



D5.7 – Roadmap of BM Canvas for stakeholders in the VLEO market

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List of acronyms and abbreviations

| | |
|------------|--|
| ABEP | Atmosphere Breathing Electric Propulsion |
| BABOK | Business Analysis Body of Knowledge |
| BM | Business Model |
| CIMA | Chartered Institute of Management Accountants |
| DISCOVERER | Disruptive Technologies for Very Low Earth Orbit Platforms |
| EC | European Commission |
| EO | Earth Observation |
| ESA | European Space Agency |
| EU | European Union |
| FE | Financing entities |
| LEO | Low Earth Orbit |
| LF | Leverage Factor |
| NASA | National Aeronautics and Space Administration |
| NSA | National Space Agencies |
| PERT | Programme Evolution and Review Technique |
| PESTEL | Political-Economical-Social-Technological-Environmental-Legal analysis |
| PMBOK | Project Management Body of Knowledge |
| R&D | Research and Development |
| SAR | Synthetic Aperture Radar |
| SME | Small & Medium Enterprises |
| SWOT | Strengths-Weaknesses-Opportunities-Threats analysis |
| TRG | Technology Research Groups |
| TRL | Technology Readiness Level |
| UK | United Kingdom |
| UPC | Universitat Politècnica de Catalunya |
| USA | United States of America |
| U.S. DoD | United States Department of Defence |
| VAS | Value-Added-Services |
| VHR | Very High Resolution |
| VHR-HP | Very High Resolution – High Performance |
| VHR-LC | Very High Resolution – Low Cost |
| VLEO | Very Low Earth Orbit |
| WP | Work Package |

1 Executive summary

This deliverable shows four business model roadmaps based on the findings of previous WP5 deliverables, more specifically D5.5 – Business models for the most promising concepts of EO at VLEO.

Roadmaps shown in this document correspond to:

- Access to Space, since the expected growth of EO and telecom missions at VLEO may boost the need for new concepts of accessing to space, different from the traditional secondary payload of large satellite missions.
- Ground Segment Services, since both the growth of VLEO missions plus the particularities of those orbits, bringing reduced communication windows and short revisit times, foster the need of new solutions at ground stations level.
- Turnkey providers, specially launching brokers, since the expansion of new space business models opens the door to newcomers providing new services at a much lower scale than traditional missions based on large corporations or national agencies. Turnkey providers may fill the gap in many different stages of a mission for those newcomers.
- New VLEO-EO platform concepts, that take advantage of the DISCOVERER findings and expectations at VLEO.

The final objective of this deliverable is to show a path, enabling and boosting the presence of EU-based companies in that VLEO-EO market, and also allowing the EU to become a key player in the overall VLEO industry. Besides, it can be stated that most of the achievements in VLEO can also be useful at LEO.

The starting point for producing this document comes from previously developed deliverables:

- D5.1, dealing with the present EO market;
- D5.2, making a deep analysis of the benefits and challenges of VLEO for EO purposes;
- D5.3, dealing with the trends for EO at VLEO;
- D5.4, drawing the most promising system concepts of platforms suited to the DISCOVERER technologies; and,
- D5.5, presenting the Business Model Canvases of those promising system concepts for companies linked with the EO services at VLEO.

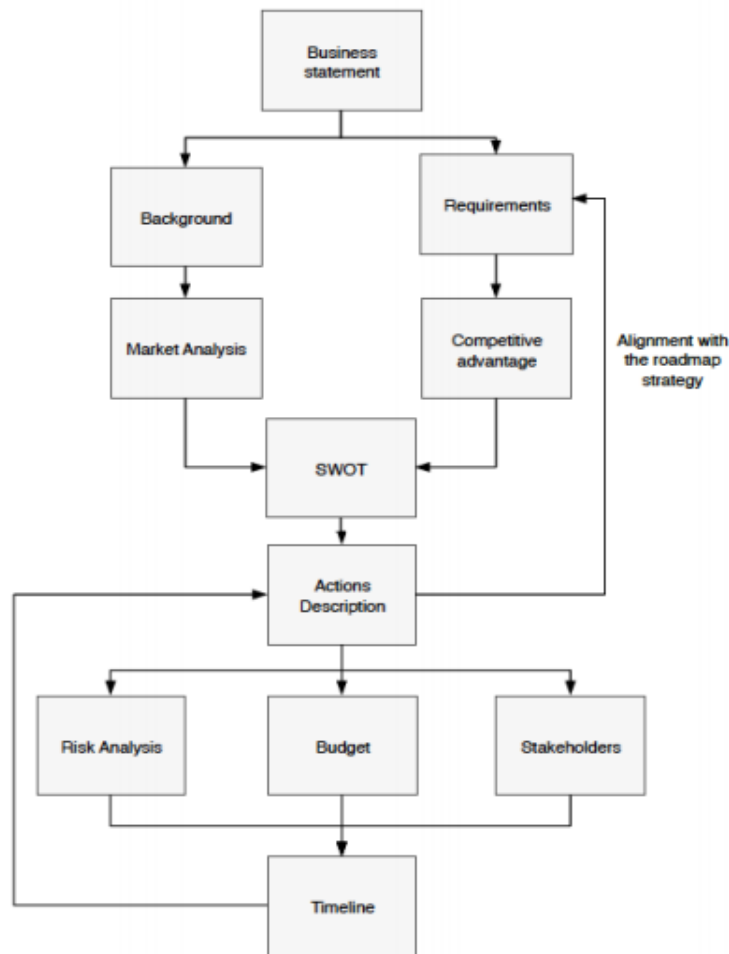
The structure of this deliverable is made up:

- A brief **Introduction** of the deliverable (**Chapter 2**), its **Purpose** with the aim of enabling and boosting the presence of EU-based companies in that market (**Chapter 3**), and **Context** that starts reviewing the literature and requirements of roadmaps application (**Chapter 4**).
- A brand **new methodology for implementing and developing DISCOVERER business model roadmaps** has been described and explained (**Chapter 5**).

The structure proposed for the roadmaps is divided in four main blocks:

- Goals to achieve.
- Situation analysis.
- Activities planning.
- Roadmap implementation.

Eleven stages perform the new roadmapping methodology:



Stage 1: Business statement

Stage 2: Background

Stage 3: Market Analysis

Stage 4: Requirements

Stage 5: Competitive advantage

Stage 6: SWOT Matrix

Stage 7: Actions description

Stage 8: Risk Analysis

Stage 9: Budget

Stage 10: Stakeholders

Stage 11: Roadmap timeline

This new methodology has been implemented in **four case studies**, the main key areas of the **VLEO sector** (launchers, ground providers, turnkey solutions and new VLEO Platforms). Each roadmap will regard the case study Space sector from the EU point of view.

Figure 1 Flowchart of the new roadmap's methodology

- **Chapter 6** focused on **Access to Space**. This roadmap mostly focused on how the EU companies could market more efficient technologies to reduce the costs and increase accuracy of their launches. Twelve actions and an overall estimated budget of 8.000 M€ are detailed.
- **Chapter 7** focused on **Ground Providers**. This roadmap mostly focused on how the EU companies could design enhanced ground stations in order to guarantee the proper exploitation of the EO information coming from the VLEO satellites. Twelve actions with an overall estimated budget of 8.000 M€ are detailed.
- **Chapter 8** focused on **Turnkey Providers**. This roadmap mostly focused on how the EU companies could boost the development of new companies inside the satellites field. Twelve actions with an overall estimated budget of 3.500 M€ are detailed.
- **Chapter 9** focused on **new VLEO Platforms** (Very High Resolution & High-Performance Platform, Very High Resolution & Low-Cost Constellation, and SAROptic). This roadmap mostly focused on how the EU companies could apply the brand new technologies defined by the DISCOVERER in order to enhance the performance of the satellites, being more efficient. Twelve actions with an overall estimated budget of 8.500 M€ are detailed.

Finally, **final conclusions** of this deliverable can be found in **Chapter 10**.

2 Introduction

In this deliverable, a roadmap is defined as a high-level strategic document, commonly used by big organisations, which serves as the bridge that aligns the business statement (mission) of a company with its business model (vision).

Nevertheless, until now, the use of a roadmap as a project management tool was not commonly established inside the engineering and technology field. In fact, nowadays there exist different ways of defining a roadmap, depending mainly on the author's criteria.

For this reason, a new methodology for creating roadmaps has been developed in this deliverable, connecting standard strategic planning concepts with the ones already established in the aerospace field and analysing, at the same time, all the areas of the business: like the market and business scenarios, the stakeholders, risk of the suggested actions, amongst others.

As a result, a detailed plan will allow to accomplish the business' and stakeholder's goals, providing more complete roadmaps than those currently produced by the companies and academic institutions analysed, which will be explained more in detail later in this document.

Therefore, this deliverable is focused on the creation of four partial roadmaps (Access to Space / Ground Services / Turnkey Providers' / VLEO Platforms), which aim to boost the presence of EU-based companies in the Earth Observation market at Very Low Earth Orbits and make the EU to become a key player in this EO-VLEO market. These roadmaps are made in accordance with the most promising BMs found in Deliverable D5.5 (Business Models Canvas for the most promising system concepts of EO at VLEO).

The new methodology can be applied in many sectors, not only in the technology or engineering field, and it also provides comprehensive tools and techniques to ensure that the main information is visually depicted and that the roadmaps can easily be tracked.

3 Purpose

The aim of this deliverable is to develop four roadmaps focused on the current main areas of EO at VLEO, with the final objective of enabling and boosting the presence of EU-based companies in that market, and allow the EU to eventually become a key actor in the VLEO industry.

The starting point for producing this document is two-folded:

- In the previous Deliverables D5.1 and D5.3, an up-to-date analysis of the EO market has been conducted. D5.1 deals with the present EO market, and D5.3 with the trends for EO at VLEO. As a result, both: the present stakeholders, and the expected growth of the market, arise.
- Deliverable D5.2 makes a deep analysis of the benefits and challenges of VLEO for EO purposes, and Deliverable D5.4 draws the most promising system concepts of platforms suited to the DISCOVERER technologies.
- Deliverable D5.5 presents the Business Model Canvases of those promising concepts for companies linked with the Earth Observation services at VLEO.
- Deliverable D5.6 establish a technological roadmap of the DISCOVERER findings for the Space Agencies.

As a result, a deep analysis of the market and system concepts, added to the Business models developed, provides a complete overview of the current industry situation, standards and milestones. This overall information is used for the roadmapping of the business analysis, and the definition of specific chapters of the different actions necessary to guarantee the objectives of this document.

Thus, the structure of this deliverable is:

- **Introduction, Purpose, and Context** are explained in *chapters 2, 3 and 4*.
- A brand **new methodology for implementing roadmaps**, focused in the technology field, has been described and explained in *chapter 5*.
- **Four detailed roadmaps regarding the main key areas of the VLEO sector** are defined in *chapter 6, 7, 8, 9*:
 - o Access to Space → Micro-launchers, and including rockoons.
 - o Ground Station Services.
 - o Space Brokers.
 - o Platforms for VLEO → Very High Resolution & High Performance Platform, Very High Resolution & Low Cost Constellation, and SAROptic.
- *Chapter 10* will draw the main **conclusions and recommendations** of this deliverable.
- *Chapter 11* summarizes the **internal and external references** of this document.

4 Context: Roadmaps current situation

4.1 Practical use of roadmaps

A brief introduction to what a roadmap is and how it works has been provided. Nevertheless, it is also necessary to analyse and explain how roadmaps are currently being applied in the industry.

A journal article of Abele and Schimpf [1], which analysed more than 2,000 companies, sets up these conditions:

- Roadmaps are mostly used for defining the strategy of a product, since more than 80% of the considered companies used it for that purpose.
- Moreover, also a significant number of companies used roadmaps for implementing and developing a technology, in a frame time period between five and ten years. Consequently, as the period of time increased, it is necessary to outline the priority tasks and depict the links between each action.
- In addition, only around half of the companies used a roadmap for R+D and technology implementation. This reduction in the number of companies is caused by the fact that longer periods are needed in R+D, as they implemented a roadmap of more than 10 years for these purposes, which is the case that best suits with the DISCOVERER's framework.
- Finally, the article also highlights the fact that most companies use multi-layered roadmaps to fulfil the developed roadmaps.

4.2 Main requirements of a roadmap

Analysing "*Technologie-Roadmap: strategisches und taktisches Technologie- management*" [2] and "*Developing a technology roadmapping system*" [3], and adapting the information according to the coming roadmap definition, it can be stated that the main requirements and goals that the DISCOVERER's roadmap must accomplish are:

- **Summarise the project evolution:** Summarise the development and explain the different steps and connections to the stakeholders that participate, with the final idea of using the roadmap as a final strategical guide.
- **Define the vision statement of the institution:** The roadmap must clearly spotlight the company's future aspirations, as well as the main goals of the activities detailed in the roadmap.
- **Prioritize tasks and resources:** The roadmap must be done analysing the actions that must be prioritized. This way, the interaction between each action, the timeline, the scope of each task, the costs and the effectiveness of all the resources must be taken into account. **Must be updated:** A roadmap has to be flexible, as it will require some modifications during its deployment. Hence, the roadmap must be regularly updated, according to the current situation of the organisation at each moment. The roadmap is an iterative process.
- **Must be visually depicted:** The idea is to present the main information in an easy and quick way, so that it can be easily followed-up.

4.3 Roadmap definition according to the DISCOVERER project

The new roadmap methodology developed in the accompanying thesis [TFE-1] can be defined as a powerful tool that: 1) graphically displays the situation analysis of the EO field at VLEO, 2) delivers a planning of the activities that must be carried out, and 3) states the objectives or goals that must be achieved in order to move to the next level status.

In this way, the roadmap will divide the final objectives into different tasks, that will be interrelated. It is also necessary to develop a time-based hierarchical plan to improve the efficiency of the process and avoid overlapping issues.

Therefore, even though the previous points should be common for all the roadmaps, each company and institution develops its own methodology. Nevertheless, the university of Cambridge published in 2001 a book [4] that included a methodology that was intended to be applied as a guide for realising a roadmap.

Finally, according to the idea presented in "Starting-Up Roadmapping Fast" [5], as the roadmaps developed in this document will analyse and present different areas of the DISCOVERER project, it will be necessary to divide the roadmaps into different layers or sections.

In conclusion, roadmaps are defined in this thesis as the bridge that aligns the business statement (mission) of a company/institution with its business model (vision). Being necessary to define the objectives, timeline, resources and costs, among others, for all the activities aimed to be included in the roadmap.

Consequently, the roadmaps created in this deliverable will be multi-layered tools that integrate in a single document the situation analysis of the company / institution, and the planning of each activity's development, in order to ensure the desired goals; explaining, in a synchronized, adapted and suitable way, all the tasks that must be done and their relations.

5 New methodology for developing roadmaps

Once the context of the deliverable has been introduced and the main information of what is a roadmap has been provided, it is necessary to define a general structure that will serve as a future guide to implement and develop the DISCOVERER roadmaps.

So, in order to obtain the necessary information and resources for creating the new methodology, more than seventy roadmaps (published after 2016) from different fields were analysed, using as a bibliographic source the references published by the *Center of Technology of the Cambridge University* [6]. Therefore, the presented methodology was defined following an iterative process:

1. Collect existing roadmaps from different sectors: Basically, the roadmaps were extracted from the sources included in [6] and some additional NASA roadmaps, considering only roadmaps published after 2016.
2. Analyse each roadmap individually, and outline their structure / chapters, and the main tools used in each of them.
3. Check the commonalities between the analysed roadmaps (+70), obtaining a preliminary idea of how the structure is defined. Most of the roadmaps started with a general overview of the market and the technology situation and finished with the implementation of the activities that must be completed to develop the business/project.

At this moment the schema was: 1. Introduction – 2. General view of the market – 3. General view of the technology details – 4. Implementation of the roadmap.

4. Brainstorm about the tools that can be used for defining the business, for example the SWOT matrix, the risk matrix and the stakeholders' matrix.
5. Start defining the final version of the methodology's schema and the different stages that were required, taking into account DISCOVERER's needs and standards.
6. Define a simple risk analysis schema for each roadmap activity as the standard risk matrix was too complex for doing it for each single activity.

Now the schema was: 1. Introduction – 2. Market situation – 3. Technology situation – 4. Activities definition – 5. Implementation of the roadmap.

7. Several cooperative iterations were done until a final proposal for the schema was obtained.
8. Once the final proposal for the roadmap was agreed, additional research was performed to find tools that are able to depict the minimum information at each stage in a visual and schematic format.
9. Finally, in order to check the viability of the methodology, a first test was done by creating a roadmap that followed the schema, which allowed the detection of possible issues and corrections for them, enhancing the schema and improving the final methodology.

Summarising, the final proposed methodology is based on the stages shown in table 1:

Table 1 Roadmap's stages

| | | | |
|--------------------------|-------------------|------------------------|-------------------|
| 1. Business statement | 2. Background | 3. Market Analysis | 4. Requirements |
| 5. Competitive advantage | 6. SWOT matrix | 7. Actions description | 8. Stakeholders |
| 9. Estimated budget | 10. Risk analysis | 11. Timeline | 12. Summary table |

Furthermore, the proposed structure is divided into four main blocks, following the procedure schema presented in Figure 1.

- Goals to achieve.
- Situation analysis.
- Activities planning.
- Roadmap implementation.

Besides, each of the stages will be explained using the following subsections:

1. Aim of the stage.
2. Tasks to be accomplished.
3. Requirements of the stage.
4. Useful, visual tools that can be applied in the stage.

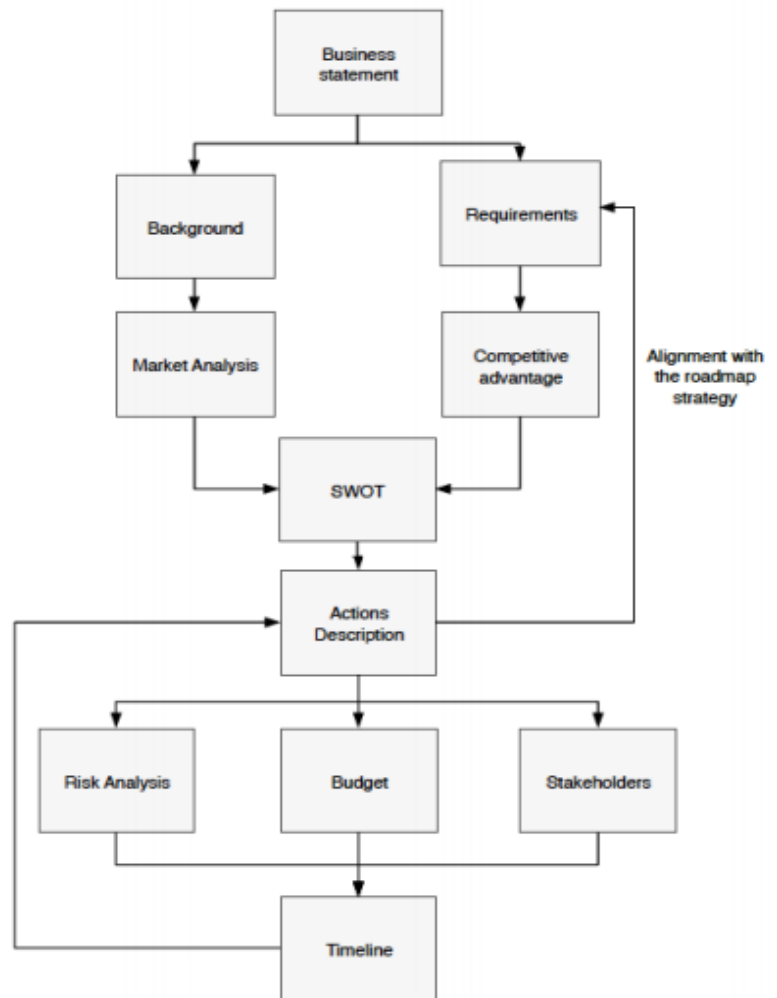


Figure 2 Flowchart of the new roadmap's methodology

A detailed description of each stage, and its tools and techniques, is provided in this chapter.

5.1 Stage 1: Business statement

5.1.1 Aim

The first stage of the roadmap will consist of a brief explanation of its high-level objectives, explaining what the roadmap is about and why the business is different from similar ones, outlining its significance or implications.

Hence, it is seen that this section could work as a brief abstract of the roadmap, allowing readers to quickly get the gist or essence of the roadmap, clearly depicting the goals that are wondered to be achieved and its key points.

5.1.2 Tasks to be accomplished

As this stage will serve as a first contact with the roadmap, it has to clearly depict:

- The roadmap's basic information: the significance of the objectives that are going to be detailed in the roadmap.
- The main goals of the activity or business that the roadmap is going to explain. Moreover, it can include a brief description of the future company's vision statement.
- The central questions or statements that the roadmap will summarise.
- The service that the business will provide to solve the user needs.

5.1.3 Requirements

This section is an opened-up section, so it can be developed following the author's own criteria. Nevertheless, it must be visual and summed up, as it should work as a first approach to the roadmap. Therefore, as you will see later, the roadmaps developed in this document solves this section by providing a brief explanation of each individual point.

5.2 Stage 2: Roadmap background

5.2.1 Aim

The definition used in [7] for describing the State of the Art of a project, could be adapted to explain the purpose of this section, which is:

Demonstrate a solid knowledge of the field where the roadmap is focused on, showing that the author has created an innovative and coherent point of view which integrates and synthesises the main aspects of the field. In order that it can now put into perspective the new direction that it is proposing to explore.

5.2.2 Tasks to be accomplished

This stage must be focused on background of the business to be promoted, needing to:

- Sum up what has already been done in the specific field that the roadmap covers.
- Analyse the technological, political and social past of the industry, in order to have a clearer idea of the current status of the field that the roadmap is based on.
- When necessary, search for possible competitors which can have the same objectives and analyse their current situation.

5.2.3 Requirements

Dr. Rishibha Sachdev outlined in an online article [7] that the background of a research topic:

- Must allow to recognise beyond doubt that what the project is attempting to develop has not been done in the past.
- Should be accompanied by comprehensive references, listed afterwards.

5.2.4 Useful tools: PESTEL ANALYSIS

The PESTEL analysis is a management method that describes and studies the different external factors that must be taken into consideration due to their influence in the operation [8].

Figure 2 presents an example of some points that a PESTEL analysis can include:

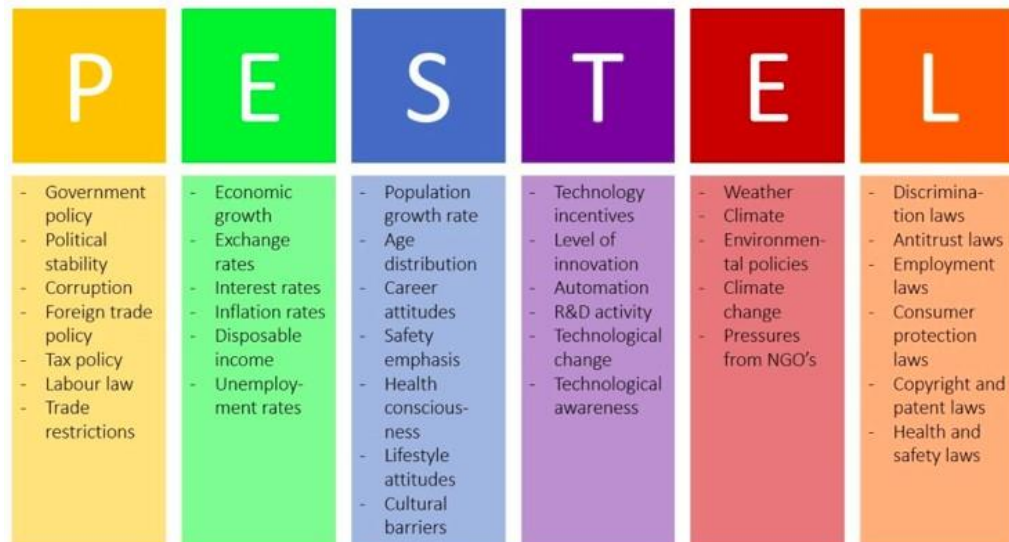


Figure 3 PESTEL example. Source: "PESTEL Analysis EXPLAINED with EXAMPLES — B2U " [9]

5.3 Stage 3: Market analysis

5.3.1 Aim

The definition of "Market Research" published in 2017 by the American Marketing Association [10] could be adapted to explain the purpose of this section, which is:

To show and monitor the market performance by specifying the information required to detect its trends and consequently analyse its results and their implications.

