

GP.Bullhound

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Geospatial intelligence: From maps to meaning



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The view

FROM GP BULLHOUND

From a distant perspective, one might view the new era of space exploration as the colonisation of Mars or the discovery of new celestial bodies. While these endeavours might drive headlines, the primary beneficiary of the recent technological advancements and innovation within the space industry is Earth – our only home.

Companies like SpaceX and Rocket Lab have transformed the space economy by enabling satellite operators a reliable and cost-effective path to orbit. And, when coupled with significant advancements in satellite manufacturing and increased variation of satellite sensors, our understanding of what is happening on Earth and where has never been higher.

We know that Earth is facing a whirlwind of challenges. The latest Intergovernmental Panel on Climate Change (IPCC) report delivered a 'final warning' on the climate in March 2023, claiming that we must act now or face irrevocable climate damage. With more destructive weather, a worsening agricultural environment, and the warmest year ever by far in 2023, the challenge at hand is clear. Additionally, recent global affairs and commercial developments have increased demand for high-resolution imagery and data visualisations of the Earth.

This is where geospatial intelligence and Earth observation come into play.

■ *“Tracking de-forestation, stopping illegal fishing, protecting the coral reefs, helping humans get better quality of life via better access to water, increased food productivity, and transportation efficiency. We help humanity take better care of our resources.”*

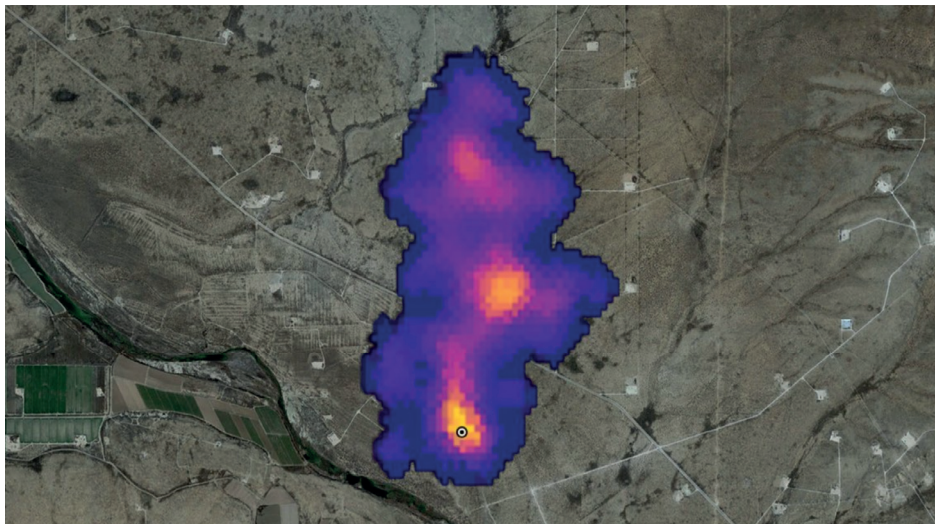
Will Marshall, CEO & Co-founder, Planet Labs

Satellite data alone was able to detect the world's largest methane leak. This leak was equivalent to the combined emissions of almost 60 million petrol cars running their engines simultaneously.

■ *Methane leaks from Turkmenistan's two main fossil fuel fields caused more global heating in 2022 than the entire carbon emissions of the UK.*

The Guardian, May 2023

A METHANE PLUME DISCOVERED BY NASA'S EARTH SURFACE DUST SOURCE INVESTIGATION IN NEW MEXICO



A Nasa satellite image of methane plumes east of Hazar, Turkmenistan, in October 2022.
Source: Nasa/JPL-Caltech/AFP/Getty

With decreasing launch costs, a fundamental shift in satellite manufacturing, the introduction of new data capture technologies, and advancements in AI, the industry finds itself at a pivotal moment. The increase in real-world applications and the variety of use cases is driving a surge in demand across sectors such as climate monitoring, defence, utilities, and infrastructure.

Geospatial intelligence is presented with a significant opportunity, as forecasted by Geospatial World, a media publication, indicating that the global geospatial market will surpass the trillion-dollar milestone by 2030. According to a chief economist at NASA, Earth observation is one of the two verticals in the space economy experiencing the most robust growth.

While the opportunity at hand is significant and the task might feel daunting, there is a real opportunity to make a lasting impact through data, software and AI – one satellite at a time, one radio frequency at a time, one step at a time.

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Key Takeaways_

↗ Geospatial intelligence	Involves the collection, analysis and interpretation of data gathered through Earth observation
↗ Cost of satellites	Fundamental changes to satellite construction decreased costs from \$1bn to anywhere between \$100k to a few million
↗ Launch costs	Launch costs have fallen 80-90%. Between 1993 and 2020 there were a total of ~2,000 satellite launches. In 2023 there were ~3,000 satellite launches alone
↗ Satellites in orbit	As of 2023, there are ~8,000 satellites in orbit, of which SpaceX and OneWeb collectively operate 60% of them. Earth observation makes up 17% of active satellites
↗ Data collected	75% of Earth observation satellites collect data through optical imaging. Radar and radio frequency are starting to witness increased demand
↗ AI	Planet Labs estimates that what would have taken an Earth observation analyst seven years can now be solved with AI in two minutes
↗ Derived analytics	Focuses on horizontal software products with a broader customer base across a variety of industries. Primary use cases are object and change detection
↗ Vertical-specific analytics	Target deeper vertical product offerings and integrations, and enable industry-specific solutions
↗ Resource allocation	It cost India \$75m to become the first country to land on the south pole of the Moon. That is half of the cost of the movie Interstellar

What is geospatial intelligence and Earth observation?

Geospatial data is information that describes objects, events or other features near or on the surface of the Earth. The data typically combines;

- **Location:** Where
- **Attribute:** What
- **Temporal:** Time

Earth observation is the collection of geospatial data from various sources, such as satellites, aerial imagery, ground-based sensors and more. Earth observation satellites and sensors capture geospatial data, including imagery, temperature measurements, greenhouse gases, etc.

Finally, geospatial intelligence involves the analysis and interpretation of this data. The insights are valuable to industries such as climate monitoring, agriculture, urban planning and disaster management. They enable informed, data-driven decisions and sustainable development based on geospatial analysis.

EXAMPLES OF CURRENT USE CASES

Infrastructure

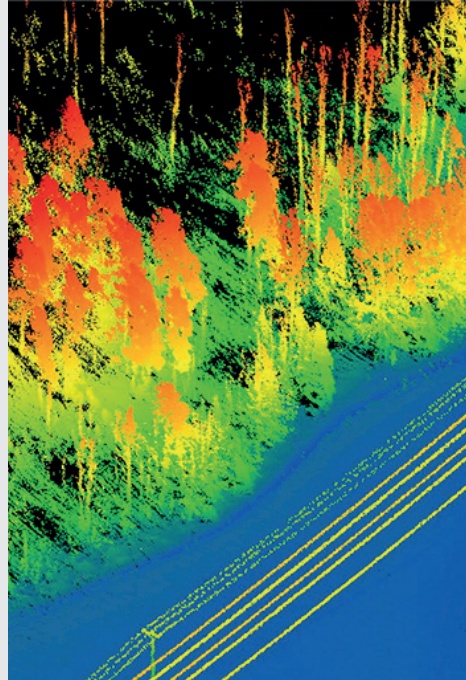
Railroads use satellite imagery for various purposes to enhance their operations and infrastructure management. Specifically regarding inspection and maintenance, where satellite imagery can help identify issues such as track damage, wear and tear, and alignment problems. LiveEO is partnering with Deutsche Bahn to ensure the vegetation in the vicinity of railway lines is resilient to storms (right).



Source: Deutsche Bahn AG | LiveEO

Energy

Utilities like electricity, gas, water, and telecommunications companies can leverage satellite imagery to improve their infrastructure, operations, and decision-making processes. For example, utilities monitor vegetation near power lines and other infrastructure to prevent potential hazards from overgrown trees or plants and inspect power transmission lines and pipelines for signs of wear, corrosion or damage.



Source: Science Direct

Agriculture

The agricultural industry uses satellite data and remote sensors to enhance productivity, sustainability and decision-making. Satellite data provides valuable information on various aspects of agriculture, from crop monitoring to land management, helping farmers detect diseases, determine crop growth stages, and estimate crop yields. McKinsey's annual Digital Farmer Adoption survey results show that 29% of row-crop farmers and 45% of specialty-crop farmers already rely on such data or plan to in the future.



