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NAVIGATING THE FUTURE: EUROPEAN SPACE PROPULSION INNOVATIONS AND MARKET DYNAMICS IN THE SMALL SATELLITE INDUSTRY

Emilia Georgiana Prisăcariu

Romanian Research and Development Institute for Gas Turbines, COMOTI
e-mail: emilia.prisacariu@comoti.ro

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Abstract

The small satellite market is set for rapid growth, driven by the need for independent space access. While current options involve ridesharing, dedicated small satellite launchers offer customized access, with nanosatellites taking as little as 8 months from concept to launch. Europe invests significantly in space transportation R&D through programs like HORIZON SPACE, aiming to boost competitiveness and reduce reliance on external providers. ESA initiatives like FLPP and BOOST! focus on technological advancements and commercial services. Despite efforts, the USA dominates the space launch market. Europe aims to double its space transportation market share by 2030 by developing low-cost propulsion and launch routes for SMEs. Over 100 projects worldwide are developing light-lift and micro-lift rockets, with consideration for geographically closer spaceports. Challenges like space debris are addressed through innovative solutions. Recommendations emphasize reusable technologies and greener propulsion systems. The COVID-19 pandemic highlighted vulnerabilities but also spurred innovation and resilience. This paper discusses the multifaceted aspects influencing the space launching market evolution, including market dynamics, European initiatives, external factors, innovation, and future potential.

Introduction

The small satellite market is expected to grow exponentially over the next ten years (DGLR Dossier, 2021). Independent space access is expected to be one of the most impactful factors. While the current small satellite launching options include ridesharing or piggybacking, the European space market could become more accessible in the future. Nowadays, the concept of a small satellite launcher, providing companies tailored access to space, is preferred, given that it provides satellite-producing companies with individual access to space on a customized orbit and at a convenient launch time. The development time for a nanosatellite from concept to launch can be as short as 8 months (Alen Space, 2022), with significantly increased values for small and micro satellites. Horizon Magazine

makes a prediction of 2500 micro satellites to be launched every year for the next 10 years, while specifying that 15 satellite constellations are in development at the current time, most of them by companies that already have satellites placed in Earth's orbit. Small satellites are mostly used for Earth observation, weather forecasting, communication, navigation, and scientific research.

The global space market is currently estimated to be a total of EUR 400 billion, with over 100 small micro launchers being developed, of which only several are operational (gminsights.com, 2023). Progress in technology, such as new manufacturing methods - including AM (additive manufacturing), new concepts such as electrically driven turbopumps, and the possibility of using newer, greener propellants, such as cryogenics or bio fuels (bio propane), are expected to have a meaningful contribution to the space market growth.

European innovation-based strategies and space-related development programs

A significant amount of funds - 137,500,000.00 EUR - granted by the European Commission in 2023, were directed towards the research and development of new space transportation solutions and services. These solutions and services were requested to reach, in some of the calls for proposals, a very high Technology Readiness Level, together with a strategy for the deployment of the proposed technologies to reach the market. The HORIZON SPACE programme concentrated on the development of technologies for recovery of space transport vehicle elements, Earth observation systems, space ecosystems, low-cost high-thrust propulsion, and launch facilities, with an emphasis on space technologies for European non-dependence and competitiveness. All of these are mentioned in the Space Cluster HORIZON-CL4-SPACE-01 and can be found on the ECAS platform (ecas.ec.europa.eu, 2024). EU looks for solutions to double the accessible space transportation service market to European industry by 2030, by providing low-cost, reliable propulsion systems, while offering the possibility to reduce the production times of European-originated micro-launchers and by developing economically viable routes to access space and space-related services for European SMEs (ecas.ec.europa.eu, 2024).

ESA programs, such as FLPP (Future Launchers Preparatory Programme) and BOOST!, are further discussed. FLPP (www.esa.int, 2024) is described as a monitoring tool for system studies and research activities for new, reliable, and performant, low-operational-cost technologies. This programme includes studies regarding performance increase and cost reduction by usage of newer, greener propellants (the cryogenic fuels are expected to provide a better ideal specific impulse, determined by the propellant combination, the highest ideal specific vacuum impulse is found in the LOX-LH2 combination, as specified by O. Haidn (Haidn, 2015). The BOOST! programme (or Commercial Space Transportation

Services – C-STS) (www.esa.int, 2024), aims at encouraging commercial initiatives that offer space transportation services, for example for micro launchers, enabling ridesharing opportunities and dispenser technologies, at lower prices.