This way, the analysis of the market will allow the determination of the level of attractiveness of the target field, as its size and value. Besides, the market analysis could also include a study and prediction of how the market will behave in the future, showing its trends and evolution.

5.3.2 Tasks to be accomplished

Following the work done by David A. Aaker [11], the market analysis of the roadmaps developed in this document will include the following points:

- Analyse the current and future market size.
- Analyse the market growth rate.
- Analyse the trends inside the market.
- Analyse the market key main factors.

Finally, the use of pie charts is highly recommended for presenting the market's division, size and trends.

5.3.3 Requirements

Consequently, in order to guarantee the accuracy of the study, it must accomplish:

- Use of reliable information sources, as for example: *Historical data, government data, customer surveys, etc.*
- Any conclusion extracted from the analysis, must be based on the statistic work extracted from the information in previous sources.

5.3.4 Useful tools: Porter's five forces

Even though each marketer will adapt the analysis to its own needs, it is considered that the use of the Porter's Five Forces methodology could very useful in order to sum up the market current situation.

According to [12], Porter's Five Forces is a method *"that draws from industrial organization economics to derive five forces that determine the competitiveness and the attractiveness of an industry in terms of its profitability"*.

Thus, this methodology consists of analysing those forces that affect its ability to serve to the customers and make profit. Consequently, if a change in any of the forces is produced, it will be necessary to re-assess the place of the project inside the market.

Besides, in order to present a visual format of the Porter's analysis, up arrows will be used to show that the threat or power that is being analysed is high. On the other hand, if the arrow points down, means the opposite.

This system is used as it serves to summarise the Porter's explanation in a visual format.

An example of the format is shown in Figure 3:

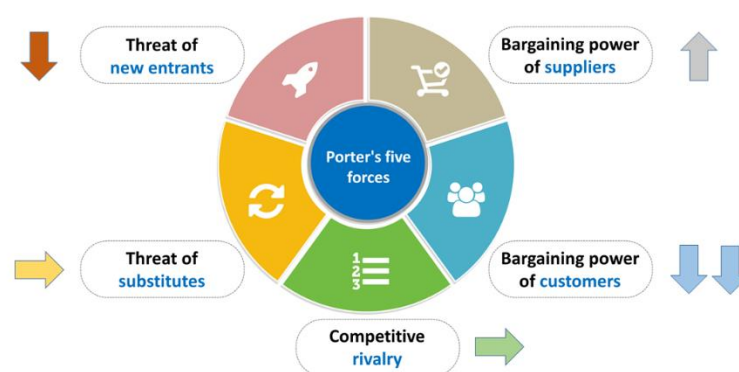


Figure 4 Example of the Porter's Five Forces summary

This is not a closed section. Consequently, it is possible to adapt it to the user's specific needs by using a wide variety of methodologies that can be applied to enhance or substitute the Porter's Five Forces market analysis.

5.4 Stage 4: Roadmap requirements

5.4.1 Aim

The definition of "Requirements" described in [13] can be adapted to explain the purpose of this section, which is:

Describe the singular or functional needs and requirements that the particular business, product, process or service aims to satisfy, according to the strategy of the company or institution that will coordinate the activities explained in the roadmap.

Therefore, the needs and requirements explained can be divided in different areas, depending on their level of specificity, as for example: Technical, economic, business, stakeholders network, among others.

5.4.2 Tasks to be accomplished

According to the Project Management Institute [14] this section should:

- Depict the conditions or capabilities that must be met or possessed by the final solution.
- Depict the conditions that must be possessed by a solution component to satisfy a contract, standard, specification, or other formally imposed documents.
- Depict the conditions or capabilities needed by a stakeholder to solve a problem or achieve an objective.

5.4.3 Requirements

It is important to spotlight that this section will be uniquely defined for a single roadmap. Thus:

- This section has to identify and define the specific requirements of all the areas that are involved, not only in the technical or social fields.
- Moreover, even though this section is done before the strategic analysis is explained in the roadmap, it must be updated each time that the current stage needs change. That is why the methodology schema presented in Figure 1 shows an iterative process.

Summarising, this section describes the needs and requirements in all the areas that the solution and stakeholders depicted in the roadmap must satisfy, according to the strategy of the business.

5.5 Stage 5: Competitive advantage

5.5.1 Aim

The previous sections partially defined the business scenario for the development of the roadmap. Nevertheless, it is important to also study the points and services that are adding value to the business, as it is important to carry out the situation analysis.

Therefore, following the work realised by Kumar and Rajeev [15], it can be defined:

The goal of this section is to analyse the services and the main points of the business that will enable to achieve a more rewarding position in the market, regarding the customer's value criteria and understanding the factors that boost the competitiveness of the business, standing out above the others.

Besides, in case that the institution prefers to analyse the whole process encompassed by a business in order to diversify the analysis, it could be interesting to expand the study to a value chain analysis.

In this case, according to [15]: *"The value chain analysis will include the full range of activities and services required to bring a product or a service from its conception to sale in its final market.[...] Value chain includes producers, inputs suppliers, operation, processors, retailers and buyers"*.

Nevertheless, taking into account the considerations provided by the DISCOVERER team, the roadmaps presented in this document will not include a value chain analysis. Consequently, in this stage they will only enumerate and detail all the different points that add value to the business.

5.5.2 Tasks to be accomplished

Consequently, the roadmap should:

- Understand and analyse the customer's needs and priorities in order to improve the quality according to the demand of customers, increasing the efficiency of the overall activities explained in the roadmap.
- Outline the factors that add value to the business, directly or indirectly, in terms of: price, cost, profit, technological advantages, etc.
- Differentiate the goods or services developed by the business from the ones provided by the competitors, taking into account that the value of a product or service depends on its capacity to accomplish the customer's expectations.

5.5.3 Requirements

There are numerous requirements for analysing the value added services of a business. Nevertheless, according to DISCOVERER's needs and [15], it can be concluded that:

- The value analysis should consider different fields, as for example: technical devices, and financial services, among others.
- The value analysis must regard all the steps of the business explained in the roadmap, from the start till the linkages with other enterprises that could be beneficial.
- As the source of the competitive advantage cannot be detected by looking the business as a whole, the business must be divided in a series of activities or goods, analysing the competitive advantages of each one.

Summarising, this section explains the value analysis of the products and services detailed in the roadmap, differentiating them from the ones provided by the rivals and attempting to ensure some competitive strategy advantages.

5.6 Stage 6: SWOT matrix

5.6.1 Aim

After revising more than 70 roadmaps from [6] (published from 2016 to 2021), it was observed that the majority of the current companies and academic institutions that use roadmaps do not depict the situation analysis of the business.

Nevertheless, this analysis is essential to define properly the BM of a company / sector. Thus, considering that the roadmap is defined as the connection between a business statement and a business model, and considering DISCOVERER's needs, it is concluded that the strategic analysis of the business must be included in the roadmap.

Consequently:

The aim of this stage is to evaluate the strategic position of the business that includes the activities explained in the roadmap, identifying and specifying the internal and external factors that are favourable and unfavourable.

5.6.2 Tasks to be accomplished

The roadmap shall:

- Provide a general idea of the business' competitiveness in order to be conscious of what can be improved, allowing changing, correcting and improving the weakest points before the activities start.
- Develop the analysis considering the needs and key factors linked to the business, which can be classified as general or specific factors.

5.6.3 Requirements

There are numerous methodologies for developing a situation analysis. Nevertheless, according to DISCOVERER's needs it can be concluded that:

- The analysis must be done considering different areas of the business which the roadmap is focused on (like market, technology, etc.), providing the most significant information at each point.
- As this stage is quite complex, the analysis must be shown in a way that it is clear and easy to follow.

5.6.4 Useful tools: SWOT matrix

From [16], it can be concluded that the SWOT analysis is a strategic planning technique related to the project's competition and planning that is used to identify its main strengths, weaknesses, opportunities and threats, followed by a discussion of the critical factors for a successful implementation.

So, the SWOT analysis has to divide the matrix in four parts, having at the top the internal factors (from left to right: Strengths and Weaknesses) and at the bottom the external factors (from left to right: Opportunities and Threats) [17].

Besides, in order to make more efficient the SWOT analysis, the SWOT matrices developed in the roadmaps presented in this deliverable will consider the "Balance Score Card" model, which is a strategic management tool.

Thus, the SWOT matrices will keep their original format, although, in order to enhance the methodology, the matrix will depict at each cell three main categories: 1) Technology, 2) Stakeholders and 3) Economy, adapting the "Balance Score Card" model.

The distribution of the roadmap SWOT matrix is presented in Figure 4:

| | |
|--|--|
| <p><u>Strengths:</u></p> <ul style="list-style-type: none"> - S1. Enhanced platforms for EO activities. - S2. Offer EO V.A.S. regarding the customer's needs. - S3. Affordable EO services. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none"> - W1. High technological barrier for entering to the EO sector. - W2. Need of high cooperation for creating strategic companies. - W3. Need of higher investment to implement the solution. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none"> - O1. Technology transfers between space and defence. - O2. Private companies growing in the EO's platforms field. - O3. EO market is currently expanding. | <p><u>Threats:</u></p> <ul style="list-style-type: none"> - T1. Technological challenges at VLEO. - T2. Data transmission services are strongly regulated. - T3. Risk of underinvestment increases due to COVID-19. |

Figure 5 SWOT matrix developed for the VLEO platforms roadmap (example)

5.7 Stage 7: Roadmapping actions description

5.7.1 Aim

The idea of this stage is to number the list of actions that the agents involved in the business must do to fulfil the expected objectives, taking into account the information provided in the previous stages.

So, regarding the schema depicted in Figure 1, it is seen that after defining the actions it is necessary to analyse different parameters of each one, as the stakeholders, budget or risk.

For this reason, it is considered that classifying the actions in different groups will allow to make the planning analysis in a more visual format, as the actions included in the same group would have similar characteristics. As a result, the following five categories, will accomplish DISCOVERER's needs:

- **Coordination:** The actions included in this category are related to planning and management of other necessary actions. Hence, this category can be divided into internal or external coordination, based on the institutions, groups or companies that participate in the development of each action.
- **Financial:** This category includes the tasks related to finance the business and boost the companies / agents that are involved.
- **Promotion & Dissemination:** This category includes the tasks that aim to promote the business and its achievements. In case of the DISCOVERER, the achievements will be mostly focused on the technology field.
- **Research:** The actions included in this category are focused on the R+D of a technology or a methodology. Consequently, this category will be basically included in the technology businesses, as the ones studied in this document.
- **Strategic planning:** The actions included in this category are focused on the market analysis and its decisions. Thus, this category could include actions related to expanding the market, promoting the entrance into the market, defining and modifying the business strategy, etc.

In this document, the legal actions (embedded inside the legislative field) carried out by the European Commission for boosting the economy and the business' market, are included inside the strategic planning category.

5.7.2 Tasks to be accomplished

This section defines the specific actions that must be done in order to achieve the objectives depicted in the “goals to achieve” stage.

Besides, in order to provide sufficient information, each specific action must be described, clarifying the barriers that must be confronted and the goals that must accomplish, taking into account the main points found in the SWOT.

5.7.3 Requirements

Basically, there are two main requirements:

- Each action must be linked to a point depicted in the SWOT matrix.
- Moreover, it is important to define the goals and requirements of the actions according to their level of difficulty and their importance inside the project.

So, for optimising the development of this section, each SWOAT matrix point will create one specific action. Consequently, the roadmaps developed in this deliverable will have 12 actions, as it is presented in Figure 5:

| | |
|---|---|
| <p><u>Strength:</u></p> <ul style="list-style-type: none"> AS1. Enables access to space sustainability in time. AS2. Promote Europe as new space hub. AS3. Analyse the access to space value chain to obtain benefits. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none"> AW1. Encourage space innovation & investments. AW2. Promote & disseminate the new technology advances. AW3. Increase the amount of public resources and funds. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none"> AO1. Support the university research groups working in the solution. AO2. Enabling advantages to small & medium EU size companies. AO3. Need to open the space field to different activities. | <p><u>Threats:</u></p> <ul style="list-style-type: none"> AT1. Reduce the dependency on non EU countries for launch capabilities. AT2. Start using the new systems in the future space missions. AT3. Boost cooperation to set new space standards. |

Figure 6 Example of the actions included in the Access to Space roadmap

5.8 Stage 8: Stakeholders to be involved

5.8.1 Aim

Expanding the information provided in the article “*Stakeholder Theory Classification: A Theoretical and Empirical Evaluation of Definitions*” [18], it can be concluded that:

Stakeholders can be defined as the organizations that have an influence over the work being realised, supporting or blocking it.

Besides, analysing DISCOVERER’s framework, the stakeholders are also defined in this deliverable as the group of actors needed to promote and carry out the activities defined in the roadmap.

Thus, it is necessary to identify as soon as possible the target stakeholders (considering their power, influence and interest in the business), as without their support the business scenario would cease to exist.

5.8.2 Tasks to be accomplished

Therefore, this section has to:

- Identify the stakeholders that can be considered as targets for the development of the business.
- Outline the level of influence of the stakeholders and their interest in the business.
- Specify the agents that will carry out each task.

5.8.3 Requirements

It is important to not forget that the stakeholders may belong to different fields, as they can have a technical, economic and social relationship (among others) with the business.

Hence, this section must accomplish the following points:

- Analyse the stakeholders considering all the fields, not only the technical ones.
- Classify them in one of the following four management strategies:
 - Keeping satisfied.
 - Managing closely.
 - Monitoring.
 - Keeping informed
- Visually, this section must be designed to be easily followed. For this reason, it is considered that the best option to depict the stakeholder's situation is to use an stakeholders matrix.

Furthermore, in this deliverable the stakeholders will be defined using general groups / institutions and not specific company names.

5.8.4 Useful tools: Stakeholders matrix

The stakeholders' matrix is a matrix that shows the level of interest (x axis) and influence (y axis) of the entities that are related to the project.

This way, the Stakeholders matrix format is presented in Figure 6:

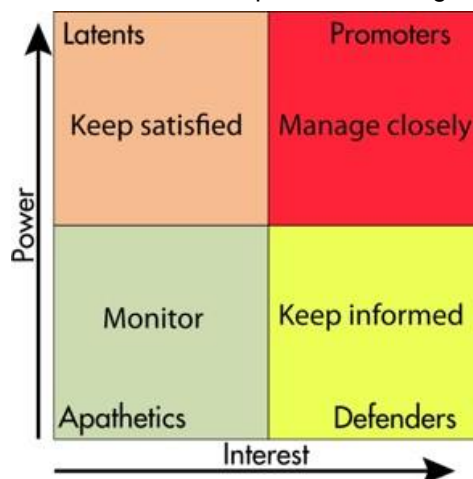


Figure 7 Stakeholders matrix example. Extracted from [33]

5.9 Stage 9: Estimated budget

5.9.1 Aim

The idea of this section is to estimate the budget required to develop each specific action, considering the difficulty of each activity and the resources required for accomplishing its objectives.

5.9.2 Tasks to be accomplished

The main tasks at this stage are:

- Allocating an estimated budget to each specific action for carrying out it and accomplishing the related objectives.
- Define the Leverage Factor of each action, which will be explained later on in this document.

5.9.3 Requirements

The budget has to:

- Take into account all the areas that may be economically involved in the tasks, not only the technological ones.
- Define the budget according the methodology explained in [TFE-1], which considers as a main reference the TRL of the technology.

5.9.4 Useful tools: Technology Readiness Level (TRL)

The TRL defines the operational capability of a technology and its maturity, classifying it in a category between 1 to 9 scale, as explained in [19].

Therefore, adapting the work develop by Ibañez J.M. [20], three main technology categories can be obtained, which will be used to calculate the Leverage Factor of the business' actions.

Table 2 Technology categories according to their TRL

| Category | Definition | TRL |
|-----------------------------------|--|--------|
| Mainly Research | Research and development (R+D) of a technology | 1 to 4 |
| Mainly Innovation / Demonstration | Implement technologies that have already finished the R+D stage and are ready to be used in the market | 5 to 7 |
| Mature / Proven Technologies | Implement technologies with a solid background and well known behaviour | 8 to 9 |

5.9.5 Useful tools: Leverage Factor (LF)

According to the work carried out by Paulino G. [TFE-1], the LF is defined as the amount of private funds that can be raised for each unit of invested public money. Consequently, the LF is considered as an estimation of the private vs public ratio investment.

Besides, following [TFE-1] it is possible to obtain the LF of a specific action regarding the TRL of the corresponding technology along the process. Nevertheless, in some cases, the TRL will change during the action. Consequently, there will be some actions that will have a specific LF at the beginning and a different one at the end.

Summarising, the LF applied to the actions is obtained following the graph depicted in Figure 7.

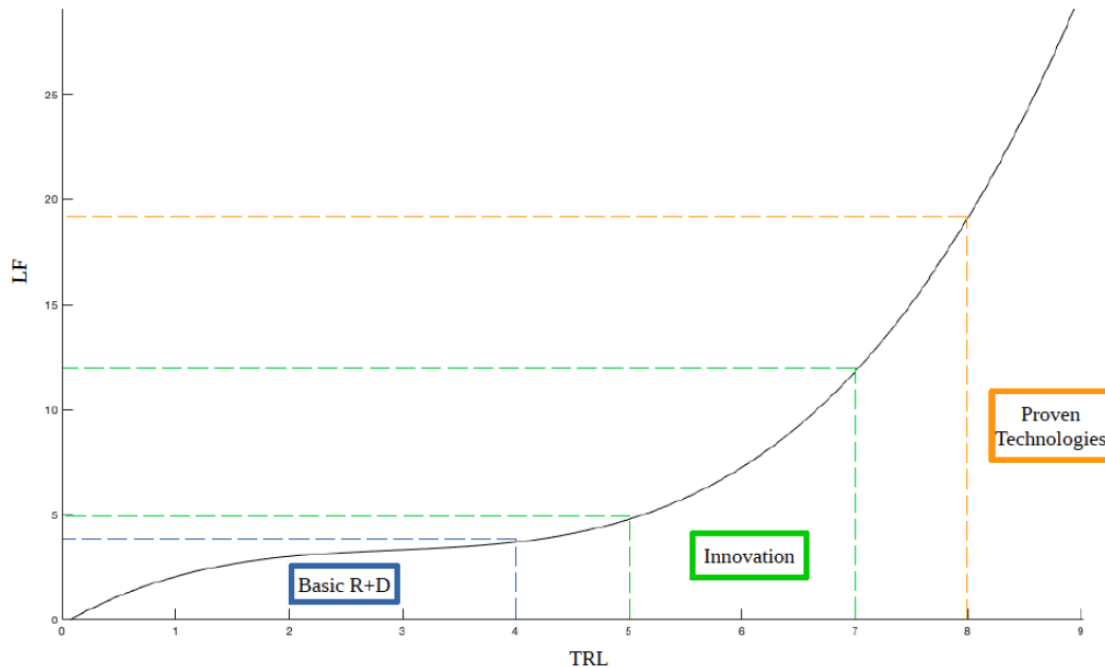


Figure 8 Graph that depicts LF vs TRL. Extracted from [TFE-1]

5.10 Stage 10: Action's Risk Analysis

5.10.1 Aim

Risk Analysis can be defined as the process that figures out how likely a risk will arise in a project and how it would impact if it finally shows up [21].

Consequently, from the BABOK Guide, it can be assumed that:

Risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project. [...] Most of the risk management processes are updated throughout the project. [22].

5.10.2 Tasks to be accomplished

To detail the risks of a Business Model project, the roadmap shall:

- Assess the risk probability and impact of all the actions of the roadmap, considering the organizational readiness of the business / technology and calculating an overall risk rating.

So, the idea is to use this information to define a contingency plan, preventive and other mitigation measures that will serve to reduce the probability of damaging the activities' viability.

5.10.3 Requirements

Adapting from [23]:

- The chosen methodology should be sufficiently rigorous to identify all the major risks in the different areas of the business.
- The methodology must be easily to follow and implement, as the risk must be calculated for all the actions.
- It should be possible to take into account interdependencies between different systems applications. The rationale for this is as follows: If system A depends critically on system B, and system B is “risky”, then system A inherits B’s “riskiness”.
- If the roadmap is going to be applied in a technology field, the risk analysis should always be up to date with current technology and with the latest security practices.

5.10.4 Useful tools: New risk analysis

Following the work presented in [TFE-1], the risk of each action will be evaluated considering three different risk elements in a 1-3 scale (being 1 the minimum risk and 3 the maximum one). The three main areas that will be taken into account are:

- **Technology maturity:** Aiming at analysing the risks linked to the technology maturity at the moment that the action is done. Accordingly, this risk will be directly assessed accordingly to the TRL of the technology, as explained in table 3.

Table 3 Technology maturity: Risk values

| Stage | TRL | Risk value |
|---------------------|--------|------------|
| Basic R+D | 1 to 4 | 3 |
| Innovation | 5 to 7 | 2 |
| Proven technologies | 8 to 9 | 1 |

- **Market maturity:** Aiming at analysing the risks linked to the market situation at the moment that the action will be done. In this case, we will adapt the “*Market life cycle phases*”, which is a macro-level methodology that aims “measure” the market maturity of the existing technical system (a complete explanation of the “*Market life cycle phases*” is presented in [TFE-1]). Obtaining, as a result, Table 4.

Table 4 Market maturity: Risk values

| Market status | Risk value |
|---------------|------------|
| Introduction | 3 |
| Growth | 2 |
| Maturity | 1 |

- **Value network maturity:** Aiming at analysing the risks linked to the stakeholders commitment in the specific action. In this case, we will consider the “*Stakeholder commitment curve*”, which estimates the status of the stakeholders involved in each action and evaluates the way that they interact along the evolution of the business.

Therefore, according to [4], the timeline should be divided in three main periods, and according to [TFE-1], the Value network maturity depends on how much advanced is the overall related business, and obtaining as a result Table 5.

Table 5 Value network maturity: Risk values

| Business Stage | Risk Value |
|----------------|------------|
| Prepare | 3 |
| Accept | 2 |
| Commit | 1 |

So, once the risks have been defined for the three areas (Technology, Market and Value network), the next step is to multiply the three obtained values, getting as a result a figure between 1 and 27, that serves as a measure of the inherent risk of each action.

Finally, the overall risk will be ranked as low, medium or high, according to table 6.

