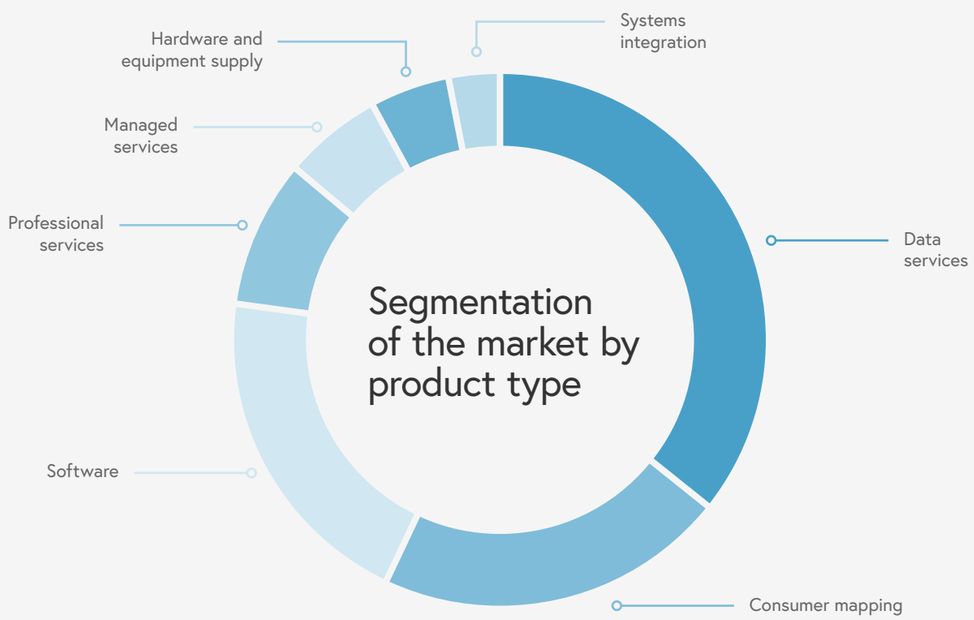
03

Current trends in the geospatial data market

Andrew Coote, CEO at ConsultingWhere

Market research suggests the supply-side UK geospatial data market was worth £2.1 billion at the end of 2019.

The market for geospatial data and services has been growing rapidly. The supply-side component of the market was estimated to be worth £2.1 billion in 2019, growing roughly 12 percent per year since 2017. Segmentation of the market by product type shows the continued dominance of data services, predominantly data acquisition and processing. However, the consumer mapping component of the market is growing, with Google and Garmin prominent in the Top10 revenue contributors.

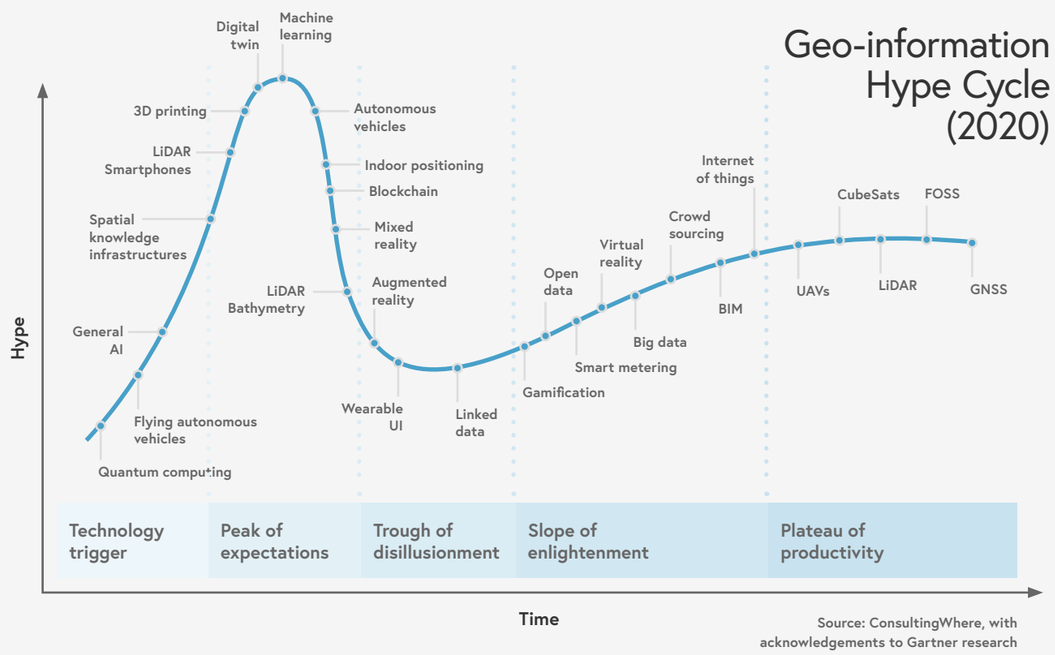


Larger companies covering multiple segments such as *Esri (UK)* and *Hexagon* have shown double-digit year-on-year increases over the last two years despite the political uncertainty since the EU referendum. Esri (UK) has grown organically but with a shifted focus based on many of the advances that characterise Geospatial 2.0, particularly moving to PaaS and positioning itself as delivering insight. Hexagon's growth has been more significantly driven by acquisition adding specialist equipment rental company SCCS to its portfolio of companies that already includes Leica Geosystems (including Erdas) and Intergraph.

There are an increasing number of new entrants exploiting a wide range of innovative use cases. Although their UK revenues are currently relatively small there are large opportunities in sectors such as financial services, defence and construction for them to thrive in well-defined niches. We would pick out *Geospock*, the Cambridge-based AI specialist and geospatial information platform provider *Orbital Insight* as companies to watch.

For the first time, ConsultingWhere have also estimated demand-side value i.e. the wider economic impact of location in generating additional revenue and facilitating cost savings elsewhere in the economy. They calculate the current value added at £10-15 billion per annum.

Their analysis of technology trends identifies three advances and a key challenge that are likely to shape the market over the next 3-5 years. These are based on the analysis of a much wider range of trends framed in terms of the Hype Cycle, originally conceived by Gartner.



Source: ConsultingWhere, with acknowledgements to Gartner research

Acquisition technology

Advances here will continue to be a game changer, resulting in an over-abundance of location data. The increasing capabilities of Unmanned Aerial Vehicles (drones) to operate "over the horizon" and support greater payloads will compete with sub-metre resolution, daily revisit EO imagery delivered from constellations of much smaller and cheaper CubeSats. This will drive competition and reduction in unit costs. Location data will become 3D by default and development of digital twin software designed primarily for architecture, engineering, and construction will "spill-over" into other markets. To this can be added the impact of the Internet of Things (IoT), particularly public infrastructure and LiDAR sensors in smartphones and connected vehicles.

Actionable insights

This will be driven by developments in machine learning, neural networks, edge computing and PaaS. We don't expect to see the emergence of general AI in this timeframe, but progress will be made in more generic approaches to machine learning and the recognition in the wider Information and communications technology (ICT) community of the value of spatial analysis.

Personal augmentation

Through the Virtual, Augmented and Mixed Reality, whether implemented through wearable User Interfaces such as Microsoft's *HoloLens 2*, watches or smartphones will make many new use cases practical. Their incorporation into devices designed for personal use will make them cost-effective for businesses to adopt. We can expect mixed reality applications for sub-surface utility location and city planning to lead the adoption of this technology.

Data privacy

Set against these great opportunities for industry growth are increasing concerns over location data ownership and location privacy. The movement to challenge the social media, mobile operators and financial institutions who resell location data and the government role in policing anonymisation will gather strength. Location privacy will be weaponised by the tech giants, such as Apple, and will potentially lead to legislation that could slow what Gartner refer to in their Top10 Technology trends for 2020 as democratisation. To this we need to overlay cyber-security, where the heterogeneity of geospatial data and its power to integrate poses some unique challenges.

Case study:

The space data revolution

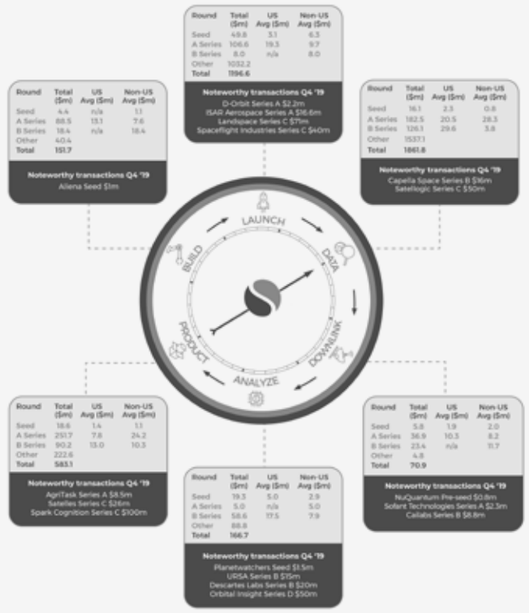
2019 marked the first year that the 'downstream' data capture and delivery segment of the space industry eclipsed the 'upstream' launch category, with investment of $1.86bn versus $1.2bn respectively, according to a report from Seraphim Capital[10].

It was a record year for the space industry with the Seraphim Space Index showing a yearly rise on investment in the sector by 21 percent. Total investment rose to $4.1bn during the year up from $3.25bn in 2018 and $2.5bn in 2017. The investments centred on the space industries that dealt with data capture and delivery, and the rise of companies looking to capitalise on the growth in demand and capability of downstream services.

Seven-year-old start-up *One Web* closed a $1.25bn round of funding to build a worldwide internet delivered from space in 2019. Despite such a strong year, the firm's future is now in doubt following financial difficulties partly due to the market turbulence related to the Covid-19 pandemic. As of March 2020, the firm is seeking a rescue takeover bid and new investors.

SpaceX raised $536m in 2019 and commenced the start of its own broadband constellation launching a record 120 satellites in 2019. Tech giants Amazon and Apple both joined the space race planning their own broadband constellations.

Other notable investments in the data segment of the space industry include $100m investment in Japanese start-up *Synspective* to develop their radar network and $70m in *Hawkeye360* to develop their Radio Frequency mapping platform. UK company *Rezatec* secured £5m in funding in 2020.



Source: Seraphim Capital

10 www.seraphimcapital.co.uk/insight/news/seraphim-global-space-index-shows-21-year-year-growth-january-2019-december-2019

Part two:

The innovation landscape

04

Innovation is a collaborative process

Luca Budello, Geospatial Insights Lead at KTN

We need to shift from an economy based on siloed intellectual property and competition to a more collaborative economy based on information sharing.

New services that combine novel business models with technology are emerging, often disrupting legacy industries.

The flagship examples of the sharing economy that appeared in the 2010s like Airbnb, and Uber, combined mobile app technology and a business model that created user-providers. Now we are seeing an altogether different trend. The need to address global challenges is leading to an understanding that no one organisation has the expertise or skills to solve significant problems alone. A new era of collaborative economy is dawning.

