

Isar Aerospace and the Spectrum Launch Vehicle -- At the Forefront of Future European Launch Services

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Abstract— *The European space industry is at a critical juncture in its development. After the past years of rapid growth, the industry has necessitated innovative launch solutions to meet the ever-increasing demand for both efficient and cost-effective access to space. Isar Aerospace SE (ISAR), headquartered in Ottobrunn, Germany, introduces Spectrum, an in-house developed launch vehicle designed specifically to address these regional needs. Spectrum has been engineered to provide flexible and economical launch solutions, catering to the varied technical demands of customers worldwide. The design and development of the launch vehicle is characterized by a fully vertically integrated approach; which ensures a particularly high degree of reliability and performance. Extensive and rigorous system testing underpins Spectrum's capacity to facilitate rapid and affordable access to space for small and medium satellites. With such a high cadence launch service, ISAR is positioned to significantly enhance market competitiveness and presence for our customers. Through the leveraging of advanced engineering and manufacturing processes, ISAR strives to redefine the space access landscape in Europe. The following paper will detail the technical innovations, operational efficiencies, and strategic benefits of Spectrum, ultimately positioning ISAR at the forefront of future European launch services.*

Keywords—Space; Launcher; Europe; Satellite

I. INTRODUCTION

Particularly over the past decade, the European space industry has undergone transformative growth, and an urgent need has arisen for innovative launch solutions that are tailored to address the increasing demand for both cost-effective and efficient access to space. The industry itself has burgeoned in support of enabling a diverse range of applications of space technologies, which range from climate monitoring to internet coverage. This array of contexts, many of which have a direct impact upon our day-to-day lives, serve to highlight the critical importance of accessible satellite launch services.

Isar Aerospace SE (ISAR), headquartered in Ottobrunn, Germany, exemplifies such an 'innovative' launch solution. Founded in 2018, ISAR originated as a spin-off from the Technical University of Munich (TUM) with a clear mission: revolutionising access to space by providing flexible and economical access. ISAR's launch vehicle, Spectrum, has been designed to address the ever-growing space access needs through innovative architecture and a fully vertically integrated development approach. The launch vehicle is particularly suitable for the deployment of small and medium satellites into Low Earth Orbit (LEO) and Sun Synchronous Orbits (SSO), thus specifically addressing a market segment undergoing significant growth. Through leveraging cutting

edge engineering and manufacturing processes, ISAR aims to redefine the landscape of space access in Europe, consequently positioning itself at the forefront of future European launch services.

The following paper seeks to provide an examination of the various technical innovations, operational efficiencies, and strategic benefits associated with the Spectrum launch vehicle. Through analysing ISAR's business approach, which gravitates around extensive vertical integration, high-cadence launch services, and customer-centric solutions, the paper will also underscore how ISAR has positioned itself to enhance market competitiveness and presence for its customers; noting the broader implications of ISAR's contributions to the European space industry and emphasizing the company's role in fostering a dynamic and sustainable space ecosystem.

In the following chapters, the paper details the background to ISAR's market positioning, the Spectrum Launch Vehicle itself, ISAR's Launch Service, and the ultimate impact of ISAR's launch services upon the European market. In doing so, this paper establishes a thorough understanding of how ISAR is evolving the future of space access in Europe and beyond.

II. BACKGROUND AND MARKET ANALYSIS

A. Evolution of the Space Industry in Europe and Beyond

The exponential growth of the European space industry, particularly of the private and 'New Space' areas over the past years has been largely driven by technological advancements (improving access to, and affordability of space tech) [1], increased investment, and a surge in demand for satellite-based services including communication, Earth observation, and scientific research. This sector, once dominated by government/ institutional entities, can be seen to be transitioning towards increased commercialisation, spurring a new era of innovation and competition among private actors [2]. This dynamic and increasingly competitive environment has enabled new players, such as ISAR, to emerge and contribute directly to the European industry's expansion.

Public sector investments worldwide are anticipated to continue to broaden, with 'new entry' countries such as Thailand and Peru investing extensively in diverse space initiatives. Simultaneously, private sector space investment continues to surge, driving innovation and access to a variety of segments, and extensive non-space private sector partnerships with space players also expand [2].

The global space economy has been forecast to reach \$1.8 trillion by 2035, up from \$630 billion in 2023 and growing at

an average of 9% per annum [2]. The global satellite market in particular has experienced substantial growth, driven by the state of proliferation of small and medium-sized satellites designed for a multitude of applications. According to a recent satellite market report by ‘Allied Market Research’, the satellite market was valued at \$5.4 billion in 2019 and is projected to grow to a value of \$18.7 billion by 2027, with a compound annual growth rate (CAGR) of approximately 16.5% [3].

