"LETTING THE WORLD SEE THE WORLD"

MOBEO

EXECUTIVE SUMMARY

SPACETECH 13

DELFT UNIVERSITY OF TECHNOLOGY

DELFT, THE NETHERLANDS

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INTRODUCTION

SpaceTech

The company of MOBEO was established in 2010 by fifteen participants enrolled in the SpaceTech program at the Delft University of Technology. The SpaceTech program educates international mid-career professionals seeking expertise in space systems and business engineering to integrate technical, systems, business, managerial and personal skills for the realisation of successful products. At the heart of SpaceTech is the Central Case Project (CCP) that aims to simulate the creation of a credible commercial space-related business to apply the concepts of developing technical systems, and to adjust its parameters in order to make the conceived business feasible and profitable.

For the 2010-2011 SpaceTech Program, the participants were given the challenge to find an innovative, yet credible, business concept to deliver accurate, up to date and relevant geo-information to the mobile mass market. Undeterred by the challenges that have traditionally prevented the mass commercialisation of satellite imagery to date, the participants harnessed their creativity and, together, developed an innovative concept that will fundamentally change the way people live by making relevant, timely and accurate geo-information readily available to the world.

Scope

The purpose of this document is to present an innovative solution developed by MOBEO that addresses an enormous market opportunity with no direct competitors, and presents a business proposal that offers an opportunity for investors to participate in a business that will create an entire new economy that is a hybrid of the space and internet industry.

The proposed business plan is expected to be valued at $40 billion within the next fifteen years with $12 billion in revenue annually. MOBEO is currently seeking a $50 million investment to launch the business in 2012 with a potential return of factor 52 within the next fifteen years.

MOBEO, a limited partnership company (Ltd.) incorporated in the Isle of Man, has fifteen founding partners, listed at the end of this document, with a combined total of 150 years space industry experience. In this business proposal, MOBEO will present the innovative concept, the market opportunity, the product, and the potential of the business.

THE COMPANY MISSION

The Vision

The vision of MOBEO is "***LETTING THE WORLD SEE THE WORLD***".

The mission of MOBEO is to revolutionise the way people live and interact with the world around them by making, within the next 5 years, geo-information universally accessible and useful – anytime and anywhere.

The Need

Geo-information is defined to be a set of information about a specific point on the earth at a specific time. Geo-information can be derived from imagery that is gathered by different types of platforms and sensors located either in space, in the air or on the ground. Geo-information, when used to enhance and augment other information sources, can significantly improve the quality of life of each and every person on the Earth.

Surprisingly, the intrinsic value of geo-information has only been exploited at national and enterprise levels, and not at all yet by the commercial mass market, despite the fact that private consumers fully expect to be able to instantaneously access up-to-date, relevant geo-information anytime and from anywhere in the mobile internet age. Extensive market research and analysis estimates that the commercial market for accessing geo-information from mobile device such as mobile phones, tablets and laptops is worth at least $6.2 billion today and over $17.5 billion annually in five years.[1]

The key challenges that have deterred players in the market place today from pursuing the enormous market opportunity for geo-information are the following:

1. ***Relevant.*** The geo-information needs of the mobile mass market are extremely fragmented, and there is a countless number of geo-information services required to meet the needs of each individual consumer. It is impossible for any one provider to address the geo-information needs of the entire mobile mass market, and there does not exist a single niche geo-information market large enough to support the infrastructure required to create, provide and deliver geo-information.
2. ***Accessibility***. The ecosystem for processing, integrating and delivering geo-information anytime anywhere from the information source to the mobile market is immature and requires significant investment to develop further.
3. ***Affordability***. Providing up to date geo-information derived from space imagery on mobile devices requires state of the art technology and is very expensive. To date, only governments and large enterprises can afford the high prices associated with procuring geo-information systems.

[1] SpaceTech13, Final Proposal, Volume 3, Section 5.

The Innovation

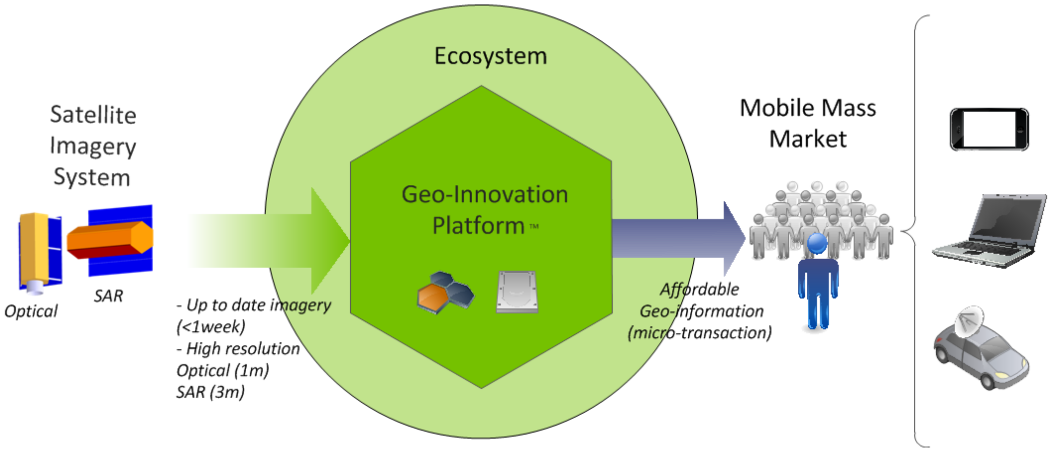

Figure 1. MOBEO's Innovative Solution[2]

MOBEO's innovation is to combine (1) a state of the art satellite imagery system, (2) a service delivery platform solution, the Geo-Innovation Platform™, and (3) a micro-transaction business model in an innovative way to overcome the challenges of relevancy, accessibility and affordability that has prevented others from effectively addressing the mobile mass market demand for geo-information. MOBEO's proposed innovation enables an entire ecosystem for processing, integrating and delivering geo-information, anytime, anywhere, to the mobile mass market.

MOBEO's state of the art satellite imagery system with one metre resolution optical imagery and three metre resolution SAR imagery that are updated at least once a week provides the foundation for deriving the world's most relevant geo-information to satisfy the needs of the commercial mobile mass market.

MOBEO's Geo-Innovation Platform™ will be the service delivery platform that enables an entire ecosystem of developers and external information & service providers. The innovation lies in the fact that MOBEO does not need to develop all of the required services desired by end users. Instead, the developer community and external information providers will create the services desired by the end users and MOBEO will provide the platform to connect the developers and external information providers to the mobile mass market.

The micro-transaction model allows MOBEO to offer geo-information at affordable prices to the mobile mass market and yet product significant revenues due to the sheer number of mobile device users who seek geo-information to enhance the applications on their mobile devices.

In summary, MOBEO's innovative solution enables an entire ecosystem of information providers and developers to serve the end user needs of both the traditional market and the mobile society for up to date and accurate geo-information by providing timely and high resolution satellite based imagery and the connecting element is the Geo-Innovation Platform™ which enables mass market commercialization of geo-information at affordable rates.

[2] SAR: Synthetic Aperture Radar

THE MARKET OPPORTUNITY

The Need

Geo-information is intrinsically valuable, and when it is made relevant, accessible and affordable anytime, anywhere, geo-information will revolutionise the way each and every person on this Earth lives and interacts with the world around them.

Imagine if people could access relevant, up-to-date and accurate geo-information from their mobile devices anytime, anywhere. With this capability, people going on vacation will no longer need to worry about arriving at their destination only to find out that the snow on a mountain is not suitable for skiing, or that the hiking trail has been closed due to fallen debris. People will be able to receive updates about road conditions and road closures before they leave for work. People will be able to remotely check on their homes from a safe location to see whether or not their house has been affected by a tornado or earthquake. Figure 2 provides a small sampling of the countless number of ways up to date and accurate geo-information can be used to change the daily lives of people.

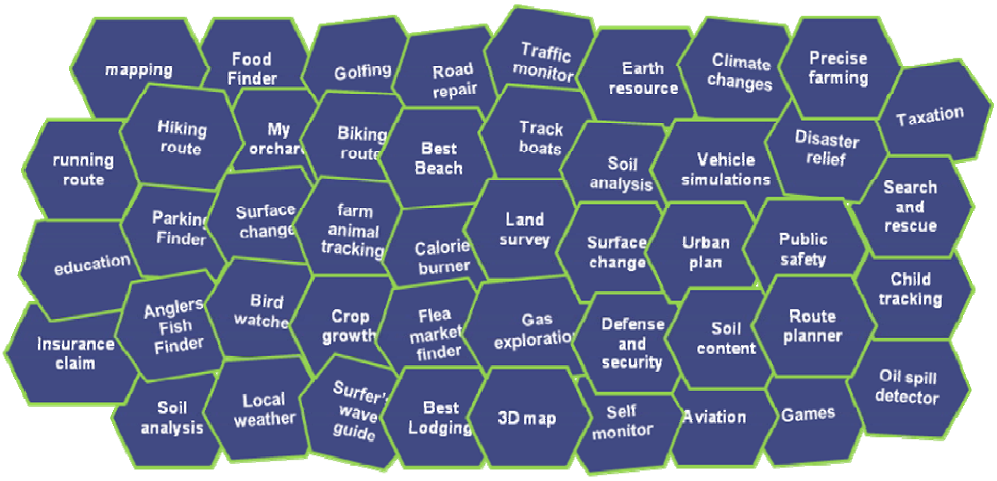

Figure 2. A sampling of potential uses of geo-information.

To provide useful and relevant geo-information data for the mobile mass market, the following primary objectives must be met:

- Imagery with less than or equal to one metre resolution to enable detection of small changes, such as a fallen tree, or the movement of a car, on the earth's surface.
- Imagery catalogue that is at most one week old to track changes on the earth's surface and to provide the commercially most up to date geo-information.
- Optical imagery to provide true colour images desired by the mobile mass market.
- Synthetic aperture radar (SAR) imagery to provide further information about the earth's surface, as well as a fully reliable imagery source independent of lighting or cloud conditions.
- Coverage of land masses between +70° and -60° latitude to ensure coverage of all populated areas.
- Accessible anytime anywhere from mobile devices such as mobile phones, tablets, or laptops.
- Affordable prices for the services that do not require the mobile mass market user to pay more than a few cents for geo-information.

