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High-Tech Startups: Creating and Scaling Up

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1 Executive Summary

Introduction
The increasing congestion in Low Earth Orbit (LEO) poses significant challenges for the sustainability of space operations. Our startup addresses this urgent issue by developing passive deorbiting solutions that ensure the safe removal of non-operational satellites and other space debris.

Products & Services
We aim to specialise in the design and development of passive deorbiting systems, including drag sails, electromagnetic tethers and plasma brakes with their correlated management software. Moreover, the delivery and the integration of the aforementioned devices are provided.

External and Internal Analyses
We target satellite operators and manufacturers, space agencies and scientific organisations. While most of the competitors focus on active deorbiting technologies, our passive solutions stand out for their simplicity and cost-effectiveness. Furthermore, our team excels in technical expertise and benefits from PoliMi resources and a first-mover advantage, but faces challenges in funding, market credibility, and building industry partnerships.

Value Proposition and Testing
Focusing on the operational environment, we tested our hypotheses against the specific value propositions tailored for each customer segment. The results of these testing procedures enhanced the team's understanding of the market landscape and lead to our next strategic steps to better align with customer needs and problems.

Conclusions
Our startup is poised to play a vital role in shaping the future of LEO sustainability. By addressing the growing challenges of orbital debris with innovative passive deorbiting solutions, we aim to establish as a standalone company and set partnerships with different customers to help them meet regulatory requirements and ensure a safer orbital environment for future generations.

2 Vision and Mission

2.1 Vision

We envision a self-sustainable and efficient space ecosystem that enhances accessibility through innovative solutions, opening up space for new exploration and collaboration. We dream of a more open and opportunity-rich environment for all space actors that will represent a cornerstone of a thriving and sustainable space future. We also believe that the European Union and other nations will place increasing importance on preserving the space environment, safeguarding opportunities for future generations, and fostering the advancement of the international space community.

2.2 Mission

Our mission is to tackle the growing issue of space congestion by providing sustainable, simple, reliable, and innovative passive deorbiting solutions. Through the design, validation, and testing of new technologies, we aim to ensure safe and efficient operations in Low Earth Orbit, addressing new regulations, and creating a more sustainable and accessible space environment for future generations.

3 SWOT Analysis

3.1 External Analysis

3.1.1 Customer Analysis

The external analysis of the company stems from identifying potential customers for its innovative, high-tech product. In addition to the key players in the space market, scientific organisations focused solely on research & development were also included. This resulted in a list of customers comprising:

Satellite Manufacturers (Airbus, Boeing, Thales Alenia Space, etc.): These clients seek solutions that offer added value and ensure compliance with new contractual requirements. Opportunities for collaboration are based on OEM contracts, direct sales, or royalties.

Satellite Operators (SpaceX, Iridium, OneWeb): These players are primarily driven by the need to comply with regulations, reduce collision risks in space, and enhance their corporate image through greater environmental responsibility. Commercial partnerships are structured around multi-year contracts with technical support and *as-a-service* revenue models.

Space Agencies (ESA, ASI, DLR, etc.): Agencies are focused on maintaining high space safety standards, investing in long-term projects, and integrating technological innovations. Relationships with these agencies are developed through public procurement contracts, departmental collaborations, or, in some cases, corporate acquisitions.

Scientific Organisations and Universities: These entities are interested in testing and developing new technologies, favouring collaborations through low-cost contracts and research results sharing. Despite financial limitations, the opportunity to gain scientific visibility increases the probability of success with this type of customer.

Space Startups: For startups in the sector, the focus is on regulatory compliance from the outset. Collaborations are structured around *pay-per-use* models, but the probability of success is lowered due to cost-related challenges.

3.1.2 Competitor Analysis

Understanding the competitive landscape is vital for refining AetherDROP's positioning in the deorbiting technologies field. Competitors are grouped into three categories: direct competitors, analysed in detail; indirect competitors, where only the most significant players are examined; and potential new entrants, identified but not fully characterised.

Company	**HPS** [1]	**Vestigo Aerospace** [2]	**NPC Space-Mind** [3]	**Aurora Propulsion** [4]	**MMA Design** [5]
Target Market	ESA, EC, DLR	Small Satellite Operators and NASA	Operators, Government Agencies and Research Institutions	Small Satellite Operators and NASA	Small Satellite Operators and Government Agencies
Key Partners	TU Munich, Max Planck Institute	NASA, NeXolve and Astro Digital	La Sapienza and other Research Institutes	ESA Business Incubation Centre and Practica Capital	NASA, JPL, US Department of Defense

Table 1: Direct competitors in passive deorbiting technologies

Company	Astroscale [6]	ClearSpace [7]
Target Market	Space Agencies and Private Companies	Government Agencies and Commercial Operators
Key Partners	NASA, ESA, Airbus, JAXA, UK Space Agency	ESA and Research Institutions

Table 2: Indirect competitors in active debris removal technologies

The competitors presented in Table 1 and Table 2 offer a range of solutions for space debris management. Below are the key insights:

- **Direct Competitors:** Direct competitors focus on passive deorbiting technologies, with variations in scalability, readiness, and market focus. Their solutions are tailored for CubeSats, small satellites, and specific payload sizes.
- **Indirect Competitors:** Indirect competitors, such as Astroscale and ClearSpace, provide active debris removal technologies using advanced methods like magnetic docking and robotic arms. These solutions target a broader range of debris challenges but involve higher costs and technological complexity.

Moreover, **potential new entrants** into the market should also be considered, including government entities and international space agencies such as ESA or SpaceX, which may develop or incentivise their own passive deorbiting technologies. Additionally, emerging startups or satellite manufacturers seeking to develop their own in-house deorbiting systems could become significant competitors.
This comparative analysis highlights the diversity in the competitive landscape, showcasing both threats and opportunities [8]. The insights gained will help refine our strategic approach to ensure a strong market position. For further details on the performed competitor analysis, refer to Appendix A.

Investor Analysis: As part of the competitor analysis, we also identified the key investors backing these companies, which may also serve as potential investors for our startup. The main categories of investors are:

- **Space Agencies**: These provide non-equity-based support, focusing on advancing research and innovation in the space sector (e.g., NASA, ESA).
- **Government Funds**: National and regional grants aimed at supporting strategic industries such as aerospace and technology.
- **Venture Capital and Private Equity**: Equity-based investors seeking high-growth, scalable companies with significant market potential.