Source: ListenField Satellite Imagery Technology

Defence

Satellite imagery can be used for monitoring and surveillance purposes. It helps track troop movements, the positioning of military equipment, and other activities on the ground. This information can be vital for military planning and situational awareness. This image shows underground construction activities detected using commercial satellite imagery south of the Natanz nuclear facility in Iran in 2020.



Source: Google, Image CNES/Airbus

What drives the evolution of geospatial intelligence and Earth observation?

The infrastructural enabler

Earth observation satellites are dominated by optical, but new technology is emerging

From seven years to two minutes

Summary

Driven by technological advancements, increased demand and a sense of urgency to deepen our understanding of Earth, geospatial intelligence is at the forefront of the space economy. The increased availability and accessibility of geospatial data from satellites and sensors have fuelled geospatial opportunities and real-world use cases.

Key drivers:

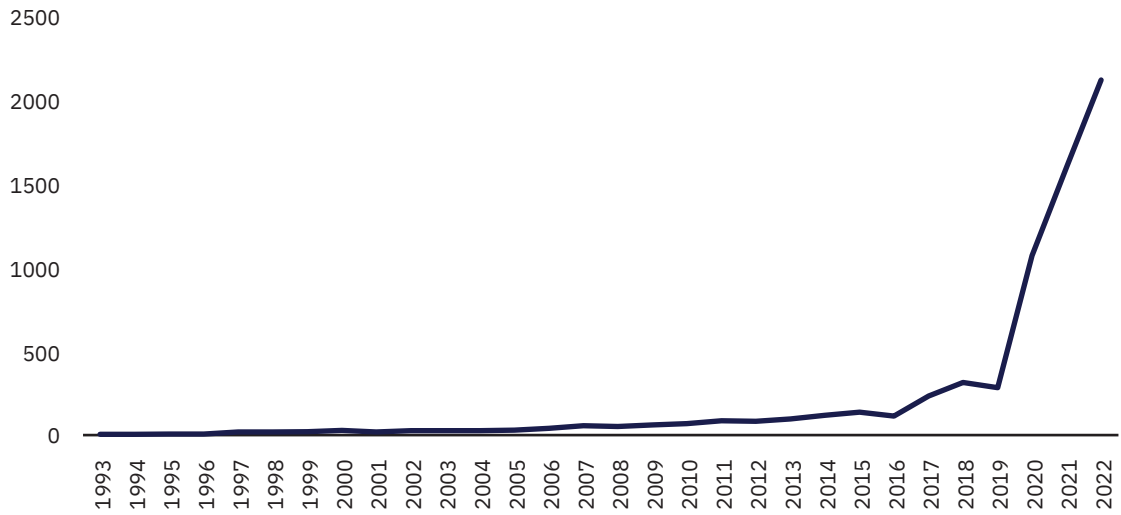
- 1. Infrastructure:** We can now build and launch smaller, more powerful satellites at a fraction of the cost.
- 2. Data:** The number of Earth observation satellites has grown at a compound annual growth rate (CAGR) exceeding 20% since 2010. Apart from optical imaging, we are beginning to witness the introduction of new sensor technology, diversifying data capture, and expanding the types of data available.
- 3. AI:** The increased volume of available data and recent advancements in AI have transformed what was once a predominantly manual process into a highly scalable and automated one. According to the provider of global daily Earth data, Planet Labs, tasks that previously required a human analyst seven years to complete can now be accomplished by AI in just two minutes.

01 The infrastructural enabler

A fundamental driver is the significant structural advancements of our ability to build and launch smaller but more powerful satellites at a fraction of the cost.

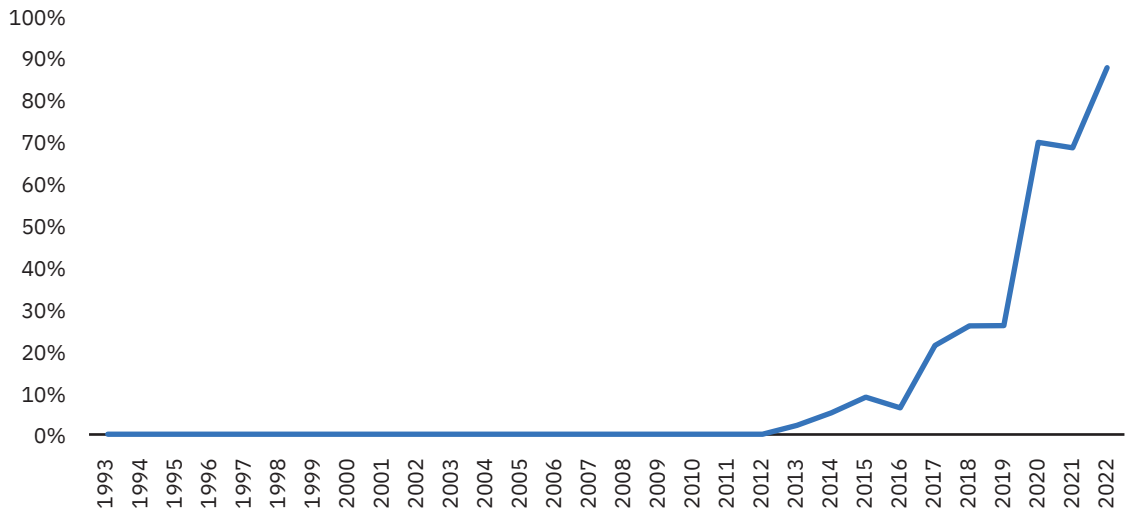
- **Satellite cost:** NASA's PhoneSat project, driven by the team that later founded Planet Labs, fundamentally altered the approach to satellite construction. Instead of the traditional, no-expense-spared billion-dollar projects with custom-made hardware, PhoneSat looked to the advancements in the consumer electronics market and embraced existing technologies. By adopting this strategy, new satellites cost anywhere from \$100k to a few million compared to NASA's Landsat-8, which cost nearly \$1bn. Additionally, instead of sending bus-sized objects to space, the size of satellites today ranges from a shoe box to a refrigerator. These smaller satellites are designed to work as a group – a constellation – and orbit closer to Earth. The shift towards more affordable and compact satellites enables operators to develop and launch new ones more frequently, ensuring a constant update of hardware and sensor capabilities. Historically, satellites in orbit often featured hardware that could be decades old.
- **Satellite launches:** From 1960 until 2019, there were approximately 2,000 satellite launches, showing slow and steady growth. However, with the introduction of reusable rockets, notably SpaceX's Falcon 9, satellite launches experienced a significant surge in 2020 and beyond. In 2023, there were ~3,000 satellite launches, and the long-term demand is estimated to reach 30,000 as predicted by HKATG. SpaceX deserves credit for reducing launch costs by 80-90% over the past few years, a trend that is expected to continue rapidly. In 2022, the Falcon 9 accounted for an impressive 88% of all launches.