Table 6 Final risk values

| Risk level | Final score |
|------------|-------------------|
| Low | Between 1 and 9 |
| Medium | Between 10 and 18 |
| High | Between 19 and 27 |

5.11 Stage 11: Roadmap Timeline

5.11.1 Aim

To summarise the implementation of the business, a timeline is required, which is defined in this deliverable as:

A calendar that shows, from the beginning until the end, the path to develop the activities described in the roadmap to accomplish the business' goals. Besides, the calendar must also depict how the actions are linked between them.

5.11.2 Tasks to be accomplished

The calendar has to:

- Show the actions that the must be followed from the beginning until the end, defining clearly the interactions and connections between the actions.
- Outline the beginning of each action and its end.
- As the roadmap will evolve, it is necessary to highlight the different “stages” and “phases” of the process.

5.11.3 Requirements

It must be considered that:

- The action's duration must be defined according to the resources, level of difficulty and importance that they have in the project. Being this information provided in the previous sections.
- Timeline must be visual and must be easy to follow.

5.11.4 Useful tools: DISCOVERER's timeline procedure

As it as previously stated, regarding DISCOVERER's needs, the best way to present the timeline is by dividing the overall schedule in different stages, adapting the timeline for the "technology developments" presented in page 49 of the T-plan book [4].

The work carried out by Abele and Schimpf [1] (summarised in section 4 of this deliverable), which analysed roadmaps from more than 2,000 companies, allows concluding that the duration of the timeline of DISCOVERER's roadmaps should be of around 10 years.

Consequently, the timeline will be divided in three main periods, presented in Table 7.

Table 7 Timeline periods

| Stage | Period |
|--------------|--------|
| Short-term: | 0 - 4 |
| Medium-term: | 4 - 8 |
| Long-term: | 8 - 10 |

5.12 Stage 12: Summary of the roadmap

In order to develop easy-to-follow roadmaps it is convenient to summarise the main information provided in the previous sections at the end of the roadmap. Thus, this summary will be done following the schema of Table 8.

Table 8 Summary table format (example)

| Action | Stage | Business challenge | Budget | Risk | Stakeholders |
|--------|------------|-----------------------------|--------|------|--------------|
| AO1 | Short-term | New technology requirements | € 6M | High | EC – F.E. |

Once the methodology has been explained, the next sections will develop four promising roadmaps regarding the main key areas of the VLEO, taking into account the results of Deliverable D5.5 of the DISCOVERER project. These four roadmaps are focused on the development of specific activities to boost the creation of EU's strategic companies for exploiting the EO market at VLEO.

6 Roadmap: Access to space

Access to space is one of the most promising areas to grow in the EO field at VLEO. Nowadays, access to space for VLEO is mainly done through ISS deployment or as secondary payloads in commercial satellites launching. Having a strong group of EU companies servicing this access to space needs may become a key for EU competitiveness and leadership.

6.1 Access to space: Business statement

This roadmap will regard the access to space sector from the European Union point of view, and it will mostly focus on the how the EU companies could market more efficient technologies in order to reduce the costs and increase accuracy of their launches.

Thus, the main key points that distinguish the "Access to space" business model (see deliverable D5.5), are:

- The business shall include solutions that enhance the current technology's efficiency, providing brand new technological and design concepts.
- The business shall provide affordable launches.
- The business shall take into account using environmental friendly systems to reduce the quantity of propellant emissions.
- The business shall give value to the customers, adapting the launches to their specific needs.
- The business shall aim at developing a strong strategic of the market evolution.
- The business will allow to new small and medium size EU companies (SMEs) to enter in the access to space business.
- The business will enable to expand the market, increasing the competitiveness and reducing the final costs.
- The business aims at a greater and sustained European presence in space.
- The business wants to become an international standard in key areas.

6.2 Access to space: Background

6.2.1 Access to space. Background context

In recent years, many companies and space agencies have been studying and developing microlaunching systems with the idea of implementing brand new technologies to make more affordable the access to space.

Nowadays there are two main concepts of microlaunching systems that, in the short term, can be implemented:

Conventional-like microlaunchers: Small rockets capable of delivering small payloads into specific VLEO orbits [24].

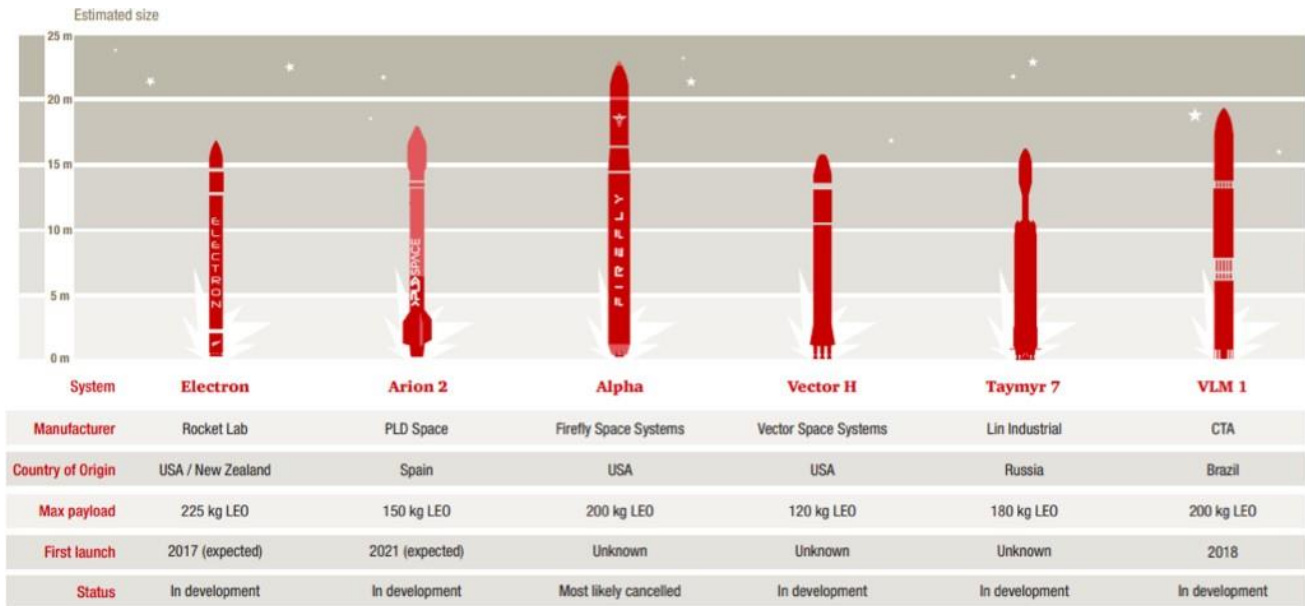


Figure 9 Conventional microlaunchers systems. Source: "Micro-launchers: what is the market?" [24]

Airborne launched systems: Consists on launching a small rocket from an air vehicle that carries it towards the first stage of the trip. Consequently, the small rocket must be optimized to stratospheric conditions, which heavily reduces the launcher propellant mass [24]. Besides, these systems offer a more efficient and affordable mission.

Currently, there are two main airborne ideas, aircraft assisted launching systems, and rockoon type systems, systems that use a high-altitude balloon for the first stage of the trip and a small stratosphere-adapted booster for the second stage of the trip. These type of vehicles are still in an early stage of development and have not yet being tested.

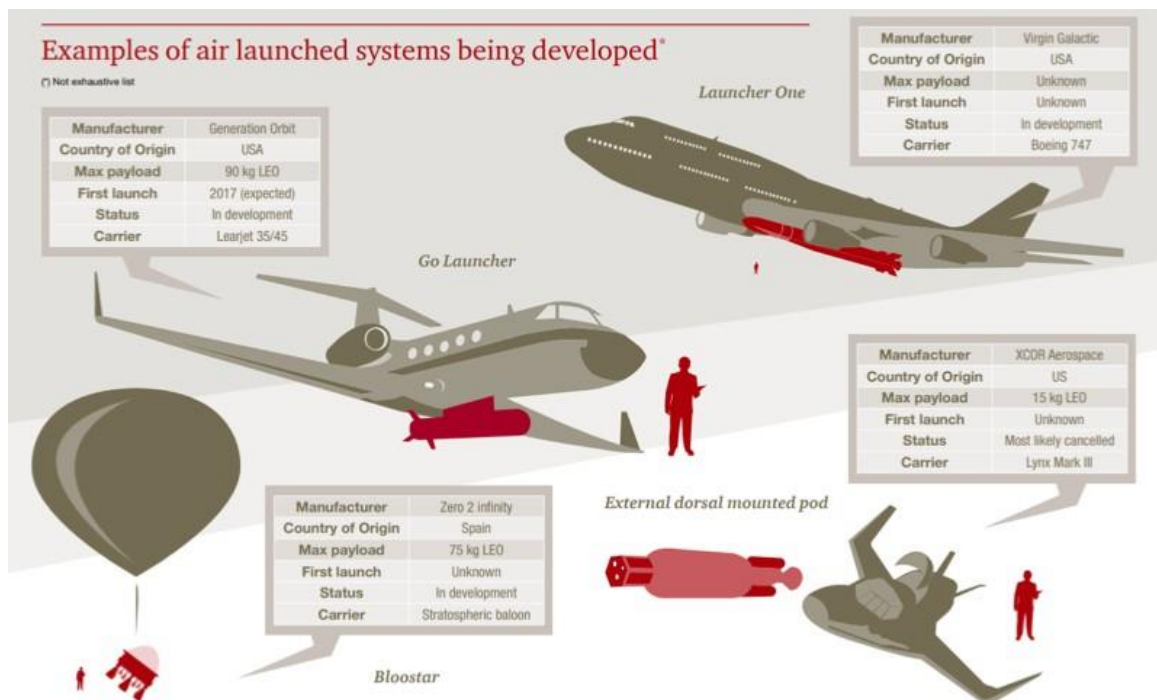


Figure 10 Airborne launching systems. Source: "Micro-launchers: what is the market?"[24]

6.2.2 Access to space. PESTEL analysis

According to the methodology developed, a PESTEL analysis must be done to identify the macro (external) forces facing an industry.

As a result of the information provided by the PESTEL, the organisations will be able to successfully monitor and respond to changes in the macro-environment, differentiating from the competition and being able to create a competitive advantage.

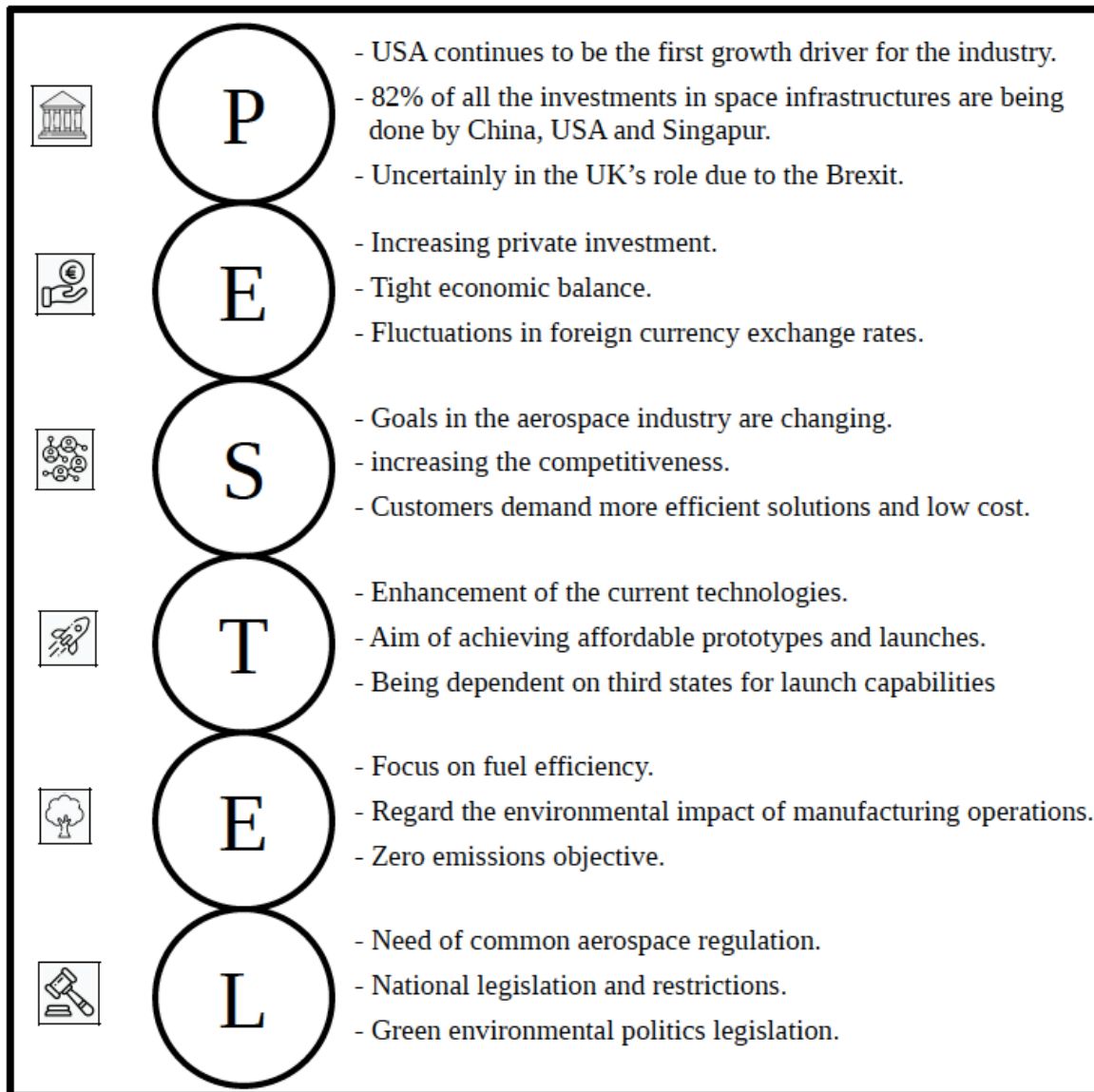


Figure 11 Access to space. PESTEL analysis. Based on [D.5.5], [25], [26], [27], [28]

6.3 Access to space: Market analysis

6.3.1 Access to space. Market context

Analysing the market, there is an expansion of constellations that will increase the demand of yearly launched satellites, directly bringing to the need of sending all these platforms into space too.

Besides, the objective of reducing costs, will increase the trend of launching smallsats (less than 500 kg) rather than larger ones, provoking a bigger diversification in the access to space. This way, it was observed how in 2017 smallsats were preferred to be launched by medium size launchers, due to their compatibility issues and the launch opportunities they offered, achieving a decrease in the number of smallsats being launched as a piggyback on heavy launchers.

Hence, the sector is expected to evolve towards two very different extremes. On the one hand, the use of super heavy launchers will enable to place dozens or hundreds of satellites in orbit, allowing to develop mega-constellation projects. Besides that, on the other hand, micro-launchers solutions could be the perfect solution to place smallsats into lower orbits.

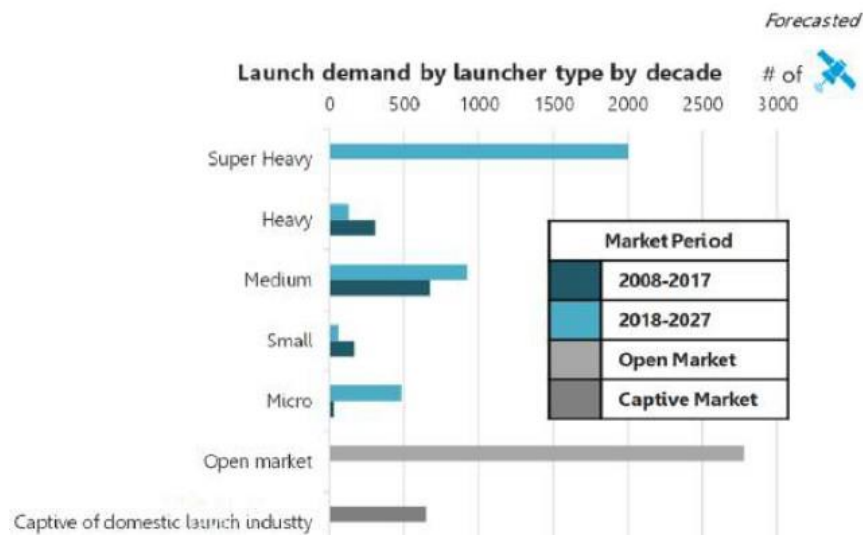


Figure 12 Launch demand type by decade. Source: "Satellite value chain: snapshot 2017" [28]

6.3.2 Access to space. Porter's five forces analysis

- **Threat of new entrants:**
 - The threat of new entrants in the access to space field is low, as this field presents a high technological barrier, requiring of strong economic support.
 - Besides, almost all the launches are carried out by established and well-known companies, which retain a significant market percentage, and making it more difficult for the new entrants.
 - Nevertheless, currently there are foreign governments supporting their national companies entering the field.
- **Threat of substitute products:**
 - In this case, the current tools that enable the access to space have more promotion inside the aerospace industry.
 - Basically, the current technology presents several years of good performance, providing more security to the customers.
 - Nevertheless, once new technology systems have a certain number of missions, the customers will regard these options with detail, being able to diversify the market.
 - Consequently, at this moment, the threat of substitutes should be classified as medium.
- **Supplier power:**
 - The access to space is a field that requires very specialised technology. Thus, there is a need of using specific instruments and materials, among others.

- Therefore, as the final technological design depends on the requirements of the solution (as the capacity of accomplish all the technical requirements will define the success of the mission), in this case the power of the suppliers is high.
- **Buyer power:**
 - In this case, as there are few institutions that offer services to access to space, the power of the customer is very low. Hence, the interested customers will accept the deals that the company will offer.
- **Rivalry between existing competitors**
 - There are few organisations that are involved in the access to space activities. Thus, these institutions compete for gaining most of the contracts with the companies related to EO activities and communications, among others.
 - Consequently, the level of competitive rivalry is medium.



Figure 13 Access to space. Porter's five forces analysis

6.4 Access to space: Requirements

In addition, the conditions and capabilities that the access to space activities and stakeholders must accomplish to fulfil the goals previously defined, are:

- The activities described in the business must be implemented taking into account that the final solution must reduce the costs of the launches, expanding the market.
- The analysis developed in the business must take advantage of the fact that private companies are entering to the sector, searching for interesting key partnerships.
- All the activities and systems related to the business, must guarantee a full accomplishment of the standards and regulations.
- The business must use a solution that reduces the amount of emissions produced while enhances the accuracy in launching and deployment processes.
- The business should be designed in order to outline the business' capability of:
 - Adapting the launch to the customer's needs.
 - Enabling a great degree of control of the mission parameters.
 - Reducing the launching time and costs.
- The key partners must contribute to add value to the business, by providing resources or specific knowledge in target areas.

- Finally, the business must be implemented regarding the VLEO sector and considering the main points explained in the roadmap.

6.5 Access to space: Competitive advantage

Conventional launchers offer the satellites companies to send their platforms to space as one of the many devices they send or as a secondary payload, called piggy-back.

Hence, with the current situation, it is impossible that the customers can choose some parameters like: specific orbital details, schedule, etc.

For this reason, the customers demand to define a satellite launching solution which offers the possibility to develop launches perfectly suited to their needs, differentiating it from the current services.

Therefore, taking into account the customer's requests and after analysing their needs, it is considered that the points that add value to the business are the following ones:

- Customised launching service: Offering new opportunities to the customers.
- Customised missions' parameters: Adapting to the customer's requests.
- Affordable price: Allowing small companies to hire the service.
- Launching and development accuracy: Doing the service more efficient.
- Reduced launching time: Increasing the number of missions carried out during the year.
- Less emissions: Accomplishing the political green aims.
- Use of brand new technology systems: As could be the reusable vehicles.

6.6 Access to space: SWOT analysis.

This section will analyse the competitiveness of the business, in order to define its strategic position according to the SWOT technique that serves to list the main facts about where the organization currently stands. Figure 13 shows the SWOT matrix of the access to space business model.

| | |
|--|--|
| <p><u>Strength:</u></p> <ul style="list-style-type: none"> 🚀 - S1. Launches more accurate in less time. 🗨️ - S2. Capacity of adapting to the customer's requests. 💰 - S3. Affordable launch systems. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none"> 🚀 - W1. Need of high level of R+D for entering. 🗨️ - W2. Lack of reputation compared to conventional services. 💰 - W3. Need of higher investment for implementing the solution. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none"> 🚀 - O1. Brand new technology systems are being developed. 🗨️ - O2. Private companies are growing in the field. 💰 - O3. Satellites market is currently expanding. | <p><u>Threats:</u></p> <ul style="list-style-type: none"> 🚀 - T1. Competitors are developing new technology systems. 🗨️ - T2. Establishment of conventional launch systems. 💰 - T3. Space R+D innovation is very slow. |

Figure 14 Access to space. SWOT analysis. Based on [D.5.5], [25], [26], [27], [28]

- **Strengths:**
 - The companies related with the "Access to space" business will carry out services that will improve the current industry standards, offering affordable launching services that can suit the customer's specific needs, and overcoming what is currently offered.
- **Weaknesses:**
 - The "Access to space field" presents a high technological barrier to enter, needing to achieve strong financial support to develop and implement the possible solutions.

- Besides, it is also necessary to define strategic key partnerships for overcoming the disadvantages that the lack of reputation produces, thus stressing the need for international coordination and cooperation.
- **Opportunities:**
 - New technology systems are being developed, provoking the expansion of the market and the growth of the competitiveness, as new private companies aim to enter.
- **Threats:**
 - The "Access to space" business presents certain doubts, as for entering to the space field a high TRL is mandatory.
 - Consequently, several years of R+D are required to implement an innovation in the space sector, provoking the establishment of the conventional launch systems.
 - Finally, the competitors are also developing new ideas to modernize the access to space sector.

6.7 Access to space: Actions' description

Once the SWOT matrix has been presented, figure 14 shows the strategic actions that allow taking advantage of every SWOT item.













| | |
|---|---|
| <p><u>Strength:</u></p> <ul style="list-style-type: none">  - AS1. Enables access to space sustainability in time.  - AS2. Promote Europe as new space hub.  - AS3. Analyse the access to space value chain to obtain benefits. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none">  - AW1. Encourage space innovation & investments.  - AW2. Promote & disseminate the new technology advances.  - AW3. Increase the amount of public resources and funds. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none">  - AO1. Support the university research groups working in the solution.  - AO2. Enabling advantages to small & medium EU size companies.  - AO3. Need to open the space field to different activities. | <p><u>Threats:</u></p> <ul style="list-style-type: none">  - AT1. Reduce the dependency on non EU countries for launch capabilities.  - AT2. Start using the new systems in the future space missions.  - AT3. Boost cooperation to set new space standards. |

Figure 15 Access to space. Actions' description

Therefore, the actions can be classified in the following groups:

Table 9 Access to space. Actions' categories

| Category of the action | Action |
|------------------------------|-------------------------|
| Coordination: | AT3 |
| Financial: | AO2, AW3 |
| Promotion and dissemination: | AS2, AW2 |
| Research: | AO1, AW1 |
| Strategic planning: | AS1, AS3, AO3, AT1, AT2 |

- **Coordination:**
 - AT3: Support the creation of new EU research projects related with the access to space field, ensuring that companies, universities and research centres can collaborate together to fulfil the expected goals and enhancing the cooperation activities in terms of providing support, consultancy, etc.