Sharing ideas

The idea of sharing ideas is not new, and one that has worked successfully for decades via licensing models. ARM, the processor design company behind much of the world's mobile processor market, operate a business model whereby their designs and their design architecture are licenced for others to manufacture. Similarly, Rolls-Royce, the aerospace manufacturer, operates both the licencing-out of its technology, and licencing-in of external inventors, facilitating a mechanism of sharing ideas without open sourcing them. These highly lucrative models work on an understanding that greater value can be achieved across the supply chain with different organisations playing different roles to get a single product or service to market.

Then there is the open-source software community. The movement, which started out as a niche community of developers sharing code on platforms like GitHub, now has several viable business models, and has overhauled the software world with Linux's success in the server market and IBM's 2018 acquisition of Red Hat, a highly profitable open software delivery business.

Open data

The data economy is undergoing similar changes to the software industry with the growing popularity of open data tools and the economic opportunities they present. For example, Transport for London has contributed £14 million in Gross Value Added[11] to the London economy and helped kick-start successful companies such as *CityMapper* by opening its location-based data to the public.

The Copernicus Open Access Data Hub provides EO data collected by the European Space Agency's Sentinel satellites free of charge, while also delivering an estimated 30 billion Euros in value to the European economy by 2030[12].

The Copernicus dataset has caused rapid and extensive uptake of EO data and data analytics. Public sector open-access projects like this drive innovation, but also present challenges for smaller players trying to enter the market. Geospatial 2.0 applications can add value by embracing both public and private data. For example, EO data can be augmented with higher resolution data sets collected by ground-based sensors to deliver insights for everything from precision farming to defence.

When different data sets are joined up and combined with geospatial data, enormous value can be achieved. To help facilitate this, the Geospatial Commission have improved access to public sector data for anyone, as outlined in the national geospatial strategy[13].

Digital Twins: digital representations of assets, processes or systems in the built or natural environment, combine data usually stored in multiple formats and locations by many organisations. The 'big picture' overview they provide of how networks intersect and interact, enable more joined-up planning of infrastructure and decision-making, ensuring systems work together to deliver wider benefits. In addition to efficiency gains, they can also be used to make communities safe and liveable, reduce waste and pollution, boost quality of life and fuel growth, productivity and prosperity.

11 www.nic.org.uk/wp-content/uploads/Data-for-the-Public-Good-NIC-Report.pdf

12 www.ec.europa.eu/budget/library/biblio/documents/2019/Programmes_performance_overview.pdf

13 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/894755/Geospatial_Strategy.pdf

Building trust

Technologically, it's clear we have the ability to share data on a big scale. But there remains a significant barrier to achieving a truly collaborative economy: incentivising data owners to share their data. Digital Twins and similar collaborative efforts will not function effectively without solving this challenge.

Currently, data owners are not incentivised to de-silo data and make it available, because there is an absence of trust that they will be able to easily share the value being created with it.

What's more, reconciling the different needs and priorities of large numbers of stakeholders can be seen as challenging when there is no guarantee of collective gain.

Building trust for effective large-scale data sharing can be made possible through cloud-based collaboration platforms, that can be used to share, aggregate and analyse data, and develop solutions together. Such platforms give organisations a clear transparency and understanding of the value derived from working together.

One such example of achieving shared value can be found in the UK's Geospatial Commission's effort to bring together existing data on underground pipes and cables to create a National Underground Assets Register[14]. To build trust, a secure prototype data exchange platform was created that all of the partners input into and can benefit from. The prototype provides a digital view of where assets are located to help planners and field engineers carry out safe excavations.

The pilot phase showed that buried infrastructure data can be shared without compromising privacy, competitiveness and security whilst proving the potential economic benefit.

The future of data sharing

The emergence of blockchain and distributed ledger technology could help to further build trust and incentivise data owners to share data, as it can log where intellectual property was created across a supply chain to distribute value accordingly. Resolving the 'trust issue' in this way would open up significant opportunities to create new value through data sharing and pave the way to a wave of new products and services.

The value of greater collaboration is financial, but also about delivering greater benefits to society. This is especially true in the era of Covid-19, when sharing information is being prioritised over generating profit from it. Global challenges we face, such as air pollution and climate change require greater collaboration, across sectors and sharing the resulting benefits: no one organisation can solve them alone.

Recognising that both industry and society can reap greater benefits through the pooling of expertise and resource, the UK government has structured new funding calls around collaborative projects. The Innovate UK Industrial Strategy Challenge Fund works on this model, making collaboration with other organisations part of its eligibility criteria for funding for projects tackling everything from disease detection to the energy revolution.

14 https://www.gov.uk/government/publications/national-underground-asset-register-project-update

Case study:

The National Digital Twin

Mark Enzer and Miranda Sharp from the Centre for Digital Built Britain's (CDBB) National Digital Twin Programme.

Over time infrastructure has become a set of complementary and interdependent systems: transport, energy, water and communications are individually essential assets, but it is the connections between them that enable communities to thrive, quality of life to flourish, and economic growth and productivity to progress. Managing these systems effectively requires a paradigm shift, because silos in policy, decision-making, development, regulation and operation lead to sub-optimal outcomes for citizens.

The Centre for Digital Built Britain's (CDBB) Digital Framework Task Group (DFTG) was launched in 2018 to facilitate and enable industry alignment required for effective information management across the built environment. Its Gemini Principles seek to establish consensus on the values required to guide the development of the National Digital Twin (NDT)[15] and its Roadmap suggests the approach that should be taken to deliver an information management framework for the built environment. These initial steps are the result of collaboration between government, industry and academia and pave the way for the development of the NDT, an ecosystem of digital twins connected by sharing data securely. CDBB's Digital Twin Hub is building a digital twin community to share experience, opportunities and benefits[16].

Collaborating on this shared vision will result in shared benefits. Society will secure better social, economic and environmental outcomes per pound of investment. Users will enjoy better-performing infrastructure, which will also lead to economic benefits. For the environment, it should mean less waste, less disruption, more re-use and greater resource efficiency as well as lower carbon emissions. And for business, it means growing a whole new market that is built around developing, using and connecting digital twins.

15 University of Cambridge (2018). Gemini Principle. Available at: www.cdbb.cam.ac.uk/DFTG/GeminiPrinciples

16 www.cdbb.cam.ac.uk/DFTG/NDTHub

Case study:

Whim

Since 2016, Helsinki has been the testing ground for Mobility-as-a-Service app ***Whim***, developed by MaaS Global, and subsidised by the state. Whim subscriptions provide access to the Finish capital's transport networks, including public transport, electric scooters, public bike rental, cabs and car hire all through a single app.

The success of the platform has seen enormous value created in a relatively short space of time, and has attracted investment from major mobility players Mitsubishi. Whim's core offer is a direct challenge to vehicle ownership, and is marketed as such[17].

Described as the "Netflix for transportation"[18], Whim has attracted major investment: its November 2019 round of funding was worth €29.5m, including the buy-in of mobility giant Mitsubishi.

MaaS services that connect multiple data sources require collaboration through the sharing of data. The future of the collaborative economy relies on the development of new mechanisms to incentivise trust-building and the development of a system for the creation of common, shared intellectual property.

17 www.medium.com/sidewalk-talk/whim-is-a-mobility-app-with-a-modest-proposal-give-up-your-car-f2db0bf2ba65

18 www.forbes.com/sites/carltonreid/2019/03/28/netflix-of-transportation-app-reduces-car-use-and-boosts-bike-and-bus-use-finds-maas-data-crunch/#2d52aa954923

05

The emergence of thinking in systems

Caroline Zimm, Research Scholar at International Institute for Applied Systems Analysis (IIASA) and The World in 2050 (TWI2050)[19]
Nebojsa Nakicenovic, Emeritus Research Scholar at IIASA and Executive Director of TWI2050
Gary Cutts, Challenge Director, Future Flight at Innovate UK (IUK)

Geospatial data and the developments that characterise Geospatial 2.0 provide a thread that will link disparate systems into a comprehensive system-of-systems fit for the future.

Our world – people and planet - is strongly interconnected, a delicate interlinked system-of-systems. Our infrastructure is a good illustration of this, consisting of various systems, providing water, power, transport and connectivity. These systems exist to provide commodities and services to individuals and society as a whole, and each system relies on the others to effectively function. The Earth system is also a system-of-systems, with our climate, biodiversity and nutrient cycles, for example, all influencing and depending on each other. Integrating our understanding of how different systems are interconnected across time and space is what systems thinking is about.

Understanding interactions across systems

When planning human systems, many decisions are still taken in silos – be it in industries, within academia, or in the ministries of government. Out of habit and institutional settings, we often focus on individual sectors, technologies and products that solve single problems. Although we understand each problem and solution, we do not manage them as a whole. As a result, the systems we are left with do not have a strategy for interconnections, resilience or long-term outcomes[20]. For example, the development of a power plant may provide a lot of short term job opportunities and additional electricity to stabilise the grid, but may not consider the needs of the local residents, the environmental impacts and long-term power generating capacity in view of climate change.

The impacts of activities in one area on another are marginalised, which leads to trade-offs when multiple goals are being tackled, and potential synergies being overlooked[21]. This can create a lack of resilience to shocks or changes that can affect the whole system. The Covid-19 pandemic, for example, has shown that resilience in many human systems, such as our economic system, is low and that knock-on effects happen quickly even in the short term. Similarly, global challenges like mitigation of climate change and reaching Net Zero are systemic and will require a system-of-systems approach to solutions[22].

To improve resilience, we need to look at the system as a whole, understanding the trade-offs incurred with every decision, and the relationship between different factors. Geospatial data is crucial to developing this understanding, as it provides a link between physical assets and the digital world, that allows the monitoring and modelling of supply and demand in systems, and their impacts on each other, in real time.

Geospatial data provides a common thread between data sets, a framework for them to be managed collectively, building actionable insights about the system-of-systems as a whole.

Focusing on the users' needs

At the core of our actions lie human needs[23]. Our systems should thus serve humans, not the other way round. Infrastructure, science, the economy, products and services are all there so humans can flourish. While humanity has advanced greatly, these advances are distributed unequally and have led to growing environmental impacts. A focus on a human centric approach facilitates thinking in systems and relationships across systems. This in turn encourages interconnected outcomes – social, environmental and economic[24] – as they are at the core of human needs.

Traditionally, the focus in many sectors has been on supply side technologies to provide goods and services that address arising challenges and human needs[25]. When we think of innovation, often a technological device comes to mind. But innovation can also be social or institutional, and not every problem needs to be tackled with a new supply-side technology. Innovation is at the core of human development and we need technological, social and institutional innovations now more than ever for a sustainable post-Covid-19 recovery[26].

