D5.1– EO market overview

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1	11	21.03.2018	Daniel Garcia-Almiñana	All sections	Minor changes – Ready for submission

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Acronyms and abbreviations

ACRONYM	DESCRIPTION
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CNES	French Space Agency
COTS	Commercial Off-The-Shelf
DARPA	Defense Advanced Research Projects Agency (U.S.)
DEM	Digital Elevation Model
DMC	Disaster Management Constellation
DoD	Department of Defense (U.S.)
DRS	Direct Receiving station
EO	Earth Observation
EU	European Union
GCPs	Ground Control Points
GDP	Gross Domestic Product
GEO	Geostationary Orbit
GEOINT	Geo-Intelligence
GEOSS	Global Earth Observation System of Systems
GPS	Global Positioning System
GPS-RO	GPS Radio Occultation
HEO	High Elliptical Orbit
H-RM	High to Medium Resolution
IMINT	Image Intelligence
LBS	Location Based Services
NGA	National Geospatial-Intelligence Office (U.S.)
NOAA	National Oceanic and Atmospheric Administration (U.S.)
NRO	National Reconnaissance Office (U.S.)
PPP	Public-Private Partnership
R&D	Research and Development
RCM	Radar Constellation Mission
SAR	Synthetic Aperture Radar
SDR	Software Defined Radio
SLA	Service-Level Agreement
SSO	Sun-Synchronous Orbit
TBC	To be confirmed
TBD	To be determined
VAS	Value-Added Services
VHR	Very High Resolution (< 1 meter)

Table of reference documents

REFERENCE #	REFERENCE
1	Euroconsult internal information
2	Satellite-based Earth Observation – Market prospects to 2026, Euroconsult, 2017
3	A Survey into the State and Heath of the European EO Services Industry", EARSC, 2015

1. Introduction

DISCOVERER is a new Future Emerging Technologies Project of the Horizon 2020 Program funded with €5.7 million over 4.25 years under grant agreement No 737183. It is a technology innovation project that aims to radically redesign Earth observation satellites for sustained operations at significantly lower altitudes than today.

Satellite-based Earth Observation (EO) is one of the success stories of the space industry having seen significant growth in size and applications in recent times. According to Euroconsult, the EO data market from commercial and government operators, such as from data distributors is expected to double to $3.5 billion in 2026 from an estimate of $1.8 billion in 2016.

Yet the key design parameters for the satellites that produce the data have remained largely unchanged, most noticeably the altitude of the orbit. Operating satellites at lower altitudes allows them to be smaller, less massive, and less expensive whilst achieving the same or even better resolution and data products than current platforms.

Even though the residual atmosphere at lower orbital altitude produces drag which decreases the orbital lifetime, and Aerodynamic perturbations challenge the ability of the platform to remain stable, affecting the quality of the image, DISCOVERER Project intends to overcome these challenges by carrying out foundational research in the aerodynamic characterisation of materials, in atmosphere-breathing electric propulsion for drag compensation, and in active aerodynamic control methods.

Additionally, DISCOVERER will also define and develop new and innovative Business Models related to proposed systems (System Models).

This will allow DISCOVERER to identify the Return On Investment (ROI) for the optimum satellite designs. DISCOVERER will also develop roadmaps depending on the state of the art of the technology and the actual EO market environment to commercialise these new technologies and make Very Low Earth Orbit (VLEO), Earth observation platforms and applications a reality.

It is important to note that meteorological satellites have not been considered in this document.

2. Purpose

The aim of this document is to provide an overview of the EO market to support decision making in other tasks of WP5 and WP2, especially for four tasks:

- 5.3: VLEO ecosystem
- 5.5: VLEO Business models
- 5.6: Roadmaps for business models.
- WP2 tasks that might require these outputs from this document

This **document focuses on the downstream of the EO value chain** to allow the detection of opportunities in WP5 for the different system concepts to be proposed by DISCOVERER. We consider downstream as raw data produced by the satellite systems such as level 0 panchromatic images and value-added services generated from raw data such as water pollution monitoring services. Upstream encompasses the manufacturing of EO satellites, their launching and their operation.

3. Overview of the EO market

Over the period 2007–2016, 181 Earth observation (EO) satellites (discounting meteorology) with a launch mass of greater than to 50 kg were launched by civilian government and commercial entities from 35 countries (plus the European Space Agency [ESA]). The cost to develop these satellites generated $17.4 billion in revenues for the world satellite industry. In addition to those 181 satellites, 235 EO satellites of less than 50 kg were launched in the same period with smaller manufacturing revenues (around $700 million).

Governments are the primary investor in EO, responsible for 87% of the satellites launched (including all civil government and dual-use satellites). The purpose of these satellites depends on the individual governments' policy priorities and objectives. For established leading space programs, such as NASA, ESA, JAXA and CNES, EO plays a key role in providing data to support environment monitoring, climate change, and the development of new sensor technologies.

EO satellite programs are also developing in many countries that will launch their first satellites in the coming years, such as Morocco (two satellites, one launched in November 2017 and one to be launched in 2018). Based on Euroconsult estimates, 601 EO satellites with a launch mass of more than 50 kg are expected to be launched in the next decade, generating $33.6 billion in manufacturing revenues for the world satellite industry to develop them. These satellites will be launched by EO programs and companies in 48 countries plus ESA. Therefore, a growth in terms of total number of satellites to be launched is expected in addition to growth in both the manufacturing revenues and the the number of countries (from 35 to 48) with EO satellites in orbit.

In 2016, 57 countries + ESA (including those not launching satellites but providing funding in the downstream) invested $9.1 billion in civilian EO programs. This is an extremely important investment increase (42% over 2015) and is the 10th year of continuous growth in global investments. Investment is highly concentrated as four countries (U.S., China, Russia, and Japan) plus Europe (ESA and the EU) contribute 83% of this amount. China is one of the main drivers of this growth as the country aims to launch 49 satellites between 2017 and 2026, many more than any other country. The Chinese space budget supports the extensive development of a national EO program within themes targeting specific application areas.

Over the course of the last few years, numerous EO companies have emerged with the objective to deliver low-cost satellites based on small satellites (smallsat) technology. Commercial constellations propose to deliver change detection services from high-frequency revisits allowed by numerous smallsats. Applications are derived from two types of systems: imaging sensors and GPS-RO (radio occultation). Both use multiple satellites to collect high-frequency data points in order to monitor change detection. **The key driver for the development of EO smallsats is the ability to build a system that provides reduced latency, moving towards as near real-time data collection as possible**.

Enablers of the increase in the use of smallsats in commercial applications are advances in satellite miniaturization and IT. Current solutions provide Very High Resolution (VHR), high geometric accuracy data from agile cameras at a relatively high cost (upwards of $200 million/unit). Smallsat solutions are invariably less stable, simpler platforms that compromise accuracy (most solutions do not carry advanced star trackers, control moment gyros, etc.). However, the lower-cost approach with reduced capital expenditures (capex) means operators can price data competitively, potentially disrupting the market. These new operators have attracted over $600 million in venture capital to fund their initiatives with prototype satellites. However, it is important to note that none of the newly announced constellation initiatives have reached full capacity; for these constellations to come to fruition, additional investments are expected to be required.

In the period 2007-2016, the commercial EO data market (including the cost of operation of the satellites) totalled $13.5 billion. In particular, the market size in 2016 was $1.8 billion; representing a 7% growth over 2015 and a five-year Compound Annual Growth Rate (CAGR) of 5%. Defense & Security is the primary market with $1.1 billion of data sales in 2016, dominated by the US government. Still, sales to non-US defense departments are growing at a rate of 10% (5-year CAGR). With a limited number of countries operating proprietary VHR systems suitable for defense, the commercial sector is proving to be a reliable source of data to support imagery intelligence (IMINT). VHR optical imagery totals 83% of all commercial data sales in 2016, with defense as the main user.

North America represented 43% ($780 million) of the data market in 2016 because of the U.S. defense

procurement through the National Geospatial Agency (NGA). Is foreseen that growth in data sales will slow (<5%) in mature markets such as North America and Europe. This is likely to be higher in other regions where the use of EO data is developing. Defense should remain the main driver for commercial revenue growth across all regions, but increased demand for satellite imagery is driven by numerous applications to support wider economic development, such as infrastructure/engineering and natural resources monitoring.

From 2017-2026, combined meteorology and other EO satellites are foreseen to generate $24.9 billion in revenues for the manufacturing community. By 2026, the market for commercial EO data is expected to reach $3 billion (5%, 5-year CAGR). Asian markets will represent around 25% of the global commercial market by year 2026 with defense, maritime, infrastructure, and resources monitoring driving demand. In the short term, growth is expected to continue to be driven by defense. Commercial applications such as in the maritime, infrastructure, and resources monitoring sectors are due to support growth in the longer term. Location-Based Services (LBS) applications for finance and insurance have been slow to develop, but the longer-term outlook for these services remains positive with the addition of new satellite capacity targeting high-frequency change detection.

Regarding the valueadded services (VAS), the cumulated market was valued at $22.6 billion from 2007 to 2016 and is expected to be $47 billion from 2017 to 2026. In 2016, VAS derived from the commercial data market accounted $3.5billion. Key markets for value added services do not mirror those for commercial data sales. Defense, whilst representing 61% of the commercial data market, only represents 15% of the VAS market. Conversely, for infrastructure and engineering is only 10% of the commercial data market, but 33% of the value-added market. This is because VAS are more internalized in the government sector than in the commercial sector. By 2026, the VAS market is expected to be $5.5 billion per year. Key markets are expected to remain similar to the present, with infrastructure, environment monitoring, and defense making up the bulk of the services market.

Table 1: Summary of Key figures on the EO market

	2007-2016	**2017-2026**
Type of prominent operator	Governments	Commercial operators
# Countries with EO sats.	35 + ESA	48 + ESA
Total launched EO sats. (>50 Kg)	181	601
Manufacturing Revenues	$17.4 billion	$33.6 billion
Cumulated Commercial data revenues	13.5	25
Cumulated VAS revenues	22.6	47

Source: Euroconsult, 2017

4. Analysis of the EO value chain

4.1 Overview on the EO upstream

The aim of this section is to provide a quick overview on the upstream of the EO value chain. The focus of task 5.1 is assess the downstream market, giving visibility on key market facts and figures that will serve as an input to other tasks.

We have divided the EO upstream into four different layers: investors, the satellite manufacturing market, the launch market and the ground segment and ground operations market.

4.1.1 Investors

The starting point for the EO value-chain is government investment to fund satellite program development for its own use. Despite the increase in private investment over the last few years, government funding still supports much of the industry. Government and private companies fund the development and the launch of the satellites, either large individual satellites or constellations of small satellites.

In 2016, **Governments invested** $9.1 billion in civil EO programs (including meteorology). Over 57 countries contributed to this investment, which represents a 4% increase over 2015. The top four countries for EO and meteorology investment (U.S., China, Russia, and Japan) plus Europe (ESA plus the EU supporting Copernicus) contribute a total of 89% of this amount.

Governments are the primary investors in EO satellite systems, responsible for 87% of the satellites launched (including civilian and dual-use satellites). The purpose of government satellites depends on the individual governments' policy priorities and objectives. For established leading space programs, such as those of NASA, ESA, JAXA and CNES, EO plays a key role in providing data to support environmental monitoring and climate change through the development of new sensor technologies. In countries with emerging satellite programs, EO is a priority to support socio-economic development. Recently established EO satellite programs in developing countries have two primary objectives:

- develop national engineering capabilities in satellite manufacturing through technology transfer agreements (TTA) with the satellite supplier
- use national satellite data to support national policy objectives across resources monitoring, infrastructure projects, etc.

Private capital is being raised by new commercial companies to fund constellations of smallsats. From 2016 to 2017, five new operators had attracted over $600 million in private equity to fund prototype satellites. Private investment has since slowed down with the fear of overcapacity due to the number of large proposed constellation projects.

4.1.2 Satellite manufacturing market

The satellite manufacturing industry produced 181 satellites that were launched for EO over 2007–2016 for a market value of $17.4 billion (an average of $96 million per satellite). In the next ten years, over 600 EO satellites are due be launched for estimated manufacturing revenues of $33.6 billion (an average of $56 million per satellite, reflecting additional smaller satellites).

4.1.3 Launch market

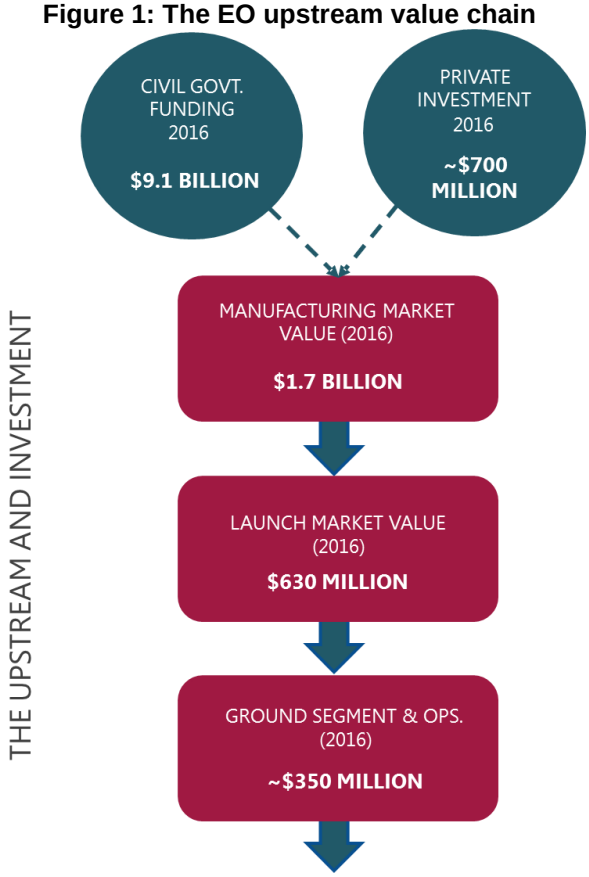
The **launch** market for these 181 satellites launched over 2007-2016 is estimated at $6.3 billion. 180 out of 181 were launched into low Earth orbits, and more specifically, 81% of those satellites were launched into Sun-Synchronous Orbit (SSO) where lighting conditions are optimal for EO. The EO launch market is expected to increase to $9 billion over 2017-2026. However, the percentage of satellites launched into SSO is expected to decrease to 61%. All LEO orbits represented 85% from

2007-2016 and are expected to represent by 2017-2026 only 75% of future launches; the rest shall be launched into GEO and HEO orbits.

4.1.4 Ground segment and satellite operations

In average, the construction or the adaptation of a given ground segment to operate the EO satellites, such as its operation cost, represented in 2016 around $350 million. Estimates for the period 2007-2016 represent around $3.7 billion and is expected to account up to $7 billion in the period 2017-2026.

Figure 1: The EO upstream value chain



Source: Euroconsult, 2017

4.2 Overview on the EO downstream

The aim of this section is to provide an overview on the downstream of the EO value chain. We have divided the EO downstream into two different layers: commercial data market (understood as the selling of raw data or processed images) and the value-added services (VAS) market.

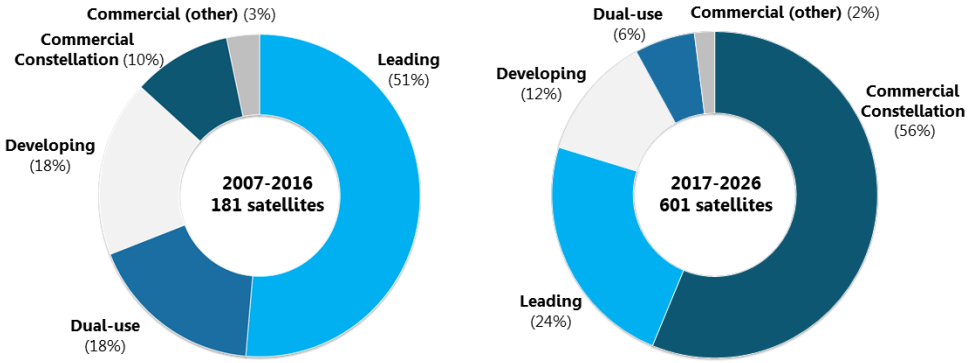
The EO downstream sector is highly fragmented along multiple vertical markets and geographical lines: typically, VAS companies focus on one or two vertical markets and provide geospatial solutions locally/regionally. There is a limited number of global players with a true global outreach such as Airbus, MDA/DG, and Telespazio/e-GEOS.

The EO market is going through a significant data capacity expansion resulting from:

- more capable satellites from the private sector in terms of resolution, revisit, accuracy, etc.
- more government satellites as a growing number of countries invest in EO systems
- leading space agencies continue to develop scientific missions to support policy objectives related to climate change and environment monitoring.

In Figure 2, the shift in terms of number of satellites launched from 2007, to the number of satellites to be launched in the future from governmental satellites ("leading" and "dual-use" in the figure) to commercial constellations (in this case from a 10% to a 56% of the total satellites launched in both periods) can be observed.

Figure 2: Satellites launches by client typology



Source: Euroconsult (2017)

In short, all three segments above are due to growth, either in terms of observation capacity (e.g. km^2 per day, pass per day) or in number of satellites. With the market for commercial data continuing to grow and develop into new service areas, an increasing number of operators are entering the fray with their own solutions (i.e. from 10% in the past 10 years to 56% in the coming years for commercial constellations), including constellations such as Blacksky and UrtheCast. In addition, at least two constellations using satellites of less than 50 kg (e.g. Planet and Spire) will increase data production capacity.

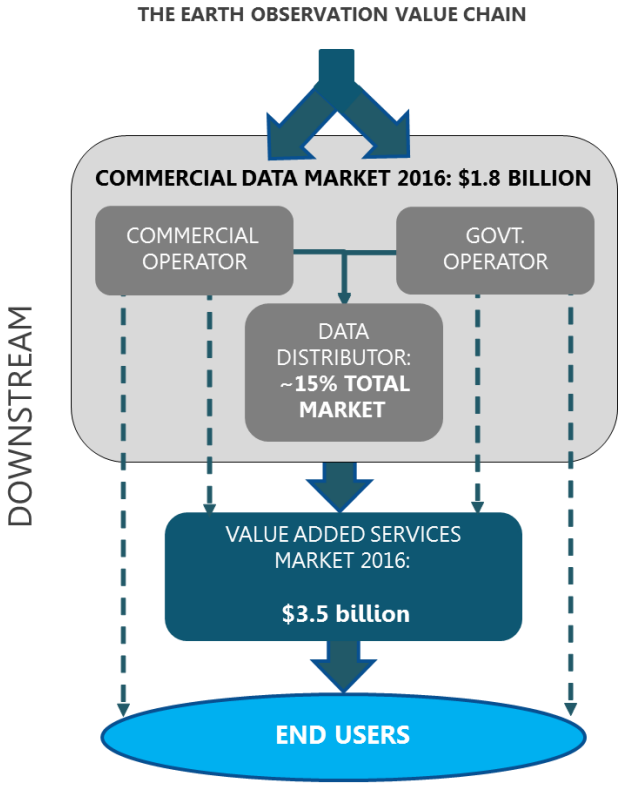
The EO market considers both the sales of satellite data and VAS using satellite data generally combined with other data:

- "Commercial" data is produced by privately-financed satellites and by government satellites when the governments want to recover some of the costs associated to the development of the satellites, or want to support the national industry. To illustrate, Airbus has commercial rights on the data produced by Pleaides funded by the French Space Agency, CNES.
- Value added Services reflects the value-added to the data produced by different sources (e.g. satellite, aerial, in-situ, GIS) in order to support geospatial decision-making in numerous vertical markets with specific requirements (e.g. defense & security, agriculture, oil & gas exploration, etc.).

Commercial data may be used for VAS if the free and/or scientific data sets do not match with the specific requirements of the application domain.

For instance, the defense agencies generally add value to the commercial data in-house without procuring from commercial service providers. Otherwise, data resellers and expert companies do value-adding services generally with a customer specialization (including agriculture, homeland security, oil & gas). In this context, value added services consider only the additional value brought, i.e. there is no accounting for the commercial data value inside the services.

Figure 3: The EO downstream value chain



Source: Euroconsult (2017)

The European Association of Remote Sensing Companies (EARSC) identifies 510+ VAS companies in Europe and ~700 companies acting as data resellers. Considering the overall size of the market, this means that most companies have revenues <$2million, and <10 employees.

Value-added service providers distribute into three categories:

- A majority of small enterprises specialists of a vertical market (remote sensing of agriculture, oil & gas exploration, etc.) and operating locally. Few specialized value-added service providers have international outreach. Data distributing companies are increasing the value-added to their "basic" products. This results in service providers focusing on products geared towards specific customer groups, such as maritime and agriculture, instead of more generic image processing for a wide area of clients and applications.
- Few larger players (20-30 companies) with multiple vertical markets. Companies are active in other business lines, such as aerial data, GIS software etc.
- A minority (10-20 companies) of larger service providers with truly international outreach and resources to develop and promote their services. These companies have access to proprietary data sets as they have their own satellites (Airbus, MDA/DG, Telespazio/e-GEOS).

The landscape showed in Figure 3 has started to change over the last few years because 1) VAS companies increasingly provide outreach to the commercial satellite operators, and 2) growing integration in the sector.

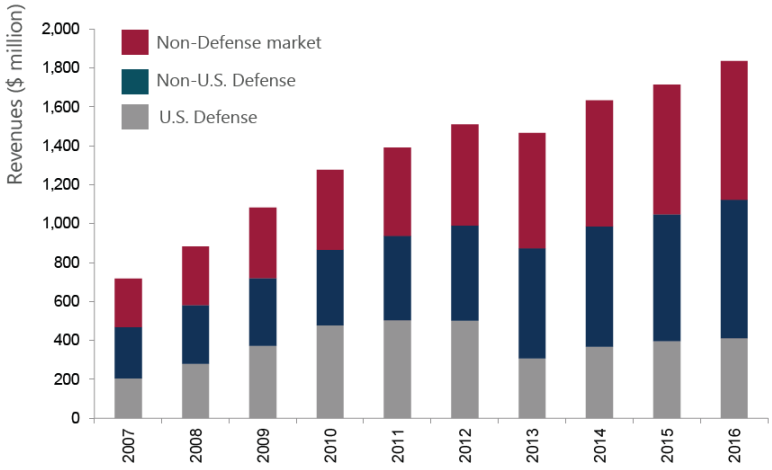
- Satellite operators anddata and service providers have increasingly become integrated as commercial data providers seek to maximize their revenue potential by partnering with VAS providers to deliver services locally. Commercial data providers have several options to enlarge data distribution, such as value-added resellers, direct receiving stations, and through web portals. Partnering with a local service company offers the operator a presence that is considered essential for accessing local contracts, particularly those of the government. In addition, resellers distribute data as part of their overall activity, often providing value-added services alongside imagery; they thus provide the operator with a link to specific end users with targeted application areas.

- More satellite operators enter the EO market with a business focus on delivering end-products rather than data alone: the so-called shift from “pixels to products”. New constellations such as Planet intend to deliver value-added products from the outset targeting specific verticals in need of change-detection analytics (applicable to site monitoring, agriculture, developing location-based-services etc.). To succeed, these companies need to work extensively with multiple end-user communities with different ecosystems. Established data providers are increasingly going downstream through acquisition, for example the recent quisition of Spatial Energy (energy sector) and Radiant by of Digital Globe.

4.2.1 Commercial EO data Market

The commercial data market totalled $1.8 billion in 2016; this represents 7% growth over 2015 and a five-year CAGR of 5% (during which the 2013 reduction in U.S. defense spending still had an impact). Growth over the period has been driven largely by defense requirements, first in the U.S. and then in other regions. As showed in Figure 4, the total defense market reached $1.1 billion in 2016, and sales to non-U.S. defense departments are growing at a rate of 10% (five-year CAGR). With a limited number of countries (France, Israel, USA, Russia and Japan) currently operating VHR systems suitable for defense the commercial sector is proving to be a reliable source of data to support IMINT requirements. Sales to non-defense markets (governments non-defense) and the private sector - enterprise markets) have been slower to develop (5%, five-year CAGR) as can be observed in Figure 4. However, over 2007-2016, there was a steady take-up in EO data procurement to support applications in infrastructure and natural resource monitoring projects, with 11% and 10% five-year CAGR respectively, particularly in fast developing regions such as Latin America and Asia, to support wider economic development.

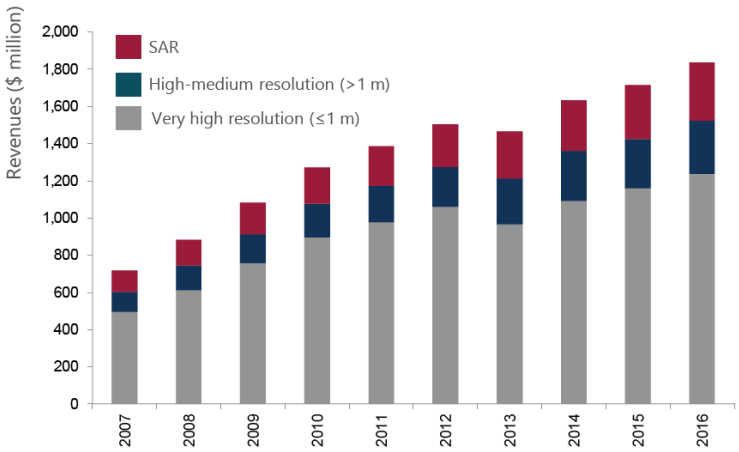
Figure 4: EO data sales by customer



Source: Euroconsult (2017)

In terms of data typology, because defense remains the main destination for EO data, it is no surprise that the largest data-type procured is VHR optical imagery. As can be seen in Figure 5 VHR optical imagery totalled 83% of all commercial data sales in 2016. Defense also remains the first destination for SAR data and the closely associated maritime domain (for maritime domain awareness applications). Lower resolution optical data sets are also a large volume market, although less in value as prices are lower than for VHR data.

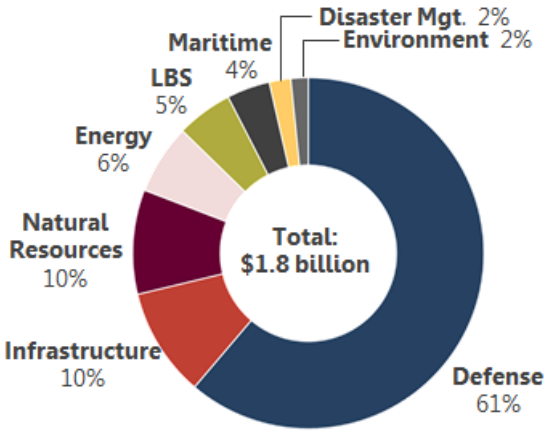
Figure 5: EO data sales by data type



Source: Euroconsult (2017)

In Figure 6, it can be seen again that in year 2016, defense-spending represented more than the 60% of the commercial data market ($1.8 billion), with infrastructure and natural resources verticals accounting a similar share to eachother. These three vertical markets represented 80% of the commercial data market in 2016.