The Opportunity Extensive market research and analysis demonstrates that the potential of the market for geo-information is enormous. The market for geo-information can be broken down into two segments (1) the traditional earth observation market that has been limited to enterprise and government customers and (2) the untapped mass market of mobile device users, or the mobile mass market, that seek relevant, accurate and up to date geo-information. The total revenue potential for the geo-information market is shown in Figure 3, and is worth an astounding $3.8 billion today, and is projected to be worth an even more impressive $14.5 billion in 2014[3].

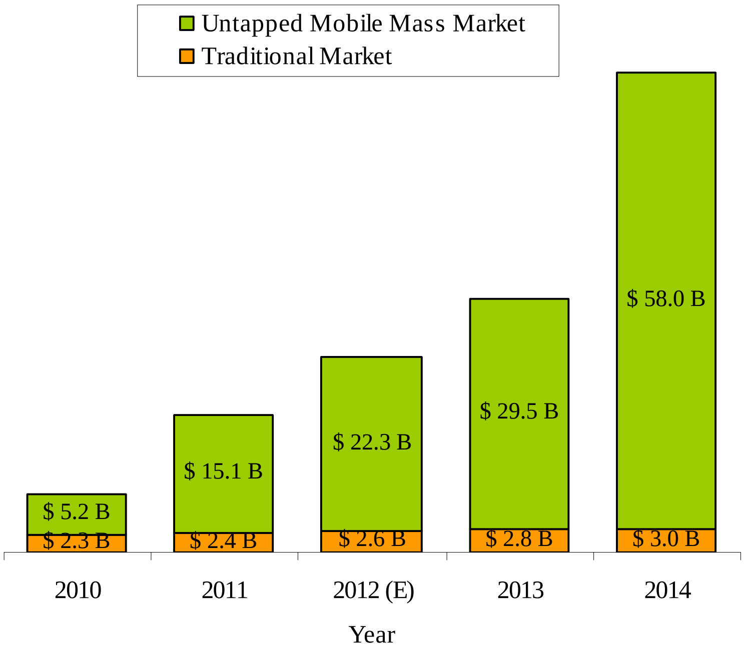

Figure 3. Total potential revenue of the geo-information market in $ billion.

Today, governments are the primary customers that can afford the high costs associated with procuring systems that provide geo-information. The revenue for the traditional earth observation market, which includes revenue from sales of satellite imagery and creation of limited value added services, was worth a total of $2.3 billion in 2010 and are expected to double to worth $4.5 billion by 2018[4].

The revenue potential of the untapped mobile mass market can be estimated by considering several key market trends that have emerged over the last decade.

- By 2015, market research forecasts predict that over an eighth of the world's population will be mobile-only internet users[5].
- By the end of 2010, over 10 billion downloads of applications have been made onto smart phones. By 2014, a phenomenal 185 billion downloads onto smart phones are predicted[6].

[3] SpaceTech13 Final Proposal, Volume 3, Section3.
[4] Euroconsult, Satellite Based-Earth Observation, 2009.
[5]http://arstechnica.com/tech-policy/news/2011/03/world-mobile-data-traffic-to-explode-by-factor-of-26-by-2015.ars.
[6]http://technolog.msnbc.msn.com/_news/2011/01/22/5899527-apple-exceeds-10-billion-apps-downloaded.

- Smart phone sales are nearly doubling every year[7].

Extensive market research and analysis show that the total untapped potential of the mobile mass market for geo-information is worth $3.8 billion today and $14.5 billion by 2014[8].

Beyond a doubt, there exists an enormous untapped market opportunity to provide geo-information to the mobile mass market through applications on mobile devices.

The Market Landscape

The geo-information market value chain can be understood by three components: (1) the information component, (2) the value added service component, and (3) the distribution of information and value added services to end user component. The relationship between these three components is shown in Figure 4.

Figure 4. Value chain for the geo-information market.

End users have a need to access geo-information from their mobile devices. The information sources component of the value chain represents the sets of information required to create value added services. The value added service part of the value chain is the process of creating, deriving or combining information together to create geo-information. The distribution part of the value chain is the process of delivering the geo-information to the end users through a mobile device.

The players in the geo-information market today can be categorised by what they offer along the value chain, as shown in Figure 5. One set of players, the imagery and limited value added service providers such as Digital Globe and Spot Image, provide high resolution imagery that is updated on the order of once a year, and only offer a limited set of value added services that are customized to each customer's needs. The second set of players, the location based service providers (LBS,) creates location based value added services for mobile devices. Players in this market include Facebook and FourSquare. The third set of players, the information delivery providers, connects people to information. Information delivery providers include both hardware device providers, such as Nokia, storage and processing players, such as Sun Systems, network platforms, such as Cisco, and information organizations such as Google and Yahoo.

Currently, the existing players are not targeting the untapped mobile mass market for geo-information for two key reasons. First, the imagery and limited value added service providers do not offer geo-information for the mobile mass market at affordable price points. Second, services and delivery of services are at the core of the business case for LBS and information delivery players, and they have not demonstrated an interest in becoming an information source for high resolution imagery. Players in the market, like Google, are currently obtaining its satellite imagery from commercial imagery companies like DigitalGlobe or Geo Eye.

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[7] http://mashable.com/2011/05/19/smartphone-sales-q1-2011-gartner/
[8] SpaceTech 13, Final Proposal, Volume 3, Section 6.

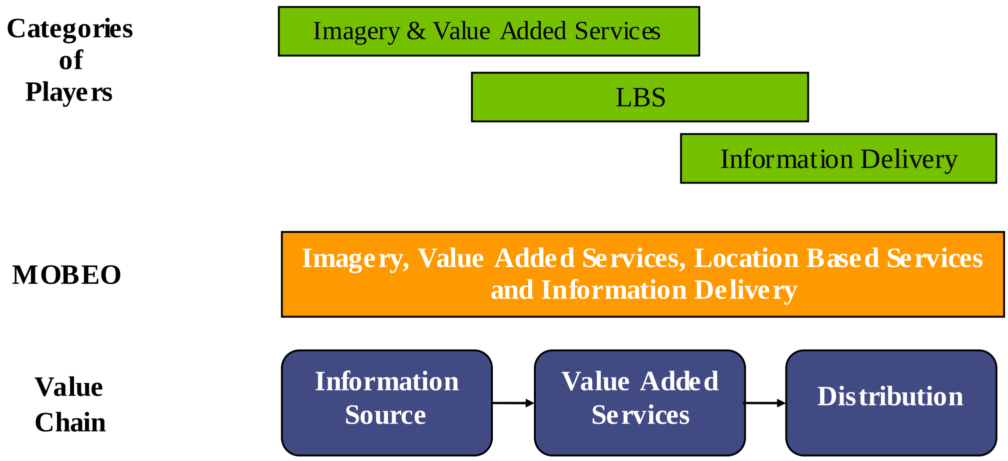


Figure 5. Categories of players along the value chain.

In the market landscape today, no one is providing an integrated solution to obtain geo-information, create geo-information value added services and to effectively organize and distribute the geo-information to each and every mobile device user in the mass market. By offering an integrated solution that combines the geo-information source and provides the platform to connect the mobile mass market to relevant and affordable geo-information, MOBEO will be uniquely differentiated from the other players in the market.

THE CONCEPT

The Value Proposition

Overall, MOBEO is well positioned to penetrate the mobile mass market for geo-information due its two key differentiators:

- Satellite imagery system: provides up to date (less than week old) and high resolution (1 m) optical and SAR (3 m) satellite imagery;
- Geo-Innovation Platform™: connects all the elements of the ecosystem and provides a library of raw satellite imagery and algorithms, enabling the mass commercialisation of geo-information.

The Approach

MOBEO's collaborative concept, shown in Figure 6, brings together different interest groups, the developers, the external information & service providers and the end users, to form an ecosystem that enables the delivery of geo-information services to the mobile mass market in an accessible and affordable way. The two key components that have already been mentioned, the satellite imagery system and the connecting service delivery platform, the Geo-Innovation Platform™, enable an entire ecosystem to address the geo-information needs of the mobile mass market at affordable prices. These two components are highlighted in green in Figure 6.

Figure 6. MOBEO innovative approach.

The first key component allows the acquisition of information of the earth surface with remote sensing satellites in a timely and global manner. This source of information provides the foundation for deriving and developing accurate, relevant and up to date geo-information.

In addition to the satellite imagery system, MOBEO opens its Geo-Innovation Platform™ to external developers who will create algorithms to derive and combine geo-information from the satellite imagery. This developer group is called algorithm developers.

In order to allow the Geo-Innovation Platform™ services to reach the mobile mass market, MOBEO will offer simple and easy to use tools for the integration of geo-information into applications. These tools are used by application developers. Application developers are a group of developers focusing on the service integration in end user applications.

The developers receive a share of the micro-transaction fee each time the geo-information service is used by an end user. Through this incentive policy, the developers will be incentivised to create geo-information services that are appealing to end users.

The Target Market

MOBEO's innovative approach addresses both the traditional market and the mobile mass market for geo-information that, in total, is worth an estimated $6.2 billion today and $17.5 billion by 2014.

Overall, the market for geo-information is an extremely attractive for MOBEO for two key reasons. First, the commercial market for geo-information is immature market and has not been effectively addressed by any existing players in the market place. The first company to successfully deliver geo-information to the mass market in a relevant, accessible and affordable way will dominate the market much like how Google has dominated the market for internet search. Second, the market potential of mobile mass market includes nearly the entire population of the globe, and by even successfully engaging just a small portion of the mass market can lead to substantial revenues. Third, there are incredibly high barriers to entry, and once the first company successfully raises the money to enter the market, it will be difficult for others to enter the market to compete.

However, it is important to note that there are some significant risks associated with the market. First, the high barriers to entry can also be considered a threat, and to be successful, MOBEO will need to convince its investors and strategic partners that it has a viable solution for providing geo-information services to the mass market. A second key market risk is that MOBEO highly dependent on the development of a sustainable eco-system with its partners, the developers and the external information and services providers. MOBEO recognizes the risk involved and has put in place a thorough risk mitigation plan which is described at the end of this document.

The Business Case

MOBEO's plans to address the entire geo-information market by offering three different business lines. Each business line targets different types of customers and provides different level of services, as shown in Figure 7.

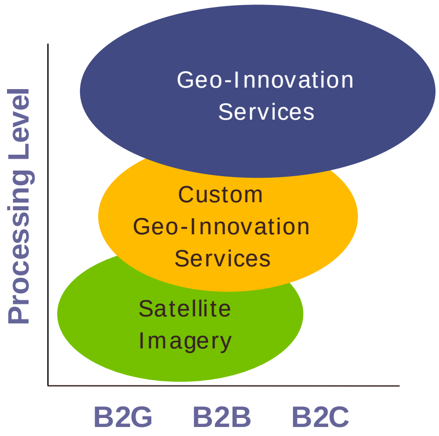


Figure 7. Overview of three business line and level of integrated services.

