European Commission

Business Innovation Observatory

Space tech and services

Big Data in Earth Observation

Case study 64

Internal Market, Industry, Entrepreneurship and SMEs

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Big Data in Earth Observation

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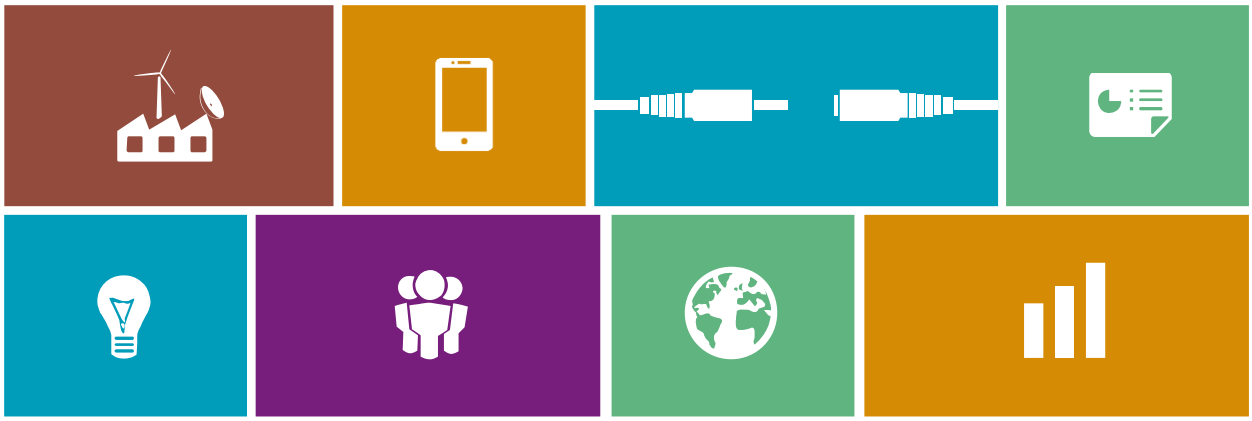
Table of Contents



1. Executive summary

Recent technical breakthroughs have a tremendous impact on data collected thanks to Earth Observation (EO) programmes – its amount and diversity will increase drastically. As a result, actors of the midstream EO segment of the value chain, *i.e.* satellites operators and data service providers, will have to find new ways to acquire, analyse, cure, store and use this new flow of information. Traditional software will no longer be sufficient to store and process the data collected.

The EO Big Data market is still immature and is expected to evolve rapidly over the coming years. Today it is characterised by large international players, but mid-size and smaller actors are gradually emerging. In addition, while the defence and security sectors currently account for the main client, new customers are expected to recognise the potential benefit and added value of those services.

These evolutions will undeniably impact the job market by creating new opportunities arising from the technical developments. Deeper technical expertise and wider area of intervention from EO midstream players will further galvanise the market. Free and open access to data widens the spectrum of users and introduces new players along the value chain.

Increasing participation of the EO Big Data experts in various projects shows the recognised necessity and added value of analysing, processing and using data emanating from EO programmes. The solutions provided by the sector are convincing international, national, local actors from the public, private and non-profit sectors to use them to solve their specific challenges. Business opportunities arising from the increasing number of satellites and the diverse data they provide will further foster market uptake.

At the same time, competition in the sector is getting tougher, forcing EO Big Data companies to strive for ever more innovative products, services and business models.

While a majority of the activities of the midstream EO market are based on public funding, support from governmental authorities remains unsecure and changing, highly depending on the political agenda and strategic priorities. Moreover, national authorities often express the need to keep control of the dissemination of data concerning defence and security issues. In addition, access to data is yet not entirely reliable and continuous, posing a major threat to the quality and sustainability of the developed solutions.

To ensure the development of this sector, public bodies need to provide the necessary solutions. The establishment of online, friendly and practical databases would help to ensure equal access to data. And the harmonisation of regulations facilitating the activities of midstream companies all along the value chain throughout the EU would help the market to reach its potential.

A strong, long-term and sustainable vision of space Big Data policy, both by national and European authorities would secure the development of the market.

