ESSEC BUSINESS SCHOOL

SIA

Final Report

Unlocking the Strategic Value of Spatial Data

ESSEC Digital Disruption Chair

Sia | BNP Paribas

Ting-Cheng LEE - *B00813564*
Anvi SINGH - *B00813713*
Hugo SANÉ - *B00719612*

Abstract

Spatial data, derived from satellite-based Earth Observation (EO) technologies, has the potential to transform decision-making across industries by offering precise, real-time, and scalable insights. Despite substantial technological advancements and widespread data availability, adoption remains limited primarily due to low awareness of its practical capabilities and benefits and perceived complexity. This topic is increasingly important as industries face pressure to become more data-driven, sustainable, and resilient in the face of economic, environmental, and technological disruption. Spatial data offers unique capabilities to enhance strategic decision-making, optimize operations, and manage risk through real-time, location-based insights.

Our research aims to understand this gap between capability and adoption. Specifically: How can spatial data adoption be accelerated across industries, and what strategies can bridge the divide between technological promise and operational reality?

To address this, we conducted a mixed-method study combining a detailed literature review, primary interviews with actors across the spatial data value chain (including space providers, intermediaries, and potential users), and analysis of a sector-specific survey in insurance. These were complemented by institutional insights and external research to validate findings and better understand global trends, barriers, and enablers of adoption.

Our key message is that adoption is not just a tech challenge, it's an ecosystem one. Barriers like awareness gaps, ROI concerns, and lack of integration are solvable through targeted education, simplified tools, and structured strategic support.

Our research shows that the availability of spatial data technologies does not automatically lead to adoption. Many organizations are still unaware of the value these tools can bring, which limits their use in practice. Our findings show five major themes limiting adoption: low awareness, integration difficulty, economic constraints, complexity of tools, and lack of scalability. We propose a three-phase strategic roadmap (Kickstart, Accelerate, Pioneer) and a maturity model to help organizations assess and progress toward full integration.

These contributions are valuable because they offer a realistic, actionable framework for both industry actors and space data providers to align expectations, reduce friction, and collaboratively unlock the full value of spatial data. By shifting the narrative from “technology-first” to “strategy-first,” we help bring spatial data out of niche pilot projects and into the core of business transformation.

Acknowledgments

We would like to express our deepest gratitude to **Marie-Kerguelen Fuchs**, Compliance Manager at Sia, for her mentorship, guidance, and continued support throughout this project. Her collaboration and feedback were instrumental in helping us shape and refine our research approach, and her insights into the insurance sector brought valuable depth to our analysis.

We also wish to thank **Jérémy Beaufils**, Director of the Digital Disruption Chair at ESSEC, and Professor **Jan Ondrus**, Chair Professor, for their continuous support and commitment to fostering innovation through academic inquiry.

In addition, we extend our appreciation to the professionals who generously participated in our interviews and shared their expertise from across the spatial data ecosystem. Their openness and insights played a crucial role in grounding our research in real-world perspectives.

This report would not have been possible without the contributions and support of all those mentioned above.

Table of Content

1. Introduction

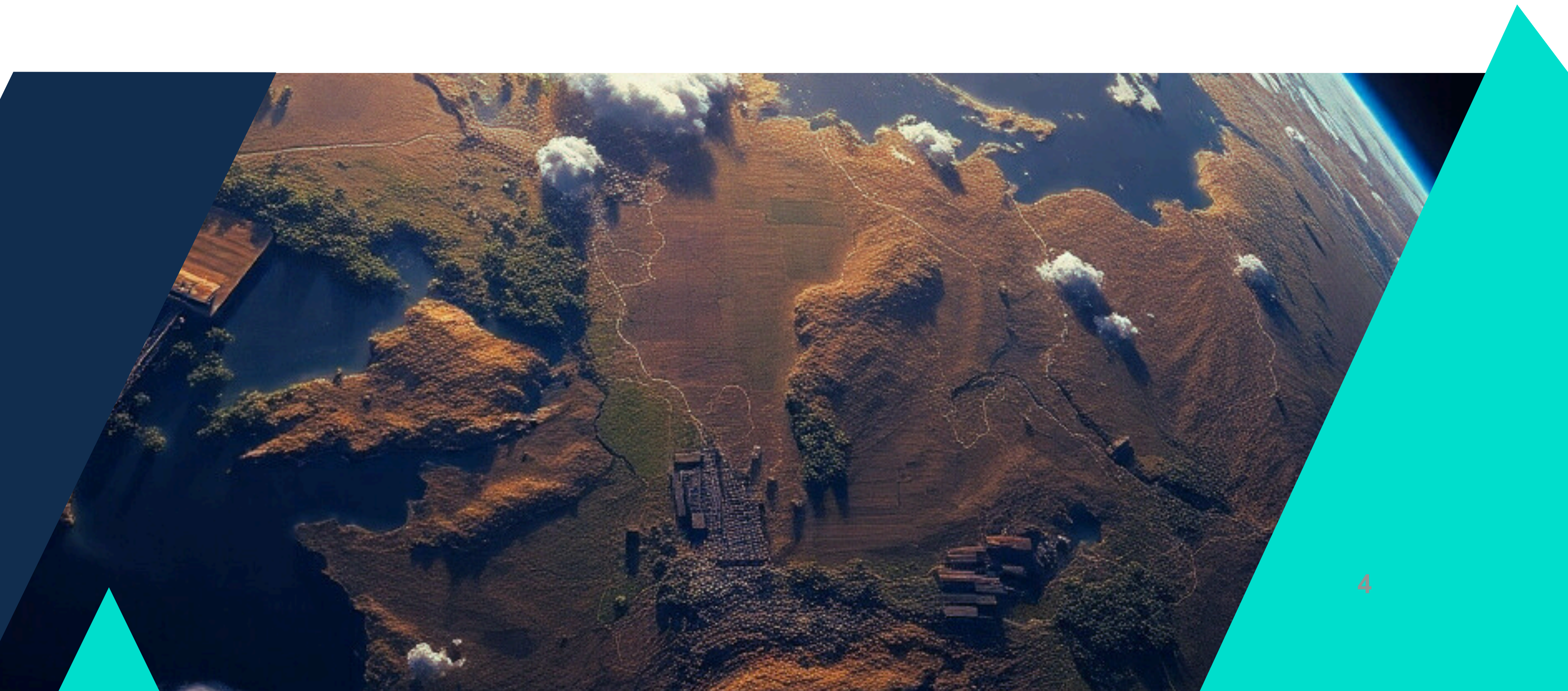
1.1 Overview & Problem Statement

Industries worldwide are increasingly turning to data driven approaches to remain competitive, sustainable, and resilient. Over the past decade, satellite technology has evolved rapidly, offering a wealth of high precision data that can be applied across diverse fields, from agriculture and insurance to infrastructure planning and urban management. Yet, despite these advancements, the vast potential of spatial data largely remains underexploited.

While space based data promises unprecedented scalability, real time monitoring, and pinpoint accuracy, its practical adoption has been constrained by issues such as limited accessibility, non uniform standards, and fragmented integration strategies. These bottlenecks have left many organizations uncertain about how best to leverage satellite driven insights for critical goals, such as enhancing risk assessment in insurance, automating workflows in supply chains, or implementing sustainable land management practices.

Addressing this disparity between technological capabilities and real world industry needs is the focal point of our research. Specifically, we explore how organizations can capitalize on spatial data's strengths while overcoming hurdles related to cost, data governance, and awareness. By tackling these challenges, we aim to shed light on scalable strategies for bridging the gap and ultimately demonstrate how industries can unlock space data's full potential for meaningful, data driven transformation.

To establish context and explore existing knowledge regarding spatial data adoption, the next section reviews relevant literature, highlighting key themes, current industry practices, and recognized adoption barriers.



2. Literature Review

2.1 Space Data Value Chain

Before addressing the complexities of spatial data adoption and its use in different cases, it is essential to understand what spatial data is, how it differs from space data. Spatial data is information that describes the location, shape, and relationship of features on Earth and is typically expressed in coordinates and other geographic parameters. In contrast, space data refers to the raw measurements and signals gathered from space-based sensors before any geographic processing. This section begins with an explanation of space technology as understanding the technical foundations of space data provides essential context for grasping the broader spatial data value chain. From satellite design and launch to data acquisition and analytical transformation, the space data lifecycle involves diverse stakeholders and specialized workflows. Grasping these upstream and downstream activities clarifies how raw signals from orbit are transformed into actionable insights used in agriculture, finance, disaster management, and more. The following overview illustrates the essential roles, technologies, and collaborations that bring space data from its origin to end users.

2.1.1 Space Technology: Remote Sensing

One of the most crucial technologies for understanding space data is remote sensing, which involves gathering information about the Earth's surface without direct physical contact. This technology is widely used in various fields, offering valuable insights into environmental and human activities.[1]

The process of remote sensing begins with a source of illumination, usually the sun, which provides the energy required for data collection. Sensors detect and record signals reflected or emitted from the Earth's surface. The collected data is stored digitally in mathematical formats, **which must be corrected and processed by scientists to ensure accuracy**. Interpreting this data requires expertise, as errors and distortions must be addressed before it can be used for decision-making.[2]

Remote sensing can be categorized into two main types: active and passive sensing. Active remote sensing involves sensors that emit their own signals and measure the response. A common example is **radar technology**, which sends out waves that bounce back to detect objects, making it useful for applications like sea ice monitoring and oil spill detection. In contrast, passive remote sensing relies on natural energy sources, such as sunlight. **Optical and thermal sensors** capture reflected sunlight to generate satellite imagery, which is commonly used in environmental monitoring and mapping.[3]

An important aspect of remote sensing is **spatial resolution,** which determines the smallest object a sensor can detect. The resolution is measured by the area covered by a single pixel in an image. For example, a 100-meter resolution image provides less detail compared to a 10-meter resolution image, which allows for a more detailed analysis of environmental and human-made changes. Higher spatial resolution is crucial for applications that require precise observations, such as land use classification and disaster assessment.[4]

2.1.2 Understanding Space Data: Characteristics, Categories, and Differences

Space data is a crucial resource for analyzing and understanding various Earth processes. Unlike regular images, space data consists of multiple layers of information that extend beyond simple visual representation. It includes **location data**, **attribute details**, and **temporal information**[5], making it a powerful tool for scientific research, environmental monitoring, urban planning etc.

One of the core characteristics of space data is **location information**, which typically consists of geographical coordinates (latitude and longitude). This ensures precise mapping and spatial analysis. Additionally, space data contains **attribute information**, which describes the characteristics of an object or event. It includes various thematic or spectral attributes such as temperature, reflectance, and vegetation indices, that describe the properties of the observed phenomena. These details are crucial for understanding the physical and environmental characteristics of the observed area. It also allows for detailed analyses in applications like agriculture (crop health), urban planning (land use classification), and disaster management.

Another important feature of space data is **temporal information**, which adds the element of time. This means that space data can capture a **specific moment** (such as the exact time an earthquake occurred), a **duration** (for example, how long a flood lasted), or a **time series** (tracking changes in land use over several years). This temporal component allows us to observe changes, analyze trends, and predict future developments.[67]

A. Space Data Imaging

Here we listed five types of space data imaging:

1. **Multispectral imagery**[8] : captures several bands of light including red, green, blue, and near-infrared, allowing for effective monitoring of vegetation health, urban expansion, and environmental changes. This type of imagery is both cost-effective and scalable, making it well-suited for applications such as agriculture and urban planning, as evidenced by data

2. **Hyperspectral imagery**: goes a step further by capturing data across hundreds of narrow spectral bands. This high-resolution spectral detail enables precise identification of materials and chemical compositions, which is invaluable for mineral exploration, precision agriculture, and pollution monitoring. Although it typically requires more

   from multispectral data.

3. **Thermal infrared imagery**[9] : measures the heat radiated from surfaces rather than reflected light. This capability is especially useful for real-time monitoring of wildfires, urban heat mapping, and industrial applications like detecting energy inefficiencies. Thermal sensors can operate both day and night, giving them a significant advantage in continuous monitoring scenarios.

4. **Synthetic Aperture Radar (SAR)**[10] : is a technology that uses radio waves to generate detailed images regardless of weather conditions or lighting. SAR is highly valued in situations where optical sensors fail, such as during heavy cloud cover or at night. It also excels in detecting subtle ground movements,

making it an essential tool for infrastructure monitoring, flood assessment.

5. **LiDAR (Light Detection and Ranging)**[11] : employs laser pulses to create high-resolution, three-
particularly effective for mapping terrain, monitoring forest structures, and uncovering archaeological features hidden beneath dense vegetation. Its ability to produce precise elevation models makes it indispensable for projects ranging from urban development to environmental conservation.

Below is an easy-to-understand table that summarizes the main space data imagery categories, their key characteristics, primary business applications, nationalities and example platforms.

Category	Key Characteristics	Primary Applications	Example Platforms
Multispectral	Captures several broad spectral bands (e.g., red, green, blue, near-infrared) Cost-effective with moderate spatial resolution Best in clear weather conditions	Agriculture & crop health monitoring Urban planning Environmental monitoring and disaster management	(EU) /DQGVDW) (US) WorldView) (US)
Hyperspectral	Captures hundreds of narrow spectral bands for GHWDLOHGVSHFWUD ILQJHUSULQWV High spectral resolution for material and chemical identification Requires advanced processing	Mineral exploration Precision agriculture Pollution detection and environmental analysis	EnMAP (Germany) PRISMA (Italy) AVIRIS (US)

Thermal Infrared	Detects heat emitted from surfaces rather than reflected light Operates day and night Useful for mapping temperature variations and identifying thermal anomalies	Wildfire detection and monitoring Urban heat mapping Industrial process monitoring	TIRS (US) ECOSTRESS (US)
Synthetic Aperture Radar (SAR)	Uses radio waves to generate images Functions in all weather conditions and at night Detects fine-scale ground movements and changes	Flood monitoring Infrastructure stability assessments Maritime surveillance	(EU) RADARSAT (CAN) 7HUUD6$5)X (GER)
LiDAR	Uses laser pulses to create high-resolution 3D maps Excellent for detailed terrain and structural analysis Provides precise elevation data	Topographic mapping Forestry management Urban planning and infrastructure development	GEDI (NASA, US), ,&(6DW) (US)

Figure 1. *Overview of Space Data Imagery Categories, Characteristics, Applications, and Example Platforms.*

Together, these diverse categories of space data imagery provide businesses with a comprehensive suite of tools to optimize operations, manage risks, and drive strategic decisions.

It is important to note the significant geopolitical, defense, and future implications tied to space data access. It is estimated that only about 8% of countries currently have access to space data, highlighting a marked global imbalance. While this report does not delve into these aspects, it is important to recognize that limited access influences national security and economic competitiveness. Initiatives like Prométhée, which deploy their own satellites, are working to democratize space data access and foster a more equitable distribution of technological resources worldwide.

B. **Cost Categorization of Space Data Imagery**

Space-based imagery varies significantly in cost depending on **resolution, frequency of updates, and data accessibility**.

At the free and open-source level[12], mainly the imagery is provided by governments and international organizations to support research, disaster response, and policymaking etc. Programs such as the Sentinel series (ESA Copernicus Program) and Landsat (NASA & USGS) offer multispectral, radar, and thermal imaging at moderate resolutions (typically 10m to 300m), making them valuable for broad-scale environmental monitoring. For users requiring higher resolution imagery at a lower cost, subscription-based or pay-per-use options offer access to moderate-resolution multispectral and radar data (1.5m to 10m resolution). Some providers offer low-cost access, making these datasets attractive for startups, researchers, and governments engaged in agriculture, forestry, and infrastructure monitoring.

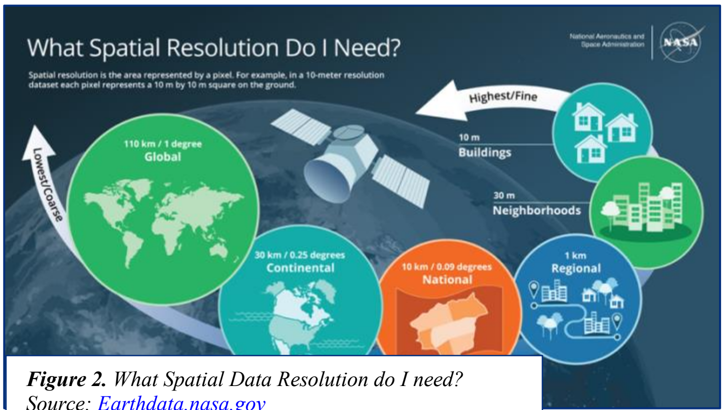


Figure 2. What Spatial Data Resolution do I need?
Source: [Earthdata.nasa.gov]()

In the medium-cost range[13] satellite imagery offers higher resolution (typically 50cm to 5m), making it suitable for precision agriculture, urban planning, and land-use monitoring. These datasets provide detailed multispectral imaging, allowing for crop health assessment, deforestation tracking, water resource management, and infrastructure monitoring. The balance between cost, resolution, and update frequency makes medium-cost imagery a valuable option for commercial applications where ultra-high resolution is not necessary but more detail is required than what free datasets can provide. Companies such as Airbus (SPOT satellites) [14] and Maxar (WorldView-2 archives) [15] provide multispectral and panchromatic imagery at 1.5m 6m resolution and archived imagery at lower costs, with moderate resolution options suitable for commercial applications.