- ***General geo-information services (BL#1):*** This is the core business line for MOBEO and is based on micro-transaction business model. The primary target is the mobile mass market (B2C), but can also address the needs of enterprises and governments.
- ***Custom geo-information services (BL#2)***: This business line provides custom solutions. MOBEO will charge a set amount to develop the customized solution according to the customer's requirements and then will charge the customer a monthly or annual flat rate subscription fee to access MOBEO's services and libraries. This business line primarily targets enterprises (B2B) and governments (B2G).
- ***Satellite imagery services (BL#3)***: This business line is based on the traditional business model of selling satellite imagery to the end user, which could be an individual consumer, enterprise or governments. Customers can access MOBEO's imagery by either pay per use or through a monthly or annual subscription.

In summary, MOBEO's innovative concept allows it to address the entire geo-information market with one end to end system solution.

Pricing Model

BL#1 General Geo-information Services

In BL#1, the developers will use the Geo-Innovation Platform™ to develop geo-information services that will be accessible to the end users. The overall service flow is shown in Figure 8. The end users could be individual consumers, enterprises or governments. Each time end users use an app that accesses any of MOBEO's geo-information services, they will be charged a micro transaction fee of five cents. The developers will receive a 30% share of the revenue each time the geo-information service is accessed by an end user (micro-transaction). In addition to the micro-transaction fees, BL#1 relies on another important source of revenue, which is the advertisement revenue mechanism. Through this mechanism, paid publicity can be attached to the geo-information services in several ways, and is typically modelled by a click-through rate and relevant revenue per number of clicks. On average, MOBEO expects that for every 1000 an ad is shown, one person will click on the ad and MOBEO will receive ten cents in revenue from the advertiser.

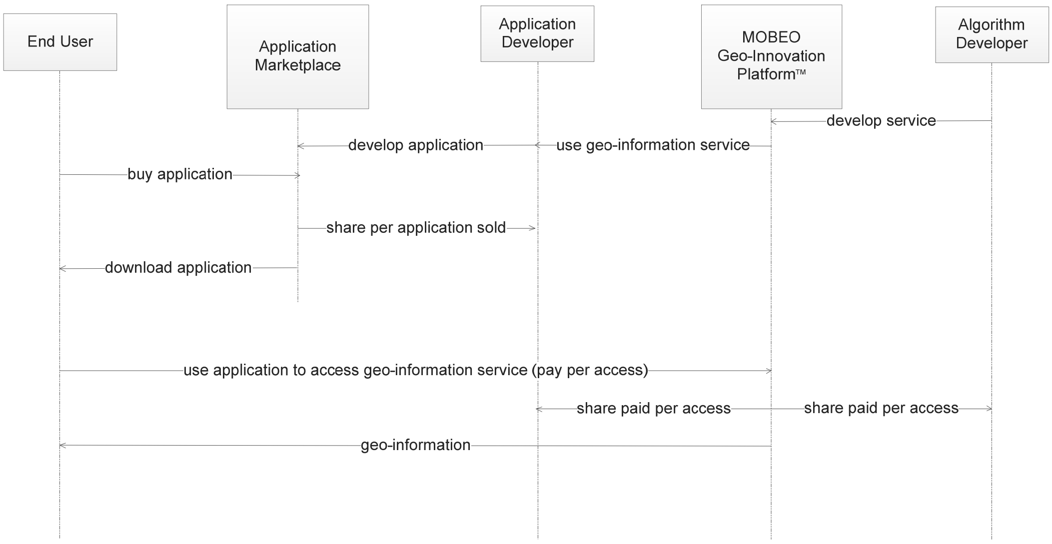


Figure 8. MOBEO general geo-information service flow (BL#1).

BL#2 Custom Geo-information Services

BL#2, there are two models for revenue which are shown in Figure 9. The first source is when an end user, such as the government or enterprise desires a specific geo-information based service and/or application. It specifies the requirements and hires MOBEO to develop and deliver the service and/or app for an appropriately negotiated price. Once the custom service has been developed, the customer would then pay a monthly or annual subscription to access the geo-information content and services for general use of the app at a negotiated price. This business line solution guarantees secure use of an application by means of control and secure accesses and that no one else would have information on the relationship or the details of the service and/or app.

The second variation opportunity for BL #2 is that an end user, such as an enterprise, seeks a license to a secure private version of the Geo-Innovation Platform™ to allow people within the enterprise to create develop private services and applications. For example, the enterprise may desire to have the Geo-Innovation Platform™ to allow its own workers to develop the apps and services most relevant to their day jobs on their own time. The enterprise may even hold a contest choose the most useful best apps or services. This way, the enterprise does not have to pay for app and services development, and the end users, i.e., its workers are best positioned to create the most useful apps and services. The enterprise would pay a negotiated annual subscription to access the desired geo-information services, the geo-information content, and a private Geo-Innovation Platform™ for use by the enterprise only.

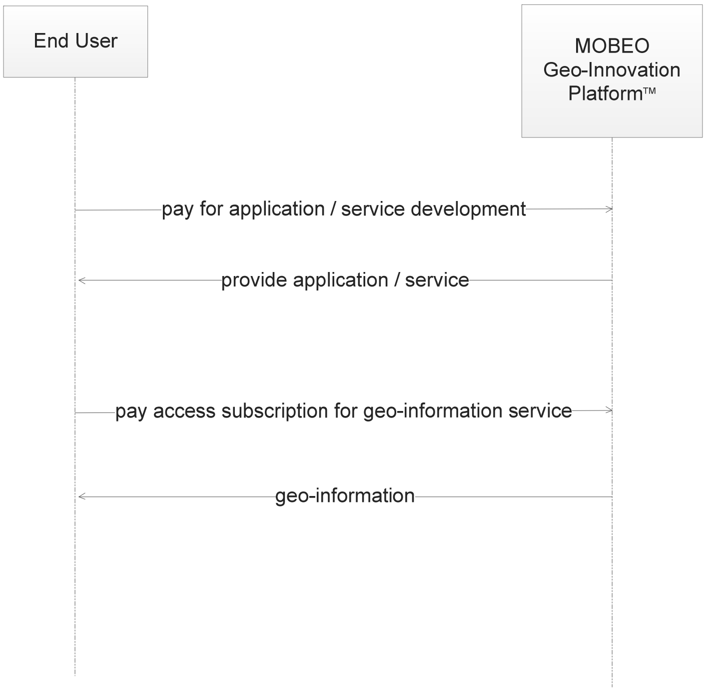


Figure 9. MOBEO custom geo-information service flow (BL#2).

BL#3 Imagery Services

BL#3 is based on the current earth observation classical geo-information data distribution scheme, i.e., the sale of satellite imagery to an end-user, who could be an individual consumer, enterprise or governments. The money flow for BL#3 is shown in Figure 10. MOBEO's satellite imagery system will provide standard (including raw images) and higher level (with value added) products of the entire earth, land mass only, where any of the images will be no older than one week. The optical images will be at least one metre in resolution and the SAR images will be 3m in resolution. In addition, MOBEO will retain an up to date 2D and 3D map in its imagery catalogue at all times.

Individual consumers will be charged on an image by image basis, and the amount of the subscription will be a negotiated price that is dependent on the number of images and types of image the customer desires to access.

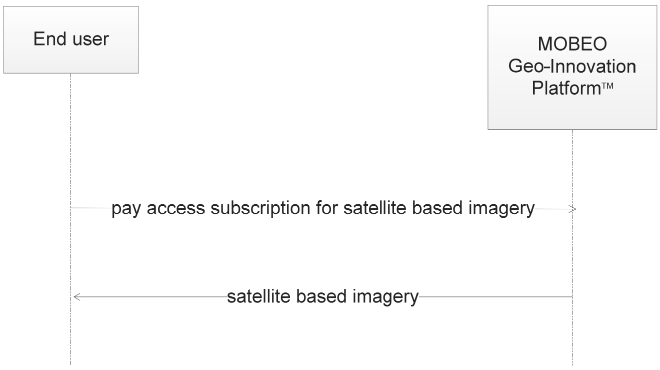


Figure 10. MOBEO imagery service flow (BL#3)

THE TECHNICAL SOLUTION

The Solution

The MOBEO system can be divided into several elements:

- ***System Core***: The system core is composed of MOBEO's own space segment and the Geo-Innovation Platform™ which comprises the Library, the interfaces to developers and external information providers, the services environment and billing & management functions. The Geo-Innovation Platform™ is a flexible system capable of processing information from different sources and making the information available for the end users in the form of geo-information services. The Library is capable of storing all the data downloaded from the space segment and all the processed data. The end users are able to access the Library data according to the existing available services provided by the Geo-Innovation Platform™.
- ***Developers and Information Providers***: The developers are an external community, and develop either algorithms for interpreting or analysing information within the Geo-Innovation Platform™, or applications for accessing the geo-information. External information is provided by external service providers through the Geo-Innovation Platform™ (e.g. weather services) for integration with other existing content.
- ***End Users***: The end users are individual consumers, enterprises and governments. Each of these categories has their own specific needs and the Geo-Innovation Platform™ is capable of providing a wide range of services to fulfil those needs. The end users can access MOBEO's geo-information services through a set of standardised interfaces.

System Core

The key feature of the MOBEO system is to provide the end users with the ability to access information, generated by MOBEO as well as by external partners. This access has to be provided with very low entry barriers to enlarge the addressable consumer range. Low entry barriers are achieved by seamless integration into the users' common environment and by provision with familiar tools.

Given the concept of MOBEO, the core of the system is the Geo-Innovation Platform™ and the connections to all entities related to the information distribution. Those entities are MOBEO's partners, as well as the end users and the MOBEO internal components: Space Segment and Library & processing environment.

External service providers and developers as well as end users connect to the Geo-Innovation Platform™ via the internet. The Geo-Innovation Platform™ is a logical entity spread over the physical components. It consists of a payload centre, which controls and manages the payload data once it is received by the spacecraft, a processing centre to process the imagery data and all other SDP services, and a storage centre to store all the data.