Figure 6: EO commercial data market in 2016

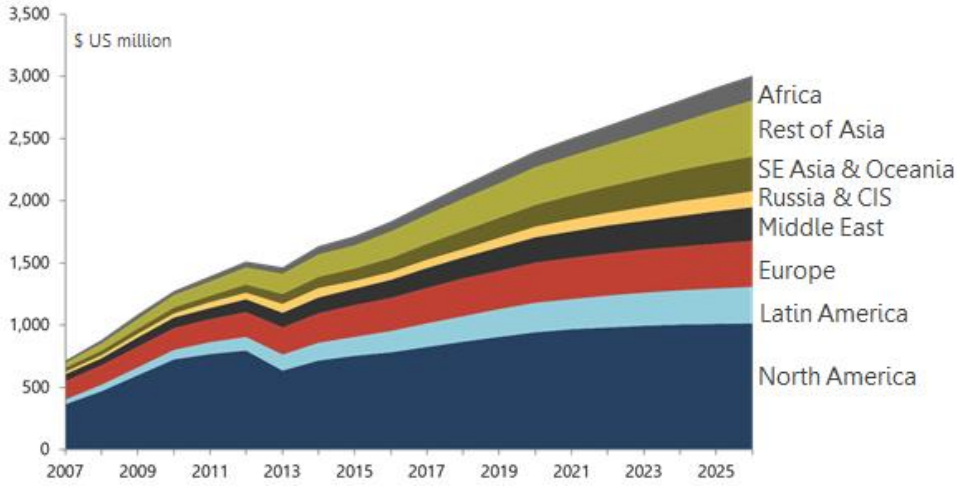


Source: Euroconsult (2017)

In 2026, the market for commercial EO data is expected to reach $3 billion (5% CAGR). Growth will be slower in the short term as:

- The ongoing economic unrest in key Latin American countries and Russia results in reduced data procurement for services development.
- Low oil and gas prices result in low procurement for the energy sector to support exploration activities.
- Strong data price decrease expected by 2020 when commercial EO satellite constellations will be at full commercial capability.
- More demand for integrated value-added products, with less focus on only data sales: especially true for emerging new services in LBS.

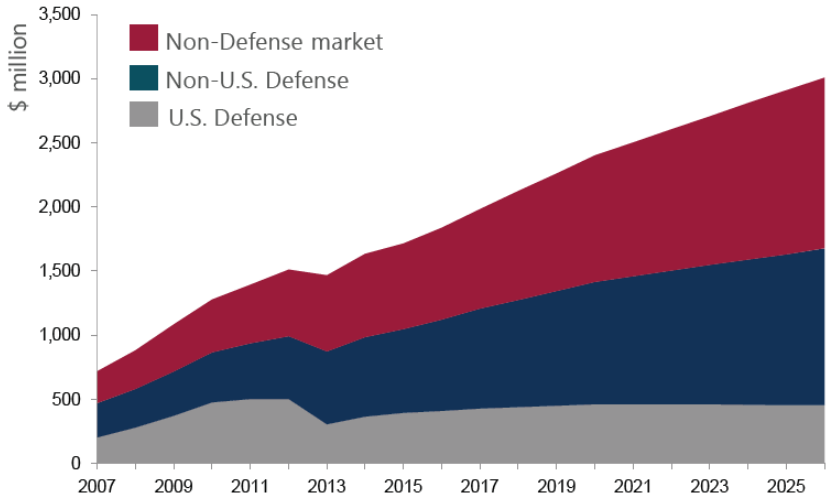
Figure 7: EO commercial data market estimates per region



Source: Euroconsult (2017)

Nevertheless, the industry continues to develop positively. In the short term, growth is expected to continue to be driven by defense, with ongoing regional unrest and growing IMINT needs of countries without proprietary military systems. By 2026, defense is expected to represent 46% the total market value ($1.7 billion). Therefore, although defense will continue to be the major client for EO imagery, their share will reduce in the coming years.

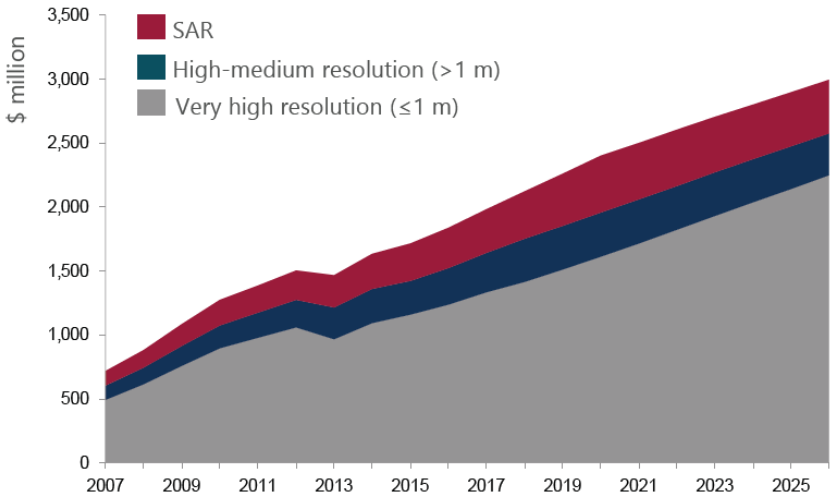
Figure 8: Historical & expected EO data sales by customer



Source: Euroconsult (2017)

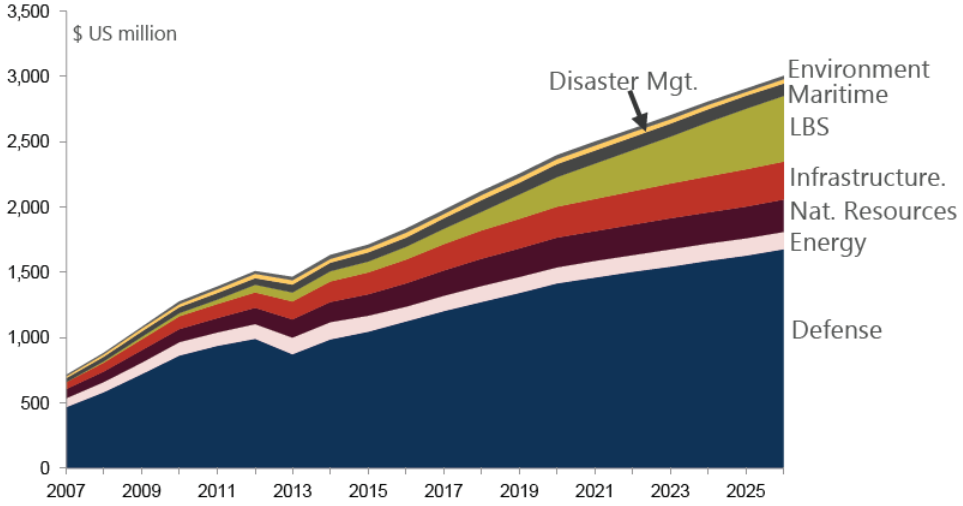
Other applications, such as maritime, infrastructure, and resources monitoring will support growth in the longer term. Together with defense, these applications should have a 5% CAGR through 2026. Emerging applications in these sectors such as critical infrastructure monitoring and precision agriculture benefit from more capable satellite systems (i.e. a combination of higher ground resolution with higher temporal resolution). LBS applications, including financial and insurance services, have been slow to develop, but the longer-term outlook for these services remains positive with the availability of new satellite capacity. For LBS applications, greater emphasis is expected to be put on integrated product offerings, requiring development of change detection analytics. In terms of revenue generation by data type, VHR optical is expected to remain the most significant in terms of data sales. More moderate-resolution data sets will be challenged by the availability of free solutions and low-cost systems offering comparable data.

Figure 9: Historical & expected EO data sales by data type



Source: Euroconsult (2017)

Figure 10: EO data market and forecast to 2026 by verticals



Source: Euroconsult (2017)

Table 2: Summary of Key figures on the EO commercial data market

	2007-2016	2017-2026
Cumulated all commercial data revenues	$13.5 billion	$25 billion
Main vertical market	Defense	Defense
Main data type	VHR	VHR
Main customer	U.S. DoD	U.S. DoD
Main customers region	North America	North America

Source: Euroconsult, 2017

4.2.2 EO value-added services market

Value-added services (VAS) considers the increase in value generated by taking data (commercial, free, scientific) and developing a product, service or research through analysis and image processing. The point of what is considered "value added" can vary by company. For example, moving data from raw imagery to a geo-rectified product is adding value; however; for the purpose of this study, value-added is considered the point that imagery moves to something application/vertical market specific (level 1 products to something more applied).

Growth in the VAS sector has been challenging, with fragmentation and standardization being key factors. The fragmentation is split by geography or areas of expertise (based on specific vertical markets), with few truly global actors. Estimates as to the number of VAS providers are difficult, but considering that around 700 companies act as data distributors and the EARSC report identified 510+ companies in Europe alone, there are likely up to 1,000 companies globally, the majority with revenues less than $2 million/year attributed to VAS (other revenues are possible through additional business lines, such as GIS software licensing and development, support to satellite operations, data sales, etc.)

This profile is starting to evolve. The emergence of the wider availability of data sources, including free data, and more integrated, standardized offerings are expected to stimulate services growth. This appears to be the case: growth in VAS globally is at 7% (last five-year CAGR) and is now growing at a faster pace than the commercial data market.

Several company typologies are offering VAS, as the following summarizes:

- Dedicated VAS providers, building solutions on top of third-party data. Companies typically are small, with revenues less than $5 million, and focus on specific regions and/or vertical markets.
- VARs (as described in the distribution section) applying their value-added skills on top of third-party data but with a preferred access to commercial data through partnerships with the operators.
- Larger organizations with smaller elements of VAS in addition to larger business lines. These companies often are business partners of the operators; for instance, they might sell GIS licenses as a core business (such as ESRI).
- Operator-integrated approaches: Particularly, new operators have an integrated approach to services delivery (such as Planet, Spire). Existing operators are also developing targeted value-added services.

In Table 3 there are some examples of current and future capabilities of EO operators. It is important to note how these operators are shifting their business models from pure EO data selling to VAS provision to fill the demand in their targeted vertical markets.

Table 3: Development of VAS-Integration examples (non-exhaustive list)

CURRENT OPERATORS & CURRENT CAPABILITY	
DIGITALGLOBE & MDA	Analytic services, analysis reports, data management and analysis for oil & gas operators through Spatial Energy acquisition. Provision of ice services, maritime domain awareness applications
AIRBUS DEFENCE AND SPACE	Data management solutions (DMS), GO Monitor services (in-depth analysis), dedicated group for the energy sector
DMCii	Programmed imagery (process, acquisition updates and delivery of data) with target applications in agriculture, forestry, environmental mapping
FUTURE SOLUTIONS	

PLANET	Subscription-based monitoring programs, Planet Platform (online processing, APIs) for agriculture, mapping, energy and infrastructure
BLACKSKY	Machine-to-machine tasking (API), web-scale software platform for business intelligence, defense applications
SPIRE	Spire Sense (pattern recognition, frequent global ship tracking, unregulated fishing detection), Spire stratos (GPS-RO-based weather data)
HERA	GeoSnap application (mobile platforms and derived information products) targeting intelligent analytics, finance, defense
URTHECAST	Cloud-based APIs, subscription-based service, engineering services targeting LBS, agriculture, infrastructure

The above market drivers/risks for commercial data reflect those of value-added services: as data is acquired to develop services, this is obviously paralleled. However, data typologies to build VAS differs depending on end-user requirements. As a rule, the service provider will utilize the lowest cost data which can adequately build the service – data being a cost item. The data-service part of the value-chain is however becoming increasingly integrated; either by operators venturing into selective VAS product lines (such as Digital Globe acquiring Spatial Energy), or new operators (such as Planet) having a focus on an integrated VAS offering from the onset.

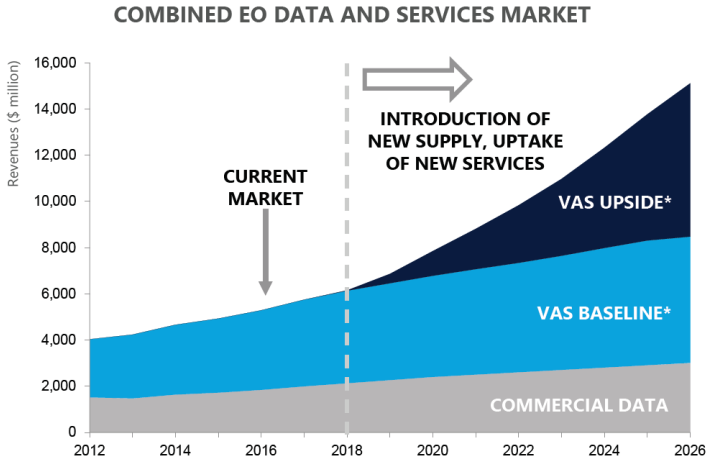
The Euroconsult model for VAS was created by applying the revenues for value-added services in Europe to create a data-to-services ratio (from Euroconsult commercial data sales figures), which was then applied by vertical market globally. If this same model is continued, it would imply a VAS market of $5.5 billion by 2026, growing at 8% 5-year CAGR. Key markets under this approach would remain similar as today, with infrastructure, environment monitoring, and defense making up the bulk of the services market. Data sources include both Euroconsult proprietary databases and data extrapolated from EARSC's report, "*A Survey into the State and Heath of the European EO Services Industry*", 2015. The model, based on the current supply situation, is represented as the VAS baseline in **Figure 11**.

This scenario is being challenged by a new supply orientation that focuses on high-frequency revisits. Being able to match high-resolution data sets with high frequency has been a technological challenge. However, with advances in IT, satellite miniaturization, and the ground segment, this is expected to be achieved at a much lower cost than currently feasible. This has the potential to open up the services market, putting greater emphasis on the regular, standardized delivery of information products and services rather than commercial data. Some sectors are expected to remain more data orientated, particularly defense, in which most analytics are expected to remain in house.

There have been numerous reports as to the potential value of an EO service, most based on a value-of-information approach as to the impact it can have on the wider geospatial or even information-technology business. Nominally, these numbers are quite large and do not consider some of the subtleties of the space business, such as vertical markets adapting to new technologies and guarantees over services delivered.

An alternative VAS market is also presented: the VAS upside scenario. It considers the implications of new supply solutions being able to open further markets. Growth scenarios are based on the points of entry of new supply solutions and their readiness to be able to enter in these new markets. To do so, we have considered two different growth ramp-ups: the initial take-up of VHR data market, following the first year of operation of IKONOS from 2000; and the take-up of imaging markets in the UAV sector, taking as reference the Euroconsult's research report, "*Prospects for Remotely Piloted Aircraft Systems*".

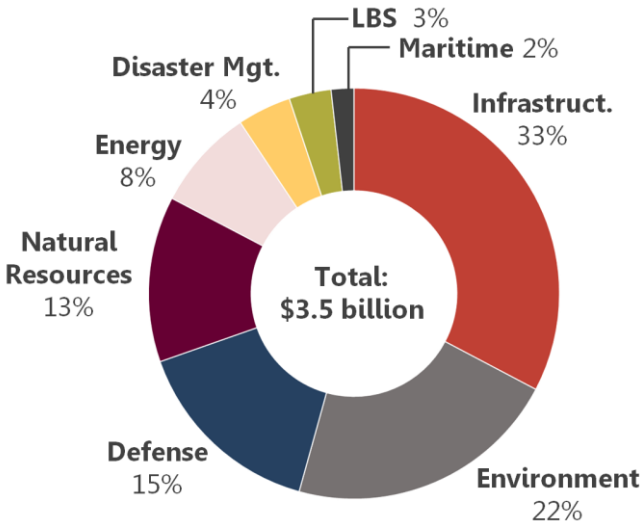
Figure 11: Growth scenarios for VAS take-up



**VAS revenues corresponding to revenues for VAS and the net of the cost of acquisition of data to support them.*

In 2016, the market for VAS was $3.5 billion. This discounts the purchase of commercial data in order to develop geospatial solutions. Key markets for value added services do not mirror those for commercial data sales. Defense, while representing 61% of the commercial data market, only represents 15% of the VAS market; conversely, infrastructure and engineering (which incorporated cartography, cadastre, etc.) is only 10% of the commercial data market but 33% of the value-added market. In this case, the downstream EO activity does not represent a fully-developed value chain.

Figure 12: Value-added services market in 2016



Source: Euroconsult (2017)

The reasoning for this is relatively straightforward: Defense end-users purchase data with many value-added analytics performed in house. On the other hand, lower-cost, coarser resolution, and lower geolocation accuracy data can be leveraged with value-adding to form greater value products and services. Environment-monitoring users, for instance, procure limited commercial data but are developing solutions using scientific and coarse resolution data e.g. pollution/aerosols monitoring, climate modelling. Many infrastructure applications for mapping also can be develop by using Landsat and Sentinel data that are free of charge.

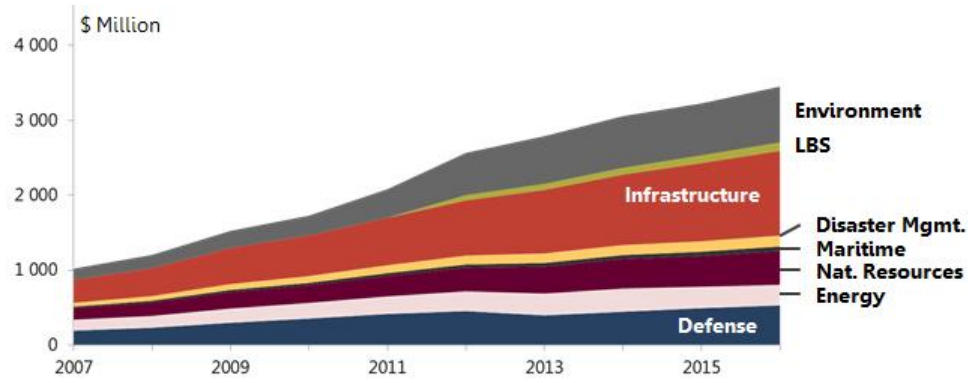
As an illustration, in a recent study by EARSC *("A Survey into the State and Health of the European EO Services Industry,"* 2015), local and regional planning, which can use coarser/free data, totaled

21% of all services use in Europe, whereas support to construction monitoring, which would require higher-resolution commercial data sets, was only 0.5% of the services market. Although still remaining a relatively small segment, LBS markets also continue to grow, with services focused on support to insurance and finance, marketing and real estate.

The data also adds to the belief that by making coarser-resolution data free, the value-added services industry can leverage this to build greater value services with the potential for two very different businesses: a “high-end” data market to support defense; and free/low-cost data sources to support commercial and civil government applications.

In this way, it can be observed in Figure 13 that the fastest growing market verticals are LBS, infrastructure and maritime with a 5-year CAGR of 12%, 11%, and 10% respectively.

Figure 13: Value-added services market: 2007-2016

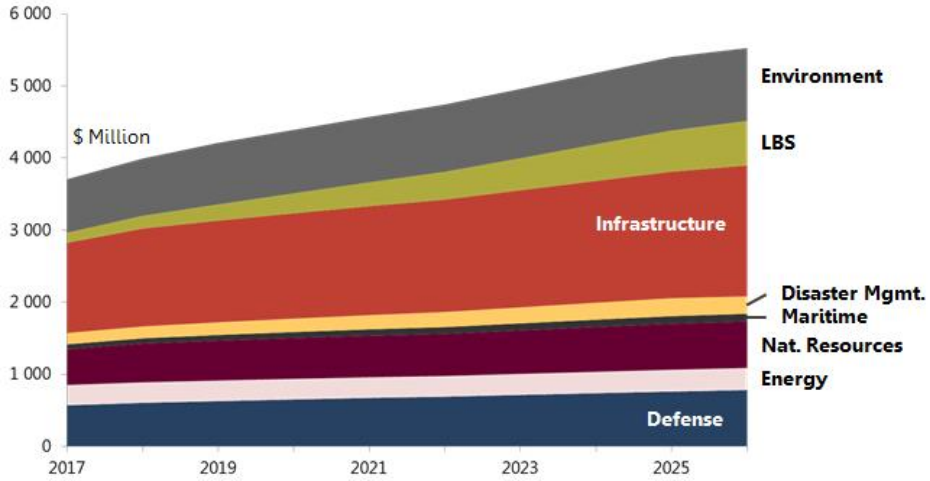


Key markets in the future would remain similar as of today. We expect infrastructure and environment monitoring making up the bulk of services by 2026 and natural resources and defense keeping a stable market share.

This scenario could be challenged if constellations with high frequency revisit increase. Being able to combine high-resolution data sets with high frequency is a technological challenge. However, with advances in IT, satellite miniaturization, COTS, and ground segment station and baseband equipment, this is expected to be achieved at a much lower cost than currently feasible. This combination has the potential to open up the services market, putting greater emphasis on the regular, standardized delivery of information products and services rather than commercial data. Some sectors are expected to remain more data oriented, particularly defense, in which most analytics are expected to remain in-house of government agencies.

Once constellations have been launched, services based on change detection could be quick to take off. It is expected that new operators already are working with end users’ communities and data analytics suppliers in order to develop products (i.e. Planets with infrastructure communities). The most promising services are for market intelligence, and financial and marketing strategy (based LBS and delivered via handheld/web portal). These new services areas can have a much faster take-up than current services have had given the cost benefits they could bring to quickly adapting vertical markets.

Figure 14: Value-added services market (forecast baseline), 2017-2026

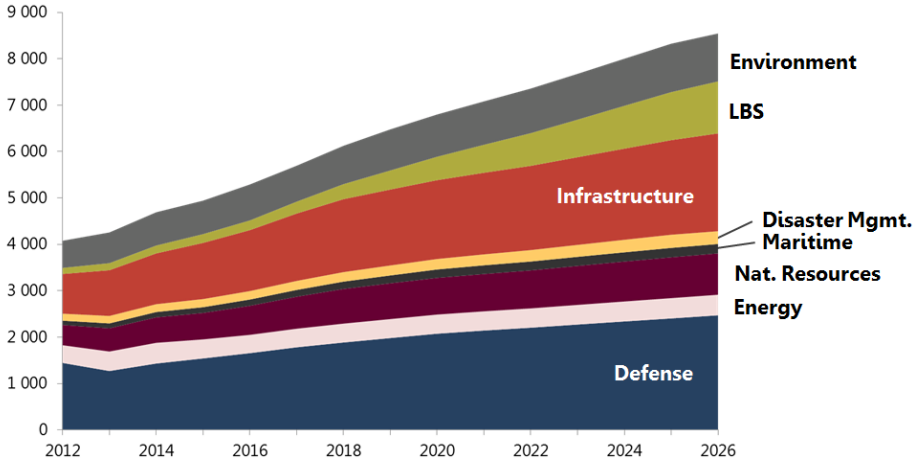


Source: Euroconsult

4.2.3 Combined EO data markets (commercial + VAS)

In combining the EO commercial data and VAS markets, revenues of $8.5 billion are expected by 2026. The upside would be conditional to the development of new services with new kinds of data such as very-high revisit. In combining greater resolution with more frequent revisit, the vertical market become more balanced, with defense and infrastructure (such as cartography, cadastre) dominating the market. Also, environment monitoring and natural resources would have the same importance. Again, the potential of the LBS market is recalled based on the emergence of low-cost constellations. The creation of frequently updated "information products" has the potential to open up the industry to new sets of end-users.

Figure 15: The combined EO data and services market (baseline) by sector 2012-2026



Source: Euroconsult

5. Key markets and stakeholders in the downstream

In this section the following will be described:

- the utility of different EO data types and their typologies
- key markets
- key stakeholders and business overview

As described in Section 1, the focus of Task 5.1 in in the downstream, and consequently the key stakeholders identified are in the downstream.

5.1 Introduction to types of data used in the key markets

Each application domain of EO has different data requirements, specifying the ground, spectral, and temporal resolutions that best match with its needs:

- **Optical data** offers the advantage of imaging in spectral bands, specifically, the ability to produce true-colour imaging and viewing via specific areas of the electromagnetic spectrum, such as near-infrared, for vegetation mapping. Optical imaging relies on natural radiation; therefore, sunlight is required. Atmospheric conditions can prohibit data collection, for example not being able to collect data through cloud cover.
- **Radar data** offers the ability to penetrate clouds and the benefit of day or night imaging through most atmospheric conditions. Radar sensors also respond to surface texture; therefore, where there is sufficient contrast, small objects can be detected by using lower-resolution data sets.

In **Table 4**, the different typologies of data within optical and radar data from EO satellites are presented.

Table 4: Overview on the types of EO data

DIFFERING TYPOLOGIES OF DATA	
OPTICAL DATA	**Panchromatic**: Grayscale imagery sensitive to all wavelengths of visible light. Generally, systems offer greater higher-resolution data than multispectral solutions (as it is less demanding in terms of data produced). Data can be used directly as grayscale to support applications with fewer spectral requirements or combined with multispectral data to form "pan-sharpened" imagery using edge detection to increase the resolution of the colour imagery.
	Multispectral: Data collection in more than one spectral band. At minimum, this implies three bands representing visible light (red, green, blue). Further bands are added depending on the satellite's purpose; for instance, band selection into the infrared (particularly in the near infrared along the red edge) is used for vegetation differentiation. The number of bands can range significantly, from three to over 30, again depending on the satellite's purpose.
	Hyperspectral: Hyperspectral sensors acquire imagery in many narrow, contiguous spectral bands, collecting data in 200+ channels. The computational power required to collect such data has limited ground resolution collection capability (Hyperion on EO-1, for instance, is 30 m). This also limits the system revisit. New solutions, however, are expected to bring hyperspectral data collection down to approximately 10 m ground resolution, with greater applicability across applications. Data allows for greater delineation of surface objects, based on their respective spectral signatures.
RADAR DATA	**Synthetic Aperture Radar (SAR):** Uses the motion of its antenna over a target region to overcome the limitations of real aperture radars in which ground resolutions degrade with the slant range. SAR systems provide commercial imagery (e.g., RADARSAT, TerraSAR-X/TanDEM-X) and derived products, such as digital elevation models.
	Radar Altimetry (RA): Measures altitude by timing how long it takes a radio beam to reflect from the ground and return to the satellite. Such data is used particularly to measure ocean/wave height and to collect data on ocean currents, such as from the Jason series. The focus is primarily on inputs for environment-monitoring.
	Passive Radar: Radar such as SAR and RA are active systems. They transmit a signal that is then received. A passive system measures signals occurring in the environment in a given wavelength. Data is used to support

	environment-monitoring applications.