Behavioural change can have great impacts across systems, for example, car sharing and its impact on mobility services, or a shift to telecommuting and home office and its impacts on office spaces, urban planning and transport needs. Small scale end-use technologies such as electric scooters or mobile phones, have been shown to spread rapidly[27], accelerating change, leading to the emergence of new systems and society-wide behavioural changes.

By taking a more human focused approach when designing systems, and being led by the macro needs of humanity, we can ensure they are more interoperable, resilient and work together to achieve long term outcomes.

19 The World in 2050 (TWI2050) is an international scientific initiative hosted by the International institute for Applied Systems Analysis (IIASA) that investigates integrated pathways for a sustainable future, acknowledging interactions across human and Earth systems. This chapter is based on several TWI2050 reports to which many authors contributed, more information at: www.twi2050.org

20 University of Cambridge (2020). Flourishing Systems - Re-envisioning infrastructure as a platform for human flourishing, available at: www.cdbb.cam.ac.uk/files/flourishing-systems_final_digital.pdf

21 TWI2050 (2018). Transformations to Achieve the Sustainable Development Goals. Report prepared by the World in 2050 initiative. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria Available at: http://pure.iiasa.ac.at/15347

22 University of Cambridge (2020).

23 TWI2050 (2018). Transformations to Achieve the Sustainable Development Goals. Report prepared by the World in 2050 initiative. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria Available at: http://pure.iiasa.ac.at/15347

24 University of Cambridge (2020).

25 Wilson C , Grubler A , Bento N, Healey S, De Stercke S, & Zimm C (2020). Granular technologies to accelerate decarbonization. Science 368 (6486): 36-39. DOI:10.1126/science.aaz8060

26 TWI2050 (2020). Innovations for Sustainability. Report prepared by the World in 2050 initiative. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. Forthcoming, July 2020.

27 Wilson C , Grubler A , Bento N, Healey S, De Stercke S, & Zimm C (2020).

Digital technologies helping systems thinking

In order to put systems thinking into practice we must develop tools, and the capacities to use these tools, to provide insights and drive actions across systems. New technologies, facilitated by advances in data science, are set to completely transform our lives in the coming years – ideally for a sustainable future for all[28]. Improved data can be used for better and more targeted policies in providing basic services to the poor, eradicating pollution and leading us to a safer, cleaner and just future.

Identifying problems and providing solutions to challenges can be augmented by the emerging geospatial knowledge infrastructure that transcends individual sectors or verticals. For example, geospatial data could underpin a system-of-systems approach to ports that provides greater efficiency to the maritime sector, reduces carbon emissions and speeds up the supply chain for international goods, better serving end users by combining data on the location and speed of ships, weather patterns, port operations and the availability of vehicles on land. Adopting such a holistic system-of-systems approach to the whole process would be of greater benefit than a sector-specific solution focusing on an individual industry or technology.

Building the future

Humanity is at a crossroads. Unbounded growth is endangering planetary support systems. Inequalities are increasing. Our established way of life has been challenged by a pandemic. Humans, as the current drivers of planetary change, are charged with the responsibility of ensuring the resilience of the systems we operate in[29]. When we put in the effort to understand how systems are connected – and integrating geospatial data will helps us greatly in this endeavour – we will be able to build the future we want[30].

The capabilities and tools to enable such a paradigm shift are already becoming available. But there is a need for greater exchange between organisations to understand the impacts of their work beyond their system boundaries, to harness synergies and mitigate trade-offs, and to work together for the larger objective of further human well-being on Earth[31]. The move towards greater use of electric vehicles, for example, will clearly need a strategy that is shared between the transport and energy sectors, in terms of funding and responsibility for charging infrastructure, trade-offs between electricity supply and demand, and impacts on human behaviour[32].

Institutions are often lagging technological developments and are overwhelmed by the increases in available data and cannot account for all interconnectedness.

We need to shift away from supply-side thinking and make human wellbeing our starting point.

It will become increasingly difficult to sustain infrastructure and society unless the system itself becomes sustainable, secure and resilient[33].

28 TWI2050 (2019). The Digital Revolution and Sustainable Development: Opportunities and Challenges. Report prepared by the World in 2050 initiative. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. Available at: http://pure.iiasa.ac.at/15913/

29 Nakicenovic N , Rockström J, Gaffney O, & Zimm C (2016). Global Commons in the Anthropocene: World Development on a Stable and Resilient Planet. IIASA Working Paper. IIASA, Laxenburg, Austria: WP-16-019. Available at: http://pure.iiasa.ac.at/id/eprint/14003

30 TWI2050 (2018).

31 TWI2050 (2019).

32 IEA (2019) Global EV Outlook. Available at: www.iea.org/reports/global-ev-outlook-2019

33 University of Cambridge (2020), p8.

Case study:

The future of aviation

The UK Research and Innovation's Industrial Strategy Challenge Fund Future Flight programme is designed to accelerate the provision of new aviation management systems.

A likely future scenario would entail more use of autonomy both for traffic control and piloting aircraft. In urban environments air taxis will soon operate in close proximity to delivery drones. A new approach is needed to manage an increase in and diversification of air traffic. This requires the creation of a whole new regulation framework which must fit into the global aviation traffic management system already in place. New classes of vehicles, such as Urban Air Mobility (UAM), will require places to land in dense urban environments, so the system must encompass novel physical infrastructure, as well as communication between aerial and land-based traffic management systems, and integration into land-based logistics and transport networks, to ensure the system meets human needs.

The introduction of electric and autonomous aerial vehicles will be gradual, meaning a partially centralised and partly autonomous system will emerge that takes into account human pilots and existing aircraft. The future of aviation will require a wide range of technologies from batteries, to autonomy, to control algorithms and digital infrastructure, as well as significant behaviour change. The Future Flight Challenge is working to bring these together as a combined system-of-systems. Vehicles and airspace management systems will be dependent on geospatial data and will form part of the Geospatial Mesh as they enter service.

06

Collective Intelligence – harnessing minds and machines for Geospatial 2.0

Aleks Berditchevskaia, Senior Researcher at Centre for Collective Intelligence Design, Nesta

At its simplest, 'collective intelligence' can be understood as the enhanced capacity that is created when people work together.

Collective intelligence emerges when people work together, often with the help of technology, to mobilise a wider range of information, ideas and insights. These contributions are combined to become more than the sum of their parts for purposes ranging from learning and innovation to decision making.

Collective intelligence emerges when people work together, often with the help of technology, to mobilise a wider range of information, ideas and insights[34]. These contributions are combined to become more than the sum of their parts for purposes ranging from learning and innovation to decision making.

Collective intelligence covers a wide range of participatory methods, including crowdsourcing, open innovation, and citizen science. Some of them rely on competition, while others are built on co-operation; some create a sense of community and teamwork, while others operate on the basis of aggregating individual contributions or microtasks.

Although collective intelligence has been around for a long time, drawing on the insights and skills of a widely distributed network of individuals was difficult to coordinate and integrate before the 21st Century. This led to some crowdsourcing efforts being sustained over years or even decades[35].

In recent years, these technological innovations have scaled up and accelerated the potential impact of collective intelligence in at least three ways, which are detailed below.

Leveraging novel data sources

Novel data sources with geographical attributes have proliferated in the last 10 years due to the availability of cheap mobile sensors that have GPS tracking capability and commercial satellites. Much of this data is generated by individuals through mobile phones.

These data can act as proxies for the tracking of migration and economic activity. For example, the UN's Global Pulse Innovation Lab has used aggregated call detail records to better understand population dynamics in response to environmental disasters[36]. When these kinds of insights are generated as a crisis unfolds in real-time, they can be used to enable more efficient coordination and allocation of resources by and between response agencies[37]. Such efforts are often reliant on public-private partnerships or data collaboratives, where telecommunications companies grant access to anonymised data[38].

Other emerging data sources include the aggregate contributions from crowdsourcing and citizen science schemes. These projects typically rely on environmental observations from large, geographically distributed volunteer communities[39].

Another key innovation opportunity for Geospatial 2.0 comes from opening up access to datasets. For example, the data collected by the European Sentinel satellites is available for free use by both businesses and researchers[40], which has stimulated entrepreneurship and enabled the exploration of new questions in basic science. The data-driven agriculture company *OneSoil* is an example of both service and product innovation that has benefitted from open data. They offer an integrated predictive analytics and decision making platform that helps farmers across the world better manage their crops and coordinate with their teams. Their platform identifies field boundaries and monitors crop health using data derived from the free Sentinel satellite images in combination with data from in-situ sensors contributed by farmers.

34 Peach K., Berditchevskaia A., Bass T. Collective intelligence design playbook. 2019. www.nesta.org.uk/toolkit/collective-intelligence-design-playbook

35 The complete first edition of the Oxford English Dictionary was crowdsourced over a period of approximately 70 years.

36 UN Global Pulse. Mobile phone network data for development. 2013 http://beta.unglobalpulse.org/wp-content/uploads/2013/10/Mobile-Data-for-Development-Primer_Oct2013.pdf

37 Such as the real-time flood monitoring platform Peta Bencana. www.globalinnovationexchange.org/innovation/petabencana-id

38 Verhulst, S., Susha I., Kostura, A. 2016. http://medium.com/@sverhulst/data-collaboratives-matching-demand-with-supply-of-corporate-data-to-solve-public-problems-dc75b-4d683e1#.wq7bnrtue

39 See et al, 2016. Crowdsourcing, Citizen Science or Volunteered Geographic Information? The Current State of Crowdsourced Geographic Information. www.mdpi.com/2220-9964/5/5/55

40 http://scihub.copernicus.eu/dhus/#/home

Connecting distributed knowledge

Technology infrastructures such as social networking sites and online information repositories are changing how groups of people interact with one another to combine, share and reuse knowledge. One of the best-known examples of sharing geospatial information is the Open Street Map project which has been used by researchers, charities and grassroots projects to mobilise volunteers to carry out crowd-mapping[41].

In order to ensure that collective intelligence builds over time, communities typically build shared resources and tools[42] using open repositories like GitHub or collaboratively document their protocols through project Wikis. These knowledge sharing tools function as a source of collective memory and allow for networked learning to take place[43].

Industry is also benefiting from the technological architecture that gathers volunteered geographic information from many users. For example, the route-planning app *Waze* taps into real-time crowdsourced information about traffic disruption to update recommended routes and help commuters navigate to their destinations. IBM's GRAF weather system supplements its weather predictions with observations by citizens to generate locally-relevant forecasts.

The meeting of minds and machines

Our ability to process the geospatial data continuously generated by sensors, satellites and people quickly runs into processing limits, even when hundreds or thousands of volunteers or workers are mobilised to help with analysis.

To make the most of the Geospatial 2.0 opportunity, diverse and distributed human intelligence needs to be complemented by new machine capabilities that analyse data at unprecedented scale and speed[44].