2. Big Data in Earth Observation

The trend "Space technologies and services" covers the latest developments in the space industry through four case studies. They each focus on innovations related to space technologies and services fostered by the European Space Policy to tackle some of today's most pressing challenges. This paper explores the latest means by which companies are making the most of developments in Big Data in EO, through the Copernicus programme.

2.1. Trend presentation

With the emergence of new technologies and applications, it becomes increasingly challenging to deal with the sheer volume, diversity and flow of data. Big Earth Observing data refers to data collected via EO programmes whose size is beyond the ability of traditional software to store, analyse, process and use. These evolutions create mounting challenges and opportunities in the EO midstream segment of the value chain.

The European Union is currently developing an independent Earth Observation capacity through its Copernicus programme, previously known as the Global Monitoring for Environment System programme (GMES). This programme is a cornerstone of the European Union space strategy. One of its main objectives is to provide reliable and up-to-date indicators to present a continuous picture of our evolving world to the scientific community and public authorities. Copernicus consists of a complex set of components that collect data from various sources: EO satellites and a multitude of *in situ* sensors (meaning on site or local) on the ground, at sea, or in the air.

Since 2014, access to Copernicus data is free, unlimited and universal: Copernicus is the 3rd largest data provider in the world, with 8 Petabytes per year. No previous EO initiative has ever provided such volume and diversity of data at such an impressive rate, which poses rising challenges to collect, reference, disseminate, process and deliver them. In the next five years for example, the Sentinel spacecraft alone will generate some 25 petabytes of EO data.[1]

Driving this transformation process are digital services such as cloud computing, Big Data (including data-driven science and geo-spatial data) and the Internet of Things (i.e. connected devices). They have become a central element of the EU's competitiveness, an enabler for innovation and a catalyst for economic growth and jobs.

Free and open access to EO data provides sound business opportunities. Today, EO data can be distributed to users through various distribution channels such as: direct sales from the company, direct access to the satellite (mainly for international government clients to ensure an increasingly secure access to the satellite), sales through dedicated resellers (which allows the company to access local markets), sales from company websites such as satellite data archives, or online image libraries which offers practical access to data.

Amazon Web Services (AWS) provides an internet cloud-based platform making available Landsat (the US Earth Observation system) data since mid-March 2015. Indeed, Landsat is organised around an open-data policy to provide multispectral data for applications in agriculture, cartography, geology, forestry, regional planning, surveillance and education. 150 days later, AWS had 500 million hits, accounting for the impressive potential of the downstream market. Innovative solutions offered by data brokering actors are necessary to bridge the gap of cloud-based infrastructure proposed by Amazon, Google or Microsoft in the US. The ability to effectively manage information and extract knowledge is now seen as a key competitive advantage, which is why many companies are establishing their capacity to collect and analyse data to extract business intelligence and insights as part of their core business. The midstream market segment, referring to the activities related to the production and dissemination of the data, is currently changing. In 2012, only three companies captured almost three quarters of the total revenue emanating from EO commercial data sales, namely GeoEye (25 per cent), DigitalGlobe (25 per cent) and Astrium GEO-Information services (20 per cent). Today, despite the continued dominance of large players on this specific market, there is scope for mid-sized and smaller companies. Indeed, the structure of the industry is evolving due to the extension of the services provided by the commercial operators in order to include more value-added applications and be able to offer complete geospatial solutions.

The EO data value chain comprises a series of subsystems each characterized by specific processes and drivers. It consists of five main high-level activities: data acquisition, data analysis, data curation, data storage and data usage.

- **Data Acquisition** corresponds to the process of gathering, filtering and cleaning data before it is stored for analysis. The acquisition of "Big Data" is mainly governed by what is referred to as "the 4 Vs": Volume, Velocity, Variety and Value.

- **Data Analysis** is equivalent to the phase of rendering acquired raw data useful and comprehensive for a specific usage (i.e. to support decision-making). One of the specificities of data analysis is use of old technologies to analyse the data but in an evolving

context, with a much wider range of data available. The analysis of data has an essential place in the value chain since it renders the data useable for others.