At the high-cost level, commercial satellites [16] provide very high-resolution imagery (30cm to 1m), used primarily in infrastructure assessment, military reconnaissance. These datasets enable detailed object recognition and monitoring, making them valuable for applications that demand precision.

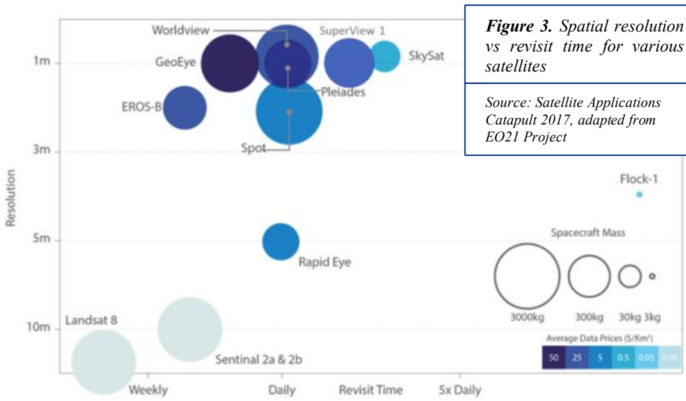


Figure 3. Spatial resolution vs revisit time for various satellites

Source: Satellite Applications Catapult 2017, adapted from EO21 Project

For ultra-premium datasets, near real-time tasking and synthetic aperture radar (SAR) imaging provide customized, high-frequency monitoring. SAR satellites can capture images through cloud cover and at night, making them essential for disaster response, security operations, and high-risk investment assessments. These datasets, often used in defense, intelligence, and financial risk modeling, come at a significantly higher cost due to their specialized capabilities.

C. How Space Data Imaging differs from Drone Images and Google Maps

Although spatial data, drone images, and Google Maps all provide valuable geographical insights, they differ in scope, accessibility, and level of detail. **Spatial data**[17] typically covers a much larger area with higher resolution and multiple layers of information encompassing air, land, and marine environments. Many spatial datasets, such as those from the **Copernicus program**, are freely accessible and widely used in research and policy-making.[18]

In contrast, **drone images** are usually privately owned, offer smaller coverage areas. **Google Maps**[19], on the other hand, is primarily designed for navigation and urban mapping. While it offers detailed street-level imagery, it often lacks the layered analytical depth available in full spatial datasets.

D. Categories of Space Data Imaging

Space data imaging can be broadly classified into three main domains based on the environment being studied:[20]

Land Includes satellite imagery of terrain, vegetation, and human settlements.
Marine Involves oceanographic data such as sea surface temperature, wave heights, and oil spill detection.
Atmosphere Contains meteorological data, including air temperature, pressure, and cloud patterns.

E. Levels of Space Data Processing

Low-level space data consists of raw, unprocessed information collected directly from space-based sensors. It includes:

Instrument Data Direct readings from satellites and scientific instruments.
Raw Data Unprocessed signals that require calibration and correction.
Environmental Variables Basic geophysical data needing further interpretation.

The primary users of low-level data are Earth observation specialists, researchers, and developers, who analyze and refine the raw data to extract meaningful insights.

High-level data is processed and analyzed, making it ready for practical use by industries, businesses, and policymakers. It includes:

Environmental Variables Processed geophysical data for decision-making.
Resampled Environmental Variables Adjusted datasets to ensure consistency.
Model Output Predictive models and simulations derived from space data.

High-level data is structured for non-experts, allowing industries such as agriculture, urban planning, and climate science to integrate it into their operations.

F. Types of Spatial Data

Spatial data is generally classified into two primary types: **Vector Data** and **Raster Data**.[21]

Vector data represents real-world features using geometric shapes:

Points Indicate specific locations, such as cities, bus stops, or GPS coordinates.
Lines Depict roads, rivers, or railway networks.
Polygons Define larger areas, such as country borders, land parcels, and lakes.

Vector data is characterized by **clear boundaries** and **scalability**, meaning it maintains quality regardless of zoom level. For example, a subway map uses points to mark stations, lines to connect them, and polygons to outline urban zones.

Raster data represents the world as a **grid of pixels**, where each pixel holds a value corresponding to an attribute (such as elevation, temperature, or land cover). Common types of raster data include:

Satellite Images Used in platforms like Google Earth.
Digital Elevation Models (DEM) Representing terrain height and landscape features.
Land Cover Maps Identifying vegetation, urban areas, and water bodies.

While raster data is excellent for continuous data representation, such as monitoring weather patterns or deforestation, it may lose clarity when zoomed in due to its pixel-based structure.

	Vector Data (Drawing)	Raster Data (Photo)
Data Structure	Uses geometric shapes (points, lines, polygons) to represent discrete features with precise boundaries.	Comprises a grid of pixels, each with a value representing information like color or elevation, suitable for continuous data.
Use case	Political Boundaries, Transportation Network Ideal for applications **requiring precision**, such as engineering designs, cadastral mapping, and network analyses.	Satellite Imagery, Climate Data etc Best for representing **continuous data like satellite imagery, elevation models, and temperature distributions.**

Figure 4. *Vector Data vs Raster Data*

2.1.3 Space Data Value Chain: Upstream, downstream, end users and intermediaries

Based on our research, we categorize them into four actors in this value chain[22]

Upstream: Satellite data providers & technology (NASA, ESA) etc.
Intermediaries: CNES, Copernicus, Consultancy providers etc.
Downstream: Synomen, Kyreman, Kermap, Kayrros etc.
Clients: Insurers, Agritech firms, Governments, Citizens etc.

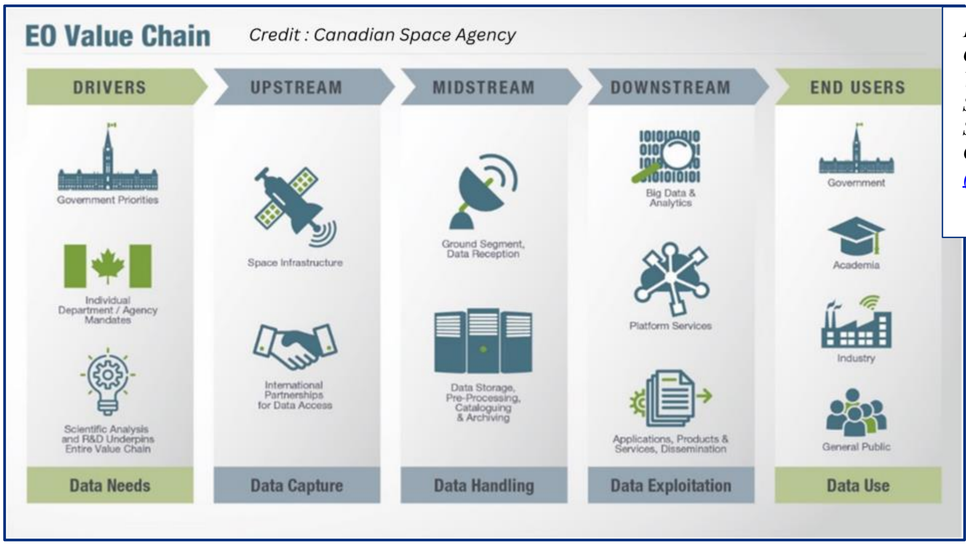


***Figure 5.** Earth Observation Value Chain Source : Agence Spatiale Canadienne [(ASC)]*

A. Upstream Players: Creating the Foundation

Upstream players are responsible for the manufacturing, deployment, and operational management of space infrastructure. This involves:

Satellite Manufacturers: Companies such as Airbus, Lockheed Martin, and Maxar Technologies design and build satellites equipped with sophisticated sensors capable of capturing detailed space data.
Launch Service Providers: Organizations like SpaceX, Rocket Lab, and Arianespace handle the critical task of launching these satellites into orbit. They also oversee ground segment operations, including mission control and payload management.

Upstream innovation is vital because it ensures that high-quality, reliable space data is generated. The sensors on these satellites capture raw information, whether it be optical, radar, or thermal, which is then fed into the next stage of the value chain.

European initiatives lead the way in the creation and deployment of EO infrastructure. For example, the **European Space Agency (ESA)** plays a central role by managing flagship programs like **Copernicus** and the **Sentinel satellite series**. ESA collaborates with major aerospace companies such as **Airbus Defence and Space** and **Thales Alenia Space** to design and manufacture advanced satellites. Additionally, **Arianespace**, headquartered in Europe, provides reliable launch services for these satellites, ensuring that high-quality remote sensing data is captured and transmitted back to Earth.

B. Intermediary: Bridging Space and Application (CNES)

Intermediaries play a vital role in linking space technology providers with end users. In France,

space technologies but also serves as a facilitator within the space data value chain. Rather than directly offering commercial products, CNES provides technical expertise, supports research and development, and fosters collaboration among academia, industry, and government.

Its dedicated service, ConnectByCNES, focuses on enabling the practical use of space data by guiding start-ups and established companies in integrating these technologies into market applications. Although sponsored by the French government and aligned with strategic initiatives, it is important to note that France 2030 is a separate government-led program aimed at boosting national competitiveness. Together, CNES and ConnectByCNES bridge the gap between upstream satellite development and downstream application, ensuring that end users receive actionable insights while driving innovation and competitiveness in the sector.

C. Downstream Players: Transforming Data into Insights

Downstream players act as the bridge between raw space data and its practical applications. Their role involves:

Data Processing and Pre-processing: Companies like Kermap, Kayrros, and Planet Labs process raw satellite imagery by calibrating, correcting, and refining data. For example, Kermap utilizes satellite imagery and artificial intelligence to monitor urban vegetation and environmental changes, providing precise insights for urban planning and environmental management. Kayrros specializes in processing satellite data to monitor energy infrastructures, greenhouse gas emissions, and environmental impacts, offering critical inputs for sustainability assessments.

Analysis and Value-Added Services (VAS): Firms such as Synomen and Orbital Insight add significant value through advanced analytics. Synomen, notably, creates predictive models to interpret agricultural and environmental data, providing actionable intelligence for farming and ecological management. Orbital Insight analyzes satellite and other geolocation data to provide insights into human activity, supporting sectors like supply chain monitoring and real estate due diligence/ Platforms like UP42 offers a marketplace for Earth observation data and analytics, allowing users to access and analyze geospatial data for various applications.

By converting raw data into refined insights, downstream players enable end users to directly integrate spatial information into strategic decision-making. They leverage the intrinsic value of spatial data, utilizing its high resolution, multidimensional attributes, and temporal characteristics. The Copernicus program illustrates this clearly. Companies like Kermap, Kayrros, and e-GEOS convert Sentinel satellite data into advanced products supporting urban planning, agricultural optimization, environmental monitoring, and disaster management, ensuring that the intrinsic value of space data, its location, attribute, and temporal dimensions, is fully realized.

D. End Users: Applying Insights to Real-World Problems

End users are the final link in the EO value chain, integrating EO-derived products into their operations to tackle sector-specific challenges. Their applications span a wide range of industries:

Agriculture: For example, EarthDaily Agro leverages high-frequency satellite imagery and agronomic analytics to enhance crop yields and reduce risks in precision agriculture.

Infrastructure and Urban Planning: Cities and municipalities use processed space data for planning transportation systems, monitoring urban growth, and managing public resources.

Environmental and Disaster Management: Agencies employ EO data to monitor deforestation, track natural disasters like floods or wildfires, and assess climate change impacts.

Insurance and Commodity Trading: These industries use spatial data for risk assessment, market forecasting, and to evaluate potential impacts on property and asset values.

By utilizing EO products, end users can make informed decisions that optimize resource management, enhance operational efficiency, and mitigate risks, all of which are supported by the rich, multi-layered data originally captured through remote sensing technologies.

E. Connecting the Dots

The European EO value chain, from upstream manufacturing and satellite deployment by ESA, Airbus, and Arianespace, to downstream processing by companies like Kermap, Kayrros, and e-GEOS, and finally to real-world applications by end users, demonstrates how satellite data becomes actionable insight. These insights tackle major global issues such as climate change, urban development, and sustainable resource use. Studies show that integrating high-resolution, multi-source space data enhances models predicting urban growth and environmental trends. Backed by strong public-private collaboration, European efforts remain at the forefront of turning space-based data into meaningful solutions. Initiatives like Copernicus have made open-access data widely available, enabling innovation across sectors.

The rise of AI-driven analytics and cloud platforms further accelerates this transformation,

ecosystem of stakeholders is well positioned to lead in delivering data-driven responses to

2.2 Space Data Applications

Recent academic and institutional research underscores the broad potential of spatial data across multiple industries. In particular, satellite-based information has proven effective for tasks such as risk assessment, supply chain optimization, and climate monitoring. However, ensuring that businesses realize tangible value from these applications remains a key challenge. Many start-ups in Earth observation struggle to transition from prototype solutions to profitable ventures, especially when there is limited awareness among end users about the practical benefits of satellite-derived insights.

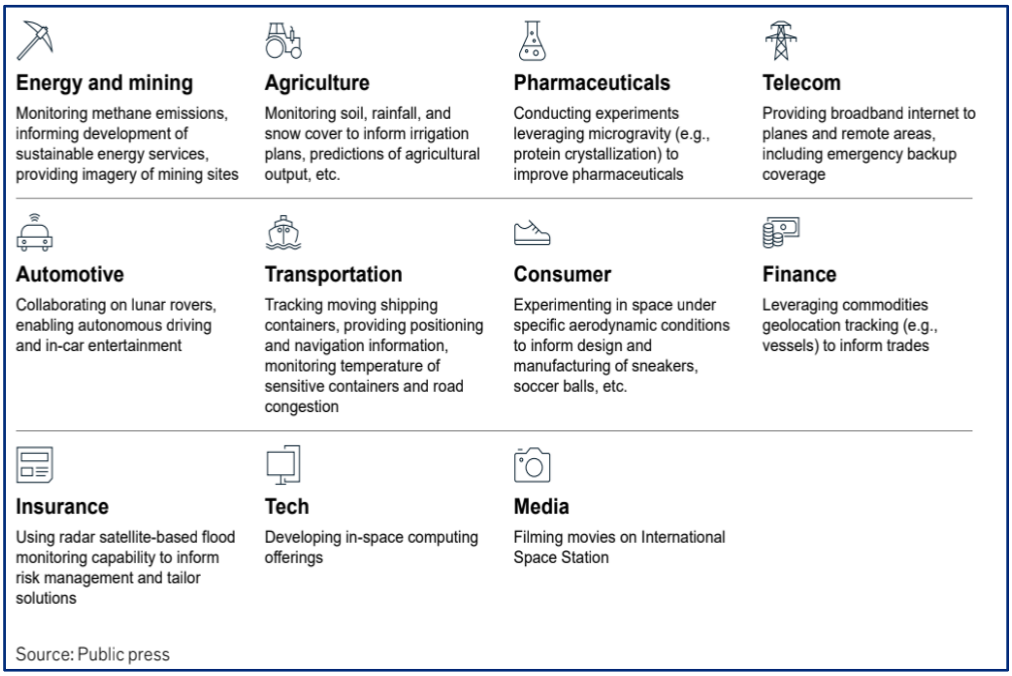


Figure 6. *EO Data in Key Economic* ***Sectors***

We have targeted two sectors where space data applications are more mature or have early adopters: **Supply Chain Management and Banking and Insurance**.

Additionally, we are exploring three additional sectors with significant potential for space data integration: **Real Estate**, **Urban Planning**. **Emergency & Disaster** and **Autonomous Vehicles**.

By examining these sectors, we aim to uncover patterns and insights that can facilitate broader adoption of space data across various industries. In each use case, our objective is to:

1. **Identify the s value chain**: Understand the sequence of activities involved in delivering a product or service within the industry.
2. **Determine the sector's pain points**: Recognize the specific challenges or inefficiencies present in the current value chain.
3. **Explore how space data can optimize or resolve these pain points**: Assess the potential applications of space data to enhance efficiency, reduce costs, or address existing challenges within the value chain.

By systematically analyzing these aspects, we aim to uncover opportunities where space data can add value and drive innovation across various industries.