Advances in AI techniques are helping geospatial collective intelligence initiatives achieve enhanced impact. Some of the methods being used include statistical machine learning algorithms that categorise and discover correlations in large structured datasets such as call detail records, as well as newer methods such as deep learning that can analyse and identify features in complex high-dimensional unstructured data such as satellite images. For example, the projects run by the Humanitarian Open Street Map Team have started to integrate a new AI-enabled tool, *RapiD Editor*, which uses a Computer Vision algorithm to make online image labelling tasks easier for their volunteers. This combination of AI and a motivated volunteer community has resulted in more efficient and higher completion rates of tasks, as well as improving the accuracy of crowd-mapping for human relief.

The potential of 21st century collective intelligence is impressive but it can be difficult to develop and implement these systems whilst ensuring widely distributed benefit. To make the most of Geospatial 2.0 will require thoughtful design and new models of collective governance and data justice[45]. Only then will we be able to apply collective intelligence towards solving some of the most pressing problems that we face, from climate change to social inequality.

41 Mooney P., Minghini M. and 2017 A review of OpenStreetMap data. In book: Mapping and the Citizen SensorChapter: 3Publisher: Ubiquity PressEditors: Giles Foody, Linda See, Steffen Fritz, Peter Mooney, Ana-Maria Olteanu-Raimond, Cidália Costa Fonte and Vyron Antoniou.

42 Benkler et al. Peer Production A Form of Collective Intelligence. In: MIT Handbook of Collective Intelligence, 2014. www.mako.cc/academic/benkler_shaw_hill-peer_production_ci.pdf

43 Goodyear et al Research on networked learning: An overview. http://link.springer.com/chapter/10.1007/1-4020-7909-5_1

44 Berditchevskaia A. and Baeck, P. The Future of Minds and Machines. 2020. www.nesta.org.uk/report/future-minds-and-machines/#content

45 Haklay, M., and Francis, L., 2018. Participatory GIS and community-based citizen science for environmental justice action, in Chakraborty, J., Walker, G. and Holifield, R.(eds.), The Routledge Handbook of Environmental Justice. Abingdon: Routledge, pp. 297-308

Case study:

KTN Innovation exchange

KTN-iX™ (KTN-innovation eXchange) is an innovation transfer programme that crowdsources knowledge from the business community to enable faster development of novel solutions. It matches large businesses tackling industry challenges with innovative companies from other sectors to develop innovative solutions.

KTN-iX™ is delivered by Knowledge Transfer Network, who has worked with key industry stakeholders to identify specific innovation challenges through a series of 'guided innovation' workshops. The challenges predominantly focus on near-term issues that could provide incremental progress in the developments within these growing sectors.

Successful solution providers in industry or academia are given a commercial opportunity to deliver their solution and receive support from KTN and the wider Innovate UK network.

KTN-iX has worked with Siemens Gamesa Renewable Energy to identify solutions to their innovation challenges including logistics management of large wind turbine component movements around port facilities. They wanted to identify solutions to track the movements, storage locations and maintenance activities of large wind turbine components, as well as a system for recording and storing this operational data with functionality to utilise it in various planning and reporting activities, including cost-tracking, performance analysis, scenario planning and data visualisation.

07

Gaining the public's trust

Ben Hawes, Director, Benchmark Initiative

While Geospatial 2.0 unlocks lots of opportunities for innovation, it also introduces risks around privacy and ethics that have a bearing on the public perception of geospatial-enabled technology.

Because location data is a fundamental enabler of technology and digital services, it is becoming so ubiquitous that we barely notice our reliance on it. Geospatial data, along with temporal data, are the two metadata categories that can link all the other data we generate, consume and transmit.

Location data can reveal personally identifiable information (PII), even when anonymised, especially when combined with other data types. It takes just four points in time and space to identify individuals[46]. As a New York Times investigation found, there is a market worth $21 billion per year in the US in collecting and trading the location data of smartphone users, often without their knowledge[47].

Low consumer trust is a challenge for companies and governments that provide digital services based on location data. It also raises difficult issues for consumers themselves, who rely on apps they may suspect are unreliable custodians of their personal data. Consumers are often unsure how many companies track their location, or what use they make of that data. There are no common guidelines for following good practice, or yardsticks to judge practice against.

This is why *Benchmark* is partnering with the American Geographical Society's *EthicalGeo* programme to launch international collaboration on a new global charter to guide the responsible use of location data[48]. The objective of "The Locus Charter" is to define what good practice is, in ethical use of location data, and provide guiding principles to assist practitioners and decision-makers in the development of applications.

Tracking software

Research has shown up to 90 percent of apps have tracking software inserted into their code, known as third-party trackers, that allows them to collect location data. The privacy, security and legal implications of third-party trackers are far reaching.

Geospatial 2.0 is enabling new markets to emerge, and is shifting the balance of power in existing markets. These changes have implications for existing industries. For example, Uber gives new opportunities to users and drivers, while impacting incumbent taxi services, but at scale it can also change a city, what people do in it, and how we plan transport.

46 www.phys.org/news/2013-03-easy-identity-cell.html
47 www.nytimes.com/interactive/2018/12/10/business/location-data-privacy-apps.html
48 www.ethicalgeo.org/introducing-the-benchmark-initiative

New market powers

When new markets and new market powers emerge, there follow questions about who exercises that power, and in whose interests. To realise the potential benefits to the public from developing geospatial technologies at scale, there is a moral imperative to protect the public, but also an economic imperative to gain public acceptance of these technologies.

There is a strong risk of the public reacting against overly intrusive mapping of their lives, if they feel that spatial applications are things that are done to them, rather than for them.

While many smartphone users are aware in principle that their movements are tracked, by and large they have no idea of which companies are using that data or why. Companies track users to predict and then to influence behaviour, and this tracking will not always align with the public interest. Transparency and equitable treatment are reasonable expectations for the public to have, or they may rightly react against "data colonialism" exercising new kinds of control and influence over them.

The pace of technological change in recent years has sometimes left ethics as an afterthought. There are costs to this for companies, as Facebook discovered in the aftermath of the Cambridge Analytica data scandal.

For geospatial professionals to benefit from the opportunities of a data-rich environment while maintaining ethical standards, it's important to develop practical ways of addressing the ethical questions that arise, and to learn from other sectors that have been grappling with similar questions.

Lessons from cybersecurity

Cybersecurity is a highly successful subsector built around management of risks, and there are lessons to be learned here for geospatial practitioners. Data privacy concerns are similarly supporting commercial opportunities for innovators who address them. In the case of Apple, privacy has arguably arisen from an incidental part of the company's ecosystem to among its major attractions.

We may see a similar pattern arising across applications of geospatial data, with markets developing for responsible practice with transparency at their core. The value of geospatial-enabled services, both to the economy and to the public is clear. Getting directions, hailing a cab or ordering food is easier and cheaper than ever before. It is in the interest of the companies that make up the geospatial value chain to win the trust of their users. Tech companies, regulatory bodies[49] and the government each have a role to play in establishing and maintaining this trust.

Pandemics and emergency powers

During the Covid-19 pandemic, a number of governments and technology companies launched various tools to monitor the movement of people during the lockdown[50]. Reports surfaced that Israel had repurposed a vast and previously undisclosed database of cellphone tower data, collected for counter-terrorism purposes, to track the movements of people who had contracted the virus in order to identify others who may have come into contact with them[51]. Google began to release 'mobility reports' on public spaces so that governments could assess whether people were complying with quarantine measures[52]. In China, the government incorporated tracking software into two of the country's most widely used apps, WeChat and Alipay, to monitor and control citizens' movements[53].

49 www.ico.org.uk/for-organisations/guide-to-pecr/communications-networks-and-services/location-data

50 www.ktn-uk.co.uk/perspectives/tracking-covid-19-with-location-data-the-privacy-versus-security-dilemma

51 www.nytimes.com/2020/03/16/world/middleeast/israel-coronavirus-cellphone-tracking.html

52 http://thetimes.co.uk/edition/news/social-distancing-google-launches-mobility-reports-during-coronavirus-outbreak-h336vjwh3

53 www.businessinsider.com/coronavirus-china-health-software-color-coded-how-it-works-2020-4?r=US&IR=T

There is now widespread interest in using phone data to track infections and social distancing, which has generated international debate on how to manage privacy and trust, without which uptake and use are likely to undermined[54]. Many advocates call for a decentralised system where data is stored on individuals' phones rather than in a central database is one proposed mechanism of anonymising data and addressing privacy concerns[55].

Privacy advocates have warned that governments could abuse the powers by increasing surveillance beyond the duration of the pandemic[56]. Government overreach in the aftermath of extraordinary circumstances such as a pandemic poses clear risks to the public's perception of the collection and use of geolocation data.

Do no harm

The New York Times published a series of investigations in 2019 into the ethics of location tracking[57]. Opinion writers there have suggested that federal regulation in the US, much like GDPR[58] in Europe, could reduce unethical practice in the use of geospatial data, which would have a beneficial impact on the public perception of it. Establishing these legal and ethical protections could be key to earning the public's trust when it comes to the use of geospatial data.

The New York Times offered suggestions for principles that regulation and legislation should uphold if implemented. These centre around greater transparency in the use of geospatial data, and a cultural shift among data practitioners implemented by a Hippocratic oath for data science to do no harm.

54 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3582550

55 www.theguardian.com/world/2020/apr/20/coronavirus-digital-contact-tracing-will-fail-unless-privacy-is-respected-experts-warn

56 www.businessinsider.com/edward-snowden-coronavirus-surveillance-new-powers-2020-3?r=US&IR=T

57 www.nytimes.com/interactive/2019/12/19/opinion/location-tracking-cell-phone.html

58 https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/news/gdpr-and-location-data

Case study:

The Benchmark Initiative

The *Benchmark Initiative* is delivering a series of engagement events, with panels of leading experts in discussion and taking questions from audiences with a range of perspectives: companies large and small, civil society organisations, government and regulators, researchers and interested members of the public.

The pandemic has led us to explore themes which have particular urgency right now, and will have lasting importance, including managing distancing at work and in public spaces, data colonialism, and public understanding of risk. These debates will also feed into our discussions on the 'Locus Charter'. Benchmarks seeks to not only open a dialogue about location data ethics, but to build practical tools to help geospatial data professionals and the wider public recognise ethical challenges around their work and promote best practice across industry.

The programme offers financial, technical and business support to innovators to develop practical applications that deliver value using geospatial data while highlighting the ethical risks and challenges that using the data represents.

Part three:
A sustainable future

08

A geospatial ecosystem for planet Earth

David Jensen, Head of Policy and Innovation at UN Environmental Programme (UNEP)
Jillian Campbell, Statistician at UNEP
Maxime Paquin, Media and Communications Specialist at UNEP

We must move towards green, circular, and regenerative economies that advance our collective environmental and climate goals and sustainability values.

The environmental clock is ticking, we have less than 10 years left to achieve the Sustainable Development Goals (SDGs) and an immediate urgency to keep the average global temperature increase within 1.5 degrees and to foster resilience. All available evidence shows that we are not on track to avert the two greatest existential environmental challenges on our doorstep: the climate crisis and the nature crisis.