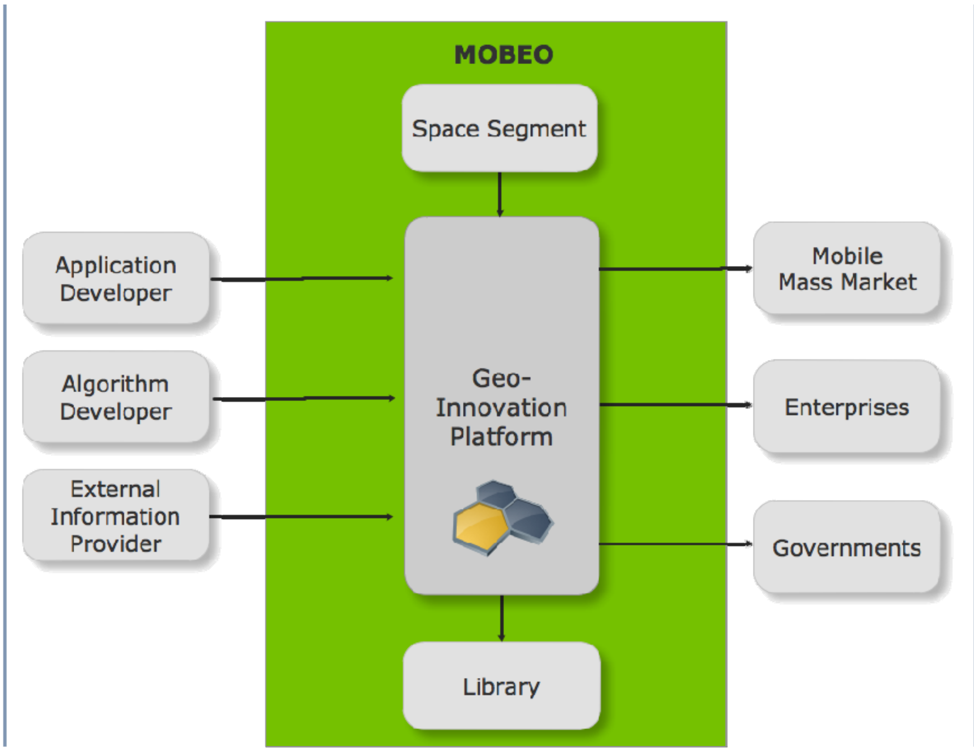


Figure 11. Geo-Innovation Platform™.

The concept of MOBEO is to serve different entities in a manner to expand their capabilities and to increase their value. To identify how MOBEO fits into an ecosystem of geo-information consumption, the following figure shows MOBEO's position in a layered approach.

The top layer is the user layer which includes all kind of active system users of MOBEO. The bottom is information acquisition layer. In between are the Provision, Distribution and Presentation layers. Provision is data offering of all kind of geo-information related data sets. MOBEO includes all of these datasets through the external information and service provider interface and distributes the information to the user layer.

The distribution is split depending on the presentation layer. If a geo-information service is used within an application, the application distribution is done over existing application market places like the Apple APP store, the Android store or the OVI store, whereas distribution of service data itself is done directly by MOBEO.

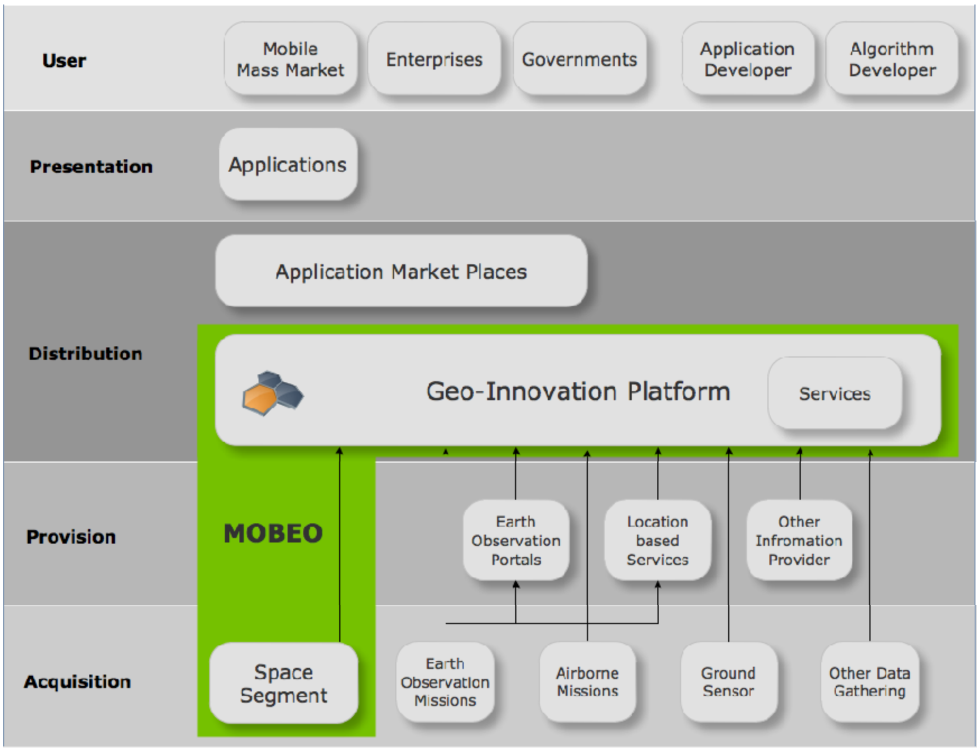


Figure 12. Concept layers.

Space Segment

After a detailed sensitivity analysis, detailed in Volume IV of the Final Proposal, the space segment is comprised of both optical and radar spacecraft.

Optical

The optical spacecraft can be divided into two parts, payload and service section. The payload is a telescope with diameter of 0.75 m and it is positioned in the middle of the spacecraft pointing nadir. The other half of the satellite accommodates the AOCS, telemetry avionics and the propulsion system. To provide the necessary power the satellite is equipped with a solar panel that is fixed to the spacecraft by means of rods. Based on the satellite accommodation analysis, the optimised width of the solar panel is 2.1 m and the height is 3.1 m.

The following figure shows an initial design of the configuration of the optical MOBEO satellite.

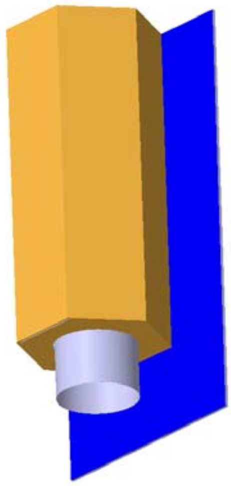


Figure 13. Concept layers

Synthetic Aperture Radar

The SAR and optical spacecraft share many common components that are of the same or similar design to reduce cost and development time.

The main differences are related to the payload and to the power section. Instead of a telescope the satellite is equipped with a 5 m long surface mounted SAR antenna. As a lot of power is needed to illuminate the target area on ground, solar arrays with an area of around 15.6 m^2 are needed. These shall remain in a fixed configuration after a potential deployment during commissioning. The angle between the nadir and the normal to the SAR antenna surface has to be 30° during imaging.

Based on the above constraint the SAR spacecraft configuration was designed with the following characteristics:

- The side of the hexagon is 790 mm (that allows accommodating the SAR antenna with height of 5 m into the conical shape of the fairing of the selected launcher.
- One side of the prism has a fixed solar panel (0.79 m × 5 m) whereas the two adjacent sides have each a pair of hinged solar panels (0.60 m × 5 m)
- The SAR antenna is accommodated on one of the faces of the hexagon opposite the solar array, which allows imaging at the correct incidence angle, and is thermally cooler as it faces away from the sun

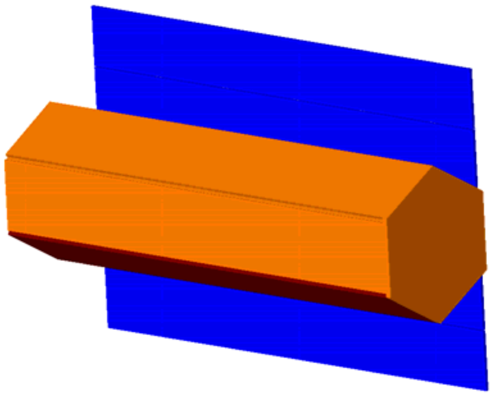


Figure 14. MOBEO SAR satellite configuration.

Ground Stations

In order to keep the initial investment costs as low as possible, it is necessary to locate ground receiving antennas at existing ground station facilities, where dedicated antennas will be installed for the mission. However the operation and maintenance will be managed by the hosting facility.

Due to the high inclination of the sun synchronous orbits, high latitude (far north and far south) ground stations are advantageous as they allow for longer and more frequent access times. Facilities with the capability to support such an antenna, at high latitudes, are: Troll (Antarctica), Svalbard (Norway), Kiruna (Sweden), and Fairbanks (USA). Of these, Troll is very expensive to operate and the link from Antarctica to the main continents still complex, while Kiruna and Svalbard are too close to each other to be used in combination. Svalbard is further north than Kiruna and therefore preferred for its longer access times, and also as it is in fact above the limit of the imaging for the system, allowing communications more often when there is no imaging. Svalbard and Fairbanks are therefore chosen as the locations for the new ground receiving antennas.

The ground receiving antennas will be Cassegrain antennas of 9.3 m diameter. These are readily available to purchase, however will require some development for the Ka-band frequency. Also, the impact of the extreme weather conditions at Svalbard and Fairbanks needs to be evaluated for this kind of antenna.

Payloads

For the two different satellite types, an optical and a synthetic aperture radar payload is needed.

Optical

The MOBEO optical payloads (panchromatic and multispectral imagers), called MOPTICS, are composed mainly of a telescope, optical elements and Focal Plane Array (FPA), where the detector is located. The telescope collects the light (photons) and converges it in the optical elements (such as filters and lens), then the light is split in the panchromatic and multispectral imagers by means of a beam splitter (in the multispectral imager the light is separated in the 4 channels), after which the detectors (one for the panchromatic and one for the multispectral) convert the photons into electrons. This yields a signal to be transmitted to the electronic elements.

The architecture of the overall camera is sketched in Figure 15, where the two main elements of the payload are highlighted: the optical telescope assembly and the imaging sensors & electronics.