- **Financial:**
 - AO2: Increase the attractiveness and competitiveness of the market by providing economic and legal advantages to the small and medium size companies that aim to enter to the access to space sector.
 - AW3: The EU should increase the amount of resources and infrastructures focused on the R+D of the required new technologies and the creation of new strategic companies, in order to boost the EU's access to space field.
- **Promotion and dissemination:**
 - AS2: Design and implement tools to attract the attention of investors, turning the EU to a key player in the access to space field and increasing its authority.
 - AW2: Promote the technology advances in order to establish in the new access to space market the current achievements, increasing their credibility and counteracting the lack of reputation that they have compared with the conventional systems.
- **Research:**
 - AO1: Support the public research to face the technological challenges associated with the access to space industry, analysing and considering the DISCOVERERs that are currently being studied at the university.
 - AW1: Support the R+D of the main issues that provoke doubts in the new access to space technologies and methodologies.
- **Strategic planning:**
 - AS1: Ensure and protect the new strategic EU companies created, once all technology has been developed and tested. Guaranteeing the sustainability and the expansion of the access to space business in Europe.
 - AS3: Support the study of the value chain of the access to space in order to discover new key points and guarantee the reduction of the launches' costs.
 - AO3. It is important to expand the space activities to different goals and sectors, which will increase the attractiveness of the private companies in the field. Considering the synergic effects of promoting smallsats activities (supporting the industry and creating new needs to be fulfilled by the market), as an indirect promotion of the access to space needs.
 - AT1: According to the European Parliament [26], it is mandatory to reduce the level of dependency of the EU on other countries inside the launch activities. As a result, the European companies will become stronger, increasing their potential, at the same time that the EU's security will increase.
 - AT2: In order to increase the reliance in the new access to space's technology systems, the EU will have to start using the new technology advances in the space missions carried out by the ESA. Promoting the brand new technology developed and obtaining, as a result, a higher interest of private companies in the new technology systems.

6.8 Access to space: Stakeholders

The stakeholders matrix is a matrix that shows the level of interest (x axis) and influence (y axis) of the entities that are related to the project. In this case, the roadmap will depict general categories of stakeholders and not specific companies.

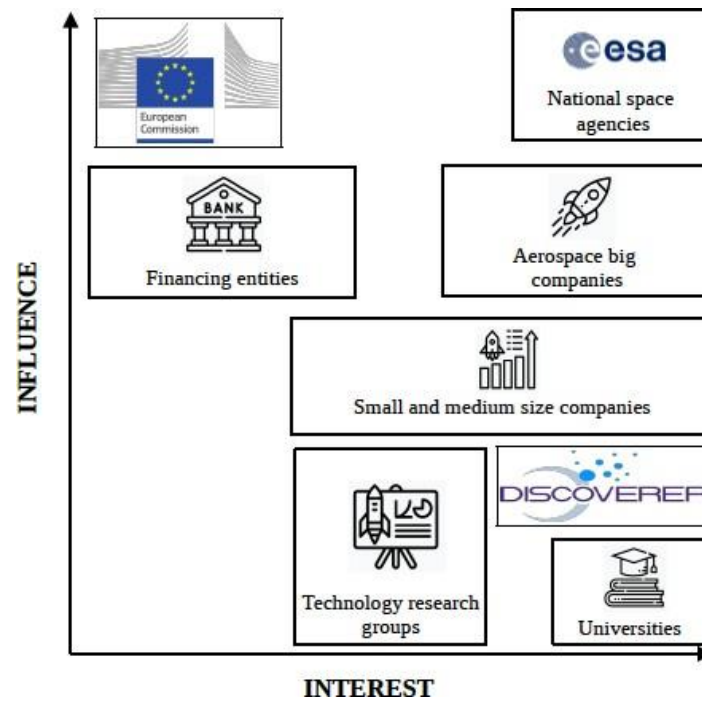


Table 10 Access to space. Stakeholders' matrix

Table 11 summarizes the stakeholders involved in each action's planning and implementation:

Table 11 Access to space. Summary of the stakeholders involved in each action

| Action | Stakeholder |
|--------|--|
| AT3 | EC - DISCOVERER |
| AO2 | EC - National Governments |
| AW3 | EC - Financing entities |
| AS2 | EC - National Space Agencies |
| AW2 | EC - DISCOVERER |
| AO1 | EC - DISCOVERER - TRG - Universities |
| AW1 | EC - National space agencies - DISCOVERER - TRG - Universities |
| AS1 | EC - Small and medium size companies |
| AS3 | DISCOVERER - Aerospace large companies |
| AO3 | EC - National space agencies |
| AT1 | EC - National space agencies |
| AT2 | National space agencies |

6.9 Access to space: Budget

Table 12 shows an estimation of the required budget to fulfil the objectives of the roadmap. The Leverage Factor formula is used to relate private to public funds to be raised.

Table 12 Access to space: Budget of each action

| Action | Category | TRL | LF | Estimated budget (€) |
|--------|---------------------------|--------|-----------------|----------------------|
| AT3 | Coordination | 4 to 5 | 4 to 5 | 100 M |
| AO2 | Financial | 7 to 8 | 12 to 19 | 400 M |
| AW3 | Financial | 5 to 8 | 5 to 19 | 1550 M |
| AS2 | Promotion & dissemination | 5 | 5 | 150 M |
| AW2 | Promotion & dissemination | 5 to 7 | 5 to 12 | 50 M |
| AO1 | Research | 4 | 4 | 100 M |
| AW1 | Research | 5 to 7 | 5 to 12 | 200 M |
| AS1 | Strategic Planning | 9 | ≥ 20 | 2550 M |
| AS3 | Strategic Planning | 4 | 4 | 25 M |
| AO3 | Strategic Planning | 5 to 7 | 5 to 12 | 230 M |
| AT1 | Strategic Planning | 8 to 9 | 19 to ≥ 20 | 2500 M |
| AT2 | Strategic Planning | 5 to 7 | 5 to 12 | 200 M |

Figure 15 shows the cumulated budget evolution, highlighting the public funding needs:

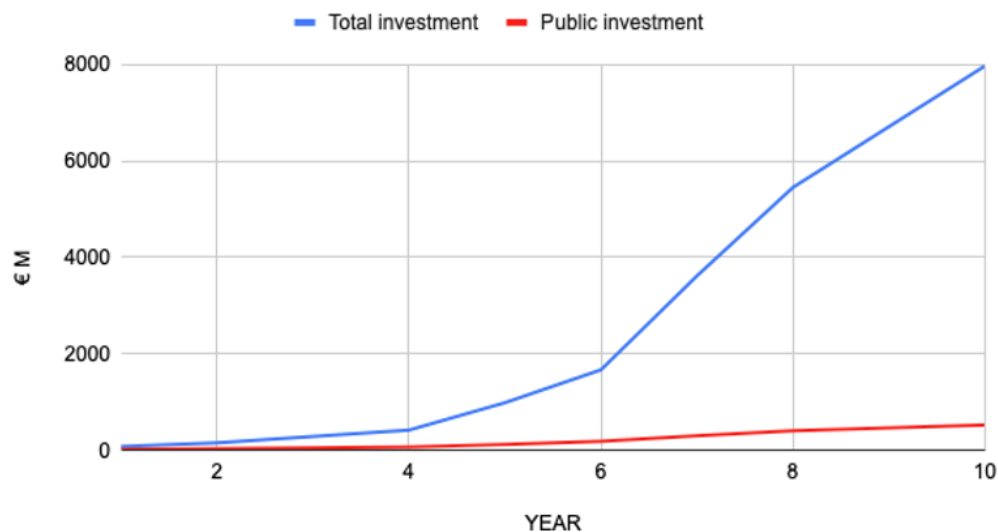


Figure 16 Access to space. Evolution of the budget with time

The budget estimations have been done considering the information provided by the European Commission in references [30], [31], [32], [33]. Besides, for the calculations, it was considered that the space sector represents a 10% of the EU's GDP [29].

6.10 Access to space: Risk analysis

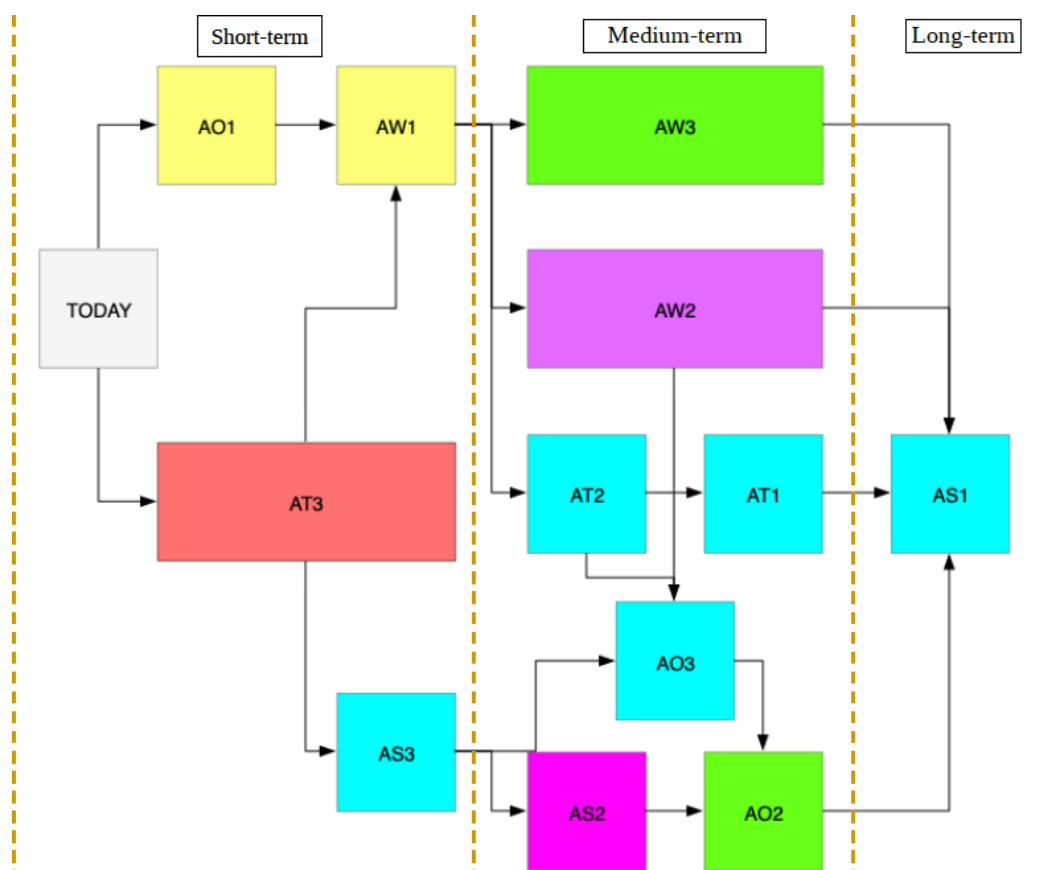
This section will show a reduced risk analysis following the methodology previously presented, extracted from [TFE-1]. Notice that it is estimated that all actions fall into low to medium risks.

Table 13 Access to space. Risk of each action

| Action | Technology | Market | Value network | Score | Total risk |
|--------|------------|--------|---------------|-------|------------|
| AT3 | 3 | 2 | 3 | 18 | Medium |
| AO2 | 2 | 1 | 2 | 4 | Low |
| AW3 | 2 | 2 | 2 | 8 | Low |
| AS2 | 2 | 2 | 2 | 8 | Low |
| AW2 | 2 | 2 | 2 | 8 | Low |
| AO1 | 3 | 2 | 3 | 18 | Medium |
| AW1 | 2 | 2 | 3 | 12 | Medium |
| AS1 | 1 | 1 | 1 | 1 | Very low |
| AS3 | 3 | 2 | 3 | 18 | Medium |
| AO3 | 2 | 1 | 2 | 4 | Low |
| AT1 | 1 | 1 | 2 | 2 | Very Low |
| AT2 | 2 | 2 | 2 | 8 | Low |

6.11 Access to space: Timeline

Figure 16 shows the timeline and relationships amongst the different tasks. This roadmap has a timeline between 10 and 15 years, although it is presented as a 10-year roadmap:



| Category of the action |
|-----------------------------|
| Coordination |
| Financial |
| Promotion and dissemination |
| Research |
| Strategic planning |

Figure 17 Access to space: Timeline

6.12 Access to space: Summary table

Table 14 summarizes the access to space roadmap:

Table 14 Access to space. Summary table

| Action | Stage | Business challenge | Budget (€) | Risk | Stakeholders |
|--------|--------|---|------------|----------|--|
| AO1 | Short | Support research of the access to space field (Low TRL) | 100 M | Medium | EC - DISCOVERER - TRG - Universities |
| AT3 | Short | Boost cooperation between SME and universities for researching in access to space | 100 M | Medium | EC - DISCOVERER |
| AW1 | Short | Encourage access to space innovation and investment (High TRL) | 200 M | Medium | EC - NSA - DISCOVERER - TRG - Universities |
| AS3 | Short | Analyse the access to space value chain to obtain benefits | 25 M | Medium | DSC - Aero large companies |
| AW2 | Medium | Promote & disseminate the new access to space technology advances | 50 M | Low | EC – DISCOVERER |
| AT2 | Medium | Start using the new access to space technology systems | 200 M | Low | NSA |
| AO3 | Medium | Open the space field to different activities focusing the access to space field | 230 M | Low | EC – NSA |
| AS2 | Medium | Promote Europe as a new space hub regarding access to space | 150 M | Low | EC – NSA |
| AW3 | Medium | Increase the resources and funds to start creating strategic companies of the access to space field | 1550 M | Low | EC – FE |
| AO2 | Medium | Provide advantages to SME in the EU's access to space to boost their development | 400 M | Low | EC - NG |
| AT1 | Medium | Reduce the EU dependency on launching capabilities | 2500 M | Very Low | EC - NSA |
| AS1 | Long | Enable EU's access to space sustainability in time & protect strategic companies | 2550 M | Very Low | EC - SME |

7 Roadmap: Ground services

Ground Services, according to deliverable D5.3 and further studied in deliverable D5.5, is also one of the emerging needs of the expanding space sector. More specifically when considering VLEO, where the communications window between satellite and ground stations is shorter, and the revisit time may be increased. The need for new Ground Service companies is also expanding, and this roadmap aims at providing some ideas on how this can be done in order to make the EU more competitive.

7.1 Ground services: Business statement

This roadmap will regard the ground stations sector from the European Union point of view and it will mostly focus on the how the EU companies could design enhanced ground stations in order to guarantee the proper exploitation of the EO information coming from the VLEO satellites.

Thus, the main key points that summarise the business statement for "*Ground Services*", are:

- The business aims to obtain affordable ground stations specialised in VLEO operations, at the same time that the cost of the ground equipment is reduced.
- The business will be expanded to new locations, in order to expand the market and pick up more amount of data.
- The business is based on the use of new ground stations concepts, as the multi-mission ground stations.
- The business includes solutions that enhance the current technology's efficiency, providing brand new technological and design concepts that enable to achieve higher data rate transmission.
- The business will take into account the complementarity of existing resources and the hybridization between physical and digital ones.
- The technology used in the business will allow to track simultaneously several satellites, based on the implementation of the Electronically Scanned Array technology.

7.2 Ground services: Background

7.2.1 Ground services. Background context

Traditionally, satellites have been accessed and tracked via parabolic-dish antennas. Nevertheless, this equipment is poorly suited to VLEO and LEO constellations, which will have numerous satellites all rapidly crossing a ground receiver's field of view at the same time.

Therefore, as the demand of satellites in EO at VLEO is rocketing [34], it is necessary to handle the challenge of the growth of the satellite market at this completely new scale. So, as a result, the ground station industry needs a new approach.

For this reason, from the mid-2010s some ground station companies and operators, as well as some start-ups, have been founded to offer this service to LEO, EO and smallsats sectors. Adapting, accordingly, their business models.

Evidence of that is the presence of automation in the ground and communications control software interfaces offered by these companies, as well as the progressive integration of Value Added Services (VAS), that are automated too, to the mentioned platforms. So, nowadays there are two main concepts of ground stations that, in the short term, can be very profitable for both providers' and customers [TFE-2], [35]:

- **Multi-mission ground stations:** A technology regarding ground stations that will contribute to make the multi-mission concept possible is the Electronically Scanned Array or Electronically Steered Antenna (ESA), able to track simultaneously several satellites, together with the use of the Ka and Ku bands, that allow higher data rate transmission.
- **Fusion of ground stations and cloud computing:** A technology that combines the recent advances in analytics with improved computing power and artificial-intelligence algorithms. Obtaining as a result, a reduction in the response times and operating costs. Besides, this technology can also be used to improve satellite control and network latency, promoting at the same time the autonomous and semiautonomous control and management of the satellite.

7.2.2 Ground services. PESTEL analysis

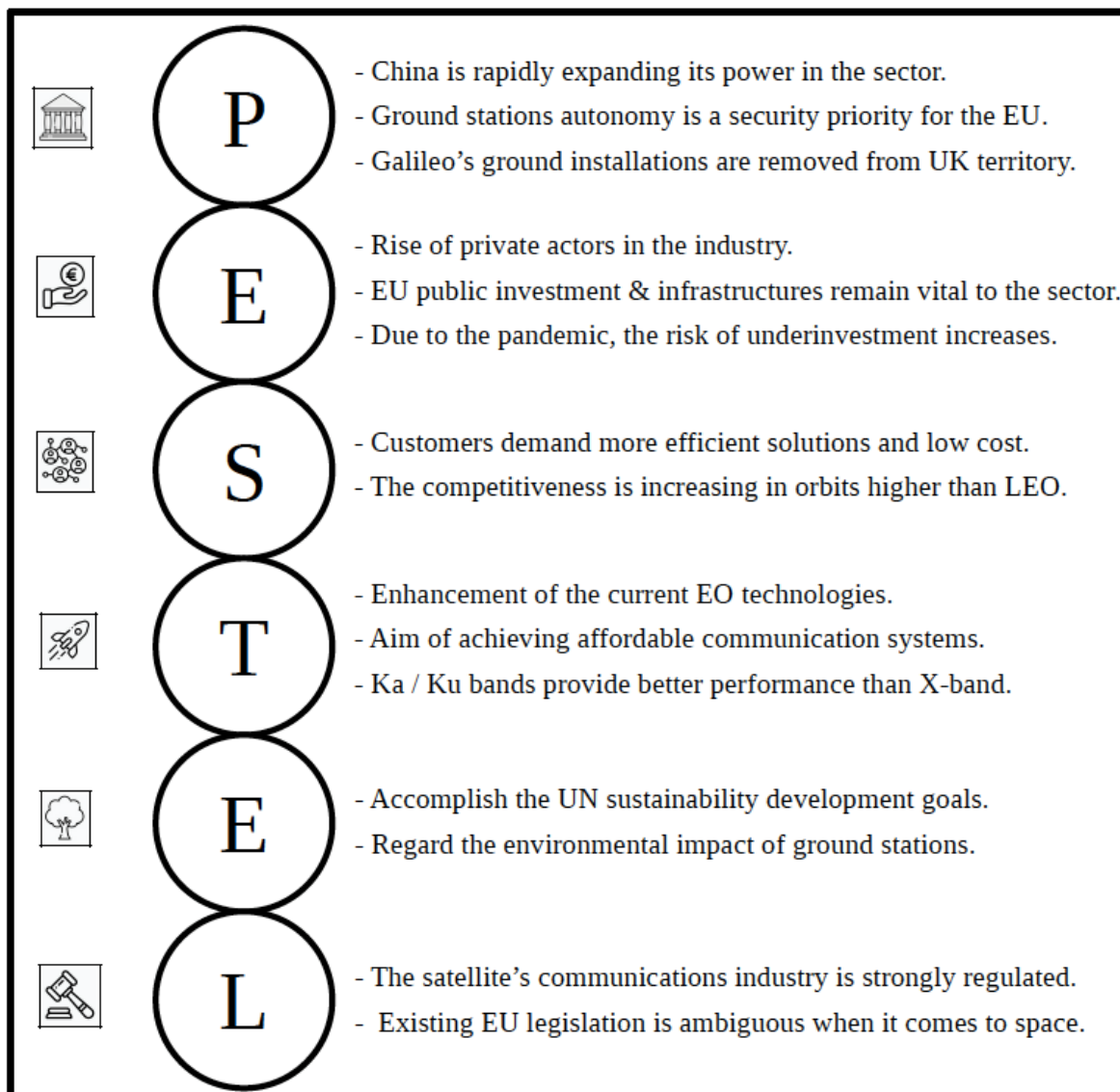


Figure 18 Ground services. PESTEL analysis. Information extracted from: [TFE-2], [26], [35]

7.3 Ground services: Market analysis

7.3.1 Ground services. Market context

The Ground Station industry has experienced an evolution in terms of a growing demand over the last decade.

Hence, according to the information presented in [D.5.3] and [34], it is expected that in the next years the market will continue expanding, as it will grow from \$264 million in 2018 to nearly \$360 million in 2028, caused by the rise of new installations in emerging regions for accomplishing the increasing demand on EO data and value-added services.

Besides, according to [35], the ground station companies will need to develop expertise in one of the following sectors of EO, as it is expected that these four sectors will gather around half of the total nine billion dollars of projected revenue for raw data and VAS in 2026 for the EO market:

- Environmental monitoring.
- Infrastructure monitoring.
- Location Based Services (LBS).
- Natural resources monitoring.

7.3.2 Ground services. Porter's five forces analysis:

- **Threat of new entrants:**
 - The threat of new entrants in the ground stations is medium. In fact, although this field has a high technological barrier to enter and it is mostly supported by public institutions, private companies are starting to enter it, having the potential to create long-term disruption.
 - Besides, there is a rise of geopolitical competition, since countries like China and Russia are increasingly investing in space for national security topics as well as economic competitiveness.
- **Threat of substitute products:**
 - Although the current technology offers a high level of efficiency, brand new technology systems are being developed in this area, supported by the fact of expanding the market to LEO and VLEO, besides the traditional orbits.
 - Moreover, the topic of ground stations is very close to national security. For this reason, governments and companies are always developing new concepts to enhance the performance and increase the security of their devices.
 - Therefore, the new technology systems will have the potential to elevate the services offered on automation and VAS capabilities. So, it can be concluded that the threat of substitutes should be classified as medium.
- **Supplier power:**
 - The activities associated with the ground stations require very specialised technology. Thus, there is a need of using specific instruments and materials, among others.
 - Therefore, as the final service of the business depends on the requirements of the solution, in this case the power of the suppliers of the technology components (as sensors, etc.) is high.
- **Buyer power:**
 - In this case, as [26] outlines, the ground stations segment is a segment highly supported by public institutions.

- Nevertheless, the number of private companies offering these services will increase. So, regarding the future, the customer will have the opportunity to choose between different options, increasing its power.
- Therefore, at this moment, the buyer power should be classified as low, almost achieving the medium level.
- **Rivalry between existing competitors:**
 - Firstly, it is important to outline that public organisations have a big degree of control in this market.
 - Besides, nowadays, the market is formed by a few number of big companies, as Amazon. Although, as the market is expanding, it is true that some small and medium size companies are entering, like DEIMOS.
 - Nevertheless, currently, the private big companies are the ones that are gaining most of the contracts.
 - Consequently, the competitive rivalry at VLEO is classified as low.