Considering the latest global environmental assessments three things become extremely clear[59]:

01 Our global institutions are not keeping pace with the speed and scale of the economic and social changes around us. We are trying to solve the problems of the future with tools and approaches from the past.

02 We are not yet working across the public and private sector to integrate geospatial data, citizen science, traditional in situ monitoring and other forms of data to generate the insights needed to transform individual behaviors, markets, and policies. 68 percent of the environmental indicators[60] in the SDG framework lack sufficient data for monitoring global progress.

03 The development of the digital economy has been accompanied by ever-increasing energy and resource consumption, as well as global production and consumption patterns that place an even greater burden on ecosystems. Digital technology is moving faster than our ability to govern it in a way that maximises sustainable outcomes while minimising risks to privacy and unsustainable outcomes. Additionally, the critical question of where technology is headed remains unanswered.

Given this urgency, the ongoing digital revolution and its collaborative economy need to be harnessed to drive forward a global transformation towards global sustainability. For this vision to become a reality, we need systems thinking to identify leverage points. Public, private, civil society, and international actors must take deliberate action and collaborate to enable a global digital ecosystem for the planet, mobilising infrastructure, software, and data to generate real-time geospatial insights that can power the structural transformations needed to achieve the SDGs and power sustainability for people and planet.

Tech companies could be leaders in advancing this agenda. Many companies have begun investing in renewable energy and exploring how to enhance sustainability across their entire supply chains. *DeepMind*, for example, has been used to cut the amount of electricity needed to cool Google's data centers by 40 percent and is also being used to predict the energy output of wind farms up to 36 hours ahead, enabling the optimisation of energy delivery to the grid.

59 Including the 2019 Emissions Gap Report from the United Nations Environment Programme (UNEP), the 2019 IPBES report, the 2019 Global Environment Outlook and other recent reports on climate and biodiversity.

60 United Nations Environment Programme. (2019). Measuring Progress Towards achieving the environmental dimension of the SDGs. United Nations Environment Programme, Nairobi. Retrieved 26 February 2020 from: https://wedocs.unep.org/bitstream/handle/20.500.11822/27627/MeaProg2019.pdf

International institutions

The UN has a key role to play in catalysing and incentivising the tech sector to work toward a sustainable future and positive environmental outcomes. The UN can accomplish this through collective dialogue and demonstrating the business case for environmental action. Collective dialogue must also incentivise collaboration between public and not-for-profit actors, geomatics experts, citizen scientists, land stewards, academia, and civil society more broadly to create a shared strategy for the future of our digital environmental commons.

As an impartial broker of environmental data and intelligence, UNEP is perfectly positioned to drive forward this vision. It has a long track record of providing technical support to supply chain environmental efficiency initiatives and has both the expertise and a clear mandate to monitor[61] the state of the environment at the global level. This mandate includes developing a global environmental data strategy[62] and building a World Environment Situation Room to aggregate, visualise, and use both geospatial and environmental data to inform decision-making. UNEP has already established the UN Science Policy Business Forum and a dedicated working group on big data and frontier technologies, which has also written[63] on the need for a digital ecosystem for the planet.

UNEP stands ready to work together with all relevant partners to advance planetary sustainability. Action can be broken down into three main tracks:

1. The first track is about enabling a digital ecosystem of geospatial and environmental data, infrastructure, and algorithms that can generate real-time insights about our environment and the health of our planet at any scale. These are the digital public goods mentioned in The Age of Digital Interdependence, the report of the UN Secretary-General's High-Level Panel on Digital Cooperation[64].
2. The second track is about the applications of those insights and digital public goods towards transforming consumption patterns, markets, economies, citizen engagement and policy, as well as monitoring the impacts of these investments in real time. For example, digital information and communication technologies can enable a 20 percent reduction[65] of global CO2 emissions by 2030 when strategically applied to five sectors: mobility, manufacturing, agriculture, energy, and buildings.
3. The third track is the governance of that digital ecosystem. Establishing a governance framework, business models, incentives, and safeguards for public-private partnerships and for global digital cooperation. This tackles a range of fundamental issues linked to data ownership, vulnerability[66], licensing, quality, privacy, inclusion, access, algorithmic bias, and security, to name but a few.

61 United Nations Environment Programme. (2019).

62 United Nations Environment Programme. (2019). Resolution adopted by the United Nations Environment Assembly on 15 March 2019 (UNEP/EA.4/Res.23). United Nations Environment Assembly of the United Nations Environment Programme, Fourth Session, Nairobi, 11-15 March 2019. Retrieved 27 February 2020 from: http://wedocs.unep.org/bitstream/handle/20.500.11822/28486/K1901170.pdf?sequence=3&isAllowed=y

63 United Nations Environment Programme. (2019). The Case for a Digital Ecosystem for the Environment: Bringing together data, algorithms and insights for sustainable development. United Nations Environment Programme, Nairobi. Retrieved 27 February 2020 from: https://un-spbf.org/wp-content/uploads/2019/03/Digital-Ecosystem-final-2.pdf

64 United Nations (2019). The Age of Digital Interdependence. United Nations, UN Secretary-General's High-Level Panel on Digital Cooperation, New York. Retrieved 26 February 2020 from: https://digitalcooperation.org/wp-content/uploads/2019/06/DigitalCooperation-report-web-FINAL-1.pdf

65 Global e-Sustainability Initiative (2015). #SMARTer2030: ICT Solutions for 21st Century Challenges. Global e-Sustainability Initiative, Brussels. Retrieved 27 February from: https://smarter2030.gesi.org/downloads/Full_report.pdf

66 Environmental Data and Governance Initiative (2018). A Sheep in the Closet: The Erosion of Enforcement at the EPA. Retrieved 27 February 2020 from: https://envirodatagov.org/wp-content/uploads/2018/11/Sheep-in-the-Closet.pdf

Equitable design

The very design of technology itself must help lead us to a sustainable and equitable human future. This must include adopting a shared set of values and ethics to underpin a more agile approach to digital governance, just like the early governance of the internet.

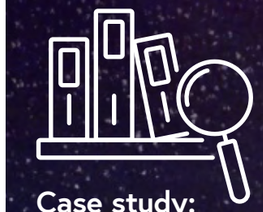
Our global environmental community must work toward improved digital and coordination, including through working to integrate data and technology governance in relevant multi-stakeholder processes. This could be facilitated by improved leadership dialogues with technology companies, including high-level engagement from CEOs, to agree on a common vision to advance sustainability through their respective platforms.

The future of the planet will depend massively on the way that we shape the values, incentives, and safeguards embedded in the digital revolution. We must move towards green, circular, and regenerative economies that advance our collective environmental and climate goals and sustainability values.

We need the general public to be aware and to accept that drastic changes are needed at a planetary scale. This starts with a digital ecosystem for the planet that monitors planetary health and produces collective intelligence for the good of our planet and people. Geospatial analytics are expected to play an important role in monitoring the health of our planet and producing those data-driven insights.

All sectors must join forces to produce intelligent outcomes that couldn't be produced otherwise. We need an inclusive, multi-scalar, multi-stakeholder, and multi-sectoral approach to produce collective intelligence, or in the words of Pierre Lévy[67], "a form of universally distributed intelligence, constantly enhanced, coordinated in real time, and in the effective mobilisation of skills". We have a tremendous responsibility to get this right and to move quickly.

67 Lévy, P. (1997). Collective Intelligence: Mankind's Emerging World in Cyberspace. Perseus Books, Cambridge, 255 pages.



Case study:

The Open Data Cube

Geoscience Australia developed and released the Open Data Cube technology and it has subsequently been supported, developed and promoted by the Committee on Earth Observation Satellites and the Group on Earth Observations. It has been modified and deployed in Colombia[68] and Switzerland[69] with approximately 50 other countries at different levels of maturity and use. Digital Earth Africa will build on Open Data Cube technology to deliver a unique continental-scale platform.

The aim is to "democratise" access to operational and analysis-ready satellite data. It will track changes across Africa in the following areas: soil and coastal erosion, agriculture, forest and desert development, water quality and changes to human settlements. And it will do so in unprecedented detail. A Steering Committee for Phase I of Digital Earth Africa was formed in 2018 and has broad representation, including Ghana, Kenya and South Africa, as well as from the World Economic Forum, the Global Partnership for Sustainable Development Data and the Group on Earth Observations[70].

68 http://cdcol.ideam.gov.co

69 www.swissdatacube.org/index.php/2018/03/27/open-data-cube-initiative

70 www.opendatacube.org

09

Enabling a sustainable world

Clare Hadley, Ordnance Survey
Deputy Head of Government Geography Profession

Nations that recognise the importance of 'location/place' can take a geospatial approach to organising their economies, government policies and technology. They can then prioritise investment in geospatial data, technology and management to allow them to make decisions with full geospatial knowledge and are better able to progress to achieve the Sustainable Development Goals (SDGs) - a set of goals to enable a sustainable world.

In this chapter we focus on two critical aspects of geospatial thinking and systems. The first is geospatial maturity. At Ordnance Survey, we talk about geospatial maturity as a way of measuring a country's geospatial capability. The second is secure land rights. Both can help countries meet these goals by increasing investment in capability and reducing inequality and conflict over land

Geospatial maturity

While geospatial maturity encompasses many aspects such as technology and governance, one of the keys to maturity is the capability to create and maintain the fundamental geospatial data[71] a country needs to function. This includes data of landscape features, natural and man-made but also non-visible feature such as addresses, property boundaries and population distributions. Creation of this fundamental data sets off a chain reaction, enabling actions and processes to support sustainable development. For example, capture of property boundaries is essential to effective land administration and can supercharge and grow an economy.

Land rights

According to the World Bank[72], only 30 percent of the world's population has legally registered rights to their land and homes, meaning huge portions of the global population don't have secure land rights.

When there is an effective legal environment, able to enforce land rights, external finance is more available. Inward investment by companies is also more likely and companies are in turn more likely to invest in the infrastructure of their buildings.

If a citizen has secure land tenure, they will have access to credit, which releases 'dead capital' to recirculate around the economy. Hence land rights are critical to building a strong economy. While many economists believe the private sector and the free market are critical to long-term economic development, the security provided by the state through secure land tenure allows capital to function.

Registration of secure, reliable land rights requires parcel boundary information which can be provided through a detailed authoritative national base map. Hence government investment in base map data can form a key part of any strategy to improve land tenure security.

In addition to securing tenure, effective land administration can assist nations to achieve at least five of the 17 SDGs. A sustainable land administration system will also enable more informed and coherent spatial planning and, if appropriate, collection of revenue from property to support investment. The UN has recently developed a Framework for the Evaluation.