There are different levels of treatment on the EO images as they are received from satellites. These different levels are depending on end user needs. It is worth noting that there are different definitions on the EO data product levels. As an example, the table below shows the definitions from NASA.

Table 5: EO imagery product levels

DATA PRODUCT LEVEL	DESCRIPTION
Level 0	Reconstructed, unprocessed instrument data at original resolution, time ordered, all communications artifacts removed
Level 1A	Level 0 data time referenced and annotated with ancilliary information, including radiometric and geometric calibration coefficients and georeferencing parameters (i.e. platform ephemeris) computed and appended, but not applied to Level 0 data
Level 1B	Radiometrically corrected and geolocated Level 1A data that have been processed to sensor units
Level 1C	Level 1B data that have been spatially resampled
Level 2	Derived geophysical parameters at the same resolution and location as Level 1 data from which they are derived
Level 3	Geophysical parameters derived from level 1 or 2 data that have been spatially and/or temporally re-sampled to a global grid
Level 4	Geophysical parameters derived by assimilating Level 1, 2 or 3 data into a land surface model

Considering the 8 key markets (defense, maritime, natural resources monitoring, energy, infrastructure, LBS, disaster management, and environment monitoring), Table 6 provides an overview on the type of data used by each of them.

Table 6: Relative data use by key market

	SCIENTIFIC-FOCUS DATA	HIGH-MOD. RES. OPTICAL	VHR OPTICAL	SAR	HYPERSPECTRAL
DEFENSE	Moderate Use	Moderate Use	High Use	High Use	Moderate Use
NATURAL RESOURCE MON.	Moderate Use	High Use	Moderate Use	Moderate Use	Moderate Use
ENERGY	Low/No Use	Moderate Use	Moderate Use	Moderate Use	Moderate Use
ENGINEERING/INFRASTRUCTURE	Low/No Use	High Use	High Use	Moderate Use	Low/No Use
LBS	Low/No Use	Moderate Use	High Use	Low/No Use	Low/No Use
MARITIME	Low/No Use	Moderate Use	Moderate Use	High Use	Low/No Use
DISASTER MANAGEMENT	Low/No Use	Moderate Use	High Use	Moderate Use	Low/No Use
ENVIRONMENT MONITORING	High Use	Moderate Use	Low/No Use	Moderate Use	Moderate Use

Source: Euroconsult (2017)

Note: Scientific focus claims for the utilisation of specific wavelengths on scientific EO missions

5.2 Key markets

5.2.1 Defense

Defense is by far the primary destination for commercial EO data. In 2016, 61% (i.e. $1.1 billion) of the total of $1.8 billion in commercial data was for defense customers. This is despite a reduction in defense procurement in 2013 as a consequence of cutbacks to U.S. defense spending. This reduction, however, did disguise growth elsewhere.

Non-U.S. defense markets remain a key growth area across the commercial data market. With continued global unrest, a limited number of countries with proprietary assets and a more diversified supplier base, defense is expected to remain the primary consumer for commercial data through the decade. By 2026, it is expected that commercial defense data sales will top $1.7 billion (4% CAGR). Despite having the most developed EO defense program, the U.S. is the foremost consumer of commercial data. In 2016 the U.S. defense sector alone accounted for 22% of the total defense market, though this percentage has reduced as more countries procure commercial solutions.

The U.S. increased its procurement from Digital Globe (DG) in 2014 following the launch of WorldView-3 and associated increased payments under the NGA's Enhanced View contract. Non-U.S. defense sales totalled $710 million in 2016 with a five-year CAGR of 10%. Asia and Latin America in particular are witnessingstrong growth in the procurement of commercial data facilitated by direct access solutions and driven by heightened regional unrest.

The value-added market for defense was valued at nearly $530 million in 2016, which is considerably lower than the size of the data market. The leverage from data to services is not clear in the defense market considering most defense analytics work is done in-house by defense and intelligence agencies. The companies engaged in value added are under contract with their respective governments. By 2026 the revenues are expected to achieve $ 780 million.

All countries require EO data to support their defense needs. The primary requirements for defense are IMINT and Geospatial Intelligence (GEOINT).

Increasing global tensions in areas such as Ukraine, Syria, the South China Sea and the EU over the last couple of years directly impact the demand for adequate EO data. Some countries have even decided to acquire proprietary defense systems in order to obtain adequate imagery. As of today, ten countries operate military and/or dual use systems, including the U.S., France, Japan, China, Israel,

Russia and Germany. This number of dedicated military systems is not expected to expand significantly in the future. A key reason is the cost associated with the development and maintenance of IMINT-capable satellites, i.e. satellites with very high resolution and geolocation accuracy. Whereas a civil multipurpose imaging satellite can be procured below $100 million, high performance defense satellites are over $500 million. Considering the limited number of proprietary systems, commercial data providers will continue to serve defense end users globally through the decade.

Table 7: Key applications and requirements for Defense

KEY APPLICATIONS	
Monitoring Activities	IMINT is gathered to support critical decision-making; applications include area mapping, target identification and reconnaissance
Mission Planning	Data used to support logistics of specific missions, run rehearsal scenarios, assess battle damage, and evaluate infrastructure; defense analytics uncover patterns and perform change detection related to infrastructure and personnel, assisting in developing more effective tasking strategies and anticipating future activity
Infrastructure Surveillance	Data are used to monitor critical infrastructure, including airports and gas pipelines, to support counterterrorism intelligence
Border Monitoring	Monitoring of frontiers for illegal activity, such as immigration and trafficking. Includes cross-border surveillance and transportation
Coastal Security	Unrecognized vessels are monitored by using AIS and SAR to detect suspicious vessels before they reach coastal waters (closely related to maritime sector applications)
APPLICATIONS REQUIREMENTS	
Ground Resolution	VHR is essential to applications where detailed feature detection, target identification and change detection are required.
Geolocation Accuracy	For the majority of defense applications, data offerings of < 10 m and sub-metric resolution products are required. U.S. defense (plus likely selective other countries) have strict requirements for native accuracy. Other departments are less stringent if it can be improved in post-processing.
Spectral Resolution	For numerous applications, optical panchromatic data will suffice. VHR multispectral data are used for specific applications such as concrete/vegetation differentiation. Hyperspectral data has the advantage of being able to delineate between camouflage/vegetation. SAR data has the advantage of producing all-weather imagery and identifying objects over water.
Temporal Resolution	Delivery as close to real time as possible is required. Securing direct access to the satellite is beneficial, both for tasking to the last minute, direct reception and local image production.

5.2.2 Infrastructure

The infrastructure and engineering data market is considered to be one of the fastest growing sectors. It has demonstrated 11% CAGR over the last five years and reached a total of $184 million in 2016. North America accounted for 46% ($85 million) of the total amount of commercial data sold in this

sector in 2016. The faster uptake of infrastructure and engineering relative to other sectors is primarily due to growing adaptation of high-resolution data solutions to support site-monitoring activities and logistics. With the expectation that continued use of EO data to support the development of infrastructure projects will remain strong, the market is projected to reach $295 million in 2026.

The value-added market for infrastructure projects reached $1.3 billion in 2016 (a five-year CAGR of 11%). In terms of revenue generation for value added, it is the first vertical market. This is considerably larger than the market for commercial data, the main reason being that many cartography, cadastre, and land-use monitoring projects can exist with low-cost and free data sources. For 2026, it is forecast that the revenues in this market shall overcome $1.8 billion.

Demand for EO data in the infrastructure sector continues to grow to support local- and national-scale projects. Countries seek to develop infrastructure but may lack topographic maps or in situ data for providing detailed mapping and continued monitoring. This is notably the case in emerging countries that are experiencing strong economic growth and wish to capitalize on developing infrastructures. For instance, Brazil and Mexico have started to utilize satellite imagery to perform urban cadastres and actively monitor the evolution of urban areas. The digital terrain models (DTM) generated by very high-resolution data are being used in Bolivia to support project planning in the capital. Further, EO data is being used to monitor expansion progress in the Panama Canal. Other national infrastructure projects, such as mapping cadastres in China and India, are repeated intermittently (every few years) with relatively high budgets (>$10 million) for EO data. It is anticipated that as regions continue to grow economically with more infrastructure required to support growth, the demand for EO data will rise in this sector.

Upcoming satellite systems offering higher temporal resolutions could allow new services to develop, particularly within the private sector, with solutions for site monitoring, improving logistics, etc. These services have significant crossovers into sectors such as energy and LBS (as in asset tracking).

Table 8: Key applications and requirements for infrastructure

KEY APPLICATIONS	
Urban Development	Data are used for chart development, cadastre plots, cartography, density maps, etc.
Telecom. Network Planning	Elevation modelling and stereo imagery are used for radio frequency measurements to evaluate existing network performance and new network planning.
Transport/ Infrastructure Planning	Data are used to identify underlying surfaces, potential obstacles, etc.; elevation modelling is used to chart the best routes.
Project Monitoring	Data are used for continuous monitoring to chart environmental impact, subsidence, etc.
APPLICATIONS REQUIREMENTS	
Ground Resolution	The ground resolution used depends on the application but primarily requires high moderate resolution data. Wider-area mapping places greater emphasis on image swath using more coarse data. For more detailed mapping, higher-resolution (metric and sub-metric) datasets are required.

Spectral Resolution	Spectral resolution depends on the nature of the area of interest. Panchromatic data are often suitable. For larger scale projects and/or across varied terrain (such as wider transportation planning and rural projects), multispectral imagery is required to delineate land cover. SAR data are utilized to map subsidence in projects developed in areas with problematic geological dynamics.
Temporal Resolution	Archive data are usually sufficient given that infrastructure projects are usually slow to develop. Up-to-date, near-real-time data are a higher requirement for progress monitoring of remote infrastructure projects such as energy/mining facilities, pipeline development, etc.

5.2.3 Natural resources monitoring

Natural resources monitoring is considered to be one of the first EO applications in terms of data use. In 2016, the commercial EO data market value for supporting natural resources monitoring applications was $ 177 million (10% of the total market value). Commercial data sales to the sector have grown by 10% CAGR over the last five years. Satellite imagery has been widely adopted to support large-scale monitoring projects in regions and countries that may have substantial natural resources but insufficient monitoring solutions to manage wide, often remote areas. With increasing populations and urban development, there is pressure to manage natural resources and increase food and water security. The market for commercial data for natural resources monitoring is expected to reach $ 246 million by 2026, with Latin America and Asia being the key markets for further growth.

The value-added service market was estimated at $450 million in 2016. It has been a key area for generating services since the onset of Landsat. As with infrastructure projects, many services can be derived from lower-cost sources. However, demand for more accurate and higher resolution data at higher cost emerge through applications such as precision agriculture. This domain implies a greater level of detail compared to regional/national scale land-resources reporting. In 2026 the revenues in this market are foreseen to achieve $645 million.

The monitoring of national, regional and global resources is becoming increasingly important due to a number of factors such as:

- growing population requiring better resource management like food security and water management,
- increasing agricultural prices, progressively infringing on natural terrains and changing climates.

Despite being one of the first applications of EO data, this sector is highly cost sensitive, and demonstrating cost-benefit is critical. Lower-cost solutions or free solutions (such as Landsat and the Sentinels) are used for a variety of application areas. Applications that require higher-cost data, such as precision agriculture, are gaining some traction but are still considered to be in the take-up phase. Although the technology is proven, with companies such as Airbus Defense & Space marketing operational solutions (such as "Farmstar Expert"), uptake is relatively slow. In this area, satellite solutions also compete with aerial solutions, with the use of civil UAVs (drones) increasing. The expected competitive pricing of emerging systems offering high revisit such as Terra Bella/Planet is due to incentivise demand in the coming years. EO use is expected to increase in support of national environmental policies. Governments are introducing geo-information in support of policy development, for which EO can serve as input. Other IGO-led initiatives that call for regular monitoring of forestry, such as UN REDD+, are beginning to stimulate awareness and foster the use of EO in regions with previously limited or lacking means to sustainably manage these resources.

Table 9: Key applications and requirements for natural resources monitoring

KEY APPLICATIONS

Agriculture	Data are used for crop classification, assessing crop health, resources management, assessing farming practices, etc.
Land cover mapping	Data are used for field classification/change, mapping, monitoring pollution, etc.
Forestry	Data are used for forest inventory, change detection maps, monitoring illegal logging, carbon counting, assessing vegetation health, etc.
Water management	Data collected by satellite and in situ data (soil, meteorological and hydrogeological data) are required for water resource and quality assessments.
APPLICATIONS REQUIREMENTS	
Ground Resolution	Ground resolution requirements depend on the specific application being used. Multiple application areas, particularly those requiring the monitoring of vast land expanses and/or governmental national land cover reporting, tend to have a greater emphasis on image swath, with data sufficient at ground resolutions of 10 m or higher. Higher-resolution data would be preferred for more detailed mapping.
Spectral Resolution	Multispectral imagery is required for classifying crop health/type bands. Bands along the "red-edge" between visible red and NIR are essential given the relative absorption and reflection differences between the two. Increased spectral resolution can provide further information on crop/vegetation classification and health. Greater granularity in the NIR and SWIR (such as from hyperspectral solutions) allows for detection of chemical and biophysical vegetation properties. SAR data are used for specific applications such as assessing soil moisture and water content.
Temporal Resolution	Revisit time can vary from daily or weekly to annually or even multi-yearly depending on the specific application, and the trade-off between ground resolution and revisit (impacted by swath width) is key. In order to obtain land cover change maps, time series data are required to map variations; therefore, archive data are key inputs for assessing long-term trends.

5.2.4 Maritime

The commercial EO data market for maritime operations reached $73 million in 2016, experiencing a growth of 10% CAGR over the last five years. The United Nations Conference on Trade and Development (UNCTAD) reported that global seaborne shipment increased 3.4% in 2014, the same rate as in 2013. Seaborne trade represents approximately 80% of global trade by volume and over 70% by value. With growing demand for shipping and continued concerns over border monitoring, the market is anticipated to reach $98 million by 2026.

The VAS market for maritime applications was $62 million in 2016, which was marginally less than the market for SAR data. This is believed to be due to much work being done in-house by governments, particularly in the maritime domain awareness closely associated with defense applications. The higher costs of SAR data compared to optical which supported the sector, also had an impact. Revenues in 2026 are expected to achieve $105 million.

The increasing global activities of the maritime sector have prompted the need to better understand natural processes that occur in the maritime environment to ensure safety at sea and monitor activities. Regional security concerns such as drug/human trafficking, maritime border security and piracy are increasing the need for accurate, timely information to monitor shipping activities globally.

Increasing trade is a main driver of demand for improved ocean forecasts in new geographic areas. China, for instance, is trying to incorporate EO applications to support its initiative for developing a 21st-Century Maritime Silk Road ("One Belt One Road [OBOR] initiative)." In other areas, such as the Polar Regions, new shipping routes are opening as a result of climate change, and the need for regular mapping of the regions will increase.

Environmental impact (brought about by illegal dumping, oil spills, etc.) is also increasing the need for data. For instance, the European Maritime Safety Agency (EMSA) has developed the CleanSeaNet program to detect pollution and link it to ships using several satellite data sources (such as Radarsat-2 and COSMO-Skymed).

Table 10: Key applications and requirements for maritime

KEY APPLICATIONS	
Met-ocean Assessment (Weather)	Data are used for monitoring ocean currents, waves and current predictions, sea-ice monitoring and detection and wind and wave forecasting.
Integrated coastal zone monitoring	Data are used for environment monitoring on near-coastal ecologies and gathering information on ocean colour through algal bloom detection, surface salinity, etc.
Pollution	Data are used for oil dumping/spill monitoring, estimating the size of the polluted area, evaluating the date/time of observation and determining wind speed and direction.
Ship Detection and Tracking	Data are used to serve operational services such as tracking, ship route planning or monitoring of illegal activities.
APPLICATIONS REQUIREMENTS	

Ground Resolution	As ships reflect strongly compared to surrounding waters (provided wind speeds are favourable), they can be identified using 30 m or higher resolution data. Lower-resolution data also have the benefit of an increased swath, which allows for wider-area coverage and a higher temporal resolution. The main benefit of high-resolution data is the increased accuracy for identifying the type of ship and its supposed direction and monitoring port/harbour activity.
Spectral Resolution	For SAR-based surveillance and tracking applications, both X- and C-bands are utilized. Other radar sources are also used to detect wave and current information (by altimeters), wind direction and speed (by scatterometers) and sea-ice conditions (by passive radar and SAR). Optical data require specific channels depending on the application. Bathymetric mapping utilizes blue channels and lower wavelengths. Ocean colour measurements require channels in the infrared. SWIR can also be used for ship detection.
Temporal Resolution	The timeliness of data delivery and continuity of data supply are critical to operational services such as tracking, surveillance and ship routing. In some cases, data tasking is required to provide near-real-time data collection one to three hours after the request.

5.2.5 Location Based Service (LBS)

In 2016, the market for commercial data to support Location Based Services (LBS) was $95 million. Given that the sector is still very much in the take-up phase, growth remains strong. It is, however, perhaps the most difficult of the sectors to characterize, while having the greatest growth potential. LBS services requires continuous data (or derived information) over a specific point – whether that be a country, site, town, port etc. With current demand, the market is expected to top $501 million by 2026, however, this could be higher if the sector breaks into more mass market business-to-business applications.

Emphasis however is expected to be on the value-added market and derived information products for take-up in the coming decade. Growth will however depend in part on the emergence of satellite constellations offering the desired revisit at a low data price. In 2016, the market for LBS value-added services is estimated at just over $114 million, with applications supporting real estate, retail, news and media. In 2026 is expected to achieve $620 million in revenues.

Taking Google Earth as an example, current LBS solutions focus on the use of very high- to high-resolution optical data sets. These images are essential to visualizing information (individuals wish to identify what they are looking at). Google Earth in itself proved a key driver for the EO industry in opening up the field to a wider group of users and the public. The challenge for the industry since then has been to build derived services based on point data, in particular change detection that has occurred at a given point.

By imaging the same point at a regular frequency (from hourly to weekly), applications are expected to develop built around change detection analytics. The need is for changes (such as through a report or simplified map) rather than a dataset or complex product offering. Such solutions can be standardized and delivered on alternative platforms, such as via a handheld “app” or on a subscription-based services.

Technology supporting this development is two-fold: First, the emergence of low-cost constellations able to deliver imagery with a much higher revisit than currently achievable; and second, advances in IT and the ground segment allow for low latency delivery, near-real-time automated data processing, and data enhancements in post-processing. This can lead to multiple data being processed quickly to highlight change detection and delivery to the end-user in a quick and efficient manner.

Table 11: Key applications and requirements for location based services

KEY APPLICATIONS	
Virtual Globes	Data usage in LBS focuses on very high- to high-resolution optical data sets. Data is used to highlight specific areas of interest to support wider marketing. Data used to support virtual globes are regularly refreshed archive imagery.
New Services Areas	Numerous applications areas have the potential to emerge, including urban planning (traffic flow monitoring, urbanization and site monitoring for new construction); Retail/market intelligence (competitive intelligence, traffic flow monitoring through car parks and assessments of peak business hours).
APPLICATIONS REQUIREMENTS	
Ground Resolution	VHR ground resolution is required for individual site monitoring, such as that of construction sites, remote oil fields, or the monitoring of retail outlets. Coarser resolution data used in large scale land monitoring applications, such as for agriculture and environment monitoring.
Spectral Resolution	To date, spectral resolution has focused on true-colour optical – such as the data used in virtual globes like Google Earth, the data being more visual. Moving towards information products, the data used would be that required to fulfil the job – the visual nature being less important to the derived product. Advances in deriving datasets from a greater spectral range to support applications is therefore anticipated, potentially even to include SAR and later, hyperspectral.
Temporal Resolution	Reducing satellite revisit is a key component of LBS services, with some providers (such as Planet) expected to target down to hourly revisit. Being able to guarantee data to the daily level in order to derive services would already be a competitive advantage.

5.2.6 Disaster management

Disaster management is a key application for EO data. As the sector relies on free data, its commercial value is limited with $36 million in 2016 (2% of the total), with a 5% CAGR over the last five years. This market is due to remain stable by 2026 as data supply after disaster events is due to remain mostly free or at a preferred rate.

The VAS market for disaster management was estimated at $ 146 million in 2016 (for a five-year CAGR of 5%), which is considerably greater than the commercial data market. Since data are provided mostly for free or low cost, revenue is then generated from value-added services. In 2026 the market is expected to achieve $243 million.

Several companies (such as SERTIT and DMCii) have yearly contracts with the International Charter on Space and Major Disasters (through their representing national bodies) for the provision of services in case of disaster events, such as for flood maps and logistics support.

The market is directly impacted by the increasing number of chartered natural and manmade disasters, technology advances, and the proliferation of EO systems to meet the sector's ranging requirements. Initiatives such as UN-SPIDER and the International Charter on Space and Major Disasters promote the use of EO data during disaster events and incorporate commercial data, although they are supplied for free on a goodwill basis or sold at a much lower price.

Commercial data, for instance, was used to support finding Malaysia Airlines flight MH370 in 2014 (using optical and SAR data to find floating debris or oil spills) and monitoring the Ebola epidemic in West Africa (to provide information on ground infrastructure and support aid teams' logistics).

Indirect benefits to commercial data providers are brought by exposing their images and capabilities to a wider audience, given the increased public interest and media coverage during disaster events. Furthermore, to coordinate efforts, commercial operators also devise their own mechanisms to support disaster management through social media or portal-based data dissemination provided free of charge. DigitalGlobe's acquisition of crowdsourcing company Tomnod in 2013 has also been viewed as a mechanism through which to extend its social profile and utilize the crowdsourcing platform to collect and disseminate information during a crisis event. The platform has been used, for instance, following Nepal's and Chile's earthquakes in 2015. Users can participate by tagging damaged areas on an image to inform disaster response teams on the ground.

Table 12: Key applications and requirements for disaster management

KEY APPLICATIONS	
Early Warning	Data are used to anticipate disaster events by monitoring soil, hydrology, geomorphology, burnt area mapping, etc., to support a variety of disaster-related applications. This includes drought prediction, wildfire prediction and flood monitoring.
Alert, Response and Recovery	Data are used in immediate/short-term actions to assist in recovery, including mobilizing civil protection/defense services and highlighting areas of special interest, such as identifying populated areas and further areas at risk.
Post-disaster Recovery	Data are used to assess damages, including insurance losses (such as to infrastructure and commodities [e.g.: forestry/agriculture])
Humanitarian Relief	Data are used for constant monitoring of longer-term humanitarian relief applications (such as for droughts, famines or refugee fallout) to mitigate further loss of life/damage.
APPLICATION REQUIREMENTS	
Ground Resolution	Higher ground resolutions are considered better for detailed feature identification. More moderate resolutions (such as RapidEye and Landsat) are also utilized, such as in wider-area monitoring.
Spectral Resolution	The focus is on optical visible data (for easy visualization). SAR data are also critical, particularly for events associated with high cloud cover, such as flooding.
Temporal Resolution	Data are nominally required as soon as an event has occurred and need to be regularly updated. In this regard, any single satellite has obvious constraints if the satellite path will not allow for subsequent images to be captured days after the first images. Increasing the number of data sources is therefore necessary to remain up to date. Archive data is also used for damage assessment by comparing before and after images.

5.2.7 Energy

The energy sector has been a long-term user of EO data, especially for oil, gas and mineral exploration. In 2016, the commercial value of the EO data market for the energy sector was $118 million (6% of the total), and it has grown at 1% CAGR over the last five years. In past years, the

market has primarily focused on exploration applications in remote areas. However, the recent evolution of oil prices continues to impact the sector and shift priorities. It is anticipated that oil prices will remain low over the next few years, decreasing the use of EO data to support the development of new exploration plays. It will increase along with the development of new services focused on site monitoring. Considering this, the commercial EO data market for energy is expected to reach $136 million by 2026.

The VAS market for the energy sector was estimated at $276 million in 2016 (a five-year CAGR of 1%), representing more than double the commercial data market. The oil and gas sector is the primary user of value-added services with applications such as geological mapping and identification of exploration sites. The VAS market associated with the energy vertical market is expected to remain quite stable in terms of revenues up to 2026, with $308 million.

The market is highly dependent on the energy industry's prices. The use of EO in the energy sector has been largely driven by exploration activities. High oil and gas prices drive new exploration activities into more remote areas, where satellites solutions are the most cost effective. The drop in oil and gas prices has stalled exploration activities. The new extraction processes for non-conventional oil are considerably more expensive than for conventional oil and, at current prices, are unprofitable. As and when oil and gas prices rise, exploration activity is expected to resume; as will activities concerning non-conventional oil (shale and fracking). Environmental concerns over the latter have led to more monitoring activities for regulatory purposes and corporate sustainability.

EO activities targeting the midstream (such as site monitoring) are expected to gain traction as oil companies seek to improve efficiencies. Service will be stimulated by upcoming high-revisit constellations offering more spectral capacity, either through hyperspectral solutions or high-resolution systems with spectral bands supporting geology (such as WorldView-3). Events such as the collapse of mining sites in Minas Gerais (Brazil) in 2016 have increased pressures on both governments and energy companies to monitor activities and support disaster management operations.

Table 13: Key applications and requirements for energy

KEY APPLICATIONS	
Exploration	Data are used for base mapping and surface geology to assist in characterizing potential exploration plays. Following initial exploration activities, the data can be further used for logistics and mapping to support in situ activities, such as seismic data acquisition.
Renewable Energies	Data are used to support the placement of renewable energy plants, such as wind and solar plants, map hydroelectric sources, etc.
Operations Support and Monitoring	Data applications include applied meteorology/met-ocean solutions to support logistics (often in remote areas prone to sudden weather changes) and monitor production sites and critical infrastructure such as pipelines to ensure efficient and safe business practices.
Environment and CSR	Data used to ensure safe exploration and extraction processes, including identifying and tracking oil spills, ground monitoring for corrosion, soil erosion and potential impacts on ecosystems.
APPLICATION REQUIREMENTS	
Ground Resolution	Applications usually require VHR to MR data. Higher-resolution, higher-commercial-value data tend to focus on detailed, precision mapping, such as on specific targets selected for increased exploration activities and in supporting logistics and infrastructure. In geological mapping, lower-resolution archive data suffice.