SATELLITE LAUNCHES



Source: UCS Satellite Database

% OF YEARLY LAUNCHES BY FALCON 9

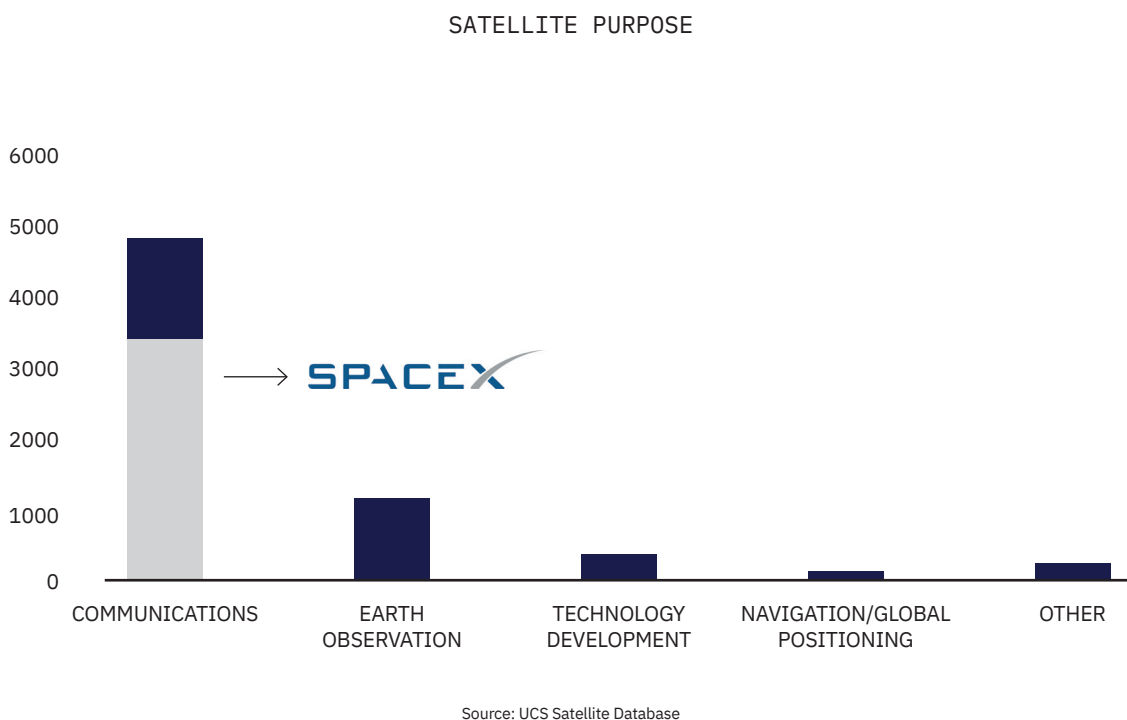


Source: UCS Satellite Database

Considering these structural trends, the decreasing cost of satellites and the increasing capacity for launches, we are witnessing exponential growth in the number of satellites in orbit and, more significantly, in the volume of data generated by these satellites.

02 Earth observation satellites are dominated by optical imaging, but new technologies are emerging

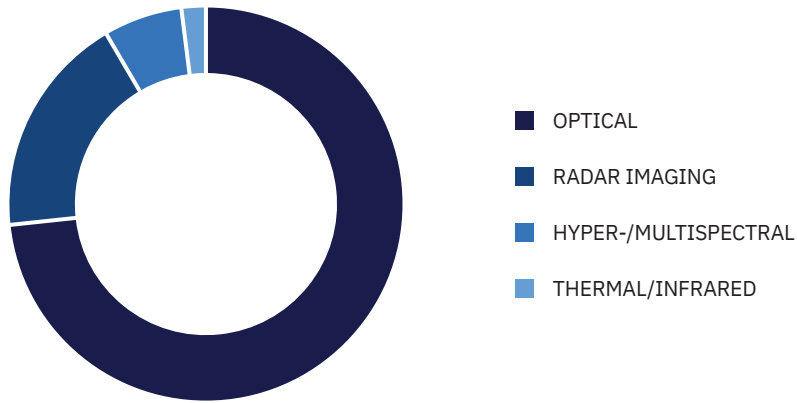
Earth observation satellites constitute approximately 20% of all active satellites, with most satellites currently dedicated to communications. SpaceX has played a crucial role in launching satellites into orbit, and it's noteworthy that their Starlink constellation has significantly impacted the overall satellite population. Approximately 50% of all active satellites are under the control of SpaceX.



Optical imaging is the predominant sensor technology within Earth observation, accounting for approximately 75% of all sensors. This trend's key contributors include Planet Labs, BlackSky, and Maxar. While optical technology is known for its accessibility and ability to provide high-resolution imagery, it is highly dependent on weather conditions and lighting.

Source: SpaceNews

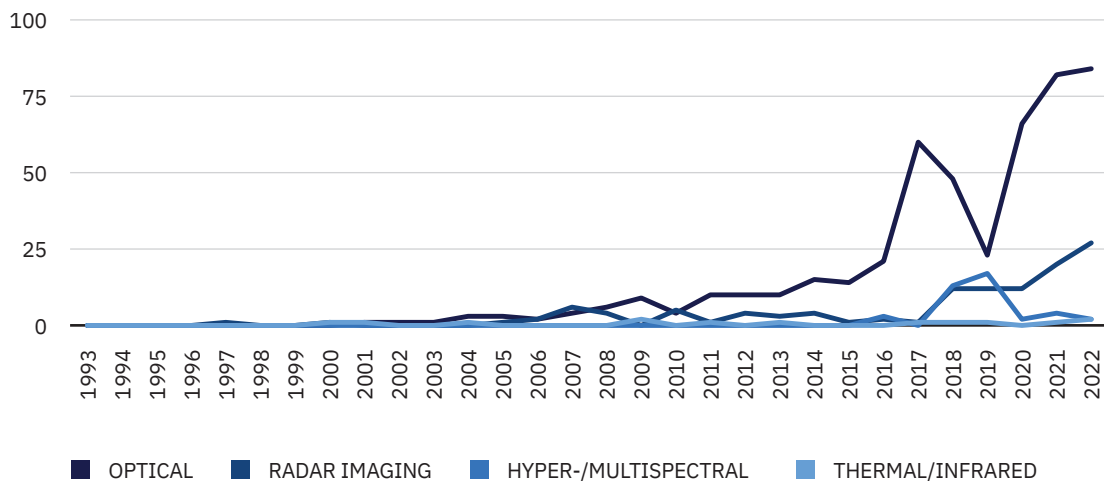
EARTH OBSERVATION TECHNOLOGY



Source: UCS Satellite Database

While optical technology remains the clear leader, advancements in sensor technology have increased the variety of sensors in orbit. Radar, radio frequency, and hyperspectral technologies are beginning to see increased adoption, led by companies such as Iceye, Capella, and Hawkeye360.

SATELLITES BY SENSOR TECHNOLOGY



Source: UCS Satellite Database

These technologies expand the use cases of Earth observation data, with radio frequency enhancing the security of sensitive marine areas. Radar, with its primary advantage of seeing through clouds and operating at nighttime, and hyperspectral imaging, allowing us to zoom in and analyse things with a finer level of detail, contribute to this broadened capability.

The accelerated deployment of Earth observation satellites, combined with a greater variety of sensors, has resulted in a surge of new real-world use cases and data. For instance, Planet Labs' archive boasts an average of >2,400 pictures for each location on Earth's landmass.

03 AI: From seven years to two minutes

Having 2,400 pictures of each location on the Earth's landmass is impressive, but the real value lies in turning that vast amount of data into actionable insights for decision-making.

Recent advancements in AI have played a crucial role in achieving significant efficiency gains and unlocking new use cases across various industries, and geospatial intelligence is no exception. Tasks like classifying, detecting, and segmenting objects and events from satellite images and other data sources used to be complex and manual. AI can tackle these tasks with speed, accuracy, and consistency, making it a game-changer in translating the abundance of satellite data into meaningful and practical information for decision-makers.

Over the past 60 years, image analysts have been responsible for analysing and interpreting satellite imagery. In his best-selling book on space exploration "When the Heavens Went on Sale", author and Elon Musk biographer, Ashlee Vance, writes: "These analysts must memorise the size and the shape of every kind of tank, truck, missile silo, etc. Once done memorising, a single analyst might look over the same fifty-square mile chunk of territory for six weeks." The purpose was to look for subtle clues, changes and patterns of life.

Human analysts still play a role in identifying life patterns, but the advent of AI has fundamentally transformed the industry. AI has reached a level of sophistication where it can count the number of trees and discern their types and heights. This capability allows for estimations of a tree's biomass and CO2 consumption. According to Planet Labs, a task that would have taken an image analyst seven years takes AI just two minutes. This showcases AI's remarkable speed and efficiency in analysing and extracting valuable information from vast amounts of satellite imagery.

UNDERSTANDING THE AI OPPORTUNITY



Source: Planet Labs

Eighty per cent of enterprises currently depend on location data as a crucial component of their data strategy. Moreover, there are plans to enrich this strategy by incorporating context and time series data, i.e. as geospatial data. While the impact of AI on geospatial data is undeniable, the practical adoption of geospatial AI remains limited due to the technical expertise required, making it accessible to only a select few.

Geospatial MLOps and platforms like Picterra can play a vital role here. These platforms empower companies to train, deploy, and manage geospatial data efficiently, saving 95% of the time needed to build geospatial AI models. These technologies bridge the gap, making geospatial AI more accessible and manageable for a broader range of enterprises.

