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Кафедра управління та організаційного розвитку

Charting a Strategic Course: A Case Study of Space Robotics in an IT Service Company

Виконав: здобувач вищої освіти II курсу, групи СУТ22
Галузь знань 07 Менеджмент та адміністрування
Спеціальність 073 Менеджмент
ОП Управління Технологіями
Освітній ступінь магістр
Демків Л.І.
Керівник: доц. Васильєва Н.

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LIST OF ACRONYMS

GEO Geostationary Orbit

TRL Technology Readiness Level 42

HIL Hardware-in-the-Loop 24

SIL Software-in-the-Loop 29

RAAG Robotics & Advanced Automation Group 2

ROS2 Robot Operating System 2 47

KPI Key Performance Indicators 52

APM Account Profit Margin 52

CM Contribution Margin 52

INTRODUCTION

The space industry is growing rapidly. According to Bloomberg [1], the global space economy grew by 8% in 2022 (up to $546 billion) and is projected to grow by 41% over the next five years. On top of services like space tourism or Earth observation, there are almost unlimited resources out there in space. For instance, a large metal asteroid called 16 Psyhe has $10 quintillion worth of metal deposits like gold, nickel, and iron [2].

After the initial first steps on the Moon in July 1969 [3] humanity made a great step forward and is about to step foot on the Moon after a 50 years pause.

Each service company's goal is to help as many clients as possible to meet their business goals, earning money for the clients and the service company. Since the space market rapidly evolves, it makes sense to enter the market early while it is still being established and undergoing transformation. Having significant terrestrial expertise, a company might swiftly find a niche in the Space market where it can map the terrestrial expertise to the Space expertise while expanding the number of services to be able to help with domain specifics once.

However, a lot of companies think that space market maturity is somewhere in the future, and there is no need to look into it now. One of the goals of this work is to show that it's not too early to enter the space domain, but rather soon, it might be too late as the number of players grows, as well as the complexity of projects. In the near future, the Space market might be too crowded for companies without Space expertise. Additionally, in this thesis, the experience of SoftServe entering the Space market is given so that a reader might be able to project the flow that was undergone by the company to the reader's own experience and current reader's company state as of the day of reading.

For Ukrainian companies, the growing Space market penetration is a great decision. Especially taking into account its significant technological heritage, Ukraine might become a significant space player as it was several decades ago, building engines for spacecraft and inventing disruptive ways for humanity to enter space exploration.

The thesis aims to define the service company's flow that would enable it to enter the Space domain. The approach might also be applicable to other emerging domains.

The thesis consists of three chapters. The first chapter contains the general justification of the space market perspectives. There, its growth projection is provided in the context of the whole Earth world as well as in the context of Ukraine. The second chapter describes the general solution for an IT service company that would like to enter the Space market. The chapter contains the business canvas as well as the value proposition canvas aimed at different clients of the IT service company. It also touches on the questions of marketing and what channels are best suited for the first steps of entering the Space market. The third chapter presents SoftServe's experience of entering the Space domain. It is the way how SoftServ applied the ideas that are presented in the second chapter, having the reasoning to enter the Space domain given in the first chapter. The thesis ends up with conclusions and references.

SECTION 1
ANALYSIS OF SPACE ECONOMY COMPONENTS

The final and ultimate goal of each company is to earn money. During this process, the company acts according to the rules established by the market. The market may be influenced by multiple actors, including the government, competitors, partners, and clients. It is not necessary these actors are different entities.

According to [10] market may be defined as follows

Definition 1 *[10] A market is a place where parties can gather to facilitate the exchange of goods and services. The parties involved are usually buyers and sellers. The market may be physical, like a retail outlet, where people meet face-to-face, or virtual, like an online market, where there is no physical presence or contact between buyers and sellers.*

Although the market forces the same mechanism, there is always industry specific. Let's define the Space economy concept to better understand the forces driving the Space market.

The OECD Handbook on Measuring the Space Economy [4] provides the following definition of the Space Economy

Definition 2 *[4] The space economy is the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing, and utilizing space.*

Hence, it includes all public and private actors involved in developing, providing, and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles, and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities. It follows that the space economy goes well beyond the space sector itself since it also comprises the increasingly pervasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services, and knowledge on the economy and society.

The very same definition is used by European Space Agency (ESA) [6] and United Nations (UN) [9].

Harvard Business Review defines two types of Space Economy

Definition 3 *[5] Space-for-earth economy: that is, goods or services produced in space for use on earth. The space-for-earth economy includes telecommunications and internet infrastructure, earth observation capabilities, national security satellites, and more.*

Definition 4 *[5] Space-for-space economy — that is, goods and services produced in space for use in space, such as mining the Moon or asteroids for material with which to construct in-space habitats or supply refueling depots — has struggled to get off the ground.*

In contrast, The National Aeronautics and Space Administration (NASA) is not talking about one economy, but it rather splits them into several chunks: Low Earth Orbit (LEO) economy [7], lunar economy [8] and others.

Further in this thesis, one will see how the clusters given in these definitions are approached by different market players. The thesis mostly focuses on definition 2 as the Space market is still evolving, and too deep a split of the activities might be premature. Though the definitions above present the vision that key market players and market influencers have in mind while working in the domain.

1.1 Establishment of the Space domain in the world and in Ukraine

Historically, it can be defined that a Space economy started in 1960th when the Apollo mission [11] successfully landed on the Moon. At that time, governments were the only investors in Space exploration missions both to Earth orbit and further Space. It all changed in 2000th. The era of the New space economy had begun. It is characterized by the active involvement of private industrial players who created new business opportunities based on technological advancements that supported economic growth. Since then, three waves of the New space economy can be defined [12]. The first wave is associated with SpaceX's Falcon 1, the first private liquid-fueled rocket that reached Earth orbit. Not to mention Falcon 9 which decreased the cargo delivery cost by half

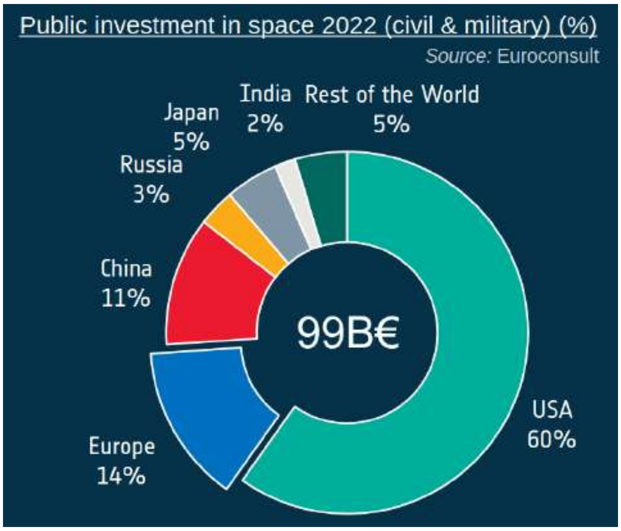

Figure 1: Public investments in space in 2022 [41]

compared with Long March carrier rocket. The second wave is associated with the fact that in 2013, the number of commercial launches exceeded the number of flights conducted by the government. Moreover, SpaceX's Starlink satellite constellation was starting to form at that time. The third wave is the one that is active right now. Despite the drop off in private investments in 2021, the enthusiasm of market players did not decrease, and in 2024, we were able to see the historical event: the Intuitive Machine's successful landing of the first commercial lunar lander on the Moon [13].

Players from various industries are interested in space exploration to advance their businesses beyond terrestrial applications. According to ESA report [41] released in 2023, the global Space market size was about 460B euros. From that number, 99B euros come from public investments. This number grew by 9‰ in 2022. On the fig. 1 the investment distribution by country is presented. As one can see, the USA is leading in the domain while Europe is in second place with significant investment differences. This means that as of 2022, the activity of private Space companies is much higher in the US, leading to a market shift. This, however, may be changed by government regulations. For instance [42], Luxembourg has enacted favorable laws and regulations related to space mining and asteroid resource utilization. The country was among the first to pass a law providing legal clarity and certainty for companies interested in asteroid mining and resource extraction in space.

Multiple space agencies were established. Among the top three agencies with the

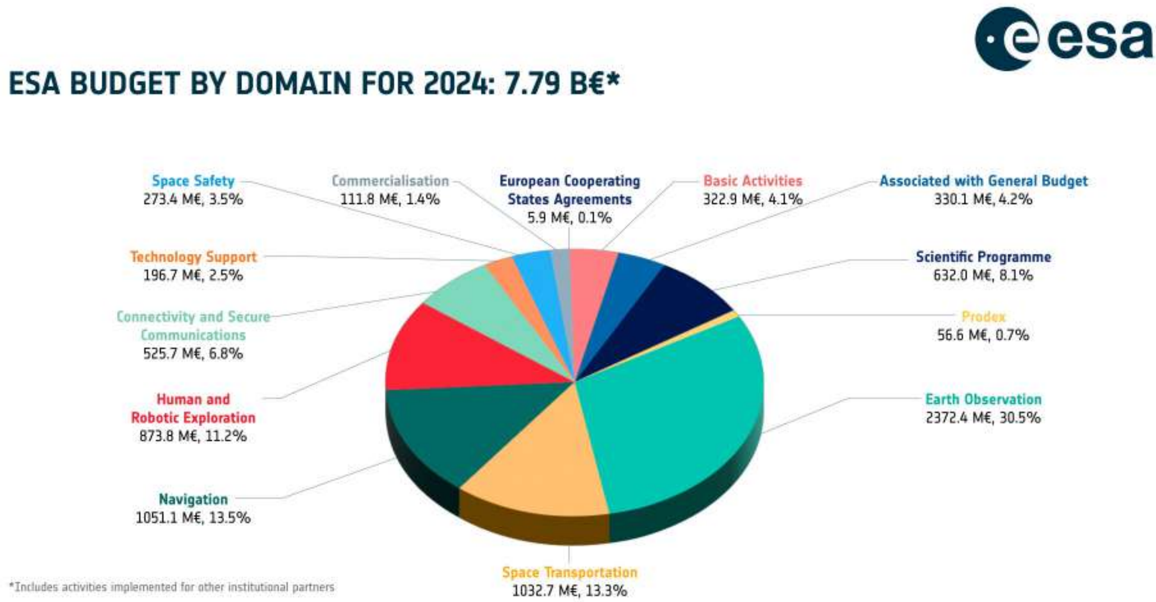

Figure 2: ESA budget by domain in 2024 [15]

highest budget are NASA ($24B in 2020), Chinese National Space Administration ($8.9B in 2020), and ESA($7.2B in 2020). In fig. 2, a list of mandatory programs to which European Union (EU) nations contribute is given. On top of that, there is a set of optional programs to which nations contribute voluntarily. From there, it might be depicted that human and robot exploration is the third biggest budget as of 2024. Which, taking into account missions like Artemis [16], might rapidly increase and take the leading positions in the budget per direction split. the list of such programs changes annually.

Nations contribute to the ESA budget according to their Gross National Product (GNP). The figure 3 presents how much each of EU countries contribute to the ESA budget. The main contributors to ESA budget are Germany, France and Italy. As one can see, Member States (MS) covers approximately 64.5% of ESA income while the rest is obtained from the EU directly, ESA European Organization for the Exploitation of Meteorological Satellite (EUMETSAT) data portal [17] and other sources.

According to [49], at the ESA Council at the Ministerial level held in Paris on 22 and 23 November 2022, government ministers representing ESA's Member States, Associate States, and Cooperating States made a significant decision. They resolved to increase

ESA's budget by 17% compared to the last Ministerial meeting in 2019. This boost in funding reflects Europe's commitment to strengthening its autonomy, leadership, and sustainability in space. Here are the key highlights of this budget increase:

Earth Observation Program: Ministers agreed to allocate €2.7 billion to ESA's Earth observation program. This funding will support initiatives like FutureEO, which is a world-leading Earth science research and development program. FutureEO harnesses innovation and develops pioneering missions while fostering innovative ways of using Earth observation data.

Climate and Sustainability: Climate remains a high priority for ESA Member States. By investing in Earth observation, Europe aims to monitor and mitigate climate change, secure communications and navigation under European control, and respond rapidly to crises. ESA's commitment to sustainability extends beyond Earth's atmosphere, ensuring responsible management of our orbital space.

Scientific Advancement: Europe's investment in space exploration also signifies a commitment to advancing scientific understanding. ESA recognizes the importance of retaining talent and inspiring the next generation. By supporting ambitious space projects, Europe aims to build a place where space entrepreneurs thrive.

UK's Contribution: The United Kingdom played a crucial role in securing this budget increase. The UK committed £615 million to ESA's core space science budget, ensuring opportunities for UK companies to bid for high-value contracts and establishing new scientific leadership roles for UK universities.

In summary, this budget boost propels Europe toward a new era of ambition, determination, strength, and pride in space exploration. It reinforces Europe's position as a leader in science, technology, and sustainability while benefiting citizens through essential space-based services.

While the benefits for bigger space agencies seem to be quite obvious, the reason for mid-sized and small agencies might be unclear. According to [18] the main advantages are

- Gain access to space activities as well as to international markets, making possible the development of bilateral cooperation with non-European countries

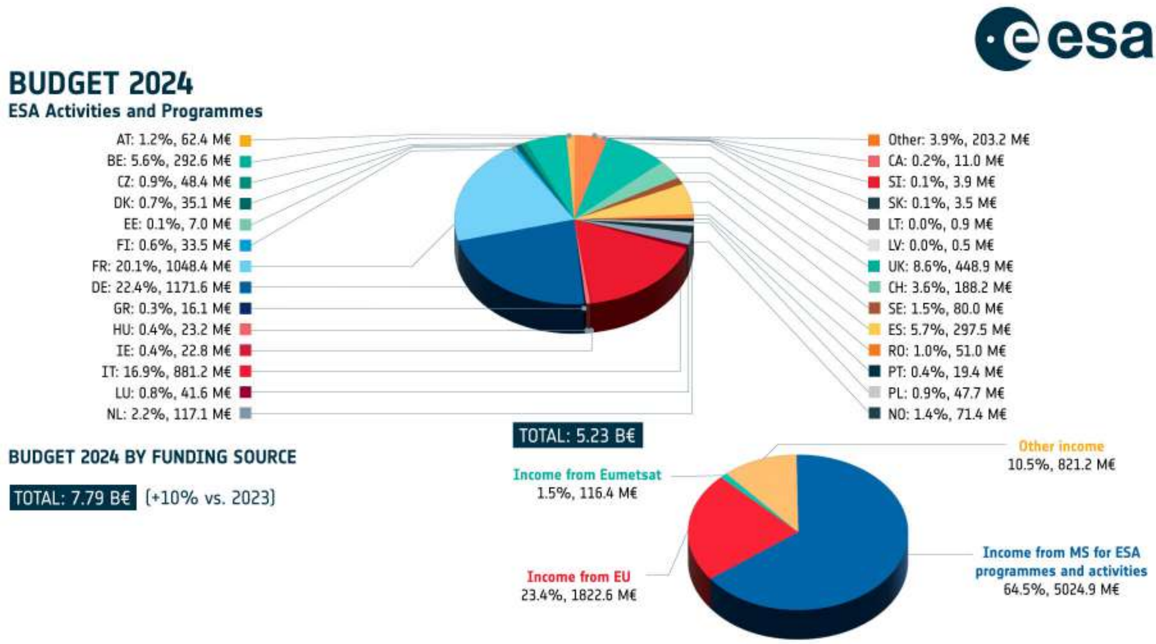

Figure 3: ESA budget pillars

- Participation in ESA programs has represented a key factor in the development of the European space industry, leading to the growth of numerous firms (both Small and Medium Sized Enterprises (SME)s and larger companies) and to the creation of new job's opportunities
- Enrichment of scientific and technological knowledge to exploit new business opportunities
- Contribution of ESA scientific and technical groups allows the application of space research and technology also to other industries.