Spectral Resolution	Optical and SAR datasets are commonly used. For applications such as geological mapping, data are often combined to delineate based on their differing spectral attributes and textural differences using SAR data. Thermal bands are also used to detect subsurface features. Hyperspectral data are utilized in precision mapping to differentiate between specific minerals and detect potential surface alterations. SAR data are used in oil spill detection.
Temporal Resolution	Revisit requirements vary according to the application. Prospecting/exploration activities generally rely on less time-sensitive imagery (archive data). Historical time-series data are required to support the placement of energy sites. More timely data are required in operational logistics and monitoring of activities.

5.2.8 Environment monitoring

Environment monitoring is the first area of investment for civil government satellites; however, the data generated are not deemed to have significant commercial value. The data are predominantly provided free of charge from R&D-driven space agencies for scientific usage. As such, the market totalled $29 million in 2016, which is foreseen to remain stable up to 2026.

The “value” is generated in longer-term science-driven goals to support information collection on the environment and climate variables as well as through value-added services generated from the freely available data. The VAS market for environment monitoring was estimated at $745 million in 2016 (a five-year CAGR of 7%), i.e. much more than the data market and accounting for 22% of the total VAS market. By 2026, this market is expected to achieve $1 billion.

Climate change continues to be at the top of government policy objectives, and support to fund environment-monitoring missions is stable across space agencies. Climate change remains in the government spotlight due to the significance it can have to the population, the economy and global long-term sustainability. To this end, EO is a key tool for measuring climate parameters over time to assess trends and counter changes. Therefore, even though the application does not correspond to significant revenue returns for the commercial operators, it remains a key driver for the industry as a whole, providing opportunities for both manufacturers and service providers. However, the role of the private sector may go through some changes, with commercial operators aiming to support environmental monitoring data collection, which they can provide to governments (such as through service-level agreements). NOAA’s Commercial Data Policy released in 2017 is expected to pave the way for the use of commercial meteorology and environmental monitoring data, allowing NOAA to procure services to complement its own collection activities.

International projects and initiatives such as GEOSS and Copernicus are expected to drive the use of EO data as a critical source of environment information over the coming decade. These initiatives also encourage free open access, data sharing and the coordination of activities to support science-driven applications.

As the sector has strongly relied mainly on data from government satellites, it has had to overcome some uncertainty in the recently agitated economic context; over the past years, NASA, NOAA, ESA and the EU have faced funding issues with respect to flagship environmental monitoring programs. For applications that rely on data continuity through follow-on missions, this uncertainty represents a significant risk, with any potential data gaps directly impacting research capabilities. Upcoming commercial satellite systems targeting environment monitoring could help to mitigate possible data gaps in government-funded data production.

Table 14: Key applications and requirements for environment monitoring

KEY APPLICATIONS	
Ocean Environment	Ocean surface and subsurface monitoring, including temperature, salinity, sea level, etc. Linkages with atmospheric variables permit a better understanding of weather systems, such as through analyses of ocean surface winds.
Terrestrial Environment	Applications are primarily focused on land cover mapping, providing a basis to a number of other applications (such as composition maps of land-based ecosystems) and monitoring of land-surface changes (such as through the onset of urbanization or desertification). Terrestrial ECVs that are fully monitored include snow, ice cover and albedo effects; soil moisture; permafrost; and glacier/ice sheets.
Atmosphere Environment	Applications incorporate operational elements such as air quality, meteorology and R&D into longer-term atmospheric evolution. Includes monitoring of the surface (air temperature, precipitation, air pressure and water vapour) and at the upper air level (Earth radiation budget, temperature, wind speed/direction, water vapour and cloud properties) as well as atmospheric composition analyses.
APPLICATION REQUIREMENTS	
Ground Resolution	Requirements vary depending on the application: precision coastal monitoring requires higher-resolution data, whereas global/regional-scale land cover monitoring and ocean current/temperature measurements utilize lower-resolution data sets and take advantage of wide-area coverage due to the increased swaths.
Spectral Resolution	Imaging capabilities vary more than in other sectors due to the wide-ranging applications and the differing climate variables to be measured. Multispectral and hyperspectral data are required to delineate differing vegetation types and their health. Radar altimetry is used in oceanography to measure sea levels on a global scale and to carry out seasonal forecasting of ocean currents.
Temporal Resolution	Real-time, continuous data are required for specific applications such as operational weather services. The current systems' data delivery is the time it takes data to be received from GEO and processed. Depending on other applications, data are required regularly (weekly/monthly/seasonally).

5.2.9 Summary of vertical markets

Table 15 summarises the revenues for EO commercial and VAS market for years 2016 and 2026.

Table 15: Summary of revenues for EO commercial data and VAS markets

	COMMERCIAL DATA MARKET ($ million)		VAS MARKET ($ million)	
	2016	**2026**	**2016**	**2026**
Defense	1130	1690	530	780
Infrastructures	184	195	1130	1810
Natural resources monitoring	177	246	450	645
Maritime	73	98	62	105
LBS	95	500	114	620
Disaster management	36	32	146	243
Energy	118	136	276	308
Environment monitoring	29	22	745	1010

Source: Euroconsult, 2017

5.3 Key stakeholders and business overview

An overview of key players and their business overview in the EO value chain is provided through 10 case studies. The ten service providers presented in Table 16 are representative of the diversity in system capabilities and businesses.

With the exception of Digital Globe, Airbus Defence and Space, and UrtheCast that are publicly-listed companies reporting financial information, the other 8 companies are start-ups owned by private equity investors with no public release of economic information. However, it is not possible to obtain detailed financial information for Airbus Defence and Space, given the size of the company and the merging of different business lines in the company's reports.

Table 16: List of companies profiled

10 EO company profiles	
Company	**Nationality**
UrtheCast	Canada
DigitalGlobe	USA (to become a subsidiary of MDA in 2017)
Airbus Defence & Space	Europe (participation of several countries)
Planet	USA (acquired Terra Bella from Google in 2017)
BlackSky Global	USA (subsidiary of Spaceflight Industries)
NorthStar	Canada
Satellogic	USA and Argentina
Hera Systems	USA
Planetary Resources	USA and Luxembourg
OmniEarth	USA

There are several motivations for a commercial operator to develop an extensive distribution network. Commercial operators rely on distribution networks to expand their geographic footprint, reaching out to the maximum number of end users; they can also tap into existing client bases or leverage on vertical market expertise brought by partnering with exiting service providers. Broadly speaking, similar distribution schemes are adopted by the commercial operators. Terminology of partnership agreements may vary, but essentially they fall into five types of distribution agreements with different rationales and contract conditions:

> **Data resellers** imply no exclusivity. They procure data from the operators and resell them to the end users. Their main value is in their proximity to the end user: whether they have a lobbying influence or are pushing for the suitable specifications from the customer; whether they speak the language and know the customs of the end user; or whether it is simply that the end user statutorily has to buy from

a local company. Their main customers' portfolios are governmental. Data resellers benefit from the operator marketing material and from support from their product managers. In terms of contract conditions, data resellers nominally sign yearly agreements with the operators; these agreements define sales targets, but they do not include financial commitments. Rather, the lever arm for operators relies on the threat of not renewing the agreement if the sales targets are not met. Conversely, the data reseller may demand a better discount once his sales target has been reached. The most common model defines a discounted price on the international price list of the operator. When the distributor brings in a specific large business with budgetary constraints from the end user, it is typical to have a dedicated agreement between the operator and the distributor for that particular case, as this takes care of a fair share of the price-setting effort. The territory assigned to a distributor may vary from a region of a large country to a whole continent. Rights may be granted for a specific market (e.g., defense, oil and gas, or agriculture) or for the whole imagery market. Most distributors are data resellers, meaning that their agreement with the operators includes clauses allowing them to trade data without any transformation. Depending on company size, data distribution may represent a minor part of their overall business. In the same way, depending on their size, revenue generation from commercial data distribution may range from $100,000 to over $5 million.

> **Value-Added Resellers** (VARs) procure data from the operators and derive products that they sell to the end users. The value added process may be as straightforward as processing level 1A images (radiometrically corrected) to produce level 3 images or further tailored processing to result in information products that are far removed from the imagery, such as statistics on crop yields or density of CO_2 sequestration, among others. Their value may reside in their capacity to offer an original product and/or in their proximity to the end user in a similar way to the local distributors. In terms of contract conditions, VARs also usually sign yearly agreements with the operators; in most cases, agreements define sales targets, but they don't include financial commitments. They also define geographic and/or sectorial criteria for the authorized addressable market. Because what they sell may be very far away from an image, they usually purchase imagery at a price that is set as a fraction of the international price list of the operator. Their discount may increase with the volume purchased.

VARs represent the main category of distributors, ranging from 50% to 80% of the distribution agreements in place with each operator. Their size ranges from very small (i.e., only a couple of employees) to quite large integrated companies (such as GIS service providers). Their turnover's range is at least as wide as that of data resellers, with larger organizations generating more than $10 million in value added reselling.

> **Exclusive distributors** have exclusive distribution rights to sell data from a given commercial operator within a defined region (country or continent). Many commercial operators have included in their network data resellers or VARs that have a privileged status; they are committed to minimum buying and getting. In exchange, several advantages are offered: closer support from the operator technical, marketing and sales teams; higher discounts on the international price list; and the right to set up their own sub-distribution networks.

The term "global alliance" used by DigitalGlobe is similar to the "exclusive distributors" of Airbus Defense & Space. DigitalGlobe usually separates exclusive distributors' contracts from Direct Receiving Station (DRS) agreements, while Airbus Defense & Space has placed several contracts combining the two aspects (such as PASCO in Japan, ScanEx in Russia, and BlackBridge in Canada). All of these exclusive partnerships include the use of a receiving station. DigitalGlobe has exclusive partnerships with Space Imaging Middle East in Dubai (for the Middle East market) and with European Space Imaging in Munich (for the European market); they do not directly own the DigitalGlobe DRS, but they get support from the stations installed locally for the UAE Space Reconnaissance Center and DLR respectively.

Unlike the data resellers and VARs, exclusive distributors usually get longer-term contracts, from two to five years. The defined sales targets are a financially binding commitment; in exchange for these contracts, the exclusive distributors get a formal exclusivity on an agreed geographic area and/or a sectorial business domain and a specific discount on the satellite operator's international price list.

> **Business partners**: In synergy with the development of new big data and cloud and streaming technologies, the operators are starting to use such technologies to disseminate their data and promote their use. Companies such as ESRI, ERDAS and Mapinfo propose to their GIS users streaming access to imagery databases; corresponding agreements with operators are de facto distribution agreements. Other companies are offering streaming capabilities (e.g., Icubed with its DataDoors solution) and virtual globes of the big web players; Microsoft, Google, Yandex, Baidu and Naver, for instance, are also disseminating imagery to end users. In that case, the agreements signed

with the satellite operators could either be seen as imagery purchases or as distribution agreements for which the end users do not pay any fees. Detailed contract conditions are tailored to each specific case and are not made public. However, they clearly define licensing conditions much more from the perspective of streaming and web publishing than the usual licenses granted to the other four categories. The business model attached to these agreements is based on volume of data streamed and displayed. Though numbers are not publicly available, one can assume that the cost per km2 could be a fraction of the catalogue list price.

> **Direct Receiving Station** (DRS) contracts are considered to have the highest value and guarantees for the operator. They are mainly targeted toward defense users that require a greater level of data acquisition on demand and a degree of autonomous and secure access to data and toward users requiring a very large quantity of data, such as maritime surveillance service providers, large data distributors, forestry or environment institutes, and remote sensing agencies. The end user can then distribute all the data received at their facilities or retain the information for internal users (such as within defense agencies).

Agreements are nominally from two to five years, as their investment in receiving hardware (antenna and receiving and producing terminal) may represent more than one year of the image telemetry fee. Beyond this, however, specific contract conditions can vary. They may for instance include the following: the right to resell received data without further fees to the operator (in such a case, a very high telemetry fee can be expected, as the corresponding market segment is fully given to the DRS owner), revenue sharing on the sales generated by the DRS or a fixed fee on each image sold. Operators' support to these special distributors includes technical aspects (such as helping them to set up their own web portal or supporting their archive storage implementation, for instance) and marketing.

Therefore, the following companies will use one or several of the five partnership agreements detailed above.

5.3.1 Urthecast

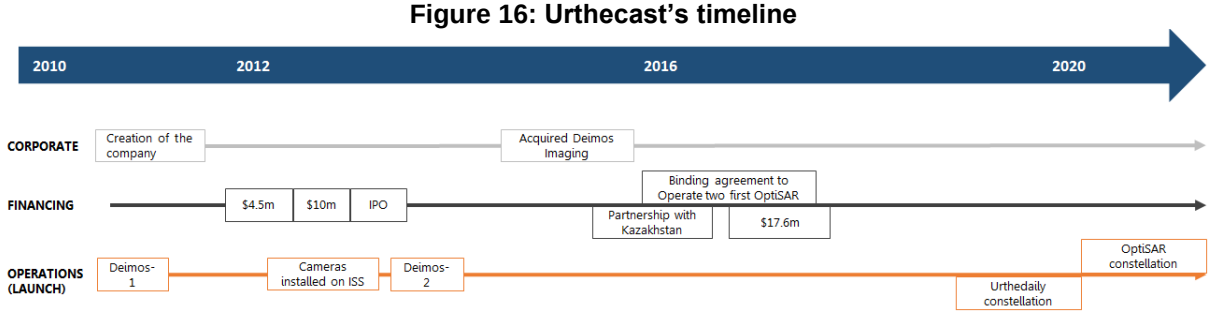
Headquarters	Vancouver, Canada		
Founded	2010 by Scott Larson, Wade Larson, George Tyc		
Investors	Two VC rounds in 2012/13 for $15 million. Publicly traded in Toronto Stock exchange		
Heritage	No previous heritage, started EO operations by installing optical cameras on board ISS. Acquired two Deimos satellites and EO operations in 2015		
Key Partners	• SSTL • ESA • Kazak Government	• Elecnor Deimos • NASA	• NanoRacks • Roscosmos

UrtheCast is a new player in the EO market which aims to deliver Earth observation data and services from cameras installed on the International Space Station (ISS). In 2015, the company acquired Deimos Imaging from Elecnor Deimos in Spain to foster its data supply and leverage on its data distribution network. In 2016, the company announced it would terminate ISS camera operations and would launch two constellations with different capabilities:

- OptiSAR with 16 high resolution satellites with 8 in optical and 8 SAR (X and L-bands).
- UrtheDaily with 8 medium resolution optical satellites.

The timeline for Urthecast since its creation in terms of operations, finance or corporate milestones is detailed in Figure 16.

Figure 16: Urthecast's timeline



Financing and revenues

Urthecast's business is based on two services: engineering and support services and Earth observation data sales. Whereas the engineering services are delivered on-demand, EO products are sold on monthly subscription through a web platform. The price range for the ISS camera is $4-$30 per km^2, much cheaper than existing commercial options which can cost upwards of $20,000 per km^2.

The company initially raised $4.5 then $10 million in 2012 and 2013 from angel investors prior to going public (Table 17). UrtheCast went on the Toronto Stock Exchange in 2013 in order to raise further funds at IPO following first financing rounds. It raised close to $70 million. In 2017, the company announced approximatively $17.6 million in funding from Canada's Industrial Technologies Office as part of its Strategic Aerospace & Defense Initiative (SADI) program. This will provide significant financial support to OptiSAR constellation.

The company acquired the EO assets of Deimos Imaging from Elecnor Deimos Space for €74 million ($89 million) in 2015. The company also received $12 million from Canadian government research and development grants. In order to finance its constellation, the company also secured a $27 million loan.

To finance the upcoming constellations, Urthecast does not seek funding from the capital markets but will finance it with commitments from upcoming customers. In 2015 the company announced that it had signed a MoU with two prospective OptiSAR non disclosed customers valued at $370 million. One of them also has financed the majority of the $72 million in R&D for the OptiSAR.

Table 17: Urthecast's funding history

DATE	ROUND	AMOUNT RAISED
2017	Post-IPO	$17.6 million
2013	Venture capital	$10 million
2012	Venture capital	$4.5 million

The company continues to increase its revenues from CAN$3.9 million (US$3M) in 2014, through a revenue of CAN$36.5 million (US$28.4M) in 2015 to CAN111.2 million (US$142.5M) in 2016. The significant increase in 2015 was primarily due to the addition of the Deimos business. According to the CEO, the Earth observation data revenue carries the highest gross-profit margin, of 80-85 percent, but engineering services are also "very profitable."

The company reported a loss of $12.9 million (compared to a loss of $2.4 million in 2014) driven by the support for the development of its constellation. In 2016, adjusted EBITDA have reached US$3.8 million.

Partnerships and external support to the development of the company

UrtheCast has established several key partnerships along the value chain to offer EO data services. For instance, the company has agreement with NanoRacks, to expand its EO data stream by operating sensors on the NASA segment of the ISS. In addition, UrtheCast has strategic agreement with Roscosmos, the Russian Space Agency for the components of ISS sensors to be developed, built, and tested by RSC Energia and partnership with NASA to stream real-time Earth video data from ISS (HDEV). For the recently announced constellation, SSTL will be manufacturing the satellites, and Elecnor Deimos will be designing the ground control segment. Before its acquisition by Urthecast, Deimos received support of the Spanish ministry of Industry for up to 20% of the cost of Deimos-2.

UrtheCast announced in 2016 the establishment of a cooperative research and development agreement with the National Geospatial-Intelligence Agency (NGA), to maximize the operational effectiveness of the OptiSAR constellation. In 2016 Urthecast signed a partnership with OmniEarth, to support the development of services for UrtheDaily. In fall 2016 Urthecast secured a partnership with Kazakhstan which will buy two OptiSAR to get access to the full constellation. The support of the Government of Canada through several grants has supported the company in its R&D effort. In 2016 UrtheCast received from Canada Technology Development Program $5M funding, as part of the $54M contribution program for the development of new satellite technologies. Urthecast is focusing, with difficulties, on agriculture monitoring for the European Commission (JRC) for the outcomes of Urthedaily constellation (5m).

In January 2017 UrtheCast made a binding agreement valued at US$180M with a confidential government customer for the sale and shared operation of the first two satellites of the OptiSAR constellation. This undisclosed customer also agreed to pay an additional $30M for other products and services related to the sale of the two satellites.

In February 2017, the company signed a long-term agreement with GEOSYS, a subsidiary of Land O'Lakes, which is considered as one of the United States' premier agribusiness and food companies.

In July 2017 UrtheCast signed a partnership with ESRI for the launch of a new EO service called Kanvas. In October 2017 the Deimos subsidiary of UrtheCast signed with e-GEOS a strategic partnership to offer a combination of joint optical and radar sensor with ground stations.

Deployment and exploitation of the satellites

Urthecast's THEIA and IRIS cameras were launched in 2013 on board a Russian Progress cargo and installed on the Russian segment of the International Space Station. Operational service was delayed by one year for IRIS camera due to malfunction leading to insurance claim. Data are transmitted through NASA data relay satellites in geostationary orbit. The use of TDRSS satellites allows bigger and faster data transmission compared to direct communication to ground stations that only have

limited line of sight.

Deimos assets were launched in 2009 (Deimos-1) and 2014 (Deimos-2) by two Dnepr operated by Kosmostras. Deimos-1 launched in 2009 for 5 years' lifetime has expired its initial design lifetime by more than 100% and still produce data. As a member of the DMC and PanGEO alliance, Urthecast has access to ground station in Dubai, Sweden and Canada in addition of those in Spain. For OptiSAR, considering the mass of the satellites the use of medium or heavy launch vehicles will be required. Details about ground segment are unknown yet.

Characteristics of space assets

Urthecast operates two cameras on the ISS: a fixed camera with a 50 km swath at 5 m resolution THEIA (MRC) and a video camera mounted on a steerable platform able to record 150 90-second videos per day at 1.1 m resolution IRIS (HRC). Imagery acquisition is limited by the ISS's orbit (between 51ºN/S). Both cameras are reported to have cost $17 million. Despite malfunctioning, IRIS (HRC) continues to produce videos that meet the needs of certain segments of the market.

The company also operates two optical satellites following the acquisition of Deimos satellite assets. Both systems are multispectral, at 4m (1m panchromatic) and 22m ground resolution respectively.

All this information is detailed in Table 18.

Table 18: Technical specifications of Urthecast's operational assets

	THEIA (MRC)	IRIS (HRC)	Deimos-1	Deimos-2
MANUFACTURER	RAL Space		SSTL	Satrec Initiative
PAYLOAD SUPPLIER			Eastman Kodak	
MASS	10 kg		88 kg	310 kg
GROUND RESOLUTION	5m, 50 km swath	1m full-color videos, up to 60 seconds video	22m, 650 km swath	75 cm, 12 km swath
TEMPORAL REVISIT	Two weeks		2/3 days	4 days
LAUNCH & ESTIMATED LIFETIME	2013, n.a	2013, n.a	2009, 5 years	2014, 10 years
ESTIMATED COST UNIT	$17 million	$17 million	unknown	$72 million
SPECTRAL BAND WAVELENGTH				
PAN	n.a	n.a	n.a	560 - 900 nm
BLUE	470 - 570 nm	n.a	n.a	466 - 525 nm
GREEN	500 - 600 nm	n.a	520 - 600 nm	532 - 599 nm
RED	600 - 700 nm	n.a	630 - 690 nm	640 - 697 nm
NIR	780 - 880 nm	n.a	770 - 900 nm	770 - 892 nm

UrtheCast plans to develop a 16 satellite SAR and optical multispectral (8 of each) constellation build by SSTL. In doing so, it is the only company to seek to develop both technologies in constellation. This dual sensor architecture was initially supposed to be installed on the U.S segment of the ISS but the Urthecast decided to move off the station to operate more sensors. Satellites are to be flown in pairs, with a SAR satellite "leading" the optical. The SAR satellite will carry a sensor to detect clouds which will send a signal to the following optical satellite via inter-satellite links, informing it to collect data or not (i.e. if conditions are cloudy, the optical satellite will not acquire data). This is expected to help

optimize the data collection process. Table 19 details the technical features of the future Urthecast satellites.

Table 19: Technical specifications of Urthecast's upcoming assets

	OptiSAR (Optical)	OptiSAR (Radar)	UrtheDaily
MANUFACTURER	SSTL		
PAYLOAD PROVIDER	SSTL		
MASS	8x 670 kg	8x 1400 kg	8x 340 kg
GROUND RESOLUTION	Optical Pushbroom collection: 50cm Video : 50 cm with 30 fps able to collect image at 25cm	Low resolution L-band (5m), (Quad-pol) high resolution X-band (1m), (Single-pol VV) AIS detector	5 m
SPECTRAL RESOLUTION	R,Y,G,B+NIR	B,G,R	unknown
TEMPORAL REVISIT	daily		
SWATH	12km	From 10km to 100km according to the selected beam mode	unknown
LAUNCH & ESTIMATED LIFETIME	Operation should start by 2021		Operation should start by 2019, for 10 years.
ESTIMATED COST UNIT	~$20 million	~$50 million	Unknown

The launch of the OptiSAR constellation has been postponed from 2019 to 2021. The constellation is assumed to be operated in pairs of satellites, one radar and one optical. OptiSAR satellites will be deployed in two orbital planes, with eight satellites in polar sun-synchronous orbit and the other eight in a medium-inclination orbit at an angle of between 20 and 45° inclined to the equator.

UrtheCast has also announced plans for additional eight optical satellites constellation (UrtheDaily) to be launched into SSO. If this constellation is realized, it will provide a strong capability for daily global collection, monitoring, change detection applications. However, the company claims it will proceed with UrtheDaily only after firm customer commitments.

Targeted market, services and key customers

Urthecast is looking at various distinct markets for optical and SAR imagery and analytics:

- **Maritime (Security):** This service requires high resolution imagery with frequent revisit, which UrtheCast sensors and satellites are well positioned to address. In addition, the company offers cloud-based APIs, services, and tools to power applications and derive answers from geospatial data.
- **Defense:** OptiSAR planned constellation intends to offer high resolution imagery well suited for defense applications that need high frequency and high resolution imagery to ensure accurate information. Applications include security and civil protection, monitoring, law enforcement, and foreign defense operations.
- **Infrastructure:** UrtheCast targets applications that include 3D mapping, urban planning and development, real estate, disaster response, transport and construction. These applications require moderate to very-high resolution imagery which can be used for planning as well as site monitoring and logistics activities.

- **Agriculture**: Especially with its High Resolution UrtheDaily constellation operating in optical at 5m resolution.

As of 2016, basic access is priced at $39, $99 for the premium, and $349 for professional access. Each of them grant access to specific number of map views. All of them offer unlimited access to the satellite tracker, archives, and area of interest.

Data from these resources is made available through UrtheCast's web-based platform. Based on open-source software it allows developers to plug their own API. The platform also provides options for camera tasking, data archives, analytics, and specialized EO applications. Since 2016 Deimos' data are accessible through the same platform. It would be expected that data from the future constellation would also be made available in a similar way.

The launch of the constellation however is likely to open up further service areas. The SAR constellation would be expected to target maritime applications and defense, particularly maritime domain awareness. Whereas the optical component would again support defense and LBS (as Black Sky). The combined offering of the two datasets, at high frequency, and potentially at a much lower cost (especially when considered SAR data) could open up service areas with combined data.

The acquisition of the in-orbit Deimos satellites allows Urthecast access to the previous company's data distribution network and existing EO service contracts. Deimos has contracts with ESA to supply imagery under the Copernicus framework and provides services to the U.S. Department of Agriculture. Further customers include the National Geographic Institute in Spain, which has an agreement under which the company provides monthly data over Spain. The strategic investment made by the Government of Kazakhstan in two satellites of OptiSAR is remarkable because the country already owns two satellites built by Airbus and launched since 2014. It is unknown yet if this partnership is designed to replace the existing satellites. If so it would open a new type of relationship where governments no longer procure their own satellite.

Schedule and outlook

With already operational assets Urthecast is able to develop a customer base and service portfolio compared to imaging constellations in planning.

The company is working with SSTL to design and manufacture the satellite buses and the optical camera payload and radar payload, and Urthecast will collaborate with ElecnorDeimos Space on the radar payload integration and ground stations.

The Urthecast constellation is expected to roll-out over 2019-2021. Delays could be caused if financing isn't achieved as it relies on customers' commitment.