PROCESS COMPARISON

Organise data	Label data	Develop Model	Train model	Deploy to production	Prod QA/QC	Model Maintenance	Results visualisation	Scaling to new type of objects
1 week	4 weeks	4 weeks	2 weeks	8 weeks	2 weeks	1 week	1 day	3 weeks
Data scientist GIS associate	Data scientist Annotator	Data scientist	Data scientist	Software engineer Developer engineer	Data scientist GIS associate	Data scientist	GIS associate	Data scientist

Using Picterra | 1 week | 95% time saved

Organise data	Label data	Develop Model	Train model	Deploy to production	Prod QA/QC	Model Maintenance	Results visualisation	Scaling to new type of objects
4 hours	8 hours	Auto-mated	1 hour	Auto-mated	40 hours	5 min	5 min	1 day

No coding skills required + easily scalable from single user to team collaboration

Source: Picterra

“With the world generating over 200TB of Earth observation imagery on a daily basis, this source of ground truth will enable every company in the world to become a geospatial driven business within the next decade.”

Picterra

04 Summary

We've already experienced the initial structural shift, getting satellites into orbit more rapidly and cost-effectively. Now, we find ourselves amid a second structural shift driven by the growing amount and diversity of data and advancements in AI. These are fundamental forces that will significantly benefit the industry for many years to come. Combining a more comprehensive array of data sources and the transformative power of AI is set to bring about long-lasting positive changes in the geospatial intelligence market.

Expert view

FOUNDER | PICTERRA



PIERRICK POULENAS

"While AI considerably minimises manual input, it doesn't entirely replace it. Human expertise remains essential for overseeing AI systems, particularly to ensure accuracy and alignment with task-specific requirements."

HOW SEAMLESSLY CAN AI TECHNOLOGIES BE INTEGRATED INTO EXISTING EARTH OBSERVATION SYSTEMS?

Integrating AI technologies into existing Earth observation systems is pivotal for harnessing the full potential of the immense quantities of data these systems generate. In the broader context, AI, particularly machine learning and computer vision, plays a crucial role in converting raw Earth observation data into valuable information necessary for decision-making and concrete action. These technologies help in various tasks like object detection, change detection, segmentation, and time series analysis based on image sequences. While substantial progress has been made, challenges remain, such as the need for data fusion from multiple sources and integrating AI systems into the Earth observation infrastructure, ideally from the planning phase.

TO WHAT EXTENT DOES AI ENABLE AUTOMATION IN DATA PROCESSING, REDUCING THE NEED FOR MANUAL INTERVENTION?

AI has revolutionised data processing in Earth observation by enabling extensive automation and reducing the need for manual intervention. This transformation is evident in several areas:

- **Handling large data volumes:** AI algorithms efficiently process and analyse vast amounts of data from satellites and aerial sensors, identifying patterns and anomalies much faster and more accurately than traditional methods.
- **Feature extraction and object recognition:** AI-driven systems autonomously recognise and categorise various elements in geospatial data, significantly reducing manual effort and increasing accuracy, especially in applications like environmental monitoring and urban planning.

- **Advanced data analysis:** AI facilitates sophisticated techniques such as predictive modelling and trend analysis, utilising historical data to forecast future events, which is crucial in fields like climate change and resource management.

While AI considerably minimises manual input, it doesn't entirely replace it. Human expertise remains essential for overseeing AI systems, particularly to ensure accuracy and alignment with task-specific requirements. Overall, AI's role in automating data processing enhances efficiency, decision-making speed, and the ability to manage complex tasks in Earth observation.

HOW TAILORED ARE AI MODELS TO SPECIFIC EARTH OBSERVATION USE CASES SUCH AS OBJECT DETECTION, CHANGE DETECTION, OR ENVIRONMENTAL MONITORING?

AI models in Earth observation can be highly tailored to specific use cases, reflecting the diverse needs and challenges of this field. The degree of customisation and specialisation depends on several factors, including the nature of the task, the characteristics of the data, and the desired outcomes. Let's explore this in the context of some key use cases:

- **Object detection:** AI models for object detection in Earth observation are designed to recognise and locate specific objects within large and complex datasets. These models can be fine-tuned to detect a wide range of objects, from buildings and vehicles to specific types of vegetation or wildlife. The training process involves feeding the model with labelled examples of the objects of interest, allowing it to learn and distinguish these objects in various settings and conditions.
- **Change detection:** In change detection, AI models are tailored to identify alterations in the landscape or environment over time. This requires models that can analyse temporal data, comparing images taken at different times to pinpoint changes. Such models are crucial for monitoring urban development, deforestation, glacier retreat, and other dynamic phenomena.
- **Environmental monitoring:** For environmental monitoring, AI models are specialised to analyse satellite imagery for tracking environmental conditions. These models are adept at interpreting indices such as the Normalized Difference Vegetation Index (NDVI) to assess vegetation health and monitor changes over time. They can efficiently identify patterns and trends indicative of environmental phenomena, such as shifts in vegetation density due to climate factors or land-use changes.

WHAT EMERGING TRENDS AND INNOVATIONS IN AI ARE EXPECTED TO IMPACT THE EARTH OBSERVATION MARKET IN THE NEAR AND LONG TERM?

Emerging trends and innovations in AI are set to significantly impact the Earth observation market, both in the near and long term. These developments are poised to enhance the capabilities, efficiency, and scope of Earth observation applications. Some of the key trends include:

- **Increased image quality enabling advanced AI applications:** The improvement in the quality of Earth observation imagery is a critical trend. Higher resolution and more accurate imagery are expanding the potential use cases for AI in Earth observation, enabling more detailed analysis and sophisticated applications, such as precise environmental monitoring and complex urban planning.
- **Integration of AI with Big Data for real-time analysis:** Today's geoAI trend is characterised by the integration of AI with big data analytics for real-time analysis and interpretation. This development enables immediate processing and understanding of large-scale Earth observation data, facilitating quick decision making and application in dynamic scenarios like disaster response and climate monitoring.
- **Automated data processing workflows for rapid response:** The ability of geoAI to quickly analyse data in crises remains a top priority. Automated workflows are increasingly sophisticated, allowing for efficient processing and analysis of complex datasets during emergencies, thereby enhancing response capabilities and potentially saving lives.
- **Enhanced predictive modelling with climate focus:** AI's role in predictive modelling is increasingly focusing on climate and environmental applications. These models are becoming more adept at forecasting climate-related changes and environmental impacts, aiding in efforts to mitigate climate change and manage natural resources sustainably.

These trends collectively point towards a future where AI in Earth observation is not just about handling larger datasets, but about doing so with greater precision, responsiveness, and relevance in real-world applications. The emphasis is on producing high-quality, actionable insights that can be rapidly deployed to address both everyday challenges and urgent crises.



Expert view

FORMER EXECUTIVE DIRECTOR |
WORLD GEOSPATIAL INDUSTRY COUNCIL



BARBARA RYAN

■ "What really gets me excited is if governments and the commercial sector could come together and start creating a virtual representation of the actual physical universe."

"The first image of Earth from space had a profound impact on people, making them realise the interconnected nature of our planet. This newfound awareness sparked public interest and became a driving force behind significant investments by the United States and the European Union in Earth observation satellites. However, a challenge emerged after spending billions to construct and launch these satellites — most of the valuable data ended up stored in archives for decades.