Figure 19 Ground services. Porter's five forces analysis. Information extracted from: [TFE-2], [26]

7.4 Ground services: Requirements

In addition, the conditions and capabilities that the Ground Service activities and stakeholders must accomplish to fulfil the previously defined goals, are:

- The roadmap should boost the entrance of small and medium size companies to the business.
- Operational efficiency is mandatory in the solution.
- The obtained solution has to be easily scalable to the future growth of the industry.
- Technology must consider improved data-compression methods, without reducing the quality of communications.
- The solution developed must be able to track several satellites at the same time.
- The solution developed must reduce the response time and operating costs, at the same time that must promote the autonomous and semi-autonomous control.
- The final solution must focus mainly in VLEO.
- The analysis developed in the business must take advantage that private companies are entering to the sector, searching for interesting key partnerships.
- All the activities and systems related to the business, must guarantee a full accomplishment of the standards and regulations.

- The key partners must contribute to add value to the business, by providing resources or specific knowledge in target areas.

7.5 Ground services: Competitive advantage

The services provided by the ground station companies will help EO-VLEO satellite operators to produce affordable, valuable, low latency retrieval EO-data by reducing the cost of the downlink activities and the complexity of the associated services.

Besides, the idea is to create an infrastructure focused on VLEO operations, leveraging the new technologies to offer unparalleled quality and efficiency. Therefore, taking into account the customer's requests and after analysing their needs, the points that add value to the business are:

- **Multi-mission:** The development of brand new technology systems, as the Electronically Steered Array (ESA) antennas, will enable to adapt the service's capacity to the future demand on VLEO, providing scalability to the business.
- **Improvements in contact time:** The use of higher frequencies downlink Ka/Ku-bands will allow to overcome reduced communications windows in VLEO.
- **Enhanced value chain:** The business is based on flexible, dedicated, and automated quality services and VAS data.
- **Relationships adapted to the customer's needs:** The customer relationships management will be done differently depending on the type of client or satellite that the operator manages. Besides, customer relationships will be focused on customer fidelity building.
- **Cloud based platforms:** The business will use high machine learning algorithms, enabling to improve the efficiency of the relations with the customers.
- **Customised missions' parameters:** Adapting to the customer's requests.

7.6 Ground services: SWOT analysis.

Therefore, the SWOT analysis of the ground services business is shown in figure 19:

| | |
|---|--|
| <p><u>Strength:</u></p> <ul style="list-style-type: none">  - S1. Multi-mission concept.  - S2. Cloud platform and machine learning algorithm.  - S3. Affordable ground station system services. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none">  - W1. Need of high level of R+D for entering.  - W2. Industry strongly regulated.  - W3. Need of higher investment for implementing the solution. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none">  - O1. High potential to elevate automatization and VAS.  - O2. New players can offer partnerships.  - O3. VLEO market is growing. | <p><u>Threats:</u></p> <ul style="list-style-type: none">  - T1. Ka / Ku band is still in development.  - T2. Existing EU legislation is ambiguous.  - T3. Risk of underinvestment increases due to COVID-19. |

Figure 20 Ground services. SWOT analysis. Based on the information obtained from: [TFE-2], [25], [26]

The explanation of the main points of the analysis, are:

- **Strengths:**
 - The companies related with the "Ground Service" business will carry out services that will improve the current industry standards. For example, the use of a cloud platform based on machine learning, which will enable to adapt to the customer's needs. Besides, it is expected that due to the technology's advances, the companies will be able to follow more than one mission at the same time and offer affordable services.

- **Weaknesses:**
 - "Ground Services" present a high technological barrier to enter, stressing the technological challenges associated with reducing the access time to the ground stations.
 - Consequently, there is a need to achieve strong financial support from public institutions to develop and implement the proposed solutions.
 - Besides, as this sector is linked to the national security, there is a need for international coordination and cooperation for developing a vast network of ground stations, beyond Europe borders.
- **Opportunities:**
 - New technology systems in data transmission and EO are being developed, provoking that new private companies aim to enter. Therefore, an expansion of the business will be obtained.
- **Threats:**
 - The Ka / Ku band presents certain doubts, as it is still in development.
 - Besides, as this sector is linked to the national security, the industry has strong regulations to accomplish. Therefore, a clearer European legislation is needed, according to [26].
 - Finally, higher investments are needed to overcome the uncertainties caused by the pandemic, as it is explained in [26].

7.7 Ground services: Actions' description

Once the SWOT matrix has been presented, figure 20 shows the strategic actions that allow taking advantage of every SWOT item.



| | |
|--|---|
| <p><u>Strength:</u></p> <ul style="list-style-type: none">  - AS1. Enable VLEO's ground stations sustainability in time.  - AS2. Promote Europe as new space hub.  - AS3. Analyse the ground stations value chain to obtain benefits. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none">  - AW1. Provide more economic advantages to do research.  - AW2. Make national legislations more attractive to investors.  - AW3. Encourage space innovation & investments. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none">  - AO1. Reduce the dependency on non EU countries.  - AO2. Boost cooperation to set new space standards.  - AO3. Enabling advantages to small & medium EU size companies. | <p><u>Threats:</u></p> <ul style="list-style-type: none">  - AT1. Support the university research groups working in the solution.  - AT2. Define an unique European space regulation.  - AT3. Increase the amount of public resources and funds. |

Figure 21 Ground services. Actions' descriptions

In addition, the actions are classified in the following categories:

Table 15 Ground services. Actions' categories

| Category of the action | Action |
|------------------------------|-------------------------|
| Coordination: | A02 |
| Financial: | AW1, AT3, AO3 |
| Promotion and dissemination: | AS2 |
| Research: | AT1, AW3 |
| Strategic planning: | AS1, AS3, AO1, AW2, AT2 |

Consequently, the main categories of the actions, are:

- **Coordination:**
 - AO2: Support the creation of new EU research projects or increase the support of the current ones, as for example the DISCOVERER, ensuring that companies and universities can collaborate together to fulfil the expected goals.

- **Financial:**
 - AW1: Provide economic and legal advantages to the companies or institutions that want to participate in the research of the tools required to boost the ground station business.
 - AT3: The EU should increase the amount of resources focused on the development of the new technologies and the creation of new strategic companies.
 - AO3: Provide economic and legal advantages to the small and medium size companies that aim to enter to the sector, once the technology is developed, increasing the attractiveness and the competitiveness of the market.
- **Promotion and dissemination:**
 - AS2: Attract the attention of investors by promoting the brand new systems, increasing the European authority in the space field.
- **Research:**
 - AT1: Support the public research, analysing and considering the findings that are currently being studied at the university.
 - AW3: Support the R+D of the main issues that provoke doubts in the new methodologies.
- **Strategic planning:**
 - AS1: Ensure and protect the new business once all the technology has been developed and tested, guaranteeing the expansion of the EU companies involved.
 - AS3: Support the study of the value chain of the business in order to discover new key points and guarantee the reduction of the ground station's costs.
 - AO1: It is mandatory to reduce the level of dependency of the EU on other countries inside the ground station's activities. As a result, the European companies will become stronger, increasing their potential.
 - AW2: Make national legislations more flexible, increasing the EU's attractiveness.
 - AT2: Define a unique space legislation in the EU.

7.8 Ground services. Stakeholders

The stakeholders' matrix of this roadmap is show in figure 21.

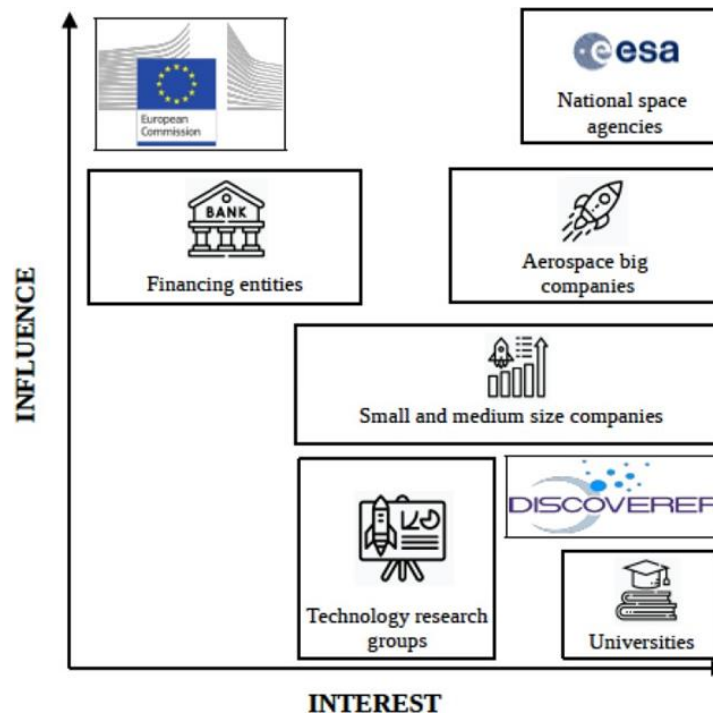


Figure 22 Ground services. Stakeholders' matrix

Table 16 summarizes the stakeholders involved in each action's planning and implementation:

Table 16 Ground services. Stakeholders of each action

| Action | Stakeholder |
|--------|--|
| AO2 | EC - DISCOVERER |
| AW1 | EC - National governments |
| AT3 | EC - Financing entities |
| AO3 | EC - National governments |
| AS2 | EC - National space agencies |
| AT1 | EC - DISCOVERER - TRG - Universities |
| AW3 | EC - National space agencies - DISCOVERER - TRG - Universities |
| AS1 | EC - Small and medium size companies |
| AS3 | DISCOVERER - Aerospace large companies |
| AO1 | EC - National space agencies |
| AW2 | EC - National governments |
| AT2 | EC - National governments |

7.9 Ground services. Budget

Table 17 shows an estimation of the required budget to fulfil the objectives of the roadmap. The Leverage Factor formula is used to relate private to public funds to be raised:

Table 17 Ground services. Budget of each action

| Action | Category | TRL | LF | Budget (€) |
|--------|---------------------------|--------|-----------------|------------|
| AO2 | Coordination | 5 to 7 | 5 to 12 | 170 M |
| AW1 | Financial | 5 to 7 | 5 to 12 | 60 M |
| AT3 | Financial | 7 to 9 | 12 to ≥ 35 | 20 M |
| AO3 | Financial | 8 to 9 | 19 to ≥ 40 | 20 M |
| AS2 | Promotion & dissemination | 7 to 8 | 12 to 19 | 350 M |
| AT1 | Research | 5 to 6 | 5 to 7.5 | 50 M |
| AW3 | Research | 6 to 7 | 7.5 to 12 | 70 M |
| AS1 | Strategic Planning | 9 | ≥ 20 | 3150 M |
| AS3 | Strategic Planning | 6 | 7.5 | 80 M |
| AO1 | Strategic Planning | 9 | ≥ 20 | 3150 M |
| AW2 | Strategic Planning | 7 to 8 | 12 to 19 | 170 M |
| AT2 | Strategic Planning | 8 to 9 | 19 to ≥ 20 | 200 M |

The budget estimations have been done considering the information provided by the European Commission in references [30], [31], [32], [33]. Besides, for the calculations, it was considered that the space sector represents a 10% of the EU's GDP [29].

Figure 22 shows the cumulated budget evolution, highlighting the public funding needs:

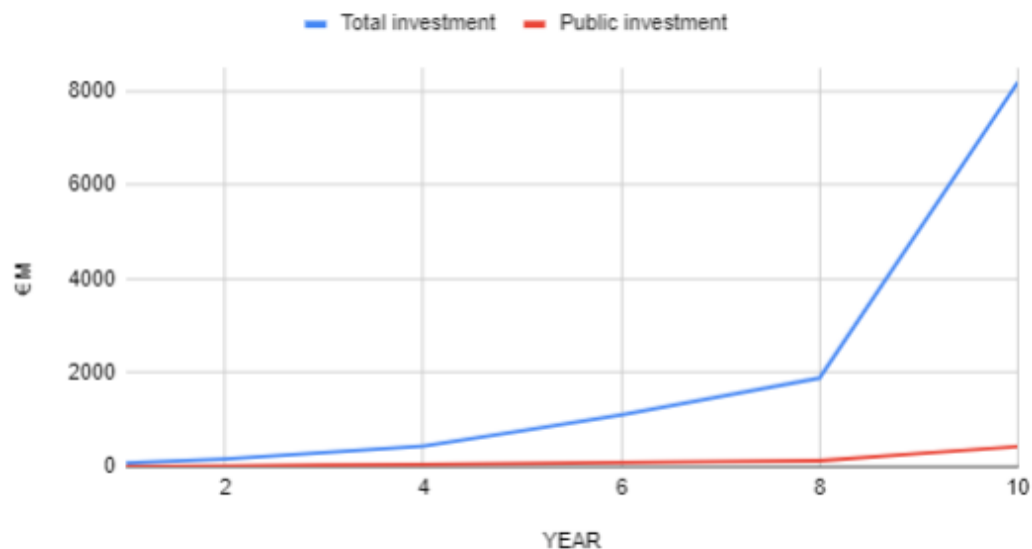


Figure 23 Ground services. Budget evolution

7.10 Ground services: Risk analysis

Table 18 presents the simplified risk assessment-classification for each action:

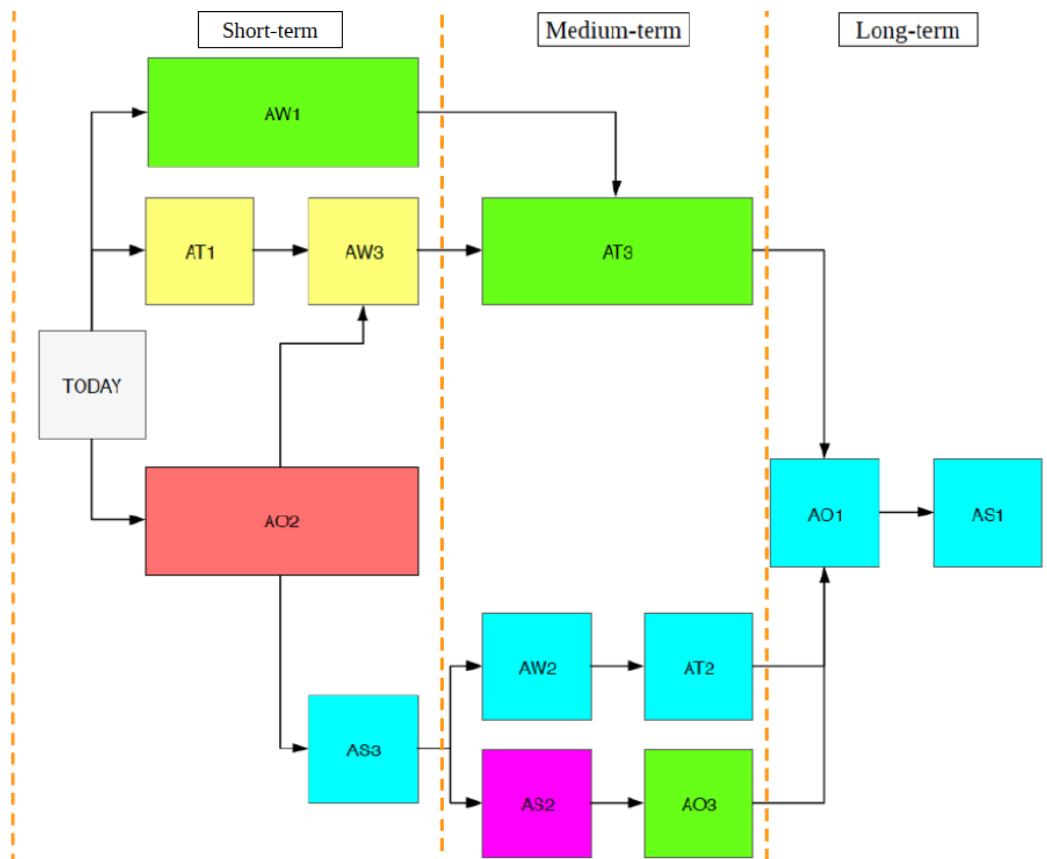
Table 18 Ground services. Risk analysis

| Action | Technology | Market | Value network | Score | Total risk |
|--------|------------|--------|---------------|-------|------------|
| AO2 | 2 | 2 | 3 | 12 | Medium |
| AW1 | 2 | 2 | 3 | 12 | Medium |
| AT3 | 2 | 2 | 2 | 8 | Low |
| AO3 | 1 | 1 | 2 | 2 | Very low |
| AS2 | 2 | 2 | 2 | 8 | Low |

| | | | | | |
|-----|---|---|---|----|----------|
| AT1 | 2 | 2 | 3 | 12 | Medium |
| AW3 | 2 | 2 | 3 | 12 | Medium |
| AS1 | 1 | 1 | 1 | 1 | Very low |
| AS3 | 2 | 2 | 3 | 12 | Medium |
| AO1 | 1 | 1 | 1 | 1 | Very low |
| AW2 | 2 | 2 | 2 | 8 | Low |
| AT2 | 1 | 1 | 2 | 2 | Very low |

7.11 Ground services: Timeline

Figure 23 shows the timeline and relationships amongst the different tasks. This roadmap has a timeline between 10 and 15 years, although it is presented as a 10-year roadmap.



| Category of the action |
|-----------------------------|
| Coordination |
| Financial |
| Promotion and dissemination |
| Research |
| Strategic planning |

Figure 24 Ground services. Timeline

7.12 Ground services: Summary table

Table 19 summarizes the ground services roadmap:

Table 19 Ground services. Summary table

| Action | Stage | Business challenge | Budget (€) | Risk | Stakeholders |
|--------|--------|---|------------|----------|-----------------------------|
| AW1 | Short | Provide economic resources for researching in the ground services area | 60 M | Medium | EC – NG |
| AT1 | Short | Support research of the ground services technology (Low TRL) | 50 M | Medium | EC - Disc - TRG - Uni |
| AW3 | Short | Encourage ground services innovation and investment (High TRL) | 70 M | Medium | EC - NSA - Disc - TRG - Uni |
| AO2 | Short | Boost cooperation between SME and universities for researching in the ground services area | 170 M | Medium | EC - Disc |
| AS3 | Short | Analyse the ground services value chain to obtain benefits | 80 M | Medium | Disc – Large Aero |
| AT3 | Medium | Increase the resources and funds to start creating strategic companies of the ground services field | 350 M | Low | EC - FE |
| AW2 | Medium | Make national legislations (data transmission) more attractive to investors | 170 M | Low | EC - NG |
| AS2 | Medium | Promote Europe as a new space hub regarding ground services | 350 M | Low | EC - NSA |
| AT2 | Medium | Define an unique European legislation regarding factors as the data transmission | 200 M | Very low | EC - NG |
| AO3 | Medium | Provide advantages to SME in the EU's ground services to boost their development | 400 M | Very low | EC - NG |
| AO1 | Long | Reduce the dependency on non EU countries in ground services activities (national security) | 3150 M | Very low | EC - NSA |
| AS1 | Long | Enable EU's ground services sustainability in time & protect strategic companies | 3150 M | Very low | EC - SME |

8 Roadmap: Turnkey providers'

Another of the most promising new Business Model fields when considering EO at VLEO is the one related to Turnkey Providers' (mainly Space Brokers). Deliverable D5.3 shows it as a present trend, and D5.5 provides also with a detailed BM for it. This roadmap aims at providing some ideas on how expansion of Space brokers BM this can be done in order to make the EU more competitive

8.1 Turnkey providers': Business statement

This roadmap will regard the turnkey providers' of the space sector from the European Commission point of view, and it will mostly focus on the how the EU companies could boost the development of new companies inside the satellites field.

Thus, the main key points that summarise the business statement of the "*Space Brokers*", are:

- The business is focused on launching small satellites into VLEO, connecting the customers with specialised launch supporting companies.
- The business has the capacity of providing brand new technology systems to the customers, offering flexible launch systems that enhance the deployment possibilities.
- The business is also focused on reducing the amount of space debris that is generated.
- The business aims to develop a strong strategic analysis that can be applied in the EU companies, regarding the market evolution.
- The business will allow to the small and medium size EU companies to enter to the space business.
- The business will enable to expand the market, increasing the competitiveness and reducing the final costs.
- The business aims for a greater and sustained European physical presence in the space market.
- The business wants to set international standards in some key areas of the space sector.

8.2 Turnkey providers': Background

8.2.1 Turnkey providers'. Background context

It is observed that nowadays there is a large number of small satellites in orbit compared to the past. Although, this can be caused by several reasons, an important fact to consider is that the cost of small satellites is relatively lower than the common satellites, which increases the interest of the companies.

Besides, as the number of small satellites in orbit is increasing, it is necessary to improve the way they are being launched, regarding at reducing launch's costs. Therefore, taking into account that common launchers are thought to be propelled by heavy rockets, the most common solution for small satellites is the "*Rideshare Launching*".

Basically, this technique is based on fitting the small satellite inside the payload of a rocket that is currently doing another launch, putting into orbit both elements at the same time. So, this means that both objects will have to adapt a little bit their orbits, as once the rocket has arrived to its desired orbit, the small satellite will be detached and it will be directed to its final altitude.

Figure 24 depicts how many vehicles are available to put nanosatellites in orbit.