As a drawback of being a part of ESA [18] mentioned

- Significant funds deduction to ESA programs and thus lack of autonomy
- Sub-optimal organizational structure inherited from ESA by European agencies
- Lack of education spread followed by low involvement of small and mid-sized national companies in the space domain.

The latter, however, is being addressed by programs like the following [19].

On the country level, investment into the space domain can also have a significant impact. Let us consider Poland, for instance. This country is compatible with Ukraine in many dimensions and thus can serve as an example of what Ukraine might have achieved.

According to the Minister of Development and Technology [20], the Space sector is one of the most advanced and innovative areas of the modern Polish economy. The Polish space sector currently consists of about 400 entities, including companies and institutes that employ approximately 12,000 people. This was achieved in a little more than a decade, as Poland has been a part of ESA since 2012.

Currently, Polish contribution to ESA is about 166M Euro, which is 1.2% of the total ESA budget. However, it has plans to increase the contribution up to 295M Euros [21] between 2023 and 2025. Moreover, according to the Ministry of Development, Poland has reserved a total of 39 million euros for optional ESA programs [22]. "In 10-15 years, the strength of countries will be judged precisely from the Space technology development" said Polish Minister of Development and Technology Waldemar Buda [21].

The main directions in which Poland wants to cooperate with ESA are observations of the Earth, space exploration, and security in Space (see [22]). These investments pay back. According to ESA data, each euro spent on scientific programs translates into 1.6 euros for the continent's economy (see [22]). This number increases to up to 4 euros in the case of Earth observation programs. According to [21], contracts won by Polish companies exceed the amount of 140 million euros. Investment in Space also boosted the adjunct domains on Poland. For instance [21], Polish domestic space companies specialize in control and robotics, application of Earth observation data, mechatronics, optics and communication systems for satellites, scientific sensors, space and terrestrial software, among others. Moreover, key European space companies, as well as Information and Communications Technology (ICT) and aerospace companies, also have their branches in Poland.

Under its national space strategy, Poland aims to take a 3% share of the European market by 2030 (see [23]). However the strategy lacks details on how this is to be achieved. As part of this strategy, Poland has set an objective to launch a mission to the moon by 2030 [23]. However, even after 11 years of space activities, according to [23], Polish companies are rather small and less experienced and, thus, less trusted. On the other hand, this allows these companies to be more flexible and adaptive. Another issue Poland faces is the scientists and engineers moving abroad to get opportunities not achievable in their native country.

As for Ukraine, the government finally adopted the plan for the country's integration into ESA [24]. The plan does not imply some immediate steps but rather a preparation for negotiations and convergence of Ukrainian and EU legislation in the field of space activities. One of the concerns of this plan [24] is the the fact that the main responsibilities for its implementation are assigned not to the State Space Agency of Ukraine but to the Ministry of Strategic Sectors of the Economy.

From the financial and technological standpoints, participation of Ukraine in ESA would be much beneficial. For instance, see fig.4, Ukraine might have become the 10th biggest contributor to the ESA budget [29]. Additionally, Ukraine would support ESA with engine design and assembly for, e.g., ExoMars and Moon programs [25]. Meanwhile, Ukrainian companies are penetrating the Space market on their own [51], [54].

During the russian full-scale invasion, the importance of the Space domain can not be underestimated. A great example of such an initiative are satellites that The Serhiy Prytula Charity Foundation [26] rented for Ukraine and which immediately led to significant intelligence insights [27].

The funds required for a successful launch of the space projects are significant, and it might be much easier for Ukraine to be a part of a bigger organization while launching the Space programs. Even NASA launched the Artemis mission together with other countries [28]. Moreover, Polish success inspires many countries to invest in the space domain. Having a significant space heritage, Ukraine should follow its steps.

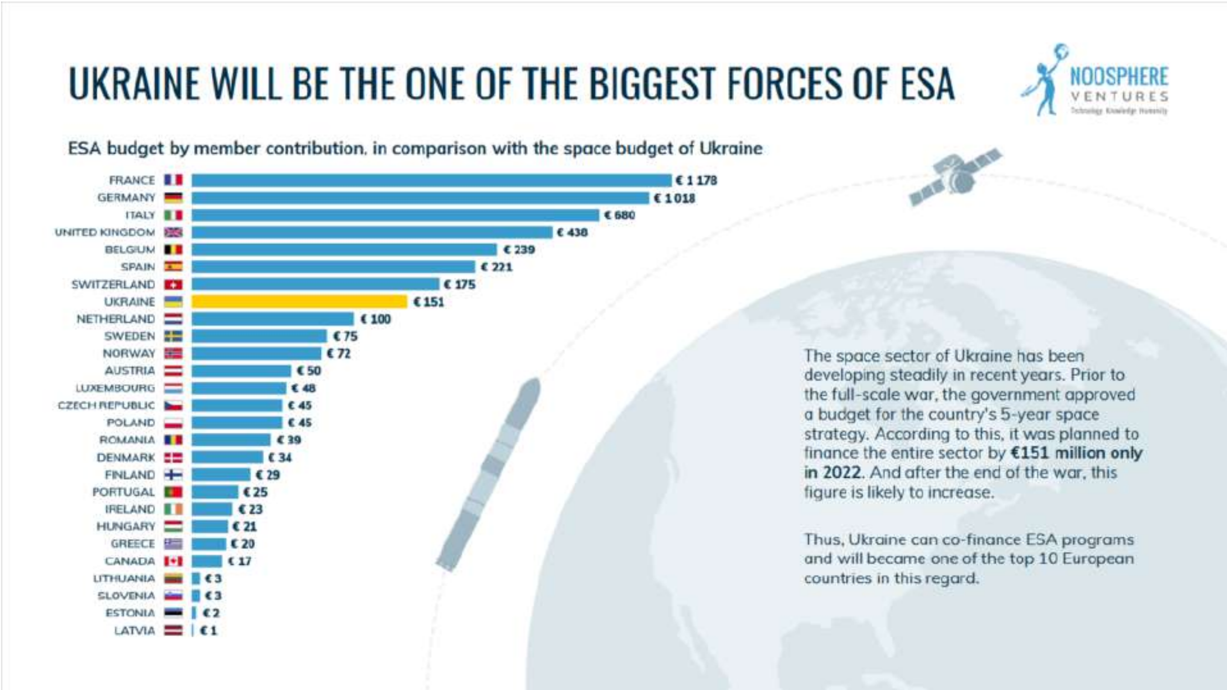

Figure 4: Projected Ukraine's contribution to ESA [24]

1.2 Space market KPIs that make it commercially interesting in middle- and long-range perspectives

According to McKinsey [30], the space market is going to grow up to $1T by 2030 see fig.5. This projection is supported by the expectation that private funding in the Space domain will grow (to more than 100) as well as cost per kilo of payload launch will decrease (to less than $100 per kilo see fig.6) and the number of satellites launched will increase, boosting the Earth, Moon, etc., observation parts of the market. These expectations are not alone. For instance, according to [31], the United States Government Accountability Office predicts up to 58,000 satellites to be launched by 2030. Euroconsult, being a bit less optimistic, predicts about 1700 launched per year by 2030. CoherentMI agrees with these estimates [47] predicting $1,110.84 Billion Space market size by 2030 with a CAGR of 8.9%. There are also slightly less optimistic expectations of the Space sector growth rate [41] shown in fig. 7.

In the latest McKinsey report [57], the projection up to 2035 of the per-industry growth is given (see fig.8). Interestingly, the Food and Beverage industry growth rate is significantly more than tripling in size by 2035. One reason for this might be a Moon

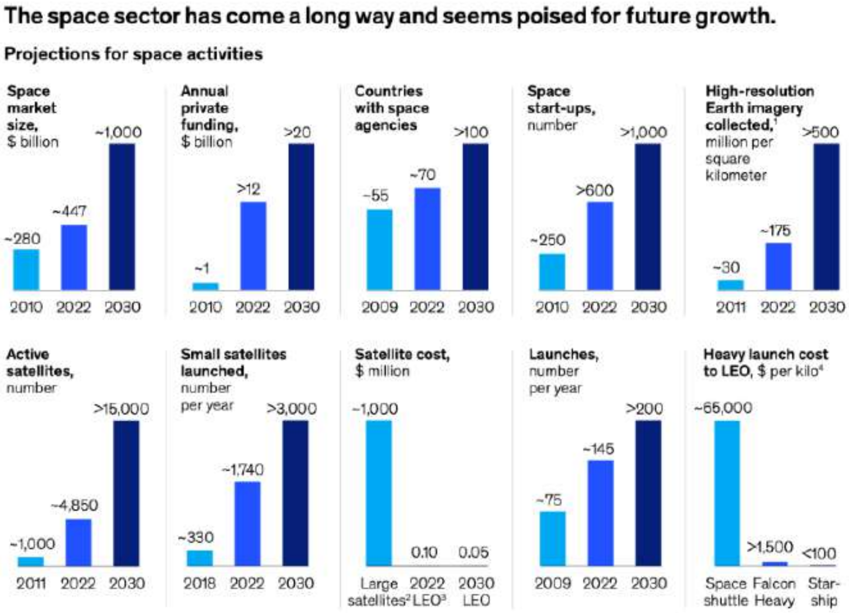

Figure 5: Space market growth [30]

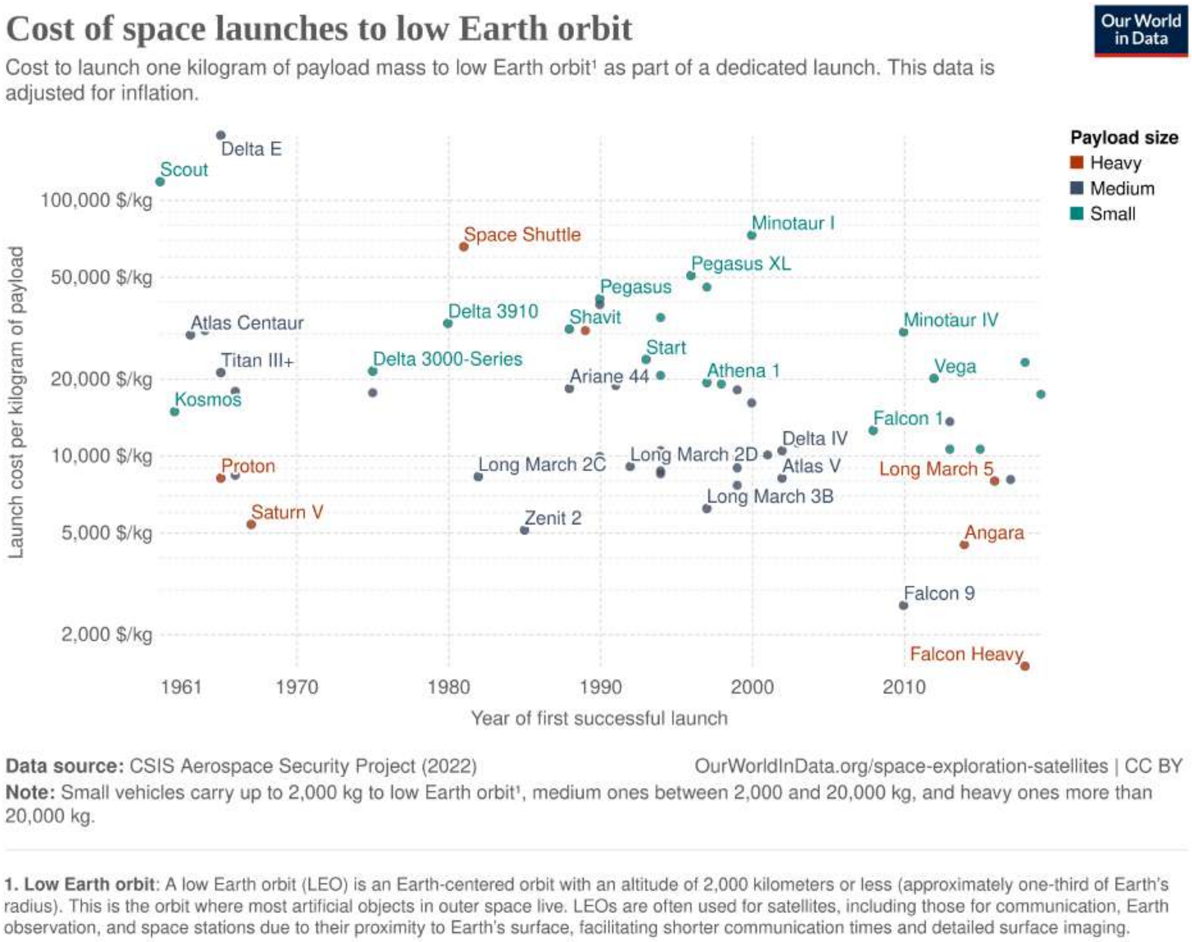

Figure 6: Cost of space launches to LEO [37]

Growth of the Space Economy

Forecaster	Date	Space Economy Estimate
Union Bank of Switzerland (UBS)	2040	$926 billion
Morgan Stanley	2040	$1.1 trillion
US Chamber of Commerce	2040	$1.5 trillion
Bank of America	2045	$2.7 trillion
Goldman Sachs	2040	Multi-trillion
Satellite Industry Association (SIA) (non-official, authors' calculation)	2040	$580 billion
Space Foundation (non-official, authors' calculation)	2040	$I billion
Euroconsult (non-official, authors' calculation)	2040	$1.2 trillion

Figure 7: Growth of the Space Economy [41]

base that might be built around 2030 on the Moon [58]. Another reason is the growing efficiency of last-mile deliveries. However, one can also see that some industries will expand to space during the next decade:

- Engineering and Construction
- Agriculture
- Information Technologies
- others

Space expansion will be a great boost for these industries, especially if the prognosis for 9% p.a. growth will come true.