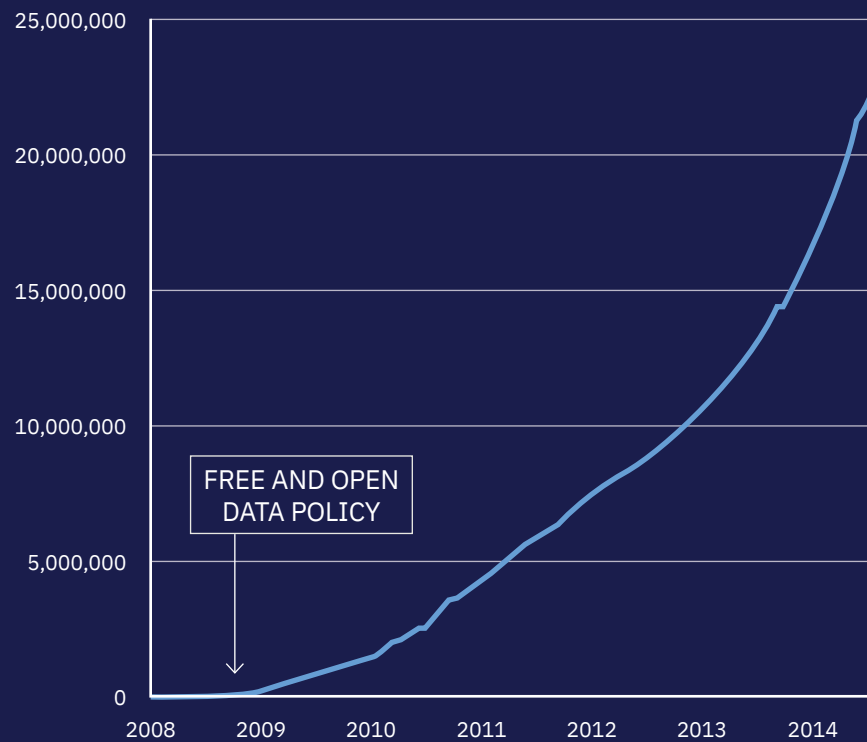
The problem arose because customers were reluctant to pay in the case of Landsat, the cost of \$500 per scene for the data. This dilemma prompted a discussion on whether, given the substantial taxpayer money invested in building these satellites, the data should be considered an indirect benefit and made publicly available. Although it took more than 30 years and a fight I fought for eight years, the governments eventually shifted their data policies. They made Earth observation images freely accessible over the web, a move that marked a significant milestone in making vital satellite data available to the public.

This shift in data policies not only revolutionised people's access to Earth observation data but also paved the way for the birth of the modern commercial geospatial sector. With data freely available, companies began developing innovative tools, products and services on top of this valuable resource.

Before the policy change, the US Geological Survey (USGC), a governmental agency, generated \$5m annually by selling data, which in this case was substantial from a government perspective. However, the dynamics changed dramatically after the shift. Prior to the change, they were selling 53 scenes a day. Once the data became freely accessible, demand surged to an astonishing 5,700 scenes a day. The economic

impact of this policy shift was significant, amounting to \$1.7bn in the United States and \$400m outside the country. The commercial sector, academia and other governmental agencies, now able to use the data without the previous cost barrier of \$500 per scene, played a pivotal role in driving this economic benefit.

LANDSAT SCENES DOWNLOADED FROM USGS EROS CENTER (CUMULATIVE)



Source: USGC

The government's shift in data policy, making Earth observation data freely available to all, marked a significant turning point. This decision not only democratised access to valuable information but also played a crucial role in raising awareness about the transformative power of Earth observation.

The decreased launch costs have increased our ability to monitor Earth through all three resolutions – temporal (time), spatial (distance) and spectral (constituents).

In recent years, there have been substantial changes in launch costs, making space more accessible. In the realm of Earth observation, these developments have notably fuelled improvements in temporal resolution, i.e., the frequency with which satellites orbit over the same place of Earth. While a satellite orbiting every eight or 16 days may suffice for certain applications (e.g. forest change and urban growth), scenarios such as troop migration or flooding demand more frequent observations.

On top of that, companies are now starting to put different instruments on satellites. This will help us look for different spectral resolutions, i.e. different constituents and frequencies, and monitor greenhouse gases and radio frequencies. With these developments, we are also seeing significant increases in spatial resolutions with options as low as 30cm available from commercial satellites.

Additionally, companies are now equipping satellites with different instruments, allowing for diverse spectral resolutions, i.e. analysing different constituents and monitoring greenhouse gases and radio frequencies. Simultaneously, there have been remarkable increases in spatial resolutions, with commercial satellites offering options as low as 30cm.

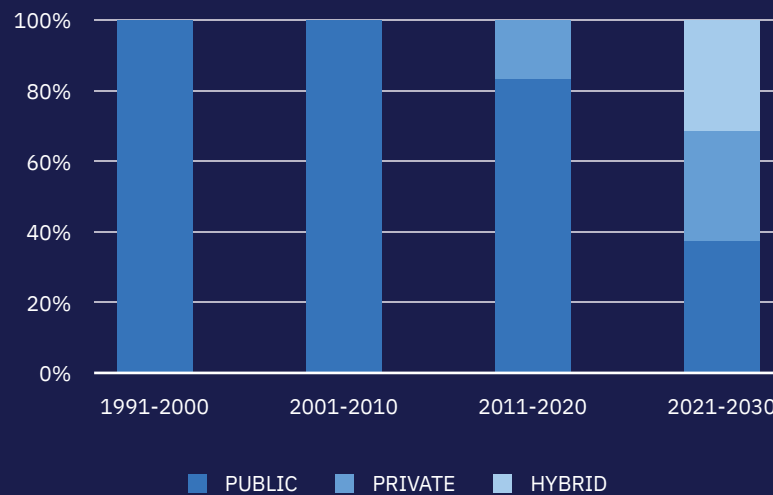
Collectively, the three advancements – improvements in temporal resolution, diverse spectral resolutions, and enhanced spatial resolutions – have played a pivotal role in developing new real-world use cases for Earth observation data.

Ultimately, when it comes to Earth observation we need to combine our efforts. Greenhouse gas monitoring is a clear example of the benefits of the public and commercial sectors working together.

In the decades spanning 1990 and 2000, greenhouse gas monitoring was predominantly the domain of government agencies. However, from around 2010, we witnessed the rise of the commercial sector, with trailblazers like GHGSat leading the way. What's particularly noteworthy today is the emergence of hybrid missions where both the public and private sectors collaborate. This collaboration will transform greenhouse gas monitoring into a landscape where a third of the data comes from the public sector, another third from the private sector, and the remaining third from hybrid missions.

This represents a substantial shift compared to two decades ago when greenhouse gas monitoring was entirely reliant on public sector efforts. The current scenario reflects a more diversified and collaborative approach, leveraging the strengths and resources of both public and private entities for more comprehensive greenhouse gas monitoring.

GHC MISSION TYPE BY DECADE



Source: WGIC

As the industry develops there are a few key challenges that public and commercial players will need to address:

- **Shift in business model** from selling pixels to selling products. In order to get higher adoption, the end-user product needs to be more suited for non-technical customers and provide more answers than questions.
- **Sustainably manage debris** in orbit. The Federal Communications Commission has already received applications to launch up to ~75,000 satellites by 2032 and the Chinese are looking to launch thousands of satellites in the coming years.
- **Data interoperability** is essential for geospatial intelligence as it facilitates the integration, sharing, and analysis of diverse geospatial data sources, enabling more effective decision-making and response.

What really gets me excited is if governments and the commercial sector could come together and start creating a virtual representation of the actual physical universe. When we walk out of the door we don't see boundaries. We integrate all of this information, the sights, the objects, the weather. How come we can't recreate this in a virtual environment?"



Market overview

Data acquisition

Derived analytics vs. vertical-specific analytics

Derived analytics

Vertical-specific analytics

The broader Earth Observation (EO) market is estimated by researchers to be valued between €9 and €17Bn in 2022. The size of the market varies on the inclusion of governmental transactions and specific vertical use-cases. Projections indicate a >10% annual growth rate in the upcoming years, with the potential for the EO market to reach as high as €31Bn by 2027.

This dynamic market involves various activities across the entire EO value chain, which we have grouped into three main sub-segments:

The initial stage of the EO value chain is **Satellite Missions**, encompassing the deployment of EO satellites, equipped with advanced sensors and imaging systems. This stage involves both the launch of satellites and operational activities.

The second phase centers on geospatial **Data Acquisition**. Involving the collection of high-resolution images, infrared data, and other geospatial information, this raw data is what fuels geospatial intelligence.

In the final phase of the value chain, **Analytics** solutions serves as a layer on top of the data. By consolidating diverse data sources and employing ML and AI, these analytical applications facilitate the extraction of unique geospatial insights. This segment is not only representing the majority share of the EO market, but will also be the primary driver of the anticipated market growth. The increasing relevance and use-cases of geospatial data across verticals such as insurance, agriculture and climate monitoring, are fostering a surge in demand for downstream analytics solutions.

Furthermore, the analytic stack of the market can be segmented into two core categories:

1. **Derived analytics:** Horizontal software products with a broader customer base, but narrower use case, where providers mainly source their data from satellite operators.
2. **Vertical-specific analytics:** Industry-specific use case with a variety of data sources and deep domain expertise.