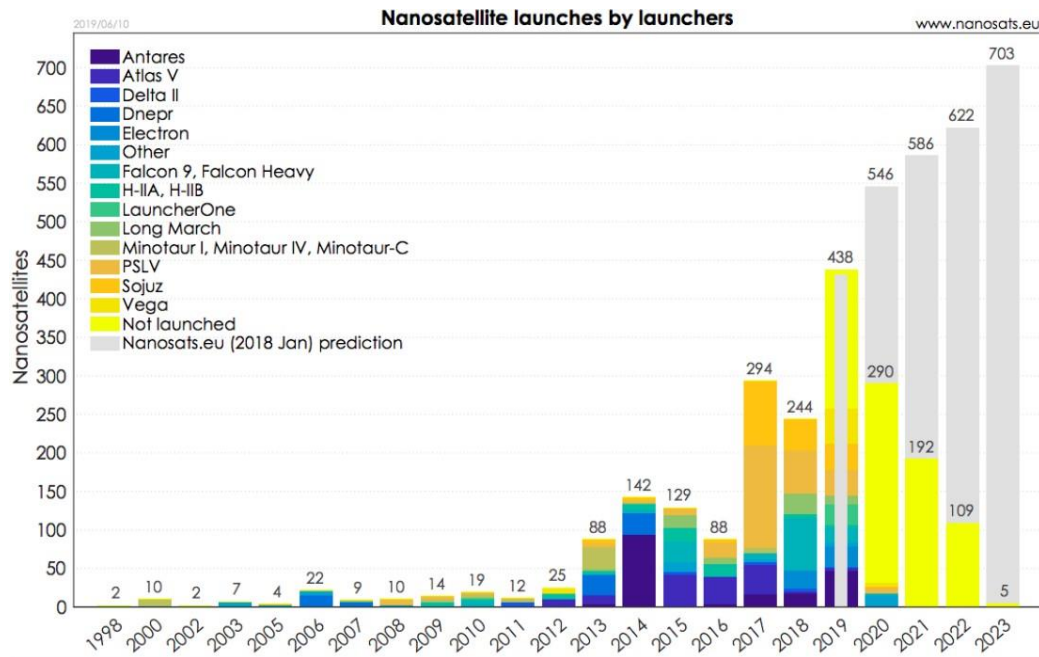


Figure 25 Options to launch small satellites. Extracted from: [TFE-3], [36]

8.2.2 Turnkey providers'. PESTEL analysis

The PESTEL analysis of the Turnkey providers' roadmap is presented in figure 25:

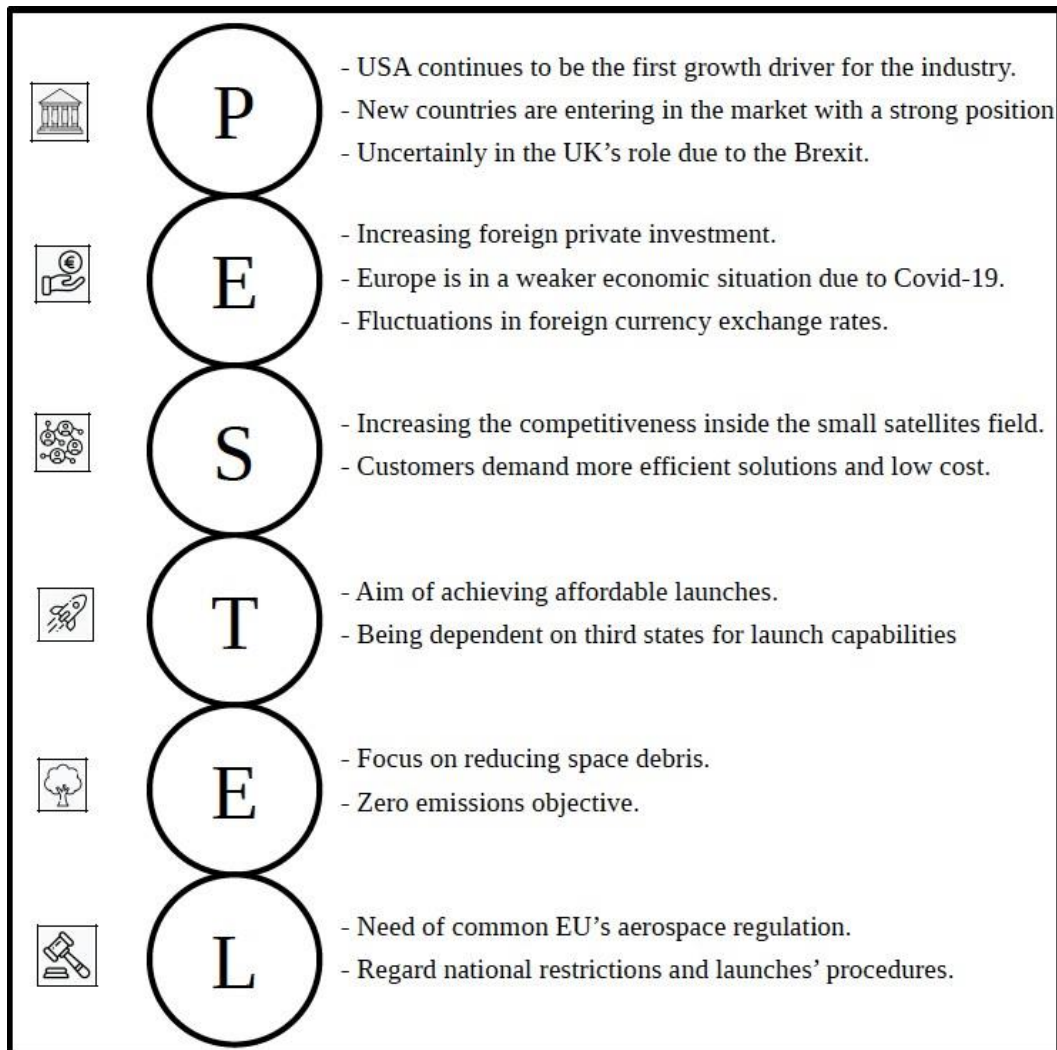


Figure 26 Turnkey providers'. PESTEL analysis. Based on [D.5.5], [TFE-3], [25], [26]

8.3 Turnkey providers': Market analysis

8.3.1 Turnkey providers'. Market context

Figure 26 shows a summary of the satellite's market situation in 2017, and the expected evolution of the demand.

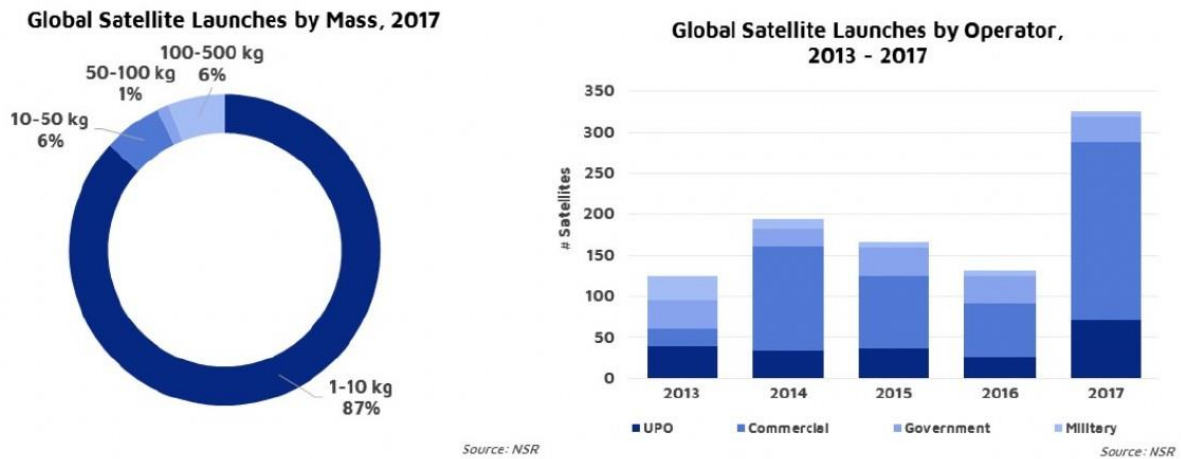


Figure 27 A summary of the satellites market. Extracted from: [TFE-3]

Besides, it is interesting to specifically focus on the small satellites market, obtaining:

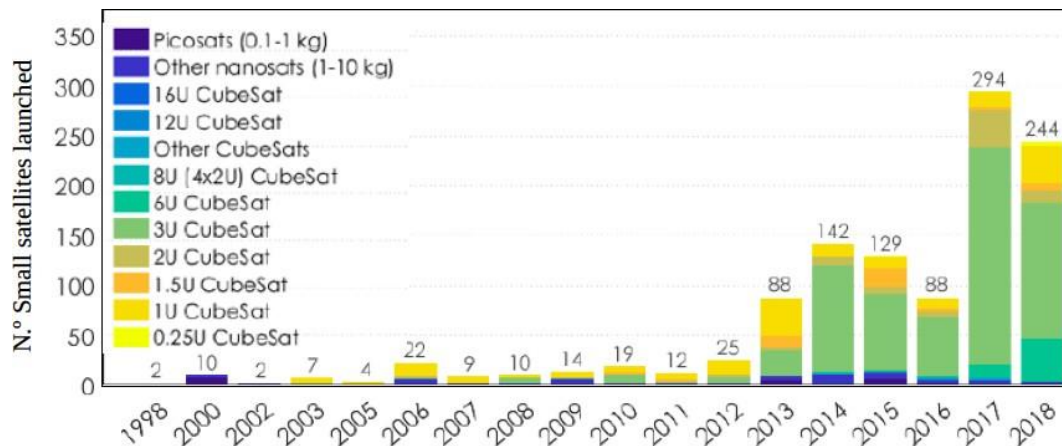


Figure 28 Small satellites launches by type. Extracted from: [TFE-3], [36]

8.3.2 Turnkey providers'. Porter's five forces analysis

- **Threat of new entrants:**
 - The threat of new entrants in the Turnkey providers' field is medium, as it presents a high technological barrier that requires of strong economic support.
 - Besides, at present, large companies have more possibilities to offer this services than small and medium size enterprises. So, as the market is still expanding, the large companies are the ones that retain a significant market percentage, making it more difficult for the new entrants.
 - Finally, outline that there are different foreign governments supporting their national companies, trying to enter in the sector.
- **Threat of substitute products:**
 - This question is directly related with the type of satellite needed to develop the services demanded by the customer. So, as it has been seen in the market context, apart from the small satellites there are many other types of satellites that can perform the demanded activities with high accuracy.
 - Besides, different technology systems as microlaunchers or rockoons are being studied, increasing the threat of substitute products.

- Consequently, this point should be classified as high.
- **Supplier power:**
 - First of all, the Space Broker companies do not have the need of dealing with big suppliers, as the work that they develop is focused on offering services and not products.
 - Nevertheless, as their final service will depend on the technological solution, the power of the suppliers is defined as medium.
- **Buyer power:**
 - In this case, as the market is still expanding, the customers could have a strong position in the negotiation. Nevertheless, for the same market reason, customers will not have the chance to switch easily to another company.
 - Therefore, the power of the customer is classified as medium.
- **Rivalry between existing competitors:**
 - Currently, the organisations that are involved in the Space Broker's activities are mainly public or big private companies, as they have much resources to do the service.
 - Therefore, at this moment, some big companies (as Virgin, Rocket Lab, ISIS, etc) compete for gaining most of the contracts. Consequently, the level of competitive rivalry inside the market is high.



Figure 29 Turnkey providers'. Porter's five forces analysis

8.4 Turnkey providers': Requirements

In addition, the conditions and capabilities that the Space Broker's activities and stakeholders must accomplish to fulfil the goals previously defined, are:

- The activities described in the business must be implemented taking into account that the final solution must reduce the costs of the small satellites' launches, expanding the market.
- The analysis developed in the business must take advantage of the fact that private companies are entering to the sector, searching for interesting key partnerships.
- All the activities and systems related to the business, must guarantee a full accomplishment of the standards and regulations.
- The business must use a solution that reduces the amount of space debris produced.

- The key partners must contribute to add value to the business, by providing resources or specific knowledge in target areas.
- Finally, the business must be implemented regarding the VLEO sector and considering the main points explained in the roadmap.

8.5 Turnkey providers': Competitive advantage

Taking into account the customer's requests and after analysing their needs, it is considered that the points that add value to the business are the following ones:

- Newness: Achieve and offer a unique service which is focused on a part of the market that is currently expanding.
- Customization: Have the possibility of choosing the launch date and orbit parameter that best suits.
- Affordable price: In order to enhance the attractiveness of the companies, small prices will be considered.
- High quality services: In the way that the service could help small companies to achieve their complex needs and speed up the process.
- Launching and development accuracy: Doing the service more efficient.
- Less debris: By reducing the amount of space debris generated.

8.6 Turnkey providers': SWOT

Therefore, the SWOT analysis of the Turnkey providers' business is shown in figure 29:

| | |
|--|--|
| <p><u>Strength:</u></p> <ul style="list-style-type: none"> - S1. Launches more accurate in less time. - S2. New players will offer key partnerships. - S3. Affordable services. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none"> - W1. Need of high level of R+D for entering. - W2. The new EU companies will have lack of experience. - W3. Need of higher investment for implementing the solution. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none"> - O1. New technology systems to reduce debris. - O2. Private companies are growing in the field. - O3. Small satellites market is currently expanding. | <p><u>Threats:</u></p> <ul style="list-style-type: none"> - T1. China and India are developing high R+D products. - T2. Big companies have a strong position in the market. - T3. Risk of underinvestment increases due to COVID-19. |

Figure 30 Turnkey providers'. SWOT analysis. Based on [D.5.5], [TFE-3], [25], [26]

The explanation of the main points of the analysis, are:

- **Strengths:**
 - The companies related with the "Turnkey provider's" business will carry out a wide variety of services that will improve the current small satellites industry standards.
 - Therefore, the idea is to boost the cooperation between public and private institutions, in order to form key partnerships between the new companies that are entering in the market and overcome what is currently being done.
- **Weaknesses:**
 - In general, the activities related with space field present a high technological barrier to enter.
 - For this reason, it is necessary to boost new coordination programs in order to reduce the lack of experience that the new entrances have and create the required infrastructures to guarantee the business development, needing to achieve strong financial support.

- **Opportunities:**
 - New technology systems are being developed in the VLEO small satellites area, provoking the expansion of the market and the growth of the competitiveness in the turnkey providers' field, as new private companies aim to enter in the business due to its attractiveness.
- **Threats:**
 - The big companies are monopolizing the market. Therefore, this is a threat for the European SMEs aiming to enter.
 - Besides, at the moment, new companies supported by foreign countries (as China or India) are entering in the market with new technology systems, being supported by their respective national governments.
 - So, in order to face both points defined above, the EU must increase the investment in the R+D of the space sector and boost the development of European structures to support the creation of strategic companies inside the turnkey providers' business, and not stand behind in the space market.

8.7 Turnkey providers': Action's description

Once the SWOT matrix has been presented, figure 30 shows the strategic actions that may allow taking advantage of every SWOT item.













| | |
|--|---|
| <p><u>Strength:</u></p> <ul style="list-style-type: none">  - AS1. Enable the business sustainability in time.  - AS2. Promote EU as new space hub.  - AS3. Analyse the business' value chain to obtain benefits. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none">  - AW1. Encourage space innovation & investments.  - AW2. Boost cooperation to set new space standards  - AW3. Provide more economic advantages to do research. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none">  - AO1. Support the research groups working in the solution.  - AO2. Make national legislations more attractive to investors.  - AO3. Open the space field to different activities. | <p><u>Threats:</u></p> <ul style="list-style-type: none">  - AT1. Reduce the EU's dependency for launch capabilities.  - AT2. Enabling advantages to small & medium size enterprises.  - AT3. Increase the amount of public resources and funds. |

Figure 31 Turnkey providers'. Actions' description

Similarly, the actions can be classified in the following groups (table 20):

Table 20 Turnkey providers'. Category of each action

| Category of the action | Action |
|------------------------------|-------------------------|
| Coordination: | AW2 |
| Financial: | AT2, AW3, AT3 |
| Promotion and dissemination: | AS2 |
| Research: | AO1, AW1 |
| Strategic planning: | AS1, AT1, AO2, AS3, AO3 |

Consequently, the main points of the actions, are:

- **Coordination:**
 - AW2: Support the cooperation between companies and universities to fulfil the expected goals. Enhancing the cooperation activities in terms of providing support, consultancy and strategic for developing a European structure regarding the main idea of creating a federation of operators.

- **Financial:**
 - AT2: Provide economic and legal advantages to the small and medium size companies that aim to enter to the sector, increasing the attractiveness and the competitiveness of the turnkey providers' market.
 - AW3: The EU should increase the amount of resources and public infrastructures focused on the development of the new technologies, to guarantee an optimal performance of the VLEO small satellites, and the creation of new strategic companies inside the turnkey providers' business.
 - AT3: According to [26], the EU must increase the resources applied in the turnkey providers' sector to boost the industry and overcome the damages caused by Covid-19.
- **Promotion and dissemination:**
 - AS2: Design and implement tools to attract the attention of investors, increasing the European authority in the space field and putting Europe as a key settler of the turnkey providers' business.
- **Research:**
 - AO1: Support the public research, analysing and considering the DISCOVERERs that are currently being studied at the university, regarding the viability and the lifetime duration of the VLEO small satellites.
 - AW1: Support the R+D of the main issues and technology challenges that provoke doubts in the coordination of the services and the creation of the required new methodologies.
- **Strategic planning:**
 - AS1: Ensure and protect the turnkey providers' business once all the technology has been developed and tested, guaranteeing the expansion of the EU companies involved and becoming Europe a world reference.
 - AT1: It is mandatory to reduce the level of dependency of the EU on other countries inside the space mission activities, starting to provide all the services without any external support. As a result, the European companies will become stronger, increasing their potential against the foreign emerging companies that are being supported by the Chinese or the Indian governments.
 - AO2: Make national legislations more flexible, increasing the EU's attractiveness in the turnkey providers' area.
 - AS3: Support the study of the value chain of the turnkey providers' business in order to discover new key points and guarantee the reduction of the costs of the services offered.
 - AO3: It is important to expand the turnkey providers' activities to different goals and sectors, which will increase the attractiveness of the private companies in the field. Being able to obtain more economic benefits.

8.8 Turnkey providers': Stakeholders

The stakeholders' matrix of the turnkey providers' roadmap is presented in figure 31:

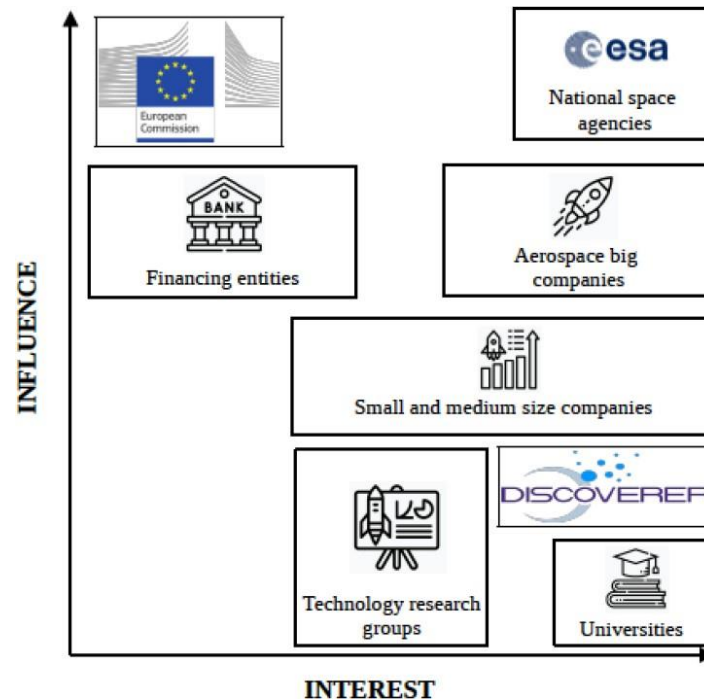


Figure 32 Turnkey providers'. Stakeholders' matrix

Table 21 summarizes the stakeholders involved in each action's planning and implementation:

Table 21 Turnkey providers'. Stakeholders of each action

| Action | Stakeholder |
|--------|--|
| AW2 | EC - DISCOVERER |
| AT2 | EC - National governments |
| AW3 | EC - Financing entities |
| AT3 | EC - Financing entities |
| AS2 | EC - National space agencies |
| AO1 | EC - DISCOVERER - TRG - Universities |
| AW1 | EC - National space agencies - DISCOVERER - TRG - Universities |
| AS1 | EC - Small and medium size companies |
| AT1 | EC - DISCOVERER - TRG - Universities. |
| AO2 | EC - National governments |
| AS3 | DISCOVERER - Aerospace large companies |
| AO3 | EC - National space agencies |

8.9 Turnkey providers': Budget

A summary of the LF and the budget of each action is presented in table 22:

Table 22 Turnkey providers'. Budget of each action

| Action | Category | TRL | LF | Budget (€) |
|--------|--------------|--------|------------|------------|
| AW2 | Coordination | 5 to 7 | 5 to 12 | 170 M |
| AT2 | Financial | 8 to 9 | 19 to ≥ 20 | 165 M |

| | | | | |
|-----|---------------------------|--------|-----------------|-------|
| AW3 | Financial | 5 to 7 | 5 to 12 | 60 M |
| AT3 | Financial | 7 to 9 | 12 to ≥ 20 | 680 M |
| AS2 | Promotion & dissemination | 7 to 8 | 12 to 19 | 130 M |
| AO1 | Research | 5 to 6 | 5 to 7.5 | 50 M |
| AW1 | Research | 6 to 7 | 7.5 to 12 | 72 M |
| AS1 | Strategic Planning | 9 | ≥ 20 | 840 M |
| AT1 | Strategic Planning | 9 | ≥ 20 | 840 M |
| AO2 | Strategic Planning | 7 to 8 | 12 to 19 | 165 M |
| AS3 | Strategic Planning | 6 to 7 | 7.5 to 12 | 110 M |
| AO3 | Strategic Planning | 9 | ≥ 20 | 170 M |

The budget estimations were done considering the information provided by European Commission in references: [29], [30], [31], [32], [37] and [38]. Besides, for the calculations, it was considered that the space sector represents a 10% of the EU's GDP [29].

Figure 32 shows the cumulated budget evolution, highlighting the public funding needs:

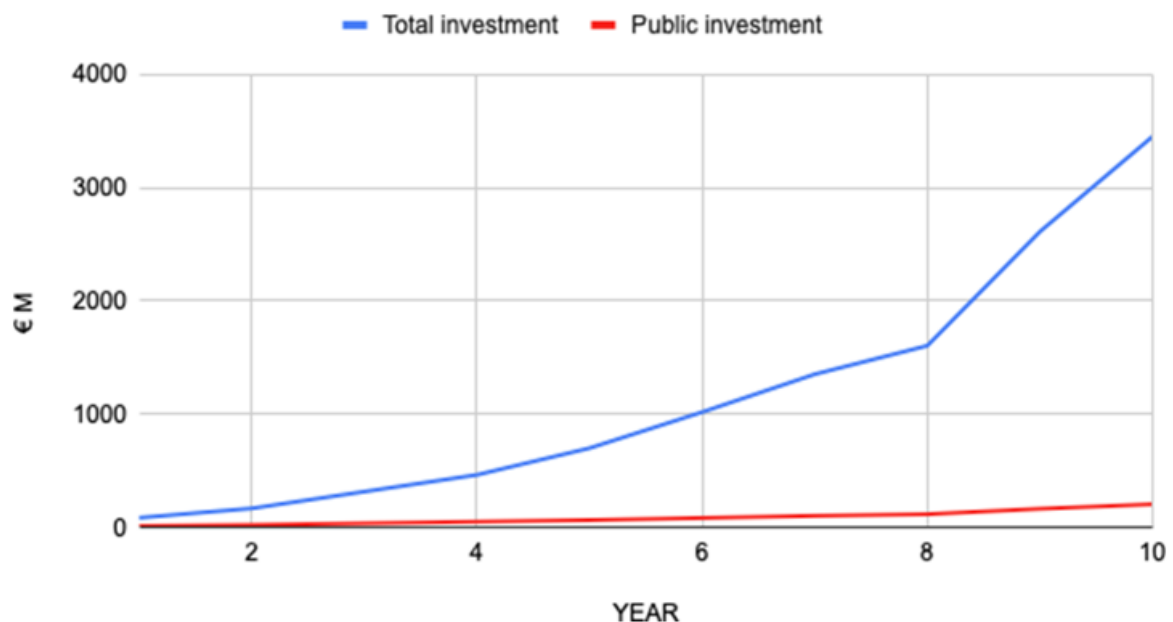


Figure 33 Turnkey providers'. Evolution of the budget

8.10 Turnkey providers': Risk analysis

Table 23 presents the simplified risk assessment-classification for each action:

Table 23 Turnkey providers'. Risk analysis of each action

| Action | Technology | Market | Value network | Score | Total risk |
|--------|------------|--------|---------------|-------|------------|
| AW2 | 2 | 2 | 3 | 12 | Medium |
| AT2 | 1 | 1 | 2 | 2 | Very low |
| AW3 | 2 | 2 | 3 | 12 | Medium |
| AT3 | 2 | 2 | 2 | 8 | Low |
| AS2 | 2 | 2 | 2 | 8 | Low |
| AO1 | 2 | 2 | 3 | 12 | Medium |
| AW1 | 2 | 2 | 3 | 12 | Medium |

| | | | | | |
|-----|---|---|---|----|----------|
| AS1 | 1 | 1 | 1 | 1 | Very low |
| AT1 | 1 | 1 | 1 | 1 | Very low |
| AO2 | 2 | 1 | 2 | 4 | Low |
| AS3 | 2 | 2 | 3 | 12 | Medium |
| AO3 | 1 | 1 | 1 | 1 | Very low |