On the Space market, according to [14], the business models and segments depicted in fig. 10 are being adopted by the players. The following parts of the market are highlighted there and split according to the end client business model and projects' timespan:

- Satelite manufacturing
- Satelite Services
- Ground equipment

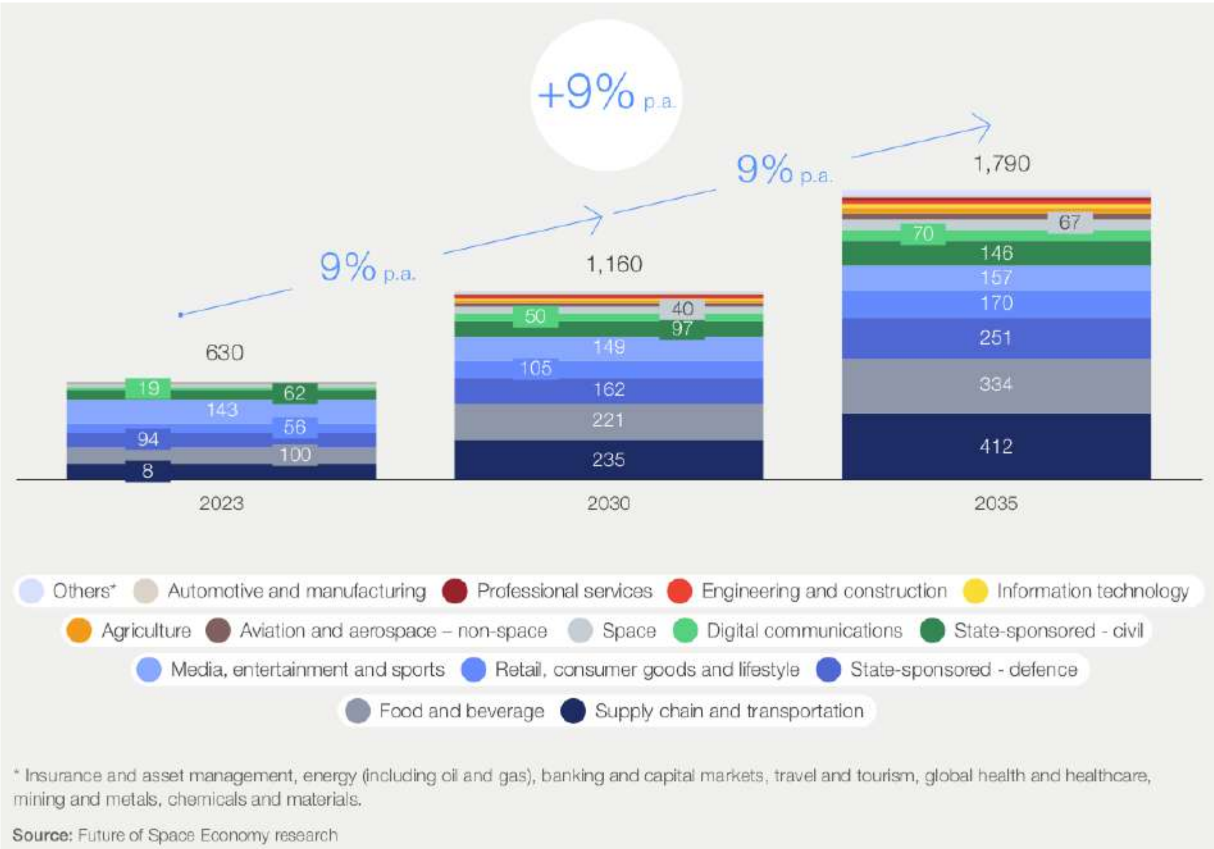

Figure 8: Space economy size by industry ($ billion)

- National security
- Launch industry
- Space Tourism and Accommodation
- Energy, Mining, processing and assembly
- Manned and Robotics Space Science and Exploration

Additionally, some new services appear on the market due to human activity. One example might be debris that are flying in the Earth's orbit. It is even becoming challenging to take a picture of Earth [38]. The debris particles may be of several millimeters to several centimeters and travel at a speed of up to 36000 kilometers per hour. With the increase in Space activity, the number of debris can be a severe threat to future launches and even cause the Space industry to decline [39]. According to European Space Strategy in a Global Context report [40], the number of debris might grow to the critical point in which the population of artificial debris will grow at a rate faster than that at which debris is removed from Earth orbit through natural decay see fig. 9. Space debris may be a threat also for humans living on Earth. For instance, in April 2024, a 1-kilogram metal object crashed the roof of a house in Florida, US [43]. The full list of documented debris accidents is listed in Wikipedia [44].

This view of the market, given in fig.10, clearly presents the perspectives of the players acting in this market. On top of that, these players can be split into two other groups: service companies and product companies.

Among the service companies, the following should be mentioned

- Accenture
- Deloitte
- IBM
- Capgemini
- Softserve

The product companies, on the other hand, are the following

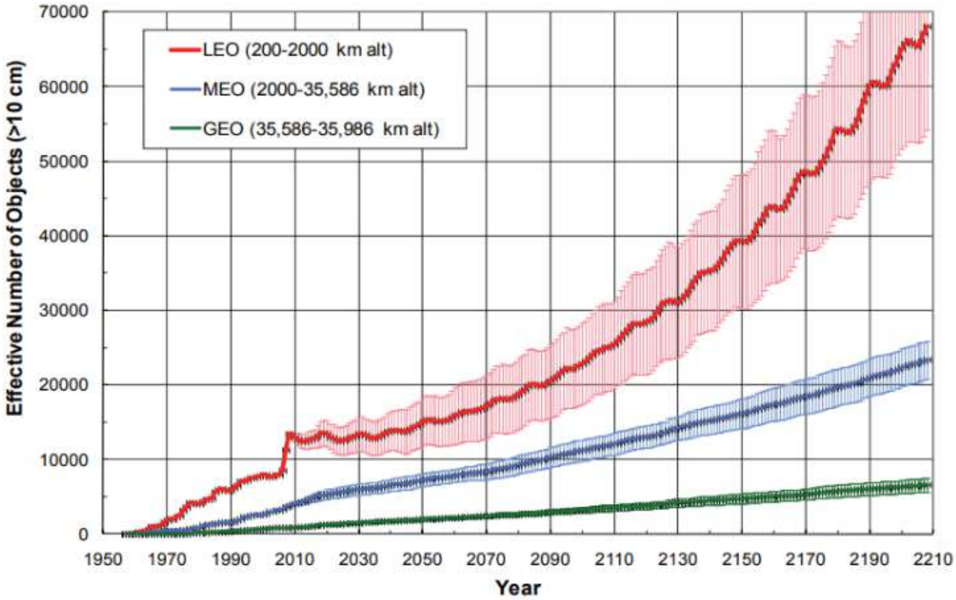

Figure 9: Evolution of the number of objects in orbit if no new satellites were launched to LEO, MEO, and GEO [40]

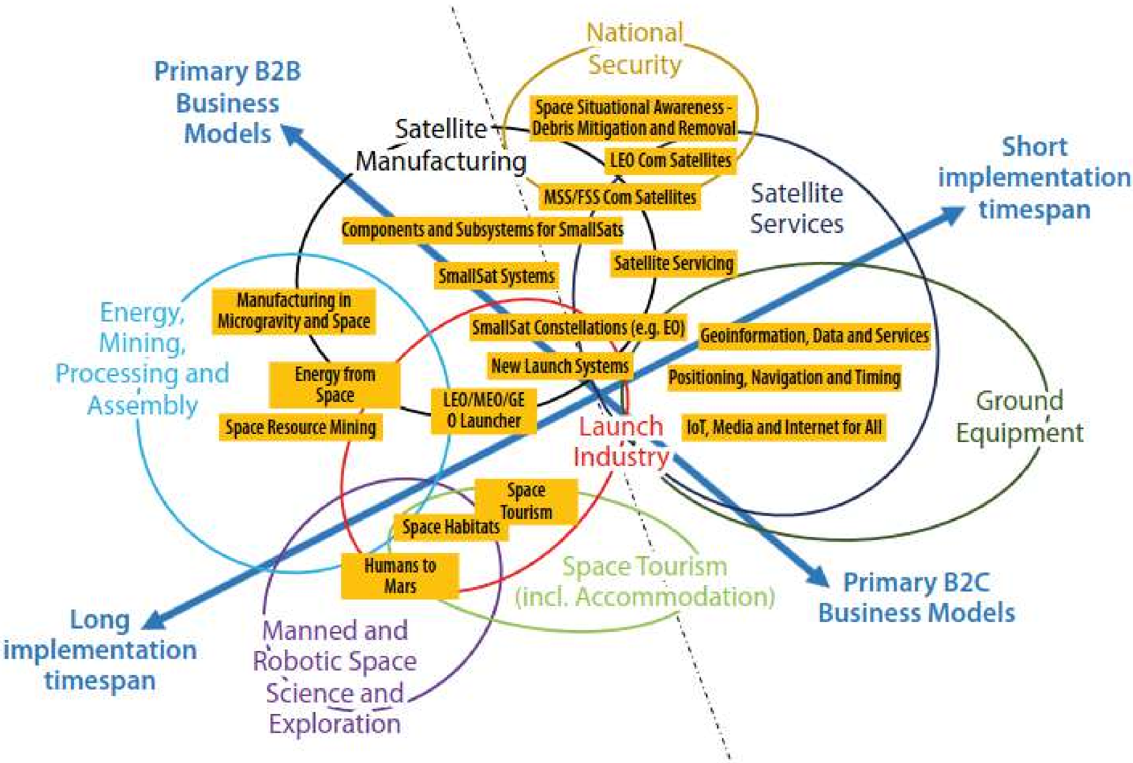

Figure 10: A landscape of space business services, business models and segments [14]

Figure 11: The model of five concurrent forces via M. Porter [33]

- Airbus
- Boeing
- Honeywell
- Thales Alenia Space
- Raytheon Technologies
- Northrop Grumman
- Lockheed Martin
- Blue Origin
- SpaceX

From the service companies' standpoint, the market can be analyzed using the M.Porter model (see, e.g., [32], [33]) presented in the fig.11.

Some selected rivals among the space market service companies are given above. However, it should be mentioned that this division is not crisp as due to market specifics frequently, product companies provide services to the government or to each other by participating in joint programs (see, e.g., [34], [35], [36]). The industry is evolving at a light speed. In order to achieve these milestones, cutting-edge technologies are applied to each new product that is launched into Space. Thus, service companies have to be fast adopting new technologies and do research in order not to be outperformed by rivals and lose the competition.

On the other hand, product companies are acting as buyers of the services provided by the service companies. Additionally, national governments and Space agencies frequently act as buyers since, as mentioned above, though private investments are growing, national governments still act as the main driving force. Though buyers purchase the products in limited quantities, the budget released for each project development is significant. Moreover, as the number of buyers is still limited, they have a significant influence on the market.

There are not many substitute products on the market due to the high speed of its evolution, and no products that can substitute what is produced. However, inside the market, some products may act as substitutions. An example of this is satellite edge computing, which may be a substitute for powerful ground stations.

The market barrier is high due to the corresponding experience requirements in space exploration, specific hardware, software, and State Of The Art (SOTA) approaches. However, since the Space market is growing at a significant speed, there is room for newcomers, both for product and service companies. Moreover, with the evolution of the New Space economy, companies require smaller budgets to enter the space market.

A great example of Space market collaboration is depicted in [48]. DARPA's Experimental Spaceplane program, formerly known as XS-1, aims to construct and fly an entirely new class of hypersonic aircraft. The primary goal is to bolster national security by providing short-notice, low-cost access to space. Here are the key features of this ambitious program:

1. Objective: The program seeks to achieve a capability that is currently out of reach—launching payloads to low Earth orbit in days, as opposed to the months or years of preparation required for traditional satellite launches.

2. Vehicle Design: DARPA envisions a fully reusable unmanned vehicle, approxi-

mately the size of a business jet. This spaceplane would take off vertically like a rocket and then accelerate to hypersonic speeds.

3. Propulsion: The vehicle would be launched without external boosters, relying solely on self-contained cryogenic propellants. Upon reaching a high suborbital altitude, it would release an expendable upper stage capable of deploying a 3,000-pound satellite into polar orbit.

4. Return and Reusability: After payload deployment, the reusable first stage would return to Earth, landing horizontally like an aircraft. The goal is to prepare the vehicle for the next flight within hours.

5. Boeing's Role: Phases 2 and 3 of the program have been awarded to The Boeing Company. These phases focus on fabrication and flight. Boeing aims to conduct a flight test demonstration, flying the spaceplane 10 times in 10 days, with an additional final flight carrying the upper-stage payload delivery system.

6. Cost Efficiency: If successful, the program could enable a commercial service with recurring costs of as little as $5 million or less per launch, including the cost of an expendable upper stage. This represents a significant reduction compared to existing military launch systems.

In summary, the Experimental Spaceplane program aims to revolutionize space access by combining rapid turnaround, cost-effectiveness, and reusability—a step toward a future of routine and responsive space operations.

Of course, all Space activities are accompanied by some portion of risk comment more on the table [46]. A great summary of risk by market segment can be found in fig.12. As you can see, market segments that are related to unmanned orbital flights are less risky from a demand, assets, and technology perspective. This fact is quite natural since satellites have continuously evolved for about 70 years. The crewed missions, tourism, and space exploration are far more risky from the demand perspective and asset intensity. This is caused by the fact that technology has only recently evolved to the level that these activities are reasonable from a commercial standpoint. It should be mentioned that the colors in the "Risk summary" row circles are inverted.

To reduce the risk, the simulation first approach is frequently used at different stages

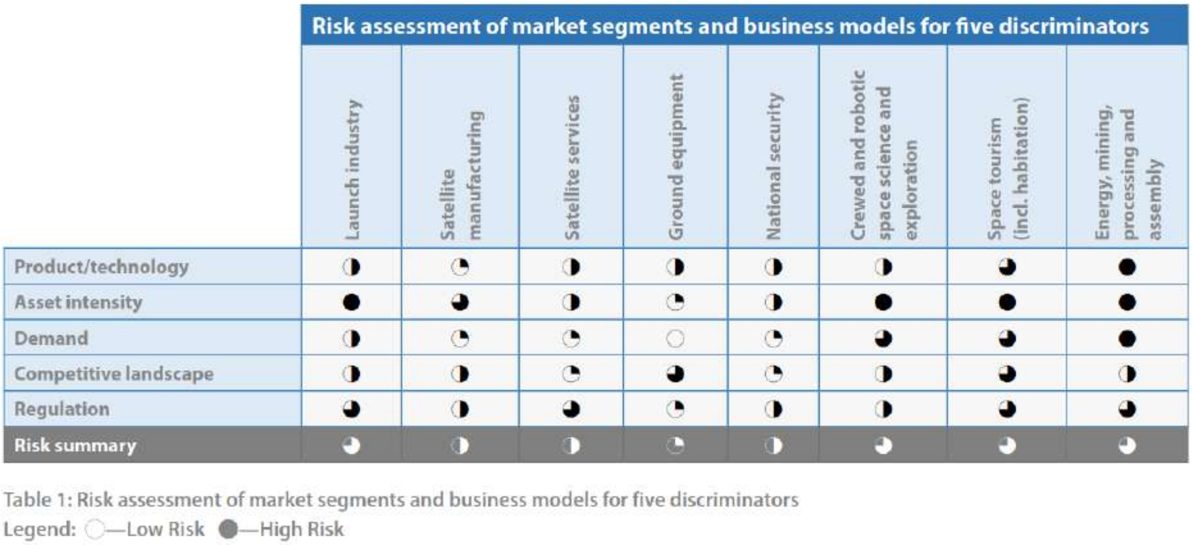

Figure 12: Risk assessment of Space market segments and business models

of the project development. The approach aims to utilize software simulation of the physical phenomena prior to accomplishing any work with real-world hardware. One can utilize the simulation first approach during various stages of the solution development process.