Coming from a software perspective, our focus is on the Data Acquisition and Analytics facets of the market.

In the context of the analytic stack, derived analytics products usually begin with data as the foundation, and solutions are built on top of this data, essentially making data the product itself. On the other hand, vertical-specific analytics take a different approach by aiming to address a particular problem. In this case, data is seen as an enabler of the product, bringing together the necessary information to solve a specific problem within an industry.

Creating solutions for vertical-specific use cases typically demands deep domain expertise, as the product is designed to tackle a particular challenge within a specific industry. This approach involves a more targeted and problem-solving-oriented strategy, where the data plays a crucial role in developing effective solutions for the identified issues.

	Product depth	Data fusion	Domain expertise
Derived analytics	Horizontal, generalist product offering	Lower	Lower
Vertical specific	Vertical, industry specific	Higher	Higher

01 Data acquisition

Data acquisition lies at the core of geospatial intelligence and Earth observation, ensuring the availability of accurate, timely, and reliable information for analysis and decision-making. This involves collecting and integrating data from various technologies, including satellites, mobile sensors, ground-control stations, and aerial images.

While all data sources are valuable, satellites have become indispensable for Earth observation. Their global coverage, persistent monitoring capabilities, ability to capture multispectral data, and adaptability to various applications make them a cornerstone in geospatial analysis. Satellites significantly enhance our capacity to monitor, analyse, and respond to different situations and challenges on Earth. As a result, satellite operators play a crucial and integral role in the geospatial intelligence and Earth observation ecosystem.


To get a deeper understanding of the value proposition and strategic positioning for satellite operators, we look at four key elements of competitive dynamics to consider:

1. Resolution and data quality: Data quality is always the primary consideration, and its significance varies based on the intended use case. For instance, when observing a ship in a harbour, the level of detail required depends on the purpose. Is it sufficient to merely identify the presence of the vessel? Or is it essential to determine the type of vessel or even its name? The resolution of orbiting satellites currently spans from 250 to 0.3 meters, the highest resolution allowed.

Most imagery with a resolution lower than 10 meters is freely available, aiding in tasks such as detecting buildings. However, higher-resolution imagery is typically obtained from commercial providers for applications requiring finer detail, such as identifying objects like cars. The availability of free, lower-resolution images serves specific purposes but may not be suitable for tasks demanding precision.

Moreover, higher-resolution imagery enhances the effectiveness of AI analysis, enabling more in-depth and accurate examination of the data. The choice of resolution is a critical consideration, aligning with the requirements and objectives of the geospatial analysis or Earth observation task.

2. Revisit time: Revisit time refers to the duration between the capture of an image and the subsequent shot of the same area. High revisit rates offer significant advantages, particularly in identifying changes over time. For example, a constellation of 150 small satellites can cover the entire Earth daily, providing frequent and up-to-date observations. In contrast, a single satellite like Landsat-8 takes 16 days to achieve the same coverage. The more frequent revisit times of constellations contribute to a more dynamic and real-time monitoring capability, allowing for the rapid detection and analysis of changes on the Earth's surface.

 *"We now have enough satellites in orbit to make it possible to gather data every hour over high-priority regions."*

John Serafini, CEO, HawkEye 360

3. Tasking: Tasking in the context of satellite operations refers to how easily and flexibly a satellite can be directed or instructed on what specific areas or targets to focus on, irrespective of its current location. The ease of tasking is a crucial aspect of satellite functionality and is influenced by the satellite's design and capabilities.

Smaller and more cost-effective satellites, or CubeSats, may need to improve their tasking capabilities. Due to their size and design, these satellites may primarily focus on capturing data from the regions directly underneath them. In other words, their ability to redirect their observation focus independently of their position may be more limited than larger, more sophisticated satellites.

4. Processing speed: The time between data collection and actually putting it in front of the end user. Maxar and the US Government aim for <10 minutes.

From a customer perspective, the high end of the satellite spectrum implies the attainment of the highest resolution, optimal revisit time, the capability to task the satellite to focus on specific areas of interest, and the ability to process and deliver the acquired data to customers within a matter of minutes.

In the past few years, there have been strategic initiatives among satellite operators to diversify into analytics and specific products, with Maxar emerging as a clear leader in this shift. However, recent trends suggest a notable retraction in this direction as satellite operators redirect their core focus back to satellite manufacturing.

This shift is evident through various indicators, such as the recent reallocation of engineers at Astra and the establishment of AI partnerships by Planet Labs. Expert interviews and industry insights also support the observation that there is a trend among satellite operators to refocus on the manufacturing aspect of satellite operations rather than expanding extensively into analytics and specialised products. This realignment of priorities underscores the dynamic nature of the satellite industry and the strategic adjustments operators make in response to evolving market conditions and opportunities.

With the shift back to satellite manufacturing, satellite operators are now concentrating on establishing long-term competitive advantages by expanding their product offerings. This expansion includes:

- **Incorporating radio frequency technology:** This allows the capture of diverse types of information, expanding the range of data collected.
- **Transitioning to radar technology instead of imagery:** Radar can penetrate through clouds and operate during nighttime, providing continuous monitoring capabilities in various weather conditions.
- **Introducing 3D imaging:** This enhances data visualisation, providing a more comprehensive and detailed perspective for geospatial analysis.

These strategic moves align well with the structural shift described earlier, emphasising the increasing variety of sensors in satellite technology. By diversifying their product offerings regarding sensor capabilities, satellite operators aim to cater to a broader range of applications and user needs, ultimately strengthening their competitive position in the evolving satellite industry.

ACCESS EARTH OBSERVATION DATA FROM



02 Derived analytics vs. vertical-specific analytics

Geospatial intelligence use cases vary widely, but the analytics stack's distinguishing factor lies in the use case's depth and specificity and product offering. This segmentation results in two overarching themes: derived analytics and vertical-specific analytics.

1. Derived Analytics:

- **Description:** Derived analytics involve the development of products that originate from geospatial data analysis.
- **Characteristics:** The focus is on creating solutions that can be applied across multiple industries but with more specific use cases.
- **Examples:** Generalised land cover classification, change detection, and broad-scale environmental monitoring.

2. Vertical-Specific Analytics:

- **Description:** Vertical-specific analytics are tailored solutions designed to address specific challenges within a particular industry or use case.
- **Characteristics:** These analytics delve deeply into the nuances of a particular domain, providing specific and targeted insights.
- **Examples:** Industry-specific solutions such as precision agriculture analytics, urban planning tools, or specialised defence and security applications.

The distinction between derived and vertical-specific analytics lies in the breadth and depth of their applications. Derived analytics offer versatility across various domains, while vertical-specific analytics provide in-depth solutions catering to the specific needs of a particular industry or use case. This segmentation allows for a more nuanced and tailored approach to geospatial intelligence, meeting the diverse requirements of different users and industries.

■ Derived analytics

Derived analytics primarily concentrate on horizontal software products with a broader customer base spanning industries such as forestry, agriculture, infrastructure, and more. Although the end-use cases may differ slightly across these industries, they share a common specificity regarding end-user experience. Derived analytics platforms predominantly leverage satellite imagery as their primary data source.

In simplified terms, there are typically two core use cases for derived analytics:

1. Object Detection:

- Definition: The capability to identify a specific object within a given area.
- Example: Utilised in forestry monitoring to count the number of trees in a particular region.

2. Change Detection:

- Definition: The ability to identify and track a specific change or alteration in a designated area
- Example: Employed by infrastructure monitoring to track and detect cracks in parking lots over time.

These two use cases represent fundamental functionalities of derived analytics, offering solutions that enable the identification of specific objects or changes within the context of diverse applications such as forestry, agriculture, infrastructure, and beyond.

Object detection

Object detection refers to identifying and locating specific objects or features within a geographical context. Object detection is crucial for geospatial intelligence as it enables identifying and tracking specific objects and detecting change.

Recent advances in AI have significantly benefitted and transformed object detection. These algorithms automatically identify and classify objects within imagery or sensor data. Object detection can be applied to various objects such as buildings, infrastructure, natural features, cars, etc.