- **Data Curation** is currently an emerging activity, and refers to the active management of data over its life-cycle to ensure it meets the necessary quality requirements for its intended usage. One of the main challenges of data curation is to deal and manage the quantity, diversity and flow of data coming from a widening range of sources. Its dedicated infrastructure aims at addressing this growing challenge in order to reduce the obstacles to generate content with high data quality in order to provide users with more complete and high quality data-driven mode.

- **Data Storage** relates to storing and managing the data that has previously been acquired, analysed and cured in an appropriate way depending on the needs of applications. The main challenge regarding data storage is related to the management of the large amount of data that is to be stored. Data storage is not a new activity and is now considered as a commodity business, especially in areas such as weather forecasting.

- **Data Usage** is mainly used in order to support business decision-making. It consists of finding a way to provide access to data and its analysis in order for business to integrate it in their decision-making. More specifically, the process comprises the analysis of the entire data set, the translation and condensation of the obtained data and the description of the results in a report or throughout a tool. Currently, the main players in the data usage industry are large companies benefiting from a complete infrastructure. Opportunities in the data usage market will arise for SMEs in order to respond to the growing need to propose innovations related to a more complex use of data.

2.2. Overview of the companies

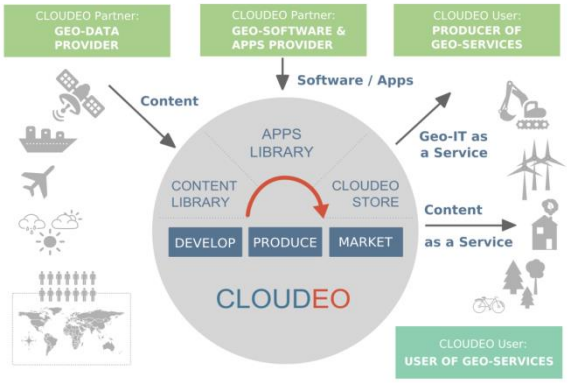
Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
Blackbridge	Germany	Blackbridge is specialised in providing in a cloud environment high-quality information for field management on large agricultural areas	- Benefited from funds from the Canadian government - Operates today throughout the world thanks to a network of 100 local partners
CloudEO	Germany	CloudEO provides a portal on which are stored EO data and applications throughout a network of partners.	- Worked in collaboration with ESA to develop new services - Has customers worldwide
CS	France	CS develops software applications on an open source basis to process and deliver data collected via EO programmes.	- Has been working in collaboration with ESA and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) for the past five years - Has worked for large international clients such as Thales, Safran, Airbus group
GIM	Belgium	GIM selects and analyses the most valuable EO data to turn this imagery into smart and actionable insight for its customers.	- Benefited from European Union (EU) programmes such as FP7 and from ESA programmes such as Value Added Element - Worked in collaboration with the World Health Organisation for a large scale public health project funded by the Bill and Melinda Gates foundation, as well as for the World Bank and UNESCO

Problem 1 – Today, actors along the EO value chain work independently from one another and are in need of an integrated ecosystem

Innovative solution 1 – CloudEO's approach is to establish a new ecosystem to facilitate in parallel commercial access to data and the development of EO related applications, thus encouraging the emergence of new business. This product is the only one of its kind and has no real competitors on the market. The initial challenge faced by CloudEO's founders was to convince suppliers to provide accurate, reliable and diverse data to their upcoming customers.

CloudEOs platform brings together data suppliers, application and software providers and producers of geo-services

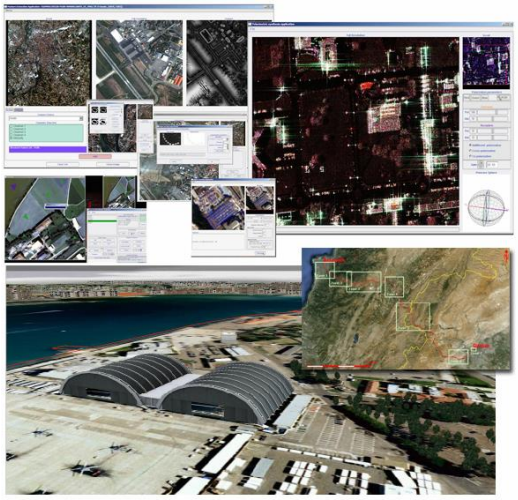


Source: CloudEO [2]