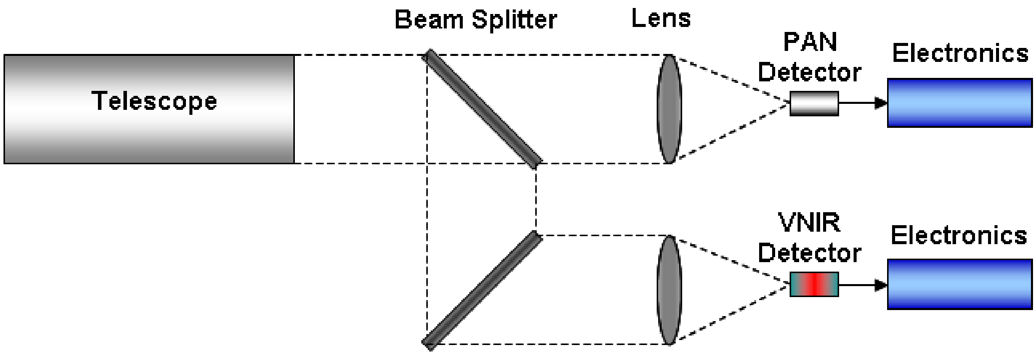


Figure 15. Basic concept of the MOPTICS architecture.

Such optical systems allow obtaining information with high spatial and adequate spectral resolution for each image. The spatial resolution allows discriminating small targets on a single image and the spectral resolution allows having an image with colours very similar to the real ones making the image comprehensible by a very large user community, one more channel in Visible Near Infra Red (VNIR) which mainly provides information on the vegetation. For MOBEO, this concept is used to meet the customer needs.

Synthetic Aperture Radar

Within the MOBEO system the use of SAR sensors can be done separately or complementarily to the optical ones. SAR can be used when optical sensors fail, for example because of the presence of clouds or during night-time since SAR can penetrate the clouds and, being an active sensor, SAR uses its own light-source to illuminate the targets. SAR can be used to add information about a target (especially roughness, geometry, humidity content) which has been seen by an optical instrument.

The high resolution is obtained using the X-band, at a wavelength of 3 cm. It has a low penetration power and can provide mapping of the forest trees top, the ice surface, etc. without penetrating the target very far. This can be useful to know the exact characteristics of the surface. Several X-band SAR systems have recently been built (COSMO-SkyMed, TerraSAR-X, TanDEM-X) and with this heritage has been selected for the MOBEO SAR sensor, called MOSARS.

The MOBEO goal is to have a SAR sensor achieving 3 m resolution with a swath of 40 km. As acquisition mode Stripmap was chosen, as in this mode long strips of the surface are acquired continuously in a high resolution.

Launch Segment

For the assessment on the selection of candidate launch services two classes of launch vehicles have been preliminarily analysed:

- Small-medium launchers: DNEPR, PSLV, Rockot, VEGA.
- Large launchers: ATLAS V401, Delta V M+(4.2), Falcon-9, Soyuz (Kourou)

Among the large launchers the most competitive one is Falcon-9 that provides a lower cost over performance ratio (15.5 k$/kg), which is 61% lower than for Atlas V401 and 120% lower than for Soyuz. Also the range of negotiation of the two launch service costs with Falcon-9 are lower than those ones calculated for the above two competitors. The Falcon-9 can ideally embark 7 optical or 3 SAR spacecraft

After conducting a detailed analysis, Falcon-9 is the baseline for launching the MOBEO satellites. As a backup the satellites will be designed to be able to be launched with PSLV as well.

Operations

The most important aspect in the area of operations is the logical separation between the operations centre and the payload centre. It should be noted that a physical separation of the two centres is currently not foreseen.

Operations Centre

The MOBEO operations centre is responsible for the operations and the health of the spacecraft. This includes the monitoring of the spacecraft status (health, etc.) and all commanding activities necessary to keep the spacecraft operational and to fulfil the mission objectives. The operations centre is the only centre which dispatches commands to the spacecraft. It is not the sole receiver of telemetry.

Telemetry ingestion by the mission control system (MCS) takes place automatically. The operations centre only concerns itself with the housekeeping telemetry. All telemetry is automatically monitored for non-nominal readings, e.g. out of limits for critical parameters (for example, power supply, temperatures, etc) and alarms are raised to the operators on console in case such readings are observed.

The current planning is that the hardware is distinct between the operations centre and the other centres (payload, processing and storage). This means, no sharing of hardware resources takes place. Thus, even if any of the latter fails to operate normally, spacecraft safety can still be ensured. Although the machines are different, the current baseline foresees common data centres for the operations and the payload centre hardware. It is understood that this poses a risk, but given the long planning intervals for the spacecraft, and the redundancy between the centres the risk seems acceptable.

In order to further enhance redundancy and to cover against a loss of connectivity from the ground station, the spacecraft carry S-band transponders that are compatible with ESA and NASA ground stations. If necessary, time can be rented at these centres to command the satellites. A link from the operations centres to these facilities is envisaged for these rare situations.

Payload Centre

The MOBEO payload centre is responsible for the operations and the health of the payload. This includes the monitoring of the payload status (health, etc.) and all commanding activities necessary to satisfy the MOBEO mission requirements. The payload centre does not have a direct communication channel to the spacecraft. Instead, the payload centre passes all information necessary to operate the payload to the operations centre where the commands are dispatched to the spacecraft. The payload centre receives confirmation from the operations centre that all commands have been received by the spacecraft correctly.

The payload operations for which the payload centre is responsible includes all calibration activities, mode switches and ensuring that the periods of activity are chosen such that the MOBEO coverage requirements are satisfied. This also includes keeping the map of the globe in the command and data handling system up to date.

Another important task of the Payload Centre is the control of the data processing and the complete service delivery infrastructure.

The redundancy concept is similar to the one for the operational centre. This means that if the communication links between the payload data receiving antennas and the payload centres is lost, the payload data needs to be stored at the station. A prolonged outage might mean the loss of some mission data. The operational areas of the payload centre are separated into four areas as for the operations centre.

Processing and Storage

Apart from the aforementioned ground stations, operations centre and payload centre, the ground segment covers data processing, storage and the network between all ground elements.

Data Processing

This element of the ground segment is responsible for the actual processing of the payload data. Here, the data sent from the spacecraft to ground is transformed into an actual product which can be further relayed to the customers.

The payload data received by the payload centre is forwarded to the storage centres and the processing centres. The tasks of the processing centres are to generate the actual mosaic images which can be passed to the customers. Also, the inclusion of value added services is handled by the processing power of these centres.

Given the amount of data generated by the space segment every day, it becomes obvious that the processing requirements on the system are quite demanding. After several research steps, the MOBEO system has been designed to rely mainly on Graphic Processing Units (GPUs) instead of Central Processing Units (CPUs) which are commonly used for processing tasks. This decision has been made after thorough research and comparison of various performance figures.

An analysis based on the amount of data that is generated by the optical and SAR spacecraft showed that in total about 800 servers are required to process the MOBEO images.

The geographic location of this data centre will be decided in a later phase of the MOBEO project. No particular requirements apply to this location from a processing point of view, however other factors such as legal aspects and connectivity of the location to the internet are decisive factors. A second data centre with the same number of servers is located at another geographic location. Most likely choices for both centres are close to some of the big internet peering nodes for a fast connection to the world wide web.

Storage

This element of the ground system is responsible for the storage of all data, except for spacecraft housekeeping telemetry. It is logically separated from the processing centres, but due to performance considerations, the centres will be physically co-located. This allows for faster turnaround of data between the processing hardware and the storage. This is important in several aspects, as the raw spacecraft payload data will be transferred into the storage centre by the payload centre from where it is picked up by the processing hardware. The shorter the network delay, the better. Also, as discussed above, since the service delivery and the payload data processing is performed by the same hardware, the fast access by the service delivery to the stored data is important.

The storage machines will be hosted in classical data centres, similar to the type used for the processing machines. The machines are hosted in racks which provide the power, cooling and network. The disks are connected to the disk controllers which control the access to the storage. The connection is via the fastest Ethernet cabling available, currently 100 Gigabit Ethernet.

The sizing of the hardware has been based on the amount of data generated by the payloads of the MOBEO spacecraft. The figures add up to around 6500 Terabyte per year of storage required to host the raw image data. In order to also accommodate all additional data, such as processed images, overlay information, 3D images and so forth, a safety multiplier of 5 has been modelled into the system. This margin gives MOBEO ample capacity to host all additional data. Initial considerations of discarding historical data after a given amount of time (with the possibility to apply an intelligent filter based on the areas of interest) have been discarded after careful trade-offs. It has been found that the possibility to retrieve any data from the past is a valuable MOBEO asset and is in fact very cheap due to the ever-decreasing price of the storage.

The redundancy concept for the storage follows the concept envisaged for the processing hardware. This choice is natural given the considerations concerning the physical location of both above. All data is duplicated between the two storage centres so that the failure of one still leaves MOBEO fully operable and does not endanger the valuable historical MOBEO data.

Network

All links have in common that no infrastructure needs to be built by MOBEO. All the connection services can be rented from commercial operators.

The connection between the payload receiving stations and the payload centres are realised on leased lines, most likely fibre-optical cables. As for the housekeeping link, the service level agreements will be chosen so that the availability of the data is guaranteed. The same is true for the connection between the payload centre and the processing and storage centres.

The connection from service delivery and processing to the customer is split in two: the part from the MOBEO system to the internet and the path from the internet to the customer. The first part needs some consideration as the amount of data which needs to be delivered to the internet is rather large. There are several steps to manage this amount of data. The data transfer between the internet and the customer end device is the responsibility of the end user. This decision is made possible by MOBEO’s decision to rely on established communications standards and by the usage of powerful compression techniques and implementations to optimise the amount of data transferred. Most likely, the customers have a flat fee contract with their operators to allow them to access the internet. This link is also available for MOBEO data. There is no need for MOBEO to build infrastructure for this part of the data transfer, a fact which greatly simplifies the set up of the MOBEO communications network infrastructure.

Schedule

The MOBEO schedule foresees to launch the full constellation by the end of 2016. To achieve this, the Space Segment and the full Ground Segment including processing, storage and the Geo-Innovation Platform needs to be developed in parallel. The overall schedule up until launching the satellites is depicted in the following figure.