3.1.3 Environmental Analysis

Subsequently, the analysis focused on identifying and positioning AetherDROP within the four fundamental areas that define its operating environment: political, economic, social, and technological.

Political: Partnerships with space agencies and the growing need for space debris mitigation technologies [9] are driving the space deorbiting market's growth. By providing financial and tax incentives, the European Green Deal [10] encourages environmentally friendly innovation and propels the creation of sustainable satellite end-of-life solutions. The worldwide minimum corporate tax plan from the Organization for Economic Co-operation and Development (OECD) [11], however, might raise operating expenses and necessitate tactical changes. In order to reduce geopolitical risks, it is crucial to diversify finance, cultivate local alliances, and comply with international laws. This is further highlighted by political instability and changing trade restrictions.

Economical: Section 3.1.4 highlights opportunities in the growing space economy [12] [13] for expanding deorbiting services and partnering with emerging space companies. Increased investments [14] in debris removal programmes present funding and profit potential, encouraging collaborations with research agencies. Raising wages in the high-tech industry, however, boosts operating expenses and make it harder to retain personnel. Offering non-monetary incentives, such as stock options and career development, can attract skilled professionals while managing salary expenses.

Social: The rising emphasis on space missions by SpaceX and NASA is fostering a skilled talent pool, crucial for addressing space debris challenges. Growing demand for sustainable technologies [15] and corporate social responsibility are drawing in investors and enhancing public opinion. At the same time, the scientific community's demand for orbital debris solutions is influencing laws and opening up new avenues for cooperation.

Technological: To address the increasing demand for space debris mitigation solutions, it is crucial to align technology development with emerging regulations and form strategic partnerships. The advent of new technologies, such as advanced drag sails and electromagnetic tethers, requires investment in R&D and in securing proprietary patents to remain competitive [16]. As space technologies evolve rapidly, the risk of obsolescence calls for a flexible technology roadmap, ongoing innovation, and exclusive partnerships to maintain a competitive edge and secure intellectual property rights.

The main factors involved in this analysis have been summarised in the PEST table and in the Porter's Five Forces table to be found in Appendix B.

3.1.4 Market Analysis and Main Trends

As previously stated in Section 3.1.3, the market in AetherDROP's sector of interest is experiencing strong growth. Space activities are crucial for industrial competitiveness, economic growth, and innovation across Europe. Every euro invested in ESA programmes generates up to 4 euros in the broader economy, and up to 90% of the funds invested are returned to governments in the form of taxes and social contributions [17]. Additionally, investments from member states create value also in space-related sectors such as telecommunications, positioning, and navigation.
In support of this, two publications from McKinsey [12] and Space Foundation [13] describe future trends in the space market, estimating that the space economy will represent a $1.8 trillion opportunity by 2035, compared to around $600 billion in 2023, already growing by 7.4% relative to 2022. The growing market trend is indeed driving governments and private agencies to increase investments in research and technological development in the sector. The U.S. Bureau of Economics [18] highlights the steady rise in annual investments in this area, as can also be observed in Appendix C. In contrast, in the EU, inflation, the increase in interest rates [19], and the higher cost of energy [20] may raise investment costs, complicating AetherDROP's initial positioning in its target sector.

3.2 Internal Analysis

3.2.1 Strengths

Consultation from Professors and Scientific Advisors: The team can benefit from the expertise of professors and advisors who offer valuable insights into complex technical issues. Their guidance strengthens the startup's technological foundation and helps solve difficult challenges.

Specific Technical Skills: The team has strong technical expertise in space and aeronautical engineering, which gives us an edge in developing deorbiting solutions. This knowledge allows for effective problem-solving and innovative approaches to managing satellites at the end of their life.

First Mover Advantage: Being one of the first startups to focus on passive satellite deorbiting, the company has the opportunity to attract attention early on and establish itself as a leader.

PoliMi Network and Facilities: Access to Polimi facilities enables cost-effective simulations and technology validation, while its extensive network offers connections to industry, investors, and partnerships, driving research, development, and growth.

Previous Experience in Startup Development: Having a team member with experience in launching and managing a startup brings valuable insights. This helps avoid common mistakes and accelerates our growth by streamlining development and decision-making processes.

3.2.2 Weaknesses

Limited Entrepreneurial and Commercial Skills: While having strong technical expertise, the team lacks direct experience in areas like entrepreneurship, marketing, and commercial strategy. This might make it harder to scale the business and compete effectively in the market.

Competition from Industry Leaders: Big players in the space industry, especially those involved in satellite technology and debris mitigation, have substantial resources, advanced technologies, and a strong market presence. Competing against these companies will be a significant challenge.

Limited Financial Resources: The startup is in a market that requires substantial investment upfront, which we can not fully cover with internal resources. Securing external funding will be crucial to develop and scale our technology.

Lack of Credibility and Market Legitimacy: As a newborn startup in a specialised and competitive field like space technology, AetherDROP may face difficulties in gaining trust and credibility from potential investors, clients, and partners. Building a solid reputation will take time and effort.

Limited Industry Network and Partnerships: Being a new startup in the space industry often means lacking strong connections, which can limit access to valuable opportunities, partnerships, and insights. Establishing these relationships will be important for our growth and long-term success.

3.3 SWOT Table

Figure 1: SWOT Table

4 Strategic Alternatives

This section evaluates the strategic alternatives, assessing its feasibility and alignment with AetherDROP's mission. The aim is to identify the most suitable option that balances operational flexibility, scalability, and potential growth. Starting from the SWOT analysis presented in Section 3, three strategic alternatives are explored in a deeper way: stand-alone company, patent licensing, and joint venture.

Stand-Alone Company: By functioning autonomously, AetherDROP may exercise complete control over its operations and technologies, establishing itself as a specialised supplier of passive deorbiting solutions. This strategy makes use of the modular nature of the aerospace sector, where satellite operators and manufacturers frequently purchase off-the-shelf components. Developing alliances for technical and business assistance and obtaining funds from public and private sources to promote expansion are important steps to take. R&D expenditures are essential for both regulatory compliance and competitiveness. Benefits include a good reputation for the brand, customisation, and market agility. However, there are hazards associated with hefty initial investments and competition from well-established firms.

