Study of Earth Observation Business Models by Means of the Business Model Canvas Methodology

Master's Thesis – Annex

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1. Introduction

This chapter includes the aim, scope and requirements of the interrupted project introduced in the report (see Previous Considerations section).

1.1 Aim

The aim of this project is to study and compare the viability of launching a VLEO (Very Low Earth Orbit) mission with a fractionated and a monolithic architecture. Specially, the fractionated architecture will apply the ‘lean business’ concept.

1.2 Scope

- Identification of the most promising market in VLEO missions and its stakeholders.
- Identification of the most representative VLEO mission within the promising market (application, payload and orbit).
- Development of the mission planning and scheduling applying both the monolithic architecture and the fractionated architecture.
- Comparison of the results of the monolithic and the fractionated architectures in terms of deployment time, economic viability and technological efficiency.
- Study of the advantages and disadvantages of the application of the Lean concept to VLEO missions.
- Identification of a new business opportunity in VLEO missions and proposal of a business model.

1.3 Requirements

1. The mean altitude of the mission shall be between 160km and 450 km (VLEO).
2. The target market shall be the European market.
3. The new business opportunity shall benefit European enterprises, precisely the SMEs.
2. Mission Analysis

A Mission Analysis must be done prior to the Mission Planning and Scheduling in order to define the mission application or objectives, the payload required and the suitable orbit parameters.

2.1 Application selection

The application of the mission developed in this study, both in its monolithic and fractionated version, is the forecasting of jellyfish blooms. The justification for this decision is presented in the following paragraphs.

While jellyfish are a natural inhabitant of the Mediterranean Sea and a necessary component of the marine natural ecology, jellyfish blooms had always been a rare phenomenon that only in the last decade has started to become common, with massive smacks of these gelatinous organisms showing up in coastal waters. The Mediterranean coasts of Spain and France are some of the areas which are regularly impacted by large concentrations of jellyfish, in particular by the stinging jellyfish *Pelagia noctiluca* [1].

Such events are an inconvenience for swimming and other leisure activities at sea such as snorkelling, sailing, surfing or the practice of other water sports, and in the case of certain species can become a real health hazard (8.7% of the cases reported in a study conducted during 2007-2011 in the coasts of Salento, Southern Italy, evoked complications, mainly due to allergic reactions [2]. And all those jellyfish-related first-aid services reported over the 5-year period had an estimated cost of 400.000 €, that is, 80.000 € per year only in Salento.

Not only that, but jellyfish are considered a pest by fishermen, since they keep away fish, consume their larvae and clog nets [3]. Species such as herring, sardines, and anchovies have also been known to compete with them for the same zooplankton meals [4]. According to a report published by FAO (“Review of Jellyfish Blooms in the Mediterranean and Black Sea” [5], increases in jellyfish populations may be one explanation behind a drop in fish stocks observed in the Mediterranean and Black Sea.
All in all, jellyfish blooms are actually having an overwhelming impact on a number of fisheries of sites worldwide [6], from Japan (30 billion yen in losses in 2005, [7] to Ireland, where an organic salmon farm was completely ruined in a 24-hour period by a jellyfish bloom [8]. Besides, several industrial marine cooling systems have recently had to be put temporarily out of operation because of jellyfish clogging the underwater pipes [3].

The socio-economic impacts of jellyfish blooms are therefore tangible. And yet our understanding of this phenomenon remains very poor. Jack Costello, a biology professor at Rhode Island-based Providence College, explains that this creatures have historically received little attention because the seafood industry does not take any profit from it. "Studying the ocean by humans is very much influenced by perception of value," said Costello [4].

While overfishing, climate warming and coastal degradation are some of the most probable drivers of this tendency, we have not been able to identify the specific causes and mechanisms behind it yet, and further investigations are hampered by this lack of reference data [3]. We should probably consider imperative acquiring a better knowledge of this gelatinous zooplankton’s behaviour and developing the ability to predict their appearance.