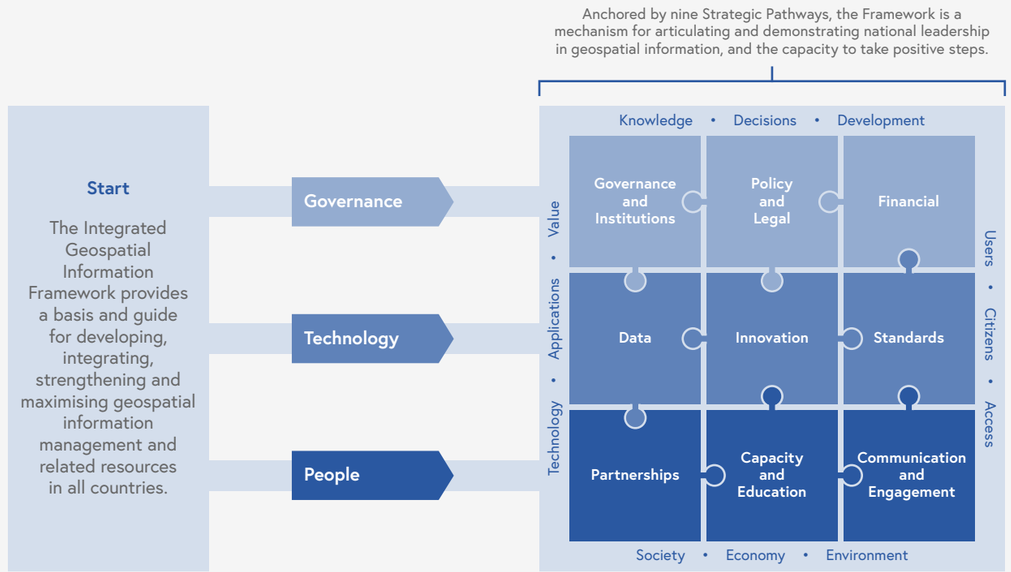
How to improve land administration

Improving land administration requires investment and expertise. Identifying property boundaries involves accurate surveying and data capture, which then needs to be registered on a secure platform. The platform will also need to capture transactions and additional data related to the property and, crucially, maintained. Only then can countries have a clear picture of land and property tenure and feature to support investment, planning and taxation.

71 http://ggim.un.org/documents/Fundamental%20Data%20Publication.pdf
72 https://www.worldbank.org/en/news/feature/2017/03/24/why-secure-land-rights-matter#

Integrated Geospatial Information Framework

How do we implement geospatial thinking and capability? The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) has put in place a framework to enable an approach to developing geospatial capability.



Developed by UN-GGIM and Member States, the Integrated Geospatial Information Framework (IGIF) communicates what is needed to make the case for investment, and then establish, implement, strengthen, improve, and maintain a national geospatial information management system and capability – increasing geospatial maturity.

The starting point for the IGIF is to understand a country's national development priorities and approach to achieving the SDGs. This then roots the future implementation of the framework in a clear benefit and value to the country to achieve political buy-in. It can then act as a catalyst for economic growth and opportunity.

The IGIF comprises three parts. Part 1 is the Strategic Framework, Part 2 is the Implementation Guide, and Part 3, which is specific to each country, is the Country Level Action Plan. The three parts comprise a comprehensive framework to serve a country's needs in addressing economic, social and environmental factors, which depend on location information in a continually changing world.

The Implementation Guide has nine strategic pathways divided into three areas of intervention: Policy and governance, technology and data, and people. The pathways are interlinked and mutually supportive. For more information on the IGIF see the UN-GGI website at *ggim.un.org/IGIF*.

Implementation of the IGIF will increase geospatial maturity, and support many critical areas of sustainable development, including land administration.

The need for geospatial is becoming more critical for governments, to create economies that are more sustainable. Geospatial expertise and investment are key to making it happen.

Case study:

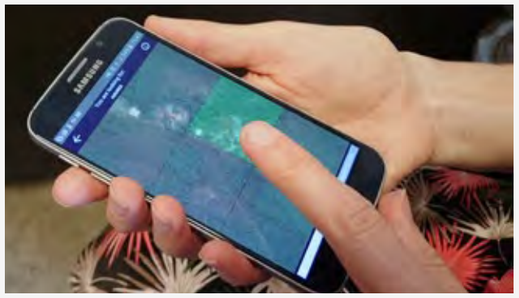
MapSwipe

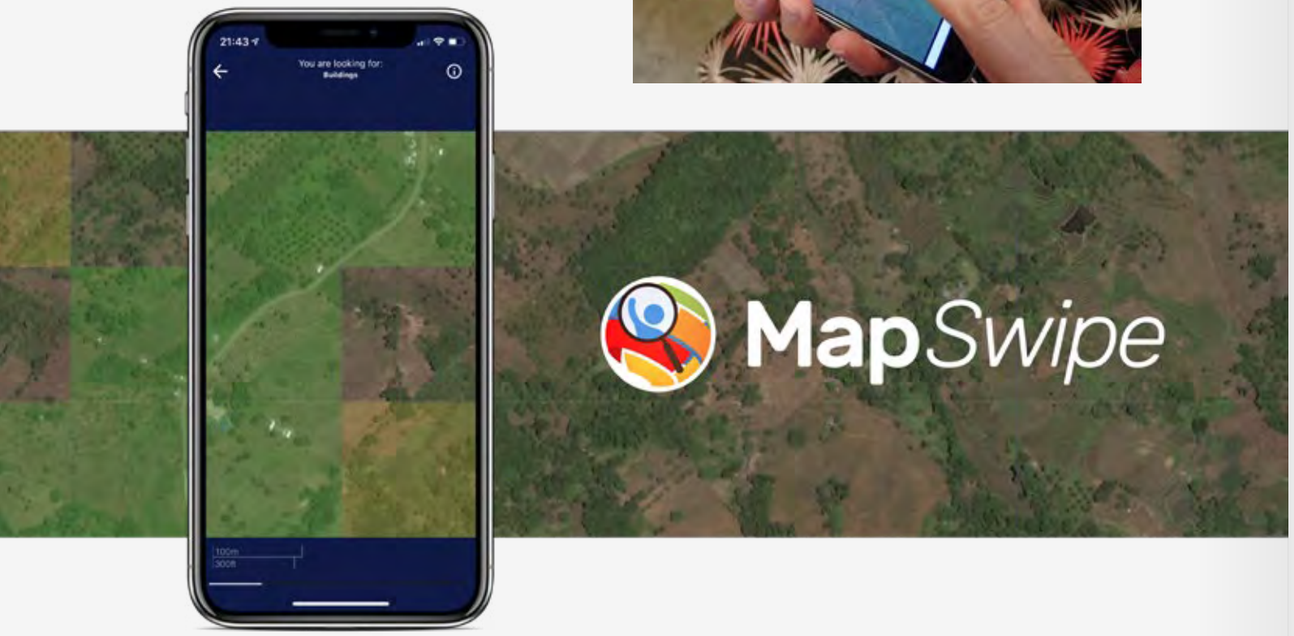
MapSwipe is an open-source mobile app that aims to make mapping more coordinated and efficient. Their Missing Maps project uses crowd-sourced data to map uncharted areas in more detail, with the aim of mapping areas vulnerable to disasters. MapSwipe allows users to support humanitarian response in by completing simple tasks that help to label satellite data.

Volunteer-driven and community-led, MapSwipe currently has 29,000 users helping to map a total area the size of Kenya, and the app provides help to any organisation or community requiring mapping of their activities on the ground.

Each set of imagery is viewed by at least three different individuals to create a mechanism for internal validation. Volunteers swipe through satellite images looking for identifiable features like buildings and roads, tapping to identify them.

Users can view images where remote mappers or AIs have identified them, providing on the ground confirmation of built environment feature. Users can also indicate tiles where these traces are inaccurate or low-quality, targeting where improved mapping is needed. A new feature focusing on documenting changes in the environment in under development.





Case study:

Sustainable infrastructure

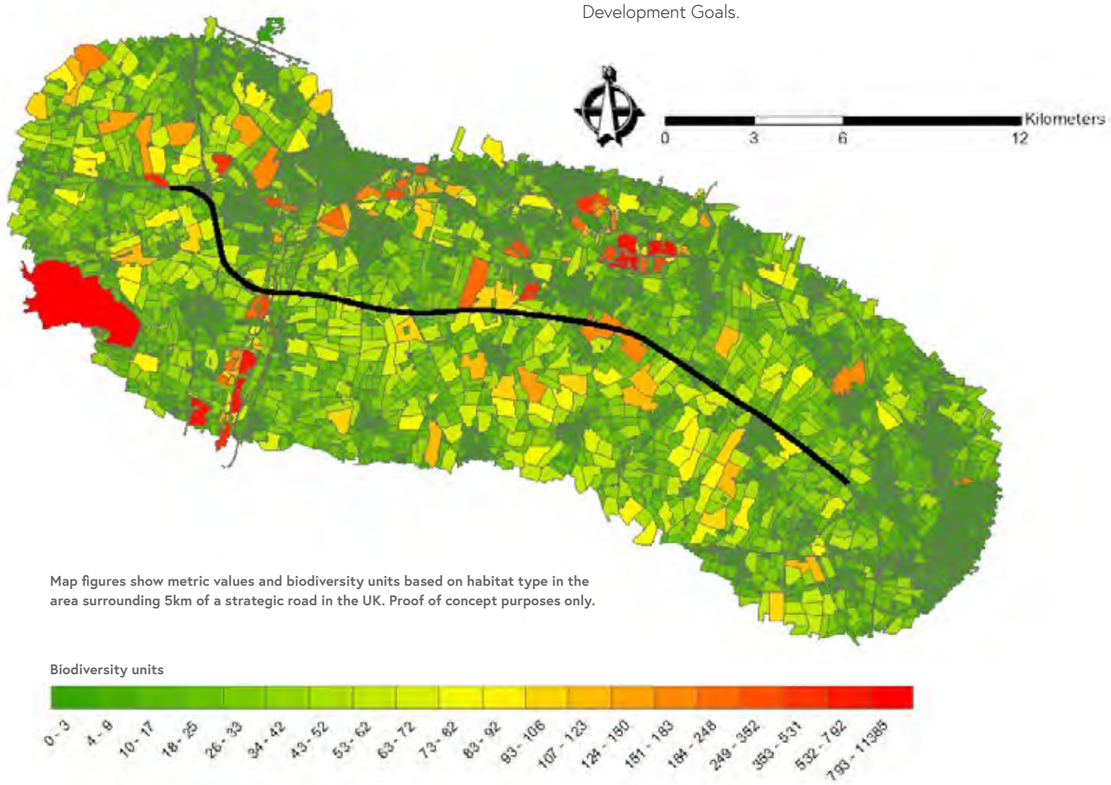
Geospatial data tools are helping infrastructure organisations minimise their impact on the environment.

Smart infrastructure solutions provider *Costain* has developed such a tool that calculates the costs associated with managing biodiversity on an infrastructure programme.