2.2.1 Potential Early Adopters: Supply Chain Management

In supply chain management, the value chain encompasses a series of interconnected activities that collectively add value to a product or service as it progresses from conception to delivery. These activities typically include sourcing and procurement of raw materials, production and manufacturing processes, logistics and distribution, retail and delivery through various sales channels, and after-sales services such as customer support and reverse logistics.[23][24]

Despite the structured nature of the value chain, the supply chain industry faces several persistent pain points that hinder efficiency and effectiveness:[25][26]

1. **Risk Mitigation**: Global supply chains are susceptible to a myriad of risks, including natural disasters, geopolitical tensions, and economic fluctuations. These uncertainties necessitate the development of robust risk management strategies to ensure continuity and resilience.
2. **Extended Delivery Times**: Delays in delivery can arise from inefficient routing, unforeseen disruptions, or reliance on multiple suppliers, leading to increased operational costs and diminished customer satisfaction.
3. **Escalating Costs**: Unpredictable shipping expenses and inefficiencies within the supply chain can accumulate, adversely affecting a company's profitability and competitiveness.
4. **Lack of Visibility**: The absence of real-time data on inventory levels, shipment statuses, and supplier performance impedes informed decision-making, resulting in reactive rather than proactive management approaches.

The integration of **space data** into supply chain operations presents viable solutions to these challenges:[27][28]

Route Optimization and Transportation Management: Geospatial analytics facilitate the planning of efficient transportation routes, thereby reducing travel time and fuel consumption. This optimization leads to cost savings and improved delivery schedules.

Real-Time Tracking and Enhanced Visibility: The amalgamation of GPS technology with Geographic Information Systems (GIS) enables precise, real-time tracking of goods and assets. This heightened visibility allows for prompt interventions in cases of delays or disruptions, bolstering overall supply chain reliability.

Risk Management and Contingency Planning: Spatial data analysis aids in identifying potential risks such as natural disasters or geopolitical instabilities. By leveraging this information, companies can devise comprehensive contingency plans, thereby enhancing supply chain resilience.

By addressing these critical pain points through the strategic application of space data, organizations can enhance the efficiency, reliability, and adaptability of their supply chain operations.

2.2.2 Potential Early Adopters: Banking, Insurance and Financial Sector

The banking, insurance, and financial services sector encompasses a complex value chain that includes credit risk assessment, investment decisions, portfolio management, policy underwriting, risk assessment, claims processing, and regulatory compliance. Despite this structured nature, the sector faces several persistent pain points:

Inaccurate Risk Assessments: Both insurers and banks struggle with assessing risks accurately due to the reliance on historical data, which may not reflect current conditions, particularly for natural disasters and environmental risks.
Slow Claims Processing and Inefficient Investment Decisions: Delays in assessing damage and processing claims in insurance, and lack of precise data on economic activities and sustainability metrics in banking, can lead to customer dissatisfaction and suboptimal investment choices.
Fraud Detection and ESG Compliance: Insurers face challenges in identifying fraudulent claims, while banks and financial institutions must ensure compliance with environmental, social, and governance standards, requiring comprehensive data.

The integration of space data into these operations presents viable solutions to these challenges:

Enhanced Risk Assessment and Claims Processing: Satellites provide real-time data on natural disasters, enabling insurers to assess risks more accurately and process claims faster. This reduces fraud and ensures fair payouts. For banks, satellite-based insights help assess risks in agriculture, real estate, and infrastructure investments by monitoring environmental conditions and economic activities.
Disaster Response & Mitigation and Sustainable Finance: Remote sensing helps insurers predict risks and take preventive measures, reducing overall losses. Similarly, space data aids banks in supporting sustainable investments by providing data for ESG reporting, including monitoring carbon footprints and biodiversity impacts.
Index-Based Insurance and Economic Activity Monitoring: Space data supports agriculture and climate-related insurance products, ensuring more precise and fair payouts. Additionally, space-based tracking of supply chains, deforestation, and industrial activity helps banks gauge economic health and make informed lending decisions.[29]

By addressing these critical pain points through the strategic application of space data, organizations in the banking, insurance, and financial services sector can enhance efficiency, reliability, and adaptability
in their operations. [30]

2.2.3 Potential Early Majority: Emergency & Disaster Management Sector

The emergency and disaster management sector relies on geospatial intelligence to enhance preparedness, response, and recovery efforts. Despite advancements in technology, several challenges limit its effectiveness:

Inconsistent Disaster Mapping: Many regions lack up-to-date geospatial data, making real-time tracking of wildfires, floods, and earthquakes unreliable.
Limited Search & Rescue Efficiency: Emergency teams struggle with inefficient routing in remote or disaster-affected areas, delaying response times.
Logistical Challenges in Crisis Zones: Poor coordination of aid distribution and resource allocation leads to inefficiencies in disaster relief efforts.

The integration of GIS into emergency management offers solutions to these challenges:

Risk Assessment & Mitigation Planning: GIS enables the analysis of hazard data to identify vulnerable areas, allowing authorities to develop proactive disaster mitigation strategies.

Real-Time Situational Awareness: Dynamic mapping provides responders with live data on evolving disasters, enabling quicker and more effective decision-making.
Optimized Resource Allocation: GIS enhances crisis logistics by identifying the best routes for emergency supply distribution and personnel deployment, reducing delays in aid delivery.

By leveraging GIS for disaster management, governments, NGOs, and private organizations can improve response times, enhance situational awareness, and minimize the impact of natural and man- made disasters.

2.2.4 Potential Early Majority: Real Estate and Urban Planning Sector

The real estate sector's value chain involves a series of activities that add value to properties, including **property valuation**, **urban planning**, **infrastructure development**, and **property management**. Despite this structure, the sector faces several pain points:

Inaccurate Property Valuations: Traditional methods may not account for environmental risks or changes in land use, leading to inaccurate valuations.
Inefficient Urban Planning: Lack of comprehensive data on urban expansion and land use can result in inefficient infrastructure planning.
Sustainability Compliance: Ensuring green certifications and monitoring energy efficiency can be challenging without precise data.

The integration of space data into real estate operations offers solutions to these challenges:

Property Valuation & Risk Analysis: Satellite imagery and geospatial data improve property valuations by assessing environmental risks such as flooding and erosion.
Urban Planning & Infrastructure Monitoring: Space-based data helps track urban expansion, plan infrastructure, and optimize land use. For instance, satellite intelligence can monitor construction progress and identify bottlenecks.
Sustainability & Green Certifications: Space data aids in monitoring energy efficiency and carbon footprints, ensuring compliance with green standards.

2.2.5 Potential Early Majority: Autonomous vehicles (AVs)

Autonomous vehicles (AVs) rely on geospatial data for precise localization, navigation, and real-time decision-making. The sector's value chain involves high-definition mapping, peer-to-peer (P2P) communication, traffic management, and AI-driven data processing. However, several challenges hinder widespread adoption:

Incomplete & Outdated Mapping: Many road networks lack updated geospatial data, making AV navigation unreliable in poorly mapped areas.
Interoperability & Data Standardization: Different companies use proprietary HD maps, leading to inconsistencies in AV performance across regions.
High Processing & Storage Costs: AVs generate terabytes of data daily, making real-time processing and storage complex and expensive.
Security & Privacy Concerns: Data sharing between AVs and infrastructure faces cybersecurity risks and competitive barriers.
Unpredictable Road Conditions: AVs struggle with real-world edge cases such as construction zones and emergency vehicles, leading to decision errors.

The integration of advanced geospatial data solutions addresses these challenges:

High-Precision Mapping & Localization: Centimeter-level accuracy HD maps enhance AV lane positioning, obstacle detection, and route planning.
P2P Communication for AVs: Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication optimizes traffic flow and improves road safety.
AI-Driven Traffic Management: Predictive analytics help AVs anticipate congestion, hazards, and road closures, reducing travel delays.
Standardized Geospatial Frameworks: Governments and private companies can collaborate on centralized databases for consistent AV mapping.
Smart City Integration: AV geospatial data can enhance urban mobility planning, optimize public transport, and improve infrastructure monitoring.

By overcoming geospatial data limitations, AVs can scale efficiently, reducing traffic congestion, enhancing road safety, and accelerating the transition to autonomous mobility.

2.3 Case Selection and Application Criteria

After thoroughly exploring spatial data applications across a range of industries in the preceding sections, we identified several sectors with promising potential. To refine our focus, we defined three key criteria:

1. **Maturity**: The sector needed to show a certain level of adoption without being saturated, with active players across the upstream, downstream, and end-user segments.

2. **Economic Feasibility**: Given the current costs associated with spatial data, we prioritized sectors that have the financial capacity to support pilot projects and absorb early investment.

3. **Impact**: The selected use case had to generate meaningful outcomes across environmental, social, and governance dimensions.

concentrated on the intersection between **Agriculture and the Banking and Insurance sectors.** Here below, we focused on specific use cases derived from the spatial data value chain. Different applications such as crop insurance enhanced by weather-indexed models, land management supported by cadastral mapping and zoning data, soil health monitoring through spectral analysis, and fraud detection using geospatial verification techniques illustrate how spatial data can unlock tangible value. These cases allowed us to explore how space-derived insights are not only feasible but highly impactful when applied to climate resilience, risk modelling, and sustainable financial instruments.

2.4 Use Cases in Agriculture & Insurance

2.4.1 Context

Agriculture is rapidly evolving, with new technologies reshaping how farms are managed and how risks are addressed. Among these, spatial data stands out for its ability to provide objective and large-scale insights, whether it is tracking crop growth, mapping soil conditions, or assessing climate impact. As the sector faces increasing pressure from climate risks and economic uncertainty, satellite-based solutions are becoming essential tools in areas like insurance, land monitoring, and soil management.

We begin by exploring one of the most impactful and mature applications of spatial data in agriculture.

2.4.2 Crop Insurance & Weather-Based Index Insurance

Crop insurance and weather-based index insurance are vital tools for mitigating agricultural risks, particularly in the face of increasing climate variability. Traditional indemnity-based insurance assesses losses after an event, which can be slow and costly. Weather-based index insurance, on the other hand, uses readily available weather data (rainfall, temperature, etc.) to trigger payouts, offering a faster and more objective mechanism. However, both approaches can benefit significantly from the integration of space-based Earth Observation (EO) data.[31]

A. Satellite Rainfall Integration for Index Calibration

In Malawi, droughts and unpredictable rainfall frequently affect maize yields, threatening the livelihoods of smallholder farmers. A weather index insurance scheme was introduced to address this risk. It uses cumulative rainfall data collected from both meteorological stations and satellite sources, to trigger payouts.

> **Design**: A rainfall index was built to reflect the maize growing season (November to March), using historical data to define a payout threshold.
> **Implementation**: If rainfall falls below 80 percent of the historical average, the insurance automatically triggers compensation.
> **Impact**: This system allows for quick disbursement of funds at the end of the season, helping farmers recover without waiting for lengthy inspections or subjective damage reports.

The insurance contract specifies a trigger level (e.g., 80% of average rainfall). If the rainfall index falls below this trigger, payouts are automatically triggered. The payout amount is scaled to the severity of the rainfall deficit. For example, a 20% reduction in rainfall below the trigger results in a 20% payout of the insured amount. Farmers purchase the insurance at the start of the season. The premium is determined based on historical rainfall data and the risk profile of the region. Payouts are disbursed promptly after the end of the growing season, enabling farmers to purchase seeds, fertilizer, or food.

B. Multispectral and Hyperspectral Analysis for Crop Condition Monitoring

1. **Multispectral Imagery:** Data from sensors like Landsat and Sentinel-2 can be used to calculate vegetation indices (NDVI, EVI) that indicate crop health, stress levels, and biomass.

2. **Hyperspectral Imagery:** Hyperspectral data offers even greater potential for crop condition assessment: according to the article Surveys in Geophysics, spectrally continuous narrow-band sampling, often referred to as hyperspectral remote sensing (HRS) or imaging spectroscopy (IS), can potentially provide additional information and/or increased sampling accuracy compared to multispectral data (Goetz et al., 1985).

3. **Stress Detection:** Hyperspectral sensors can detect subtle changes in crop reflectance caused by disease, pest infestations, or nutrient deficiencies before they are visible to the naked eye.

4. **Yield Prediction:** By combining weather data with crop condition information derived from satellite imagery, more accurate yield predictions can be generated. These predictions can be used to improve the pricing and risk assessment of crop insurance products.

5. **Loss Assessment:** Satellite imagery can be used to assess the extent of crop damage after a disaster event (flood, drought, etc.), facilitating faster and more accurate claims processing.

C. Challenges and emerging technological frontiers

While satellite enhanced index insurance is gaining traction, several structural and technical limitations still hold back its full potential. These challenges affect both the design and deployment of insurance products and require targeted innovation to unlock scalable, reliable, and farmer centric solutions:

Data Gaps and Accuracy: Traditional weather data can be sparse or inaccurate, especially in remote agricultural regions. This can lead to inaccurate index calculations and basis risk (discrepancies between the index and actual farm-level losses).

Inability to Assess Crop Condition: Traditional methods often lack real-time information on crop health and development, making it difficult to accurately assess potential losses before a disaster strikes.

Efficient Monitoring Capabilities: Space-based EO provides timely, synoptic, cost-efficient, and repetitive information about the Earth's surface, according to (Justice et al., 2002 in Atzberger, 2013).

To overcome these challenges, researchers and insurers are focusing on several key innovations[32] :

Data Fusion for Enhanced Coverage: Combining high resolution optical imagery with radar data provides a more reliable view of the field, especially in cloudy or complex terrains. These hybrid approaches reduce gaps in observation and allow for more consistent measurement of vegetation health and rainfall proxies.

Satellite Informed Phenology Mapping: By detecting the exact timing of crop growth stages, insurers can adjust index parameters to match when crops are most vulnerable.

This helps reduce both temporal and design basis risk and supports more accurate contract structuring.

Localized and Scalable Index Design: Machine learning models trained on regional crop data are being used to develop tailored indices that reflect the realities of local production systems. These models take into account soil type, crop variety, and regional climate trends to improve precision.

Open Source Tools and Simplified Platforms: Institutions like the FAO and ESA are investing in the development of user friendly platforms that allow local actors to access, visualize, and apply spatial data for index design. This includes plug and play interfaces for insurance pilots and automated calibration tools.

These advancements are paving the way for more inclusive and data driven insurance products. As capacity grows and tools become more accessible, satellite data is expected to play a central role in reducing agricultural vulnerability and supporting long term climate resilience.

2.4.2 Land Management

Modern land management systems have evolved significantly, leveraging spatially enabled databases to revolutionize the way we track, analyze, and manage land resources. These sophisticated systems integrate a diverse array of spatial data, including high-resolution topographic maps, aerial and satellite imagery, and three-dimensional urban models, to create comprehensive digital representations of the physical landscape[33]. This integration enables precise monitoring of land parcel boundaries, ownership records, and topographic features, forming the backbone of efficient urban planning, infrastructure development, and environmental governance strategies. The core strength of these systems lies in their ability to consolidate and analyze vast amounts of geospatial data in real-time, providing decision-makers with up-to-date information crucial for sustainable land management [34]. By incorporating advanced Geographic Information Systems (GIS) and remote sensing technologies, these platforms offer unprecedented capabilities in spatial analysis, predictive modeling, and visualization of complex land-use patterns.[35]

A. Hong Kong Lands Department

The Hong Kong Lands Department operates a multi-purpose Land Information System (LIS)[36] that consolidates various spatial datasets to enable real-time updates on lease enforcement, land valuation, and zoning regulations Such systems enable real-time updates for lease enforcement, land valuation, and infrastructure development. By combining cadastral data with environmental metrics, governments can optimize land allocation for housing, agriculture, and conservation efforts. Spatial analytics further enhances land-use planning through predictive cant government sites and short-term

These models incorporate variables like soil quality, slope stability, and proximity to ecological reserves, ensuring balanced development.

B. LADM and Social Tenure Models

The Land Administration Domain Model [37] (LADM), provides a global framework for structuring cadastral data to ensure interoperability across different jurisdictions. It is designed to facilitate **interoperability between land administration systems**, ensuring a common structure for cadastral data worldwide. By formalizing relationships between people, land rights, and spatial units, LADM enables integration of state-recognized and customary tenure systems[38]

million land parcels in Accra, reducing title registration times from 18 months to 45 days through standardized workflows for boundary surveys and ownership verification[39]. Parallel efforts like the Social Tenure Domain Model (STDM) extend this by capturing informal land

where 3D participatory mapping tools documented overlapping claims in vertical slum structures[40]. Although, despite progress, 68% of African nations lack LADM-aligned systems, perpetuating siloed data [41]

incompatible coordinate systems, causing 23% boundary overlaps in Accra[42].