Development of the solution that involves hardware is frequently done using the V-Cycle [59] approach (see fig. 13). There, the simulation-first approach might be used in the majority of development phases. During Phase I, the goal is to conduct a feasibility study that would ensure the plausibility of the idea's implementation as well as the reasonability of each idea's usage in terms of effort. The fastest way to perform the feasibility study is by doing the simulation (in contrast to hardware prototyping) [1].

During the development stage (Phase II), the simulation is the fastest and cheapest way to develop real-time control, navigation, manipulation, and business logic (killer app) of the solution. Of course, one will have to face the sim-to-real gap. Though anyway, the final tests are possible only in Space.

Additionally, during the tests (Phase III), simulation still might be useful while doing integration and Hardware-in-the-Loop (HIL) tests. In this case, some portions of the solution might be executed on the onboard PC with the potential usage of real sensors. Such a gradual porting of the solution from simulation to real hardware allows

[1] It should be mentioned that sometimes a hardware prototype might be faster to implement, especially when, during the feasibility study, the effort is compared against the implementation of a high-fidelity physical model

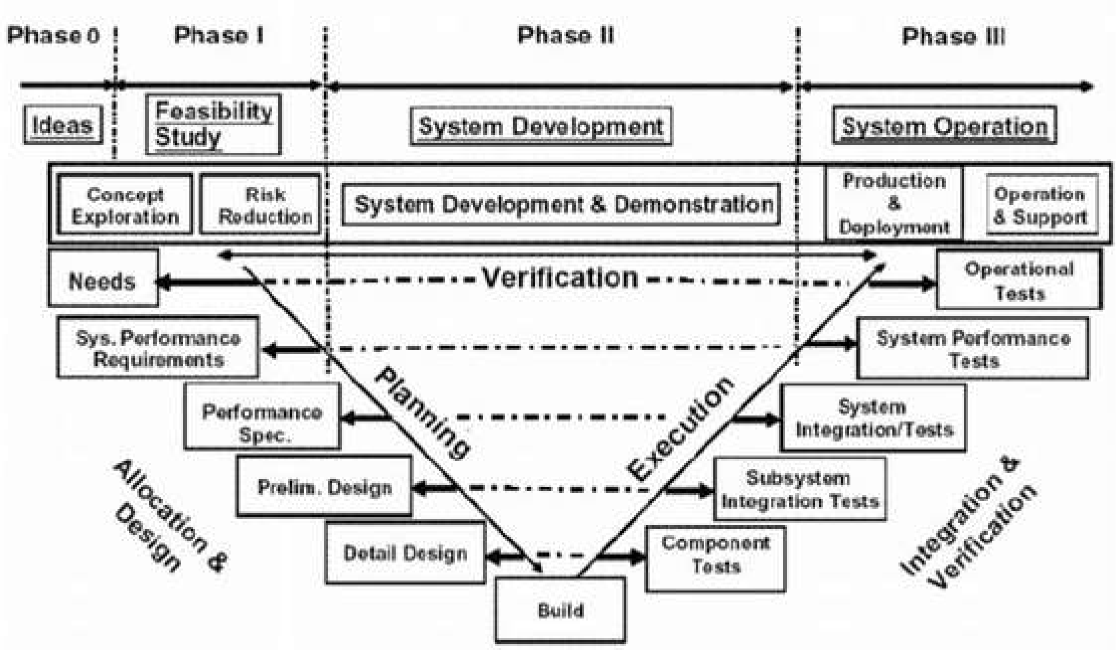

Figure 13: V-cycle for system design building [59]

a more granular approach to system verification. Additionally, a well-architectured simulation might serve as a solid foundation for Digital Twin, which enhances the solution, decreasing the risks during its performance while adding to maintenance efficiency.

While V-cycle is rather a common approach not only for the Space industry, NASA (see fig.14) has modified and adapted it to the Space industry [60]. Here, as described above for the V-Cycle, the simulation might be used for concept studies that may also be called a feasibility study (Pre-Formulation). During the Formulation phase, the simulation might be used to develop the first prototypes, failing fast, which is within the concept of a New Space Economy where the speed of development and product costs matter. During the Implementation phase, the simulation might be used as described above during the HIL test or as a part of the Digital Twin. Moreover, it will be a valuable tool during all the reviews provisioned along the NASA Life Cycle Phases fig. 14.

However, let us go one step deeper and see how the simulation first approach can help us with different stages of the system development process. Let's take, for instance, the decision analysis cycle displayed in fig.15. There, you can see that the decision process contains the situation assessment and development process. Here, obviously,

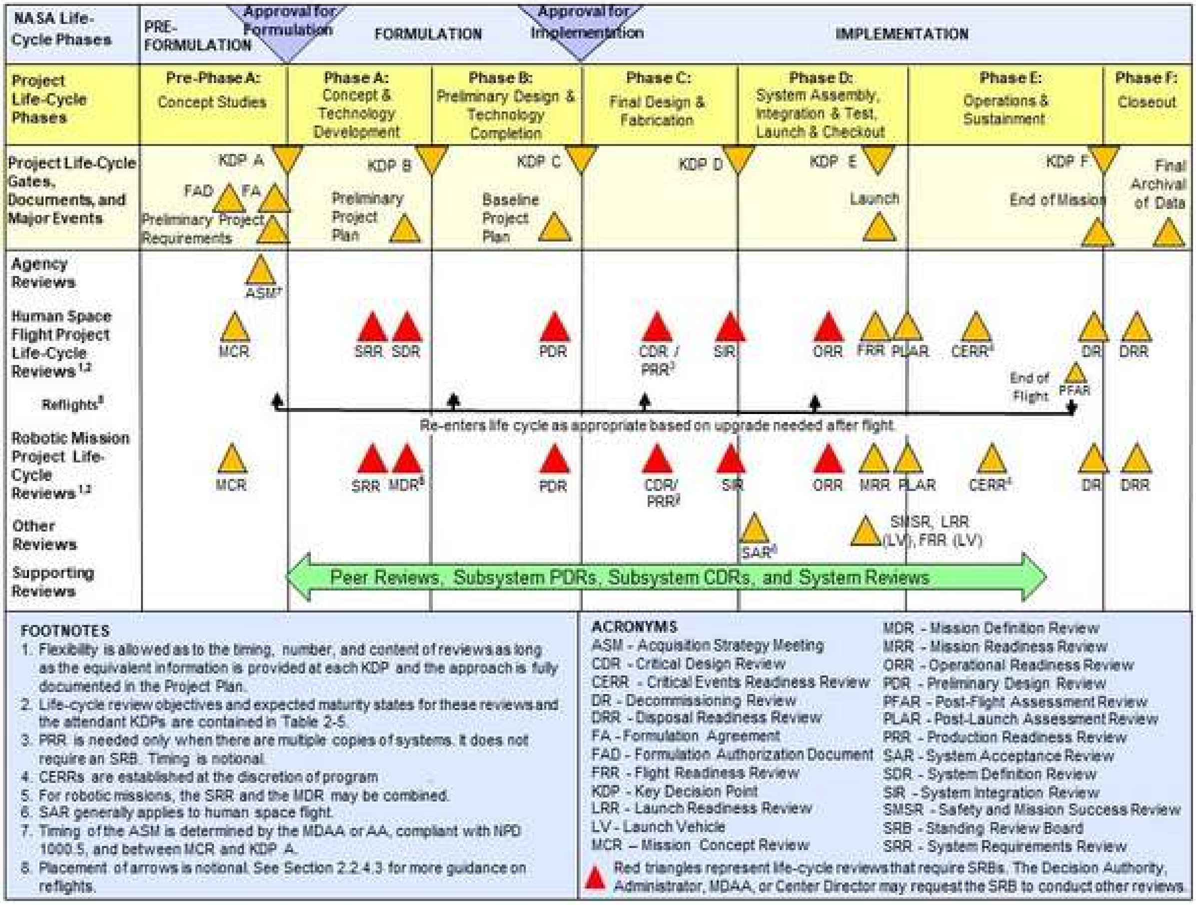

Figure 14: NASA Project Life Cycle [60]

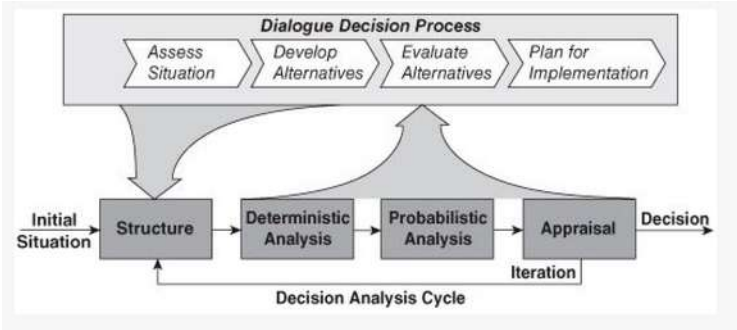

Figure 15: Decision Making Process [61]

using the simulation significant degrees is the time and effort required to develop several alternatives as well as evaluate them and prepare the implementation plan in order to make the proper decision. Additionally, the usage of simulation speeds up the decision analysis cycle after the assessment. Some decisions are discarded, while other decisions may be combined in order to increase the overall outcome of the decision-making activity that will be obtained as an outcome of the aforementioned process.

After the final idea selection, the overall scope can be decomposed into several stand-alone tasks that can be implemented in parallel while further integrated together. The development of those tasks can possibly be done using simulation. For instance, in fig.16, one can see the following tasks: thermal control, propulsion, data handling, electrical power, etc. All these tasks can be simulated in various software, which includes tools like Gazebo, NVIDIA IsaacSim, ANSYS, Matlab, etc. They all can be coupled together using a co-simulation technique, which will be discussed in detail later in this chapter. The black arrows in the figure highlight the dependencies between tasks that are to be taken into account in the architecture as well as provisioned in the simulation as the data exchange plugs. It is much beneficial for the software development company to have accelerators that are able to speed up the development process of some fundamental capabilities while being fine-tuned for mission-specific expectations. As the project evolves each block will be transferred from pure simulation to the hardware that will be used to bring the mission to space.

As is highlighted in fig.17, the design iteration and integration process has several levels that are highlighted in different colors. This color prioritizes their design and provides guidance on how the subsystems should be optimally integrated. This means

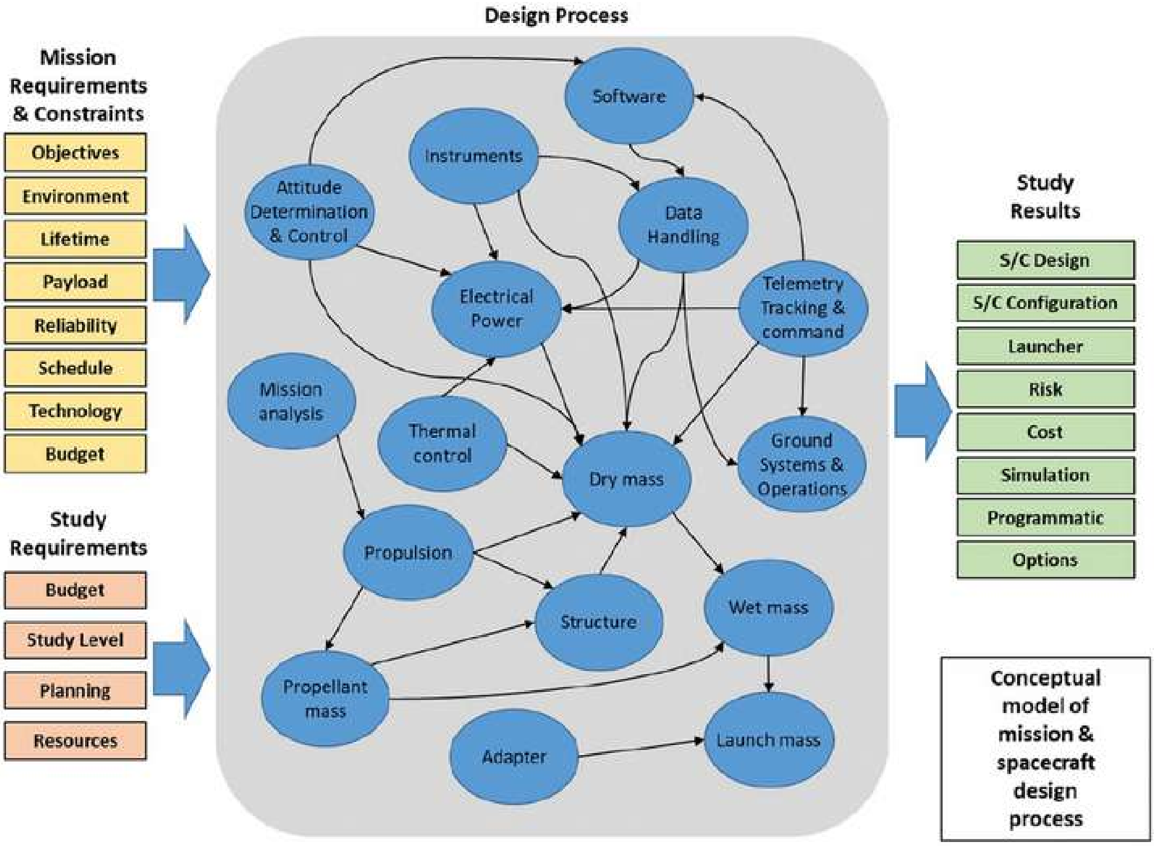

Figure 16: Sample space mission design process [62]

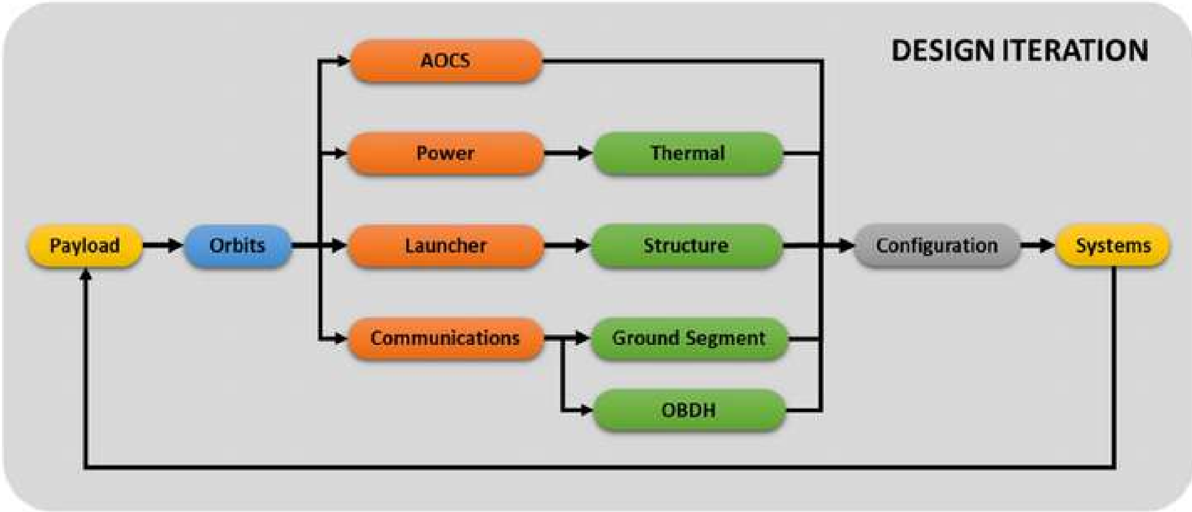

Figure 17: Space Mission Integration [62]

you have to first integrate the subsystems of the lower level before coming to the upper one. This all can be achieved using the Software-in-the-Loop (SIL) and HIL approaches, where you use simulation to do the components' integration gradually. For instance, it's hard to talk about the orbits of future space missions if you don't know what payloads will be carried. As soon as one knows the orbits, you can talk about the power, launchers, communication, etc. Further, one is able to design the thermal structure and other components. While doing the integration, you might want to go in the opposite direction, first doing the integration of some basic system and its configuration and then moving on to the upper level. The other approach is first to do the integration of the high-level subsystems based on the priorities from the fig.17. Once the integration is done, the fidelity of the model will be increased by introducing the subsystems of the lower level. Both ways are valid, and the final approach depends on the strategy and the details of the system that is being developed. Here, as it was highlighted during the development, the simulation and modeling in different tools are handy, and the co-simulation approach allows the binding of everything together to ensure the proper data exchange, taking into account the payloads and communication frequency.