Depending on the final price point of the satellites, Urthecast could be in a position to sell SAR data at a much lower cost than what is currently available. Although activities are expected to focus on existing solutions, such as in supporting maritime domain awareness (ship surveillance etc.), the lower price point could mean lowering the barrier for further global end-users. However, current investment/revenue levels are not expected to be at the level required to fund the full constellation.

5.3.2 Digital Globe (purchased by MDA in 2017)

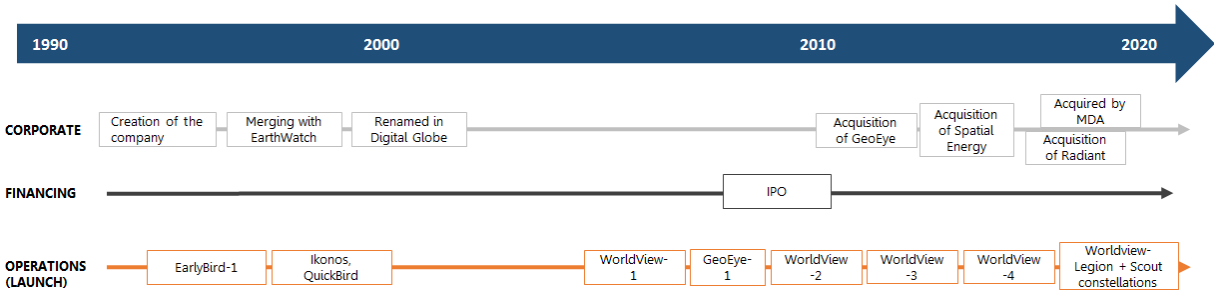
Headquarters	Westminster, United States		
Founded	1992 by Walter Scott, Doug Gerull		
Investors	Publicly traded in New York Stock exchange. Acquired by MDA early 2017.		
Heritage	Initial heritage in mapping and data collection at federal research facilities. Additional heritage from mergers with Earthwatch and GeoEye		
Key Partners	• National Geospatial Intelligence Agency (NGA)	• Taqnia Space • SAAB • Timbr	• Radiant • Spatial Energy

DigitalGlobe (DG) is the oldest and largest commercial Earth observation company that results from:

- the consolidation with two other American satellite operators (Earthwatch, GeoEye)
- the acquisition of several American service providers (including Radiant for $140m in 2016).

In Figure 17 is detailed the timeline for Digital Globe since its creation in terms of operations, finance or corporate milestones.

Figure 17: Digital Globe's timeline



In 2016, DG announced it will develop and market a constellation of 6 smallsat jointly with Taqnia Space of Saudi Arabia (Worldview Scout).

Financing and revenues

In Feb. 2017, MDA announced it will acquire DG for $2.4 billion and completed it in October 2017 forming the largest deal to date in the EO market. With this acquisition, MDA achieves the double strategic objective of becoming:

- a vertically-integrated company, from satellite systems to satellite services
- a major supplier of the US government, both for satellite systems and satellite services.

Maxar Technologies is now the parent holding of a large portfolio of companies including MDA, SSL (for $1.1B in 2012), DigitalGlobe, and Radiant ($140m in 2016) and is estimated at $3.6B. Concomitant to the acquisition, MDA announced a large satellite constellation project with DG (Worldview Legion). In 2017/2018, DG will have to engage into the replacement of its two oldest satellites (WorldView-1 and 2). Before being part of MDA, DigitalGlobe anticipated an approximate four-year build cycle for a total cost not to exceed $600 million, excluding capitalized interest.

Previously to the acquisition by MDA, Digital Globe sold data and services through a combination of direct and indirect channels, consisting of a global network of resellers, strategic partners, direct enterprise sales, and web services to U.S. Government and commercial customers. The company sells imagery and services. However, value-added services have been more challenging to develop. The company has established multi-year framework agreements with large government customers (such as EnhancedView for the NGA). Such agreements guaranteed revenue if data volume and quality requirements are met. The Direct Access Program (DAP) is a multi-year subscription agreement that allows tasking DG satellites.

DG revenues increased by only 3.3% in 2016 to $725.4 million. Growth had been stronger in 2015 (+7.2%) driven by the EnhancedView SLA with the NGA and the 11th DAP partner. For 2016, the company reported an adjusted EBITDA growth of 7.6% year to $382.7 million.

For 2017, DG expects revenue in the range of $840 to $865 million and an adjusted EBITDA in a range of $380 million to $395 million.

Partnerships and external support to the development of the company

At its inception the company has leveraged from founders' background in mapping at Intergraph Corporation and optics at Laurence Livemore Laboratory.

The support from the U.S Government has been a key driver of the company success. The various framework agreements with the NGA are the result of both lobby and policy effort to outsource partially imagery supply to the private sector (the NRO still operates reconnaissance satellites in the meantime). This dual supply gives flexibility to the U.S government in imagery public disclosure. In 2014, the U.S Government relaxed imagery regulations, allowing Digital Globe to sell 30 cm imagery of the Worldview-3, the only commercial capable satellite at that time, giving a competitive advantage to Digital the companies over its competitors.

The acquisition of value-added services companies has produced mixed results, for example, the acquisition of Spatial Energy focused on the energy sector at the time when the industry was hit by lower oil prices. Location-based service applications have also proven to be more difficult to develop. In 2016 Digital Globe made the acquisition of Radiant to expand its geospatial services business and U.S. government customer base and Timbr to improve its data analytics and fusion capabilities.

The joint venture with KACST and Taqnia Space to build Worldview Scout constellation of at least six smallsats, is a different direction for the company as it would assumedly give the company a lower-cost data supply to build services and share the capex with its Saudi Arabia partners. Taqnia will manufacture the satellites in exchange of half of the data over Middle East. Digital will sell the remaining imagery over MENA and have exclusivity for the rest of the world.

After the purchase of DG by MDA, DG's partnerships are expected to be continued, although they might change.

Deployment and exploitation of satellites

The deployment of Digital Globe's satellites reflects the company history of merger and acquisition and its legacy. Most of the operational assets have been launched between 2007 and 2009 and the company delayed further launches to avoid an oversupply. For example, the launch of the Worldview-4 (GeoEye-2) was planned for 2013 but in the course of the planned merger of GeoEye and Digital Globe, the launch was postponed until 2016 due to the increased demand;

Digital Globe owns or has service agreements for ground station remote ground terminals in eight locations throughout the world.

Characteristics of space assets

As of 2017Q1, the company operates a constellation of five satellites: GeoEye-1, WorldView-1, WorldView-2, WorldView-3 and WorldView-4. The company markets them as the Digital Globe constellation for marketing purposes but this name is misleading as the satellites have different technical specifications and orbits. Worldview-1 can capture 500,000 km^2 at a 50 cm ground resolution.

Geoeye-1 was initially operated by Orbimage and later Geoeye. Worldview-2 and 3 share the same design, offering half-meter panchromatic resolution and 1.8-meter multispectral resolution. In addition, WV-3 brings the first satellite to offer a ground resolution of 30cm and infrared capabilities. All this information is detailed in Table 20.

Table 20: Technical specifications of Digital Globe's operational assets

	Worldview-1	Geoeye-1	Worldview-2	Worldview-3	Worldview-4
MANUFACTURER	Ball Aerospace	General Dynamics	Ball Aerospace		Lockheed Martin
PAYLOAD SUPPLIER		GD-AIS	Harris		ITT Corp.
MASS	2500 kg	1955 kg	2800 kg		2600 kg
GROUND RESOLUTION	0.50 m, 18 km swath	0.41 m, 15 km swath	0.46 m, 16 km swath	0.31 m, 13 km swath	0.31 m, 13 km swath
TEMPORAL REVISIT	2 days	<3 days	1 day	1 day	1 day
LAUNCH & ESTIMATED LIFETIME	2007, 7,5 years	2008, 8 years	2009, 7,5 years	2014, 7,5 years	2016, 12 years
ESTIMATED COST UNIT	$473 million	$212 million	$463 million	$650 million	$835 million
SPECTRAL BAND WAVELENGTH					
PAN	400 - 900 nm	450 - 800 nm	450 - 800 nm	450-800 nm	450 - 800 nm
COASTAL	425 – 450 nm	n.a	400 - 450 nm	400 - 450 nm	
BLUE	480 – 510 nm	450 - 510 nm	450 - 510 nm	450 - 510 nm	450 - 510 nm
GREEN	545 – 580 nm	510 - 580 nm	510 - 580 nm	510 - 580 nm	510 - 580 nm
YELLOW	605 – 625 nm	585 - 625 nm	585 - 625 nm	585 - 625 nm	
RED	660 – 690 nm	655 - 690 nm	630 -690 nm	630 - 690 nm	655 - 690 nm
RED EDGE	725 – 745 nm		705 - 745 nm	705 - 745 nm	
NEAR IR	• 835 - 895 nm • 950 - 1040 nm	780 - 920 nm	• 770 - 895 Nm 860 - 1040 nm	• 770 - 895 nm • 860 - 1040 nm	780 - 920 nm
SWIR	n.a	n.a	n.a	• 8 SWIR 1195 nm - 2365 nm • NDVI-SWIR 405 nm - 2245 nm	n.a

With the Scout constellation, Digital Globe will operate in 2019 its first true constellation of six satellites. The satellites will be built by Taqnia Space. The satellites will collect imagery with a resolution of 80 cm and native accuracy from 10 to 20 m CE90 (native). At this stage Scout will be more optimised for point collection with a smaller footprint, obtaining collages of 100x100 km^2 with 600 images. Taqnia will leverage the knowledge acquired through a joint venture with Lockheed Martin to manufacture telecommunication satellites. Table 21 details the technical features of the future Digital Globe satellites.

With Worldview Legion constellation, Digital Globe will operate six satellites with sensors in 8 bands,

providing 30 to 50cm of resolution. Two out of the six satellites will be placed in SSO and the other four in MEO with an inclination of 45°, which will increase the revisit frequency for mid latitudes. The objective of DigitalGlobe is to get an accuracy from 3.5 to 5m CE90 (native).

Table 21: Technical specifications of Digital Globe's upcoming assets

	Scout (x6)	WorldView Legion
MANUFACTURER	TAQNIA, KACST	SSL (Raytheon Space Systems for payload)
MASS	6x ~50 kg	6x (~kg?)
GROUND RESOLUTION	80 cm	30 to 50 cm
ACCURACY CE90	10 to 20m	3.5 to 5m
SPECTRAL RESOLUTION	4 bands	8 bands
TEMPORAL REVISIT	9 times daily	More than 13 times daily
SWATH	2x2 or 4x4 km²	Between 12 and 16km
LAUNCH & ESTIMATED LIFETIME	2019, 5 years	After 2019
ESTIMATED COST UNIT	$50 million	?

Targeted market, services and key customers (previous to the acquisition by MDA)

Before the acquisition by MDA, the company had been looking at various markets for optical imagery and analytics:

- **Defense:** the two Worldview satellites (3-4) with native 30 cm resolution are well suited for defense and security applications that include civil protection, border monitoring, law enforcement, and foreign military operations.
- **Infrastructure:** Worldview-2 stereoscopic imagery and photogrammetry are useful for land use monitoring and urban planning.
- **Agriculture:** GeoEye1 and WorldView -2 imagery is used to monitor and characterize crops production environments, better manage distribution networks and minimize the impact of farming, fisheries and livestock but VHR from Worldview-4 will allow high precision agriculture
- **Environment**: Worldview-3-4's 30 cm resolution and powerful analytics allows the company to monitor crop and forest health, yield, irrigation or sickness levels, as well as various metrics allowing a deeper understanding of our biomass.
- **Oil & Gas:** Natural resources and asset tracking, monitoring of various oil & gas industry facilities and stocks for changes but the company investment's in Spatial Energy occurred right before oil and gas market drop.
- **Location-Based Services:** DG is facing strong competition from competitors and end users which are developing proprietary solutions and only require data. UBER is a new relatively small customer of Digital Globe's LBS to improve its mapping division (acquired from Microsoft) which aims to identify and improve pick-up and drop-off locations.

Digital Globe sell imagery and services based on the level of processing (basic, standard, ortho-rectified imagery, mosaic imagery, stereo imagery). With competition intensifying, the company has upgraded its services toward higher quality more reactive products and more recently to value-added services. Digital Globe services are delivered through GBDX web platform using Amazon Cloud services. The portal aggregates latest data to the company archives. For specific services, the MAPS API fuels a third party application with Digital Globe data.

In the past, U.S Government mostly purchased raw imagery and performed in-house the data interpretation and analytics. With the development of multiple imagery sources like drone, processing and interpretation have become a bottleneck issues for the government.

A Direct Access Program (DAP) allows premium access to Digital Globe's satellites. The DAP is designed to meet the enhanced information and operational security needs of a select number of defense and intelligence customers and certain commercial customers. Under this agreement, customer can directly task over its region and receive imagery up to the volume of the contract. The constellation's data will diversify the scope of services offered by Digital Globe by allowing higher revisit for the applications that do not require <50cm resolution.

The U.S. Government is the company's first customer (63% of the total revenue in 2015). The EnhancedView contract with the NGA includes deliverables totalling $300 million per year for six years beginning on September 2014. DAP is structured as one year plus one-year options. The acquisition of Radiant brings new intelligence clients to Digital Globe like the National Reconnaissance Office (NRO). International defense contracts are proving to be a growth driver for the company through its Direct Access Partner (DAP) scheme. The company has signed DAP contracts in 10 countries, earning $120.7 million in revenues in 2015. It signed the 11th DAP customer in 2016.

WorldView-4 launched in Nov. 2016 is not part of the company's obligations under the EnhancedView contract. Hence, DigitalGlobe can offer its capacity to commercial customers and include guaranteed-access provisions in contracts.

Schedule and outlook

Digital Globe has pushed the limits of optical imagery provided by commercial operators and created a demand for VHR imagery with its operational satellites. Facing more competition from on the ground resolution and spectral resolution, its new constellation aims to diversify its products portfolio with higher revisit.

The company has successfully secured a strong relationship with the U.S Government and generates a bulk of its revenues from the intelligence sector. The company will face important capital expenditures to both replace its upcoming satellites and finance the constellation. Therefore, the creation of the joint venture with Saudi Arabia is expected to reduce this effort. However, the Saudi have not yet manufactured satellites domestically.

As an established player facing competition, the company has both to evolve its business model by both maintaining its VHR data core business and developed value-added services based on high revisit. The development of these services remains a challenge.

5.3.3 Airbus Defence and Space

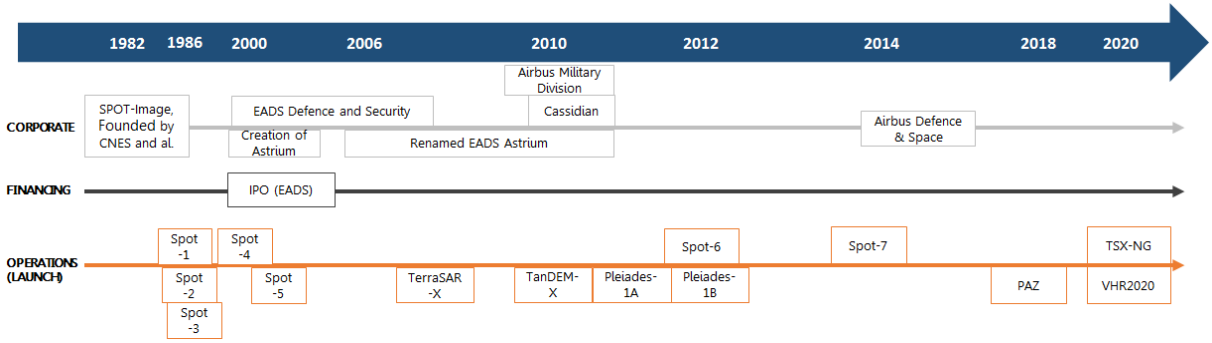
Headquarters	Toulouse, France		
Founded	January 2014 as “Airbus Defence and Space”, previously EADS (from 2000)		
Investors	Publicly traded in Euro Stoxx 50 Stock exchange.		
Heritage	Airbus DS heritage is from Aerospace both civil and military as result of the merging of different European companies (CASA, MATRA Marconi Space, DASA, etc.).		
Key Partners	CNES Hisdesat Hexagon Geospatial	DLR ESA	ST Electronics Azercosmos

Airbus group is publically participated up to 28% by France, Germany and Spain.

Airbus Defence and Space (Airbus DS) is part of the Airbus group, contributing to a 21% of its revenues. Within Airbus DS there are four sections: Military Aircraft, Space Systems and Communication-Intelligence-Security (CIS) and the new Unmanned Aerial Systems. In particular, the EO commercial data and VAS services are offered by Airbus DS/CIS.

The group has been largely restructured over the 10 past years as follows in Figure 18. As an overview of the past 5 years (starting in late 2013), the EADS group announced a restructuring of its Space (Astrium) and Defence (Cassidian) activities into a single branch. At the same time, it decided to rename the group Airbus Group and to name each branch under the Airbus brand; yielding Airbus DS.

Figure 18: Airbus Defence and Space’s timeline



Financing and revenues

Airbus DS revenues are not fully disclosed (only as part of the wider group). Unlike Digital Globe, the company does not have a strong anchor tenant (such as the NGA) but benefits from satellite funding from the government: commercialization of the French government dual-use program, Pleaides, and its SAR satellites, which are PPP financed.

Airbus DS had estimated revenues from $320 to $500 million in 2016 dedicated to EO data services. Approximately 80% of Airbus Defence & Space data are purchased by government customers, of which 75% is used for defense and security applications. Over half of this revenue is attributed to sales outside of Europe, with ~30% of the total generated in the home countries (France, Germany, U.K. and Spain).

During the 2006-2015 period, Airbus captured close to $2billion in manufacturing market value. Similarly, Airbus built 16 satellites, six of which were for operators outside of the European region.

Partnerships and external support to the development of the company

Inheriting from the Infoterra (TerraSAR-X and Tandem-X satellites) SAR program and the optical HR (SPOT 1 to 5 satellites) and VHR (Pleiades satellites) programs from the French Space agency (CNES), Airbus DS has complemented its sensor portfolio with the self-funded Spot 6 & 7 satellites. The completion of these satellites was followed by agreements with the NSPO of Taiwan for international distribution of Formosat-2 satellite (2m resolution), now decommissioned and replaced by a collaboration with Kazakhstan with KazEOSat-1. Airbus DS has an agreement with DEIMOS imaging of Spain (now UrtheCast) for international distribution of DEIMOS-1 satellite (22m resolution) and with hisdeSAT of Spain for the future international distribution of PAZ satellite (SAR satellite similar to TerraSAR-X, 1 m).

The SPOT series was initiated by CNES in the 1970s and was developed in association with the SSTC (Belgian scientific, technical and cultural services) and the Swedish National Space Board (SNSB). The first satellite, Spot-1 was launched in 1986. The SPOT series was financed by French government until SPOT-5. Airbus had a license granted by CNES to distribute data worldwide exclusively from SPOT satellites.

The two Pleiades spacecraft were publicly funded by DGA (French MoD) and CNES, but are operated for commercial use by Airbus DS. The copyright of Spot remains with CNES, and Airbus has an exclusive right to use and reproduce data.

TerraSAR-X satellite is a joint venture carried out under a public-private-partnership (PPP) between the German Aerospace Centre DLR and EADS Astrium GmbH (now Airbus DS).

Airbus DS has an exclusive partnership with ScanEx in Russia, Beijing EastDawn in China, and PASCO in Japan. All of these exclusive partnerships include the use of a receiving station.

Airbus DS and Kongsberg Satellite Services (KSAT) have signed a multi-million-euro agreement for the delivery and installation of a Direct Receiving Station (DRS) for TerraSAR-X and its twin satellite TanDEM-X in Norway. With this new DRS, Airbus Defence and Space extends its receiving station network of some 40 DRS worldwide – confirming its status as the largest in the world today. However, KSAT will also have the option of drawing on Airbus Defence and Space's entire satellite constellation, including the Pleiades twins, SPOT 6 satellite and the upcoming SPOT 7, as well as the future PAZ satellite.

The total number of resellers was evaluated as 128 in 2014, in second position behind DG with 160. In 2016, this became 178 agreements and the leading position globally. Most of these news agreements were established in the Middle East and Africa. Airbus DS Partnered with Hexagon Geospatial to provide access to data in smart applications.

Airbus DS has 7 regional subsidiaries over the 5 continents: Australia, Brazil, China, Hungary, Japan, Singapore and the U.S. For instance, DMCii is a wholly owned subsidiary of Surrey Satellite Technology Ltd (SSTL), which is a subsidiary of Airbus Defence & Space.

Deployment and exploitation of satellites

In July 2008, EADS's Astrium Services (now Airbus DS) unit acquired a majority stake in Spot Image S.A. Astrium invested $400 million in the SPOT-6 and 7 satellites of its own funds for their development. This was the first time in the remote-sensing industry that satellite development costs have been funded entirely with private funds.

Airbus transferred the ownership of SPOT-7 satellite (renamed Azersky) to Azercosmos as part of a long-term partnership in commercial remote sensing, retaining preferred marketing rights to Azersky. This company has the distribution rights of these satellites in the Caucasus and CIS (Commonwealth of Independent States - part of the former Soviet Union) countries. Airbus DS continues to be the distributor of both SPOT -6 and SPOT -7 data for the rest of the world.

Developed under the responsibility of CNES and financed by CNES and by military funds, Airbus DS developed Pleiades, a VHR dual system responding to the needs of civilian users and the Defence. This system consists of a constellation of two identical satellites, Pleiades 1A and 1B, phased in the same orbit to guarantee a capacity for daily revisit in any part of the globe.

DLR is responsible for the scientific use of the TerraSAR-X data, whereas commercial marketing is

performed exclusively by Airbus DS specializing in the collection and processing of air- and satellite-based data.

Airbus DS and its subsidiary, SSTL succeed in providing solutions to third parties outside their European region of operation. SSTL will manufacture the UrtheCast constellation.

Characteristics of space assets

The company has the most diverse commercial data offering. It operates and distributes EO data from three satellite families offering different capabilities. Spot-6/7 HR series provides a wide-area coverage (60 km swath) at 2.2 m resolution resampled to 1.5 m PSH; Pleiades1-A/B VHR provides image across a narrower field of view but at a 0.7 m resampled to 0.5-m ground resolution.

Thanks to its partnerships and PPP, Airbus with TerraSAR-X and TanDEM-X offer up to 25 cm ground resolution SAR datasets that constitutes the most precise resolution for civil SAR offer. The SAR satellites fly "in tandem" to create accurate digital elevation modelling (DEM) products. The "WorldDEM" is considered to be one of the most accurate elevation data set at 2 m relative vertical accuracy. The company also supplies a wide range of value-added services, targeting oil and gas, mining, agriculture and defense.

***Disclaimer**: Deimos1 mission is fully owned and operated by Deimos Imaging (DMI), an UrtheCast company but as explained previously Airbus DS has a distribution agreement. TerraSAR-X belongs to DLR but as mentioned previously Airbus DS has fully commercial rights distribution as for KazEOSat-1satellite, which belongs to KGS, a national Kazakhstan company charged of the development of Kazakhstan Space program.

Table 22: Technical specifications of Airbus Defence and Space's operational assets

OPTICAL SENSOR	**SPOT 6/7**	**Pleiades 1A/1B**	***UK-DMC/ Deimos1**	***KazEOSat1**
MANUFACTURER	Airbus DS	Airbus DS	SSTL	Airbus DS
PAYLOAD SUPPLIER	Airbus DS	Airbus DS	SSTL	Airbus DS
MASS	714 kg	970 kg	96 / 88 kg	830 kg
GROUND RESOLUTION / SWATH	2.2 m, 60 km swath	0.7 m, 20 km swath	22 m, 660 swath	1 m, 20 swath
TEMPORAL REVISIT	1 day, 5 days (30° ONA)	1 day, 4 day (30° ONA)	1-2 days for mid latitudes	2-3 days for mid latitudes
LAUNCH & ESTIMATED LIFETIME	2012 / 2014, 10 years	2011 / 2012, > 5 years	2009 / 2009, > 5 years	2014, >7 years
ESTIMATED COST UNIT	$127 x2 million	$165 x2 million	$44 x2 million	$132 million
OPTICAL SPECTRAL BAND WAVELENGTH				
PAN	450-750 nm	480-820 nm	n.a	450-750 nm
COASTAL	n.a	n.a	n.a	n.a
BLUE	450-520 nm	450-530 nm	n.a	450-520 nm
GREEN	530-600 nm	510-590 nm	520-620 nm	530-600 nm
YELLOW	n.a	n.a	n.a	n.a
RED	620-690 nm	620-700 nm	630-690 nm	620-690 nm
RED EDGE	n.a	n.a	n.a	n.a
NEAR IR	760-890 nm	775-915 nm	760-900 nm	760-890 nm
SWIR	n.a	n.a	n.a	n.a

RADAR SENSOR	*TSX TerraSAR-X TanDEM-X
MANUFACTURER	Airbus DS
PAYLOAD SUPPLIER	Airbus DS
MASS	1230 kg/ 1340kg
GROUND RESOLUTION / SWATH	ST: 0.24x1.0, ~2.5x6km swath HS: 1m, 5x10km SM: 3m, 30km ScanS:16m,100km
TEMPORAL REVISIT	2,5d in left and right looking mode
LAUNCH & ESTIMATED LIFETIME	2007 / 2010 > 5 years
ESTIMATED COST UNIT	$194 / 207 million
RADAR	
BAND	"X"
SINGLE POL	VV or HH or HV or VH
DUAL POL	HH+VV or HH+HV or VV+VH
QUAD POL	Experimental
InSAR	Yes

Table 23: Technical specifications of Airbus Defence and Space's upcoming assets

PAZ - RADAR	
MANUFACTURER	Airbus DS
MASS	1200 kg
GROUND RESOLUTION, SWATH	SL: 1m, 5x10km SM: 3m, 30km ScanS:15m,100km
BAND	"X"
POLARIZATION	Single and Dual
TEMPORAL REVISIT	< daily associated with TSX
LAUNCH & ESTIMATED LIFETIME	2017 / 2018, >7 years
ESTIMATED COST UNIT	$~160 million

"VHR 2020" Future of PLEIADES	
MANUFACTURER	Airbus DS
MASS	Non disclosed
GROUND RESOLUTION	< 0.7 probably reach 0.4m
SWATH	Non disclosed
POLARIZATION	n.a

TEMPORAL REVISIT	< daily
LAUNCH & ESTIMATED LIFETIME	2020, 2021, >7 years
ESTIMATED COST UNIT	Non disclosed

Targeted market, services and key customers

After the restructuration of the company and the different agreements achieved, the company has been looking at various markets for SAR, optical imagery and analytics:

- **Defence:** Airbus DS offer complementary systems with TerraSAR-X and Pleiades together with SPOT 6/7 for increased revisit time and different data types and ground resolutions. TerraSAR-X is a precious asset for maritime surveillance by ship/vessel detection for example. Airbus DS also offers VAS in this vertical market as "GO Monitor", an on-demand surveillance service in change detection and analytics of target sites with chosen frequency. It can be for managing safety, security on emergencies, or strategic and tactical oversight. Airbus experts can also deliver insights. This service is also dedicated for Infrastructure monitoring.
- **Infrastructure:** Pleiades satellites carry the only one VHR sensor offering Tri-stereo, allowing no mask through urban corridor. This detailed mapping can be enhanced by precise WorldDEM product delivered through TerraSAR-X acquisitions.
- **Agriculture:** Agriculture monitoring implies a series of temporal acquisition. Providing HR data through SPOT satellites, allows large swath for detecting field growth evolution and VHR data, allows precise identification and parcel measurement. Precise agriculture with FarmStar VAS program allowing better input management.
- **Oil & Gas:** SAR and VHR from Airbus' imagery is used for geological survey, exploration and exploitation of oil & gas wells. A database developed and provided by Airbus DS from its long historical interpretation of imagery named Global Seeps allows a retrospective analysis of all coastal Oil Spill detection that can be relevant to determine which one can be natural revelling possible off shore deposit.