Patent Development Company: In order to lower operating costs by eliminating manufacturing, AetherDROP, a patent development business, would concentrate on developing and licensing passive deorbiting technology. Royalties and licensing agreements would provide income. This strategy calls for developing a solid portfolio of patents, collaborating with satellite producers, and offering technical assistance. To maintain quality standards and keep technology competitive, ongoing research and development is crucial. Rapid scalability, market penetration, and a variety of revenue streams with reduced financial risks are all made possible by the strategy. However, it restricts AetherDROP's direct market effect while requiring robust R&D and IP management. This model provides long-term, sustainable value if properly implemented.

Joint Venture: Working with a major space firm allows AetherDROP to concentrate on research and development and customised solutions while using its partner's resources, infrastructure, and market network. With this arrangement, product development and market entrance are accelerated, and the partner handles commercialisation. The correct partner selection, objective alignment, and the establishment of precise responsibilities and revenue-sharing agreements are all necessary for success. Access to resources, knowledge, and market prospects with lower financial risk are among the advantages. However, loss of operational control and possible reliance on the partner are obstacles. This approach allows for quick expansion while maintaining AetherDROP's strategic independence with the correct partner.

4.1 Assessment of the Strategic Alternatives

The assessment of the Strategic Alternatives explained above has been performed considering a set of evaluation criteria. Each criterion has been weighted according to its importance for AetherDROP, and then each strategic alternative has been evaluated accordingly. The criteria adopted are:

- Operational Flexibility
- Strategic Alignment
- Innovation Capacity
- Access to Funding and Growth
- Financial Risk
- Industry Partnerships
- Scalability
- Intellectual Property

For a more detailed explanation of the selected criteria, refer to Appendix D.

4.2 Selection of the Best Alternative

Based on the detailed assessment of the Strategic Alternatives, the **Standalone Company** has been selected as the most suitable option for AetherDROP. The rationale behind this choice is supported by the comparative analysis reported in Appendix E, in which the three strategic alternatives are evaluated across all the criteria.
The results show that the Standalone model excels in operational flexibility, scalability, and strategic alignment, aligning with AetherDROP's focus on autonomy and scalability. The Joint Venture offers strong funding and growth potential but risks dependency on partners, while the Patent Development Company, despite low financial risk, lacks flexibility and scalability.
In conclusion, Standalone Company is the best alternative for AetherDROP's vision of becoming a leader in passive deorbiting solutions. By targeting the right niche market to reduce competition with big companies, and by seeking strategic funding and partnerships to address its financial risks, AetherDROP can fully express its innovative capabilities while maintaining strategic flexibility and autonomy.

5 Value Proposition

This section presents the Value Proposition Canvases for the three main customer segments, which were deemed the most relevant for AetherDROP. Each canvas outlines the specific challenges and opportunities that can be addressed with the proposed products and services, showcasing how they could meet customer needs while contributing to space sustainability.
For a more detailed explanation of the VPCs, refer to Appendix F.

Satellite Manufacturers

The VPC for satellite manufacturers can be consulted in Figure 2. AetherDROP's passive deorbiting solutions provide a competitive edge by ensuring high-quality, reliable components and simplifying regulatory compliance. These solutions help balance cost, efficiency, and sustainability, while the ability to deliver and integrate these devices helps mitigate supply chain risks and reduce development costs, improve technological leadership, and support long-term market trends.

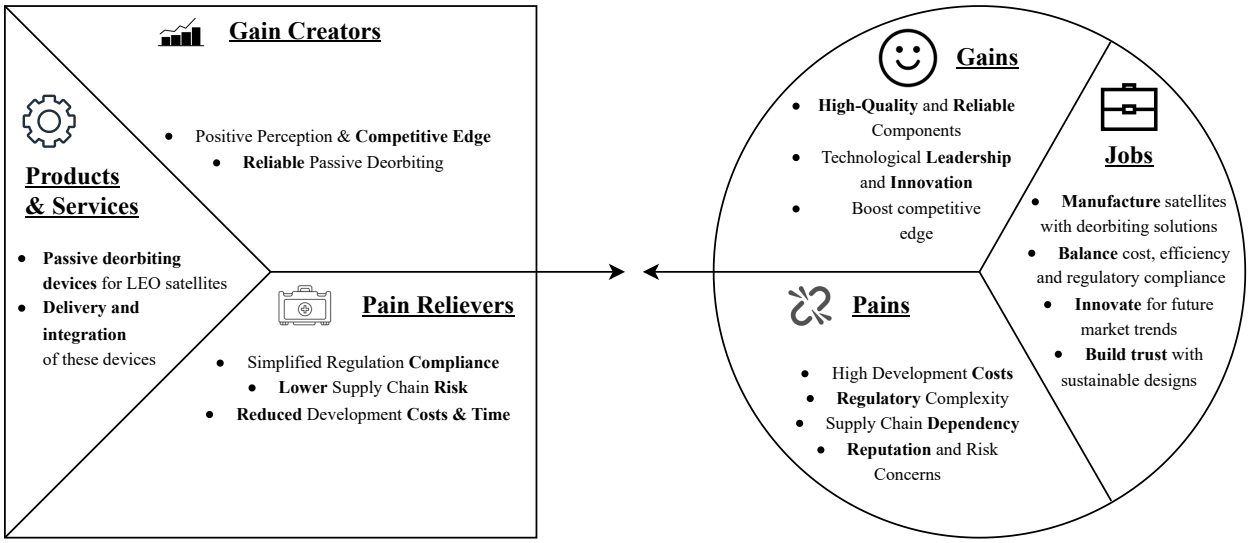

Figure 2: VPC: Satellite Manufacturers

Satellite Operators

Figure 3 shows the VPC for Satellite Operators. AetherDROP's products and services offer enhanced satellite life, improved reputation, and simplified compliance with regulatory requirements. These

services also reduce lifecycle costs and collision risks, while ensuring safe end-of-life disposal and efficient operations. By integrating collision avoidance and tracking features, AetherDROP helps maintain service continuity and supports sustainability.