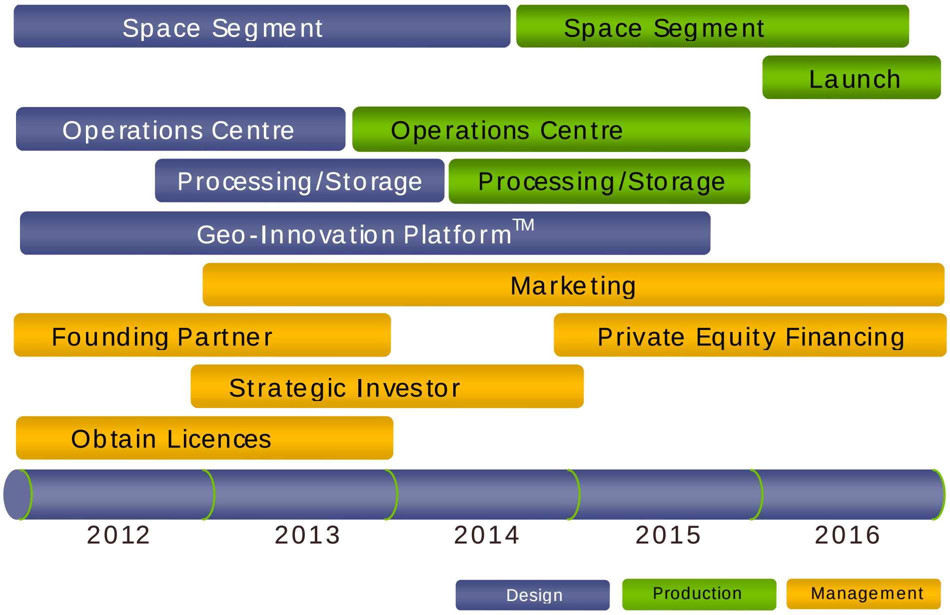


Figure 16. Overall project schedule.

Launching 17 satellites in one year is challenging, therefore the spacecrafts need to be produced in an effective way.

The approach that was chosen is to built an optical proto flight model (PFM) first and then produce several spacecraft in parallel. Overall the production is organised in batches, starting with optical satellites, continuing with SAR spacecraft before finally producing another set of optical satellites.

Based on these assumptions, the optical proto flight model will be built from September to November 2014. After the completion of the PFM, an extensive testing phase will follow which includes shaker, acoustics, thermal vacuum, electromagnetic compatibility and a few other tests in order to discover errors in the design. This may take until January 2015. After the successful tests of the PFM the standard satellites will be built and tested which concludes batch 1 of the MOBEO satellites. Testing of the standard satellites will be shorter than the testing campaign of the proto flight model and be limited to mainly functional tests, as the design has been validated already with the PFM.

Then the SAR PFM will be built and tested extensively from July to November 2015 followed by the series production of another 4 SAR satellites.

Finally the third and last batch of satellites will be produced, consisting of 5 optical satellites. The concept is to leverage commercial production with manufacturing lines similar for each satellite, except for the unique items such as the payload (SAR and Optical), power structure, and structure. This will ensure the lowest cost for the space segment.

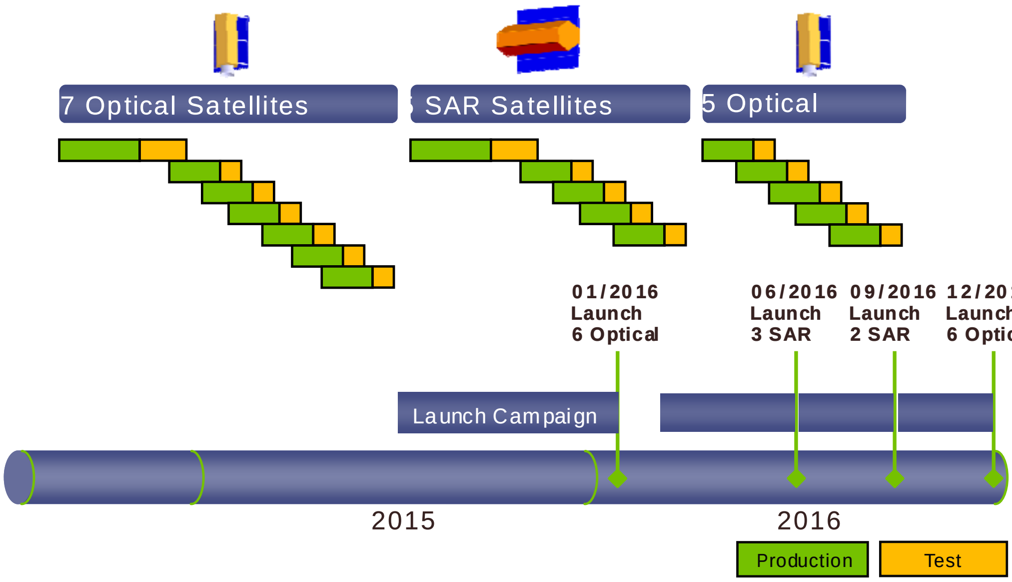


Figure 17. Detailed schedule for Phase D of the Space Segment.

IMPLEMENTATION STRATEGY

Strategy

MOBEO has developed an innovative business and technical solution to target the enormous market potential of the mobile mass market. However, MOBEO recognizes that just having an unique and innovative idea alone is not enough, and it has developed an integrated implementation strategy to ensure that it is the first to market to address the geo-information needs of the mobile mass market. The integrated implementation strategy considers the following key components:

- Service roll out strategy
- Marketing strategy
- Legal and regulatory strategy
- Management strategy
- Investment strategy

The cornerstone of the strategic plan is to establish a viable investment strategy to complement the business plan. The proposed strategic plan carefully addresses the needs of the targeted investors by considering the level of risk that its potential investors will be willing to take, and when to provide an exit strategy for each investor.

Detailed Strategic Plan

MOBEO's key differentiation in the market place is its library of high resolution imagery that is updated at least once a week, and its Geo-innovation Platform™ that connects the mobile mass market to geo-information services. MOBEO has developed a strategic implementation plan that takes into consideration development time, marketing, regulations, financing and key risks to successfully penetrate the mobile mass market is summarised in Figure 18.

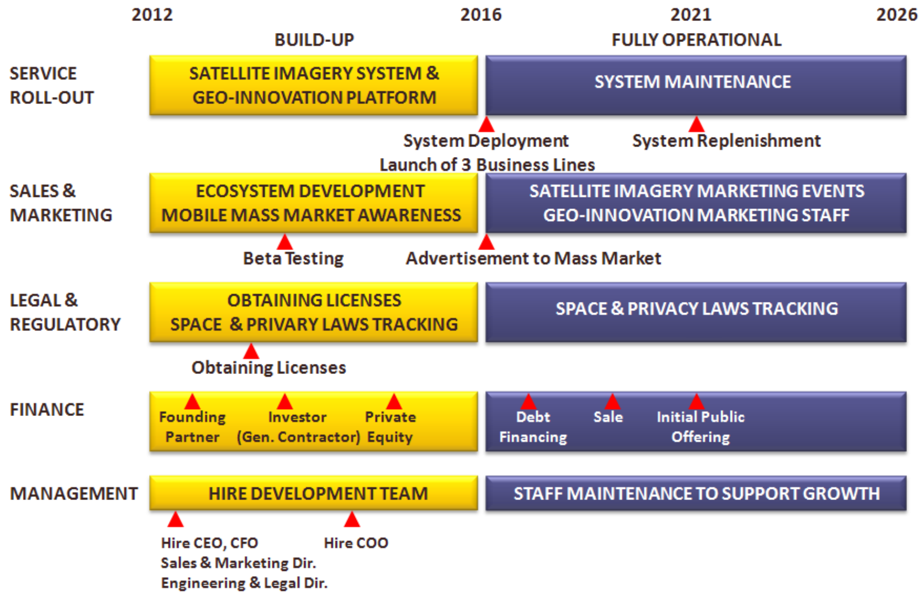


Figure 18. Top level overview of implementation strategy.

The first phase of the strategic implementation plan is the build up phase, where the business is started. The build up phase will last five years and will be focused on developing the satellite imagery system and the Geo-Innovation Platform™. MOBEO will roll out its services in Year 5. However, in Years 3 and 4, in preparation of launching its services to the market, MOBEO will begin beta testing with the developer community and launch a marketing campaign to the mobile mass market to educate them on geo-information and what MOBEO can provide them. In Years 1 and 2, MOBEO will begin to address all the legal and regulatory issues for obtaining licenses and for tracking national regulatory. It expects no issues in this regard, and will acquire all necessary licenses for launch and operation by Year 3.

The second phase of the strategic plan, the operational phase begin in Year 5 and will be focused on rolling out the three business lines to the market place. BL#1 and BL#3 will both come on line immediately after the launch of the satellite imagery system in Year 5. It is expected that the ecosystem of developers, external information & service providers and end users will take at least a year to mature, whilst BL#3 will be immediately able to generate significant revenues from governments and enterprises, sustaining in that way the start-up of revenues in Year 5. By Year 6, BL#1 and BL#2, after one year in the market, will start to mature and create more demand in the marketplace. In Year 11, the satellite imagery system will be replenished.

It is expected that by Year 7, potential investors can begin considering an exit strategy through either an initial public offering of the company or sale of the company.

One key note the MOBEO plan addresses the first system to be deployed in great detail and does not address the next generation system. MOBEO plans to consider the next generation system after the launch of the first system and the needs of the market have been better understood and evaluated.

Projected Revenues and COGS

Together, the revenue and cost of goods sold profiles are shown in Figure 19. The estimates shown are based on the pricing models for business lines described earlier. COGS is expected to be approximately 20% of revenue, which is in line with the aerospace industry averages.

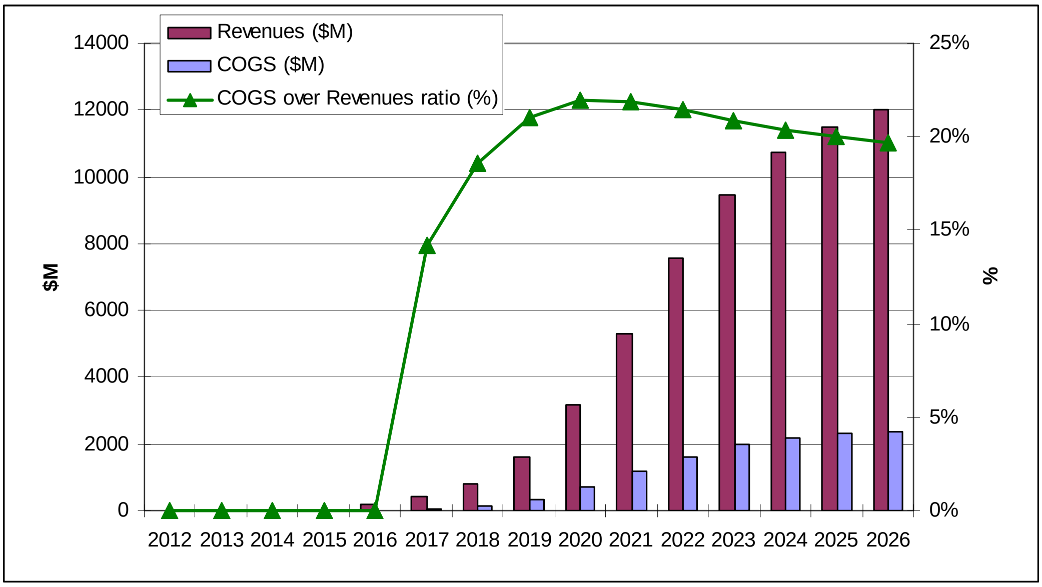


Figure 19. Revenue and COGS forecast for MOBEO.