One may notice a similar approach in the diagram in fig.18, where it is displayed how NASA approaches modeling and simulation at different stages of the project development. Everything starts with model system engineering, where the requirements

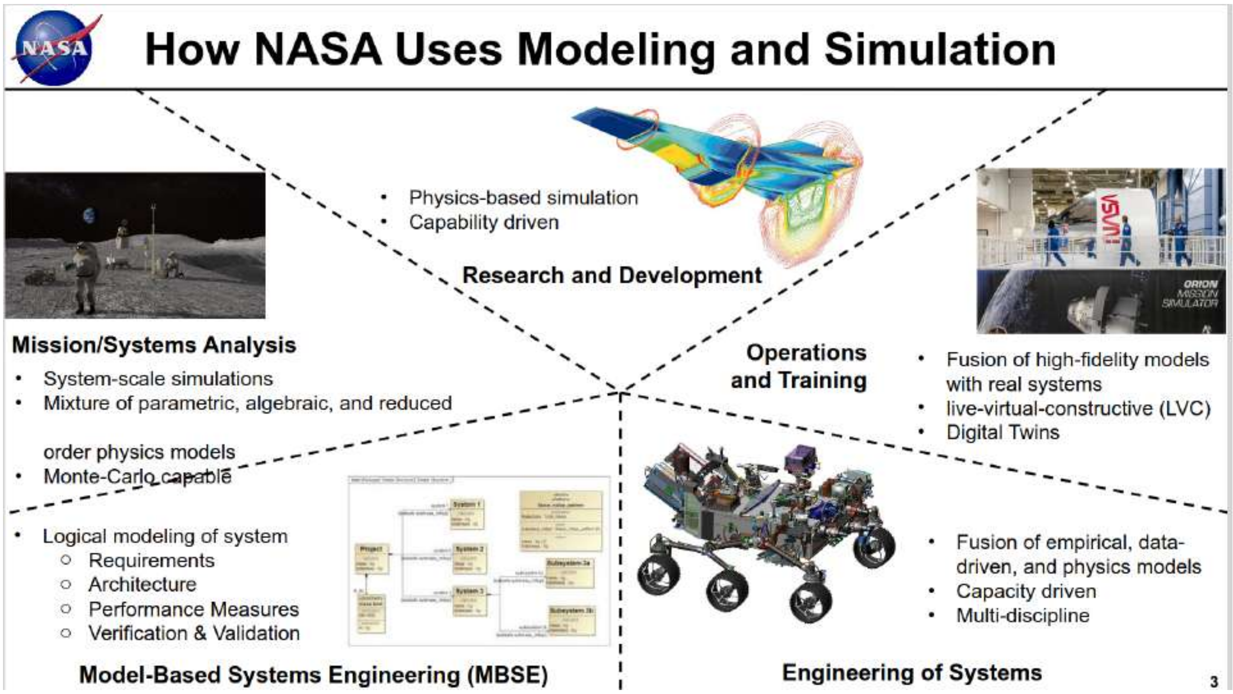

Figure 18: NASA approach to modelling and simulation [63]

architecture performance measures are highlighted and assembled together to ensure that the mission development plan is appropriate. Then, the system-scale simulation is implemented along with mixed parameters, algebraic, and other physical models, which are designed at that stage. Moreover, the Monte Carlo simulation might be used to take into account the stochastic processes happening in the real world. Next, the physics-based simulation is done using corresponding tools to ensure the proper approximation of the physical phenomena that the parts of the system will encounter. The following stage is operation and training, where the fusion of the high-fidelity models takes place. Additionally, the Digital twin of the whole system is created at that stage. The last one is the engineering of the system, where the hardware adoption happens. This means that the simulation is adopted to the real hardware. As one can see those steps are pretty similar to the ones that are described above in this chapter. This means that the services that software development companies can offer to the corresponding end users coincide with the best practices that are followed by the biggest space agency on our planet.

The future of the Space sector according to McKinsey [45] might depend on several possibilities (see fig. 19):

- The accessible, self-sustaining space economy scenario: Extensive international cooperation, ample financial support, and a thriving market environment drive unparalleled technological advancement. The space industry not only sustains itself but also enriches life on Earth. Efficient governance nurtures the establishment of a secure and accessible space realm.

- The "domain of the Titans" scenario: As space endeavors expand and secure funding, governance remains entrenched in outdated and restrictive frameworks. Space becomes increasingly congested with debris and transforms into a playground dominated by affluent nations and corporations. The extensive benefits of space exploration remain largely untapped.
- The unrealized potential scenario: Technical, economic, and regulatory hurdles hinder the realization of the space economy's full potential. Private investment diminishes, stalling innovation. While conventional uses of space-based communication, Earth observation, and research endure, the vision of a thriving space economy with sustainable applications remains far from reach.
- The national security arena scenario: A succession of space catastrophes prompts governments to reclaim primary oversight of space endeavors. In response, they implement regulations that stifle innovation and diminish investor confidence. Prioritizing national security concerns, the drive for technological commercialization recedes into the background.

As the Space market grows, new players are rapidly joining it. They are both governmental and commercial institutions. The new Space economy longs for new business models that would decrease time-to-market while increasing the quality of the final product. Since Ukraine is a major player in the IT market, it is natural to assume that it might be beneficial and faster to penetrate the Space market, suggesting scientific-driven software services. During the war, as it was seen during the course of the history [55], [56], a technological boom happens. To some extent, this can be seen also in Ukraine. Significant advancements in drones of various kinds (water, air, land) allow Ukraine to stand against the stronger enemy. However, we have to invest in the technology of the future, not the present or past. Therefore, space should be on the

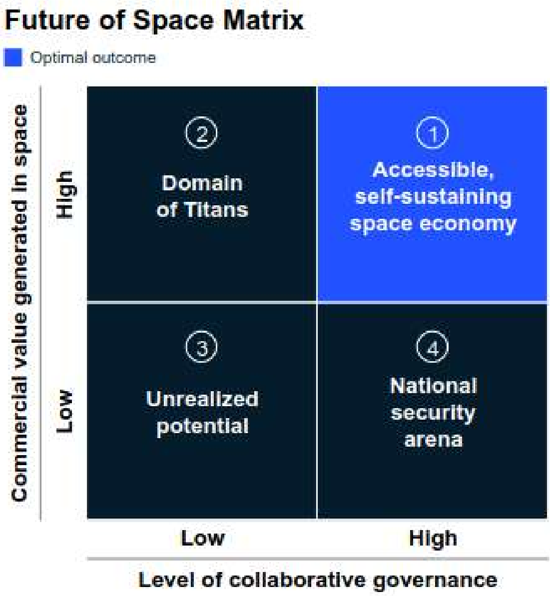

Figure 19: Four scenarios for how the space sector could develop by 2050

country's radar, not only from a civilian perspective. As Taiwan achieved significant advancement, focusing on research and innovation, Ukraine might evolve economically by investing in Space-related technologies. However, not only the technological sector might be changed. Significant legal relaxations in taxation, space resources ownership, etc., similar to Luxembourg, the USA might be introduced in Ukraine in order to become more attractive for big and small Space companies. Propagation of Space science and education might help not only create a corresponding workforce but also bring in money from the funding provided by various National and International Space agencies. Last but not least Ukraine should resurrect existing and invest in new local Space companies and research companies, which would help increase the export part of the GDP.

However, as mentioned above, commercial companies in Ukraine are already active in the Space sector even without much government support. Due to recent advancements in exporting IT software, making a bet on the software part of Space solutions development seems reasonable. Simulation first approach [50] might be a great response to the market needs. Its applicability to the Space domain can be observed in the example of the NASA project where Ukrainian companies participate alongside US companies [52], [53]. Taking into account the significant Space heritage that Ukraine has, it would be wise to combine hardware products with software solutions to enhance the role of

Ukraine in the world space landscape, adding to the accessible and self-sustaining Space economy fig.19.

1.3 Conclusions

This section presents the following findings:

- aligning definitions of the Space economy are presented to ensure that the reader follows the further stages of the thesis
- historical excurse from the first human steps into Space till the current state - the third wave of New space economy
- Space industry budget split with a closer look into ESA since it combines numerous EU space players
- Poland as a space player
- Ukraine's perspectives on becoming a valuable member of the Space market
- Space market acKPIs
- Space market business models and growth projection
- an up-streaming approach for space solution implementation

SECTION 2
SOLVING THE PROBLEM OF A COMMERCIAL BUSINESS MODEL ALLOCATION FOR PROVIDING IT SERVICES TO SPACE INDUSTRY PLAYERS

Having the setup described in the previous section, it is obvious that it is worth jumping in the constantly growing market, which is expanding not only in size but also in the number of terrestrial industries involved.

Let us consider the case of a Ukrainian company that wants to enter the space market. The pros and cons of this decision is given in the table 1

Pros	Cons
• Fast growing market. • High interest from governments and big commercial space companies. • Return of investment is high in case of success • Brand enhancement • Revenue streams diversification • Technological advancement	• High-threshold for entering the market. • Project risk factor is high. • Number of experts in Ukraine and in the world is limited. • Regulatory Hurdles • High hardware cost • Competition with international companies • Long-term development cycle • Political and geopolitical risks

Table 1: Pros and Cons of entering the Space market

The following business model canvas table 2 presents an approach that is similar to the companies entering the Space market.

Table 2: Business model canvas

Key Partner	Key Activities	Value Propositions	Customer Relations	Customer Segments
• Academic Institution. • Space mechatronics companies. • Software product/platform vendors.	• Participation & Organizing of Space events. • Customizable solution development. • B2B marketing • Regulatory compliance. • Consultancy services. • Space project delivery • De-risking and validation. • Process scale-up • Expertise strengthening	• Decreased time-to-market. • Increased solution quality. • Reduced risks. • Additional validation layer. • Operational cost reduction. • Capital expenses reduction. • Testing effort decrease. • Digital Twin foundation.	• Personal assistance. • Foster relations with end users.	• Space agencies. • Space mechatronics companies. • Satellite operators. • Space exploration companies & Startups. • Spacecraft launch companies. • Government.
	Key Resources		**Channels**	
	• Scientific expertise and industrial knowledge from team members. • Terrestrial robotics projects portfolio.		• Conferences and other Space events. • 1 on 1 meetings. • Partnership network. • Social media. • Website.	

Cost Structure	Revenue Streams
• Internal projects development. • Travel/marketing. • Legal consideration. • Salaries.	• Government grands & Awards. • Funding from Space agencies. • Technology and consultancy services.

2.1 Value proposition

The value proposition that a service company might offer is the simulation-first approach, a great differentiator enabling space market entry for a software IT company. Let us discuss several value proposition canvases (fig. 20 – fig.23) that are tailored to the customer segments that we have spoken about above.

Despite some differences in collaboration, space agencies and governments can be treated similarly in terms of value proposition. They are looking for cost reduction, a decrease in time-to-market, and a reduction in risk. Though the latter three are common to a majority of space market players, there are some particular pains that are these entities have. Among them are space debris, which was discussed in the previous chapter, public perception, and environmental impact. All the pains from the 20 can be addressed with simulated software that enables the ability of mission planning and simulation data analysis. By doing this, we reduce the costs of the actual hardware required for system tests. A significant portion of tests can now be done in simulation, limiting the time and effort required for ground tests. The following subsection will reveal more insights into the simulation first approach.

The mechatronics space company (see fig.21), on the other hand, will gain a competitive advantage as its hardware may be wrapped up as a ready solution with the help of a software company. It might be either a standalone solution or a missing piece of the puzzle in some bigger solution aimed at working in space. As mechatronics companies are dealing with innovation, it is important that the validation of the ideas implemented by the mechatronics companies follow the fail-fast approach. This can be achieved with the help of simulation software that tries to simulate hardware behavior in a real-world environment. Having a set of input signals and simulated hardware behavior, one can analyze how far the output is from what is expected from it taking into account the design. Additionally, if the hardware interacts with real-world objects, this interaction can first be validated in the simulated world. An additional benefit is the ability to provide technical support and/or training to end clients using simulation, including virtual reality. This helps to onboard people who might even be at some decent distance from the hardware device.