It is well-known that the ESA Director General's Agenda 2025, published in March 2021, reiterated the importance of making ESA a greener organization, advocating the implementation of the Paris Agreement and the European Green Deal (esa.int, 2021).

Although ESA is working towards building a greener, more accessible climate while expanding its market presence through fantastic support provided to innovative ideas, the space launchers market and satellite market are dominated by the USA. The global Space Launch market size has been evaluated at 13188.77 mil. USD in 2023, with a CAGR of 12.41%, during a forecasted period from 2024 to 2031, and it is expected to reach 26611.4 mil USD by 2031 (LatestBusinessInsights.com,2024). Predictions regarding the USA's market dominance from 2021 included the fact that the USA will remain the main investment hub for space launch services at least by 2027 (marketsandmarket.com, 2023).

The link between the satellite market and the launch industry is very strong. Nevertheless, potential investors rank each market segment separately, giving them an individual risk assessment. Figure 1 presents the risk assessment of market segments and business models along five delineators, as provided by SpaceTec Partners in the "European Investment Bank Report", realized for the European Commission in 2019.

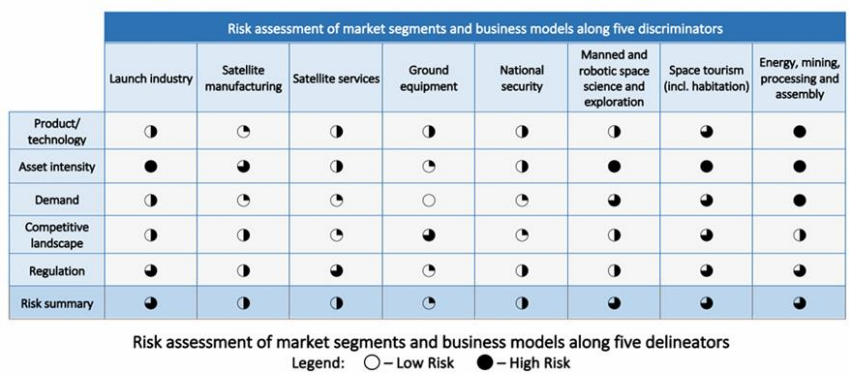

Fig. 1. Risk assessment of market segments and business models along five discriminators (SpaceTec, 2019)

The same study presented above offers insight into the current situation of the space industry climate and the provenance of the funds invested in the space sector at the global level. It is mentioned that around 90 nations have a government

space budget, at least 9 of them surpassing the 1 billion USD mark, while nearly 20 are close to 100 mil. USD (SpaceTec, 2019). The report also presents a short analysis of the satellite market, by directly linking it to the progress in technology, allowing them to become cheaper and smaller, more and more of them being launched in recent years, and providing the statistics that in 2020, there were circa 3000 operational satellites, a considerable amount when compared to the ones active in 2009 (circa 986 operational satellites). The 3000 operational satellites belong to 95 different countries, of which very few have access to their own launching infrastructure.

A global approximation of the number of small satellites (under 500 kg) to be launched per year in the next decade is provided by Henkel and We to be in the range of nearly 4.000. Europe is assessing the fact that it expects a mass of 3.3 tons per year of total satellites to be launched by European operators in the 2025-230 period (DGLR Dossier, 2021).

The wish to provide a custom, faster, safe, low-cost solution to launching can, therefore, be anticipated. The development of multiple small rockets is said to make the launching campaign customizable, by providing the required satellite orbit and launching times, at lower costs. Globally, there are over 100 projects developing light-lift and micro-lift rockets. The graph from Figure 2 illustrates the geopolitical spread of the 100 projects.