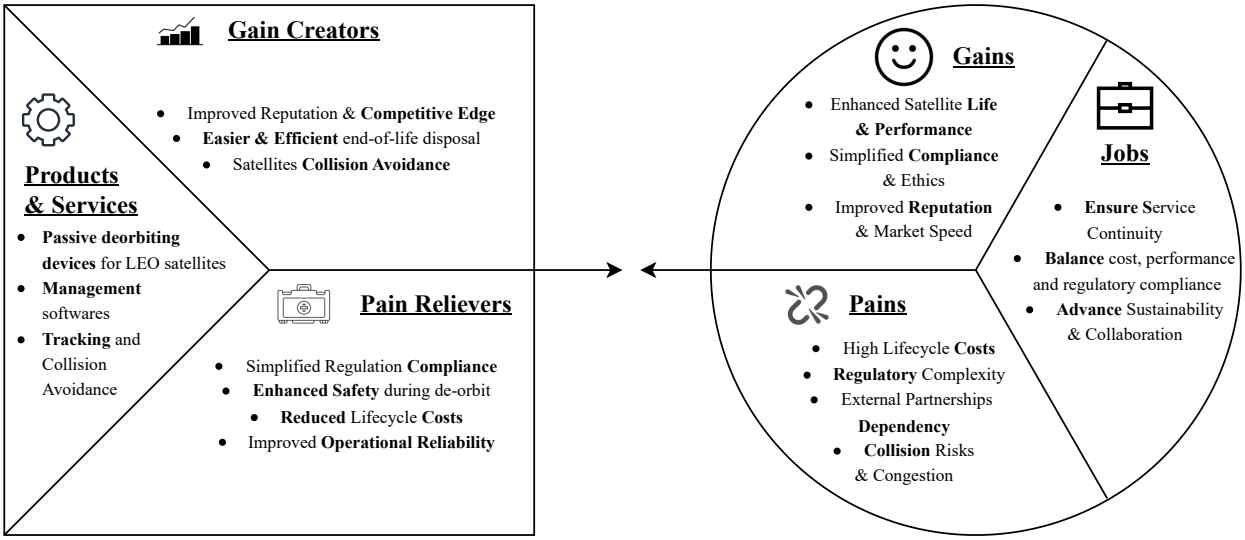

Figure 3: VPC: Satellite Operators

Space Agencies

For Space Agencies, the VPC is showcased in Figure 4. The integration of deorbiting devices and management software supports national space programs and public perception, while mitigating collision risks. AetherDROP's offerings align with the agencies' institutional goals of innovation, leadership, and environmental responsibility.

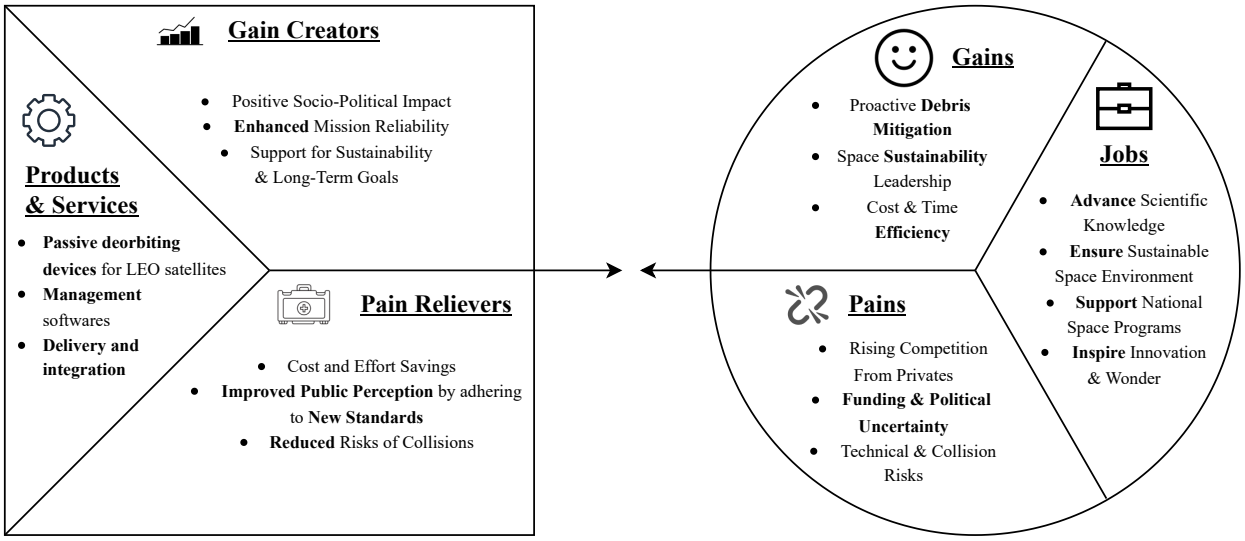

Figure 4: VPC: Space Agencies

5.1 Hypotheses and Testing Procedure of the Value Proposition

AetherDROP developed a set of assumptions about the perceived value of its suggested solution to create Value Proposition Canvases (VPCs) for the different sectors of interest. Verifying these theories is not just a formality; it is an essential part of determining how much value our solution can truly create. By methodically evaluating these hypotheses, AetherDROP aims to close the gap

between the theoretical proposal and the real-world market demands, making sure that its solution satisfies the demands and specifications of the identified customers.
This procedure will allow us to refine and adapt our strategy to the particular requirements of each sector, while also validating our suggested value proposition. The hypotheses were developed for each sector examined in Section 5, and the key ones are summarised in Table 3.

Satellite Manufacturers	**Satellite Operators**	**Space Agencies**
Pre-tested and ready-to-integrate solutions are prioritised since they reduce the costs and time required for satellite development and production.	Operators are willing to invest in passive deorbiting devices to reduce the operational costs of satellite lifecycle management.	Space agencies are increasingly prioritising the resolution of the space debris problem and the management of satellite end-of-life.
The availability of a single supplier for devices, integration, and after-sales support simplifies supply chain management.	To reduce operational burdens and dependency on satellite CPU, operators are seeking autonomous or semi-autonomous de-orbiting devices.	Agencies aim to strengthen their image on sustainability by adhering to environmental policies and regulations in the field.
Passive deorbiting devices increase the overall reliability of satellites, ensuring regulatory compliance and minimising reputational risks.	Regulatory compliance has a crucial priority for operators, particularly in relation to space debris and environmental sustainability.	Private companies are becoming more important in collaborations with ESA.