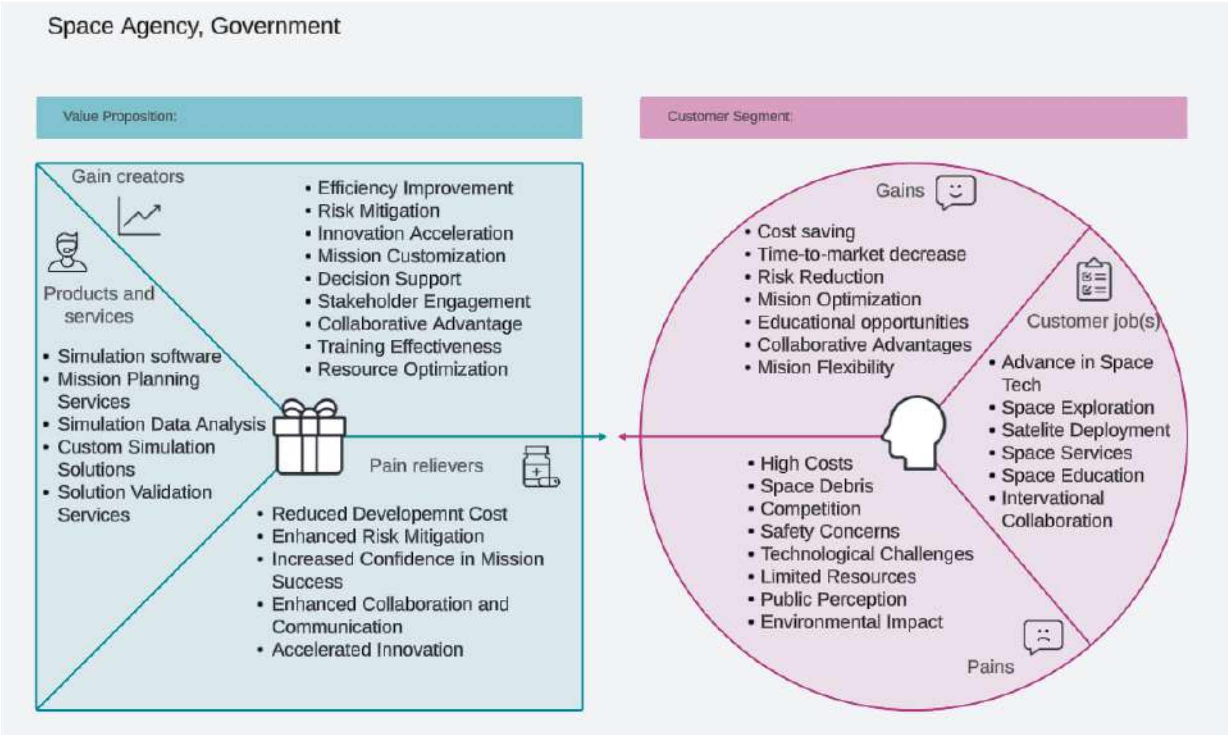

Figure 20: Value Proposition Canvas: Space Agencies and Government

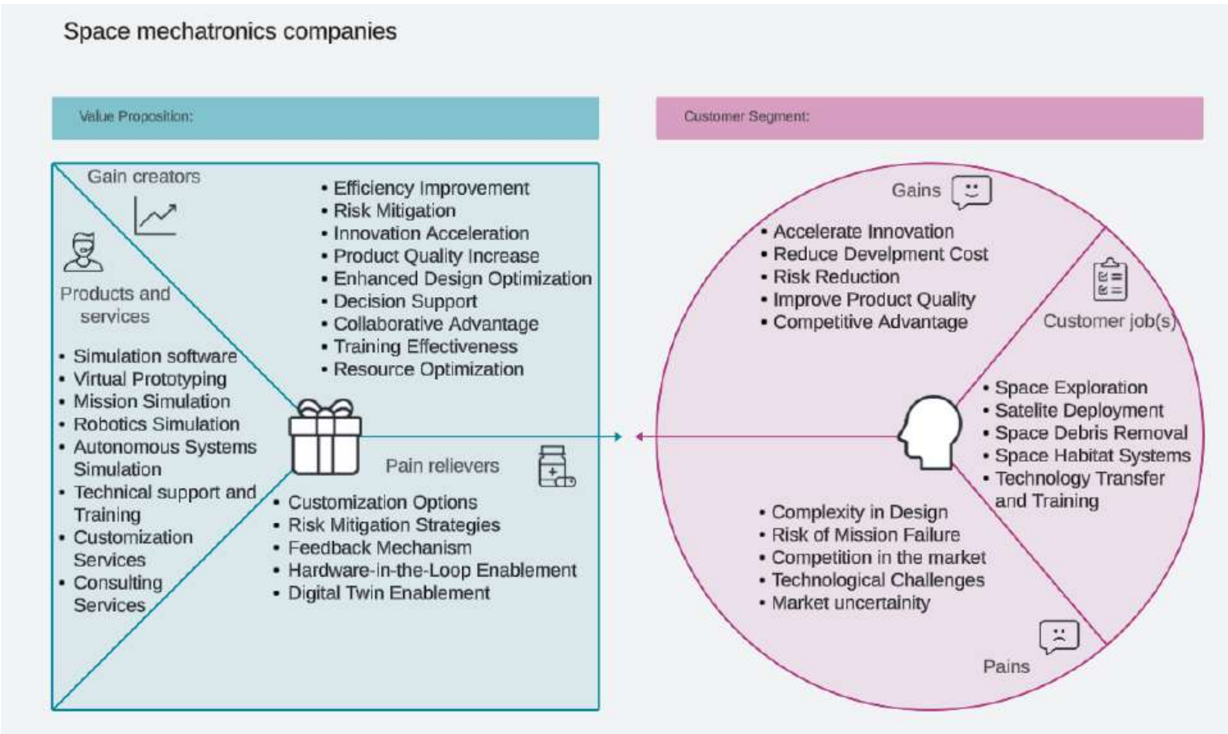

Figure 21: Value Proposition Canvas: Space Mechatronics Companies

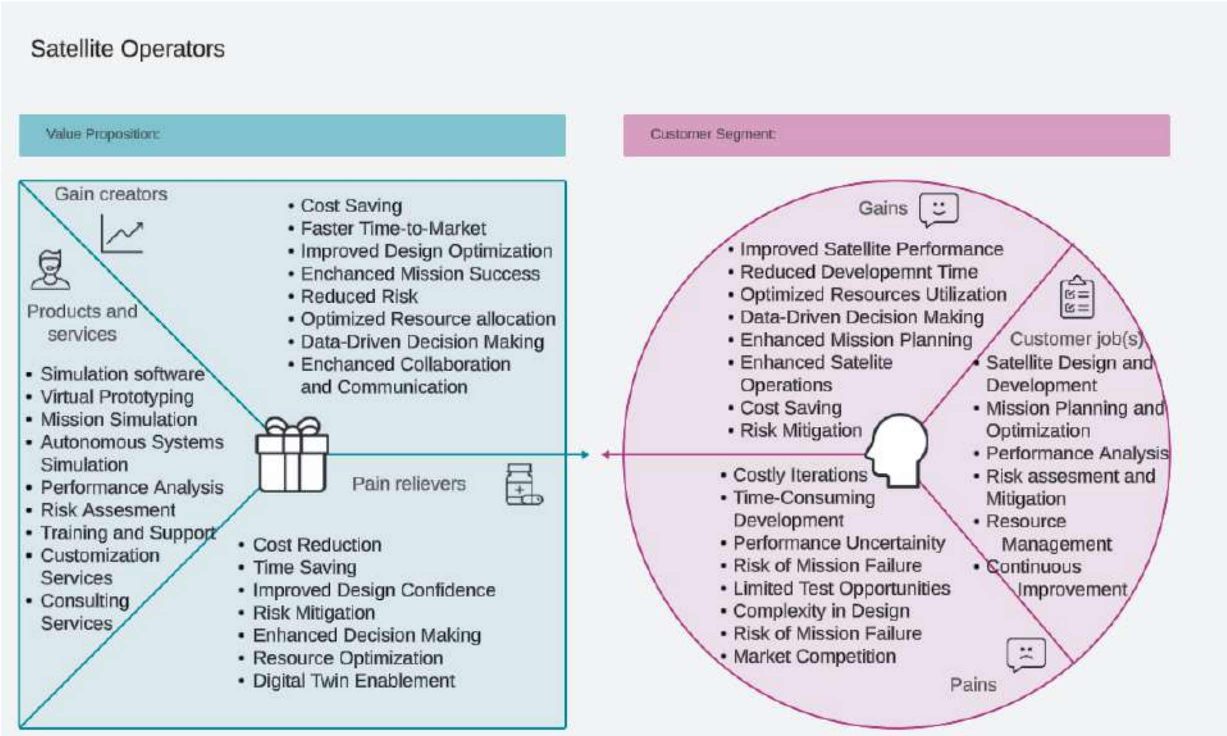

Figure 22: Value Proposition Canvas: Satellite Operators

The main challenge for satellite operators (see fig.22) is the bandwidth of the communication channel that allows data to be streamed to Earth. An alternative option is to use onboard computations. The development and tests of such an approach may be done using a simulation of the Space environment and readings from the simulated sensors that the satellite is equipped with. Additionally, when working on the satellite design, a high-fidelity simulation of the satellite components and their behavior in Space might save the development costs as well as decrease risks and time-to-market. Mission planning for satellites, as well as their docking-undocking, is a huge challenge for satellite operators. Each possibility to address this challenge is highly welcomed.

Space exploration companies (see fig.23) might benefit most from the simulation first approach as mission planning can be validated in simulation. Risk reduction for Space missions is perhaps the most valuable option for Space exploration companies. Saving costs while optimizing the design of both individual robots and their interactions, both mutual and with other objects in the environment, enhances the mission outcomes and attractiveness to investors. Moreover, such an approach increases the system's autonomous capabilities since it can be verified beforehand.

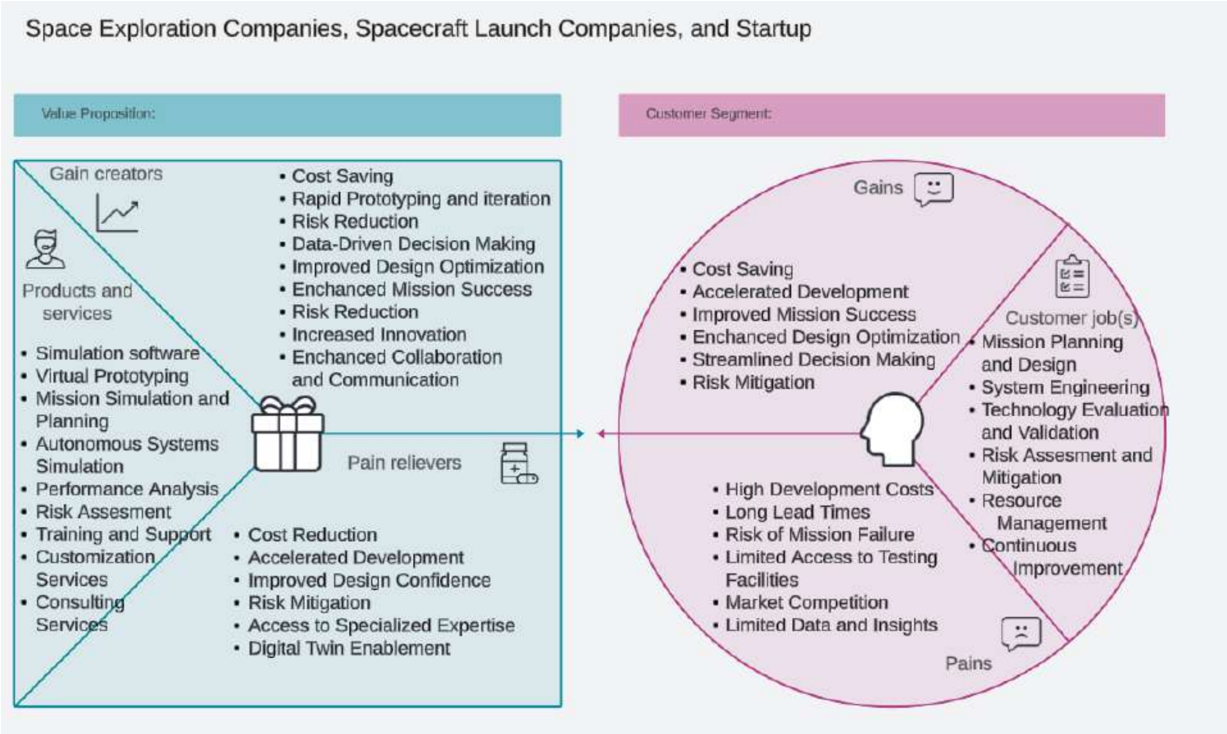

Figure 23: Value Proposition Canvas: Space Exploration Companies, Spacecraft Launch Companies, and Startup

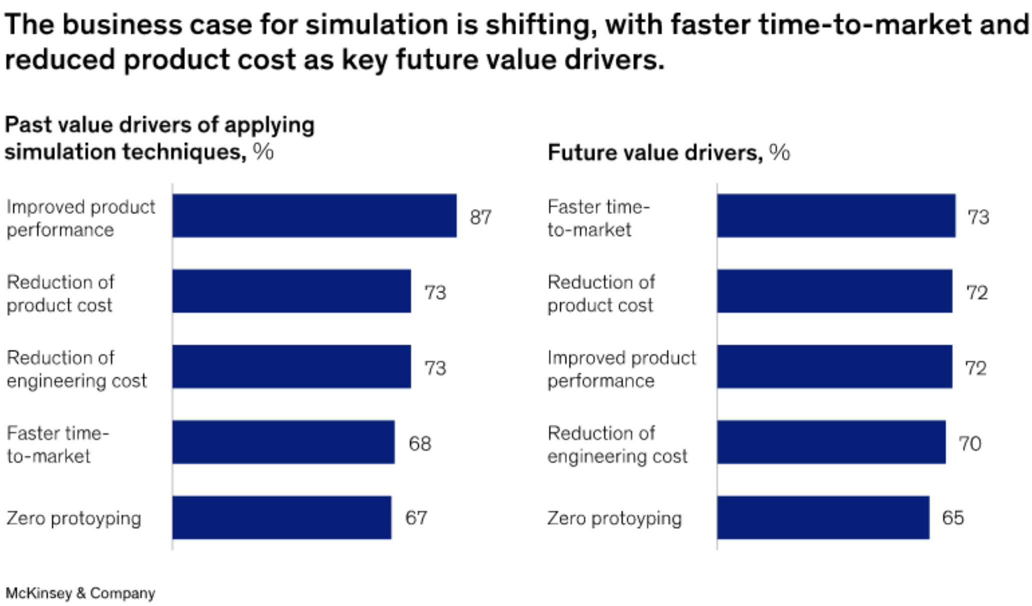

Figure 24: Simulation value shift for industrial projects

As it was highlighted in the McKinsey and NAFEMS report see fig.24, the simulation-first approach reduces time-to-market while decreasing the costs.

In case of Space robotics applications, the simulation first approach may be introduced using tools like NVIDIA Isaac Sim, Gazebo, CoppeliaSim, and others. These tools allow the simulation of the behavior of the robotics solution, taking into account both the visual and physics of the environment where the robot operates.

Utilization of this approach allows to test the behavior of the system before deploying the solution to the real hardware. Of course, the tests of the space subsystems were done before. However, the majority of tests were to ensure that subsystems of the Space solution work well. The performance of the whole system was already tested on the hardware.