Problem 2 – EO raw data needs to be processed and made available to become exploitable

Innovative solution 2 – CS responds to the challenges of its customers by the conception, integration, exploitation and operational readiness of innovative systems by developing complex software proposing solutions to process data. The company intervenes throughout the entire midstream value chain: from data acquisition to data dissemination. The applications provided are highly disruptive: they are developed on an open source basis. One of CS' applications "Rugged", is a sensor-to-terrain tool providing an operational, open-source solution for Sentinel-2 mapping. This tool is the first ever online data library accessible by all and generates high quality time series over land.

Screenshot of the CS's application Geostorm



Source: CS[3]

Problem 3 – Extracting information, analysing it and selecting it to make it available to customers is difficult, but essential for it to become a useful decision-making tool

Innovative solution 3 – GIM benefits from an extensive portfolio of satellite images thanks to partnerships with leading providers. The company then selects the most suitable data and analyses it to derive relevant information for its customers. GIM is particularly recognized for its expertise and technical capacity in the processing of very high resolution imagery, which distinguishes it clearly from its competitors. GIM has developed the technical capacity to analyse and use data coming from various sources and captured at different scales. By reconciling and processing this data, GIM is able to provide its customers with accurate and tailored information depending on their needs.

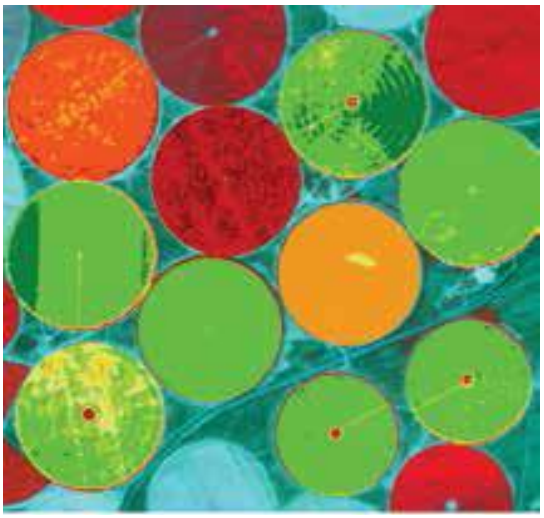
Satellite image processed by GIM to extract, analyse and classify small landscape elements

Source: GIM[4]

Problem 4 – In the agriculture market, finding reliable supply of high-quality and affordable information for field management is difficult.

Innovative solution 4 – Blackbridge developed monitoring programmes for agriculture based on a cost-effective satellite imaging solution for a comprehensive and regular coverage of large agricultural areas. This innovation has a tremendous collection capacity: it can capture more than 5 million square km per day.

A capture of fields near Washington in the US using the Normalized Difference Vegetation Index (NDVI)



Source: Blackbridge[5]

With Blackbridge's product, called Rapideye, it is the first time that EO data is being used operationally by the agriculture market. Blackbridge proposes a strongly innovative business model for its customers: the data collected is set up in a cloud environment and available within 24 hours to all subscribers.

3. Impact of the trend

Small & Medium Enterprises (SMEs) see a strong potential in better analysing Big Data, and companies involved in the space industry are in a position to capitalise on this. According to a recent study among CEOs6, 80 per cent of CEOs think that data mining and analyses are strategically important to their company, 65 per cent say that the Internet of Things - a concept where everyday objects, such as cell phones, coffee makers, headphones, would be "connectable" - is strategically important, while 60 per cent mention the strategic importance of cloud computing.[7]

3.1. The market potential of the trend

Big Data from space is an emerging market and will expand rapidly thanks to the tremendous amount of new developments related to Big Data in other sectors.

Technological breakthroughs in hardware and software developments, multi-temporal data analysis and data management are key accelerators of space technologies and applications in the field of Big Data.

The free and open access to the data collected widens the spectrum of users and increases the awareness among the public, while creating additional opportunities for experts and innovating companies. The market will rapidly expand and see the emergence of many additional players.