The tool, due to be trialled in 2020, provides a way to communicate the value of a habitat using biodiversity units developed by Defra. It also identifies risks to habitats as a whole, risks to individual species and flags regulatory constraints based on geography by identifying sites of special scientific Interest.

By integrating geospatial data tools early in the planning process, Costain can assess the impact of infrastructure projects on the environment, with the goal of achieving biodiversity net gain. Costain also provides insights for improving the safety of construction projects by mapping accident data.

In 2020 Costain launched its responsible business commitments to help create a greener future in line with the UN Sustainable Development Goals.



Map figures show metric values and biodiversity units based on habitat type in the area surrounding 5km of a strategic road in the UK. Proof of concept purposes only.

10

Finding net zero

Denise McKenzie, Chair at Association for Geographic Information (AGI)
James Cutler, Vice Chair at AGI

Call it what you will – geospatial, place or location. Understanding "where" in our world has never been more relevant or important.

The challenge

We live in extraordinary times. Increases in global disasters, pandemics, population and pollution. Whilst some carbon emission is a natural part of life on earth, we now understand that through human actions and consumption increases those levels have almost doubled in the past decade at scale that is now causing our planet to be unnaturally warm. The UK government has recognised this problem and has committed to achieving net zero carbon emissions by the year 2050. Government, private industry and individual citizens are taking action – with the geospatial community essential in enabling solutions in areas such as transport, energy and planning.

The UK's political intent is clear, with renewed efforts announced for including targets in the national recovery planning following the lockdown. In June, the United Nations Climate Change group's Race to Zero was launched to mobilise leadership from businesses, cities and nations to spur a zero-carbon recovery and commitment to net-zero support ahead of the postponed COP26 summit.

Understanding our planet is an inherently geospatial exercise. Therefore, the geospatial community is fundamental to many aspects of addressing the NetZero. To explain this we will explore the role through the lens of three main sectors: Energy, Transport and Planning.

Energy

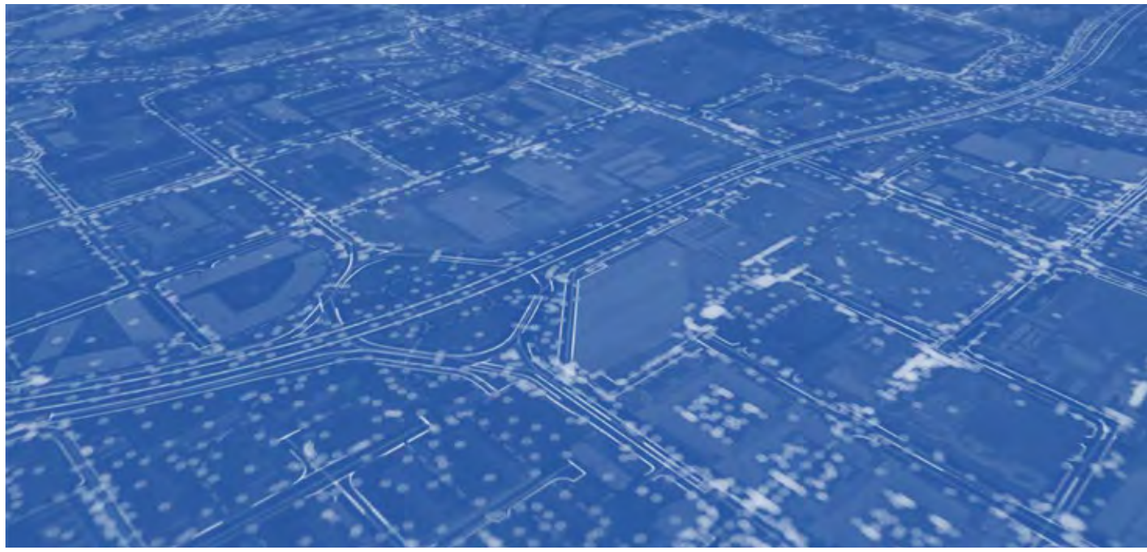
In the past two years, just over 50% of all electricity generated in the UK has come from low carbon sources[73]. Location data is a critical factor in maximising the potential of energy assets in specific towns or cities. If we do not know the location of existing assets, or where new assets are in relation to other parts of the network, we will inevitably end up failing to utilise them effectively.

The Energy Data Taskforce believes digitalisation will help achieve a net-zero carbon future. It plans to create a digital map, ensuring that all the assets in the UK energy network are recorded and located to a high degree of accuracy. This will provide important operational data for cross-sector infrastructure solutions as well as lay the foundations for a national Digital Twin. It will also allow investors and innovators to identify new opportunities based on technology, location and need. In addition, the map will unlock economic development planning and local solutions to issues around energy use and demand.

Projects exploring ecologically sustainable energy creation are being carried out worldwide, with many leading to the successful implementation of green technologies. Large scale renewable energy installations, particularly wind and solar farms as well as the use of ground heat, hydro and wave power are being used as clean energy sources. With Drax being converted to wood pellet the death knell for coal is clear but only with effective large scale location based renewable energy permitting and small scale solar adoption can centralised carbon emissions be eliminated by 2050.

Geospatial data is crucial in implementing these technologies, making sure the best solutions are placed in the best locations. There is little question that the UK needs to wean itself off natural gas while at the same time recognising that over 80% of houses have gas boilers. Innovative integration of hydrogen, thermal and especially ground-source heat into the existing distribution network is an increasing part of future energy supply. In the case of ground-source energy location data is critical to identifying greenspaces that have the capacity to generate sufficient energy and are in areas with a complementary level of demand to maximise efficiency and benefit.

73 https://es.catapult.org.uk/reports/energy-data-taskforce-report



Transport

Our experience of 'place' is often defined by its mobility. The Black Cabs and Red Buses of London. In Amsterdam, its bicycles. And Mumbai perceived to be permanently choked with traffic. However times are definitely changing this area of life. The power of place is evident in the evolving intelligent mobility sphere - where investment and research into future mobility is carried out, it will advance the acceleration to low carbon economies.

Electric vehicle infrastructure, upgrading existing public transport and adapting urban environments in response to transformations in working and commuting exemplarised by the response to Covid-19 and reinforced by the UK's net zero response to the threat of climate change as well as the emerging autonomous vehicle juggernaut all need location data and expertise if they are to become a part of our reality. Much of the investment in enabling self-driving developments focus on the standards and mechanisms for safe and successful exchange of data in real-time between cars and with their environment, both the relative, dynamic one and the more slowly changing absolute one.

The likes of Waze already represent the nature of an autonomous future where, in areas of heavy congestion, traffic is re-routed using real-time data or infrastructure. The advent of driverless PAYG utility transport will use dynamic location-based information not only for such routing choices but also for deployment, pricing and charging.

Multi-modal transport can have a big impact on the social, ecological and economic health of a nation. In a hybridised 'working from anywhere' world, cycling and walking will become an increasingly important part of the mobility mix, alongside PAYG electric vehicles - rented and shared, 2-wheeled or 4, micro-mobility and CAVs. To sustain this ambition more journeys in the future will require large amounts of information to talk to each other, across devices and systems.

Efficient multi-modal mobility will depend on data sharing. Data on where people are going, and when, throws up genuine public concern around data privacy and security. The geospatial community has been wrestling with this tension for a long time and brings an array of expertise and thinking to the security and privacy concerns in the context of individual rights and public safety. The *Benchmark Initiative* is working towards a charter to provide guidance on the ethical and responsible use of location data.

Transport is the single biggest contributor to the UK's carbon emissions. Reducing the number of vehicles and the number and length of journeys on our roads by creating optimised multi-modal transport systems will help ease congestion, increase air quality and reduce emissions. Geospatial data and expertise is key to innovative mobility thinking and achieving these outcomes.

Planning

We hear much about smart infrastructure where physical and digital assets come together to create cyber-physical systems[74]. This thinking when applied to the circular economy and investing in infrastructure can help the UK meet net-zero carbon by 2050.

One of these investments, highlighted by RICS, is an overhaul in the energy performance of the UK's buildings. Decarbonising of the UK's existing housing stock is one of the most cost-effective routes to achieving net zero ambitions. Bringing multiple data sets together, spatial and the spatially-attributed, allows users to optimise intervention options. Mapping, addresses, thermal imagery, data on building performance and solar energy capability, utility networks, EV uptake and other data sets will help energy providers and installers drive down the cost of installation, carbon emissions and energy cost in a win-win for UK net zero ambitions.

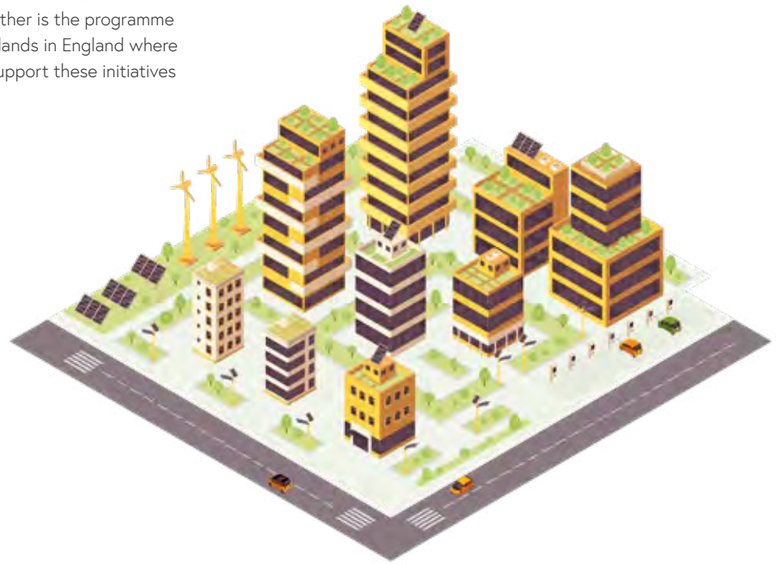
Building information management, digital twins and the sensed environment of modern adaptive buildings share and embed location to optimise electricity and water loads. The rise of 'smart' (buildings, grids, traffic, cities) will continue in the UK's journey to 2050 and will eventually enable modelling of city scale energy use and the control of emissions from the building level up.

The role of geospatial data and expertise is as important in our rural and moorland environments. This is true in agriculture, forestry, protected areas and also for innumerable towns particularly in response to the opportunities for reinvigorating town centres and mixed use urban fabric in response to the impacts of Covid-19 and the wider working from anywhere expectations of digital natives and worldly-wise commuters. Planned precision agriculture, selective planting of 50 million trees a year and conservation of high absorbing biodiversity rich carbon sinks all play to carbon sequestration and are demanding of location intelligence. Another is the programme for the planting and restoration of peatlands in England where a £640m Nature for Climate fund will support these initiatives to enhance carbon capture.