AI IMAGE: ARMoured VEHICLES DETECTED BY PRELIGENS AI IN MALI DESPITE HEAVY FOG



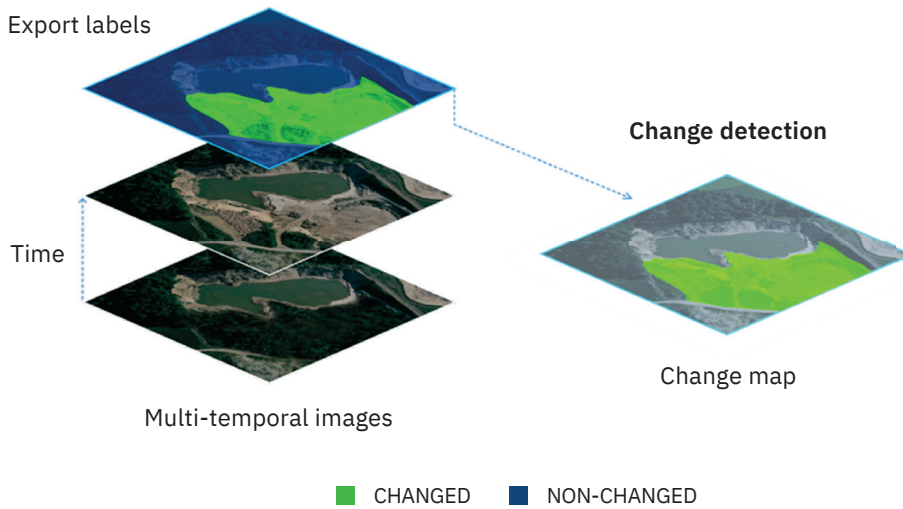
Source: Preligens.AI

Object detection is frequently succeeded by geospatial analysis. In this process, the coordinates and characteristics of the detected objects are integrated into software products, offering context and facilitating decision-making. Ultimately, this integration enables object identification and tracking automation, streamlining the monitoring and response to various events and changes.

Change detection

A few years ago, the geospatial market underwent a notable shift, transitioning from primarily focusing on object detection to encompassing the capability to classify changes.

Derived analytics platforms can identify changes by comparing identical images captured over time.



Source: Picterra

From a change identification perspective, there are generally four key use cases:

Object disappearing: Focus on a well-defined object, such as trees being cut down, water bodies shrinking, etc.



Source: Picterra

Object **appearing**: Trees being planted, oil spills, infrastructure, etc.



Source: Picterra

Object **shifting/moving**: Typical use case for utilities and infrastructure to determine if objects that are not supposed to move have moved. E.g. railroad tracks.



Source: Picterra

Object is **changing in appearance**: Typically used in farming and climate activities to detect changes in vegetation.



Source: Picterra

Derived analytics solutions empower many industries to become more data-driven, proactive, and efficient. Satellite imagery plays a significant role in driving this shift.

COMPANIES TO TRACK

cloudeo

Geospatial data marketplace

CAPEANALYTICS

Combining AI with satellite imagery to power property insurance









URSA
SPACE

Providing satellite intelligence infrastructure from the world's largest virtual radar satellite constellation

Picterra

AI-powered geospatial solutions

Non-exhaustive list

 AIRMØ	 ASTERRA
 DANTI	 EDGYBEES
 Orbital Insight	 PRELIGEINS
 Risilience	 tomorrow.io

■ Vertical-specific analytics

Derived analytics caters to a broad spectrum of customer profiles, focusing on a few key use cases. In contrast, vertical-specific analytics delve into deeper vertical product offerings and integrations. While satellite data remains the enabler and a crucial driver for continuous and scalable monitoring, satellite data alone cannot address all questions.

For more complex problems, additional data is necessary; this is where data fusion becomes imperative. Companies operating within vertical-specific analytics typically adopt a more holistic approach to Earth observation, considering a wider range of data sources beyond satellite imagery.

Numerous industries have experienced positive impacts from vertical-specific analytics, with climate monitoring as a key vertical that has significantly benefited from recent advancements in Earth observation – the ability to track the effects of carbon offsets and create transparent climate risk management at scale.

Many groundbreaking products are emerging, with companies like BeZero, Cervest, Sylvera, and Kayrros leading the way. These companies typically form data partnerships with space agencies, research institutes, commercial providers, and scientists in the field. They leverage a combination of satellite imagery, airborne lidar, on-site measurements, and proprietary software to develop innovative solutions.

Taking a closer look at BeZero to further exemplify the strategic and operational position of vertically focused products:

- **Problem:** The market for voluntary carbon credits needs help managing risk and understanding the actual impact of carbon credits.
- **Solution:** A rating product for assessing carbon credit efficiency, rating and qualifying carbon credits.
- **Approach:** Deep aggregation of data sources, partnerships and proprietary data models.
- **Product:** Platform to help participants in the voluntary carbon market make informed decisions.

UNIQUE AGGREGATION OF DATA AND PARTNERSHIPS

Space agencies



- Spaceborne LiDAR, radar and multispectral measurements
- Medium to coarse resolution with repeat global coverage
- Supports large scale monitoring and longer time periods

Commercial providers



- Multispectral measurements at higher spatial resolution
- Enables tree crown segmentation for monitoring of low canopy density, planting and degradation

Airborn LiDAR



- Dense point clouds for structural canopy measurement
- Calibration and validation of canopy height, cover and biomass

In situ measurement



- Vegetation composition and structure, physical and chemical soil properties, eDNA
- For understanding uncertainties in satellite-derived biomass, project carbon stocks, and biodiversity

Source: BeZero

Regarding satellite imagery, BeZero states that this in itself is not enough to track carbon stocks:

■ *“Currently, it is not possible to accurately benchmark, let alone track, ecosystem carbon using satellite data alone. Doing so requires detailed information on vegetation structure (for volume), species composition (for biomass and carbon concentration), and especially for boreal or tropical dry forest, mangrove, grassland or peatland projects, local measurement of soil organic carbon and a sound understanding of how carbon cycles, above and below ground, seasonally, and over longer time periods.”*

With that said, for scalability and continuous monitoring remote sensing is a key piece of their product:






■ *“Earth observations will enhance the utility and analytical depth of the BeZero Carbon Rating for a substantial section of the market, but ongoing research and development is essential to realise the potential. The first step is to take stock of all the different satellite imagery and other remote sensing technologies, analytical tools, and field data available.”*

What distinguishes vertical-specific analytics is that as they accumulate a diverse range of data sources and develop proprietary models, they can optimise the utilisation of satellite data alone. This makes them significantly more scalable and defensible. The unique combination of data allows companies to enhance their understanding of ground-based developments from space and augment satellite data. While this is promising, it's important to acknowledge that near/on-ground measurements will continue to be crucial in the short to medium term.

COMPANIES TO TRACK

- LiveEC**
Earth observation solution to safeguard ground bases assets
- BeZero**
Carbon rating agency
- cervest**
Climate intelligence that helps organisations manage and adapt to asset-level risk
- Sylvera**
Machine learning-based tools to track the performane of arbon offsets

Non-exhaustive list

7Analytics	
Beacon	Calyx Global 
CART 	 Descartes Labs
EARTH AI	OELX
 Pachama	

Expert view

CO-FOUNDER | LIVEEO



DANIEL SEIDEL

"The end user doesn't care which data source was used. They want insights such as work recommendations or decision-making tools."

WHAT ARE THE KEY BENEFITS OF VERTICALISATION WITHIN EARTH OBSERVATION?

One of the key benefits is automation, as the end-to-end stack is complicated to build. Without automation, you will always sell man-hours and have issues with scalability. On top of that, the requirements for different verticals can vary significantly. Ending with a map does not enable enterprise customers to gain additional value – you need to move multiple levels away from the map into the actual customer problem. For example, integrate it into a workforce management system.

With a vertical focus, you get requirements from multiple customers who all want to solve the same problem. We take this diverse input and build one product to service many customers and then transfer learnings from one customer to another. Ultimately, with every vertically focused customer, we continuously improve our software.

This is an effect which, at some point in time, makes it very difficult for others to compete. You can build vertical-specific tech to outcompete non-vertical companies on quality, timelines and price. This will be the critical decision criterion in an educated market. For example, we have full automation of making customers' grid data (powerlines) analytical-ready. This goes into reconstructing geospatial assets for customers who don't have complete geodata of their assets. It took us months for every customer to do this manually in the early years, but now it takes less than a day – cheaper, more accurate and faster. Another product and sales perspective advantage is that you can tell a specific user persona-centric value story and create business cases for the customers with a clear ROI.