May different initiatives have been born trying to monitor jellyfish, and especially in the Mediterranean Sea: Jellyrisk [9], Cubomed [10], the JellyWatch Program by CIESM (the Mediterranean Science Commission) [3] and many jellyfish spotting campaigns, like the one promoted by Perseus (the marine environmental research project funded by the European Commission) [11]. But EO data offer a great opportunity that only a few are taking advantage of. This includes large-scale monitoring in a cost-effective way by means of specially tailored data products regarding the status of coastal environment and land use change [12].

In 2009 the European Space Agency (ESA) funded a project called Eojelly specifically aimed at forecasting jellyfish blooms. Eojelly is the first operational jellyfish prediction service with a global coverage [13]. Focused on the western Mediterranean and Ireland, Eojelly has a majority of Spanish stakeholders, including Barcelona-based high-tech company StarLab as prime contractor and the Catalan Water Agency as user [14]. It uses satellite images and numerical models to create a neural network that is trained and validated with real-time oceanographic monitoring systems [8], to finally produce a forecast of predicted jellyfish occurrence in a given area. This service is provided to...
water agencies and fishermen’s organizations or as a jellyfish alarm system on the smartphone of a private user.

This pioneer project was followed by the JellyFor project, which developed a service to predict jellyfish occurrence for given temperature, salinity and chlorophyll-a conditions [13]. JellyFor, again developed by StarLab (Spain) together with TechWorks Marine (Ireland), was selected as a Eureka Eurostars programme and funded with 1,35 M€ [15].

For all the above reasons, I select the forecasting of jellyfish blooms as the application of the missions developed in this study. It is an application that has an impact from the scientific point of view (increase our understanding of the marine ecosystem), from the social one (tourists and locals can make a better use of their leisure time by avoiding going to the wrong beach at the wrong time) and of course from the economic one, in all the SMEs related to tourism, fishing and other activities directly or indirectly linked to the sea.

Besides, this is a good option for this study because, as will be explained in the next section, this application requires a number of different instrument types, which allows a more interesting analysis and comparison between a monolithic and a fractionated architecture.

### 2.2 Payload selection

Some physical and biological ocean parameters favour jellyfish blooms and thus can be used to forecast them. The following table includes these parameters that strongly affect jellyfish occurrence [16] and the type of instruments to measure each of them [17].
Table 1. Ocean parameters required and the instruments to measure them.

<table>
<thead>
<tr>
<th>Ocean parameter</th>
<th>Satellite Instrument type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea surface temperature (SST)</td>
<td>Infrared radiometer, or Microwave radiometer, or Spectroradiometer</td>
</tr>
<tr>
<td>Currents</td>
<td>Altimeter and Scatterometer</td>
</tr>
<tr>
<td>Salinity (S)</td>
<td>Microwave radiometer</td>
</tr>
<tr>
<td>Chlorophyll content (CHL)</td>
<td>Spectroradiometer</td>
</tr>
<tr>
<td>Sea-surface height (SSH)</td>
<td>Altimeter</td>
</tr>
</tbody>
</table>

Out of these five parameters, the first three ones (SST, currents and salinity) can also be measured using in-situ techniques, and all of them can be studied using numerical models (models simulating chlorophyll concentration have emerged in the past few years [18]. Remote sensing is therefore the only way to get real data from a global perspective, and numerical models and in-situ measurements make a good team with them. 3D ocean models take into account all this ocean data (from satellite and in-situ measurements), allowing to create a complete 3D description of these physical and biological parameters of the ocean and forecast their evolution in time.

If we take a look at the information compiled in the State of the Art of EO, we can check that Envisat, the mission which provided the EO data used in Eojelly project, includes all of the instruments required for this application.
Table 2. *Some Envisat instruments for ocean forecasting.*

<table>
<thead>
<tr>
<th>Envisat instrument</th>
<th>Instrument type</th>
<th>Parameter measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>MERIS</td>
<td>Imaging spectrometer (spectroradiometer)</td>
<td>CHL, SST</td>
</tr>
<tr>
<td>MWR</td>
<td>Microwave radiometer</td>
<td>S (and SST)</td>
</tr>
<tr>
<td>RA-2</td>
<td>RADAR altimeter</td>
<td>SSH, currents</td>
</tr>
</tbody>
</table>

Likewise, Sentinel-3, the main ESA space mission to support ocean forecasting systems in the near future, also counts with an analogous list of instruments.