Table 3: AetherDROP Hypotheses *(green: confirmed, yellow: to be further analysed, red: incorrect)*

Given the highly specialised nature of the industry and the difficulty in reaching a significant number of specialists of the field, the team used two different approaches to validate the assumptions.
First, two in-depth interviews with key experts of satellite manufacturers and space agencies were successfully completed by AetherDROP. These interviews were conducted primarily to determine the market's present demands and new trends, as well as to gain the industry leaders' possible interest in AetherDROP's suggestions. AetherDROP aimed to get important insights from these conversations about the iterations and the refinements of its value proposition in order to better meet market demands and improve its products in line with them.
Furthermore, a brief survey was designed and distributed via LinkedIn to professionals in the satellite and space industry, targeting roles such as satellite operators, engineers and managers. The survey included multiple-choice and importance-ranking questions to assess perceived value, verify company priority hypotheses, and gather diverse statistical insights from a broader user base.
Triangulation of data was made possible by this dual method, ensuring that the results included both in-depth qualitative insights from expert interviews and a wide industry viewpoint from the survey. Together, these techniques offered a strong foundation for assessing the viability of the proposed hypotheses and adjusting the value proposition as necessary.

5.2 Testing Results and Conclusions

The findings of the testing process will be concisely analysed in this section, with a spotlight on how well they match the original hypotheses and how they might affect the Value Proposition.

First Interview: The first interview was conducted with Luisa Innocenti, Founder and Header of ESA Clean Space Office. The detailed transcript can be found in Appendix G.
During the interview, Innocenti confirmed one of our main assumptions by underscoring ESA's considerable emphasis on resolving the space debris issue. She additionally supported the hypothesis

that ESA is working with small businesses more and more, which opens up new opportunities for innovative solutions. Presenting the technology as a way to reduce operating costs was another crucial argument made by Innocenti. She emphasised that satellite operators are more likely to embrace new systems for financial reasons than just for regulatory compliance, which supports another of our assumptions. Regulations are, however, crucial for operators but more in terms of burdens which constrain the design of a satellite.
She also recommended prioritising companies that produce and operate small spacecrafts, such as CubeSats, as they often lack specialised deorbiting mechanisms. This response emphasises how crucial it is to focus on a particular market niche while building a background and gaining the experience needed to take advantage of ESA's willingness to collaborate with up-and-coming companies.
One of the initial assumptions was ultimately denied by Innocenti. Specifically, satellite operators may express preference against autonomous devices due to their susceptibility to electronic failures and the potential risk of unintended system activations. Consequently, it is deemed more reliable to retain direct control over the deorbiting systems throughout the satellite's operational lifecycle.

Second Interview: Regarding the second interview, AetherDROP managed to contact Annamaria Piras, Programme Manager at Thales Alenia Space and currently head of several programmes focused on Low Earth Orbit exploration and commercial stationing. The full transcript of the interview can be found on Appendix G.
Piras, representing the Satellite Manufacturers sector, expressed concerns about the challenges that adding an additional device, like the one AetherDROP is considering, particularly in terms of testing, integration, and supply chain management. Thus the two hypotheses formulated by AetherDROP in Table 3 are confirmed, even though her comments emphasised the necessity to ensure our solution is completely integrated and tested before contacting a major satellite manufacturer like Thales. This supports Innocenti's findings about the fundamental background that a new business like AetherDROP needs to set up before engaging with large-scale organisations.

Survey: The full outcome of the survey, which can be found in Appendix H, highlighted that reducing operational costs, ensuring regulatory compliance, and integrating innovative solutions are the driving priorities of stakeholders when talking about devices for passive de-orbiting.
Instead, according to the survey, low initial reliability and high upfront costs for testing and integration continue to be the two primary barriers to their adoption.
Despite the small sample size, due to the limited time available to carry out the analysis and the lack of specialised questions to probe preferences for particular technological options, these responses from Space Sector experts can be seen as supporting the conclusions of the two interviews that were done.

Next Steps: This initial phase of testing is designed as a preliminary assessment and is not intended to yield conclusive results. Next steps will include conducting other in-depth interviews with decision-makers, C-level executives or key stakeholders in the space environment. These efforts aim to further validate the untested hypotheses and refine AetherDROP's value proposition, setting the stage for the development of a reliable business model.

6 Conclusion

This report aims to analyse the market environment, competitors, and internal strengths to define AetherDROP's strategic direction. AetherDROP positions itself as a stand-alone company with the goal of developing and delivering its own products and services. The company aims to fill a critical gap in the passive deorbiting market while meeting the growing demand for sustainable solutions. Our offering is particularly aligned with the emerging era of large constellations of small satellites and the latest trends in the space industry, addressing both current needs and future opportunities. To solidify its role in the market, further validation, testing, and detailed analysis are essential, but the chosen path demonstrates strong potential. With a clear vision and alignment with industry trends, AetherDROP is well-positioned to become a key player in the sustainable space sector.

Appendix

A Competitor Analysis

In this section are listed and presented the analysed competitors:

High Performance Space Structure Systems GmbH (HPS) [1]

- **Services**: Products for aerospace applications, including antennas, deployable structures, and multilayer insulation systems. Involved in new space technology and nanosatellite components designed to withstand space conditions.
- **Passive Removal Technology**: The ADEO subsystem is a scalable drag augmentation device that uses residual Earth atmosphere in Low Earth Orbit (LEO) to passively deorbit satellites weighing between 1 to 1,500 kg. A large drag sail is deployed to increase drag and initiate deorbiting.
- **Target Market & Customers**: European Space Agency (ESA), the European Commission, and the German Space Agency (DLR).
- **Key Partners**: Technical University Munich, University of Applied Sciences Munich, Frauenhofer/University Hof, University Bern/Swiss, Max-Planck Institute, INEGI Portugal.
- **Cost**: High development and operational costs due to advanced technology required.