8.11 Turnkey providers': Timeline

Figure 33 shows the timeline and relationships amongst the different tasks. This roadmap has a timeline between 10 and 15 years, although it is presented as a 10-year roadmap:

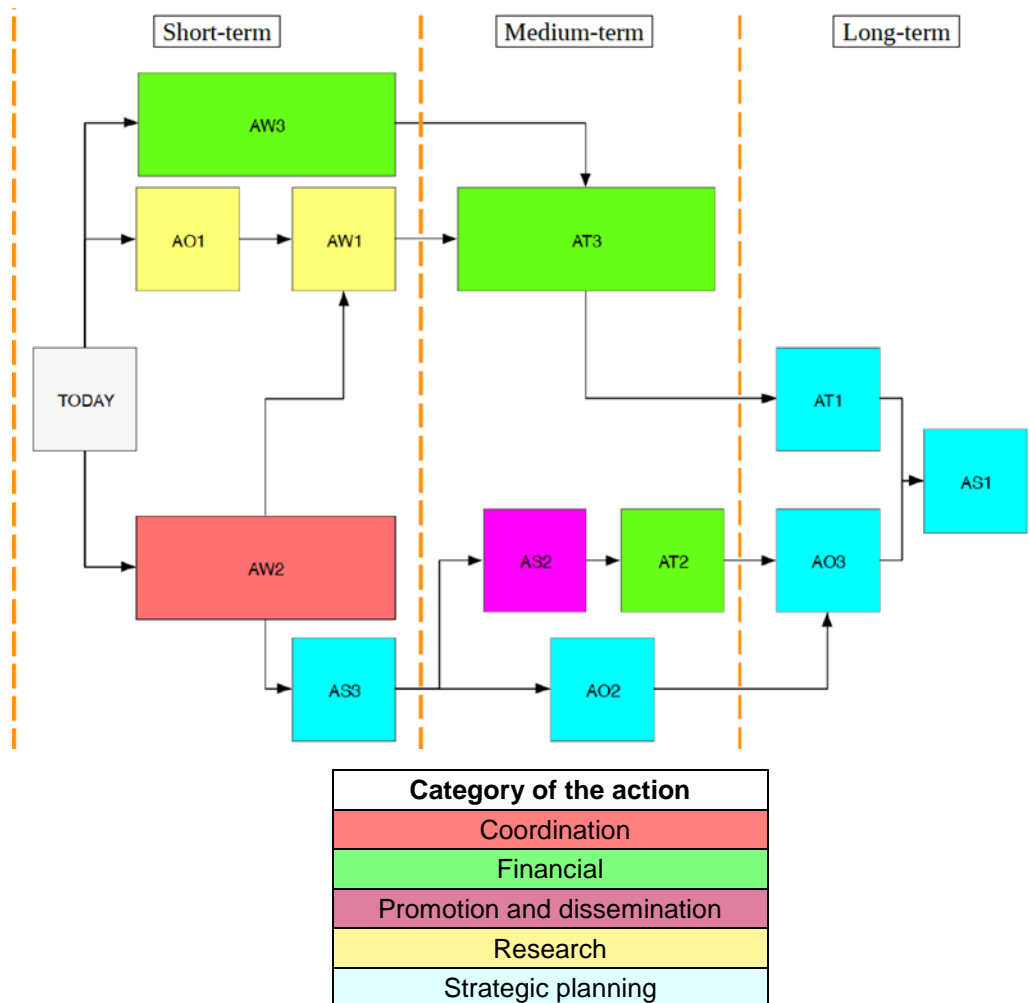


Figure 34 Turnkey providers'. Timeline

8.12 Turnkey providers': Summary table

Table 24 summarizes the Turnkey Providers' roadmap:

Table 24 Turnkey providers'. Summary table

| Action | Stage | Business challenge | Budget (€) | Risk | Stakeholders |
|--------|--------|--|------------|----------|--------------------------|
| AO1 | Short | Support research of the required turnkey providers' technology (Low TRL) | 50 M | Medium | EC - Disc. - TRG - Univ. |
| AW3 | Short | Provide economic resources for researching in the turnkey providers' area | 60 M | Medium | EC - FE. |
| AW2 | Short | Boost cooperation between S.M.E and universities for set new standards regarding this business | 170 M | Medium | EC - Disc. - SME |
| AW1 | Short | Encourage turnkey providers' innovation and investment (High TRL) | 70 M | Medium | EC - NSA - Disc. - TRG |
| AS3 | Short | Analyse the turnkey providers' value chain to obtain benefits | 110 M | Medium | Disc. - Large aero |
| AS2 | Medium | Promote Europe as a new space hub regarding the turnkey providers' | 130 M | Low | EC - NSA |
| AT3 | Medium | Increase the resources and funds to start creating strategic companies of the turnkey providers' field | 680 M | Low | EC - NG - FE |
| AO2 | Medium | Make national legislations (activities inside this business) more attractive to investors | 165 M | Low | EC - NG |
| AT2 | Medium | Provide advantages to S.M.E in the EU's turnkey providers' to boost their development | 165 M | Very low | EC - NG - SME |
| AO3 | Long | Open the space field to different activities focusing on the turnkey providers' field | 170 M | Very low | EC - NSA |
| AT1 | Long | Reduce the EU dependency on launching capabilities | 840 M | Very Low | EC - NSA |
| AS1 | Long | Enable EU's turnkey providers' sustainability in time & protect strategic companies | 840 M | Very Low | EC - SME |

9 Roadmap: New VLEO platform concepts

The fourth roadmap will depict the current situation of VLEO platforms and constellations field, outlining its main key points and weaknesses, according to the technological requirements of the industry and the new DISCOVERER's advances.

Besides, the roadmap will also provide a general planning and implementation of the activities that must be carried out to ensure the strategic goals of the business. Presenting all the required information in a visual format, and following the methodology schema previously defined. This roadmap is complemented by deliverable D5.6 (technological roadmap).

9.1 New VLEO platforms: Business statement

This roadmap will regard the new proposals of the VLEO platforms from the European Commission point of view, and it will mostly focus on the how the EU companies could apply the brand new technologies defined by the DISCOVERER in order to enhance the performance of the satellites, being more efficient.

Thus, the main key points that summarise the mission of the business and that distinguish these activities from others that are currently being done, are depicted in the following points:

- The business includes brand new solution concepts that enhance the current technology's efficiency, providing services with a better resolution and accuracy, caused by the use of the technology advances developed by the DISCOVERER.
- The business is based on the following proposals for affordable platform concepts: "Very High Resolution-High Performance (VHR-HP), Very High Resolution-Low Cost (VHR-LC), and Synthetic Aperture Radar Optic (SAROptic)".
- The business will expand the Earth Observation activities, enabling the entrance of new small and medium size EU companies in the space business.
- The business wants to expand the space market, increasing the competitiveness and reducing the final costs of the services.
- One of the main objectives of the business is to achieve a greater and sustained European physical presence in space, setting international standards in key areas.

9.2 New VLEO platforms: Background

9.2.1 New VLEO platforms. Background context

The next represents different examples of EO satellites, depicting their revisit time, spatial resolution, mass and the average data prices.

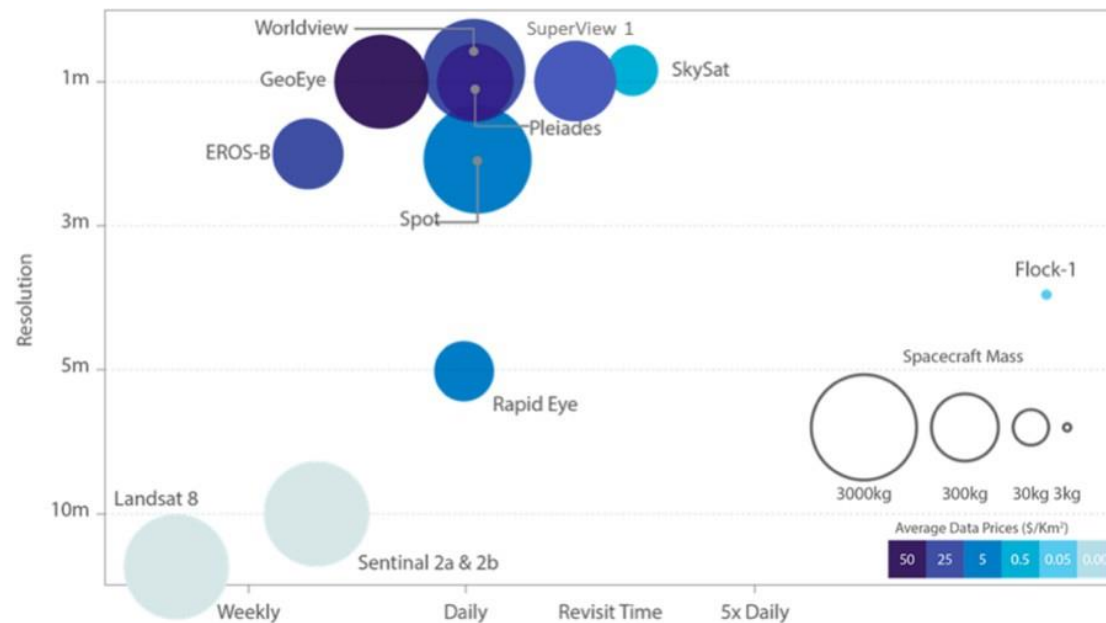


Figure 35 Spatial resolution vs the revisit time for different EO satellites. Based on [D.5.5], [TFE-4], [39]

So, as it is explained before, this roadmap will be only focused on three specific platforms: VHR-HP, SAROptic and VHR-LC Constellations.

Firstly, taking a closer look to the VHR-HP platform technology, the corresponding GSD (Ground Sample Distance) of this optical sensor is lower than 1 meter, being the better resolution commercially available lower than 30cm, as it is explained in [TFE-4].

For this reason, it is considered that a potential costumer of this business would be the disaster management sector and the infrastructure market, among others.

Secondly, as the VHR-LC platform technology has a spatial resolution between 1 and 5 meter (GSD), the aim of these type of platforms is to offer extensive coverage high-resolution imagery at a lower price. Taking into account that the revisit time, the collection capacity and the data transmission problem can be improved thanks to the use of a constellation.

Therefore, the solution of using one smallsats constellation has recently become more popular due to the various benefits, mainly because of the fact that it is less expensive and more reliable than a single satellite.

Finally, highlight that the SAROptic platform technology has an active sensor. So this technology has the main advantage that it still works in cloudy areas or at darkness conditions, being able to acquire samples constantly under any meteorological conditions [40]. For this reason, it is considered that this type of platform could be used for services as the forest mapping and monitoring.

9.2.2 New VLEO platforms. PESTEL analysis

Finally, the PESTEL analysis is presented:

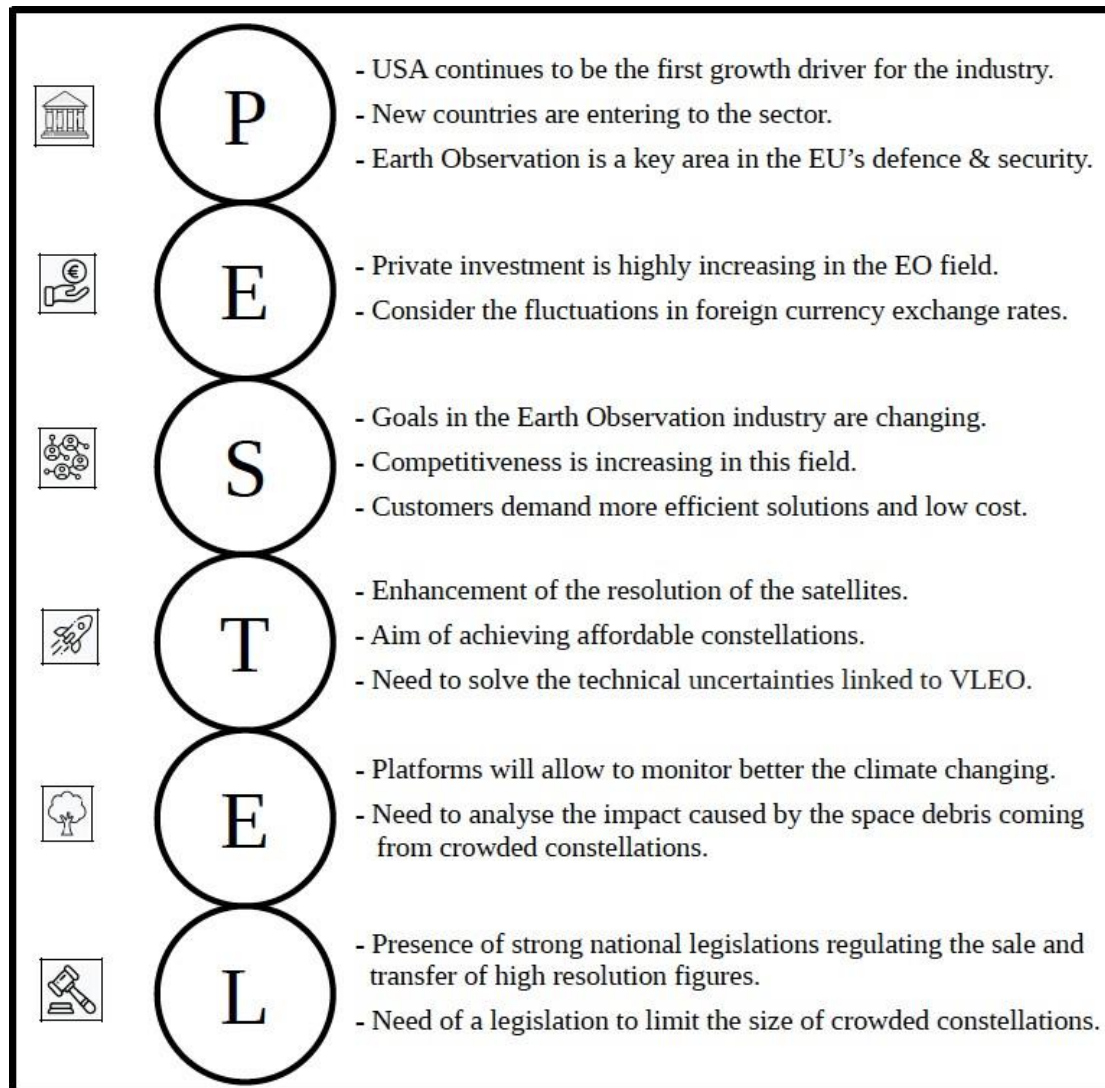


Figure 36 New VLEO platforms. PESTEL analysis. Based on [D.5.5], [TFE-4], [25], [26], [28]

9.3 New VLEO platforms: Market analysis

9.3.1 New VLEO platforms. Market context

The Earth Observation (EO) space industry has significantly grown during the last years, as can be seen in figure 36. Usually, the non-meteorological EO satellites are at Low Earth Orbit (LEO), but recently the Very Low Earth Orbit (VLEO) is being more researched and used due to the benefits they provide.

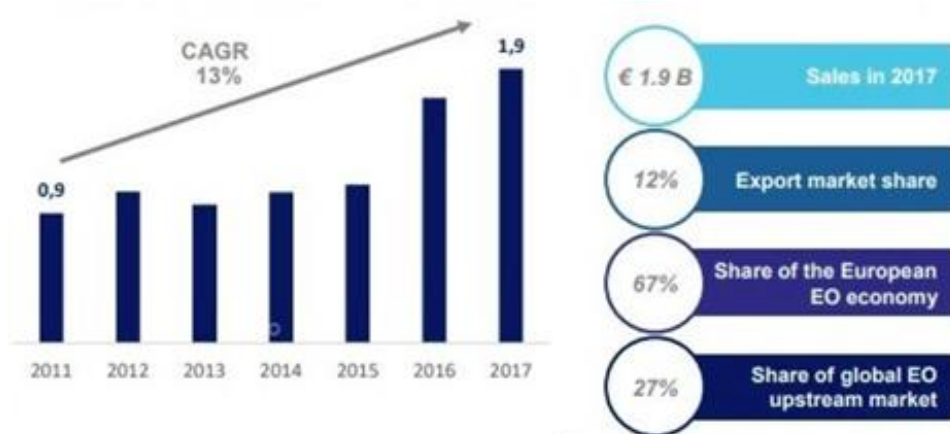


Figure 37 Evolution of European EO upstream sales and industry in 2017. Extracted from: [41]

Therefore, regarding more deeply the Earth Observation market, the evolution of the launches along the years is presented in figure 37.

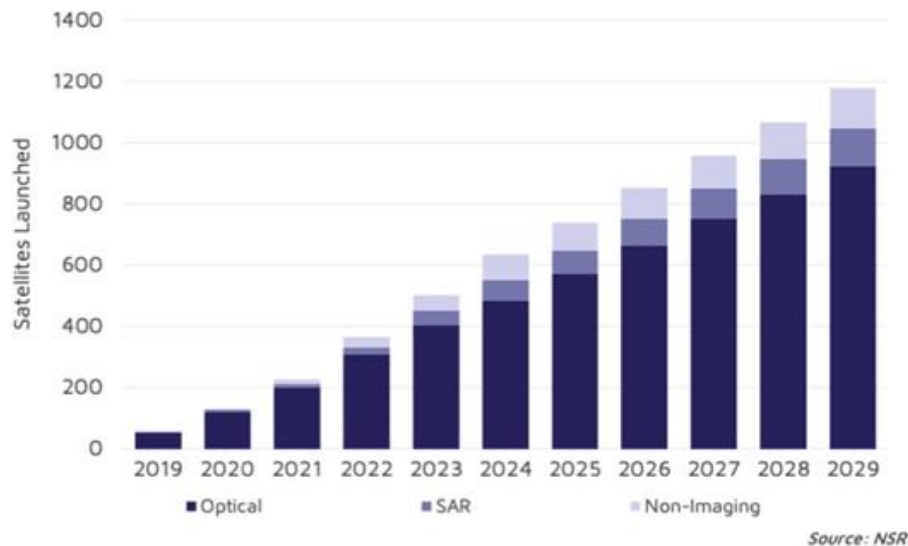


Figure 38 Announced cumulative EO satellite launches by sensor type. Extracted from: [42]

9.3.2 New VLEO platforms. Porter's five forces analysis

- **Threat of new entrants:**
 - The first thing that must be considered is that this field presents a high technological barrier for entering, which requires of strong economic support.
 - Nevertheless, even though the services are provided by established and well-known companies that retain a significant market percentage, new private companies are entering in the market (some of them being supported by their national governments).
 - For these reasons, the threat of new entrants in the platforms field is medium.
- **Threat of substitute products:**
 - In this case, the current tools that compose the platforms field will be enhanced by the use of the new technology developed following the DISCOVERER's advances.
 - Basically, the reason for that is the fact that the use of the VLEO will enable to improve the resolution. Enhancing the Earth Observation activities.
 - Besides, once the new technology systems have been implemented, the market will expand, providing more diversification. Therefore, the threat of substitutes for the current technology systems should be classified as high.

- **Supplier power:**
 - The VLEO platforms require very specialised technology.
 - Therefore, as the final technological design depends directly on the requirements of the solution (as the capacity of accomplish all the technical requirements will define the success of the mission), in this case the power of the suppliers is high.
- **Buyer power:**
 - In the recent years, the Earth Observation market has expanded, which will also continue in the future.
 - Consequently, there will be more institutions offering services based on EO activities. Therefore, the customers will be able to choose between a bigger number options, increasing their decision power.
 - For this reason, the power of the customers is classified as medium.
- **Rivalry between existing competitors:**
 - As the market is currently expanding, and it is not established yet, the competence in this field is increasing.
 - Consequently, the level of competitive rivalry is currently classified as medium.



Figure 39 New VLEO new platforms. Porter's five forces analysis.

9.4 New VLEO platforms: Requirements

In addition, the conditions and capabilities that the business' activities and stakeholders must accomplish to fulfil the goals previously defined, are explained in the following points:

- The activities described in the business must be implemented taking into account that the final solution must reduce the costs of the service, expanding the market.
- The analysis developed in the business must take advantage of the fact that private companies are entering to the sector, searching for interesting key partnerships.
- All the activities related to the business, must guarantee a full accomplishment of the national legislations and regulations regarding the fact of commercialising data.
- The business must use a solution that enhances the accuracy of the current technology, taking profit of the VLEO characteristics.

- The technology applied in the business should expand the current VLEO satellite's constellation lifetime.
- The key partners must contribute to add value to the business, by providing resources or specific knowledge in target areas.
- The roadmap must be developed considering the main points of the VHR-LC, VHR-HP and SAROptic constellations and platforms. Which are deeply presented in [TFE-4] and summarised in [D.5.5].
- Finally, the business must be implemented considering as a reference the implementation of the activities presented in this roadmap.

9.5 New VLEO platforms: Competitive advantage

Taking a closer look at the operators that are willing to exploit the VLEO for Earth Observation purposes and taking into account the customer's requests and needs, it is considered that the points that add value to the business are the following ones:

- Higher resolution: The implementation of the new DISCOVERER's advances will enable to increase the resolution of the technology, enhancing the results.
- Value added services: These new concepts of platforms and the use of brand new technology systems will create completely automate services that will increase the efficiency of the activities, providing more value to the business.
- Extended life-time: The new technologies will enable to increment the life-time of the current VLEO constellations.
- Affordable price: Allowing to small and medium size companies to hire the service, which will boost the Earth Observation field.
- Expand the EO's activities: The implementation of these brand new satellites constellations will offer new Earth Observation activities to the customers, which will be an opportunity to expand the market and attract more investment.
- Customised mission parameters: The services will have the capacity to adapt the service to the specific customer's requests and needs.
- Enhancement of the security: The business will contribute to increase the national security of the EU. Therefore, the business will accomplish and improve the standards presented in the data acquisition and transmission legislation, specially the one regarding the commercialising with high resolution images.

9.6 New VLEO platforms: SWOT analysis

The SWOT analysis of the business is presented in figure 39:

| | |
|--|--|
| <p><u>Strengths:</u></p> <ul style="list-style-type: none"> - S1. Enhanced platforms for EO activities. - S2. Offer EO V.A.S. regarding the customer's needs. - S3. Affordable EO services. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none"> - W1. High technological barrier for entering to the EO sector. - W2. Need of high cooperation for creating strategic companies. - W3. Need of higher investment to implement the solution. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none"> - O1. Technology transfers between space and defence. - O2. Private companies growing in the EO's platforms field. - O3. EO market is currently expanding. | <p><u>Threats:</u></p> <ul style="list-style-type: none"> - T1. Technological challenges at VLEO. - T2. Data transmission services are strongly regulated. - T3. Risk of underinvestment increases due to COVID-19. |

Figure 40 New VLEO platforms. SWOT analysis. Based on [D.5.5], [TFE-4], [25], [26]

- **Strengths:**
 - The business will develop brand new concepts of platforms for satellites operating at VLEO. Thus, as a result of these improvements, the companies will be able to provide enhanced services, surpassing what is currently being done in the EO market.
 - The technical advances connected to the new system of platforms will enable to offer VAS regarding the customer's needs. Consequently, these advances will enable to adapt the EO activities carried out by the company to the specific customer requests. Creating a better interrelation between the customer and the company.
 - The design of these new platforms will have a direct impact on the final cost of the services provided. Therefore, due to the enhancement of the technology, it will be possible to offer affordable EO services, which will reduce the economic barrier for entering in the business. Causing an expansion of the market, as a result of the SME that will start participating
- **Weaknesses:**
 - The platforms business presents a high technological barrier to enter, needing to achieve strong financial support to develop and implement the proposed constellations.
 - Besides, as the technology solution is quite complex, the business needs to boost the cooperation between public and private actors to implement the advances and create strategic companies.
- **Opportunities:**
 - New technology systems are being developed, provoking the expansion of the market and the growth of the competitiveness, as new private companies aim to enter.
 - Thus, as "*The European space sector as an enabler of EU strategic autonomy*" document outlines [26], the EO activities are essential for the defence of the EU, being both areas connected.
- **Threats:**
 - Firstly, a higher investment is needed to overcome the uncertainties caused by the pandemic and boost the space sector, as it is explained in [26].
 - Besides, it is necessary to take into account the different legislations that regard the data acquisition and the transmission and commercialisation of images obtained by the satellites.
 - Finally, regarding the current status of the VLEOs, there are some uncertainties that must be solved. As for example: the erosion of the materials due to the atomic oxygen, the presence of aerodynamic forces, the management of a lower revisit time and the lower life-time duration of the satellites.