Planning is dependent for its effective outcome on existing national infrastructure. A great example of the power and value of place is the bringing together of infrastructure data to optimise infrastructure delivery, minimise construction impacts and reduce ongoing streetworks. Work being undertaken by the Geospatial Commission in 2019-20 brings together existing data on underground pipes and cables to create a prototype underground asset register[75] for London and NE England. Streamlining the provision of accurate site data to surveyors, planners, developers, builders and street workers will reduce potentially lethal accidental strikes on underground pipes and cables and save an estimated £1.2 billion a year. The efficiency gains in reducing road-works and congestion contribute to supporting net-zero targets.

Making it all work

Sadly, there is no single activity we can undertake that will magically reduce our carbon emission and reach NetZero. It is only through a collaboration of activities, data sharing and evidence based decision making across our community that we can hope to be successful in this endeavour. Already we are seeing greater need for geospatial skills across a broad range of industries that are trying to address the carbon emissions problem. This brings both great challenge and opportunity to the geospatial community to meet the needs and also to inspire young people throughout the nation to pursue a geospatial career and aid us all in tackling the great problems of our time. In AGI our mission is to be a thriving geospatial community, actively supporting a sustainable future. We are proud that the UK's geospatial community is rising to this challenge and are confident that by working together we will all succeed in reaching NetZero in 2050.



74 University of Cambridge (2020). Flourishing Systems - Re-envisioning infrastructure as a platform for human flourishing, available at: www.cdbb.cam.ac.uk/files/flourishing-systems_final_digital.pdf

75 https://www.gov.uk/government/publications/national-underground-asset-register-project-update

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A catalyst for responsible investment

Christophe Christiaen,
Sustainable Finance Lead at Satellite Applications Catapult

'Spatial finance', where geospatial data is integrated into financial theory and practice, creates a significant opportunity for the geospatial and financial services sectors alike.

"Climate change has become a defining factor in companies' long-term prospects[76]" according to Larry Fink, CEO of Blackrock, the worlds' largest fund manager. This is leading to a fundamental reshaping of finance.

Over the last few years, climate change and environmental issues have reached the top of the agenda in terms of global risks across the world's leading economic and financial institutions such as the World Economic Forum[77] and the Bank of England[78]. There is an increasing awareness of the impact that climate change has on the economic performance and long-term value of businesses on the one hand, and the indirect impact of these businesses have on the climate and environment on the other hand.

The financial sector is waking up to this reality. By the end of 2019, over 2,300 investors representing USD $86 trillion under management had signed up to the UN Principles of Responsible Investment[79], 450 investors with USD $40 trillion in assets under management had signed up to the more ambitious Climate Action 100+ scheme[80] and over 1,000 organisations worldwide, representing a market capitalisation of over $12 trillion, had expressed support for the Taskforce on Climate related Financial Disclosures[81] (TCFD).

Information Asymmetry

A common challenge for financial institutions has been the lack of reliable, consistent and comparable information on environmental, social and governance (ESG) performance of investments. As it is not yet mandatory to disclose ESG risks, opportunities or impacts, investors have to rely on investee's self-disclosed information, if the information is available at all.

ESG information is typically only disclosed once per year as part of a corporate sustainability report looking back at the previous financial year, which means the data is outdated by the time it is published. Lack of reporting standards mean the quality of reports varies heavily which means investors struggle to compare one company against another.

Information is vital for financial markets to function effectively. Recent technology developments and enhanced capabilities will have profound implications for information markets as they help address existing information asymmetries between investees and their investors and between financial institutions and their regulators. EO and remote sensing combined with AI has the potential to transform the availability of information in our financial system and change how risks, opportunities, and impacts are measured and managed by financial institutions and civil society. AI applied to EO allows for bottom-up asset-level analysis of risks, impacts, and opportunities on a global scale on a much timelier and more frequent basis.

76 www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter

77 www.weforum.org/reports/the-global-risks-report-2020

78 www.bankofengland.co.uk/climate-change

79 www.unpri.org/pri

80 www.climateaction100.org

81 www.fsb-tcfd.org/tcfd-supporters

Spatial finance

The use of geospatial solutions in the financial sector is not new. Research by the Spatial Finance Initiative[82] (SFI) has found over 100 organisations offering one or more geospatial products or services to financial institutions. The bulk of these services target the insurance sector, to improve risk and damage assessments, or provide business and market intelligence to inform short term trading decisions. New services covering climate and ESG risks are on the rise but are still limited. This means that in a sector where information is vital to gain a competitive edge, many spatial finance use cases remain unaddressed.

Asset managers could use spatial finance techniques to differentiate between companies and projects based on risks and impacts, enhance risk management and stress testing or actively engage with investee companies in a timely manner. Asset owners like pension funds could use spatial finance techniques to assess their portfolios against their investment values. Regulators could use spatial finance to assess risks within the system and verify corporate disclosures. Policymakers could use spatial finance to track progress against the Paris agreement and implementation of the sustainable development goals.

Understanding all the possible use cases of spatial finance is in its infancy but it is clear that these technologies will enable new ways for governments, regulators, businesses, investors, and civil society to tackle a wide variety of challenges around the world. Spatial finance applications are relevant beyond climate and environmental risk assessment across corporate strategy, financial analysis, financial supervision, public policy and the Sustainable Development Goals. Future SFI research, engaging the spectrum of financial institutions, will highlight additional spatial finance use cases and data needs.

Multidisciplinary approach

To stimulate the uptake of geospatial analysis within the financial sector, the Alan Turing Institute, Green Finance Institute, Oxford Sustainable Finance Programme and the Satellite Applications Catapult have set up the SFI to bring together the relevant multidisciplinary capabilities and networks to accelerate advances in this field.

The key challenge in accelerating spatial finance is the multidisciplinary nature of the topic and the various communities associated with each discipline. Broadly, the financial community is unaware about the advancements in EO and AI and the possibilities of geospatial solutions and finds it hard to articulate its data needs. The geospatial and data science communities are unaware of the trends within the financial sector and its associated data needs and find it hard to articulate their capabilities in a format and language that is relevant for financial decision making.

Another major challenge is linking observations on the ground with the full chain of ownership from suppliers to buyers to fund managers to asset owners. Asset-level data tied to ownership is a prerequisite for a comprehensive and thorough understanding of company, portfolio or system performance.

There is a need to establish the right ecosystem that brings together geospatial and finance, academia and industry, start-ups, SMEs and corporates across the various value chains. Geospatial data on itself cannot not address the challenges of greening the financial system. However, combined with the relevant contextual knowledge it can be a catalyst for better decision making, economic growth and societal impact. Successfully mainstreaming spatial finance is inherently dependent on delivering the promise of Geospatial 2.0.

To realise a more transparent and resilient financial sector, better data is needed now. It is necessary to understand both the impacts that investments will have on the local and global environment, as well as the stranded-asset risks investments face from different physical and transition risks related to environmental and climate change. Spatial finance is the key to unlocking these insights for the financial system, our governments and society more broadly.

82 https://spatialfinanceinitiative.com

Case study:

The Investor's Perspective, from Asif Ghafoor, Private investor

Today the world of Geospatial and business investment and investors is disconnected by a language and ease of use gap. Limited in time and making serious cost impacting decisions, investors expect clear, refined signals often communicated through dashboards and business intelligence platforms like Tableau, Microsoft PowerBI or Google BI Engine.

Investors often don't realise that geospatial insight can assist in making business decisions and enhancing the return and outcomes, particularly in new technology where traditional reliance on 'gut instinct' is impossible.

Take the example of setting the price for charging electric vehicles, and deciding where to place the charge points. By using publicly available information from power sources and combining it with population and geospatial data, optimal price points and location of charge points can be decided.

Such insights can improve investment returns but can also address societal level problems, like addressing social exclusion and improving sustainability. For example, getting consumers to charge vehicles at set off peak times, with targeted support will result in less vehicles driving around looking for unoccupied chargers, and providing adequate charging infrastructure will encourage electric vehicle ownership in socially deprived areas, helping to close social inequality.

By opening a dialogue between the investor community and the geospatial community, we can ensure spectacular results across all infrastructure investment, delivering better returns and social benefits.

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Conclusion

Embracing the power of place

We are on the edge of a geospatial transformation. No longer a simple data set for use in specific applications, location data will be integrated with data from a plethora of other sources to unlock rich new insights, power better decision-making and catalyse new products and services across all industry sectors. It has the potential to add billions to our economy, boost the quality of life and wellbeing among our communities, and help protect our planet.

While many of the technological barriers have already been scaled, the future winners of the geospatial market recognise the human challenges that remain. Overcoming those will require a change in approach and behaviour. Action is needed to bring together people from different verticals and with different skill sets to ensure innovation is needs-led. Data silos must be broken down and a common geospatial framework built, in order to unlock shared value and enable collective intelligence. And we must shift from a competitive to a collaborative way of working, both among organisations but also in partnership with the general public, to build trust and incentivise sharing of data.

From tackling climate change to fighting pandemics, it is clear that Geospatial 2.0 has a central role to play in overcoming our greatest challenges as a species. Now is the time to work together to ensure that we can build a more resilient and human-centred future.

About KTN – Connecting for Positive Change

KTN create the diverse connections that enable positive change. Our knowledge and expertise enable innovators to transform bright ideas into real-world solutions. Our powerful industry and academic connections can guide entrepreneurs, start-ups and companies through the complex challenges of bringing new products, processes and services to market.

KTN's Geospatial Insights Special Interest Group (SIG) exists to connect data holders and data processors with users that can derive value from the insight geospatial data provides. Topics that have been explored in the SIG include the maintenance of infrastructure assets using geospatial data, the optimal placement of trees for mitigation of flooding, topography and its effect on our highways and the new applications enabled by High Altitude Pseudo Satellites.

For further information on how Geospatial 2.0 can benefit your business, visit *www.ktn-uk.co.uk/interests/geospatial* and join our newsletter and LinkedIn group.

About Ordnance Survey

Ordnance Survey (OS) is the national mapping service for Great Britain, and a geospatial data and technology organisation. As a reliable partner to government, business and citizens across Britain and the world, our trusted data provides location insight for positive impact. OS expertise and data supports efficient public services and infrastructure, new technologies in transport and communications, national security and emergency services and exploring the great outdoors. By being at the forefront of geospatial capability for more than 225 years, we've built a reputation for world-leading geospatial expertise.

Ordnance Survey

Head Office:

Explorer House
Adanac Drive
Southampton
SO16 0AS
United Kingdom

OS Grid Reference : SU 37294 15540
Latitude: 50 56 15.75 N, Longitude 1 28 13.56 W, Height: 73.84m

+44 (0) 3456 050505
www.os.uk

Knowledge Transfer Network

Head Office:

Knowledge Transfer Network Ltd
Suite 218 Business Design Centre
52 Upper Street
London
N1 0QH

enquiries@ktn-uk.org

+44 (0) 3333 403250
ktn-uk.org