Vestigo Aerospace [2]

- **Services**: Provides deorbit capabilities for CubeSats, small satellites, and launcher upper stages, enhancing the sustainability of space operations.
- **Passive Removal Technology**: The Spinnaker product line uses a thin-membrane deployable dragsail, significantly increasing the spacecraft's frontal area to enhance drag. Two primary models are under development: a 17.7 sqm dragsail for small satellites and an 18 sqm version for objects over 1,000 kg. These technologies have reached TRL8, with a planned flight demonstration in 2025.
- **Target Market & Customers**: Small satellite operators, CubeSat operators, and government space agencies like NASA, who are looking for cost-effective, passive deorbiting solutions.
- **Key Partners**: NASA, NeXolve, Astro Digital, Maverick Space Systems, Manhattan Asset Management.
- **Cost**: High due to advanced technology development and ongoing flight demonstrations.

NPC SpaceMind [3]

- **Services**: Focuses on the design, manufacture, and integration of CubeSat platforms. Also produces high-performance pointing systems used for tracking in space missions.
- **Passive Removal Technology**: Developed and launched a series of CubeSat missions demonstrating their ARTICA deorbit system, which consists of a deployable 2.1 m^2 drag sail. The total size of the deorbiting system is 0.3U, making it suitable for CubeSats as small as 1U. The system is ready-to-market and has extended flight heritage.
- **Target Market & Customers**: Predominantly works with commercial satellite operators, while also collaborating with government agencies and research institutions, such as La Sapienza, for scientific research and testing of new technologies.
- **Cost**: High development and operational costs due to the advanced technology required for active deorbiting and servicing missions.

Aurora Propulsion[4]

- **Services**:
  - **Water-based propulsion**: Enables station keeping and collision avoidance with high thrust at minimal weight and power consumption.
  - **De-orbiting solutions**: Propellant-free deorbiting for satellites of up to 1000 kg.
- **Passive Removal Technology**: Aurora's Plasma Brake. By deploying an electrically charged microtether, it generates a Coulomb drag force to deorbit satellites. The microtether is made of 50 micrometer-thin wires, ensuring no interference with other space assets.
- **Target Market & Customers**: Serves satellite operators and builders in need of reliable, compact, and efficient propulsion and deorbiting solutions, particularly for small satellites such as CubeSats and SmallSats. As part of the ESA Business Incubation Centre, Aurora benefits from partnerships that extend its reach into European and global markets.
- **Key Partners**: EIC, Tesi, Practica Capital, The Flying Object, ALIENA, OKAPI Objects, ESA, AVARU Space, ILMATIETEEN LATIOS.
- **Cost**: High development and manufacturing costs due to the precision components required, alongside expenses for space testing and regulatory compliance for orbital safety.

MMA Design[5]

- **Services**:
  - **Deployable Solar Arrays**: Especially applied to small satellites and CubeSats, where size, weight, and power efficiency are critical.
  - **Deployable High Gain Antennas**: For space-based communications, tailored to small satellites that require high-bandwidth capabilities in limited space.
  - **DragSails for Passive Deorbiting**: Including the FASTSAT DragSail, designed specifically for passive deorbiting.
- **Passive Removal Technology**: MMA Design's dragNET de-orbit system is a compact, stowable drag sail that fits in a shoebox-sized volume and deploys to 12.5 square meters to create drag for passive deorbiting. The system uses carbon fiber-reinforced elements for deployment and fits within specific keep-out zones, minimising storage impact. It can be adapted for various mounting configurations, supporting spacecraft up to 3000 kg.
- **Target Market & Customers**: MMA Design primarily targets operators of small satellites and CubeSats, commercial satellite constellations, and government agencies like NASA. Their solutions are aimed at optimising power, communication, and end-of-life deorbiting while ensuring compliance with orbital debris regulations.
- **Key Partners**: NASA JPL, U.S. Department of Defense, CALTECH, Agile RF Systems.

Astroscale[6]

- **Services**: Astroscale delivers a variety of innovative and scalable on-orbit servicing solutions, including life extension, in-situ space situational awareness, end-of-life, and active debris removal.
- **Active Removal Technology**: Astroscale's advanced magnetic technology for active satellite retrieval is a key competitive advantage. This system uses a "chaser" satellite to capture a defunct satellite with a magnetic docking mechanism, enabling precise and safe de-orbiting.

- **Target Market & Customers**: Astroscale collaborates with NASA, ESA, JAXA, UK Space Agency, and private sector entities like Airbus. Their market is primarily focused on space agencies for debris removal services, while also engaging private companies for satellite servicing needs.
- **Key Partners**: NASA, ESA, JAXA, UK Space Agency, Airbus.
- **Cost**: High development and operational costs due to the advanced technology required for active de-orbiting and servicing missions.

ClearSpace[7]

- **Services**: ClearSpace specialises in active debris removal (ADR) services, focusing on safely deorbiting defunct satellites and other orbital debris. Their solutions are scalable and environmentally friendly, aiming to mitigate the growing issue of space debris.
- **Active Removal Technology**: ClearSpace employs advanced capture technologies, including robotic arms and innovative capture mechanisms, to retrieve defunct satellites. Their flagship mission, ClearSpace-1, aims to demonstrate these technologies by capturing a specific piece of debris and safely bringing it back to Earth.
- **Target Market & Customers**: ClearSpace targets government space agencies for debris removal contracts and engages commercial satellite operators looking for end-of-life solutions.
- **Key Partners**: Collaborates with the European Space Agency (ESA) and various research institutions to develop and test debris removal technologies.
- **Cost**: Development and operational costs are substantial due to the complexity of the technology involved in active debris removal and the need for rigorous testing and regulatory compliance.

B PEST and Porter's Five Forces Tables

The summary layout of the PEST analysis conducted in Section 3.1.3 is provided below, along with the table of Porter's Five Forces applied to AetherDROP.