Simulation is a great tool for taking into account risks and showcasing the value in order to do the trade-off analysis and select the best ideas while ranging the rest of them. For instance, in fig.25, the system design process [61] might also be approached in the cycle of parallel processes utilizing the simulation first approach on multiple stages. Such an approach presumes a non-stoppable process of design improvement, producing candidate solutions that are to be implemented. During the solution design, rapid prototyping is what's required most as it allows enhanced ideation and preparation of the comparison table of multiple potential solution candidates. While the solution is being implemented frequently, it is a good idea to decompose and start doing the implementation in parallel. Here, the simulation-first approach works very well for the distributed team that is able to work together from different locations frequently, making the overall cost of the project lower while speeding up the development of the solution. During the hardware adoption phase, the simulation first approach allows the gradual adopt the software from simulation to the real hardware, ensuring that each piece of the solution works well on the selected hardware while the rest parts of the solution are still in simulation, working as it was expected from them on the previous stages. Moreover, simulation can be a great source for further advancement of the solution since you don't have to make all the changes at once. In contrast, in the simulation, you are able to do the changes one by one, changing small pieces and watching how this change will

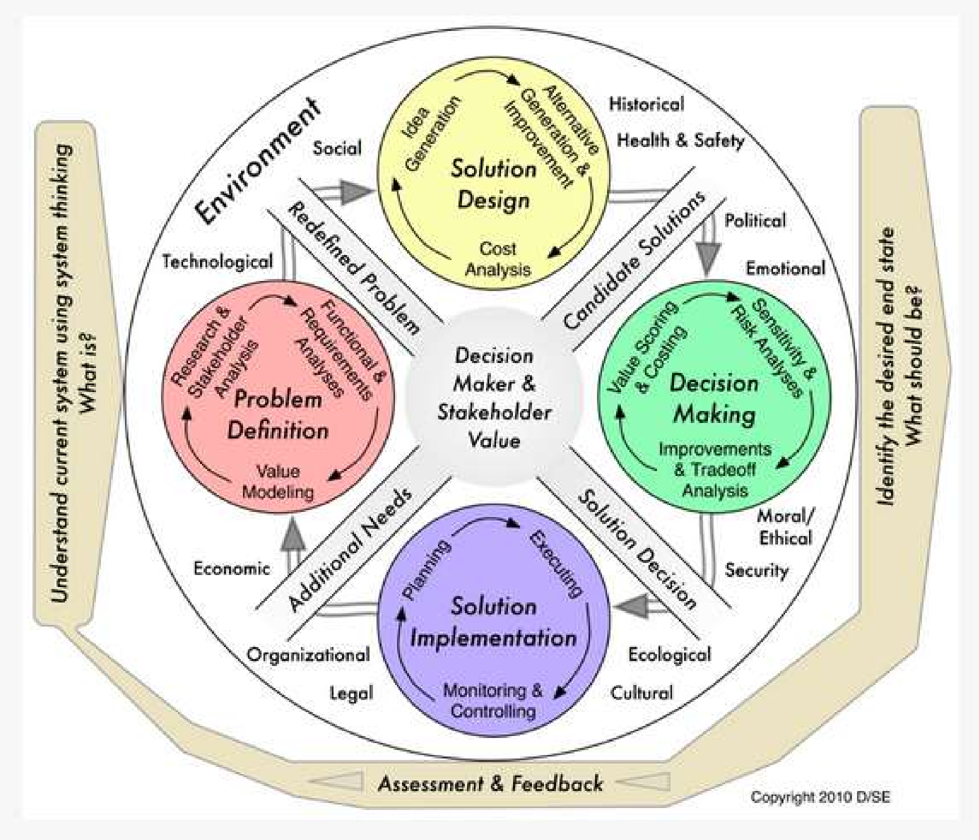

Figure 25: System Design Process [61]

influence the overall solution. While presenting the results to the board, it's useful to visualize the project's outcome, showing its performance in simulation. At the same time, it would be super difficult to do it in the case of the hardware-only approach.

It should be pointed out that the best simulator for space missions is still pending. One option might be a result of the collaboration of the US government and Microsoft (see [64]).

As one can see, the importance of the simulation-first approach cannot be underestimated. All levels of the system fidelity play a significant role during the process of design and testing. Having such a value proposition, together with some accelerators that allow decreasing time-to-market for the selected parts of the mission, composes a strong business proposition on the Space market.

2.2 Distibution channels

The easiest way to enter the Space market is to partner with academic institutions and submit a scientific proposal to a government entity (e.g., EU committee). Of course, it will not necessarily be Technology Readiness Level (TRL)9 project, but this is a great door opener for a company that enters that Space market. Additionally, an application to a Space agency is a significant next step for the company. These types of applications presume not only important scientific impact but also an implementation that enables the utilization of scientific results in Space missions. This means that the result of the consortium effort might be sent to Space with the help of the Space Agency funding. Another option is to partner with a mechatronic company. For these types of companies, extending the expertise for the software part of the solution is frequently hard. Thus, having a software company that is able to complete the other part of the solution is a valuable partnership. It can be used to submit proposals to space agencies or approach commercial space companies. Last but not least option is a collaboration with software product/platform vendors. These entities are making money by selling their products to Space or maybe even terrestrial companies. With the help of software companies that use the product to deliver the solution to end-client. Such a partnership might be a strong alliance, especially if the product/platform company is a significant player in the market.

Customers may be divided into several segments. Space agencies that aim to deliver huge projects, splitting them into smaller pieces and assigning them to various consortiums. Space mechatronics companies, besides being partners, may act as end-users of the software that controls the hardware parts they manufacture. Satellite operators are constantly seeking improvements in software solutions that increase satellite performance. Space launch companies are looking for improvements to features that are hard to test and validate on the ground without flying to space. Thus, each possibility of software solutions that preceded the actual space performance is highly welcomed. Space exploration companies and startups undertake even higher risks than other market players. Not only is their business model highly dependent on the project outcomes, but the final tests also coincide with a product launch. Therefore, similar to other entities, they are looking for each and every chance to improve their stakes and validate the solution while it is still on Earth.

Customer relations are tightly connected with distribution channels since in the beginning, the distribution is heavily based on personal connections.

2.3 Go-to-market plan

In order to achieve a successful implementation of business canvas from table 2, it has to be accompanied by a Go-to-Market-Plan. Let one present a version of such a plan for the Space Companies

- **Management Goals**
  - Create and preserve a solid brand identity as a reliable vendor of space mission simulation solutions, acknowledged for your expertise, reliability, and creativity.
  - Gain more market share and penetration in the space industry by bringing on new clients and strengthening ties with current ones.
  - Increase revenues for simulation tools and associated services to space businesses in order to attain sustained revenue growth.
- **Inbound product and market data**
  - Participation in events.
  - Hosting events.
  - Personal contacts.
  - Commercials presenting
- **Target audience**
  - Owners and Co-owners.
  - CEO, CTO
  - VPs of innovation.
  - Space agencies officers.
- **Messaging strategy**
  - Write white papers.
  - Present demo videos.
  - Adopt terrestrial experience to Space needs.

2.4 Conclusions

This section presents the following:

- business model canvas
- value proposition canvas for each customer segment
- go-to-market plan

SECTION 3
SPACE MARKET PENETRATION BASED ON THE EXAMPLE OF RAAG AT SOFTSERVE

In this section an approach of how a IT software company can change or update it's strategic course entering the space domain on the example of SoftServe and it's Robotics & Advanced Automation Group is presented.

3.1 Context description

The company decided to enter the space market in H2 2022. At that time Robotics & Advanced Automation Group already had a significant expertise in terrestrial robotics project that included

- mechatronics team who was able to manufacture hardware robots
- modeling control and optimization team dealing with high-fidelity physics, real-time control, etc.
- various simulators and deal with mobile platforms, drones, roboarms, as well as had experience with legged robot in simulation
- robotics perception that included data acquisition from various types of sensors, sensor fusion, synthetic data generation and the AI
- RoboOps, integration, and cloud robotics

It is important to understand this background as if one looks a bit deeper, there is some overlap between space and terrestrial robotics projects. For instance, optimal pathfinding algorithms, obstacle avoidance algorithms, sensor fusion algorithms, and high-fidelity physics approaches mostly remain the same. Thus, having this background and having a team that was able to and was eager to deal with challenging projects, the decision to expand the services has been made.

The first step was obvious. The group had to gain some expertise that was lacking. Thus Space expert with multi-year experience in space. He was responsible for several Mars missions that lasted 7 and 14 years on Mars. Additionally, an expert had a great number of personal connections in the space domain. Additionally, SoftServe opened positions and successfully hired engineers with space experience. It took a while since these people are rare to find. Luckily, Robotics & Advanced Automation Group succeeded. After a while, the Space team that was able to approach the Space project was ready to face the challenges. It is worth highlighting that terrestrial experts do not rest aside, and the Space team is frequently augmented with people with terrestrial expertise who are able to work on the part of the solution that coincides with the terrestrial cases. Hence, at the end of the day, Robotics & Advanced Automation Group can gather a significant amount of people who are able to work on the Space project.

3.2 Space accelerators

In parallel, RAAG started to work on marketing to ensure the potential clients or partners that they are a proper company to work with. The group worked on accelerators that aim to serve as differentiators on top of the expertise that the company had in the Space domain. RAAG created some accelerators[2]. The Lunar drone accelerator aims to control the drone contained navigational system of the drone and enable accurate localization and mapping so the drone can fly around the Moon's surface also, entering craters and cases to create a 3D map looking for resources, basically ice. Ice is a very valuable resource on the Moon as it can be converted to water, oxygen to breeze, and also liquid hydrogen and liquid oxygen,, which are the fuel for the rockets having enough eyes. The Moon can become basically a fuel station for Space missions, so ice search is important for lots of companies that either plan to build a settlement on the Moon or to do space exploration or any other activities on the Moon. What has to be taken into account is that bringing up one kilo of anything to the moon costs from 1 to 1.5 million US dollars, which is a significant number and makes the cost of the 1 kilo of ice found on the moon equal to 1 million dollars. However, this accelerator doesn't accelerator was not only meant for the moon but also eat serves as it can be used for as a terrestrial it can also be used for terrestrial applications. For instance, there is a need to do the mapping of the caves or 3D mapping during bridge and other building inspections also

[2]Accelerator is called a general not-production-ready solution that aims to solve some problem. It can be further adapted to the specific client's needs and turned into a product. The IP for the accelerator belongs to SoftServe, while everything built on top of it belongs to the final client

Figure 26: Lunar Drone Accelerator

during the disaster natural disasters, we need to explore the area creating the 3D map so the beautiful restaurant it can be projected also to other domains outside Space. Figures 26-28 represent different stages of the Lunar surface exploration. Being in the simulation, the drone experiences the influence of simulated physics as well as is able to acquire data from simulated sensors: two cameras and IMU. The robot is able to create a point cloud of the environment where it flies fig.31 and additionally collect the set of images that can be mapped to that point cloud. In the figures 30-31, the ice in the cave in simulation and on the 3D recreated map.

L-REX is an accelerator 33 that enables ice search via scooping the regolitf̀ootnoteRegolith is Lunar soil. The accelerator consists of the mechatronic part, which was designed by RAAG mechatronic team, the robotics arm controlled by the Robot Operating System 2 (ROS2), and also the perception 34 for the robot to be able to detect the ice which is under the surface of the Moon. Additionally, terra mechanics was used to calculate the forces between regolith and scoop. The optimal energy consumption of the mobile platform is obtained using differential equations in a Modelica while the robot is simulated in the robotics simulator. A co-simulation was utilized to combine different pieces of the solution. Additionally, the robotic arm is equipped with a vibratory unit that enables the lateral motion of the scoop and makes the scoop act as a knife to penetrate the regolith when the stiffness of the regolith is too high. Thus, this set reduces the energy consumption required to scoop the regolith.