C. Challenges and emerging technological frontiers

Modern land management systems are evolving rapidly, yet several challenges continue to limit their effectiveness and scalability. These issues affect how land is documented, monitored, and governed, particularly in regions with fragmented administrative systems or informal tenure arrangements:

Fragmented Data Standards: Land records are often siloed across agencies, with inconsistent coordinate systems and outdated formats. This fragmentation creates overlaps, delays in registration, and difficulties in verifying ownership.

Informal and Unmapped Tenure: A large share of urban and peri urban land remains undocumented or informally occupied. Without integrated systems to capture these patterns, policies risk excluding vulnerable populations from land access and formal recognition.

Limited Real Time Access: Many land administration platforms do not operate in real time, preventing responsive planning and enforcement. Static systems reduce transparency and make it harder to support dynamic urban development.

Interoperability Barriers: Different land and planning departments frequently work with incompatible datasets. This lack of interoperability leads to duplicated efforts, inefficiencies, and coordination failures in land use decision making.

To overcome these challenges, institutions and researchers are advancing several key strategies:

Adoption of Unified Data Models: Global frameworks such as the Land Administration Domain Model are helping standardize how cadastral data is structured. These models improve data sharing, reduce boundary errors, and ensure consistency across jurisdictions.

Integration of Informal Tenure Records: Tools like the Social Tenure Domain Model and participatory mapping are making it possible to document non formal land rights. By combining community input with spatial analytics, these approaches help close the recognition gap for underserved groups.

Real Time Spatial Data Infrastructure:
Land Information System are demonstrating the value of real time land monitoring.

These systems integrate zoning, valuation, and lease data into dynamic dashboards that support timely governance.

Spatial Analytics for Predictive Planning: Geospatial modeling is enabling authorities to anticipate land demand, environmental risks, and development pressures. These insights support more balanced land allocation, particularly in fast growing urban areas.

Open and Interoperable Tools: International institutions are investing in the development of open source platforms that streamline land management. These tools allow local actors to update records, visualize risks, and coordinate more effectively across sectors.

As these technologies mature, land systems are becoming more inclusive, efficient, and responsive. Spatial data will continue to play a foundational role in shaping equitable land governance and supporting sustainable urban growth.

2.4.3 Soil Health Monitoring

Soil health monitoring has entered a new era with the integration of **multi-spectral satellite imagery**, **LiDAR**, and **AI-driven analytics**. These technologies facilitate non-invasive, large-scale soil analysis, enhancing decision-making in irrigation planning, carbon sequestration, and erosion control. For instance, platforms like Spatialise[43] leverage neural networks trained on 350,000+ soil samples to predict nutrient levels (nitrogen, phosphorus, potassium) at 10-meter resolution across six continents. This approach achieves 85% accuracy in diverse geo-ecological zones, enabling farmers to address deficiencies before crop yields are affected.[44]

Soil Moisture Content: -
band radar measurements to assess soil dielectric properties, providing a foundational methodology for irrigation planning and drought risk assessment. Contemporary remote sensing platforms, such as Sentinel-1, offer daily soil moisture updates, enabling the detection of anomalous hydrological patterns associated with drought conditions.[45]

Organic Matter Estimation: The assessment of soil organic carbon (SOC), a key metric for carbon sequestration and soil fertility is facilitated by hyperspectral remote sensing. Instruments such as PRISMA employ visible-near-infrared (VNIR) spectral analysis to estimate SOC concentrations with high accuracy, supporting initiatives focused on climate-resilient agricultural practices and ecosystem restoration.[46]

Erosion Patterns and Land Degradation: LiDAR-derived Digital Elevation Models (DEMs) enable the identification of erosion-prone areas by detecting topographic changes at sub-
datasets inform contour farming strategies, which have been shown to reduce topsoil loss by up to 40%, demonstrating the practical applications of remote sensing in soil conservation and land rehabilitation.[47]

A. Precision Irrigation with AWS-Powered Soil Sensors

CropX, an agricultural analytics firm, deployed 850,000 IoT soil sensors across North American farms using AWS cloud infrastructure. Their tri-sensor probes measured volumetric water content (VWC), salinity, and temperature at 15 cm resolution, reducing irrigation water use by 22% in California almond orchards[48]. Machine learning models integrated satellite derived NDVI with soil conductivity data to predict nitrogen leaching risks, enabling farmers to cut fertilizer costs by $38/acre in 2024[49]. This innovation helped CropX quadruple annual sales to $28 million by 2024, with a 92% customer retention rate among midwestern corn growers[50].

B. Hybrid Monitoring Systems for Soil and Water management

The integration of remote sensing technologies with ground-based sensors has significantly enhanced **soil moisture assessment, irrigation planning, and erosion monitoring.** By combining thermal imaging, spectral analysis, and in-situ measurements, these hybrid monitoring approaches provide high-resolution insights into soil-water interactions, supporting sustainable agricultural practices and land conservation efforts:

Drone-Based Thermal Imaging and Ground Sensor Integration: In Australia, the deployment of drone-mounted thermal sensors alongside soil conductivity probes has demonstrated substantial improvements in water-use efficiency. By correlating canopy temperature data (collected via thermal imaging) with subsurface soil conductivity measurements, farmers can dynamically adjust irrigation schedules based on real-time soil moisture variations. Empirical studies indicate that this approach has led to a 25% reduction in water consumption while maintaining optimal crop yields, underscoring the value of sensor fusion techniques in precision agriculture[51].

Remote Sensing for Erosion Monitoring and Soil Conservation: The EU-funded PREPSOIL[52] initiative has leveraged Copernicus Sentinel-2 satellite data to develop erosion prediction models across 20 European regions. These models align with the

land degradation risks. By analyzing multi-temporal satellite observations, the initiative has facilitated the implementation of targeted soil conservation measures.

Localized Soil Mapping and Fertilizer Optimization: Field trials in Norway and Poland have demonstrated how localized, high-resolution soil maps contribute to enhanced fertilizer application efficiency. By incorporating precision soil nutrient data into variable-rate fertilization strategies, researchers observed an 18% reduction in nitrate runoff, mitigating agricultural pollution while maintaining crop productivity. These findings highlight the role of spatially informed decision-making in advancing environmentally sustainable farming practices[53].

C. Challenges and emerging technological frontiers

Despite significant advancements in soil health monitoring technologies, several challenges persist that limit widespread adoption and efficacy. Simultaneously, emerging innovations promise to revolutionize the field further:

Data Integration and Standardization: The diversity of soil monitoring systems and methodologies across regions hinders data comparability. A 2024 EU study revealed that 68% of European nations lack standardized soil health indicators, impeding continent-wide assessments.[54]

Spatial and Temporal Resolution: Current satellite-based monitoring systems struggle to provide sub-meter resolution for precise field-level analysis. Sentinel-2's[55] 10-meter resolution, while improved, still limits detection of small-scale soil variations crucial for precision agriculture.[56]

Cost and Accessibility: High-end soil sensors and spectroscopy equipment remain prohibitively expensive for many farmers, particularly in developing regions. A 2025 survey indicated that only 15% of smallholder farms globally have adopted advanced soil monitoring technologies.[57]

Data Interpretation Complexity: The abundance of data generated by modern monitoring systems often overwhelms end-users. A study found that 68% of farmers struggle to translate raw soil sensor data into actionable management decisions.[58]

To overcome these limitations, researchers and agritech firms are integrating next-generation AI, hyperspectral imaging, and blockchain technology into soil health assessment frameworks:

AI-Driven Predictive Modelling: Machine learning algorithms, trained on vast soil databases, are improving the accuracy of soil health predictions. The BENCHMARKS project in Europe is developing AI models that can forecast soil degradation trends with 85% accuracy, enabling proactive conservation measures.[59]

Hyperspectral Satellite Constellations: Next-generation satellite missions, such as the planned HyspIRI, will provide global hyperspectral coverage at 30-meter resolution. This will enable more accurate and frequent assessments of soil organic matter and mineralogy across diverse ecosystems.[60]

The integration of these emerging technologies with existing monitoring frameworks promises to overcome current limitations, providing unprecedented insights into soil health dynamics. As costs decrease and user interfaces improve, widespread adoption of advanced soil monitoring techniques is expected to accelerate, contributing to more sustainable land management practices globally. However, addressing issues of data standardization, accessibility, and interpretation remains crucial for realizing the full potential of these innovations in soil health assessment and management.

2.4.4 Fraud Prevention & Risk Mitigation

The integration of geospatial information systems (GIS) with machine learning algorithms has become a key pillar in **fraud prevention** and **risk mitigation** for insurers. By leveraging spatiotemporal analytics, satellite imaging, and forensic weather verification, **insurance companies** can detect anomalous claim patterns and prevent financial losses with greater accuracy and efficiency. These advancements represent a fundamental shift from reactive fraud investigation to proactive risk assessment, reducing the burden on adjusters and minimizing erroneous payouts.

A. Weather Data Correlation for Anomaly Detection

One of the most effective fraud detection strategies involves overlaying meteorological datasets

geospatial platform, for example, cross-references high-resolution weather models (e.g. WindSpeed from WeatherSource) with insurance claims to detect fraudulent filings.

Weather Verify | Hail model to compare hail storm trajectories against auto glass repair claims. The analysis uncovered a $4.2 million fraud ring that exploited outdated storm maps, filing claims for hail damage in areas that were never affected[61]. By integrating radar data, social media posts, and meteorological records, this approach increased fraud detection accuracy by 37%, significantly improving the industry's ability to combat fraudulent claims.[62]

B. Satellite Imagery for Damage Verification

Remote sensing technology has further enhanced claims validation by enabling insurers to verify reported damages using pre- and post-event satellite imagery. Traditional on-site inspections are often costly, time-consuming, and prone to manipulation, whereas multispectral analysis of satellite data offers objective, scalable validation methods. A case study using ArcGIS Pro demonstrated how Sentinel-2 satellite imagery was utilized to assess crop damage from hailstorms in Iowa. By calculating the Soil-Adjusted Vegetation Index (SAVI) difference between pre- and post-storm images, analysts identified a 1.2 km-wide diagonal swath of vegetation loss, guiding adjusters toward legitimate claims while reducing fraudulent crop damage filings by 29% in 2024.[63] This capability is particularly valuable in catastrophic risk assessment, where insurers must differentiate between authentic damage patterns and exaggerated claims, ensuring faster and more accurate compensation disbursement.

C. Forensic Geospatial Authentication

Beyond traditional satellite verification, forensic weather analytics have emerged as a powerful tool to combat sophisticated fraud schemes. Insurance companies are now leveraging **dual-polarization radar data, AI-driven building footprint analysis, and historical weather datasets** to authenticate claim legitimacy. For example, CoreLogic technology uncovered a roofing fraud scheme in Colorado, where contractors filed 84 claims for "hail damage" on dates when no precipitation was recorded. By analyzing dual-polarization radar reflectivity and cross-referencing with social media images, investigators confirmed the absence of any hail events, preventing $1.7 million in fraudulent payouts.[64]

Similarly, __________ property analytics detected inconsistencies in claimant-submitted roof damage reports by cross-referencing historical building footprints, satellite images, and material composition data. This forensic validation method helps insurers identify artificially inflated or fabricated claims, strengthening fraud prevention measures.[65]

D. Challenges and emerging technological frontiers

Despite its successes, geospatial fraud detection still faces critical limitations that must be addressed to improve precision, scalability, and global applicability:

Data Resolution Constraints: Existing hail mapping systems lack the capability to verify damage below 10-meter resolution, making it difficult to detect small-scale fraud in mixed land-use areas.[66]

Temporal Latency: Satellite revisit times range from 3 5 days for Sentinel-2, creating delays in near-real-time claim validation. However, emerging CubeSat constellations are expected to provide hourly updates, significantly improving fraud detection speed.[67]

Algorithmic Bias and Regional Variability: Fraud detection models trained on North American weather patterns have 23% higher error rates when applied to tropical cyclone-related claims in Southeast Asia, highlighting the need for localized model training and adaptation.[68]

To overcome these challenges, insurers are now integrating next-generation AI, blockchain technology, and IoT-enabled real-time monitoring systems into their fraud detection frameworks.

Quantum Machine Learning for probabilistic fraud scoring: A pilot study conducted by Zurich Insurance demonstrated 91% fraud detection precision using quantum-enhanced risk models, which can assess probabilistic anomalies in claims submissions with greater computational efficiency.[69]

Blockchain-Immutable Claim Geotags: Some insurers are embedding blockchain technology into geotagged claims to prevent data tampering and fraudulent modifications post-submission, ensuring greater transparency and auditability.[70]

IoT-Integrated Parametric Insurance:
which uses ground-based hail sensors to trigger claims disbursement when predefined weather thresholds are met, has reduced human verification costs by 44%, offering a scalable alternative to traditional loss assessments.[71]

These advancements underscore the growing role of geospatial analytics in stabilizing the insurance market, with industry projections estimating **$12.6 billion** in annual fraud-related savings by 2030 through enhanced detection capabilities and automated claim validation.[72] As insurers continue to refine spatial risk modeling and integrate AI-powered geospatial intelligence, the industry is poised to transition toward fully automated, real-time fraud prevention frameworks, ensuring greater efficiency, cost reduction, and data-driven decision-making in insurance claims management.

3. Methodology

3.1 Project Scope

This project scope focuses on the Geospatial and Earth Observation data sectors, with particular attention to the business applications that drive real-world adoption. Rather than exploring the upstream domain of satellite manufacturing or launch infrastructure, our work is positioned at the intersection between space data providers and industry end users. The objective is to identify barriers to adoption and propose strategic levers that can accelerate the integration of Earth Observation data across sectors.

Our research follows a recognized hourglass approach. We began by reviewing the current and emerging applications of spatial data across six broad sectors. From this initial landscape, we selected one use case : agriculture and insurance for in-depth analysis. This allowed us to study adoption dynamics at a granular level and derive strategic insights that can be applied more broadly. The goal is not only to understand what is slowing down adoption, but also to suggest pathways for building scalable and sustainable solutions grounded in real operational needs.

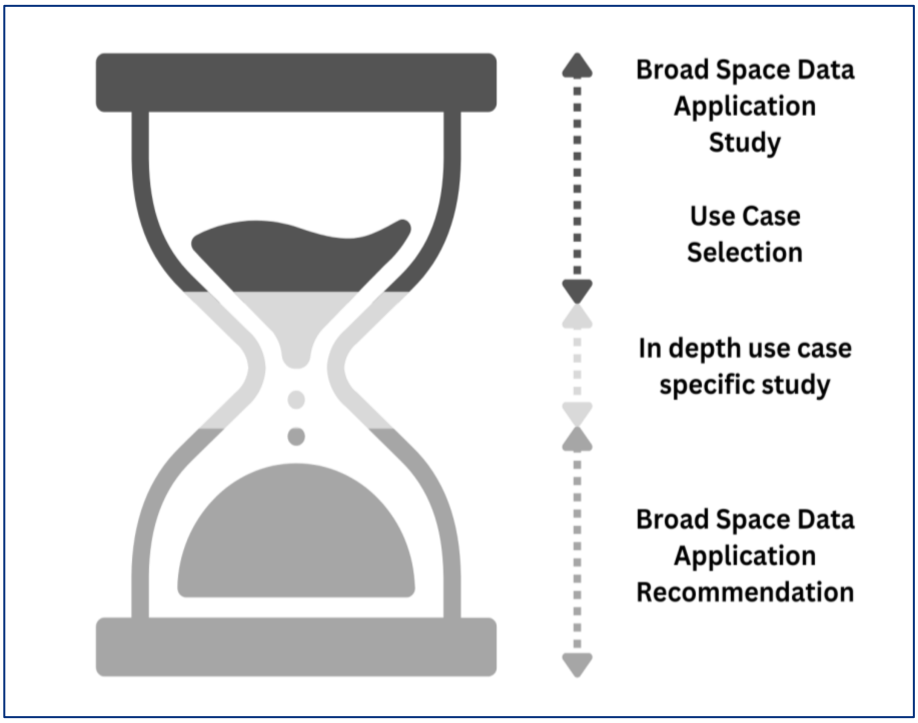


***Figure** 7. Hourglass Approach*

3.2 Market Research Approach

Our research will be primarily qualitative, based on in-depth interviews with key stakeholders across the Earth Observation data value chain. The objective is to gain first-hand insights into the adoption, challenges, and opportunities associated with EO data from multiple perspectives:

1. **Space Actors** Companies developing and supplying EO data and analytics solutions.
2. **Industry Actors** End-users who integrate EO data into their operations (e.g., agriculture, insurance, finance, logistics).
3. **Intermediaries** Organizations facilitating the adoption of EO data, such as consultancies, data aggregators, or regulatory bodies.

3.2.1 Interview Objectives

Our goal is to map the EO data adoption potential framework by understanding:

Challenges faced at different points in the value chain.
Opportunities and gaps that could accelerate adoption.
Decision-making factors influencing EO data investments.