Factors	Response
+ Space debris mitigation regulations + European initiatives supporting deorbiting solutions − EU Dual-Use Regulation and governments instability	• Satisfy the request and develop partnership with space agencies • Potential access to funding and develope sustainable technologies • Strengthen relations with global partners and ensure compliance with international trade

Factors	Response
+ Rapid expansion of the space economy in the last years + Space investments generate significant profits − Rising Salaries in the Space and High-Tech Sectors	• Expanded deorbting services • Take advantage from the increasing investments and public funding • Offer non-monetary incentives to attract talent without inflating salary costs

Factors	Response
+ Public and cultural interest in projects like NASA's Mars missions can create a supportive culture for startups like ours + A stronger focus on sustainability in space will drive demand for debris mitigation solutions	• Educational programs and initiatives create a huge pool of highly skilled talents for companies like ours • Align technology development with emerging regulations and *form strategic partnerships*

Factors	Response
+ New technology development − Obsolescence risk due to speed of technology innovation	• Invest in R&D and *secure proprietary patents* to remain competitive • Keep a technology roadmap and build exclusive partnerships to be informed and to maintain a competitive edge

Figure 5: PEST Table

Force	Intensity	Principal Factors
Competitive Rivals	Moderate	• **Limited number of players** with specialised solutions (very low amount) • Low amount of technological differentiation (dragsails, tethers, ...) that increases direct competition • High market growth that reduces direct competition
Potential for New Entrants	Moderate/High	• High capital required, technical expertise (R&D is necessary), and regulatory barriers • Established customer relationships and reputation challenges make it difficult for new firms to enter (need to exploit the timing) • Distribution channels and access to satellite manufacturers are critical.
Supplier Power	High	• Few specialised suppliers that can dictate terms and prices due to their unique expertise • High switching costs (need for more tests and certifications) that disincentivise changing suppliers and rather accepting price increases
Customer Power	Moderate/High	• Large customers with high bargaining power but the industry is expanding towards smaller and private customers with less influence over terms and costs • Potential vertical integration: large companies may develop their own active solutions
Threat of Substitutes	Low	• Passive solutions prioritise cost effectiveness and reliability, making them resilient against potential new substitutes

Figure 6: Porter's Five Forces

C Space Investments Trend

Investments trend graph presented in the space market analysis of the U.S. Bureau of Economics [18].

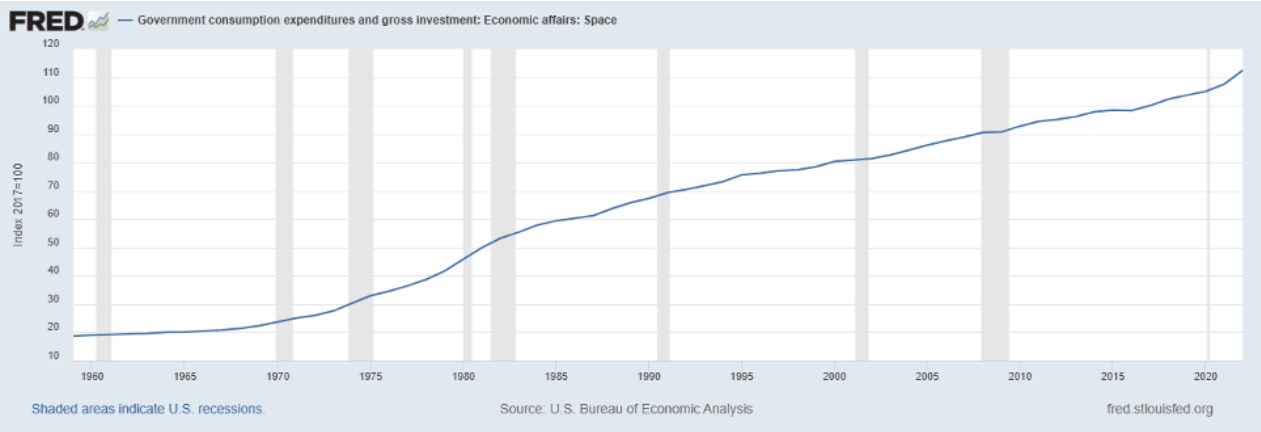

Figure 7: Government consumption expenditures and gross investment in Space affairs

D Strategic Alternative Criteria

A brief rationale of the selected criteria is here provided:

- **Strategic Alignment**: Evaluates how well each strategic alternative, along with its characteristics, fits with AetherDROP's mission and long-term objectives.
- **Operational Flexibility**: Assesses the capacity to maintain control and strategic autonomy, while having the agility to face market challenges and evolution.
- **Innovation Capacity and Intellectual Property**: Evaluates the margins in terms of technological improvements and the protection of intellectual property in each strategic alternative.
- **Access to Funding and Growth**: Assesses the possibility and the challenges to access to public or private funding and the company's growth opportunities.
- **Financial Risk**: Analyses the financial risk at which the company is exposed in each of the alternatives, including the investments required and the operational costs.
- **Industry Partnerships**: Measures how each alternative impacts relationships and collaborations with key industry stakeholders.
- **Scalability**: Evaluates each alternative's potential for long-term growth and the potential capacity to adapt to market demands and scale operations.

E Strategic Alternative Selection

In this appendix are presented the output of the comparison analysis between the three strategic alternatives presented in Section 4.