Schedule and outlook

Airbus has an agreement with Hisdesat, the owner of Paz satellite, to commercialize Paz's SAR data when it will be launched by SpaceX in late 2017.

Continuity in SAR is expected through TerraSAR-NG (Next Generation), currently being developed under a PPP between Airbus DS and DLR with an expected launch in 2020.

In addition, Airbus DS will finance, apparently on its own, a constellation of four VHR satellites to launch in 2020 and 2021 with features at least equal to those of Pleiades. This new constellation is temporary named "VHR-2020". The program, which industry officials said likely represents a capital investment of more than €500 million ($550 million). If future Pleiades system is expected to keep delivering data for military use, DGA has not yet validated a firm commitment for its replacement as it was for Pleiades1A/AB.

5.3.4 Planet (ex-Planet Labs; acquired BlackBridge and TerraBella)

Headquarters	San Francisco, USA		
Founded	2010 by Robbie Schingler, Will Marshall, Chris Boshuizen		
Investors	Dylan Taylor, Draper Fisher Jurvetson, Data Collective, AME Cloud Ventures, Ray Rothrock, Lux Capital		
Heritage	No previous heritage, fundamental shift in building satellites by adopting agile aerospace methodologies, lowering lead times, development cost. Acquired Blackbridge and its RapidEye constellation. Acquired Terra Bella satellites and EO operations in February 2017		
Key Partners	• Nanoracks • Blackbridge • Google** • SSL**	• RocketLab • MDA* • ECAPS** • KSAT**	• ESA* • Harris Corporation* • Japan Space Imaging** • European Space imaging**

* These partners are Blackbridge partners inherited from the acquisition of the company.

** These partners are Terra Bella partners inherited from the acquisition of the company

Planet (formerly Planet Labs) aims to image the entire Earth every day through a constellation of at least 150 cubesats, providing imagery at high-frequency, moderate resolution, and low cost. Planet's business focuses on derived information products based on change detection analytics rather than raw imagery. Planet is one of the most disruptive emerging EO operators, and the most advanced in terms of satellite deployment, with:

- the launch of more than 293 cubesats, both demonstrators and operational Doves/Flock
- the acquisition of BlackBridge (RapidEye) in 2015
- the acquisition of Terra Bella (Skybox) from Google in February 2017.

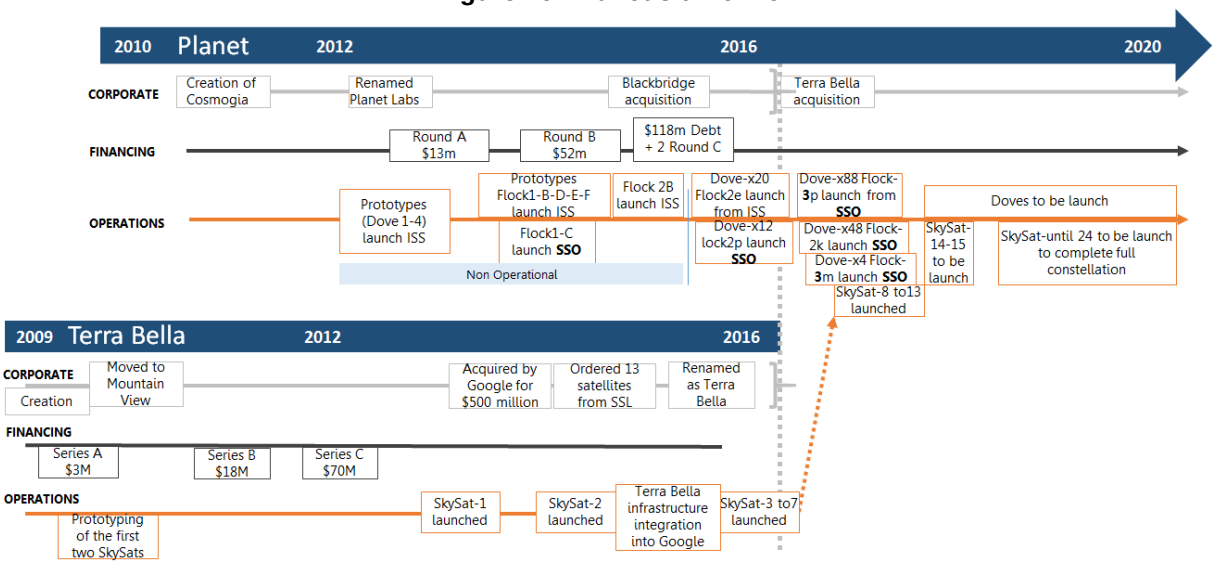
Planet's strategy consists in developing the assets from TerraBella (Skybox) of ~1 m resolution, while those from BlackBridge (RapideEye) with 5m resolution are going to be totally integrated into the Dove-cubesat assets solution.

We have included detailed information on TerraBella (ex-Skybox Imaging) business as a separate company in this profile since in the interest of other tasks of the DISCOVERER project it will provide an additional view on a different business model compared to the other nine profiles studied in this report, based on the delivery of raw data but also value-added services.

Skybox Imaging was created in 2009, as part of a Stanford graduate entrepreneurship course with the purpose of lowering the costs and changing the approach towards building and operating metric resolution optical satellites. After securing venture capital funding, the company manufactured its first two satellites in-house and launched them in 2013. In 2014 the company was acquired by Google to fuel the company's mapping and location-based services. Skybox Imaging was renamed as Terra Bella to indicate its focus on image analytics for Google needs.

The timeline for Planet since its creation in terms of operations, finance or corporate milestones is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Figure 19: Planet's timeline



Financing and revenues

Planet is the EO operator who has managed to raise the most venture capital funding with a total of $183 million (see **Fehler! Verweisquelle konnte nicht gefunden werden.**), through various financing rounds.

On the other side SkyBox (future TerraBella), raised a total of $91 million from venture capital. It initially raised $3 million from Khosla Ventures as a Series A financing round in 2010, then $18 million as a Series B from Khosla Ventures and Bessemer Ventures in 2011, and finally completed a Series C financing of $70 million from Canaan Partners, Norwest Ventures, Bessemer Ventures, and Khosla Ventures.

In 2014 Skybox Imaging was acquired by Google for $500 million. These funds allowed the development and expansion of the company's assets on the ground and in orbit, permitting the production and launch of new SkySat satellites. On the Google side, the objective was to acquire both Skybox's high-revisit satellite imagery to benefit applications such as Google Maps, as well as its analytics and data processing capabilities (one of the key expertise areas of Google) to consolidate and develop its position on the market. SkyBox targeted the market segments interested in Very High-Resolution up-to-date information.Its satellites offered a compromise between the two extremes of the revisit-resolution pair, with better resolution and lifespan than extremely small satellites but higher revisit rates.

Meanwhile, Planet raised money through debt in 2015, allowing Planet to purchase European EO operator Blackbridge and its already deployed RapidEye constellation. With this acquisition Planet got access to Blackbridge's imagery, customer network, and sales revenues. Multiple venture capital companies have invested in Planet through various rounds. Investors include Data Collective, Capricorn Investment Group, Draper Fisher Jurvetson (DFJ), FF Angel LLC, Innovation Endeavors, First Round, Oreilly AlphaTech Ventures, DBL investors, Space Angels Network, Dylan Tailor, Yuri Milner, AME Cloud Ventures, Felicis Ventures, Founders Fund, Lux Capital, and many more others.

In March 2016 Google announced a change of name for the company from Skybox Imaging to Terra Bella. In the same way, the business model changed, as the company moved from providing just imagery to the provision of a variety of information products and analysis using its imagery and other data sources.

In February 2017 Planet agreed with Google to acquire Terra Bella and its SkySat constellation for an estimated $500 million. However Google took an Equity stake in Planet in addition to a multi-year imagery contract.

In March 2016 Planet declared that it was not yet profitable. We estimate that the company has contracts of a total value around $160 million. Planet's 2017 revenues remain undisclosed but are estimated between $45 and $70 million.

Table 24: Planet's funding history

DATE	ROUND	AMOUNT RAISED
April 2015	Round C	$23 million
January 2015	Round C	$70 million
January 2015	Debt	$25 million
December 2013	Round B	$52 million
June 2013	Round A	$13 million

Planet's business focuses on imagery and analytics services based on change detection. These services are sold on a subscription basis. Unlike raw imagery providers, Planet aims to sell information processing and analytics based on real-time, fact-based data, allowing customers to make decisions based on the latest information commercially available. This business approach is quite different from the traditional EO companies. Planet wants to offer global monitoring with low cost and daily online data delivery in place of the traditional localized task of collecting expensive data with higher responsiveness of acquisition.

The company is vertically integrated, with the engineering, manufacturing and operation of satellites. Planet designs, produces, and operates all of its "Dove" satellites in its headquarters in San Francisco, reducing production and operation costs. This approach is based on using consumer-grade COTS equipment and technology, including the optical imaging payload itself, procured from a non-space-rated supplier Imperx.

The acquisition of BlackBridge assured first revenues for Planet, whilst Terra Bella is expected to complement the current assets with higher resolution and lower revisit data.

The satellite imagery acquired by Planet's Dove constellation is processed and made available on end-user platforms with a short latency, thanks to the company's processing APIs.

Partnerships and external support to the development of the company

The company's core philosophy relies on vertical integration and the use of COTS technologies. Therefore, Planet has established few partnerships with industry players since its establishment. This might change as the company seeks to develop its applications and enter into new markets with existing service providers.

- Planet benefited from NASA expertise at its very beginnings, when it was still named Cosmogia Inc., as most of its co-founders were working at NASA and leveraged this experience to found the start-up.
- For all satellite deployment from the ISS, Planet has partnered with Nanoracks to use its NRCSD, a self-contained Cubesat deployer capable of deploying two Planet Doves at once (per deployer) from the Japanese Kibo module.
- Planet and Rocket Lab have signed a Launch Services Agreement in July 2016 for at least three dedicated launches on Rocket Lab's Electron launch vehicle. It is the first time Planet will be launched as a primary payload on dedicated flights.
- Acquisitions and multiples assets:
    - Through its acquisition of Blackbridge, and its RapidEye constellation, in 2015, Planet has gained five satellites of similar data offering at 6.5m resolution multispectral. It also gives Planet an existing customer base, existing data archive, and a distribution platform (on-line and resellers) in which it can leverage. Planet has inherited other partners such as MDA who built the RapidEye constellation payloads, but also its subsidiary Geospatial Services for a distribution deal in Canada. In Europe ESA is a customer of imagery and data and Harris Corporation was selected as a geospatial information distribution partner for the US.
    - Through its acquisition of Terra Bella, Planet is linked to Google and granted from a multi-annual contract. Planet is using Google cloud data center.
- In 2016, NGA has granted Planet with a $20 million contract to provide global imagery content to defense and intelligence agencies. With CIBORG initiative, NGA intends to benefit from

commercial imagery by buying commercial imagery as easy as possible for a GEOINT agency. The USGS which works closely with the NGA has identified Planet and some other concurrent as eligible for this initiative.

Deployment and exploitation of the satellites

To date Planet has launched more than 200 cubesats out of which 133 to 149 are operational. This is the largest fleet ever put in orbit, and the Flock-3p launch of 88 cubesats was the represented the most satellites deployed by a single launch. Planet first used the ISS as a deployment base for demonstrators and then the company deployed its constellation in SSO, where two main products could be retained, the Flock 2 series with Multispectral sensors and the Flock 3 series which in addition incorporate NIR band to better support land classification.

The constellation began deployment in 2014 through a combination of the International Space Station's Nanoracks cubesat deployer and various orbital launch vehicles, such as Orbital ATK's Antares, SpaceX's Falcon 9, Kosmotras' Dnepr, MHI's H-2B, ULA's Atlas V, and ISRO's PSLV-XL launchers. The variety of launchers used by the company shows that Planet is more interested in the launch date than in the launcher reliability or the launch cost. The deployment of the operational constellation will be made through three dedicated launches to SSO on Rocket Lab's Electron launcher.

Planet has developed its own global network of ground stations to support both spacecraft mission operations and image data downlink. It operates 10 X-band ground stations and will increase this number to 28 at 10 separate locations, in order to meet the downlink capacity requirements for a planned constellation of over 200 satellites operating simultaneously.

On the Terra Bella side, SkySat-1 was launched on a November 2013 cluster launch on a Dnepr rocket, while SkySat-2 was launched on 2014 as a secondary payload on a Soyuz-2-1b Fregat-M rocket. The first two satellites were built in house; the manufacturing of follow-on satellites is contracted to SSL. SkySat-3 to 7 were orbited as secondary payloads in 2016: SkySat-3 was launched in June on a PSLV-XL rocket commercialized by Antrix, ISRO's commercial arm, and SkySat-4 to 7 were launched together on Arianespace's Vega rocket in September. In October 2017, SkySat-8 to 13 were launched together with 4 Doves (Flock 3m) from Minotaur-C vehicle of Orbital ATK. This made Planet the primary customer for a launch for the first time, being able to choose the orbit and time of the launch. The full constellation of SkySats is expected to reach 24 units.

Characteristics of space assets

With vertical integration and the use of COTS hardware, Planet's satellites are deemed to cost under $500,000. Their limited lifespan (below one year) allows faster iteration and performance upgrade than heavier traditional satellites.

All Dove cubesats have the same 3U form factor and use a proprietary bus with 90mm aperture optical payload. They do not have a propulsion system and cannot be tasked as they take continuous imagery. While previous payloads in ISS orbit at 420km altitude (Flock-1) produced data in three visible spectral bands (RGB) from 3 to 5m ground resolution, the later launches to higher-altitude SSO featured better acquisition systems to maintain the same resolution. The expected lifetime is doubled and even tripled from ISS to SSO at a higher altitude and reduces atmospheric effects. The company has explored further bands into the near-infrared (for instance comparable to the SPOT-series array) in order to better support vegetation-monitoring land-use. Visible-only channels cannot assess crop health and typology in the same way as the addition of infrared channels. On the other hand, the Near Infrared (NIR) imaging sensor in Flock-3 series is built to ensure the smooth transition after the RapidEye constellation's end of life in the next year or few years.

The native geo-localisation accuracy is from 10km to 60km and after being processed with mosaic, color-corrected, and ortho-rectified, the product allows a 10m RMSE horizontally. During the month of May 2017, the 90th percentile of the imagery that was rectified and passed quality metrics was published within 5.5 hrs of being downlinked by a ground station.

Since October 2017, Planet is able with its Dove constellation to map the entire Earth daily including

open water areas.

Considering the SkySat constellation, SkySat-1 and 2, were the two first prototypes built in-house to test the acquisition of high resolution panchromatic and multispectral images of Earth. SkySat-3 to 21 satellites are part of the C series of SkySat design, with upgraded performance and propulsion. Terra Bella is currently working on the development of the SkySat next generation (D series), although no technical information has been released up to date. The use of COTS is deemed to reduce manufacturing costs.

Technical details of Planet's satellites are consolidated in **Fehler! Verweisquelle konnte nicht gefunden werden.** below.

Table 25: Technical main specifications of Planet's operational assets

	DOVE IN ISS ORBIT (x132) Not anymore in Operation Dove, Flock-1, Flock-2e	**DOVE IN SSO ORBIT (x163)** x11 Flock-1c, x12 Flock-2p, x88 Flock-3p, x48 Flock-2k, x4 Flock-3m	**RAPIDEYE** (BlackBridge) **(x5)**	**SkySat-1 & 2** (TerraBella) **(x2)**	**SkySat-3 to 7** (TerraBella) **(x11) SkySat-8 to 13**
MASS	~5 kg, (3U Cubesat)	~5 kg, (3U Cubesat)	~156 kg	83 kg, 60x60x80 cm	120 kg, 60x60x95 cm
PAYLOAD SUPPLIER		Imperx		In house by SkyBox (TerraBella)	Provided by SSL or MDA
ORBIT INCLINATION	52°	98°	98°	97.56°	98.3° - 97°
GROUND RESOLUTION	• 2.7 - 3.7m for 4 Doves • 3 - 5m for Flock-1	3.7-4.9 m	6.5 m	1.1 m PAN 2 m MSP Video PAN 1.1m 30fps	0.9m-1.1m PAN 2 m MSP Video PAN 1.1m HD 30 fps
TEMPORAL REVISIT	Two weeks	Whole Earth daily	1 day	Up to 3 to 7 times a day (as a constellation)	
SWATH	n.a	n.a	77 km	8 km	8 km
ALTITUDE	420	506 and 630	630	500	515km SkySat3 695km SkySat-4-7 500km SkySat-8-13
LAUNCH & ESTIMATED LIFETIME	2013 – 2016, 1 year	2016 - …TBC 2-3 years	2008, >7 years	2013 – 2014, 6 years	2016 – 2017, TBC, 6+ years
ESTIM. COST UNIT	<$500 k		unknown	$20-$30 million	
SPECTRAL BAND WAVELENGTH					
BLUE	420 - 530nm		440 – 510 nm	450-900 nm	
GREEN	500 - 590nm		520 – 590 nm	450-515 nm	
RED	610 - 700nm		630 – 685 nm	515-595 nm	
RED Edge	n.a		690 – 730nm	605-695 nm	

NIR	n.a	Available from Flock 3	760 – 850 nm	740-900 nm

The Dove satellites have been deployed simultaneously into a single orbit as a Flock. Planet has flown three main generations of optical instruments so far, while staying within the 3U Cubesat form factor.

The SkySat optical imager covers five multispectral channels, achieving a multispectral resolution of 2 m Pansharpened at the 0.9m delivering a VHR imagery with a narrow VHR swath of 8 km at nadir, almost half of a regular VHR sensor. Stereo imaging is supported by the satellite, which also acquires high-definition video in its Pan channel with durations of up to 90 seconds in which the satellite can keep looking at the ground target by slewing to compensate for the movement in its orbit. With the first civil VHR video products, the SkySat satellites offer an interesting potential for the development of new future applications.

Targeted market, services and key customers

Planet is looking at various distinct markets for optical imagery and analytics:

- **Agriculture and environment:** The Planet constellation offers high-frequency imaging satellites that can deliver a constant stream of current information to identify changes in agriculture (crops and soil), forestry, and water data. The third generation of Flock integrates NIR spectral band to ensure service continuity with RapideEye. The SkySat constellation with a submeter resolution will also better respond to this demand.
- **Government and Defense**: Its high resolution imagery and high revisit rate is well suited for defense applications and government clients, such as applications including security and civil protection, monitoring, law enforcement, and foreign defense operations. In addition, the company offers APIs, services, and tools to power applications and derive answers from geospatial data.
- **Infrastructure:** Planet imagery offers web-platform to make well-informed decisions faster with global situational awareness and frequent data offerings, but TerraBella's offerings target applications that include 3D mapping, urban planning and development, real estate, supply chain changes, transport and construction. These applications require moderate to very-high resolution imagery with frequent revisit rate, which can be used for planning as well as site monitoring and logistics activities.
- **Energy:** Monitoring of regulation enforcement, pipelines, construction sites, encroachments is made possible by the Planet assets, allowing a quick detection of intrusions or encroachment on energy and utility infrastructures, and detecting changes that can impact businesses, whether mining growth, land reclamation, wells or exploration.
- **Location-Based Services (LBS):** LBS require imagery with high revisit rates, which Planet constellation offers. In addition, the continuous data reveals changing land use, new road construction, urban development, and more, ensuring maps are accurate, up-to-date, and relevant that can be captured by Google' powerful machine learning and analytics capabilities.
- **Disaster Response & Emergency Aid**: Terra Bella's products and services could aid first responders in rescue coordination as well as long-term monitoring of reconstruction, recovery and relief efforts.

The company reports 400 customers, using Planet's services to develop analytics on top of the company's APIs, creating applications dedicated to specific markets of interest, such as FarmersEdge, FarmDrive, Descartes Labs and FarmLogs for example, who work specifically to address the agriculture analytics. Other companies include Remote Sensing Metrics, Geoplex, Orbital Insight, Geospatial Services, and the Washington Post, for example. Planet won a major National Geospatial-Intelligence Agency contract in October 2016, worth $20 million for a 7-month period, as part of the White House "Harnessing the Small Satellite Revolution" initiative, to access Planet's global imagery archive, updated every 15 days. From this information, we can estimate Planet's global world map price point to be around $1.4 million.

Schedule and outlook

The transition from Blackbridge (RapidEye) imagery to Planet's assets will be a change of paradigm for the company and its customers, for which continuity of service is critical. Planet will have to prove it is capable of ensuring this service continuity with its own constellation.

With the acquisition of the TerraBella, the SkySat constellation continues its development under Planet's control. The objective of Planet is to provide a diversity of resolution and to ensure a suitable geolocation with enough accuracy able to capture the defense market.

Planet will have to launch several dozens of new Dove satellites into SSO every year to maintain its full operational capability, which is a challenge considering the current bottleneck in the launcher market. The company will also need to prove how to monetize its services.

From a financial standpoint, the company has been successful in raising capital but has to prove the validity of its business model and keep a continuous investment flow to finance its fleet replacement and generate a return on investment.

Planet's success depends on various other aspects. Among them, its capacity to monetize their products and services in a profitable and sustainable way; the interest on the commercial market for medium-resolution imagery and data as well as for global monitoring instead of localized monitoring; and finally the competitive environment, with other EO operators that could propose a better resolution/revisit package.

Planet is also working discreetly on SAR for its Dove satellite according to a press release of June 29 2017. It is anticipated that the company will develop integrated change detection analytics in-house and work with third-party service providers. The company is supposed to continue with the development of SkySat satellites since TerraBella owned a transmission license to operate a total of 24 satellites granted in 2013.

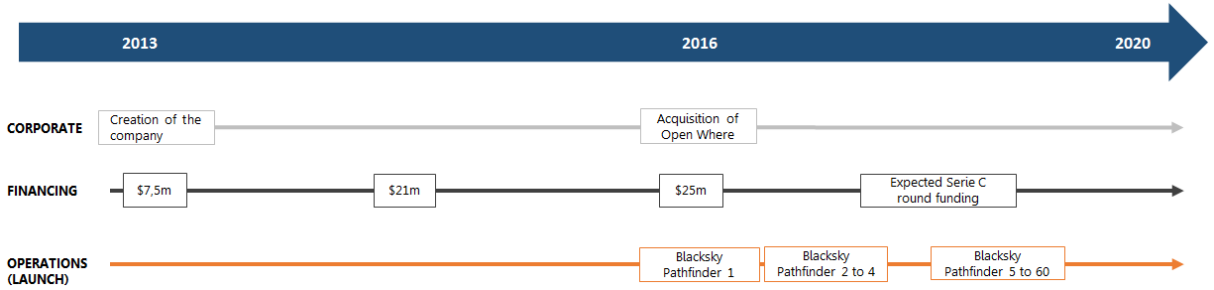
5.3.5 BlackSky Global

Headquarters	Seattle, United States	
Founded	2013 by Jason Andrews, Marc Andreessen	
Investors	Vulcan Capital, Razor's Edge, Chugach Alaska Corporation, Mithril Capital Management	
Heritage	BlackSky Global was founded in 2013 and is now a wholly-owned subsidiary of Spaceflight Industries	
Key Partners	• AllSource Analysis	• Hexagon Geospatial

BlackSky intends to provide cost-effective, high-resolution solutions towards revisit measured in hours through a constellation of 60 small optical satellites to be operational by 2020. The company targets markets with need for location based services (LBS) applications which rely on high-frequency change detection monitoring. BlackSky Global is a wholly-owned subsidiary of SpaceFlight Industries.

The timeline for Digital Globe since its creation in terms of operations, finance or corporate milestones is detailed in Figure 20.

Figure 20: Black Sky's timeline



Financing and revenues

Spaceflight Industries (BlackSky's parent company) has raised a total of $53.5 million over the past two years, a portion of which has gone toward funding BlackSky Global. Among the $25 million raised in 2016, $18 million of the 2016's Serie B round table were dedicated to the acquisition of OpenWhere a data analytics company (see Table 26). The company claims it is fully funded to deploy six spacecraft by the end of 2016 and has plans to conduct larger series C-funding round to support the deployment of full constellation.

BlackSky does not report revenues yet.

Table 26: Black Sky's funding history

DATE	ROUND	AMOUNT RAISED
June 2016	Series B	$25 million
February 2015	Series B	$21 million
July 2013	Series A	$7.5 million

BlackSky intends to offer satellite imaging and product services to companies, organizations, and governments. The company plans to follow a "pay-per-picture" revenue stream by capturing images of single sites with high temporal coverage or covering larger areas, as well as providing video at 1 FPS. BlackSky anticipates that its low pricing and high revisit rate will open up further EO markets relying on

high resolution change detection. BlackSky has announced that data price will be a fraction of currently available solutions, with premium service offerings for priority tasking. The company hopes that once its satellites are fully operational, it can provide high-resolution images (1m) in less than few hours upon request for under $100 per image. The first prototype satellite was launched in 2016.