In 2012, the Global EO midstream turnover amounted to approximately EUR 1.2 billion and is expected to reach EUR 3.4 billion by 2022.[8] Countries with **high imagery intelligence requirements in the defence sector** are the main drivers of this market. A Booz&Co study indicates that in 2010, about 65 per cent of EO global data sales revenues came from sales to defence or intelligence users.[9] The commercial data market will be boosted by the launches of new satellites with technical improvements in terms of high resolutions. By 2022, commercial data sales are expected to rise by 8 per cent for Defence & Security customers and 15 per cent for private companies from 2012 levels. More generally, natural resources management, engineering & infrastructure as well as defence are expected to be the main application areas supporting growth in EO Big Data. From a geographical perspective, sales in emerging countries are expected to grow considerably by 2022: 21 per cent in Latin America, 15 per cent in Asia and 14 per cent in Africa.[10]

90 per cent of today's data was produced over the past two years[11] and comes from very diverse sources. Copernicus' satellite Sentinel 1 provides around 3 terabyte per day and 1 petabyte per year - companies are not used to deal with such a volume of information that will need to be processed and distributed to the users. No previous EO initiative has ever provided such volume of data which brings tremendous challenges regarding the flow and storage of information. These challenges bring new opportunities for **data brokering actors**, who collect personal information about consumers to sell it to other organisations. Similar issues were faced by the Landsat programme in the US and were tackled by Amazon, throughout an online cloud-based platform. With no similar solutions existing in Europe, data brokering actors need to provide innovations. Many elements point to a further surge in gathering, storing, reusing our personal data – the size and scale of data collections will increase as storage costs continue to decline and analytical tools become more powerful.[12] Big Data Storage technologies are mature and thus enable companies to store and analyse more information at a lower cost while simultaneously thriving their analytical capabilities. Google and Twitter are examples of recognized players in the field but data storage also creates opportunities in other sectors. In the field of EO, climate change research could highly benefit from a better integration and analysis of environmental related data.

Besides, a disruptive trend in the EO data markets emerges with **EO 2.0 providers**, a new generation of space companies manufacturing smaller and cheaper satellites, compared to the existing private EO data provider. The impact on the EO market is disruptive and enables the development of new markets not covered by traditional EO data providers. The new generation of EO actors brings together EO, Space and Software, IT and Internet. This coupling leads to a breakthrough in the industry with radical innovations being made thanks to the availability of a large volume of data for an affordable cost, from different types of sensors and in a short revisit-time. EO 2.0 providers propose a core innovation: render cloud-based EO data available, on which anyone can work without having to actually download the data.

3.2. The social potential of the trend

The launch of numerous innovations related to Big Data impacts the job market directly and indirectly: directly throughout the **employment** of people by an organisation of the space industry and indirectly via the employment of individuals in other industries impacted by the evolution and activities in the space sector. Regarding Big Data activities related to EO, the midstream and downstream industry segments in Europe employed approximately 5,080 FTEs in 2012.[13]

As a matter of fact, the main players will face mounting difficulties in capturing, cleaning, curing, integrating, storing, processing, indexing, sharing, transferring mining, analysing and visualizing the large volume of fast-moving highly complex data. Companies will need to tackle the "talent gap" predicting that only one third of the predicted jobs created worldwide will be filled by the end of 2015.[14] Indeed, mining data requires a very specific set of skills - deep business insights, data visualization, statistics and computer programming.

4. Drivers and obstacles

4.1. EO Big Data is becoming recognised as an important way to tackle current challenges

The midstream EO market is growing and evolving. While knowledge and awareness of Big Data processing technologies can be further promoted and improved**, the recourse to Big EO Data in many sectors is increasing.**