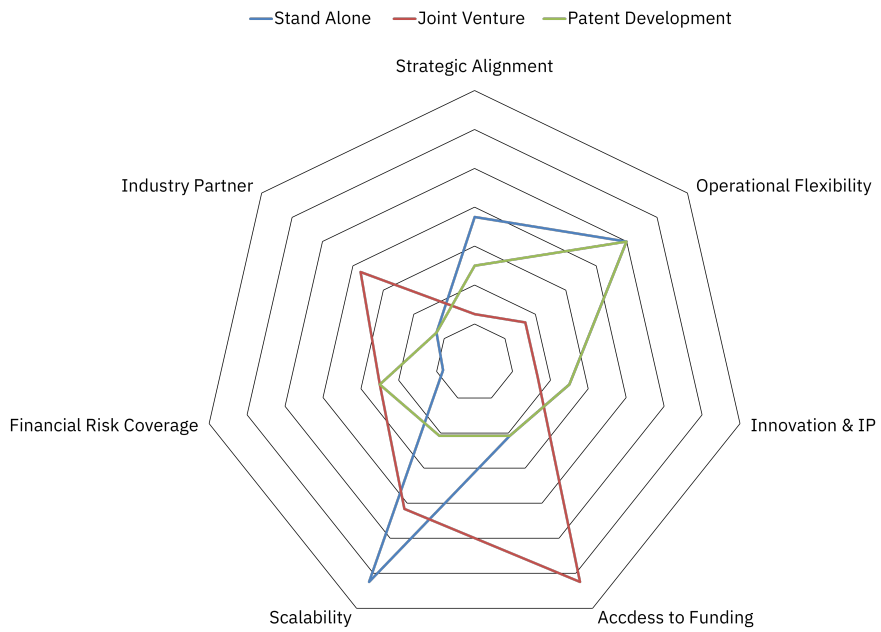

Figure 8: Strategic Alternatives Evaluation

The chart highlights the Standalone model achieves top scores in **Operation Flexibility**, **Scalability**, and **Strategic Alignment** criteria. This outcome is strictly aligned with the AetherDROP's mission and long-term objectives, where strategic autonomy and operational control are key. Furthermore, also **Innovation Capacity and Intellectual Property** criterion reach a good score, reflecting the interest AetherDROP has in enhancing and improving its technology.
Regarding the other two alternatives, for the **Joint Venture** although it excels in **Access to Funding and Growth**, the weak point was the lower score in **Operational Flexibility**, which underline the potential risk of dependency on partner's strategic decisions. Similarly, the **Patent Development Company** has achieved strong results in **Financial Risk** criteria, but the reduced flexibility and innovation potential make it less suitable as the Standalone model.

F Value Proposition

In this section, a more detailed explaination of the Value Proposition Canvas presented in section 5 will be presented, to have a better understanding of AetherDROP's proposed solutions to address some key needs of the identified customers.
The increasing commercialisation of space and the rapid deployment of satellite constellations are driving significant growth in Low Earth Orbit (LEO) traffic. This presents critical challenges, such as escalating collision risks, increasing regulatory complexity, and the urgent need for sustainable end-of-life management. Key stakeholders, such as satellite manufacturers, operators, and space agencies, are facing more and more pressure to address these issues while maintaining operational efficiency and market competitiveness.
AetherDROP would offer innovative solutions tailored for each customer segment to aim at mitigating these challenges, focusing on passive deorbiting devices like drag sails and plasma brakes. Drag sails function by deploying large, lightweight surfaces that increase atmospheric drag, accelerating satellite re-entry and ensuring a fast and safe disposal. Plasma brakes, on the other hand, use charged tethers to create an electromagnetic drag force, offering a more compact and efficient deorbiting alternative.
In addition to these technologies, AetherDrop would provide tracking and monitoring services, collision avoidance software, and integration support for deorbiting devices. These comprehensive offerings would enhance the reliability and safety of satellite missions, while also contribute to the long-term sustainability of the orbital environment.

In the following sections, a more in-depth overview of the VPCs for each of the customers will be analysed.

Value Proposition Canvas

Satellite Manufacturers

The VPC for satellite manufacturers is showcased in Figure 2. The value proposition for satellite manufacturers focuses on addressing their need for compliant, cost-effective, and efficient solutions while improving their competitive positioning in the aerospace industry. Manufacturers face key challenges such as high development costs, regulatory complexity, and supply chain dependencies. These issues often result in delays and increased expenses, highlighting the demand for efficient solutions.

AetherDROP's value map for satellite manufacturers emphasises its range of products and services, providing passive deorbiting devices, such as drag sails, electro-magnetic tethers, and plasma brakes, alongside integration services and deorbit monitoring.

These solutions would help manufacturers in satellite development, reduce costs, and ensure compliance with regulations like ESA's Zero Debris Approach. By managing device installation and integration, AetherDROP minimises the need of even more external suppliers and simplifies adherence to debris mitigation guidelines. This set of technologies helps increase system reliability and reduces failure risks during critical deorbiting phases, addressing some of the key challenges faced by manufacturers.

The gains created for manufacturers include improved market perception and a stronger competitive edge, as they could position themselves as leaders in sustainable space technologies. The use of AetherDROP's solutions would enable manufacturers to deliver high-performance satellites faster and at lower costs, meeting the diverse needs of operators while complying with regulatory requirements and market trends.

Satellite Operators

Figure 3 shows the VPC for Satellite Operators. For satellite operators, the value proposition aims at optimising operational efficiency and ensuring uninterrupted service delivery while mitigating risks and costs associated with satellite end-of-life management, which are all critical factors operators face.

Operators contend with high lifecycle costs, regulatory compliance challenges, and collision risks due to increasing orbital congestion. These issues are further augmented by dependency on external partnerships, which can introduce delays and misalignments during the execution of the project.

AetherDROP's products and services aim to directly address some of these concerns by providing cost-effective passive deorbiting devices and real-time tracking and collision avoidance software. These solutions simplify compliance with international regulations and significantly reduce lifecycle costs by offering technologies that are ready to be integrated and require less maintenance than active deorbiting devices. Improved safety during deorbiting phases could further strengthen operators' reliability and customer trust, as real-time monitoring and collision avoidance tracking would minimise the risks of accidents during the reentry of satellites.

The adoption of sustainable deorbiting technologies could also enhance the operators' market reputation, positioning them as leaders in responsible space operations. These benefits collectively enable operators to maintain service continuity, balance cost-performance considerations, and contribute to global sustainability efforts.

Space Agencies

For Space Agencies, the VPC is showcased in Figure 4. The value proposition for space agencies emphasises their institutional role in advancing scientific knowledge, promoting sustainability, and supporting national and international space programs. Agencies face unique challenges, including funding and political uncertainties, technical risks, and negative public perception that could be provoqued by debris-related incidents. Additionally, increasing competition from private actors

demands for innovative and cost-efficient solutions to maintain their leadership in the global space ecosystem.
AetherDROP's value map includes passive deorbiting devices and management software, to offer solutions that align with agencies' goals of ensuring the sustainable use of space. By reducing collision risks using innovative debris mitigation systems, agencies could enhance their operational reliability. The integration of these technologies into their missions could reinforce their leadership in sustainability initiatives, serving as a model for private satellite operators, who frequently overlook the issue of orbital congestion by not incorporating end-of-life disposal measures for their satellites. The proposed solutions could help agencies optimise their budgets while meeting their ethical responsibility to protect the orbital environment for future generations. Moreover, the deployment of innovative debris mitigation measures would enhance public trust and showcase agencies as pioneers of sustainable and responsible space exploration.

G Interview Transcripts

The full transcripts of the conducted interviews can be consulted at the following documents:

- *First Interview: Luisa Innocenti*
- *Second Interview: Annamaria Piras*

H Survey Questions and Results

The complete layout and the results of the survey are detailed in the subsequent document:

- *Survey Results*

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