Table 3. *Sentinel-3 instruments for ocean forecasting.*

<table>
<thead>
<tr>
<th>Sentinel-3 instrument</th>
<th>Instrument type</th>
<th>Parameter measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLCI (following MERIS)</td>
<td>Imaging spectrometer</td>
<td>CHL (and SST)</td>
</tr>
<tr>
<td>MWR</td>
<td>Microwave radiometer</td>
<td>S (and SST)</td>
</tr>
<tr>
<td>SRAL</td>
<td>SAR altimeter</td>
<td>SSH, currents</td>
</tr>
<tr>
<td>SLSTR</td>
<td>Imaging radiometer</td>
<td>SST</td>
</tr>
</tbody>
</table>

Note that the later mission, Sentinel-3, maintains the imaging spectrometer and the microwave radiometer (in newer, better versions), changes the RADAR altimeter for a SAR altimeter, and adds a temperature radiometer specifically designed to measure sea surface temperature (and land surface temperature), although this parameter could as well be measured by two of the rest of instruments.
Following this line, I choose as payload the following instruments.

<table>
<thead>
<tr>
<th>Instrument type</th>
<th>Parameter to measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging spectrometer</td>
<td>CHL (could as well measure SST)</td>
</tr>
<tr>
<td>Microwave radiometer</td>
<td>S (could as well measure SST)</td>
</tr>
<tr>
<td>SAR altimeter</td>
<td>SSH</td>
</tr>
<tr>
<td>Imaging radiometer</td>
<td>SST</td>
</tr>
</tbody>
</table>

While altimeters can measure geostrophic currents, scatterometers need to be added to see surface currents and winds. Furthermore, one of the main applications of ocean-applied numerical models is precisely forecasting currents [19]. Therefore this parameter, required to forecast in which direction jellyfish will be drifted, will be rather obtained by numerical models than by remote-sensing measurements.

### 2.3 Orbit selection

Again using the information collected in the state of the art, one can easily see that the most common orbit type for EO is a polar Sun-synchronous orbit (SSO).
Out of the 14 missions studied in the state of the art use this type of orbit. The remaining 3 use a geostationary (GEO) orbit (MSG and Sentinel-4) or a non-SSO with 66-degree inclination (Sentinel-6).

The two versions of the mission developed in this study will use a polar, Sun-synchronous orbit. This orbit is the most interesting choice for many reasons:

- **Global coverage**: with the spinning Earth, a polar-orbiting satellite with its orbital plane inclined around 90° ends up sweeping over different swaths of ground in each orbit and eventually covering the whole globe [20].
- **Constant lighting conditions**: due to the fact that the orbit is specifically designed to ensure that the angle between the orbital plane and the Sun remains constant [20]. This affects both the images taken from the satellite and the thermal conditions of the spacecraft itself.
- **Easily attainable orbit**: the larger inclination (near 90°) of a SSO compared to a GEO orbit (equatorial, 0°), makes it achievable from virtually any spaceport, increasing the launch opportunities from the logistic point of view.

As for the altitude, each of the two versions of the mission will have a different one.

The monolithic version wants to be a typical example of EO mission in LEO, like those studied in the state of the art. The following figure helps to have a global perspective of the altitudes found among those missions.
As Figure 1 shows, most missions have altitudes between 775 and 825 km, with 785 and 817 as the modes. Sentinel-3, the one with objectives and instruments more similar to the 2 missions (or versions of the same mission) developed in this study, has an altitude of 815 km, which, according to the previously stated, is a very representative value. Therefore I choose 815 km as the altitude of the monolithic (LEO) mission.

Differently, the fractionated mission follows the line of the low-cost constellations by Planet Labs as an example of a multi-satellite mission in VLEO. This company’s constellation in SSO has an orbital insertion altitude of 475 km, along with an operating lifetime of 2-3 years per satellite [21]. Hence, the fractionated (VLEO) mission will have an orbital insertion altitude of 475 km.
3. Bibliography


[12] “→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT → MEETING AN EMERGING DEMAND → PARTNERSHIPS FOR GROWTH.”


[14] “→ INNOVATION IN EO SERVICES.”