Partnerships and external support to the development of the company

The Pathfinder constellation is to be built by Spaceflight Services (its parent company), while Harris Corp.'s Exelis division provides the imager. For product development, BlackSky has established partnerships with imagery intelligence provider AllSource Analysis, and information technologies provider Hexagon Geospatial. Partnerships with these companies is expected to target the development of change detection analytics which can support several vertical markets. BlackSky through Spaceflight recently acquired OpenWhere, a company that develops software to collect, process and analyze geospatial data, aimed to support data gathered from BlackSky.

BlackSky also established a partnership with United Nation Institute for Training and Research (UNITAR) to explore how imaging can be applied to humanitarian relief, human security, climate change adaptation, sustainable water management, territorial management, high priority peace-keeping missions, and maritime monitoring of illegal activity.

BlackSky recently signed a two-year contract with $16.4M value with the US Air Force Research Laboratory to provide a geospatial data platform for on-demand analytics and multisource information. This platform is developed in partnership with the US NGA.

Deployment and exploitation of the satellites

Black Sky Global plans to launch its 60 satellite constellation by 2020. The BlackSky Pathfinder-1 satellite was launched in 2016 into a 450km SSO on a multi satellite launch using a PSLV rocket. Instead of sending a second demonstrator as planned, BlackSky Global will launch a first batch of 4 satellites in 2018 with Spaceflight services. In September 2017 a joint venture between Thales Alenia Space and Telespazio was announced to build and operate the 56 remaining satellites of the constellation and to establish a new smallsat manufacturing facility in the United States.

The BlackSky constellation leverages atypical orbits, using a combination of typical SSO orbits and inclined orbits (52°) to improve the revisit rate.

The company intends to use Spaceflight Networks for ground stations, around 17 of them, both owned and leased from others.

Characteristics of space assets

Each satellite has a mass of 44kg and costs approximately $15-$20 million. The satellites are designed to provide cost-effective, high-resolution solutions (data and video) with hourly revisit. It also will provide video at 1 FPS. The satellites have 30GB of data storage memory onboard and the onboard propulsion system will enable to stay in orbit for about three years of projected life. This would imply that in order for services to continue, replenishment of the satellite constellation would need to be launched in the 2020-2021 timeframe. The multispectral component of the individual’s satellite units covers the three visible channels. The company refers to night data collection and the use of other sensors sensor without disclosing specific details. All details are consolidated in

Table 27: Technical specifications of Black Sky's operational assets

	Pathfinder
MANUFACTURER	Black Sky and Spaceflight Industries
PAYLOAD SUPPLIER	Harris Corp'.s Exelis for the fisrts 4 satellites Thales Alenia Space and Telespazio (#5-60)
MASS	44 kg
GROUND RESOLUTION	1 m
SPECTRAL RESOLUTION	Color / Multispectral
TEMPORAL REVISIT	>80 / day
SWATH	6.6 km x 450 km
LAUNCH & ESTIMATED LIFETIME	2016 demonstrator: 1 sat. 2018: 4 satellites 2020 full constellation 60 sat. 3 years lifetime
ESTIMATED COST UNIT	$10 to 20 million
SPECTRAL BAND WAVELENGTH	
BLUE	400-510 nm
GREEN	510-580 nm
RED	590-750 nm

The specification of the upcoming satellites are deemed to be identical to the Pathfinder. With 60 satellites the company aims increase its revisit capacity, up to 42 times / day for cities at 33° like Baghdad, 52 times / day for cities at 39° like Beijing and up to 80 time / day for the 48° latitude like Seattle.

Targeted market, services and key customers

BlackSky is looking at various distinct markets for optical imagery and analytics:

- **Location Based Services (LBS):** LBS requires imagery with high revisit rates, which BlackSky is positioning to offer through 60 satellite constellation. Some of the target applications could include resource management, intelligence, geospatial technology, weather, disaster response, human rights, media and entertainment.
- **Defense:** BlackSky Global's satellite-imaging constellation with resolution of 1m or lower can provide time-critical imagery for high-priority national security, defense and law enforcement actions, customs and border protection and critical infrastructure protection
- **Infrastructure:** The planned spacecraft will fly over most major cities and economic zones between 40-70 times/day. This high revisit rate allows organizations to monitor basic infrastructure, economic activity, borders and key natural resources for abnormal or illegal activity.

BlackSky is creating a Web-scale software platform for customers to request and receive imagery online. Customers can request imagery through the website, and depending on the position of the satellite at the time, imagery will be captured and sent to the nearest ground station. Services are expected to be delivered either ad-hoc, or through a subscription basis from the online platform. The

company aims to achieve “social media speeds” for content acquisition and delivery with a Tasking, Collection, Processing, Exploitation and Dissemination (TCPED) below 90 minutes.

Key customers will be offered an API (application program interface) into the system so they can order imagery directly. However, for interested customers, the company is considering to offer dedicated ground stations for direct control of the satellite over their region.

Schedule and outlook

BlackSky Global is in advanced stages of development with one demonstrator in orbit and a first batch to be launched during 2017. In that regard, compared to imaging constellations in planning – this would make it one of the first.

Even though, Black Sky is established as an autonomous company with its own management, it leverages services from subsidiaries of Spaceflight in manufacturing, launch and operations. Access to space is also becoming an issue: even if the company benefits from its Spaceflight services launch brokering, the unavailability of a launch vehicle remains critical to the deployment of the constellation on time.

Current levels of investment are not considered sufficient for full constellation roll-out, therefore other investment partners are likely to be sought. BlackSky’s business model of ‘pay-per-picture’ is relatively new to the industry and has the potential to open up demand from diverse markets.

It is developing a platform that will allow customers to rapidly request, receive, and interact with satellite imagery via the internet. This will decrease the turnaround time for data requested and delivery. This is a shift from the “traditional” more ad-hoc, tailored services currently delivered – there are few standardised services currently available. Market acceptance for new services can always be an issue, but it is felt that there is a need for high frequency product delivery to guide decision making in near-real time. Such services for instance can have high value in finance, agricultural markets etc. if proof of concept is achieved. Such services are expected to be developed with partners. Some services however, and especially defense end-users, require a higher geolocation accuracy than what can be achieved with a less stable, smaller platform. Post-processing is thus expected to be required to increase the satellite’s native accuracy, such as by using Ground Control Points (GCPs).

5.3.6 NorthStar

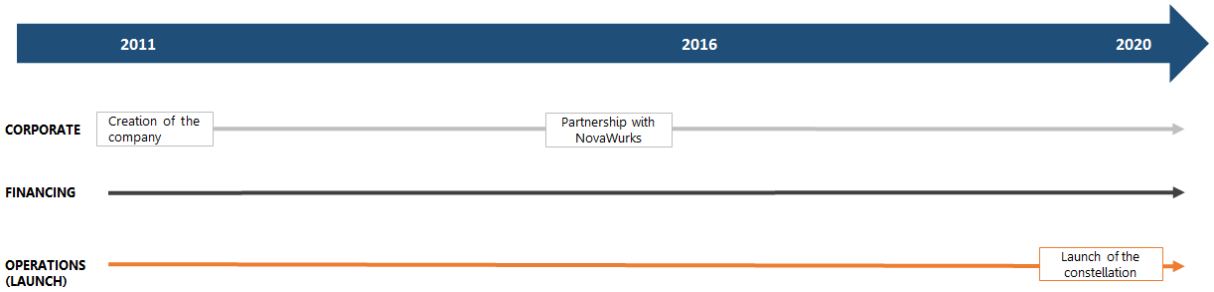
Headquarters	Montreal, Canada
Founded	2012 by Steward Bain, Kjell Stakkestad, Bob Maskell
Investors	KinetX
Heritage	EOSat technology and operation heritage of founders
Key Partners	• IBM • Boeing

NorthStar Space Data Inc. (NSDI) aims to be the first commercial hyperspectral constellation with up to 40 satellites. NorthStar focuses on wide spectral resolution combined to medium temporal resolution rather than high ground resolution only. The company wants to develop a market for hyperspectral value-added services collected from space (as of today, the commercial sector relies on aerial/UAV sensor data). NSDI estimates its constellation will downlink more than 3 Gbps of data, equating to 259,200 Gb every day.

Early in 2015 NovaWurks of Canada, signed an agreement to provide NorthStar's space segment specification, satellite design and concept of operations to support the NorthStar satellite constellation.

The timeline of NorthStar since its creation is detailed in Figure 21.

Figure 21: NorthStar's timeline



Financing and revenues

NorthStar's business is based on the commercialization of hyperspectral imagery collected at high temporal resolution through a constellation. With high temporal resolution becoming a new standard of the industry, NorthStar aims to offer more spectral resolution than its competitors while some of them are more focused on higher ground resolution. At this stage, NorthStar did not disclosed details about its revenue model (pay per picture or subscription agreement). The processing knowledge required to develop hyperspectral solutions will be a differentiator.

Partnerships and external support to the development of the company

Early in 2015 NovaWurks, a high-technology space applications company, signed an agreement to provide NorthStar's space segment specification, satellite design and concept of operations to support the NorthStar satellite constellation. NovaWurks is developing satellite building blocks dubbed satlets under a contract with the U.S. Defense Advanced Research Projects Agency.

NorthStar has established several key industrial partnerships and continues to explore for other partnership opportunities including with IBM, Boeing, ABB, NSSI, NovaWurks, VARDEC, LOOKNorth.

NorthStar has expressed interest in additional partnerships to access different geographic areas or the infrastructure necessary to bring customers the design.

Deployment and exploitation of the satellites

NorthStar plans the plan to launch a 40 satellite constellation with a goal to have initial operations by 2020, and full operations TBD.

Characteristics of the space assets

NorthStar's specific technical solution is not disclosed. The company aims to operate a 40 satellites constellation. However, collecting hyperspectral data in the range of 10m ground resolution with a revisit allowing for biweekly or even monthly revisit are the minimum specification to develop commercial application. The satlet concept developed by NovaWurks would likely apply to NorthStar's fleet. It gives more flexibility than traditional satellites by combining building blocks to perform various satellite functions and that can be assembled together in different ways depending on the mission. According to public statement from a company executive, the NorthStar satellites will likely not all carry the same complement of payloads. In addition of Earth-facing sensors, satellites will include sensors looking at space situational awareness including launch, space debris and asteroid tracking.

Once the constellation is operational, the company reports they will be able to downlink more than 3 Gbps of data, equating to 259,200 Gb every day. All details are consolidated in Table 28.

Table 28: Technical specifications of NorthStar's operational assets

	Pathfinder (x40)
MANUFACTURER	NovaWurks
PAYLOAD SUPPLIER	Unknown
MASS	750 kg
GROUND RESOLUTION	<10m (estimated)
SPECTRAL RESOLUTION	More than 100 bands
TEMPORAL REVISIT	Unknown
LAUNCH & ESTIMATED LIFETIME	>2020, unknown
ESTIMATED COST UNIT	Unknown

Targeted market, services and key customers

NorthStar is looking at various distinct markets for hyperspectral imagery and analytics:

- **Agriculture:** The improved spectral capacity will allow for better yield prediction, identifying problem areas (under/over fertilized/irrigated), biophysical properties of crop health
- **Forestry:** There are similar applications in the forestry sector, and also included invasive species monitoring.
- **Environment and water:** compared to existing solutions, NorthStar's constellation would offer more precise information on the water quality of rivers and oceans for government environmental organizations.
- **Energy and natural resources:** Mining and energy corporations would benefit from

NorthStar's services to manage the environmental impact of explorations. As a Canadian company, the oil sand industry is expected to be a key customer.

- **Defense:** Identifying camouflaged objects is key. The benefit over UAV solutions will be in being able to monitor more regularly, and at a lower cost.
- **Space situational awareness:** with the ability to monitor launch and space activities, NorthStar targets the military and astronomy communities. Space monitoring and traffic management is a growing issue in established space nations. The U.S DoD is currently in charge of the activity relying on in-house capabilities. However, there are current discussions to transfer this authority to the Federal Aviation Administration.

Schedule and outlook

NorthStar is in the early development phase of its constellation, in that regards the company is behind other its competitors but more innovative with the goal of selling hyperspectral services.

NorthStar wants to produce Earth observation solutions to diverse markets worldwide via predictive analytics based on hyperspectral imagery. Target markets are those which can benefit from a greater spectral response. If hyperspectral data is collected in the range of 10m ground resolution with a revisit allowing for biweekly or even monthly revisit, there is significant potential in services which require greater granularity across the infrared part of the electromagnetic spectrum: especially in especially in agriculture, energy, and defense. In that regards aerial/UAVs are the only imagery provider on the market yet, for instance in supporting the mining, agriculture, and defense sectors.

Market acceptance for new services can always be an issue, but it is felt that there is a need for high frequency product delivery to guide decision making in near-real time. Such services for instance can have high value in finance, agricultural markets etc. if proof of concept is achieved. The company has yet to secure its new business case on a market which does not exist yet. In order of comparison previous and smaller commercial hyperspectral initiative like HyspecIQ have failed to secure commitments.

One blockage could be US regulations allowing for commercial higher resolution hyperspectral solutions in the US (noting that Northstar is Canadian). Concerns over the ability to monitor camouflaged objects are likely to be a key factor.

From a manufacturing point of view, the NovaWurks's HISat concept still has to be proven.

Current levels of investment are not disclosed and therefore other investment partners are likely to be sought.

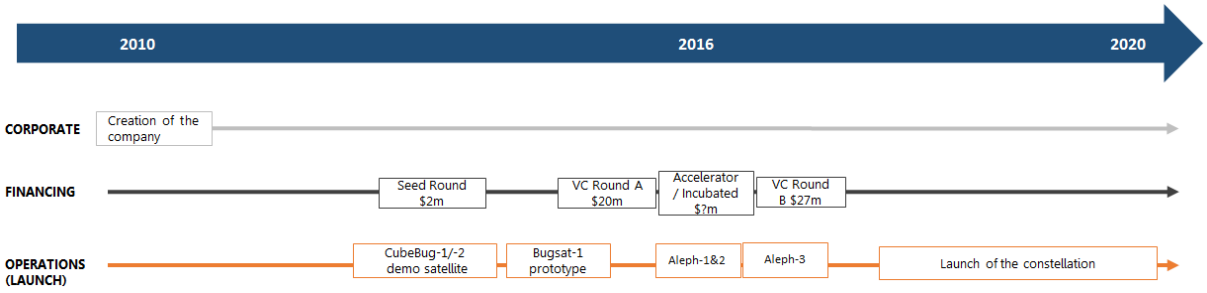
With this in mind, the plan to launch a 40 satellite constellation with a goal to have initial operations by 2020, and full operations two years after could be seen as too ambitious. Strong support will be required to face difficulties regarding hyperspectral analysis and its hyper-sensibility to weather conditions, in particular of lighting, of humidity and other local conditions.

5.3.7 Satellogic

Headquarters	Palo Alto, United States	
Founded	2010 by Emiliano Kargieman	
Investors	Pitanga Fund, Tencent Holdings, Valor Capital Group	
Heritage	No previous heritage, fundamental shift in building satellites by adopting agile aerospace methodologies, lowering lead times, development cost	
Key Partners	• National Atomic Energy Commission	• INVAP

Satellogic is an American and Argentinian company aiming to better address the management and distribution of scarce natural resources. The target applications include food production and security, energy production and distribution, infrastructure monitoring, and disaster response. The satellites plan to provide high-resolution and hyperspectral imagery as well as Thermal InfraRed and video on a real-time basis. Imagery will be provided by a constellation up to 300 small satellites by 2020.

Figure 22: Satellogic's timeline



Satellogic has so far raised more than $49m. Of this, $10m is funded by the Science portfolio through an investment together with the INVAP and private investors (see Table 29). To complete the development and launch of its initial constellation, Satellogic raised additional funds (the amount was not disclosed) in 2016 while the company was incubated. In 2017 Satellogic raised $27 million in a Serie B round led by Chinese internet giant Tencent, this time orienting the development toward an additional asset with Hyperspectral sensors.

Table 29: Satellogic's funding history

DATE	ROUND	AMOUNT RAISED
2017	Serie B	$27 million
February 2016	Incubated	Not disclosed
2013	Series A	$10 million
2013	Seed round	$2 million

Financing and revenues

Satellogic wants to market data and services based on a very high revisit rate (every 5 minutes once the constellation is operational).

Few details have been disclosed regarding the company's revenue stream regarding the use of subscription or "pay-per-picture". It intends to offer high temporal coverage or cover larger areas, as well as provide real video. Satellogic anticipates that lower pricing (compared to current high resolution data solutions) and high revisit rate will aim to open up further EO markets relying in high resolution change detection.

To achieve its pricing objective, the company is vertically integrated from satellite manufacturing of low cost satellites to delivery of value-added services.

Partnerships and external support to the development of the company

The initial two CubeBugs were developed by Satellogic in collaboration with INVAP (an Argentinian company), which acted as the project incubator, and financed by Argentina´s Ministry of Science, Technology and Productive Innovation as well as private investors. Since then the company has not established any major partnerships and focused on developing capabilities in-house.

The company is even developing analytics platforms in-house to facilitate ease of usage for end customers. However, Satellogic has expressed interest in collaborating for ground operations.

Deployment and exploitation of the satellites

The company implements an incremental development approach towards building the constellation of 300 satellites, named Aleph. Satellogic launched three first prototypes (named CubeBug and then BugSat) between 2013 and 2014 to test the platform and payload.

Satellogic opened a manufacturing facility in Montevideo, Uruguay in 2015 with a 10,000 square foot clean room to produce several dozen satellites per year.

The company expects to launch 12 to 18 satellites in 2018 with the aim to complete a constellation of over 60 satellites by 2019. The goal remains to launch 300 by early next decade.

Satellogic will use a combination of its own ground stations and third party stations to tap into a network of more than 20 around the world. Satellogic currently has two of its own stations operational, and plans to complete another two before the end of the year.

Characteristics of space assets

Satellogic aims to operate a constellation up to 300 satellites. The prototype satellite launched has less than 2m resolution, future satellites are expected to reach Very High Resolution (1m) in multi-spectral, and 30m in Hyperspectral from a range of 450 to 850 nm. The constellation architecture will allow the spacecraft a 5 min revisit rate at full constellation (300 satellites).

Satellogic plans to equip the constellation with a mesh topology that enables each satellite to remain in constant communication with other units. This is set to reduce costs and increase the speed of data delivery by reducing latency (data can be shifted through the network and downlinked to the appropriate ground station). All details are consolidated in Table 30.

Table 30: Technical specifications of Satellogic's upcoming assets

	Nusat / Aleph (x300)
MANUFACTURER	Satellogic
PAYLOAD SUPPLIER	Unknown
MASS	37 kg
GROUND RESOLUTION	• 1 m for MSP, • 30m for Hyperspectral • 90m Themal InfraRed • 1080 and 4K video

SPECTRAL RESOLUTION	PAN 400-900 plus a Large band color (400-690), B (400-510), G (510-580), R (580-690), NIR (750-900), Hyperspectral (450 to 850 nm), Thermal Infra-Red (8um-14um)
TEMPORAL REVISIT	>12 / day at first and up to 5min at full constellation
SWATH	5km: MSP and PAN same swath 150km: Hyperspectral 92km: TIR
LAUNCH & ESTIMATED LIFETIME	2016, 2017, 2018, 2019,etc. 3 years
ESTIMATED COST UNIT	< $5 million

Targeted market, services and key customers

Satellogic is looking at various distinct markets for optical imagery and analytics:

- **Environment Agriculture:** Satellogic targets natural resources monitoring, by providing quantified data with distributed sensor network around the Earth. The company sees potential customers for this service as both individual, with farmers and even consumers subscribing to this information, as well as large corporations and governments. The company is also examining opportunities in forestry related to calculating and maintaining wood stocks, and looking at carbon capture.
- **Energy:** Satellogic has pilot programs with end users in the energy markets today. The energy studies will focus on pipeline monitoring for oil and gas.
- **Disaster Response**
- **Business Intelligence**
- **Infrastructure monitoring**

The major area of interest for the company is to help better address the management and distribution of scarce natural resources. The target applications include food production and security, energy production and distribution, infrastructure monitoring, disaster response. Defense could also be expected to play a role depending on achievable geolocation accuracies.

The company has begun working with customers on co-developing applications for the constellation. For instance, the company is building pilot studies targeting agriculture and oil and gas.

Once the full system is operational, Satellogic intends to open the platform to developers, engineers and others who want to build their own code and software that will run on the platform and use the data from the constellation's sensors to generate data streams for analytics and decision making.

Schedule and outlook

Satellogic is in the early development phase of its constellation, in that regards the company is behind other its competitors.

Satellogic's business model of offering imaging solutions at high frequency revisits through a large satellite constellation is very similar to what is currently being offered by other companies profiled. The system is expected to move to 1m ground resolution which would put it in the range of BlackSky, TerraBella (Planet) and Hera Systems. In addition, compared to Satellogic, some of the competitors are in more advanced stages of development.

The constellation of 300 satellites is the largest in the EO sector, enabling a higher revisit rate compared to the competitors. However, without the full constellation being operational, temporal revisit would be reduced. The company therefore would not be able to refresh data as quickly – a key differentiating point compared to the competition.

In addition, Satellogic uses moderately customized COTS solutions, which means the shelf life of the satellites is at the lower end (2-3years). In order to maintain the whole system of satellites fully operational, it has to continuously launch the satellites to replace those which are close to the end of life.

5.3.8 Hera Systems

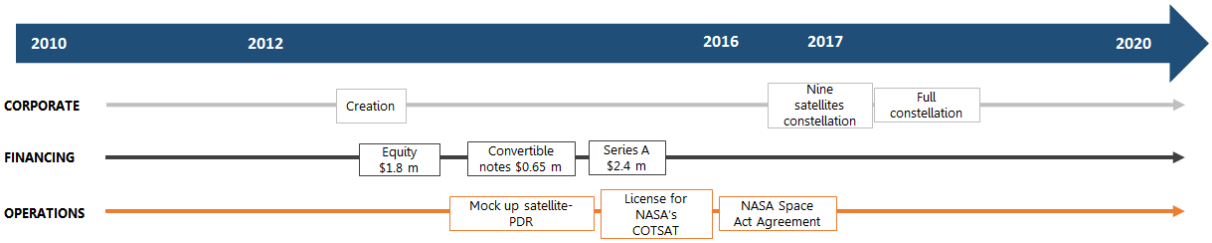
Headquarters	San Jose, California
Founded	2013 by Bobby Machinski, Dave Squires, Satish Chetty
Investors	Firsthand Technology Value Fund
Heritage	No previous heritage, company founded in 2013
Key Partners	• NASA (Ames Research Center)

Hera Systems was founded in 2013 and aims to capture and market Very High-Resolution Earth images, video, geospatial information and analytics in near-real time. The company aims to deliver such services for a fraction of the price offered by other EO operators.

It plans to launch a constellation of nine small satellites starting in 2018 with a 12U cubesat format, with plans to expand further to a constellation of up to 48 satellites. Bobby Machinski, Hera Systems' founder announced that Roger Robert, a long-retired Boeing executive, would be replacing him as CEO.

A detailed timeline of Hera Systems since its creation is shown in Figure 23.

Figure 23: Hera Systems' timeline



Financing and revenues

Hera Systems has not to date managed to raise the funding required its full constellation. It has successfully raised a total of $7.7 million since 2013, half of which from Firsthand Technology Value Fund in late 2015. The company to closed a Series B investment round of $2.99 million (see Table 31) that will help to complete the development and launch of its first satellite of its initial constellation. In particular, the company estimates a total investment of $45 to 53 million to complete the constellation.

The company's revenues remain undisclosed, but one can assume it is not profitable; as it remains without any operational assets generating revenues while dedicating resources to R&D and production.

Table 31: Hera System's funding history

DATE	ROUND	AMOUNT RAISED
August 2017	VC Serie B	$2.99 million
September 2015	VC Series A	$2.4 million
June 2015	*Convertible Notes*	*$0.65 million*

December 2013	Angel funds	$1.8 million

Hera Systems wishes to expand the EO value-added services market by widening its customer base. The company has adopted a breakthrough extra low-cost pricing and simplified ordering process aims to minimize the obstacles that usually put such imagery products. Hera has unveiled the industry's most aggressive pricing for high-resolution satellite imagery and video, with a per-square-kilometre pricing as low as $1 for archived 1 m resolution imagery, $2 for freshly tasked 1 m imagery orders, and $3 for 50 cm resolution products. The Hera constellation differs in it's an approach to data collection when compared to other large imaging constellations: whilst some, such as Planet, target a more continuous global coverage data collection, the Hera model targets repetition over specific points.

The company revenue streams based on subscription for value-added services delivered from a web portal.

Hera Systems is targeting organizations whether commercial or government, with important needs in Earth information products for continual, ongoing monitoring activities, and seeks to offer the most affordable, easy-to-access high-resolution satellite imagery possible through a one stop shop provider.

To achieve its pricing objectives, the company is vertically integrated from satellite manufacturing of low cost satellites to delivery of value-added services.

Partnerships and external support to the development of the company

As of Q1 2017 the company has only signed one partnership with NASA. The company will seek business and market alliances with a number of companies, including distributors and companies that are already operating in Hera's priority vertical markets.

Hera has partnered with NASA Ames through a Non-Reimbursable Space Act Agreement (SAA), to collaborate on the development of an upgraded satellite design based on NASA's existing COTSAT program. COTSAT is a rapid-prototype, low-cost spacecraft for science experiments and technology demonstration. Through this agreement Hera hopes leverage on NASA experience. CEO Bobby Machinski claimed this partnership will shorten the time to market by 18 months and reduce its R&D expenses Hera systems has confirmed that it had discussions with the U.S. National Geospatial-Intelligence Agency, to understand better the product offering of the satellite. Other partners are expected to be in discussion with for developing applications targeted at specific verticals (defense, agriculture etc.)

Deployment and exploitation of the satellites

Hera Systems has not launched any of its 48 satellites yet.

The company missed its initial 2016Q4 launch target for the first six satellites but and never released any details on the launch service provider. With the deployment of the first generation of nine satellites slipping to 2018, the second generation initially anticipated for late 2017 will likely be delayed too after 2018.

No information is available about the ground segment

Characteristics of space assets

1HOPsat will capture imagery using a telescope and camera combination optimized for the 12U form factor. The imaging system offers a 31cm Ground Sample Distance (GSD) in four spectral bands (Red, Blue, Green, and Yellow) and a 1m GSD in eight spectral bands (RGBY, Coastal Blue, Red Edge, and two NIR bands). They will also be capable of capturing full color, full frame high-resolution video. With the second generation Hera targets to capture imagery with a 22cm GSD.