In its role as a European launch service provider, one that is also positioned at the forefront of this burgeoning market, ISAR focuses primarily upon launching small and medium-sized satellites to LEO and SSO. These market segments of these orbit types are particularly promising for several reasons:

- **Low Earth Orbit (LEO):** Typically, satellites in LEO are utilized for communication services, including global internet access. Satellites in LEO also support Earth Observation missions, another rapidly growing segment in Europe, providing valuable data insights for areas such as agriculture, energy, construction, and climate research. The LEO launch services market is expected to grow at a CAGR of 23.17%, reaching \$38.29 billion by 2027 [3].
- **Sun Synchronous Orbit (SSO):** Consistent illumination is offered by Satellites in SSO, making them ideal for many remote sensing applications. The market for SSO launch services is anticipated to grow at a CAGR of 18.97%, reaching \$21.82 billion by 2027 [3].

The significant increase in satellite constellations designed for the above highlighted orbits underscores the necessity of reliable and economical launch solutions, which ISAR aims to provide.

B. Market Landscape

The satellite launch industry is characterized by intense competition, with numerous providers vying for market share. Established launch service providers such as SpaceX, Rocket Lab, and Arianespace are setting the standard in regard to, e.g., launch cadence and cost-efficiency; however, the increasing demand for satellite launches and ever shifting geo-political climate has created opportunities for new entrants, such as ISAR, to introduce innovative approaches and service offerings tailored to specific market needs.

Alongside innovations being carried out by Europe’s space companies, Europe’s satellite launch market as a whole is expected to expand significantly, driven by both commercial and governmental initiatives. Two of the primary regional institutions involved in space, the European Commission and the European Space Agency (ESA), are actively supporting commercial launch providers, such as ISAR, to enhance Europe’s autonomous and sovereign access to space. This support is critical for ongoing and future endeavors towards overcoming the challenges posed by a limited regional launch capacity and the need for alternative solutions amidst pressures from the surrounding geopolitical and competitive environments.

ISAR’s entry into the market with its Spectrum launch vehicle has been able to strategically capitalise on these aforementioned growth opportunities. The company’s focus on launch services for small and medium satellites positions it to directly serve the burgeoning demand for access to LEO and SSO across the satellite market. And through offering flexible and cost-effective launch solutions, whilst simultaneously leveraging advanced engineering and manufacturing processes, ISAR aims to carve out a significant share in the European and global satellite launch markets and redefine space access in Europe; subsequently enhancing market competitiveness and presence for its customers.

III. THE SPECTRUM LAUNCH VEHICLE AND ISAR’S LAUNCH SERVICE

A. Technical Specifications of the Spectrum Launch Vehicle

ISAR’s Spectrum launch vehicle, a two-stage rocket developed in-house, represents a significant advancement in satellite launch technology. Designed to offer flexible and economical launch solutions, Spectrum serves the diverse technical demands of customers worldwide, with particular optimisation for the deployment of small and medium satellites into Low Earth Orbits (LEO) and Sun Synchronous Orbits (SSO). Following the first successful test on March 20th, 2025, during which Spectrum successfully cleared the launch pad, and was terminated at T+30 seconds [4], ISAR’s launch vehicle is now positioned to begin to serve the commercial market. This achievement also established as the first European commercial space company to launch an orbital rocket from Continental Europe.

Spectrum’s design choices are driven by balancing proven technologies with new design and manufacturing concepts to achieve minimum complexity and maximum performance and reliability. This is combined with the lowest cost and development time to ensure the scalability of the launch services, including rocket reusability.

This is achieved by maximum commonality between the two stages and the systems used. Therefore, structures, fluid systems, propulsion, and avionics all follow the same baseline for both stages. The vehicle is designed to execute high-performance in-orbit transfer maneuvers and accurate payload deployment without an additional kick-stage, thereby minimizing the number of critical separations and developments required to achieve full-service capability.

Moreover, Spectrum’s systems are designed to be REACH-compliant. The propellant combination is liquid oxygen (LOX) and liquid propane (LPP), driven by a few crucial factors: environmental friendliness and superior performance to other hydrocarbon fuels due to the usage of densified propane at LOX temperature (90K), as well as unhampered availability in Europe. This also allows for high-efficiency designs, e.g., standard bulkhead tanks and single-shaft turbopumps.