Investment Strategy

The investment strategy introduced previously will require a total investment of $2.3 billion over 15 year, of which $1.1 billion is needed in the first 7 years of the business. Figure 20 shows the investment profile required to finance MOBEO. In order to overcome the large investment required, MOBEO has developed a conservative investment plan that matches the level of risk with the investor type at each stage.

Exit strategies considerations are possible when the company starts earning revenue which is in Year 5. Two viable exit strategies are that MOBEO can either sell to another company, or pursue an Initial Public Offering (IPO).

Such strategy can be summarized in the Table 1 and Figure 20 which provide the different investors involved year by year for implementing the plan, assuming an exit strategy for private equity investors in 2017 by Initial Public Offering (IPO) with the involvement of public investors, or alternatively by trade sale to a private company interested in MOBEO's business.

Table 1. Financing scheme.

Year	Founders	Strategic Investors	Private Equity Investors	Public Investors	1^st Loan	2^nd Loan
2012	$50M					
2013		$90M				
2014			$200M			
2015			$70M			
2016			$90M		$500M	
2017				$864M		$200M

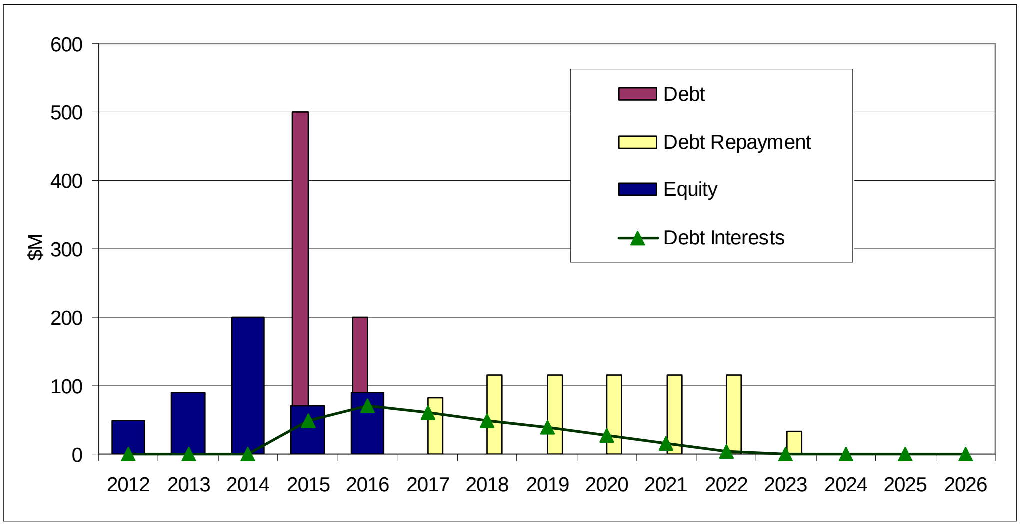


Figure 20. MOBEO financing plan.

Examining in more detail the numbers, MOBEO requires a total of $1.2 billion in financing, with $0.5 billion from equity and $0.7 billion from debt. The debt assumes a repayment scheme of 6 years, starting 2 years after the initial equity investment at an interest rate of 10%. The debt will be fully repaid by 2023.

According to that financing plan, the shareholder structure will foresee a final dilution of shares between founding partners, strategic investors and general public investors, as for Table 2.

Table 2. Shareholders structure and dilution.

Year	Founders	Strategic Investors	Private Equity Investors	Public Investors
2012	100%			
2013	80%	20%		
2014	40%	10%	50%	
2015				
2016				
2017			0%	50%
Final Sharing	40%	10%	-	50%

As final step, Table 3 shows the potential returns for the investors, calculated in terms of multiple, capital gain, dividends and internal rate of return (IRR), highlighting the actual attractiveness of the MOBEO business proposal, which means for example an IRR of 52% per year for the founding partners, of 29% for the strategic investors and of 82% for general public investors.

Table 3. Potential returns for investors.

	Founders	Strategic Investors	Private Equity Investors	Public Investors	1$ Example		Banks
Investment	$50M	$90M	$360M	$864M	$1		$700M
Multiple	108.3	15.0	2.4	20.1	-		(1.45)
Capital Gain	$5300M	$1260M	$504M	$16600M	-		$315M
Dividends	$5400M	$1350M	-	$17400M	$20.1		$315M
Internal Rate of Return	52.1%	29.5%	43.5%	82.4%	-		10%
Terminal Value	$16000M	$4000M	-	$20000M	$23.1		-

FINANCIAL STATEMENTS

Assumptions

The key driving assumptions for the financials are the revenue forecasts, the capital expenditure (CAPEX) and operational expenditure (OPEX) investment assumptions, the loan conditions for debt, and the staffing sizing for the company, and they are modelled based on the strategic implementation plan described in the previous section. The following additional assumptions have been made:

- A planning period of 15 years, beginning in 2012 and ending in 2027.
- The MOBEO system will be deployed in 2015 and revenue flow starts in 2016 and will reach $12 billion in 2027.
- The country of incorporation is in the Isle of Man and there will be no tax payments.
- The loan conditions obtained by MOBEO will have a repayment schedule of 6 years with an interest rate of 10%. The first loan will be required two years after financing.
- The operation of the company requires 160 personnel to support the implementation strategy. Company organisation includes a technical team (for engineering and operations), a financial team, a marketing and sales team, legal team and administrative support.

Profit & Loss

Based on the forecasted revenue, capital and operational expenditures and the financing plan described above, the profit and losses account (P&L) for MOBEO can be derived. Figure 21 shows the key profit and loss line items in terms graphic trends.

As expected by the revenue forecasts and by the profile for the capital expenditures, net income is negative in the first six years of the business, but in the Year 7, the business generates positive net income.

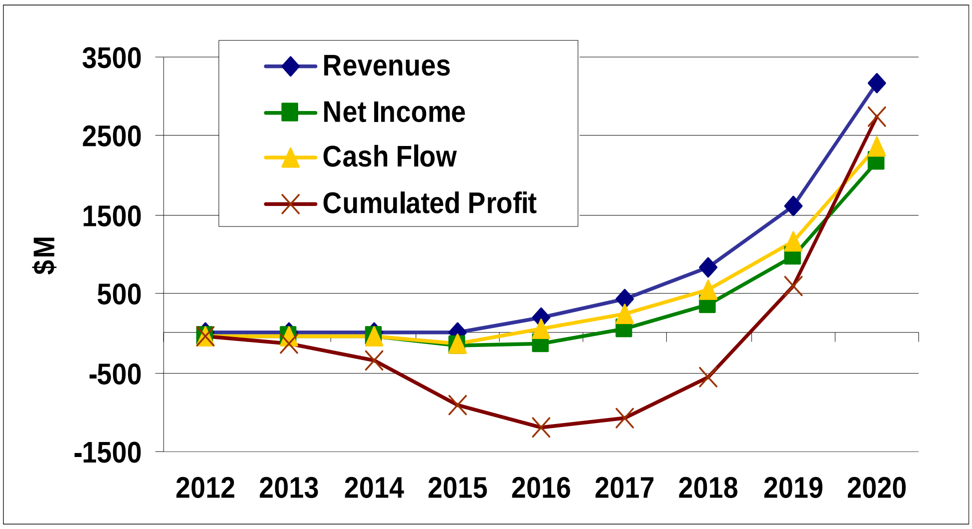


Figure 21. MOBEO's financials projections.

MOBEO will begin generating revenue in Year 5 immediately after launch. By Year 7, MOBEO will generate positive net income, and the break even point by Year 8. Overall, the MOBEO business proposal is attractive for investors and reliable for banks.

Examining three different scenarios with varying market penetration rate assumptions, which are shown in Table 4, reveals that the time to profit and break even point to do not change significantly, and that MOBEO's financial approach is solid.

Table 4. Sensitivity Analysis.

Scenario	Final Share	Time to Profit	Break Even Point
Pessimistic	10%	6 years	8 years
Baseline	20%	6 years	8 years
Optimistic	40%	5 years	7 years

Cash Flow

Now examining the cash flow statement to properly understand the development of the business, it is useful to focus on the first 10 years of the planning period. Figure 22 shows the investments and financing described above and the overall derived. Overall, the amount of liquidity and free cash flow that can be achieved starting year 10 is quite significant.

Analysing more in detail this starting phase, the first 5 years are the most critical period, due to significant outflows for the investments and the other system costs. After that, the cash inflow became significant thanks to revenue flows, and then the outflow component quite small if compared with it, with a net result of an increase of liquidity.

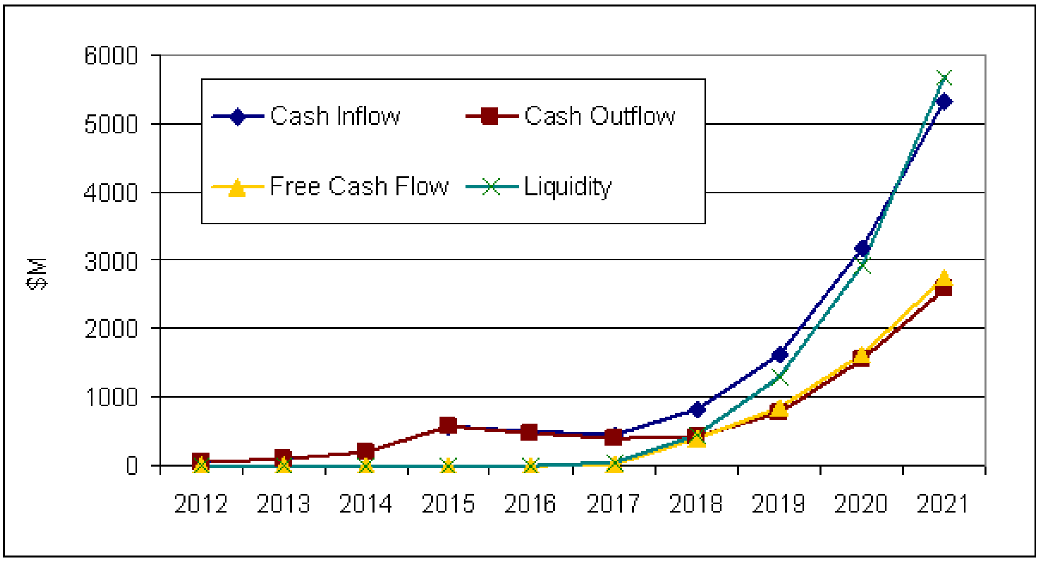


Figure 22. MOBEO's cash flow projections.