3.2.2 Interview Questions

To deepen our understanding of the spatial data value chain, we conducted interviews with stakeholders across its three main streams: space data providers, intermediaries, and end users. Our initial objective was to complete six to ten interviews, but limited interest and awareness from industry actors narrowed the scope. In total, we conducted five interviews, including three with downstream players (Kayrros, Kermap, and Synomen) and two with intermediaries (Sia and CNES). While fewer than planned, these discussions offered valuable insights into the current state of adoption, technological readiness, and the role of ecosystem enablers.

Within our interview questions, we tried to assess the following aspects for each stream of actors:

Interviewee	**Objective**
Space Actors	Gain in-depth insights into the current state of the spatial data value chain, including technological capabilities, cost structures, and market dynamics.
Industry Actors	Understand barriers to spatial data adoption in industry value chains.
Intermediaries	Understand the broader landscape and challenges.

Please refer to the appendix for the detailed list of questions for each segment of interviews.

4. Findings & Results

Based on the data collected from our interviews and the survey provided by Sia, we have structured our findings into two key parts: **Primary Data** and **Secondary Data**.

> Primary Data: Derived from our qualitative thematic analysis, this part captures the nuanced challenges, perceptions, and opportunities identified through interviews with stakeholders across the spatial data value chain. Participants ranged from downstream providers (Kayrros, Kermap, Synomen) to intermediaries (Sia, CNES), ensuring balanced perspectives.
>
> Secondary Data: Complementing our primary research, we analyzed quantitative data from the industry-specific survey provided by Sia. This allowed us to measure awareness levels, usage gaps, and industry-wide barriers more concretely. Additionally, we drew on insights from authoritative industry reports to back up our findings and make sure our conclusions aligned with broader trends.

4.1 Primary Data - Interviews Thematic Analysis

(See appendix Part 7.1 for full interview questions)

4.1.2 Key Themes

We used a thematic analysis methodology to extract key insights from four in-depth interviews. Each participant brought a distinct perspective within the satellite data value chain:

> Synomen CEO of Synomen, a start-up specializing in satellite-based solutions for damage assessment and yield forecasting, primarily for the insurance sector.
> Kayrros VP Security at Kayrros, the global leader in environmental intelligence, providing data-driven insights and monitoring services.
> Connect by CNES Support & Partnerships at Connect by CNES, a division of the French national space agency dedicated to facilitating spatial data adoption and supporting industry integration.
> Kermap Product Manager at Kermap, offering satellite imagery products and analytics services dedicated to agriculture and environmental monitoring.

Each transcript was thoroughly reviewed to identify recurring challenges, opportunities, and best practices. These insights were grouped into five main themes (A to E), from **awareness and integration to cost, simplification, and future scaling**.

A. Awareness & Education Gaps

The starting point in our analysis focuses on a foundational barrier: many organizations simply do not understand what satellite data can do, or they assume it is inaccessible or irrelevant to their operations. Across interviews, a lack of awareness, perceived complexity, and limited exposure to use cases emerged as consistent themes. Educating users on the possibilities and practical applications of satellite data remains one of the most critical first steps in enabling broader adoption.

Diane (Synomen) - Initial pilots and small-scale tests are crucial to building confidence in satellite- -site assessments remains a

Jérémy (Kermap) -

Julien (Kayrros) -
the value to reassure people.

Observations

Public agencies such as CNES also struggle to demystify satellite data for end users. Many prospective clients mistakenly believe they need specialized geospatial expertise or extremely high-resolution imagery in order to gain any concrete advantage.

Implications

Demonstrations, brief pilot projects, and approachable training programs help reduce the perception of complexity. Marketing strategies that spotlight clear ROI move potential users from initial curiosity to tangible adoption.

B. Integration & Trust

Even when awareness exists, a second layer of resistance often appears in the form of integration challenges and trust barriers. Organizations may struggle to incorporate spatial insights into existing workflows, and many remain sceptical about relying on remote-sensed data for decisions that have historically been based on physical inspections or ground data. Interviewees emphasized that trust must be earned through validation, transparency, and alignment with business realities.

Diane (Synomen) -

Antoine (CNES) -

Jérémy (Kermap) - We target domain specialists, not imagery experts, so we need a very

Observations

Parametric or index-based insurance (Synomen) highlights the tension: farmers may still favor a hands-on assessor, even though satellite-based triggers can speed payouts if properly trusted. ing block to convincing users that remote-sensed data is reliable.

Implications

Providers must showcase validated metrics or usage success stories, thereby bridging the gap between raw satellite information and intuitive, user-friendly interfaces. A detailed explanation of how algorithms and ground truth data align is also crucial in building stakeholder trust.

C. Economic Constraints and ROI Focus

Having already highlighted issues with awareness (Theme A) and integration trust (Theme B), our next topic focuses on the financial dimension. Interviewees frequently emphasized the importance of minimizing costs and demonstrating near-term value to justify investment in satellite-based analytics. Below, we delve into these core budgetary constraints and the return-on-investment mindset:

Diane (Synomen) -resolution imagery can be prohibitively expensive, making it feasible primarily for high-

Julien (Kayrros)

Antoine (CNES)

Observations

Although open-access programs like Sentinel reduce licensing costs, the substantial outlays for analytics, cloud computing, and specialized talent remain. For budget-sensitive entities (e.g., small agricultural players), any new solution must quickly show tangible benefits to secure funding. Meanwhile, larger corporations (in finance or energy) can generally absorb these expenses more comfortably, though they too expect clear returns.

Implications

Pilot projects that deliver rapid, demonstrable ROI (for example, raising yields or mitigating risk) encourage adoption among budget-constrained customers. Public private partnerships or multi-actor consortia can also share the costs of deployment. Moreover, articulating tangible returns such as lower input expenditures or faster reporting helps expand satellite data use beyond a handful of test cases.

D. Simplification and Automated Tools

Beyond budgetary considerations, our interviews underlined a drive toward simpler, more automated solutions. By transforming raw satellite data into easily digestible metrics or dashboards, providers aim to reduce end-user overhead and accelerate the assimilation of these insights.

Julien (Kayrros)
deliver easy-to-

Jérémy (Kermap) -free mosaics, so users get a clean visual,

Observations

Interviewees note a shift toward more intuitive interfaces, where complex steps (AI, big data processing) happen behind the scenes. Automating tasks like anomaly detection or parametric triggers reduces dependence on staff trained in raw satellite imagery. Still, algorithmic transparency (ground validation, metric reliability) remains crucial to reassuring non-specialist decision-makers.

Implications

User-friendly platforms can facilitate mainstream adoption because many professionals (insurers, agronomists, urban planners) lack GIS or AI expertise. To maintain credibility, providers should clarify data sources and possible limitations (e.g., residual cloud cover, effective resolution). Clear, domain-specific metrics (e.g. soil coverage duration, risk indices) support long-term integration of satellite tools into decision chains.

E. Future Directions and Scaling Up

Finally, our interviewees consistently anticipated an evolving future in which technological progress (e.g., hyperspectral sensors, near-real-time coverage) intersects with regulatory shifts to stimulate further adoption. However, new capabilities alone will not suffice without organizations prepared to exploit them effectively.

Antoine (CNES)

Diane (Synomen)
satellite-triggered pay-outs

Jérémy (Kermap) -daily coverage becomes

Observations

All interviewees foresee broader adoption of satellite data, driven by improved sensors and increasing environmental requirements (deforestation rules, ESG monitoring). However, technical upgrades alone do not guarantee mass uptake; organizations must also adapt culturally, financially, and operationally to harness this data in practice.

Implications

Beyond environmental mandates, new use cases are expected to fuel a surge in demand. -in- championed by national space agencies like CNES or through industry alliances (e.g. the Open Geospatial Consortium) could smooth the transition and prevent fragmented solutions. As parametric and supply-chain services grow, large-scale near-real-time data processing will become essential.

4.1.3 Actionable Insights

This thematic analysis highlights five essential insights for scaling satellite data adoption. First, most organizations face awareness gaps and need concrete use cases to understand the value of satellite data (Theme A). Even with interest, integration remains a challenge, as many lack trust in remote-sensed outputs and struggle to align them with internal systems (Theme B). Economic pressure adds another layer: organizations expect quick, measurable returns, especially in cost-sensitive sectors (Theme C). Simplified platforms and automation (Theme D) can reduce complexity for non-experts but must be supported by transparent methods. Finally, while regulatory and technological advances promise growth (Theme E), adoption depends on readiness and practical usability. Taken together, these themes show that adoption is not just a matter of access to data, but of designing the right tools, incentives, and partnerships to make spatial intelligence truly operational.

4.2 Analysis of the Space Guild - Insurance Survey 2023

(See appendix Part 7.2)

4.2.1 Target Goal of the Survey

The survey aims to assess the awareness, adoption, and challenges of space data in the insurance sector. It explores how insurance companies use spatial data, the barriers they face in integrating it, and the role of external data providers and specialized teams in this process.

4.2.2 General Results

A. Familiarity vs. Usage Gap

While many insurance professionals are familiar with satellite imagery **(88%)**, climatic and meteorological data **(86%)**, and urban infrastructure data **(68%)**, actual usage remains significantly lower. This **familiarity vs. usage gap** suggests that despite recognizing the potential benefits, companies struggle to fully integrate space data into their workflows.

B. Challenges in Adoption

One major challenge in adoption is the lack of expertise, with **51%** of respondents stating that they lack the necessary technical skills to analyze geospatial data effectively. Additionally, **42%** cited limited computational resources, making it difficult to process large datasets. **39%** reported high costs as a barrier, while **36%** noted the lack of standardization, which **complicates integration across multiple data sources**.

C. Use of Specialized Teams

Only **27%** of companies have a dedicated space data team. Instead, spatial data tasks are often distributed across various departments, primarily risk modeling **(62%)**, underwriting **(45%)**, and IT/data analytics **(38%)**. This fragmented approach may **contribute to inefficiencies in data utilization.**

D. External Data Providers

Due to limited in-house capabilities, **64% of companies** rely on external providers for space data. However, there is a lack of transparency regarding these providers, suggesting that procurement strategies are not well-coordinated across the industry.

4.2.3 Main Barriers to Space Data Adoption

The survey identifies several key obstacles:

- Lack of expertise **(51%)** Difficulty in analyzing and interpreting space data.
- Limited computational resources **(42%)** Insufficient processing power for large datasets.
- High costs **(39%)** Expensive data acquisition limiting widespread use.
- Data & Integration challenges **(36%)** Difficulties in integrating multiple sources.

4.2.4 Actionable Insights

Despite growing awareness, the adoption of space data in insurance remains slow due to technical complexity, cost, and resource limitations. However, strong industry interest in collaboration and best practice sharing suggests opportunities for improvement. Addressing these challenges through training programs, industry-wide data standards, and partnerships with public data providers could accelerate adoption and maximize the value of space data in insurance.

4.3 Institutional insights

To enrich our thematic findings from interviews (Section 4.1) and survey results (Section 4.2), we conducted an additional institutional analysis of recent authoritative studies from leading global and European organizations. This analysis serves two primary purposes:

Validate and strengthen our primary data insights through external expert evidence.
Expand the strategic understanding of the Earth Observation (EO) adoption landscape, highlighting global adoption trajectories, critical barriers, effective enablers, and relevant sector trends.

4.3.1 Global Trajectory of Spatial Data Adoption

The global EO market is rapidly expanding, expected to generate more than **$700 billion annually by 2030**, contributing cumulatively around **$3.8 trillion** to global GDP from 2023 to 2030 (World Economic Forum & Deloitte, 2024). This remarkable growth underscores a significant economic opportunity echoed by our interviews, where actors emphasized potential ROI gains but cited uncertainty around realizing these benefits. Additionally, global studies highlight that the strongest EO uptake is occurring in agriculture, public services, and renewable energy sectors, also frequently referenced in our interviews, reinforcing the sectoral priorities identified.

4.3.1 Common Barriers to Adoption

Our interviews consistently revealed substantial barriers around awareness, complexity, economic constraints, and integration challenges which are also findings confirmed by Deloitte (2024)[73] and ESA (2020)[74]. Institutional sources highlight technical hurdles like fragmented data standards, insufficient interoperability, and overly complex data marketplaces as primary barriers preventing widespread EO data adoption. These barriers directly align with interviewees' concerns about usability and economic viability. Furthermore, institutional evidence emphasizes organizational and educational gaps: companies often lack the internal expertise required to leverage EO data effectively, reflecting our own findings regarding insufficient internal capabilities and a significant awareness gap among potential end-users.

4.3.2 Key Enablers and Triggers

Institutions such as ESA (2020), Deloitte (2024), and the World Economic Forum (2024)[75][76] identify clear strategies that have successfully mitigated these barriers, strongly aligning with solutions proposed by our interviewees and survey respondents. Open data policies (e.g., Copernicus), improved standardization efforts (like STAC standards), and advancements in AI-driven automation for data processing have proven effective in increasing adoption.

5. Recommendations

5.1 Overview

Building on the insights developed throughout our research, from stakeholder interviews to sector-specific use cases, this final section introduces a set of concrete recommendations to support the adoption of spatial data. The objective is to move from analysis to action by equipping industry actors with tools that respond to the barriers identified and help scale spatial capabilities in a structured way. These recommendations are intended to be practical, flexible, and relevant across different contexts. They focus on enabling downstream users and intermediaries to unlock operational value, build internal alignment, and guide strategic decision-making.

First, the **four-quadrant maturity model** will serve as a strategic tool for evaluating the adoption of space data across various industries. It aims to bridge the gap between technological capability and industry awareness by providing a structured framework for understanding where an organisation stands in terms of readiness, willingness, and integration of space data solutions. By leveraging a diagnostic survey, industry players can evaluate their technical infrastructure, financial strength, organisational culture, and external integration capacity. The resulting scores help position them within a **Maturity Framework**, guiding them toward enhanced adoption and innovation.

Additionally, to support awareness and facilitate adoption, our recommendations include curated **use case presentations** designed to help intermediaries make the value of space data concrete and relatable for end users. These cases allow intermediaries to build stronger narratives around operational benefits and sector-specific applications, making conversations with clients more targeted and effective.

To complement these tools, the framework also introduces a **product catalog** and a **strategic roadmap** to support adoption. The catalog provides tiered spatial data offerings aligned with different levels of organizational maturity, helping end users engage with relevant tools based on their capabilities. In parallel, the roadmap outlines three key stages: Kickstart, Accelerate and Pioneer, offering a clear progression toward full spatial data integration and data-driven decision making.

5.2 Use Case Presentation

(see appendix Part 7.3)

The use case presentation component of the maturity model is designed to address the most prominent barrier identified throughout our research: the widespread lack of awareness regarding space data and its practical applications. It aims to support intermediaries (Sia, CNES) in their role by equipping them with sector-specific examples that make the value of space data tangible for end users. Rather than focusing on abstract capabilities, the use cases serve as targeted entry points to spark interest and build relevance based on actual business needs. As part of this framework, we have compiled a repository of three illustrative use cases, each mapped to a different early adopter context:

1. **Agriculture and Insurance** Public Private Partnership
2. **Green Bond and Finance** Private Sector
3. **Autonomous Vehicles** Public Sector

5.3 Maturity Assessment Framework

5.3.1 Overview

The four-quadrant maturity model (Maturity Assessment Framework) is the core analytical framework of this project. -driven entity by assessing its ability to leverage various types of data (structured, unstructured, real-time), and **determines its readiness to adopt and scale all type of data solutions,** including spatial, across four key dimensions. The four quadrants capture different levels of data maturity, ranging from Unaware Participants, with limited capabilities and awareness, to Aspiring Innovators, who are beginning to explore data opportunities, Resilient Incumbents, with strong foundations but limited agility, and Data-Driven Leaders, who embed data strategically across their operations and decision-making processes.

The assessment is structured around a **diagnostic survey**, developed based on insights from our primary and secondary research. It includes four main categories that reflect the internal and external enablers of adoption:

Technical Infrastructure
data infrastructure.
Financial Strength
capacity to invest in space data.
Buy-in and Culture: Measures internal alignment, openness to innovation, and employee awareness.
Integration and Trust: Focuses on partnerships, data sharing readiness, and trust in external providers.

Each category includes 4 to 5 targeted questions, with each answer scored from 1 to 5. The scoring range reflects increasing levels of maturity, from minimal awareness to strategic integration: Non-existent or negligible; Basic or reactive; Developing or partially planned; Established or proactive; Advanced or strategic.

Each category is weighted equally, contributing up to 25 points for a total possible score of 100. However, individual questions within categories are weighted based on their relative importance and observed impact during our research. The outcome of the assessment is a total score, **-quadrant model**. This visual and strategic tool helps organizations identify their adoption stage and clarify the next steps for progression.