As an example, GIM has been mandated by the Bill and Melinda Gates Foundation to contribute to the effectiveness of the polio vaccination programme by mapping the Nigerian states of Kaduna and Bauchi as part of the Global Polio Eradication Initiative. The objective was to create a fresh and accurate map of all human infrastructures in order to have a comprehensive view of places and people to target. Hence, in collaboration with Airbus Defense & Space, GIM collected and delivered a vast and very challenging area (225,000 square km), in difficult cloud and weather conditions. Despite the important landscape variations, a large amount and variety of housing structures and poorly contrasted landscape features to be extracted from the imagery, GIM leveraged its recognised expertise in semi-automated processing of very high resolution imagery to successfully cover the requested area in a record time of five months. In close collaboration with e-health Africa (eHA), an NGO in charge of the local coordination of the immunization campaigns, GIM provided to the vaccination teams current and decisive information to locate every last child and end polio. GIM has also been working in collaboration with the World Bank on an ESA project to map all slum areas in the Philippines capital Manila.

Players will **build on the success of such projects** which bring concrete proof of their added-value. This will attract additional actors from a wide range of sectors.

4.2. Business opportunities will arise to capitalise on ever-increasing amounts of EO data

Data emanating from EO programmes will continue to grow in an exponential way in the coming years. Indeed, **over 400 civil and commercial EO satellites are expected to be launched in the world in the next decade**, compared to 179 from 2005 to 2014.[15] These units will come from both government and private sources and will be launched in a much wider geographical area, with an investment expected to top EUR 9.3 billion in 2015.[16]

The first and most impactful consequence of these many launches will be the **increase of the data supply** to serve a range of applications. Data will indeed grow in flow and diversity, which will have sound effects on the midstream EO market. Players dealing with Big Data collected via EO space programmes will face challenges that are linked to its very particular nature: the volume of the data collected that will continue to increase over the coming years, the high-velocity information, and the extreme-variety of the data.

Rapid technological change is creating new opportunities: new satellite and payload technologies, new sensors, software advances. New players are entering the market, proposing ever more innovative and low-cost solutions. This drives the companies to adapt constantly to these changes and to **strive for new products and innovative business models** in order to face the mounting competition. The multiplication of players in the EO

"How tough is the competition? It is increasing, and had a very clear impact on prices in the past three years. Commercial competitors, free and open data policy in the US and in Europe have a huge impact on the industry. Selling in a traditional way won't work."
Blackbridge

downstream market creates additional confusion on the solutions available.

Not only will the number of satellites providing data grow, but their nature will change as well. Indeed, multiple small satellite constellations are being used increasingly, with a growth of the sub-meter resolution imagery supply. This will put additional pressure on Big Data players, requiring distribution models to be ever more efficient and secure. Competition will be emphasized due to the **transformation of the commercial satellite EO markets**, with innovative business models and new technologies.

In addition, due to the highly technical aspect of the applications developed, there is an important lack of awareness and understanding of these innovations. This has one major consequence: potential customers do not weigh the value of the application and have a limited overview of the potential benefits of an investment in such technologies. With the EO downstream market being mainly comprised of SMEs, **innovations do not reach their potential visibility on the market**.

According to Euroconsult, growing global investment and a developing commercial sector will support the increased activity[17] As an example, the French organisation responsible for the future investments programme "Commissariat-General for Investment" will be funding 12 R&D projects linked to Cloud computing and Big Data. "SparkIndata" is one of them. This Cloud platform developed by a consortium of 11 partners is the first of its kind to bring together different sources of environment data to provide new services for agriculture, urban planning, security, climate, health, etc.[18]

The evolution of the size, diversity and flow of the data collected will arouse interest in other large untapped sectors. For example, the demand emanating from the agricultural sector will grow with the development of Oil & Gas and location-based services. Innovating companies developing solutions will need to adapt to these rising demands in order to respond to the emerging challenges.