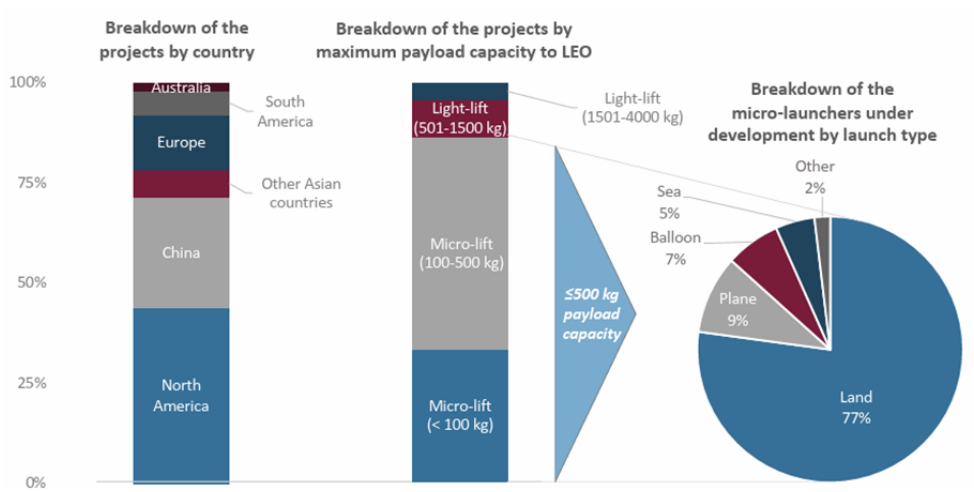

Fig. 2. Geo-political spread of the 100 projects, developing light-lift (501-4000 kg payload capacity) and micro-lift rockets (≤500 kg payload capacity)

By providing multiple launching solutions, at a faster launching pace, the issue of access to a geographically closer spaceport arises.

Most of the existing active spaceports are in the USA, Europe (French Guiana), Russia, and China. The SpaceTec report mentions the fact that Europe's number of spaceports presents significant growth, as seven sites in the UK have already applied for a license and cover most types of launches.

There are many tools available to the general public designed to help understand the development of the satellite market in recent years. An interesting interactive map of active satellites can be found on the ESRI portal. This map was developed by Richie Carmichael for the Prototype Lab. In 2017, the Department of Defense's US Space Surveillance Network announced that they can track objects orbiting the Earth as small as 5cm in diameter, and therefore obtaining a map that separates the space debris from the actual satellites represented a challenge for a long period (Datta, 2017). The concerning aspect to be mentioned from the ESRI portal is the amount of space debris registered. The solution to stop space pollution found by the European Union is, amongst others, offering support to projects proposing the implementation of recoverable and reusable technologies.

The "Small launchers: A European Perspective" document issued by DGLR and AAE (DGLR Dossier, 2021), has a number of 15 recommendations, discussing the potential focus point in the development of new small launchers, their ideal payload, the engine stages configuration (recommended re-usable/recoverable technologies for at least the boost stage, its propellant – mainly development of hybrid, green, cryogenic propellants), and the importance of aligning the launching regulations to the rest of the world.

The intent to provide a launching option for small satellites has been opened through the development of small launchers, Vega. The Vega programme is managed by ESA, ASI, and CNES. The launcher has a total payload of 1.500 kg and is powered by: a 1st stage single solid-rocket motor (P80) and two liquid rocket engines serving as the 2nd and the 3rd stages, Zefiro23 and Zefiro9, respectively (ESA, 2007). The engines have been used on the Vega launcher since 2019, and Zefiro40, a derivative, is used on Vega-C. The Zefiro engine is produced by Avio S.p.A and has been successfully tested for the first time in December of 2005.

The information provided above is relevant in terms of engine development times. The first tests were conducted in 2005, and the first flight was conducted in 2012. The Zefiro9 engine has had previous variants, like the Zefiro16, which was tested in 1998, 1999, and 2000. The propellant used by the Zefiro rocket engines is Aluminum-Hydroxyl-Terminated Polybutadiene (Al-HTPB) (ESA, 2007).

Other engines using greener propulsion (LOX-LCH4, LOX-LH2, etc.) have been developed or are at the moment in the testing stages.

Discussion and conclusions

Several aspects have a smaller influence on the market trend analysis. The probability of impactful, global negative events is very low, but as history has proven, it is never zero. One of these events was the 2019 pandemic, when multiple factories shut down their activity, together with the transportation services. Launches have been delayed due to the global character of the phenomenon, and market trends have become obsolete. Teleworking became mandatory for most staff, including NASA, who kept their personnel in charge of keeping the ISS running and responsible for launching on the ground. The COVID-19 pandemic has been fatal to many small enterprises. According to (OECD, 2019), small companies create the biggest number of jobs in the field, and most of their activities are based on the development of innovative products, specific key elements, and special components, vital to the space launch industry. Governmental support has been offered to the affected companies. Although government support has proven to have a critical positive impact in some cases, for others, aid schemes implemented and the identification of appropriate support programmes proved to be difficult to navigate (OECD, 2019).