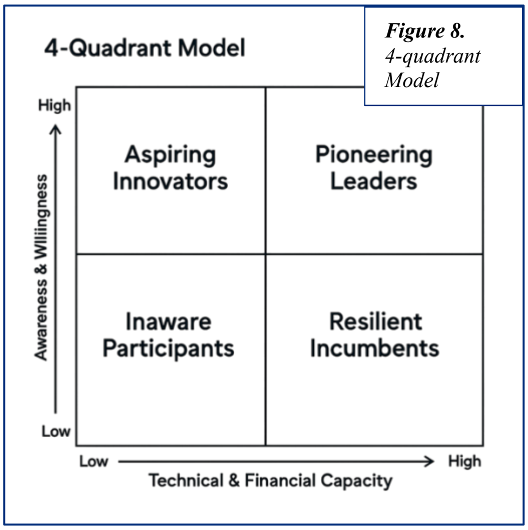


Figure 8. *4-quadrant Model*

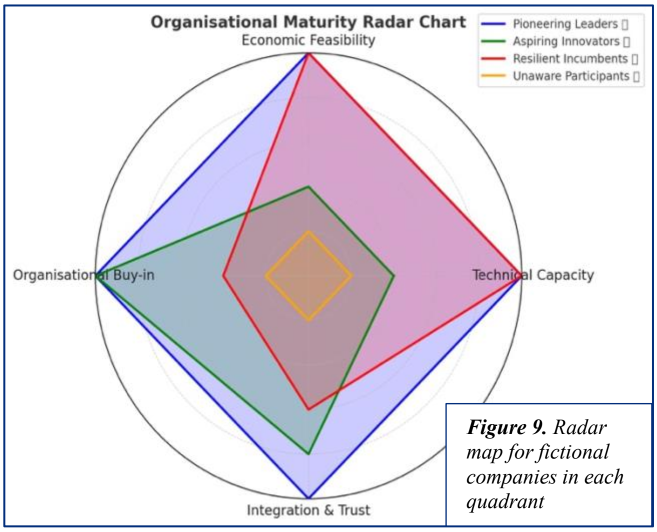


Figure 9. *Radar map for fictional companies in each quadrant*

5.3.2 Survey questions

(see appendix Part 7.4)

Based on the conducted interviews, we understood the needs and gaps in the application of space data in broad industries. We identified 4 key categories within industry actor operations and organisation to address using a ranking based survey. Each category comprises 4-5 questions covering extensive topics such as data infrastructure readiness, employee and company culture buy-in etc.

These categories are as follows:
1. Technical Infrastructure - Readiness for Space Data Adoption
2. Financial Strength - Economic Feasibility & Cost Perception
3. [Internal] Buy-in & Culture -Openness to Space Data Adoption
4. [External] Integration & Trust (Perception & Ecosystem Readiness

5.3.3 Four quadrant model

Once the company assessments are completed, the scores will be aggregated based on their responses and the assigned weight of each question. The overall score will then determine their placement within one of four quadrants, as outlined below:

Score Range	4 Quadrants
20-29	Unaware Participants
30-44	Resilient Incumbents
45-80	Aspiring Innovators
81-100	Pioneering Leaders

We intentionally designed the scoring scale to be skewed toward higher scores for Aspiring Innovators and Pioneering Leaders. Our belief is that many companies tend to be conservative in their evaluations. Since the goal of this report is to encourage innovation and integration with spatial data, we designate the quadrant ranges so as to motivate companies to categorize themselves/shift towards becoming Aspiring Innovators or even Pioneering Leaders.

Our Four Quadrant Model is based on two key axes:

X-axis: Technical & Financial Capacity This axis is derived from our assessment of Technical Infrastructure and Financial Strength.
Y-axis: Awareness & Willingness This axis reflects the level of internal buy-in (Buy-in & Culture) and external engagement (Integration & Trust).

Based on the scores from these categories, companies are positioned into one of four quadrants, which represent high or low levels of Technical/Financial Capacity and Awareness/Willingness. This model helps us clearly identify where an organization stands and what areas need further development for full-scale adoption of space data initiatives.

4 Quadrant Model		
High Awareness & Willingness	Aspiring Innovators	Pioneering Leaders
Low Awareness & Willingness	Unaware Participants	Resilient Incumbents
	Low Technical/Financial Capacity	**High Technical/Financial Capacity**

(Graph Maturity Model)

Below is a concise explanation for each quadrant:

1. Pioneering Leaders (High Technical/Financial Capacity, High Awareness & Willingness)**:**

These companies have a robust technical infrastructure and strong financial resources. They not only recognize the strategic value of space data but also integrate it into their decision-making processes. Their proactive approach and substantial investments position them at the forefront of innovation and industry leadership.

2. Aspiring Innovators (Low Technical/Financial Capacity, High Awareness & Willingness)**:**

Organizations in this quadrant are enthusiastic and aware of the benefits of space data. However, they currently lack the necessary technical infrastructure or financial capacity to fully implement these solutions. With targeted support, strategic partnerships, or phased investments, they have significant potential to harness space data for transformative growth.

3. Resilient Incumbents (High Technical/Financial Capacity, Low Awareness & Willingness)**:**

These companies possess the technical and financial strength to adopt space data, yet they have not fully embraced its potential. Often operating within traditional frameworks, they tend to be more risk averse. Cultivating greater awareness and fostering a culture of innovation could help them unlock untapped opportunities in their existing operations.

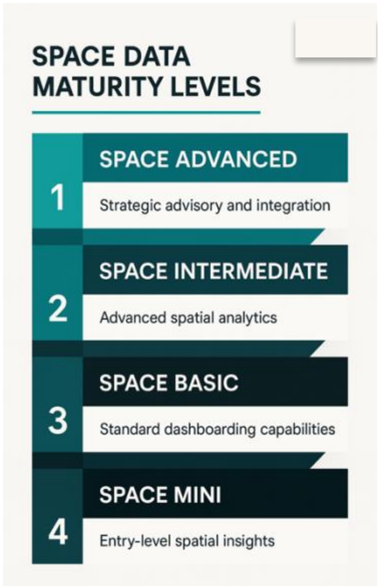
4. Unaware Participants (Low Technical/Financial Capacity, Low Awareness & Willingness)**:**

Companies in this category face challenges on both fronts. They lack the necessary resources and do not prioritize or recognize the strategic benefits of space data. This group requires significant efforts in both capacity building and cultural transformation to move toward a more proactive, data-driven approach.

5.4 Strategic Recommendations and Plans

5.4.1 Product Catalog

The Product Catalog is primarily targeted toward **downstream actors and end users**, **providing clearly defined technical products, analytics solutions, and support tools** suitable for varying organizational maturity. Building on the insights gathered from the maturity model, we propose four progressive levels of space data integration. Each level reflects a different stage of organizational readiness, from early exploration to full strategic integration. The structure is designed to guide industry actors along a scalable path, acknowledging both their current capabilities and future potential.



Rather than assigning rigid quadrant-based restrictions, each level is linked to an indicative target audience based on their position in the maturity model. This allows flexibility, encouraging actors to start small and experiment with lower commitment options even if they are positioned in a more advanced quadrant. The goal is to create a pathway that promotes exploration and de-risks early engagement. **Each level includes a foundational set of services and tools** designed to support adoption and reduce entry barriers. These core components are meant to provide a minimum viable environment for industry actors to explore, test, and scale space data solutions based on their current capacity.

As organizations progress, the offering becomes more sophisticated. At higher levels, data inputs shift from public sources (e.g. Sentinel) to premium commercial imagery providers such as Maxar and Airbus. These packages feature increased spatial resolution, frequency, and analytical depth, enabling more complex and business-critical applications. The product catalog is not intended as a one-size-fits-all solution but as a **flexible roadmap** to help industry actors progressively unlock the value of space data in a way that aligns with their capabilities and ambitions.

Level 1: Space Mini *Exploration & Awareness*
Indicative audience: *Primarily Unaware Participants and Resilient Incumbents seeking initial understanding.*

This foundational offering targets initial exploration, providing accessible resources to familiarize organizations with basic spatial data and its potential.

Satellite Imagery:

Sources: Public, open-access data (Sentinel-2, Landsat-8).
Resolution & Frequency: Medium resolution (10 30 meters), regular revisit cycles (5 16 days).
Use-Cases: Basic vegetation indices (NDVI), crop monitoring, broad land-use changes, preliminary disaster assessments.

Tools & Capabilities:

Simple visualization dashboards (EO Browser, Sentinel Hub).
Introductory training sessions to demystify spatial data concepts.
Access to community portals showcasing entry-level case studies and peer interactions.

Level 2: Space Standard *Adoption & Integration*
Indicative audience: *Aspiring Innovators beginning pilot initiatives and selected Resilient Incumbents seeking internal capability building.*

Focused on structured pilot implementation, this level enhances data quality, analytical depth, and integration into existing business workflows.

Satellite Imagery:

Sources: Sentinel-1 (radar imagery for all-weather monitoring), Planet Labs (daily revisit imagery).

Resolution & Frequency: Improved resolution (3 5 meters), daily imagery availability.

Use-Cases: Precise monitoring of agricultural health, infrastructure tracking, asset management, and basic environmental risk modeling.

Tools & Capabilities:

GIS integration tools (ArcGIS Online, QGIS) to support operational analytics.

Certification programs in spatial data analytics for internal talent development.

Integrated BI dashboards (Power BI, Tableau) for operational decision-making.

Level 3: Space Intermediate *Expansion & Optimization*
Indicative audience: *Mature Aspiring Innovators and Pioneering Leaders ready for strategic adoption.*

Here, spatial data is fully integrated into business-critical operations, using high-resolution commercial imagery, advanced analytics, and predictive modeling, as emphasized in our expert interviews (Synomen, CNES, Kermap).

Satellite Imagery:

Sources: Premium commercial providers (Airbus Pleiades Neo, Maxar WorldView, Capella SAR).

Resolution & Frequency: Sub-meter resolution imagery (<1m), on-demand tasking, and frequent revisits.

Use-Cases: Precision agriculture (early disease detection via hyperspectral imagery), infrastructure precision monitoring, risk assessment (insurance sector), and predictive urban growth analytics.

Tools & Capabilities:

Cloud-native spatial analytics (AWS Geospatial, Google Earth Engine).

Machine learning and AI-driven predictive analytics for detailed spatial insights.

Technical support and expert consultancy (Kermap, Kayrros, Synomen, Sia) for tailored data integration and analytics.

Level 4: Space Advanced *Strategic Transformation*
Indicative audience: *Pioneering Leaders integrating spatial intelligence into strategic and competitive positioning.*

This top-tier offering aligns closely with the strategic vision emphasized by our institutional research and expert interviews, positioning spatial data as a core driver of operational excellence, sustainability, and innovation.

Satellite Imagery & Data Fusion:

Sources: Integrated multi source imagery (Maxar, Airbus, ICEYE SAR), hyperspectral sensors (e.g., PRISMA, Pixxel), LiDAR, and advanced IoT spatial data.

Resolution & Frequency: Near real-time capabilities, continuous monitoring, ultra-high-resolution (sub-meter accuracy), hyperspectral data to capture detailed spectral signatures for advanced analytics.

Use-Cases: Integrated digital twins, advanced risk modeling (insurance and disaster response), environmental compliance and sustainability tracking.

Tools & Capabilities:

Enterprise-level Geospatial Data Infrastructure (GDI) enabling real-time spatial analytics (AWS, Azure).

Advanced AI/ML solutions (Databricks, TensorFlow), quantum computing for complex spatial modeling.

Strategic innovation partnerships (academia, technology firms, government bodies) ensuring continuous leadership and innovation within spatial data ecosystems.

To conclude this section, the comprehensive visual representation of our Product Catalog presented below provides a clear, detailed pathway for strategically adopting and scaling spatial data capabilities. By mapping actionable services, training programs, and advanced analytical tools to specific maturity levels, organizations can incrementally unlock the full value of spatial intelligence, guiding them step by step toward meaningful business transformation.

Figure 10. Product Catalog

Level	Name	Imagery Cost Type	Imagery Type	Frequency	Training	Dashboard	Quarterly Reports	Dedicated Analyst	Expected/Target Quadrant
1	***Space Mini***	Open Source Low Cost	Sentinel Data Landsat	Daily Monthly	Quarterly introductory workshops covering basic spatial data usage, initial GIS concepts, and potential industry use-cases. Regular webinars showcasing practical examples and encouraging initial exploration.	Basic data visualization and analytics. Automated alerts for significant spatial events (e.g., vegetation stress, flood warnings). Data API connections available for easy integration into internal systems (CRM, ERP). Access to community portals for shared learning. Repository of introductory use cases to encourage experimentation.	No	No	*Unaware Participants, Resilient Incumbents*
2	***Space Basic***	Open Source Low Cost	Sentinel Data Landsat	Daily Weekly	Bi-monthly workshops for change management, deeper integration strategies, and hands-on training on dashboard capabilities. Custom onboarding sessions to align dashboards with specific operational goals.	Interactive analytics dashboard with automated alerts, insights, and actionable recommendations. Capability for basic scenario modeling (what-if analyses). Full data API connection supporting standardized integration workflows. Quarterly Analyst-generated reports summarizing key insights, recommendations, and integration guidance. Access to industry-specific use cases and community portals.	Yes	No	*Resilient Incumbents, Aspiring Innovators*
3	***Space Intermediate***	Open Source Low Cost Medium Cost	Sentinel Data Landsat SPOT (Airbus)	Daily Weekly Monthly	Monthly deep-dive workshops on advanced analytics methods, predictive modeling, and operational optimization. Change management sessions to facilitate internal adoption. Dedicated training modules for business intelligence (BI) integration (Power BI, Tableau).	Advanced analytics dashboard with AI/ML-ready data layers (anomaly detection, predictive yield, environmental indicators). Integrated business intelligence tools (Power BI, Tableau). Fully customized data workflows and integration into internal decision-making processes (automation of detection → internal reporting → task triggers). Customized automated alerts (e.g., crop health, asset condition) triggering internal operational responses. Comprehensive Quarterly Reports featuring ROI & impact tracking framework (ESG targets, efficiency gains, risk mitigation outcomes).	Yes: Includes ROI and Impact Tracking	Yes (at organizational level)	*Aspiring Innovators, Pioneering Leaders*
4	***Space Advanced***	Open Source Low Cost Medium Cost High Cost (Based on use case)	Sentinel Data Landsat SPOT (Airbus) Maxar	Daily Daily Fortnightly Monthly	Continuous customized workshops and strategic advisory sessions to refine and expand spatial intelligence across all business operations. Sandbox environments to test new use cases internally before deployment. Dedicated internal capability-building (advanced spatial analytics, AI integration).	Comprehensive data analytics dashboards leveraging multi-source data fusion (spatial + financial, IoT, CRM, weather data). Advanced AI-driven predictive analytics and scenario planning. Advanced, real-time API integration and dedicated sandbox environment supporting innovation, testing, and rapid deployment of new spatial solutions. Project-specific dashboards providing real-time data and tailored recommendations. In-depth Quarterly Analyst reports (ROI, ESG compliance, efficiency tracking, strategic planning).	Yes: Includes ROI and Impact Tracking	Yes (one per key project or asset)	*Pioneering Leaders*

5.4.2 Strategic Roadmap

The Strategic Roadmap is tailored primarily for **intermediaries and end users**, providing them with **structured implementation phases to develop internal capabilities** and proactively address common barriers in spatial data adoption. Complementary to the Product Catalog, it lays out a step-by-step pathway to guide organizations through the practical complexities of adopting and scaling spatial data solutions. Many organizations initially experiment with spatial data through isolated pilots, often encountering unforeseen challenges such as technical complexity, internal resistance, or budget constraints that limit wider adoption. By implementing a clear, phased strategy that is tied to well defined capability pillars, they can break through these barriers and systematically elevate spatial data from a novelty into a core asset.

To that end, we propose a structured transformation journey that helps organizations evolve from having no spatial data capabilities to becoming fully spatially intelligent enterprises. As satellite imagery and geospatial technologies grow more accessible and actionable, industries can gain powerful insights that drive efficiency, reduce risks, support sustainability, and foster innovation. Our roadmap uses three phases named **Kickstart**, **Accelerate**, and **Pioneer**, corresponding to short term (0 to 12 months), mid-term (1 to 2 years), and long term (3 years plus). Each phase guides organizations through progressive improvements across four pillars: **Technical Infrastructure**, **Financial Strength**, **Internal Buy in and Culture**, and **External Integration and Trust**. Taken together, these pillars provide a balanced route to spatial maturity, one that builds capacity step by step and positions the organization for leadership in a data driven future.

Phase 1: Kickstart (0 12 Months) *Build Awareness & Foundations*

In this initial phase, the focus is on building a foundational understanding of spatial data capabilities and testing low-cost, low-risk pilot projects. The goal is to generate momentum and prove value early on with minimal investment.