4.3. Evolving priorities cause an unsecure public investment in the EO midstream market

The upcoming challenge will be to ensure this continued investment and interest in the field of space Big Data. Indeed, government priorities depend on wider policy objectives. **Environment monitoring and climate change are currently top priorities in governmental agendas**, striving for the development of science-driven EO missions within R&D programmes. In countries where EO programmes are at a different stage of their development, priorities and purposes vary. As an example, in India and China, EO programmes strive towards self-sufficiency for data development.[19]

In order to pursue their investment, public authorities will require rapid and tangible results as well as prompt adaptations and developments due to the evolution of the number and velocity of the data provided. With the **defense sector** being the primary customer, the strongest demand will be expected for high-resolution, high-accuracy data sets. More specifically, the synthetic aperture radar data market has also known significant growth since 2007.[20]

The high public interest and investment in the EO midstream market may be seen as a threat for the development of the several sub-sectors. Growing public funds will stimulate and strengthen the global value chains, but the main risk is for certain nations to keep control over sovereign interests, for example defence space programmes. Indeed, public and private actors do not necessarily have converging objectives and interests, which may be a source of conflict. It is highly probably that national authorities will keep control over the dissemination of data concerning defense and security issues. In order to mitigate this risk, governments and international organisations should take the opportunity to develop and implement a global and unified strategy.

"Most of the companies comprising the EO midstream market are mainly living on EU and ESA programmes" ***CloudEO***

4.4. A lack of public support initiatives early along the value chain

The development of EO programmes funded, sponsored and supported by public institutions is the source of undeniable opportunities. However, **companies need to have reliable, continuous access to the data collected** in order to be able to develop efficient and sustainable innovations to process and make it available to its customers. Public authorities should set up specific projects and initiatives to provide all the midstream EO players with equal access to the flow of information available.

Public authorities should understand that private companies need support at an earlier stage of the process. Small and young companies cannot invest millions and take too much risk." ***CS***

5. Policy recommendations

5.1. Providing the necessary tools to manage the flow and diversity of EO data

Innovative companies in the EO midstream segment of the value chain need strong support to ensure reliability, quality and storage of data. Public authorities have a clear role to play in this respect.

Fostering harmonised regulations for the access to EO data

Today, regulations governing access to data differ from one EU Member State to the other. This situation creates obstacles to market development as it hampers access to data vital by related businesses: including data resellers, data processors, value-adding service providers and software developers.

Therefore, in 2014, the European Commission proposed a directive on the dissemination of EO satellite data for commercial purposes. Its main purpose is to establish a more reliable access to high-resolution satellite data while safeguarding security interests. This directive should be adopted and enforced as quickly as possible for the benefit of all players of the midstream sector.

Providing practical tools facilitating and ensuring access to reliable data

"The European Commission's proposition to set up platforms on which all EO midstream players can access to data and develop their activities is a crucial step", ***GIM***

In order to deal with the flow and diversity of data collected via EO satellites, the EU should implement online tools, accessible to all, to facilitate access to data.

One possibility would be to provide a single access point via an online data portal, accompanied by workshops and seminars to showcase how to access and use the available data.

The cloud solution could also be envisaged: the data would be stored on tens to hundreds of servers to manage data efficiently and to ensure that failure of several servers would not impact the entire system.

EU should also guarantee equal, reliable and continued access to EO data coming from the Copernicus programme to all players of the midstream EO segment.

5.2. Shaping a long-term vision of space Big Data policy

The EU bodies and national authorities need to clarify the role of the Copernicus services and the envisaged role of the public sector in the upcoming years in the midstream sector.

Ensuring a long-term vision of the Copernicus programme to secure sustainable applications

Data collected via the Copernicus programme, accessible freely and by all, will help to develop many new applications, services and products. In order for the applications based on Copernicus to be sustainable on the long term, the EU needs to ensure predictability and availability of its data in a long term.

Inserting space Big Data in a global data-driven strategy

In order to reach an optimal use of the data collected throughout the EO programmes, Big Data coming from space should be considered in a wider context of the data-driven economy. Linking and merging both trends would bring a clearer vision of the benefits linked to the collection, analysis and usage of data as such.

Moreover, the use of EO data should be promoted in multiple sectors of the economy, e.g. public health.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Blackbridge	Cesar Santos Gonzalez	VP Marketing
CloudEO	Manfred Krischke	CEO
CS	Lydia Huttin	Account Manager ESA and EC
GIM	Vincent Tigny	Business Development Manager EO

6.2. Websites

Company	Web address
Blackbridge	http://blackbridge.com/
CloudEO	http://www.cloudeo-ag.com/
CS	http://www.c-s.fr/
GIM	http://www.gim.be/

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