However, in spite of fighting the incertitude brought on by the pandemic, several important steps in space launching have been taken. Globally, the year 2020 has presented several disparities between the satellite launching companies. While SpaceX started operation of the Starlink constellation, making history, OneWeb, set to start launching at the same time, filed for bankruptcy due to the new conditions brought on by the COVID-19 pandemic (IP Access, 2023). With good downsizing and reorganizing strategy, expanding their partnerships and diversifying their portfolio, OneWeb managed an amazing market resurgence.

In 2020, ESA launched very few satellites, meant to conduct measurements regarding the Sun's heliosphere and ocean topography measurements. 2020 is considered relevant for the present study due to its temporal positioning in the COVID-19 pandemic, being situated in a moment of uncertainty, when drastic measures were implemented, including full-country or country-area lockdowns.

The opposite reaction is obtained when breakthrough technologies are implemented, with regard to existing forecasts. Innovative technologies can generate considerable impact for the company owning the patents, ideas, or new products. Innovation can come from different types of activities, and its huge importance counterbalances the risks implied by the development of a new idea. Innovation can be obtained in several ways, such as product innovation, process innovation, business model innovation, and marketing innovation (fastercapital.com, 2024).

In the space sector, one can state that the market has a lot of untapped potential, coming from the development in material science, manufacturing methodologies, chemistry findings, social studies, and more.

One of the most impactful factors could be the development of new propulsion systems, shortening the production times from decades to a few years, adding the aspect of stage-communality.

The present article underlines the importance of 6 aspects in the evolution of the space launching market: a) the exponential growth of the small satellite market, b) the contribution of several European programs to the process of achieving space-launching autonomy, c) global space market dynamics – the European strive for growth and innovation, d) impact of potential external factors: the influence of those factors on the most vulnerable – the small enterprises, e) role of innovation in market resilience, f) the untapped potential in space sector and drive future market expansion.

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ПЪТ КЪМ БЪДЕЩЕТО: ИНОВАЦИИ В ЕВРОПЕЙСКИТЕ КОСМИЧЕСКИ ЗАДВИЖВАЩИ ТЕХНОЛОГИИ И ДИНАМИКА НА ПАЗАРА НА МАЛКИТЕ САТЕЛИТИ

Е. Присакариу

Резюме

Пазарът на малки сателити отбелязва динамичен растеж, обусловен от нарастващата необходимост от независим достъп до Космоса. Докато настоящите възможности включват споделени изстрелвания, специализираните ракети за малки сателити предлагат персонализиран достъп, като наносателитите могат да преминат от концепция до изстрелване в рамките на едва осем месеца. Европа инвестира значително в научноизследователска и развойна дейност в сферата на космическия транспорт чрез програми като HORIZON SPACE, насочени към повишаване на конкурентоспособността и намаляване на зависимостта от външни доставчици. Инициативи на Европейската космическа агенция (ЕКА), като FLPP и BOOST!, се фокусират върху технологичния напредък и разширяването на търговските услуги. Въпреки тези усилия, САЩ продължават да доминират на пазара на космически изстрелвания. За да повиши своята конкурентоспособност, Европа си поставя за цел да удвои дела си в сектора на космическия транспорт до 2030 г., като разработва икономически ефективни технологии за задвижване и изстрелване, насочени към малките и средните предприятия. Над 100 проекта по света работят върху развитието на ракети с малък и микро полезен товар, като се отчита необходимостта от стратегически разположени космодруми за оптимизиране на разходите и логистиката. В същото време предизвикателства като космическите отпадъци изискват иновативни решения. Препоръките в сектора подчертават значението на многократно използваемите технологии и разработването на по-екологични задвижващи системи.

Пандемията от COVID-19 разкри уязвимостите на индустрията, но също така стимулира иновациите и устойчивостта. Настоящият доклад анализира комплексните фактори, оформящи еволюцията на пазара на космически изстрелвания, включително пазарната динамика, европейските инициативи, външните влияния, технологичните иновации и бъдещите перспективи.