Technical Infrastructure:

Kermap. Initiate one or two pilot projects using basic spatial data tools. Introduce GIS software or cloud-based services that allow access to free satellite data (e.g., Sentinel or Landsat). Ensure your IT team can handle the ingestion and storage of external data files or API feeds. **Process simple datasets to begin developing internal expertise** and establish basic protocols for data governance, security, and compliance.

Financial Strength:

-resolution imagery can be prohibitively expensive, limiting its use to high-
- *Synomen.* Allocate a modest R&D budget for initial experimentation. **Focus on leveraging free and open data sources to minimize costs**. Reallocate existing innovation or IT funds and explore grants or government programs to support early efforts. A successful pilot that yields tangible insights will help justify additional funding in subsequent phases.

Internal Buy-in & Culture:

- *Kermap.* **Build awareness** internally by showcasing relevant, easy-to-understand spatial use cases. Organize internal workshops or demos highlighting real business applications, such as overlaying facility locations with risk zones. Create an informal innovation team to champion the initiative and begin spreading spatial literacy within the organization.

External Integration & Trust:

-scale tests are crucial to building confidence in satellite-based *Synomen.* **Establish relationships with external data providers or analytics partners** to guide the pilot. Explore open-source communities or join industry webinars to build knowledge. Using reputable and widely recognized data sources helps establish early confidence in spatial insights.

By the end of this phase, organizations achieve initial technical readiness, spark internal curiosity, and lay the groundwork for future scaling. At this point, they transition from spatially unaware to early-stage adopters capable of basic integration, and are ready to advance to the next phase.

Phase 2: Accelerate (1 2 Years) *Scale & Institutionalize*

With the foundation in place, the second phase focuses on expanding the reach of spatial data within the organization, increasing the sophistication of its use, and embedding spatial insights into everyday operations and strategic decisions.

Technical Infrastructure:

Upgrade from basic tools to more centralized, enterprise-grade platforms. Expand data types to include higher-frequency or synthetic aperture radar (SAR) data for deeper insights. Integrate spatial data feeds into core business systems (e.g., ERP, CRM). Apply automation and AI/ML models to extract actionable intelligence, such as predictive alerts or operational optimizations. Improve scalability and performance of your cloud environment to handle increased data volumes.

Financial Strength:

Move beyond one-time experiments to sustainable investment. Use ROI from pilot projects to secure ongoing funding. Integrate spatial programs into the annual budgeting process and seek co-funding opportunities with partners or public innovation funds. Consider subscriptions for data and analytics platforms that offer flexibility and scalability. Demonstrated alignment with strategic business goals will make it easier to defend larger investments.

Internal Buy-in & Culture:

Formalize training programs across departments to build geospatial awareness and capabilities. Expand the use of spatial data through innovation challenges and collaborative cross-functional initiatives. Leadership should visibly endorse spatial insights in key decision-making processes. Communicate successes widely to reinforce the value and increase internal momentum.

External Integration & Trust:

Deepen collaboration with data vendors, analytics firms, and research institutions. Formalize partnerships through agreements or joint ventures. Adopt vetting and quality assurance protocols to assess the reliability of new data sources. Begin to use external data for core operational decisions and share curated insights with partners to reinforce credibility and trust.

By the end of this phase, organizations are no longer experimenting but systematically leveraging spatial data across business functions. Their infrastructure and processes are scalable, their teams are equipped and engaged, and their external relationships are producing value. They now qualify as spatially capable and innovation-oriented enterprises.

Phase 3: Pioneer (3+ Years) *Innovate & Lead*

With the foundation in place, the second phase focuses on expanding the reach of spatial data within the organization, increasing the sophistication of its use, and embedding spatial insights into everyday operations and strategic decisions.

Technical Infrastructure:

Build and maintain an enterprise-grade spatial data architecture. Consolidate multiple data sources, including commercial imagery (e.g., Maxar), LiDAR, IoT sensors, and hyperspectral data into a unified system. Ensure near real-time ingestion and processing is in place. Implement AI-driven analytics and scenario simulations for forecasting and strategic planning. Use advanced data fusion to combine spatial data with financial, CRM, or operational data. Provide user-friendly dashboards or API access so non-specialists can act on spatial insights.

Financial Strength:

Tie spatial data initiatives directly to business outcomes. Whether it's cost savings, revenue generation, or risk reduction. Develop structured ROI tracking frameworks. Fund large-scale investments, including high-resolution imagery subscriptions, dedicated analytics teams, or innovation partnerships. Maintain financial agility to scale new spatial applications quickly when opportunities arise, or crises demand fast response.

Internal Buy-in & Culture:

Make spatial intelligence a core part of your organizational identity. Appoint dedicated roles (e.g., Chief Geospatial Officer), sponsor advanced training, and support staff participation in external conferences or hackathons. Encourage open innovation by running collaborative programs with universities, start-ups, or NGOs. Foster an environment where spatial experimentation is welcomed and rewarded.

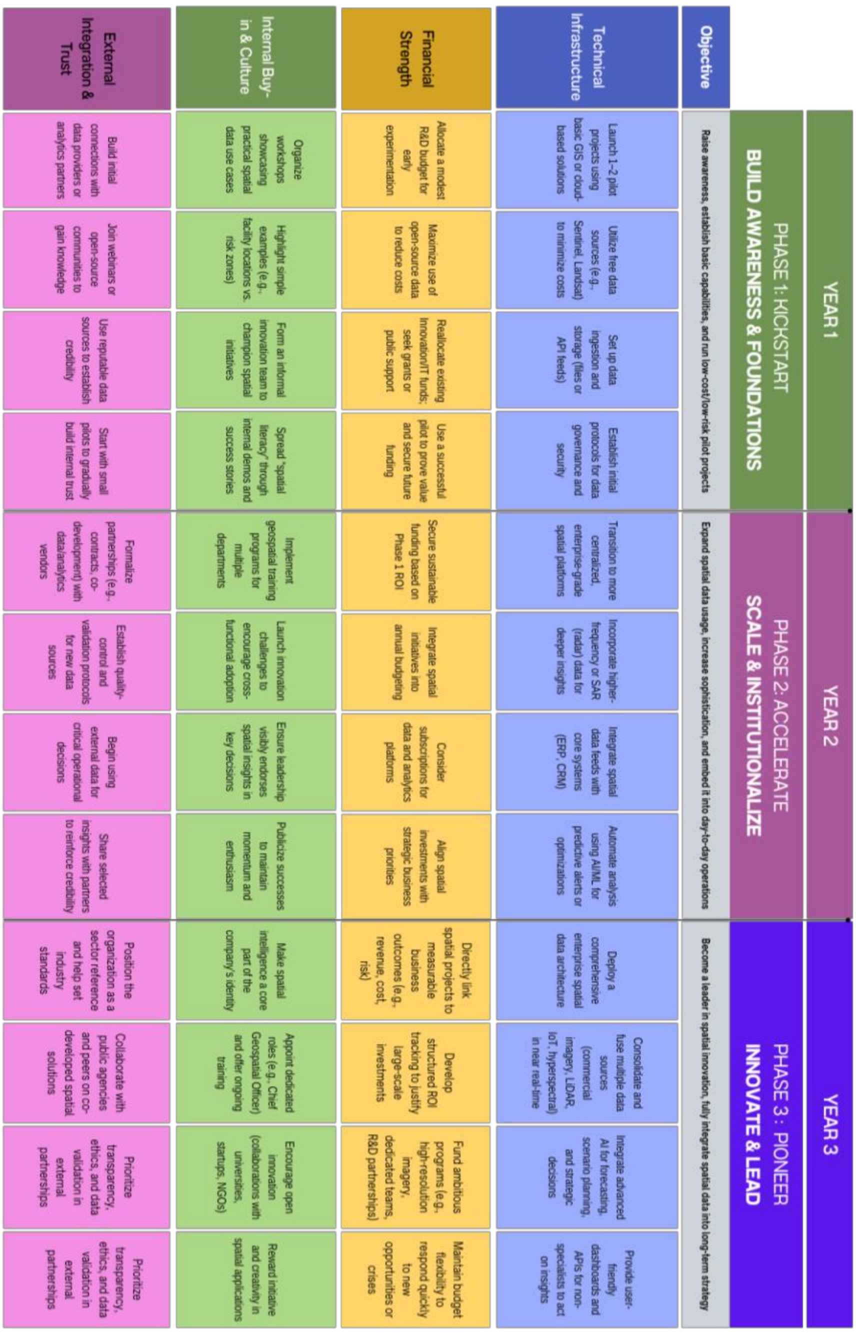
External Integration & Trust:

Position the organization as a leader in the spatial ecosystem. Actively contribute to the development of industry standards, collaborate with public agencies, and co-develop spatial products with peers. Prioritize transparency, ethics, and validation when using external data sources. Establish the organization as a go-to reference for spatial expertise in your sector, trusted by clients, regulators, and partners alike.

By the end of this phase, the organization is a spatial pioneer. It has the infrastructure, culture, financial resources, and external credibility to lead the market in spatial data innovation. It continuously adapts to new challenges and remains resilient and future-ready through its mastery of spatial intelligence.

By systematically following this three-phase strategic roadmap (Kickstart, Accelerate, and Pioneer), organizations can move beyond isolated pilots to fully capitalize on the value of spatial data. This journey enables them to <u>build internal capabilities</u>, <u>develop external partnerships</u>, and <u>embed spatial intelligence into decision-making</u>, all while staying agile in a rapidly evolving technological landscape. As the field of spatial data continues to advance at high speed, early movers who build the right foundations today will be best positioned to seize -driven foresight.

Figure 11. *Strategic Roadmap*



6. Conclusion

Throughout this extensive research project, we've demonstrated that spatial data offers significant potential to transform industries by enhancing decision-making, optimizing operations, and unlocking new avenues for innovation. However, widespread adoption remains hindered by technical complexity, high costs, limited internal expertise, and a **low degree of awareness and trust among stakeholders**.

Our detailed analysis across multiple sectors, including agriculture, insurance, supply chain management, finance, emergency management, real estate, and autonomous vehicles illustrates clear opportunities for the integration of spatial data. Each sector faces unique challenges that can be effectively addressed through targeted spatial data applications, from enhancing risk assessment in insurance to precision agriculture and infrastructure planning.

Through a detailed assessment of sector-specific challenges and opportunities, we highlight practical pathways for integrating spatial data into core business functions. The maturity model, product catalog and strategic roadmap presented here give organizations a structured way to gauge their current capabilities and chart a plan for progression. By identifying specific gaps in areas like technical infrastructure, financial resources, cultural readiness, and external partnerships, decision-makers can prioritize investments and initiatives more effectively.

Several guiding principles arise from this research:

1. **Strategic Alignment** Spatial data initiatives must directly address business objectives and use cases. Early demonstrations of value help secure leadership support and reduce organizational resistance.
2. **Incremental Progress** Starting with small pilots, then gradually expanding the scope and sophistication of spatial data projects, lowers risk and builds internal momentum.
3. **Ecosystem Collaboration** Robust external partnerships spanning data providers, technology firms, and academic institutions that can accelerate adoption, reduce financial barriers, and instill confidence in new solutions.
4. **Cultural Transformation** Beyond deploying technology, organizations must foster a data-driven culture. Training, awareness campaigns, and visible success stories are essential for embedding spatial thinking into day-to-day activities.
5. **Financial Sustainability** While early projects can leverage lower-cost or free data, larger-scale adoption typically requires robust budgeting. Linking spatial data projects to measurable ROI supports sustained funding and expansion.

Ultimately, spatial data should no longer be viewed as an experimental tool reserved for specialized teams. Rather, it is poised to become a foundation for competitive strategy, operational excellence, and innovation. Organizations that embrace a structured adoption journey; one that addresses both technical and cultural dimensions, stand to achieve enduring benefits. By following the roadmap outlined in this report, they can progress confidently from pilot initiatives to enterprise-wide leadership in spatial intelligence, driving tangible improvements in efficiency, decision-making, and long-term resilience.

7. Appendix

7.1 Interview Questions (EO Space Value Chain Actors)

Interviewee Space Actors

Objective Gain in-depth insights into the current state of the space data industry, including technological capabilities, cost structures, and market dynamics

Question Category	**Questions**
Part A: Technology	1. Could you describe the evolution of space technology over the past ten years and the main technological breakthroughs? 2. What do you perceive as the primary strengths and weaknesses of the current spatial data technology? 3. In your opinion, how might the decreasing costs of technology influence the adoption and popularity of spatial data usage? 4. What challenges or opportunities do you foresee in scaling up operations as technology costs continue to decline?
Part B: Cost Structure and Business Model	Could you elaborate on the cost structure and business model for your spatial data services? What are the variations across different use cases and industries?
Part C: Current Clientele	1. Who comprises your current client base? What are the most common pain points or challenges for your clients? 2. In your assessment, which industries do you believe are potential users of spatial data? Could you categorize them into early adopters, the majority, and late adopters? (optional)
Part D: Industry-Specific Insights	From a technical perspective, what do you anticipate as the main challenges or pain points for the agriculture and insurance industries in adopting spatial data technologies?

Interviewee Industry Actors

Objective Understand barriers to spatial data adoption in industry value chains

Question Category	**Questions**
Part A: Spatial Data Perception	1. Based on your perception, what are the primary applications of spatial data in your sector? 2. Who do you consider to be the main providers of spatial data?
Part B: Industry and Value Chain Analysis	2. What do you perceive as the main challenges or inefficiencies in your value chain? 3. Are you aware of any current innovations related to spatial data within your organization? - If yes, what factors have driven this recent adoption? - Could you describe the specific product or solution if possible?
Part C: Use Case Presentation	(Details to be added based on specific use cases relevant to the industry.)
Part D: Integration of Spatial Data in Industry Value Chain	1. **Implementation Status:** - If not yet implemented, what are the primary barriers? (implementation costs, limited use cases, resistance to change, or technological complexity) - If implemented, what is the current scope of implementation? How has it been integrated? What limitations have you encountered? 2. What strategies do you think could raise awareness of spatial data in your industry? How might board members be encouraged to consider spatial data as a strategic priority, similar to ESG factors? 3. How do you envision spatial data being integrated into your value chain to optimize processes or increase value? Which departments or functions do you anticipate would be the primary users of spatial data? 4. How do you believe third-party intermediaries could facilitate the integration of spatial data services?