This enables a speed-up in sales and opens up budgets in a new market. For a horizontal or project-based company, it's tough to get this deep because it also needs a lot of interactions with the potential customers in this vertical. Furthermore, with a vertical focus, you understand the necessary accuracy requirements and also a good understanding of technical capabilities and limitations to solve customers' problems. The continuous feedback creates a flywheel effect. The more customers from a specific vertical give you feedback, the better your product gets. It also builds a better go-to-market motion with a dedicated sales team and a reputation at industry events. Hundreds of companies do or want to do vegetation management for utilities. Still, you don't see them at specific industry events because they also do many other things. This also has the positive impact of getting inbound from new customers once you have established your product in the vertical and can significantly reduce customer acquisition costs.

DO YOU SEE ANY CLEAR TRENDS IN HOW A CUSTOMER'S USE CASES OF EARTH OBSERVATION EVOLVE?

At first, enterprises love Earth observation because it's about space. They think of a blockbuster movie, such as the Jason Bourne series, and their expectations for products are set too high. On the other hand, the customer's technicians have a lot of scepticism. Then, you demonstrate a fancy small-scale pilot (often with the innovation team of a big corporate), which works fine and is done fast. People become curious; you sell another bigger follow-up contract for 10 to 1000 times the area. This is the Death Valley of scaling with a lot of pain points. However, with the hype and initial success, you sell to a handful more and potentially realise requirements you didn't consider before. This helps you to improve the product with more anchor customers. In this phase, with the first rollouts, you have to invest a lot in quality control and accuracy on scale. To not lose money by scaling, you need to do a lot of cloud optimisation to get costs down, which typically takes over two years if you are doing it for the first time and requires a completely different skillset (cloud engineers) compared to the pilot phase (geospatial engineers). The frustrating thing is that in an uneducated new market, you sometimes still lose against new players on the block who completely overpromise and underprice. If your success gets public in the industry, it creates much noise. I had seen this multiple times in the early years when we lost deals against the overpromises and underachievers, and I know of at least three competitors who raised a seven-digit seed round that had to file bankruptcy. But with patience and quality delivery, you survive until the market becomes more educated. You've built a good reputation if you had a clear focus and delivered on your objectives by then. This is the starting point of real scale and competition for a handful of companies.

HOW DOES DATA FUSION LEAD TO INCREASED ACCURACY?

Different sensors contain different information which represent the same real-world object. Using multiple sensors for the same object representation helps to make the correct prediction, specifically in edge cases or deeper second-level analytics. An example of first-level analytics is the accurate segmentation of a tree. Second-level analytics would be the temporal condition of the tree regarding health. Using a more tailored sensor for each problem with increased accuracy improves the product. One aspect you also solve with data fusion is cost efficiency by merging datasets with very different temporal and spatial characteristics. Updated high-resolution imagery is more expensive than medium-resolution imagery. It could be that you find a precise object characterisation on a submeter image which is a year old. Fusing updated medium-resolution data into the prediction tells you if the object is still there. On the other side, an old high-resolution image from the archive could be cheaper than a super-fresh medium-resolution image. You need to know what's enough to solve the customer's problem. Data fusion is also why independent analytics vendors are better positioned to build most vertical products than the hardware operators if multiple sensor types improve the product. The hardware operators have a bias in using their existing hardware. It's like if you are a company with many trucks and excavators, but you also want to build a transportation service and compete with a company with buses and cars. You may be able to transport people in the truck and excavator, but it will be less efficient and more costly, and you won't have the capital left to buy buses and cars. This won't work long term. Another point is that data fusion in geospatial does not only mean combining different imagery.

Furthermore, you typically also have to merge other geospatial datasets, which may not be derived from imagery but which you must bring into the reference system. An example given is a precise field measurement from a land surveyor, which represents the exact location of the railway with sub-centimetre precision. Let's imagine you have a precise image classification and identify a risky object for the rail, but the customer only acts if it is a meter away. Typically, there are significant shifts in the imagery, and it could be 10 meters shifted from the land surveyor measurement. The accuracy of your prediction will be close to 0 if you don't master the data fusion of the two geospatial datasets. The last aspect of why data fusion is so important is coverage. Combining multiple sensors from different vendors for the same problem can give you more spatial or temporal coverage. We monitor pipelines on a biweekly basis, ideally with optical data, because it has a better cost/capability ratio for this problem. The accuracy here is measured against real-world incidents. This works perfectly in the Middle East, but it's already hard in the summer in Germany, and it could be that your detection accuracy against actual incidents is zero because you have no data. Using radar data that penetrates clouds for these data gaps of the optical data makes this monitoring reliable and possible in many geographies.

DO YOU BELIEVE LONG-TERM SOLUTIONS WILL COMBINE DIFFERENT DATA SOURCES – I.E., OPTICAL + HYPERSPECTRAL + RADIO FREQUENCY?

The end user doesn't care which data source was used. They want insights such as work recommendations or decision-making tools. Different datasets have different costs, availability and capabilities. A product that combines the advantages of different data sources will build a better end-user product. Customers don't need a map or geospatial components in many use cases because the derived information is ingested and deeply integrated into enterprise processes. So, the answer is a clear yes.

WHAT EMERGING TRENDS AND INNOVATIONS IN AI ARE EXPECTED TO IMPACT THE EARTH OBSERVATION MARKET IN THE NEAR AND LONG TERM?

Geospatial Foundation models based on large-vision model architectures are one of the trends that will unlock the unknown potential of the data. The biggest challenges in remote sensing analytics are gathering training data and having algorithms that understand context and generalisation across geographies, sensors and different seasonalities. We have seen that these challenges are the advantages of large foundation models based on transformers. The industry has established the term LVM (large vision models) or GeoFM. Another aspect that will have a huge impact is the interaction with geospatial data through large language models or multi-modal language-vision models, which some call LVLM or LLVM.

LiveEC

Summary

From the first ever photo of Earth taken in outer space, the ether has provided a unique and magnificent vantage point for studying our planet.

Observations from satellites provide one of the only ways to get consistent and frequent data on the high-level developments we see on Earth. Simultaneously, we are in a technical transition. The surge in data, variability in data types, the shift towards higher resolution satellite data, and advancements in AI collectively enable more accurate and insight-driven solutions.

The challenges associated with this shift involve extracting meaningful insights and delivering products, not just pixels.



Few industries are as strategically intertwined with the significant structural tailwinds we are currently experiencing as geospatial intelligence. In addition, the industry could be a key player in addressing some of the core problems we must solve.

The significance of the challenges and the opportunities is evident, indicating that we should allocate our resources accordingly. With the recent successful launch of the Chandrayaan-3, India became the fourth country to land on the Moon and the first country to land on its south pole. India did so on a budget of \$75m, half what it took to produce the movie *Interstellar*, and 75% less than this year's blockbuster, *Oppenheimer*.

With everything said, we want to offer industry outsiders like ourselves the opportunity to fully grasp the significance of the ongoing change and the importance of supporting the ecosystem. We are just at the beginning of the next great infrastructure shift.

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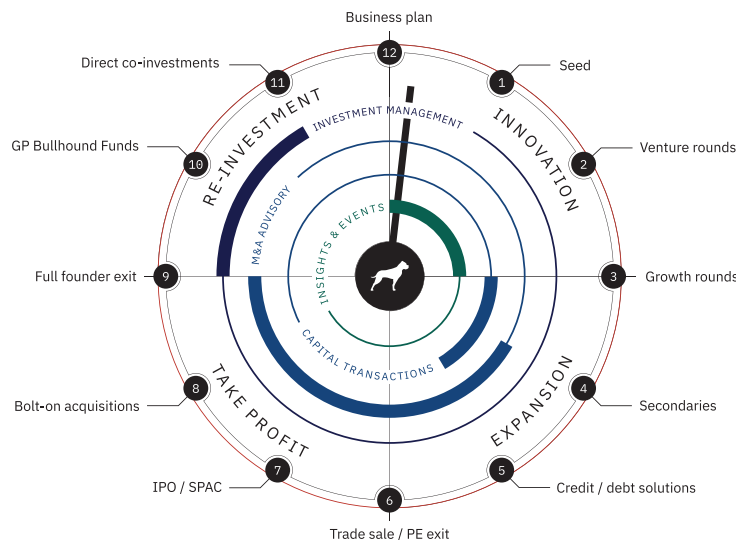
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