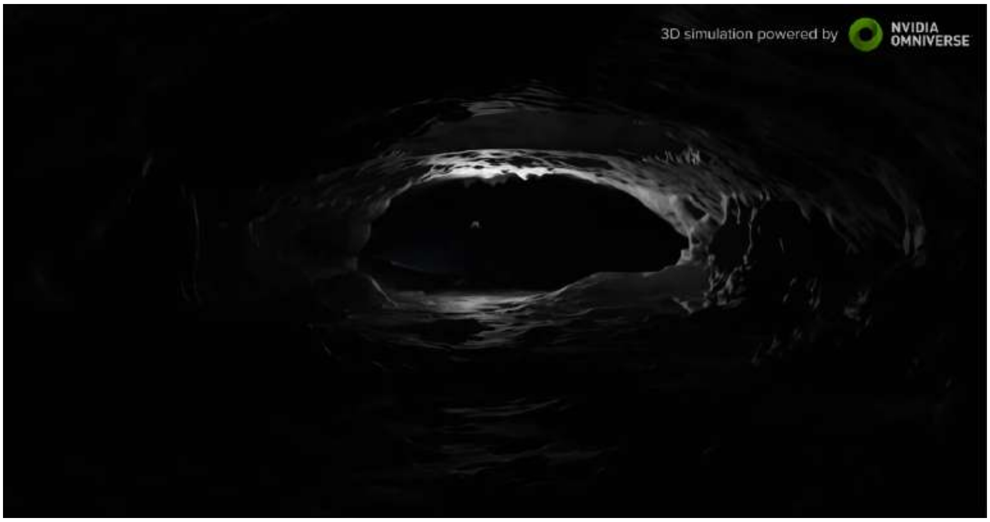

Figure 27: Lunar Cave Exploration

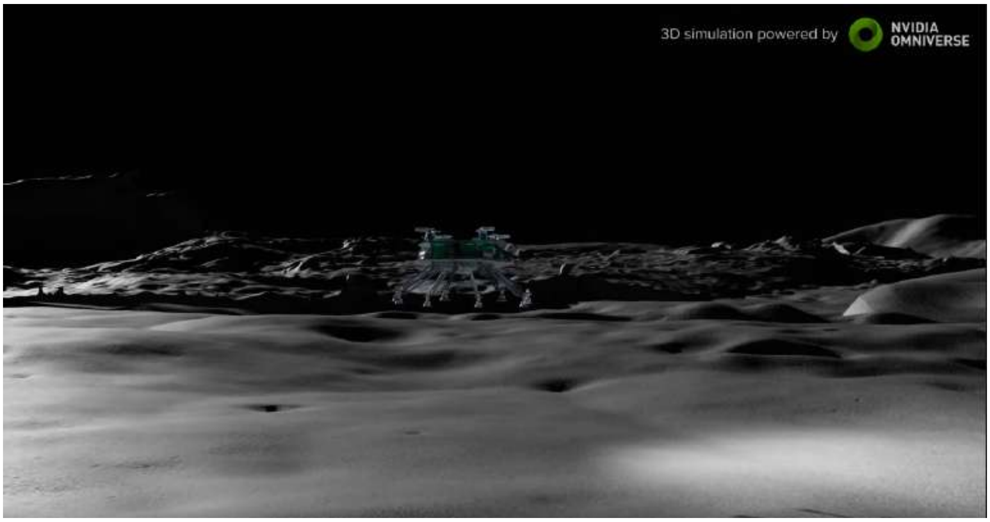

Figure 28: Lunar Surface Exploration

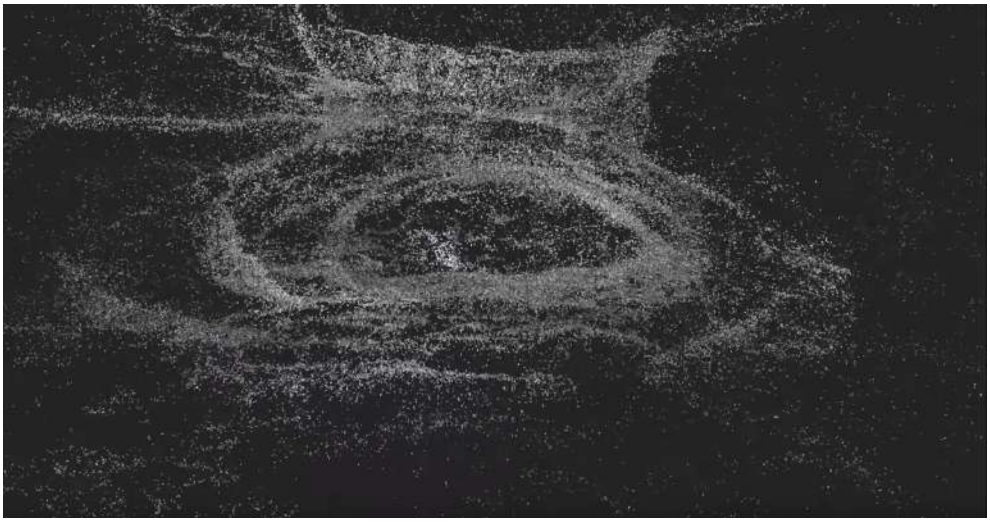

Figure 29: Poincloud creation

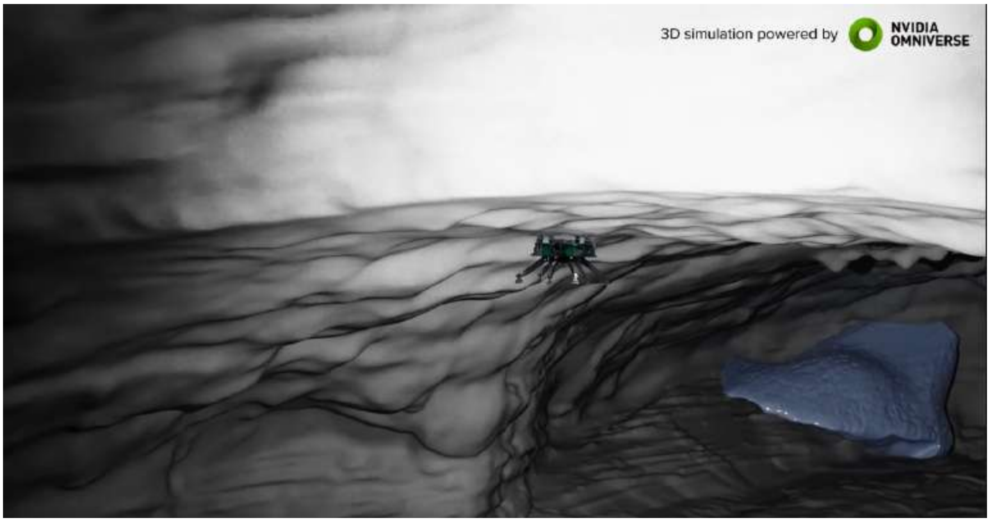

Figure 30: Ice Deposit in Simulation

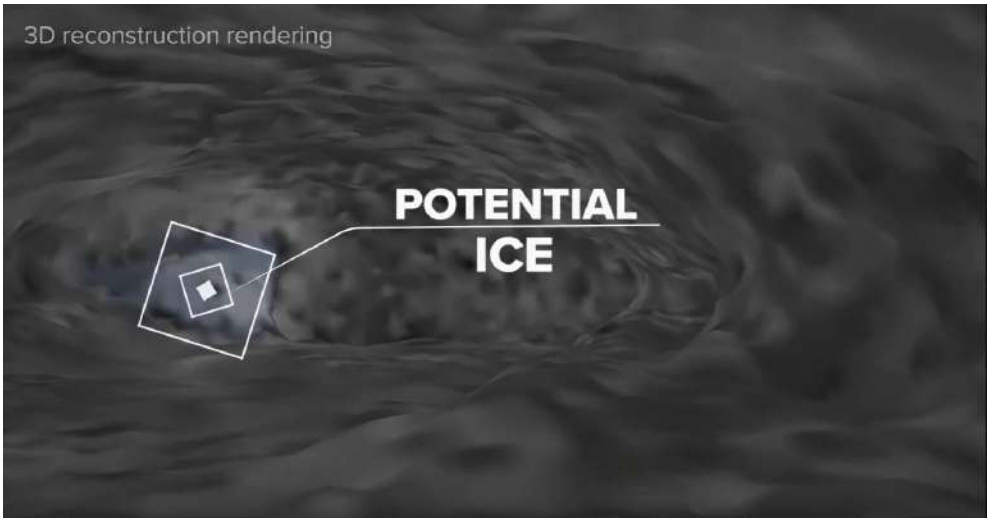

Figure 31: Potential Ice Detection on Recreated 3D Map

Skills	Person/days	Rate	Cost
Architect	18	A	18*A
Space Consultant	18	B	18*B
Space Robotics Eng.	90	C	90*C
Space Robotics Eng.	45	C	45*C
Total	171		18*(A+B) + 135*C

Table 3: Lunar Exploration Project Expenses

The co-simulation approach mentioned above is highlighted in fig.32. It aims to combine the software created by different teams in different software tools, taking into account the quantity of data and the frequency of data that is to be exchanged between these subsystems. For co-simulation,the FMI/FMU standard can be used in order to integrate the subsystems together. To prepare those subsystems, which are part of the bigger system or basically the whole solution, we have to convert the subsystems following the FMI/FMU standard. The co-simulation master ensures the proper data exchange between subsystems. The subsystems can be divided basically into different chunks fig.32: conventional robotic simulation and high fidelity simulation. Robotic simulation can be split into the simulation of the environment with all the objects that will be further detected by the sensors of the robot, and the robot or robots themselves that are being controlled. The final quantity of robots depends on the mission that is to be implemented. As for the high-fidelity simulation, one can depict the models of the sensors and models of the physics phenomena for which the partial differential equations are used to approximate the physical phenomena accurately. For the first chunk, one uses tools like NVIDIA Isaac Sim, Gazebo, CoppeliaSim, etc. For the second chunk, one can use ANSYS, Matlab, Modelika, pure Python, C++, or any other tools depending on the requirements of the project. The main goal is to achieve the necessary fidelity to reflect the physical phenomena and the characteristics of the system and ensure that the overall mission goal is going to be achieved.

3.3 Finance and marketing

SoftServe's clients can utilize the accelerator IP owned by SoftServe, covering its price. The accelerator price is calculated by taking into account investments made by the

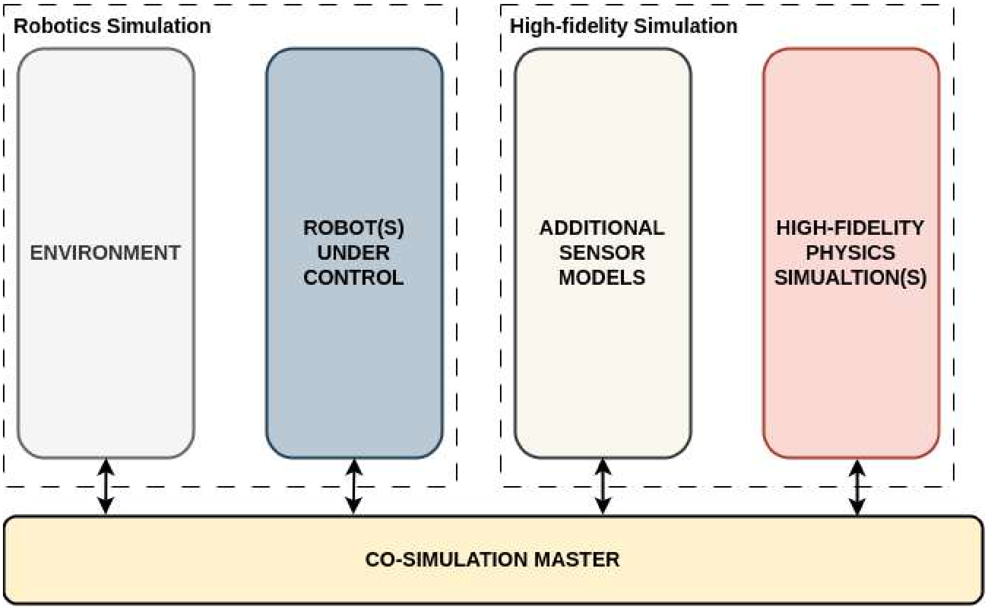

Figure 32: Co-Simulation

Figure 33: Lunar Robotics Excavator

Skills	Person/days	Rate	Cost
Architect	18	A	18*A
Space Consultant	18	B	18*B
Space Robotics Eng.	105	C	105*C
Space Robotics Eng.	90	C	90*C
Co-Simulation Eng.	45	D	45*D
Mechatronics Eng.	10	D	10*D
Total	286		18*(A+B) + 195*C + 55*D

Table 4: L-REX Project Expenses

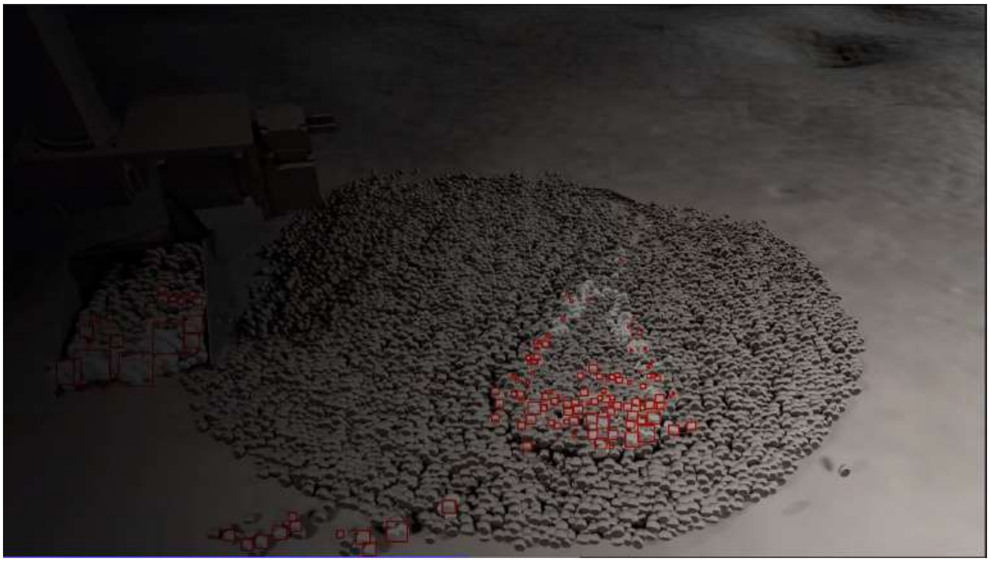

Figure 34: Ice Detection

company divided by the number of deals that the accelerator is projected to support.

In table 3, one can see the expenses for the Lunar drone exploration project. The rates are under NDA. The expenses given here do not include marketing expenses for marketing video creation. However, these are relatively smaller numbers in comparison with development.

Table 4 provides the expenses for the L-REX project. As one can see from the team roles, not only Space engineers took part in the project. This team optimization allows for the reduction of overall RAAG expenses while preserving the ability to assemble the proper team for the challenging project.

An important topic is the budget that was spent during the project and where it came from. Basically, the first project (see table 3) and some activities around it in 2022 were SoftServe investments. However, after that, RAAG had to stay within the Key Performance Indicators (KPI)s, which means that the evolution of Terrestrial robotics was a driver for Space robotics. For this reason, sometimes people from the Space team joined terrestrial projects for some short period of time. These KPIs included revenue, Account Profit Margin (APM), Contribution Margin (CM).

The business canvas presented in the table 2 is pretty much adopted by RAAG. All the reasoning behind it given in the previous chapter is implemented by RAAG.

The list of conferences where group members are present consists of the following events (see table 5). Based on this table, the annual group's budget is planned and executed. Of course, the marketing budget does not consist just of the conference attendance. Writing white papers and creating video clips based on the demos developed by the group, webinar [66], and other activities.

Among the results obtained by RAAG, one should mention the successful win of the NASA project [65] that aims to create a launch and landing pad on the Moon. The kick-off of this project took part in March 2024. Moreover, recently ESA announced that RAAG won the project that aims to launch a satellite to the Moon orbit. This project will start in 2024. RAAG is also actively taking part in commercial project presales that seem to be promising.

The income projection for 2024 includes participation in NASA and ESA projects. Marketing activities are selected from the table 5 and may vary depending on the needs.

3.4 Conclusions

This section presents the following:

- context in which SoftServe made the strategic decision to enter the Space domain
- Space accelerators that enhances market penetration
- finance and marketing part of the space direction developemnt

Conference name	Repeat rate	Organizers	Registration fee
IEEE International Conference on Robotics and Automation	Annually	IEEE	955 GBP
Space Resources Week		ESRIC	100 Euros
Space Symposium	Annually	Space Foundation	2710 USD
International Astronautical Congress (IAC)	Annually	International Astronautical Federation (IAF)	1300 Euros
Workshop on Simulation for European Space Programmes (SESP)	Each 2 years	ESA	240 Euros plus VAT
"New capabilities and countries in European Space" Conference		ESA	50 Euros plus VAT
International Planetary Caves Conference		ESA	330 Euros
IEEE Aerospace Conference	Annually	American Institute of Aeronautics and Astronautics - AIAA; IEEE Aerospace and Electronic Systems Society; PHM Society	1590 USD

Table 5: Space conferences

CONCLUSIONS

Space is a place full of treasures and mystery. It is a place that humanity will long to explore as long as it exists. The work briefly describes the potential of the Space market. Additionally, it presents the market segmentation based on the most typical problem solved by the industry as well as the business outcomes that might be achieved during the penetration of each segment. The work describes the business models applicable to penetrating each market. Moreover, some considerations about the applicability of these ideas for a market newcomer are discussed.

The thesis aims to highlight the following topics:

- potential of the Space market based on the current and projected state;
- various stages of the Space market evolution,
- main players including Space agencies, private companies, etc.;
- reasonability for a country like Ukraine to enter the space market and why it is crucial, despite all the problems that Ukraine faces, to enter the Space domain;
- is an attempt to compare Ukraine and Poland regarding Space domain penetration. As can be seen from this comparison, despite having a great heritage, Ukraine didn't manage to use it as a foundation for the consequent steps. It felt behind in the current space race, but it is not all over yet;
- steps for the software IT company to penetrate the space market, i.e., the flow for the service IT company that is new to the space market based on which the company might undergo the steps that would lead it to the successful Space market entrance
- a value proposition for Space market newcomer service IT company is provided as well as the customer segmentation potential key partnerships distribution channels, etc.
- as an example of the successful first steps in the Space domain penetration a case of Robotics & Advanced Automation group (RAAG) at SoftServe is given which includes the following:

- how the team was assembled to pursue the Space penetration;
- description of the Space accelerators that were created by RAAG at SoftServe;
- the financial aspect of the initiative
- marketing campaign and the communication channels that were used to meet the players from the Space market

The ultimate goal of this work is to enable as a company to widen its service spectrum and extend its services to the Space domain. The space race is the frontier that can present Ukraine as a powerful player in the world arena, especially in times of Russian invasions. Having multiple Ukrainian Space companies will enable the bottom-up approach to entering the Space race and potentially make Ukraine a key partner for multiple entities out there.

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