One innovative and discernable feature offered by Hera is the on-board analytics capabilities, which it

claims is an industry first. With detection systems based on algorithms, the possibility to run third-party applications, and a convolutional neural network, its satellites can detect, process and alert other satellites to an emerging situation, and actually process the imagery by itself. Furthermore, its propulsion system allows a certain flexibility to launch on a number of launch vehicles at varying altitudes and inclination. The use of 12U cubesat form factor gives more flexibility to Hera by using standardized deployers that can be flown as secondary payloads on launches. A miniaturized star-tracker on-board a smallsat will also assist in keeping the platform stable – resulting in a higher native geolocation accuracy than perhaps what can be achieved by other smallsat imaging solutions.

With 48 satellites the company should be able to provide near-hourly updates with a mix of sun-synchronous and inclined orbit capabilities, these satellites will enable coverage of the entire globe and at varying times during the day. The satellites will also feature AIS (Automatic Identification System) receiver for ship and plane monitoring. All details are consolidated in Table 31.

Table 32: Technical specifications of Hera System's upcoming assets

	1HOPSat (x48?)	2HOPSat (2nd generation)
PAYLOAD SUPPLIER	Unknown	
MASS	22 kg, (12U Cubesat)	< 300 kg, TBD
ORBIT INCLINATION	n.a	n.a
GROUND RESOLUTION	31cm to 1m	0,22 m
TEMPORAL REVISIT	Daily	Hourly
SWATH	n.a	n.a
LAUNCH & ESTIMATED LIFETIME	2018 3 to 5 years	n.a
ESTIMATED COST UNIT*	~$30 million	n.a
SPECTRAL BAND WAVELENGTH		
COASTAL BLUE	400-450 nm	n.a
BLUE	450-510 nm	
GREEN	510-580 nm	
YELLOW	585-625 nm	
RED	630-690 nm	
RED EDGE	705-745 nm	
NIR-1	770-895 nm	
NIR-2	860-1040 nm	

Targeted market, services and key customers

The company in the short term is targeting the more traditional approach of delivering solutions to government and enterprise customers. Once the constellation is fully deployed it intends to develop more consumer-based mobile applications: providing services, business analytics etc. to portable devices. Target markets mirror that of the other constellation, including, energy, infrastructure development and operations monitoring, and natural resources monitoring. Although not recalled specifically, defense would also expect to be targeted.

Hera Systems is looking at various distinct markets for optical imagery and analytics:

- **Government**: Hera systems intends to primarily serve government and commercial organizations that need to monitor the Earth's changing features and to make smart decisions. The company sees potential applications in infrastructure monitoring, national security needs assessments.
- **Finance and Business Intelligence:** Hera system will enable customers to acquire imagery and video, as well as intelligent analytics and derived information, through a simplified user interface. The company's platforms offer imagery coupled with business intelligence to enterprises at a reasonable price. The satellite system has on board analytics with feature detection that is designed for faster processing and dispersion of required data.
- **AIS & ADS-B:** Maritime and aeronautical traffic monitoring is a potential market for Hera. The on-board analytics capability permitted by change-detection algorithms allows potential unusual activity or change-detection alerts to be sent in near-real time to the end user.

Hera Systems' will deliver daily imagery and video, as well as producing intelligent analytics and derived information products – and make them available on demand through a simplified user interface. The products for civil use will be made available "self-service" style via GeoSnap app, supported on a variety of platforms including mobile devices, smart phones and tablets, delivered in a variety of formats and imaging modes, and configured according to customers' specific technical data needs. However, it is unclear at this stage if the company will focus on a centralized distribution for data/services deliver (from its web-portal) or if it will seek global distribution partners.

Schedule and outlook

Hera is in the early development phase of its constellation, in that regards the company is behind some of its competitors.

Hera Systems success will largely rely on its guarantees to deliver data with the daily revisit it proposes. At 1m ground resolution, this would have the potential to open up further markets in the location-based-services domain. With its proposed data price points, it also has the potential to open up the imagery market to more cost-sensitive customers, or reduce the risk for potential new customers in adopting new solutions. However, there is also the potential for these other companies to price data even more competitively than the prices put forward by Hera. On the other hand, with the addition of the star-tracker Hera could increase native accuracies when compared to the competition. Deployment schedule has been over optimistic since the contract with the launch company is still not announced. While the build-up approach to the larger constellation is a way of spreading cost and building up incrementally, the ability to image daily with a constellation of nine smallsats is questionable.

This could present challenges in certain sectors if cost-benefit becomes difficult to prove. A major and required milestone for Hera would be to secure the investments necessary for the full design, production and launch phases of its constellation. Distribution is a further element to consider:

Civil government clients tend to prefer to work with local service providers to deliver solutions – explaining why existing operators have extensive data distribution networks – therefore centralizing activity may risk uptake to such end-users.

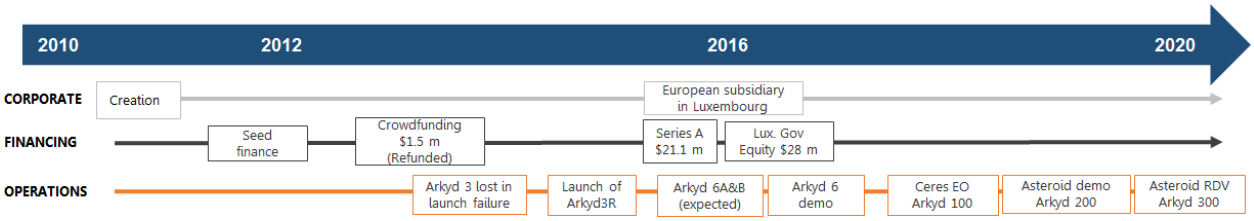
This said, a competitively priced high resolution data solution with high revisit, and a good native geolocation accuracy could be an interesting proposition from defense end-users to more consumer driven mobile applications. In addition, Hera has disclosed pricing structures for its imagery (archived / tasked) at $1 to $3, and if they could manage achieving these price targets, it could further strengthen Hera's competitive position in the industry.

5.3.9 Planetary Resources

Headquarters	Seattle, Washington		
Founded	2009 by Eric Anderson, Peter Diamandis		
Investors	• Larry Page • Bryan Johnson	• Eric Schmidt • Ross Perot, Jr.	• Charles Simonyi • Space Angels Network
Heritage	Founders are entrepreneurs who previously founded a space tourism company and the X Prize foundation. The executive/engineering teams have NASA experience in robotic planetary missions.		
Key Partners	• Bechtel • NASA • Bayer	• 3DSystems • Zooniverse • Nanoracks	• AGI • Luxembourg Government

Planetary Resources is the first private space mining company, founded in 2009, which plans to start extracting materials from asteroids by 2025. The company has set-up a strategic plan of cash-generating intermediate milestones until 2020. With Ceres, an EO constellation of 10 small hyperspectral satellites, the company aims to both bring new spectral capabilities on the market and test technologies to be used for asteroid identification and characterization.

Figure 24: Planetary Resources' timeline



Planetary Resources successfully raised $1.5 million in one month from the crowdfunding platform Kickstarter in 2013 (17,000 backers). It was later cancelled and refunded. The company now relies on venture capital with $21.1 million to be dedicated to for Ceres constellation. This financing round was led by Bryan Johnson and the OS Fund; with participation from Idea Bulb Ventures, Tencent, Vast Ventures, Grishin Robotics, Conversion Capital, The Seraph Group, Space Angels Network, and Google co-founder Larry Page. Finally, Planetary Resources sold a minority stake in its European subsidiary to the Luxembourg government for €25 million, of which €12 million was direct capital investment and €13 million was grants from the Government of the Grand Duchy of Luxembourg, and the banking institution Société Nationale de Crédit et d'Investissement (SNCI).

Table 33: Planetary Resource's funding history

DATE	ROUND	AMOUNT RAISED
June 2016	Equity and Grant (Luxembourg Government)	€25 million ($28 million)
May 2016	Series A	$21.1 million
July 2013	Crowdfunding (Refunded in 2016)	$1.5 million
April 2012	Seed	Undisclosed

Note: In this section, we will focus on Planetary Resources' short term business operation on an EO satellite constellation only.

Financing and revenues

Planetary Resources intends to sell imagery services to identify materials and temperature signatures – a unique capability that does not exist on the market today through a hyperspectral. The company targets agriculture, oil & gas or financial markets.

To compete with established EO operators that are already providing commercial imagery in different multispectral wavelengths, the company plans to differentiate itself by offering enhanced data-driven services and imagery thanks to the additional spectral bands it covers, offering more data per pixel than multispectral solutions, with a high revisit rate and at a significantly lower cost.

The company will market weekly "service agreements", offering hyperspectral/mid-wave infrared data for any location on Earth at a cost lower than what competitors offer for multispectral data.

Partnerships and external support to the development of the company

Even though the company tries to be vertically integrated and independent as a way to develop its satellite by itself while reducing development and production costs, Planetary Resources has managed to develop several partnerships. The list below only features partnerships relevant for the Ceres constellation:

- The Luxembourg Government is a strong supporter of the company. It has agreed to purchase 49% of the equity in Planetary Resources' Luxembourg subsidiary operations (€25 million from the equity sale of which €12 million is cash and €13 is grants).
- Planetary signed a MoU with chemical and pharmaceutical giant Bayer in May 2016, for the development of applications and products based on its satellite imagery. Bayer intends to purchase these data from Planetary Resources to create new agricultural products and improve existing ones. The collaboration will be part of the Digital Farming Initiative at Bayer.
- For all prototype satellite deployment from the ISS, Planetary Resources contracted Nanoracks for deployment from the ISS
- Planetary Resources signed a MoU with Virgin Galactic in 2012 to deploy its Ceres constellation of Arkyd-100 spacecrafts.
- Analytical Graphics, Inc (AGI), a company that produces COTS software products for the aerospace and defense industry, such as the Satellite and Orbit Determination Tool Kits for space asset monitoring.
- NASA awarded two key contracts in 2015 to Planetary Resources, assisting the company in the development of critical small satellite technologies such as a compact hyperspectral imager, a 3D printed integrated structure, and propulsion systems. It will likely play an important role as a customer and as a funder.
- Luxembourg's law on space resources has evolved to foster space exploration attracting multiple space start-ups. Luxembourg is investing $225 million in asteroid mining initiatives, and Planetary Resources now has an office in the country.

Deployment and exploitation of the satellites

No Planetary Resources satellite other than the Arkyd 3R prototype has been successfully launched to date, as the first Arkyd 3 was lost in the 2014 Antares launch failure (3R stands for Reflight). Arkyd 3R was launched in April 2015 on a Falcon 9 v1.1, and deployed from the ISS. The next technology demonstration prototype Arkyd 6A is due to be launched in December 2017 as a secondary payload on an India's PSLV-C40 booked by Spaceflight Industries.

By 2019, the company plans to have the 10 satellites Ceres constellation operational. It is unclear if Planetary Resources will use the MoU with Virgin Galactic to launch Ceres constellation

No information is available about the ground segment.

Characteristics of space assets

First Planetary Resources satellites were technology demonstrators for the Arkyd-100 series. Ceres constellation features thermal infrared and hyperspectral and make use of the same hardware that is being tested on the Arkyd prototypes including, avionics, attitude determination and control, and instrumentation.

With arc-second resolution and hyperspectral sensors permitting data collection in 40 colour bands ranging from visible light to near-infrared, the 10 small satellites will collect data with higher spectral resolutions – out of the visible band – by measuring thermographic properties and detecting the composition of materials on Earth's surface. The mid-wave infrared sensor is the first commercial capability from space to offer thermographic mapping and night-imaging. The satellite will support optical communications for data exchange at high data rates, the Ceres constellation will feature an on-board processing to optimize collect and downlink. No propulsion system is anticipated before the introduction of the second generation of Arkyd satellites.

Table 34: Technical specifications of Her System's upcoming assets

	Arkyd-100 (10x)
PAYLOAD SUPPLIER	Unknown
MASS	15 kg (6U)
ORBIT INCLINATION	n.a
GROUND RESOLUTION	10 m Hyperspectral 15 m Midwave Infrared
SPECTRAL RESOLUTION	40 color bands hyperspectral, from the visible to near-infrared spectrum + midwave-infrared sensor
TEMPORAL REVISIT	Twice daily (Day and night)
SWATH	n.a
LAUNCH & ESTIMATED LIFETIME	December 2017, 4 years
ESTIMATED COST UNIT	n.a

Targeted market, services and key customers

Ceres can analyse the spectral signatures of crops and provide customized information to growers, identify energy and mineral resources, and monitor pipelines and remote infrastructure. The use of hyperspectral sensors allows services customization with either full hyperspectral data, or the requested wavelengths, temperatures and material composition only. Planetary Resources is looking at various distinct markets for the hyperspectral constellation:

- **Agriculture:** The Ceres constellation can offer high revisit hyperspectral and infrared data, and deliver daily information to identify changes in agriculture (crops and soil), forestry, as well as water quality and temperature data. Farmers can get advance warning of potential trouble spots in their fields, reduce losses and maximize their yield. The night imaging capability made possible by the mid-wave infrared sensors opens a new potential applications and add revisit.
- **Energy, Oil & Gas, Security:** Monitoring of pipelines or tanks for leaks, monitoring

construction sites and land encroachments is made possible by the Ceres constellation, as well as detecting changes that impact businesses, whether mining growth, land reclamation, or prospecting spots for future wells and exploration of potential mining sites.

- **Finance & Business Intelligence:** Ceres offers global situational awareness and fresh competitive intelligence. Monitoring of global crop yields, mine outputs and port traffic, progress tracking and much more is possible.
- **Infrastructure:** Planetary Resources' imagery offers platform to make well-informed decisions faster with global situational awareness and frequent data offerings. These applications include availability of up-to-date data for progress tracking, land use policy, economic development plans, monitor mine outputs, port traffic and more.
- **Disaster Response & Emergency Aid**: Planetary Resources' services can aid first responders in rescue coordination, for example in the case of wildfire tracking or pipeline failures. It also has the ability to keep on aiding rescue efforts at night thanks to its night imaging capability.
- **Meteorology**: Another capability permitted by the system's specifications is weather monitoring, wind, temperature and currents mapping, as well as climate-change surveillance.

It remains unclear how the data will be processed and distributed to the end user, however a corporate video suggests every end user will be able to access the company's imagery and analytics.

It remains unclear who the customers will be as the hyperspectral market remains unproven, although the Bayer partnership to process the imagery into geospatial information and analytics suggests that the agriculture and farming industry will be one of the main customer for the company's EO services. Bechtel Corporation, a world leader in construction and civil engineering, invested in the company 2013 and could also be an anchor customer.

Schedule and outlook

Planetary Resources has still to demonstrate its proof of concept phase of its constellation initiative but has achieved several milestones.

2016 proved to be a successful period for Planetary Resources. It managed to raise a lot of public interest in space mining, with its first demonstrator Arkyd-3R sent into space; U.S. President Obama's signing of the latest Commercial Space Launch Competitiveness Act that includes the first-time legalization of commercial asteroid-mining missions; and the announcement of a business model shift towards the operation of an Earth Observation constellation as a required milestone to generate revenues while testing key technologies for future asteroid prospection.

From a financial standpoint the company has been successful by raising of nearly $50 million to proceed with this schedule by producing and launching the Ceres EO constellation.

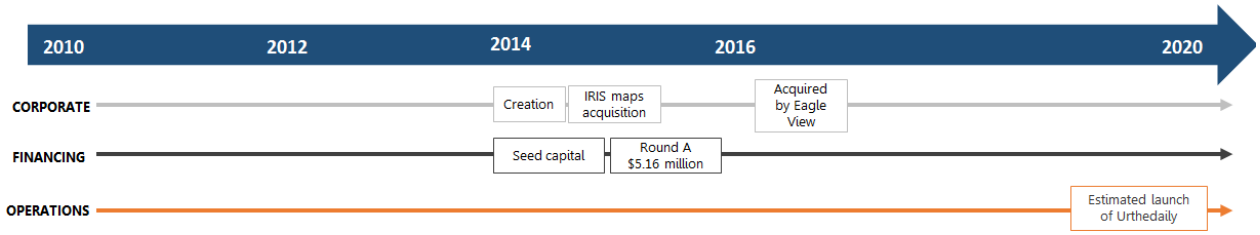
However, the market for hyperspectral solutions remains to be proven today, as its business case and profitability have not yet been determined. It remains to be seen whether Planetary Resources can keep up with the milestones it set, most importantly the production and launch of its Ceres constellation. So far, six years from the company set-up, the foundations have been laid but only a single cubesat prototype mission was launched. The hyperspectral remote sensing market remains to be proven as technically feasible, useful to the end-user, and economically attractive. As to short term revenue generation, the targeted Earth observation market is fiercely competitive while the market for commercial applications of hyperspectral imaging is very much unproven. Generating revenues through its EO hyperspectral and infrared constellation remains a required step to achieve its long term goals.

5.3.10 OmniEarth (EagleView)

Headquarters	Arlington, Virginia		
Founded	2014 by Lars Dyrud, Carter Old and Dylan Taylor		
Investors	Space Angels Network and Dylan Taylor		
Heritage	Grew out of GEOScan, a 2011 Johns Hopkins University Applied Physics Laboratory project		
Key Partners	• Dynetics • Harris Corporation • IBM	• Ball Aerospace • Spaceflight Industries • UrtheCast	• Draper Laboratory • Solers Inc. • Nearmap

OmniEarth plans to sell change-detection services and analytical to commercial, research and government organizations, in order to better monitor land-use. Initially the company planned to operate 18 satellites aiming to deliver medium to high resolution multispectral imagery data and products, as well as offering hosted payload volume on its satellites. The company now focuses on value-added services.

Figure 25: OmniEarth's timeline



The company is backed by InSpace Inc. and Fieldstone Partners. The company has so far raised a total of $5.16 million of venture capital in addition to seed capital, financed by the Space Angel Network and Dylan Taylor.

OmniEarth received a grant of $1.5 million from through California's Emergency Drought Grant program to develop its platform of water conservation management.

OmniEarth did not managed to raise the full funding required for the launch of its planned 18-satellite constellation, which was estimated to be around $250 million.

Despite the absence of any operational space assets to date, OmniEarth has started to sell data analytics services from an aerial supplier but the revenues are unknown.

Table 35: OmniEarth's funding history

DATE	ROUND	AMOUNT RAISED
Nov. 2016	Convertible	Undisclosed
May 2015	Series A	$5.16 million
2014	Seed	Undisclosed
2014	Seed	Undisclosed

Financing and revenues

Analytics is one of the key differentiators in OmniEarth's offering. Facing competitive data supply and financing difficulties the company changed its business model in 2016. It now focuses on value-added services and no longer plans to operate its constellation. OmniEarth now focuses on the value of information. The intent is to remove the human component from image analysis and deliver automated image recognition and change detection. The company seeks to leverage the analytics synergies between the Earth Observation, the Internet of Things, and the Big Data industries, which it sees merging into a much larger and faster growing global industry with huge potential in the future.

OmniEarth seeks to deliver its products and services through a platform based on a subscription model basis. This differs from current "traditional" service offerings which tend to focus on more tailored services delivered on an ad-hoc basis. Subscribers will have access to imagery and information products on demand through a constant stream of uploaded data and derived analytics.

The company's coarser (2m) resolution multispectral system lends itself more to agriculture, forestry, and water management applications. Applying change detection in this context, the company aims to support national reporting and decision making for land-use, as well as the private sector through, for instance, precision agriculture products.

The company has started commercial operations by offering water management tools and was contracted by two California water districts to deliver custom analytics via a cloud-based, geospatial solution that automatically classifies and calculates land cover-based water budgets through analysis of high-resolution aerial imagery. This is a first step for the company to operate without space assets, and OmniEarth wishes to extend this business model to other land-use markets beyond water management, such as agriculture, oil & gas and natural resources management. It also plans to extend its operations geographically.

Partnerships and external support to the development of the company

OmniEarth has established many partnerships across the entire value-chain, bringing together significant expertise and heritage in space mission design and realization.

- OmniEarth signed in 2014 a MoU with Spaceflight Inc. for rideshare launch services to its planned constellation of up to 18 satellites.
- OmniEarth acquired IRISmaps in 2014, a provider of cloud-based solutions capable to deliver the geospatial data to organizations, enabling them access to the information. OmniEarth integrated its software developers' experience with rich data fusion and analytics.
- In July 2016, UrtheCast and OmniEarth signed a strategic partnership to collaborate on UrtheCast's planned UrtheDaily constellation, which includes joint system development, the sharing of intellectual property and customer-marketing activities.
- OmniEarth partnered with Nearmap, an EO aerial operator providing both government agencies and commercial businesses with very high-resolution aerial imagery, to support their planned analytics product expansion and AI-related product offerings.
- OmniEarth partnered with IBM to use its IBM Watson machine learning automated intelligence system. Watson uses advanced algorithms and change-detection software and can sort through an estimated 150,000 images in 12 minutes. This data is eventually integrated marketed by OmniEarth.
- OmniEarth has partnered with Solers Inc. for secure cloud computing infrastructure and services, to support their expanding analytics.
- OmniEarth partnered with Dropcountr, a digital water management solution provider, to provide the Santa Ana Watershed Project Authority (SAWPA) with individualized water conservation recommendations directly to customers.
- Before the company shelved its constellation the following partnerships were secured:
    - OmniEarth partnered with Dynetics to manufacture scheduled satellites, based on Dynetics' TerraSense, a high-bandwidth and maneuverable smallsat platform featuring heritage from NASA's Fast, Affordable Science and Technology Satellite (FASTSat) program.
    - OmniEarth was also partnering with Ball Aerospace, for the optical systems.

As part of a hosted payload partnership, Harris Corporation was supposed to integrate the hosted payloads using Harris' AppStar reconfigurable payload platform, to leverage the available capacity for

secondary missions.

Deployment and exploitation of the satellites

Following the change of business model in 2016, OmniEarth no longer plans to operate its own asset and will rely on Urthecast's Urthedaily (see Urthecast profile). In the meantime, OmniEarth uses aerial imagery for nationwide high-resolution imagery delivered by its strategic partner Nearmap for its operations since June 28th, 2016.

Characteristics of space assets (as envisioned before the change of business model)

OmniEarth does not have any operational assets nor capabilities to date, and has reviewed the schedule for its constellation (15 satellites plus three spares), initially planned to be deployed in 2019. The satellites were expected to be in the high end of the small satellite segment with 80kg available for hosted secondary payloads. As a 15-satellite constellation at 2 to 5m resolution, the company targeted at least a daily revisit. These satellites were scheduled to use a time delay integration mode and the motion of the spacecraft to produce imagery in five colour bands. The cancelled constellation planned for each satellite to orbit seven minutes behind the next, each covering a 200-kilometer swath, allowing global coverage and high revisit with fewer satellites. The coverage was set to overlap by 20 kilometers, creating a constant flow of data that could have been compared to calibrate for accurate and precise measurements. The satellites' on-board propulsion system should have enabled to spacing of these satellites precisely throughout the orbit and maintenance of that position.

The satellites would have carried a 1m resolution panchromatic channel; this would have been expected to "pan-sharpen" the multispectral data sets in order to build a higher resolution data set. The five channels of the multispectral sensor were scheduled similar to the SPOT-series, with channels across the visible spectrum.

OmniEarth said its system would have offered a richer database than its competitors, because of its spacecraft capabilities leveraging Dynetics' experience on the flight-proven FASTSat NASA prototype, but with enhanced unique features included. Such features included Ka-band downlink capability of up to 4 Gbps instead of the traditional S-band (which remains in use for the uplink transmissions such as commands and telemetry), and a terabyte on-board data storage. Additionally, it would have featured a high-performance propulsion system for precise positioning and spacing between the satellites.

Table 36: Technical specifications of OmniEarth's assets that are no longer scheduled

DELETED FUTURE ASSETS **Now OmniEarth (Acquired by EagleView) focuses on Service side from Urthecast and Aerial Nearmap acquisitions** ***OmniEarth scheduled Constellation before having restructured its strategy***	
MANUFACTURER	*Dynetics*
PAYLOAD SUPPLIER	*Exelis, Harris*
MASS	*18 satellites x 300 kg (of which <80kg hosted payload)*
GROUND RESOLUTION	*MS: 2 to 5 m* *Panchromatic: 1 to 2 m*
SPECTRAL RESOLUTION	*MS: 5 color bands*
TEMPORAL REVISIT	*Daily*
SWATH	*200 km*
LAUNCH & ESTIMATED LIFETIME	*7-10 Years*
ESTIMATED COST UNIT*	*$10-20 million*

Targeted market, services and key customers

OmniEarth targets commercial and government organizations that need to use geospatial information for a variety of land-use purposes ranging from monitoring agricultural crops to monitoring infrastructure and natural resources management;

- **Agriculture, Natural Resources Monitoring:** The OmniEarth partnerships with data providers Urthecast (satellites) and Nearmap (aerial) can deliver daily information to identify changes in agriculture (crops and soil), forestry, and water data. Its data flow and analytics support multiple dimensions of agronomy, from optimizing field production to informing global food security, as well as water usage and quality.
- **Energy, Oil & Gas:** OmniEarth's access to a wide variety of imagery and geospatial data sets, along with proprietary decision support tools, inform all phases of development, from exploration to production, asset integrity, basin monitoring, and decommissioning.
- **Finance & Business Intelligence:** OmniEarth can offer global situational awareness and fresh competitive intelligence, as its on-board analytics capability allows geospatial information and analytics to be delivered directly to the cloud and the end user. Monitoring of global crop yields, mine outputs and port traffic, as well as supply chain tracking is therefore possible.
- **Asset Monitoring:** OmniEarth leverages a variety of satellite and aerial imagery partners to provide subscription-based monitoring of pipelines and other fixed assets. Change-detection algorithms identify differences in and around physical structures, providing customers with up-to-date information to manage and protect valuable assets.
- **Civil Government:** As in the SAWPA program for water utility agencies, OmniEarth supports local government agencies in their efforts for development, utility improvements, maintenance and emergency response by connecting sensor systems to geographic information systems (GIS) – improving efficiency and lowering costs for taxpayers.
- **Defense:** Now under contract with DARPA, OmniEarth aims to provide high-resolution decision making maps.

OmniEarth has started to sell data analytics services on the water management market thanks to its strategic partnership with Nearmap which produces very high resolution aerial imagery.

Through the partnerships it has developed, OmniEarth should offer its products and services directly to the end user via cloud-based infrastructure, enabling direct access from the web, or mobile devices.

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