9.7 New VLEO platforms: Action's description

Figure 40 shows the strategic actions that allow taking advantage of every SWOT item.













| | |
|---|---|
| <p><u>Strengths:</u></p> <ul style="list-style-type: none">  - AS1. Enable the EO's industry sustainability in time.  - AS2. Promote Europe as a new space hub in the field of EO.  - AS3. Analyse the VLEO platforms value chain to enhance benefits. | <p><u>Weaknesses:</u></p> <ul style="list-style-type: none">  - AW1. Encourage the DISCOVERER's innovation  - AW2. Boost cooperation to set new standards in the EO field.  - AW3. Increase the amount of public resources and funding. |
| <p><u>Opportunities:</u></p> <ul style="list-style-type: none">  - AO1. Create technology commonalities between space & defence (high TRL)  - AO2. Expand the EO's market to different activities.  - AO3. Enable advantages to the EU's S.M.E. linked with EO activities. | <p><u>Threats:</u></p> <ul style="list-style-type: none">  - AT1. Support the research of the current VLEO's issues.  - AT2. Make national legislations more attractive to the investors.  - AT3. Provide economic resources to strategic areas. |

Figure 41 New VLEO platforms. Action's description

In addition, the actions are classified in the following categories:

Table 25 New VLEO platforms. Actions' categories

| Category of the action | Action |
|------------------------------|--------------------|
| Coordination: | AO1, AW2 |
| Financial: | AO3, AW3, AT3 |
| Promotion and dissemination: | AS2 |
| Research: | AW1, AT1 |
| Strategic planning: | AS1, AO2, AT2, AS3 |

- **Coordination:**

- AO1: As "The European space sector as an enabler of EU strategic autonomy" document outlines [26], the EO activities are essential for the defence of the EU. Therefore, it is necessary to create technology commonalities between the space and defence areas.
- AW2: In order to implement the final technological solution and enable the creation of strategic companies, it will be necessary to boost the cooperation between public and private actors, creating a solid infrastructure regarding the EO's space field and ensuring that companies and universities can collaborate together to fulfil the expected goals.

- **Financial:**

- AO3: Provide economic and legal advantages to the small and medium size companies that aim to enter to the EO sector, increasing the attractiveness and the competitiveness of the market.
- AW3: The EU should increase the amount of resources focused on the R+D of the new technologies required to do the EO activities at VLEO.
- AT3: Firstly, at this moment the big companies are the ones that monopolize the EO market at VLEO. Therefore, it is necessary to increase the amount of resources focused on the development of new strategic companies, in order to counteract the current situation of the industry.

- **Promotion and dissemination:**

- AS2: Following the work presented in [26], some countries as Japan or Russia are currently in an advanced position inside the platforms business (for example, Russia plans to roll-out a next-generation satellite system called Sfera in 2022). Therefore, it is necessary to design and implement tools to attract the attention of investors in the platforms industry, increasing the European authority in the space field.

- **Research:**

- AW1: Support the R+D of the DISCOVERERs that are currently being studied at the university (as for example inside the DISCOVERER project). Basically, their advances will enable to develop brand new technologies required to do EO activities at VLEO.
- AT1: It is mandatory to solve the technological challenges linked with the VLEO in order to ensure that the business could properly work and guarantee the efficiency of the EO missions.

- **Strategic planning:**

- AS1: Ensure and protect the new business once all the technology has been developed and tested, guaranteeing the expansion of the EU companies involved in the EO activities.

- AO2: It is important to expand the EO activities to different goals and sectors, which will increase the attractiveness of the market, attracting a higher number of private companies to the field.
- AT2: Make national legislations more attractive to investors, as some European countries do not allow to commercialise figures with a resolution below 0.3 m. In this case, it is interesting to define an unique European legislation, guaranteeing also the security of the citizens.
- AS3: Support the study of the value EO chain in order to discover new key points and guarantee the reduction of the services' costs.

9.8 New VLEO platforms: Stakeholders

It is necessary to identify as soon as possible which are the target stakeholders, as without their support the business scenario would cease to exist. Obtaining:

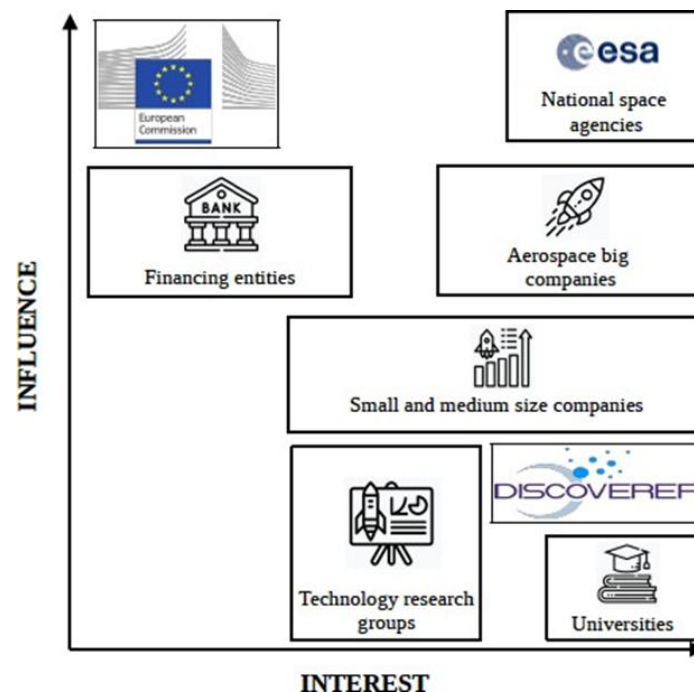


Figure 42 New VLEO platforms. Stakeholders' matrix

Therefore, the following table shows the stakeholders involved in each action's planning and implementation:

Table 26 New VLEO platforms. Stakeholders of each action

| Action | Stakeholder |
|--------|--|
| AO1 | EC - National governments - National space agencies |
| AW2 | EC - TRG - Universities - Small and medium size companies |
| AO3 | EC - National governments |
| AW3 | EC - National governments - Financing entities |
| AT3 | EC - National governments - Financing entities |
| AS2 | EC - National space agencies |
| AW1 | EC - DISCOVERER - TRG - Universities |
| AT1 | EC - DISCOVERER - TRG - Universities - National space agencies |
| AS1 | EC - Small and medium size companies |
| AO2 | EC - National space agencies |

| | |
|-----|--|
| AT2 | EC - National governments |
| AS3 | DISCOVERER - Aerospace large companies |

9.9 New VLEO platforms: Budget

A summary of the budget of each action is presented:

Table 27 New VLEO platforms. Budget of each action

| Action | Category | TRL | LF | Budget (€) |
|--------|---------------------------|--------|-----------------|------------|
| AO1 | Coordination | 8 to 9 | 19 to ≥ 20 | 185 M |
| AW2 | Coordination | 4 to 6 | 4 to 7.5 | 60 M |
| AO3 | Financial | 6 to 8 | 7.5 to 19 | 340 M |
| AW3 | Financial | 4 to 6 | 4 to 7.5 | 45 M |
| AT3 | Financial | 8 to 9 | 19 to ≥ 20 | 490 M |
| AS2 | Promotion & dissemination | 6 to 8 | 7.5 to 19 | 340 M |
| AW1 | Research | 4 to 5 | 4 to 5 | 36.5 M |
| AT1 | Research | 5 to 6 | 5 to 7.5 | 50 M |
| AS1 | Strategic Planning | 9 | ≥ 20 | 3780 M |
| AO2 | Strategic Planning | 6 to 8 | 7.5 to 19 | 2565 M |
| AT2 | Strategic Planning | 8 to 9 | 19 to ≥ 20 | 205 M |
| AS3 | Strategic Planning | 6 to 7 | 7.5 to 12 | 107.5 M |

Budget estimations were done considering the information provided by European Commission in the following references: [29], [30], [31], [32], [43]. Besides, for the calculations, it was taken into account that the space sector represents a 10% of the EU's GDP [29].

And the evolution of the budget is:

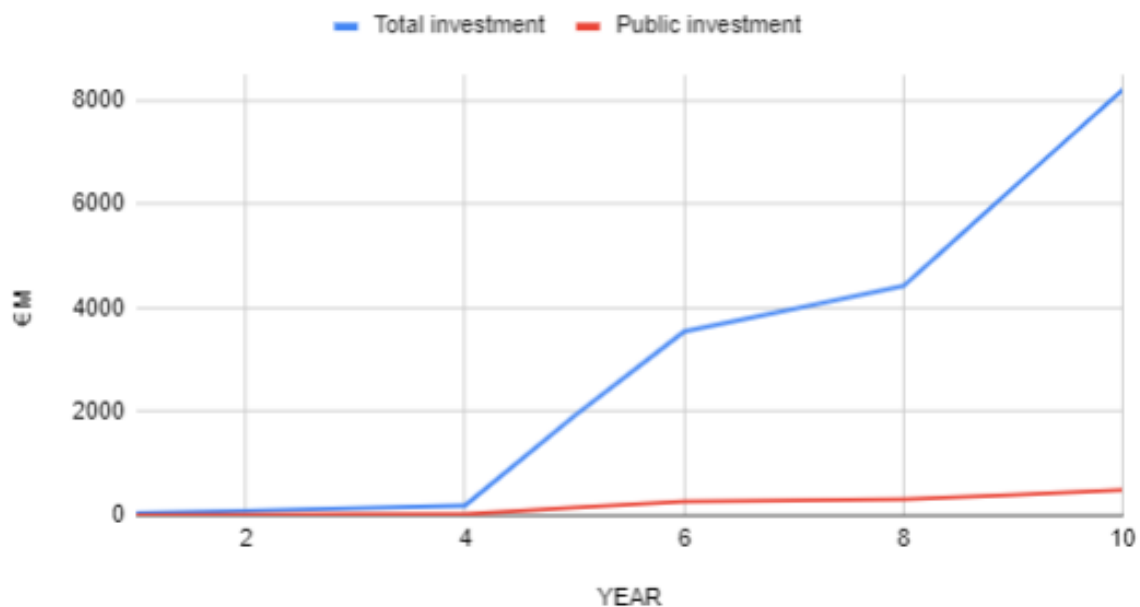


Figure 43 New VLEO platforms. Evolution of the budget

9.10 New VLEO platforms: Risk analysis

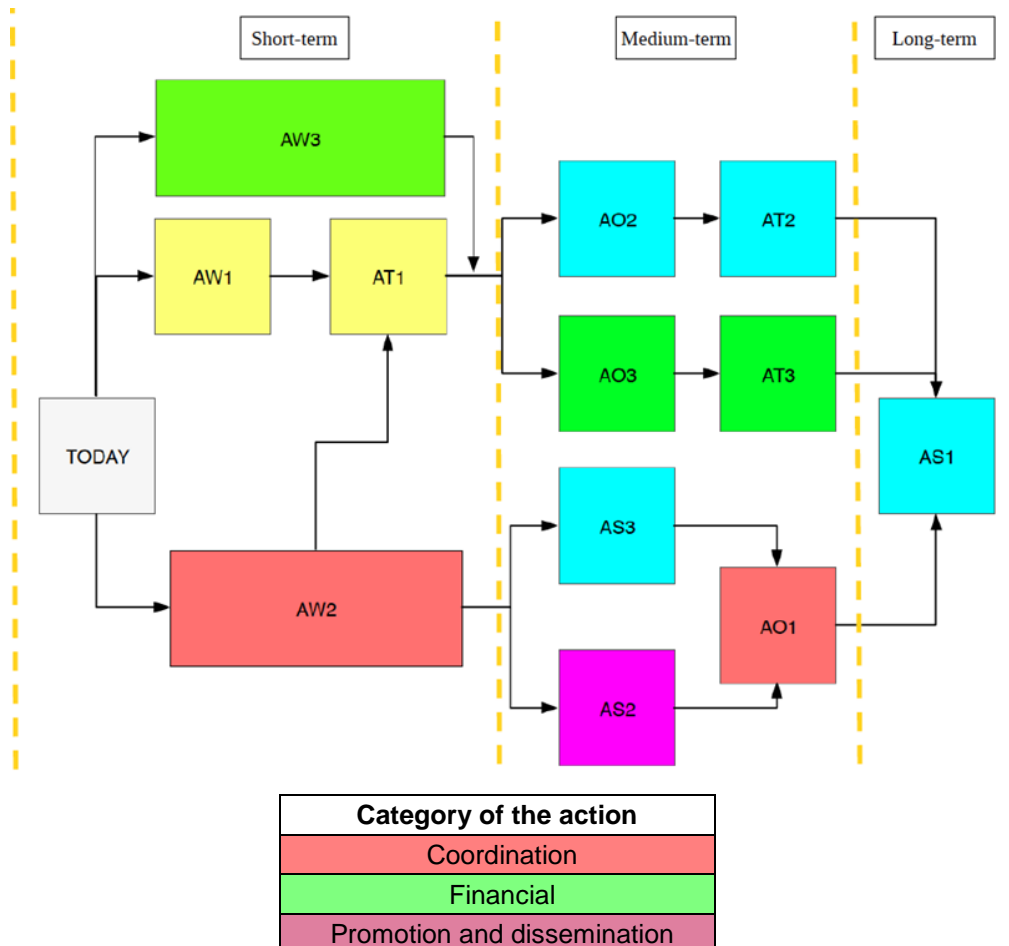
Following the methodology, it is obtained:

Table 28 New VLEO platforms. Risk of each action

| Action | Technology | Market | Value network | Score | Total risk |
|--------|------------|--------|---------------|-------|------------|
| AO1 | 1 | 1 | 2 | 2 | Very low |
| AW2 | 3 | 2 | 3 | 18 | Medium |
| AO3 | 2 | 2 | 2 | 8 | Low |
| AW3 | 3 | 2 | 3 | 18 | Medium |
| AT3 | 1 | 1 | 2 | 2 | Very low |
| AS2 | 2 | 2 | 2 | 8 | Low |
| AT1 | 2 | 2 | 3 | 12 | Medium |
| AW1 | 3 | 2 | 3 | 18 | Medium |
| AS1 | 1 | 1 | 1 | 1 | Very low |
| AO2 | 2 | 2 | 2 | 8 | Low |
| AT2 | 1 | 1 | 2 | 2 | Very low |
| AS3 | 2 | 2 | 2 | 8 | Low |

9.11 New VLEO platforms: Timeline

Finally, the timeline of the actions is presented. Obtaining:



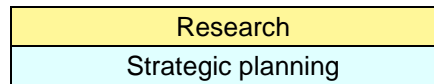


Figure 44 New VLEO platforms. Timeline

9.12 New VLEO platforms: Summary table

To conclude, a summary table is included:

Table 29 New VLEO platforms. Summary table

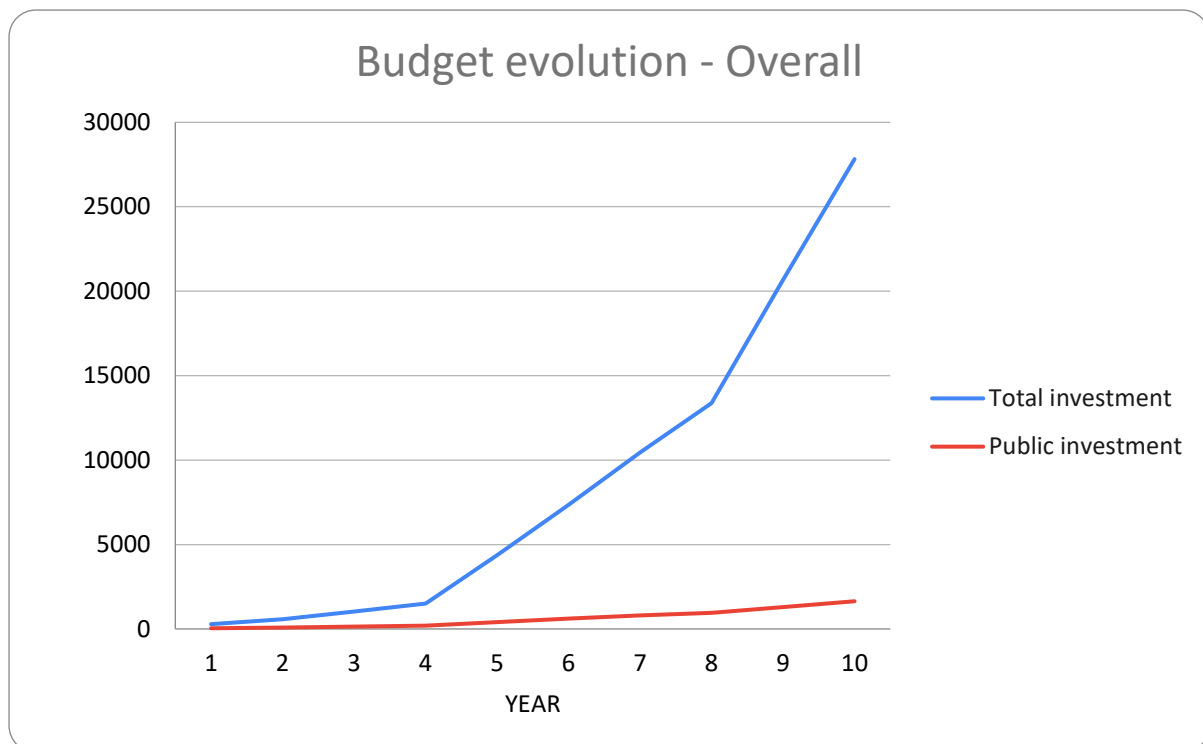
| Action | Stage | Business challenge | Budget (€) | Risk | Stakeholders |
|--------|--------|--|------------|----------|--------------------------|
| AW2 | Short | Boost cooperation | 60 M | Medium | EC - TRG - Univ. - SME |
| AW3 | Short | R+D platform's innovation | 45 M | Medium | EC - NG - FE |
| AW1 | Short | High level R+D barrier for entering | 36.5 M | Medium | EC - Disc. - TRG - Univ. |
| AT1 | Short | VLEO challenges | 50 M | Medium | EC - Disc. - TRG - NSA |
| AS3 | Medium | New business concepts | 107.5 M | Low | Disc. - Large Aero. |
| AS2 | Medium | Promote Europe as a new space hub | 340 M | Low | EC - NSA |
| AO2 | Medium | Market is expanding | 2565 M | Low | EC - NSA |
| AO3 | Medium | Nº of private companies is growing | 340 M | Low | EC - NSA |
| AT2 | Medium | Make legislation more attractive | 205 M | Very low | EC - NG |
| AT3 | Medium | Develop strategic companies | 490 M | Very low | EC - NG - FE |
| AO1 | Medium | Cooperation between space & defence | 185 M | Very low | EC - NG - NSA |
| AS1 | Long | Achieve access to space sustainability | 3780 M | Very Low | EC - SME |

10 Conclusions

The European Commission has concluded that for ensuring a EU's broader strategic autonomy in space, it is vital to provide a consistent level of prolonged investment to implement the new progress that the space industry is requiring to place mega-constellations into VLEOs. Therefore, these challenges face the complexity of strategic management, generating a new situation where the traditional planning tools are unable to accomplish the current managers' demands. Being evident the need of creating a business roadmap methodology as a guideline. For doing this, the current document presents a new business roadmap methodology that defines a strategic management plan focused on boosting the creation and development of new SME into different aspects of VLEO space industry: access to space; ground services, turnkey providers and new VLEO Platforms.

In general, the analysed case studies business roadmap depicts that firstly it is necessary to create key partnerships for the R+D of the technology required, boosting the collaboration between aerospace big companies, public national space agencies and technological research groups. Besides, as in the short-term the technology will present a low TRL, the amount of public and private financing in this stage will be very similar. Afterwards, once the technology presents a higher TRL, the reliance on the technology will raise, causing that the Leverage Factor of the business will increase in the mid-term. Consequently, the EU's investment must be then focused on ensuring the market's expansion and the creation of new strategic companies. Finally, in order to guarantee the European Commission's goal of certifying a EU's broader strategic autonomy in space, the actions carried out in the long-term for each case study must be mainly focused on providing mechanisms for achieving the EU's strategic space goals sustained in time.

All in all, a series of 48 interlinked actions have been detailed, scheduled and budgeted in a timeline of 10 years, bringing to a figure of around 28.000 M€, of which 1.640 M€ are supposed to be public funds whilst the rest will be leveraged from private investments.



Four Case Studies are presented as specific attachments. Besides, it can be stated that most of the achievements in VLEO can also be useful at LEO.

11 References

11.1 External references

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11.2 Internal DISCOVERER reference documents.

| Ref. | Document Title | Version, Date | Type of document |
|--------|---|-----------------|------------------|
| RD-5.1 | DISCOVERER-D5.1 - EO Market Overview | 11 - 21/03/2018 | Public |
| RD-5.2 | DISCOVERER-D5.2 - Benefits and Applications of VLEO for EO | 01 - 30/01/2018 | Public |
| RD-5.3 | DISCOVERER-D5.3 - Analysis of New Stakeholders in the VLEO Market | 06 - 07/05/2020 | Confidential |
| RD-5.4 | DISCOVERER-D5.4 - System Models Description of VLEO Platforms with Promising Opportunities in the EO Market | 01 - 21/07/2020 | Confidential |
| RD-5.5 | DISCOVERER-D5.5 – Canvas business models for the most promising system concepts | 05 - 01/04/2021 | Public |
| RD-5.6 | DISCOVERER-D5.6 – Technology Development Roadmap for future VLEO platforms | 01 - 22/11/2021 | Public |

11.3 Internal UPC reference documents

| Ref. | Reference |
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| TFE-1 | Gil, P. (2021). Study: Improved roadmaps for the development of EU companies in Earth Observation activities at Very Low Earth Orbits. (MSc). Universitat Politècnica de Catalunya. Not yet published. |
| TFE-2 | Amador, F. (2021). Study and Design of a Business Model Canvas for a Ground Station Company. (BSc). Universitat Politècnica de Catalunya. Not yet published. |
| TFE-3 | Salas, M. (2019). Study and Design of a Business Model CANVAS for a space broker company focused on Very Low Earth Orbit (VLEO) Missions. (BSc). Universitat Politècnica de Catalunya. Available at: https://upcommons.upc.edu/handle/2117/185700 . [Accessed: 17- 06-2021]. |
| TFE-4 | Riba, M. (2021). Study of business model CANVASEs and feasibility studies for different platform technologies suited to the H2020 DISCOVERER project results. (BSc). Universitat Politècnica de Catalunya. Not yet published. |

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