Balance Sheet

The health of the MOBEO business can be clearly assessed by means of the analysis of the balance sheet, which shows the trend of the equity ratio, which is a sensitive parameter for assessing the margins against bankruptcy conditions.

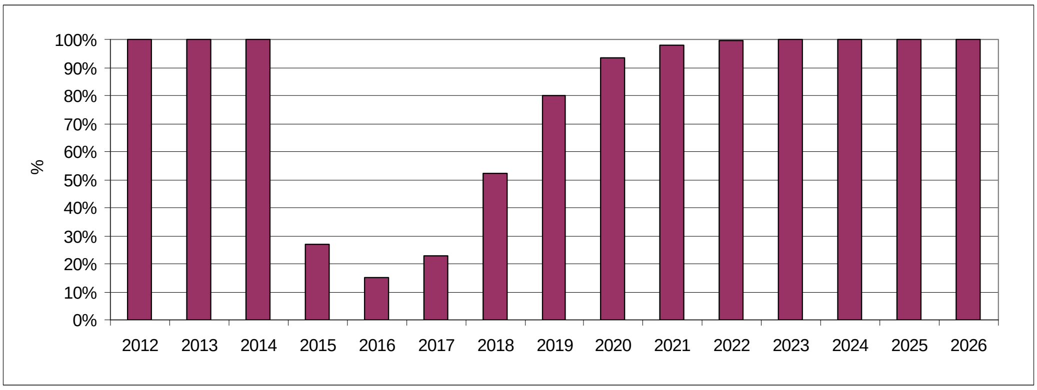


Figure 23. MOBEO's balance sheet projections.

Critical Risks and Challenges

Risk Classification

As mentioned before, there are a few challenges to overcome for MOBEO. MOBEO has identified the risks it needs to track and mitigate. Table 2 shows the top risks for MOBEO, and Figure 24 provides the risk assessment for each risk.

Table 5. Top 6 risks

#	Identified Risk	Risk Description
1	Time to market	The first player to penetrate the mobile mass market will likely dominate the market. It is critical that MOBEO is first to market.

2	Market adoption	The mobile mass market for geo-information is a new market and while evidence shows that there is a strong need for geo-information, there is no proven market yet.
3	Satellite production schedule	The schedule is tight for production, and any delays in production may impact MOBEO's ability to be the first to market.
4	Financing	MOBEO requires $1.2 billion in investment in both equity and debt. The proposed investment is attractive, but the investment partners to date have not been secured.
5	Implementation of required levels of automation	In order to minimize costs, it is imperative that MOBEO be able to create an automated system to keep operational costs down.
6	Instrument design and development	One of MOBEO's key differentiators is its state of the art satellite imagery system that can provide one meter resolution imagery on a global level at least once a week. If the instruments required cannot meet this requirement, MOBEO's differentiator will be in danger.

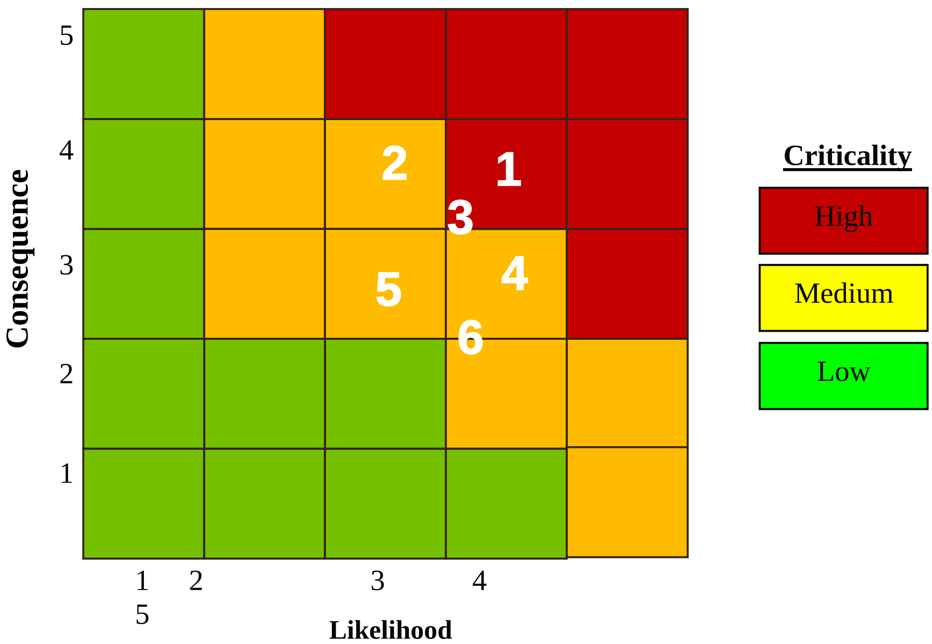
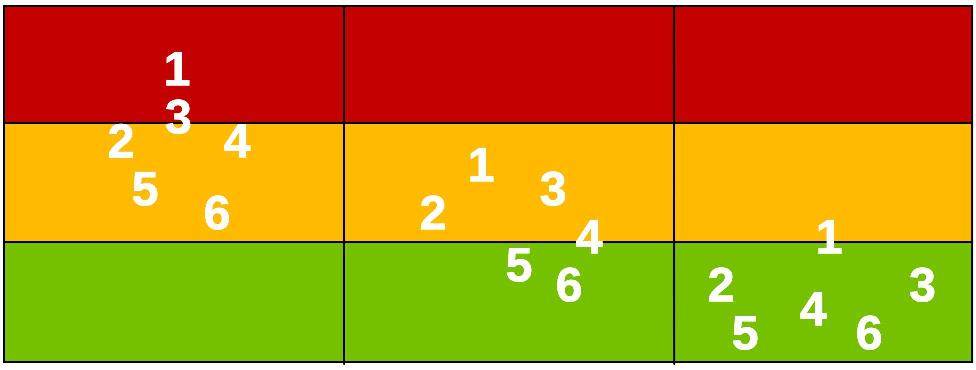


Figure 24. Risk Classification Matrix

Risk mitigation plans have defined for each of the identified risks and can be found in Volumes 2 and 3. Figure 25 shows the expected development of the criticality of the risks. At kick-off they are rather high, but through mitigation actions the criticality can be reduced over time.



2012 2013 2014 2015

Figure 25. Risk Waterfall chart

CONCLUSION

MOBEO presents a highly innovative new business concept, forming a hybrid between the space sector and the internet community. Until today, the mass market has not yet been successfully accessed by space companies which provide earth observation imagery. The reason for this is mostly based on three factors: missing relevance as commercially available imagery is not up to date, accessibility as there is no integrated solution to bring imagery to customers' familiar environments and affordability as prices for space imagery are not attractive to the mass market. MOBEO combines three well established concepts in order to overcome those challenges: firstly, the satellite imagery will be collected by MOBEO's own fleet of spacecraft, which had been designed in order to provide high resolution images with a guaranteed update frequency of once per week, secondly, a technical platform which serves as connector between various stakeholders in the mass market and in earth observation imagery and which is able to serve the mass market in a way that is accessible via users' mobile devices and finally, the usage of a micro-transaction model to charge for access to the data. This combination creates a completely new ecosystem to enter the huge market.

This concept answers the challenge that SpaceTech has put on the participants which was "Can we provide a massive and automated representation of the whole Earth with 1 m resolution and on a daily basis to the mobile community".

According to the analysis performed there is an enormous untapped market beyond the existing traditional one for delivering geo-information to the mass market. MOBEO's geo-information services can be used to enhance the daily lives of the end user in a countless number of ways.

MOBEO will be well positioned in the competitive landscape, being differentiated from the current players in the geo-information market as it will be the only player to provide services across the entire value chain. MOBEO's end-to-end concept will be the first to serve the end users due to a very streamlined implementation plan, and once the services are commercially available, it will certainly set high entry barriers, mainly due to its strategy of delivering geo-information to the end users at very competitive prices.

No significant legal and regulatory issues that could impact MOBEO's time to market have been identified and all potential issue can be resolved in maximum two years.

Based on the financial analysis presented, MOBEO's business will provide a time to profit in five years, a break even period of seven years and a payback period of four years. The proposed business plan is expected to be valued at $40 billion within the next fifteen years with $12 billion in revenue annually. MOBEO is currently seeking a $50 million investment to launch the business in 2012 with a potential return of factor 52 within the next fifteen years. All this makes MOBEO's business proposal attractive to possible partners and investor.

Finally, MOBEO's concept is designed with a high degree of flexibility which makes it easy to absorb the expected exponential market growth after the services enter commercial operations. In addition, the technical solution is mostly based on existing technology or already flown hardware.

In combination this means that although the technical concepts and technologies are proven and traditional, the idea behind MOBEO will revolutionise the way people live and interact with the world around them.

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Alessandro Gabrielli	Agenzia Spaziale Italiana
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Theresa Huang	The Boeing Company
Michael Koller	European Space Agency
Martin Maier	Deutsches Zentrum für Luft- und Raumfahrt
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Shahrizal Ide Moslin	Angkasa
Noah Saks	Astrium
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Sonia Toribio	European Space Agency
Markus Töpfer	Deutsches Zentrum für Luft- und Raumfahrt

ACRONYMS

AOCS – Attitude and Orbit Control System

App – Application

B2B – Business to Business

B2C – Business to Customer

B2G – Business to Government

BL – Business Line

CAPEX – Capital Expenditure

COGS – Costs of Goods Sold

CPU – Central Processing Unit

ESA – European Space Agency

FPA – Focal Plane Array

GPU – Graphics Processing Unit

IPO – Initial Public Offering

IRR – Initial Rate of Return

LBS – Location Based Services

MCS – Mission Control Room

MOPTICS – MOBEO Optical Sensor

MOSARS – MOBEO SAR Sensor

NASA – National Aeronautics and Space Agency

OPEX – Operational Expenditure

P&L – Profit and Loss

PFM – Proto Flight Model

PSLV – Polar Satellite Launch Vehicle

SAR – Synthetic Aperture Radar

VNIR – Visible and Near-Infrared