Interviewee Intermediaries

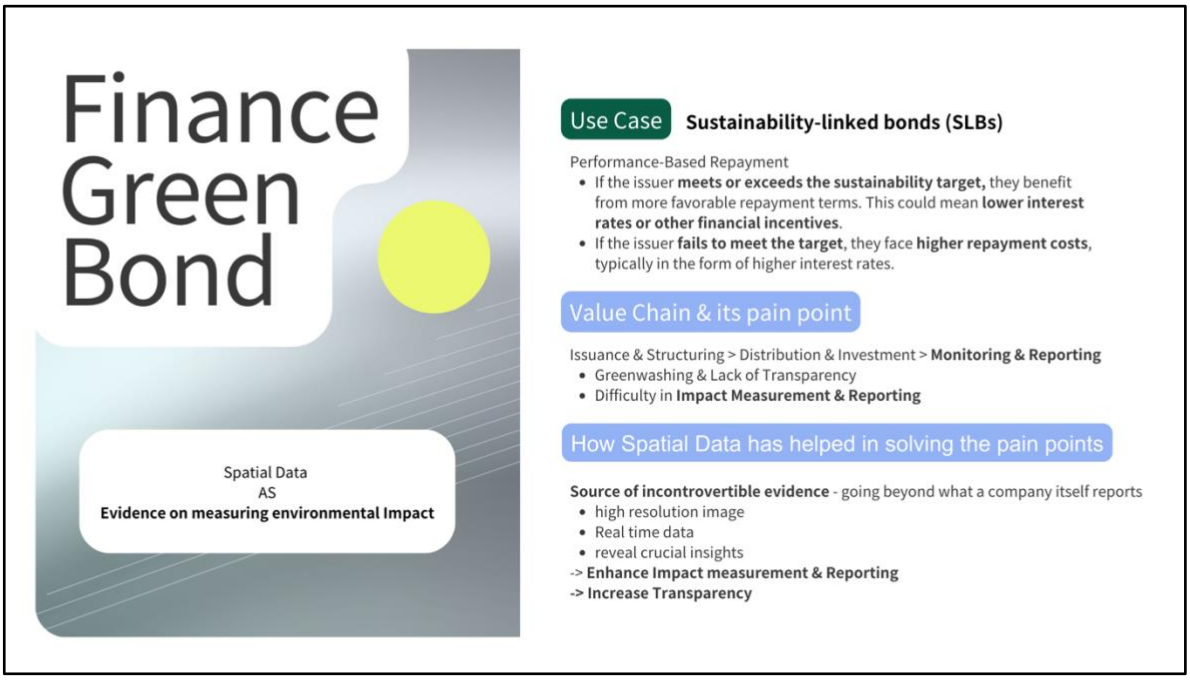
Objective Understand the broader industry landscape and challenges

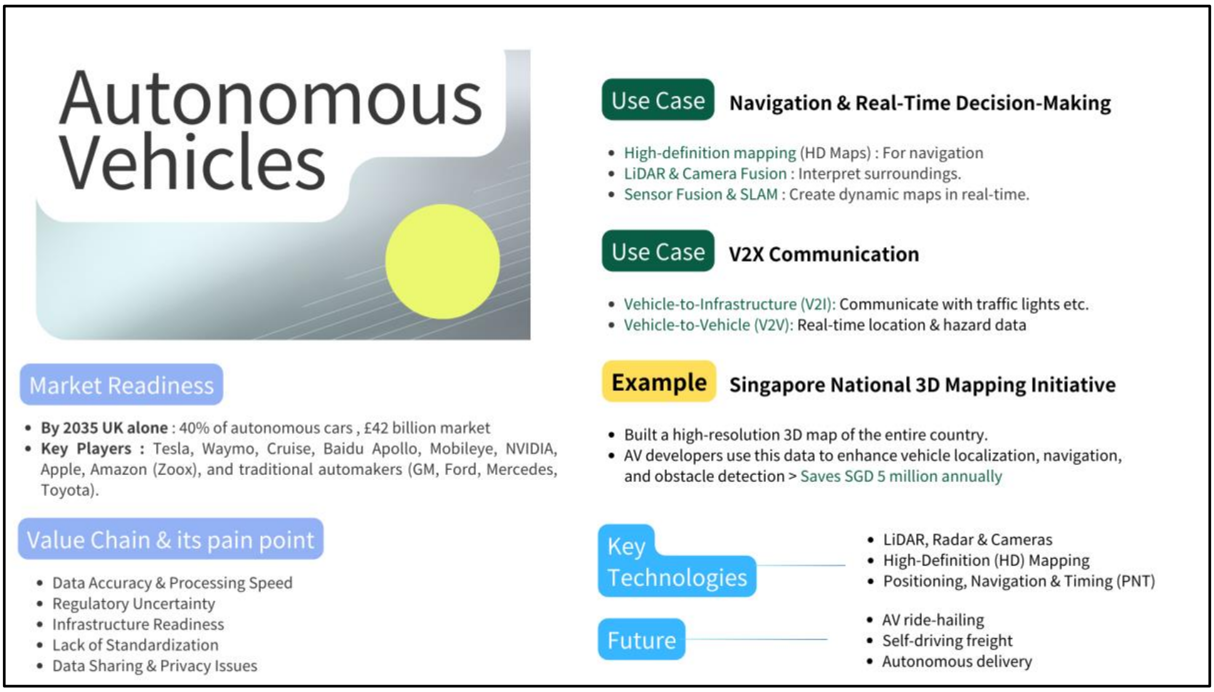
Question Category	**Questions**
General Industry Perspective	1. What is the scope of your operations within the space data industry? 2. How would you define your organization's role in the space data value chain? 3. What are the primary challenges or pain points you encounter in your position within this value chain? 4. In light of the SPACE 2030 agenda, how do you envision the future potential of the space data industry evolving? 5. What do you perceive as the current threats facing the space data industry? 6. Looking ahead, what emerging challenges or threats do you anticipate for the industry in the coming years?

7.2 Survey Insurance (Sia)

See next pages

7.3 Use Cases Slides (Recommendations)





Agriculture and Insurance

Use Cases **Crop Insurance & Weather-Based Index Insurance**

Problem Statement

Traditional claim verification is slow, costly, and prone to disputes

How Spatial Data helps: Process

- Farmers purchase index-based insurance linked to satellite-monitored drought and rainfall patterns.
- Automatic payouts are triggered when satellite data confirms adverse weather, reducing claim disputes and fraud.

How Spatial Data helps: Insurers

- Faster claims processing, lowering administrative costs
- Objective and scalable risk assessment
- Automated, verifiable claims assessment based on independent satellite data
- Real-time weather tracking to prevent fraudulent claims
- Improved customer trust and retention

Example: ESA-backed insurance models use space data to protect African farmers from climate risks.

Existing Value Chain and Pain Points

Underwriting > Risk Assessment > Claims Processing & Fraud Prevention

- Pain Points for Insurers:
- High cost of verifying claims in remote areas
- Delayed payouts lead to customer dissatisfaction and reputational risk
- Potential fraud and lack of transparency

7.4 Maturity Assessment Framework Survey Questions (Recommendations)

I) Survey

Weight	Technical Infrastructure (Readiness for Space Data Adoption)
35	How capable is your organization at integrating spatial data via APIs and ensuring compatibility with your existing IT infrastructure and software systems?
25	Does your organization have sufficient storage capacity and data management capabilities to effectively handle the volume of spatial data received?
20	How frequently does your company invest in upgrading or expanding its capabilities to effectively integrate and utilize new technologies within its existing systems and workflows?
15	How effectively can your organization ensure the security and integrity of spatial data within your systems, including access control, data encryption, and compliance with relevant data privacy regulations?
5	How effectively does your organization utilize and integrate external data into your existing business workflows and systems (e.g., ERP, CRM, BI)?"
Financial Strength (Economic Feasibility & Cost Perception)	
35	Describe your company's approach to budget allocation for data-driven decision-making over the past two year.
25	How would you characterize your company's budgeting process in terms of its flexibility to accommodate the adoption of new digital tools and external data sources?
20	Characterize your company's level of comfort and approach to adopting pay-as-you-go or subscription-based models for accessing and utilizing spatial data.
15	How would you describe the structure and detail of your company's financial planning process for digital transformation initiatives?
5	Describe your company's strategy regarding the pursuit of external funding, partnerships, or grants specifically for technology and data innovation related to spatial data.

(Internal) Buy-in & Culture (Openness to Space Data Adoption)	
35	Characterize your company's leadership receptiveness to adopting and integrating new data sources into strategic decision-making processes.
25	Describe how your company fosters a culture of innovation through internal initiatives, pilot projects, or dedicated programs related to data-driven solutions.
20	Describe your company's approach to seeking external expertise or consultation specifically for digital transformation initiatives.
15	Describe your company's approach to exploring and evaluating emerging technologies to enhance decision-making.
5	Characterize your company's commitment to providing comprehensive training and development programs for employees on new data-driven approaches.
(External) Integration & Trust (Perception & Ecosystem Readiness)	
40	Characterize your company's level of trust in external data providers when it comes to informing or driving business-critical decisions.
25	Characterize your company's preparedness to scale investments in data infrastructure when a strong external business case is presented.
20	external data providers or sources.
15	knowledge-sharing forums focused on data innovation.

II) Scoring Table and Legend

Technical Infrastructure (Readiness for Space Data Adoption)	
Score (1-5)	**Definition**
1. Non-Existent/Negligible	Represents a complete lack of capability, security, integration, storage, or investment.
2. Basic/Reactive	Represents limited capability, basic security, manual integration, limited storage, or reactive investment.
3. Developing/Partially Planned	Represents developing capability, established security protocols (but with gaps), limited automated integration, developing storage, or periodic investment.

4. Established/Proactive	Represents proficient capability, strong security, partial automated integration, adequate storage, or regular investment.
5. Advanced/Strategic	Represents expert capability, advanced security, seamless automated integration, scalable storage, or strategic investment.

Financial Strength (Economic Feasibility & Cost Perception)	
Score (1-5)	**Definition**
1. Non-Existent/Negligible	Represents a complete lack of financial commitment, strong resistance to change, or no existing structure.
2. Basic/Reactive	Represents minimal financial resources, limited flexibility, reactive funding attempts, ad-hoc planning, and some discomfort with new models.
3. Developing/Partially Planned	Represents some financial allocation, moderate flexibility, occasional funding pursuits, basic planning, and neutral openness to new models.
4. Established/Proactive	Represents consistent financial allocation, good flexibility, regular funding pursuits, structured planning, and comfort with new models.
5. Advanced/Strategic	Represents significant financial investment, high flexibility, continuous funding pursuits, comprehensive planning, and active pursuit of innovative models.

(Internal) Buy-in & Culture (Openness to Space Data Adoption)	
Score (1-5)	**Definition**
1. Non-Existent/Negligible	Represents a complete lack of capability, commitment, or structure; no evidence of planning or implementation.
2. Basic/Reactive	Represents minimal resources or effort, reactive actions responding to immediate needs, and limited planning.
3. Developing/Partially Planned	Represents some resources or effort, developing processes with limitations, and basic planning but lacking consistency.
4. Established/Proactive	Represents consistent resources or effort, well-defined processes with proactive planning, and good flexibility.
5. Advanced/Strategic	Represents significant resources or effort, optimized processes with strategic vision, and continuous improvement.

(External) Integration & Trust (Perception & Ecosystem Readiness)	
Score (1-5)	**Definition**
1. Non-Existent/Negligible	Represents a complete lack of engagement with external networks or providers, no trust in external data, no structured evaluation processes, and no readiness to scale investments.
2. Basic/Reactive	Represents minimal engagement, limited trust, reactive evaluations, and limited readiness to scale.
3. Developing/Partially Planned	Represents some engagement, moderate trust with verification, basic evaluation criteria, and moderate readiness contingent on resources.
4. Established/Proactive	Represents regular engagement, high trust and integration, structured evaluation processes, and high readiness with streamlined approval.
5. Advanced/Strategic	Represents active leadership and collaboration, complete trust and strategic partnerships, comprehensive evaluation and monitoring, and immediate readiness with strategic resource allocation.

8. Bibliography

[1] https://www.youtube.com/watch?v=N49PzLDUIFQ

[2] https://www.youtube.com/watch?v=-7_0Z_tm2Z8

[3] https://www.youtube.com/watch?v=vzfGMMEEz5w

[4] https://www.youtube.com/watch?v=7rV3Q3YTMH4

[5] https://ltb.itc.utwente.nl/491/concept/79777

[6]

[7] https://geographicbook.com/spatial-data-characteristics/#Spatial_Data_Characteristics

[8]

[9] https://landsat.gsfc.nasa.gov/satellites/landsat-8/spacecraft-instruments/thermal-infrared-sensor/

[10] https://nisar.jpl.nasa.gov/mission/get-to-know-sar/overview/#:~:text=Synthetic%20aperture%20radar%20(SAR)%20refers,of%20NISAR%2C%20orbiting%20in%20space.

[11] https://oceanservice.noaa.gov/facts/lidar.html

[12] https://eos.com/blog/free-satellite-imagery-sources/

[13] https://eos.com/blog/latest-satellite-imagery/

[14] https://space-solutions.airbus.com/imagery/our-optical-and-radar-satellite-imagery/spot/

[15] https://resources.maxar.com/data-sheets/worldview-2

[16] https://www.precedenceresearch.com/commercial-satellite-imaging-market

[17] https://www.ramboll.com/en-gb/galago/geospatial-intelligence-101-ai-drones-vs-satellites

[18] https://www.copernicus.eu/sites/default/files/2021-03/Copernicus%20Europe%20Eyes%20on%20Earth.pdf

[19] https://agilestorelocator.com/blog/google-maps-vs-google-earth-guide/

[20] https://www.copernicus.eu/sites/default/files/2021-03/Copernicus_Market_Report_2019.pdf

[21] https://fme.safe.com/blog/2021/10/non-spatial-data-difference-fme/#:~:text=Spatial%20data%2C%20also%20known%20as,is%20independent%20of%20geographic%20location.

[22] https://www.copernicus.eu/sites/default/files/2021-03/Copernicus_Market_Report_2019.pdf p.13&14

[23] https://corporatefinanceinstitute.com/resources/management/supply-chain/

[24] https://online.hbs.edu/blog/post/what-is-value-chain-analysis?utm_source=chatgpt.com

[25] https://www.forbes.com/councils/forbesbusinesscouncil/2022/07/12/4-pain-points-in-todays-supply-chain/

[26] https://www.mhcautomation.com/blog/biggest-supply-chain-pain-points-and-how-to-solve-them/?utm_source=chatgpt.com

[27] https://benjamin-gordon.com/the-role-of-geospatial-analytics-in-modern-supply-chain-solutions/

[28] gep.com

[29] https://commercialisation.esa.int/2021/11/space-in-support-for-the-insurance-sector/

[30] https://axaxl.com/fast-fast-forward/articles/space-data-how-satellites-are-changing-insurance

[31] https://doi.org/10.5194/egusphere-2024-1527

[32] https://openknowledge.fao.org/server/api/core/bitstreams/ed11f4ad-c6ed-46ca-a5bb-dc41e682a0ed/content
[33] https://intapi.sciendo.com/pdf/10.1515/remav-2017-0008

[34] https://www.landsd.gov.hk/en/spatial-data/LIM-SD-analytics.html

[35] https://communitylands.com/communitychronicle/the%20role%20of%20technology%20in%20modern%20land%20management

[36] https://www.landsd.gov.hk/en/spatial-data/LIM-SD-analytics.html

[37] https://www.gdmc.nl/publications/2015/Land_Administration_Domain_Model.pdf

[38] https://www.fig.net/organisation/council/council_2007-2010/council_members/enemark_papers/enemark_gsdi9_nov_2006_paper.pdf

[39] https://essay.utwente.nl/96366/1/Joannides_MA_ITC.pdf

[40] https://www.gdmc.nl/publications/2015/Land_Administration_Domain_Model.pdf

[41] https://openknowledge.fao.org/server/api/core/bitstreams/1106a91d-6d67-416b-b659-e8c6660a6c43/content

[42] https://essay.utwente.nl/96366/1/Joannides_MA_ITC.pdf
[43]https://www.spatiali.se/

[44]https://www.spatiali.se/technology

[45] https://earth.esa.int/eogateway/news/remote-sensing-data-underpin-research-on-soil

[46] https://prepsoil.eu/soil-monitoring

[47] https://thefarminginsider.com/monitoring-soil-health/

[48] https://aws.amazon.com/solutions/case-studies/cropx-case-study/

[49] https://www.no-tillfarmer.com/articles/13909-technological-advancements-in-soil-health-monitoring-and-management

[50] https://aws.amazon.com/solutions/case-studies/cropx-case-study/

[51] https://thefarminginsider.com/monitoring-soil-health/

[52] https://prepsoil.eu/soil-monitoring

[53] https://prepsoil.eu/soil-monitoring

[54] https://prepsoil.eu/news/new-report-shines-light-soil-monitoring-whats-next-europes-soil-health

[55] https://sentiwiki.copernicus.eu/web/s2-mission

[56] https://nutrinews.com/en/technological-advances-in-soil-monitoring-sustainable-management/

[57] https://thefarminginsider.com/soil-health-monitoring-tech-trends/

[58] https://thefarminginsider.com/soil-health-monitoring-tech-trends/

[59] https://sfecologie.org/offre/phd-position-requirements-opportunities-and-challenges-of-monitoring-reporting-and-verification-frameworks-for-soil-health-assessment/

[60] https://www.nature.com/articles/d41586-024-02396-4

[61] https://carto.com/solutions/fraud-detection-machine-learning

[62] https://www.corelogic.com/intelligence/forensic-weather-data-combats-insurance-claims-fraud/

[63] https://www.korem.com/gis-data-for-insurance/

[64] https://www.reddit.com/r/Roofing/comments/15if5lr/is_this_a_scam/

[65] https://www.ecopiatech.com/resources/blog/the-ultimate-guide-to-geospatial-data-for-insurance

[66] https://www.corelogic.com/intelligence/forensic-weather-data-combats-insurance-claims-fraud/

[67] https://carto.com/solutions/fraud-detection-machine-learning

[68] https://www.korem.com/gis-data-for-insurance/

[69] https://www.korem.com/gis-data-for-insurance/

[70] https://www.korem.com/gis-data-for-insurance/

[71] https://www.korem.com/gis-data-for-insurance/

[72] https://www.adci.com/blog/gis-the-newest-technology-fraud-detection-and-prevention

[73] https://www2.deloitte.com/us/en/insights/industry/public-sector/earth-observation-sustainable-economic-growth.html

[74] https://eo4society.esa.int/wp-content/uploads/2020/06/Caribou-Space_ESA-EO-for-Agenda-2030.pdf#:~:text=Donors%20particularly%20in%20Europe%20have,The%20German%20donor%20BMZ%20has

[75] https://www.weforum.org/stories/2024/05/earth-observation-will-unlock-huge-value-for-these-6-industries/#:~:text=,of%20that%20value%20generated

[76] https://intelligence.weforum.org/topics/a1Gb0000000LGrIEAW?utm_source=chatgpt.com