Spectrum’s design is characterized by a fully vertically integrated approach, ensuring high reliability and performance. This integration allows ISAR to maintain control over cost, time, and quality throughout the development process. Key technical specifications include:

- **Propulsion System:** Spectrum is powered by 9 ‘Aquila’ rocket engines. The engine has been entirely developed in-house, showcasing ISAR’s capability in advanced propulsion technology.

- **Structural Components:** The vehicle's carbon composite structures are also manufactured in-house using automated winding machines and large autoclaves. This ensures the high strength-to-weight ratio necessary for efficient space launch.
- **Avionics and Control:** Spectrum features fully integrated avionics, guidance, navigation, and control (AGNC) systems, including an in-house developed flight termination system (FTS). These systems are critical for ensuring the precision and safety of launches.
- **Staging:** Spectrum is designed with only two stages for the least amount of separation events to minimize potential failures associated with these events. Stage separation uses completely pyrotechnic-free systems to ensure a low-shock environment for the payload.
- **Vertical integration:** Spectrum has been inherently designed to meet high launch cadence. The vehicle is manufactured, processed, and integrated horizontally. This results in no need for crane-based material movement and in reduction of structural overhead and accident risks.

B. Operational Strategy

ISAR's operational strategy revolves around providing high cadence launch services and maximum convenience for its customers. This strategy is supported by extensive infrastructure development and a customer-centric approach.

To ensure high flexibility and coverage of various orbit inclinations, ISAR offers a choice of multiple launch sites. The Spectrum launch vehicle currently operates from Andøya Space Center (ASX) and will soon also operate from the Guiana Space Centre (CSG). ISAR operates an exclusive launch pad in Andøya, which is ideal for accessing polar and Sun-synchronous orbits, offering launch inclinations ranging from 87 to 111 degrees. ISAR will also operate an exclusive launch pad at CSG in Kourou, which will be available from 2027 and is suitable for a wide range of inclinations, from equatorial to mid-inclination to sun-synchronous inclinations. The access to these launch sites ensures maximum launch availability for the European market, with the infrastructure at said launch sites being designed and built with rapid deployment in mind; including flexible cleanroom solutions and facilities for payload final preparation, fueling, and integration.

Parallel to ISAR's launch site access, ISAR proposes high cadence launch services as a fundamental component of its launch service offering, which will accelerate its competitiveness and presence in the marketplace worldwide. This high cadence is enabled by ISAR's 'vertical' manufacturing approach, with over 90% of Spectrum being built in-house and the manufacturing capabilities of ISAR's existing and future manufacturing facilities. ISAR recently started the construction of its new campus, which will combine manufacturing and headquarters under the same roof. The new facility, located in Vaterstetten, Germany, will roughly cover more than 40.000sqm, scaling up and supporting high-cadence manufacturing and launch services. This ability to offer frequent and reliable launch opportunities is crucial for critical European market segments, such as satellite constellation deployments, which require coordinated and timely launches.

Through its role as launch service provider, developer, and manufacturer of the Spectrum launch vehicle, ISAR offers a comprehensive end-to-end service. This approach includes the construction of necessary launch infrastructure, full system testing, and operational support, which seeks to provide maximum convenience and reliability to customers; further strengthening ISAR's market positioning

C. Strategic Positioning

ISAR has strategically positioned itself to compete effectively in the international satellite launch market by leveraging several unique value propositions. These propositions are highlighted briefly in the following chapter.

Vertical Integration

Vertical integration enables ISAR to maintain full control over the cost, time, and performance of all systems. This approach allows for a smooth transition from development to operations and supports future upgrades to Spectrum for increased performance / payload capacity. Through owning the design, manufacturing, assembly, and testing processes, ISAR ensures high quality and reliability whilst simultaneously reducing overarching lead times and costs.

Scalability in Manufacturing

ISAR has created in-house infrastructure which achieves manufacturing scalability through high levels of automation, serial production, additive manufacturing, rapid prototyping, and in-house testing. These innovations reduce the time required for critical systems' design-to-test cycles to less than a month, which significantly lowers costs and increases ISAR'S production capacity. ISAR has reduced the time required to build each of its engines to fourteen days, enabling the manufacture of up to 50 engines a year.

Flexible and Cost-Effective Offerings

ISAR offers flexible and cost-effective launch configurations that adapt to both small and medium payloads, including options for Rideshare, Lead, and Dedicated Configuration launches.

- The Dedicated Configuration option enables customers to select the desired orbit and time of launch with zero dependencies on other passengers.
- The Lead Configuration enables customers to select the desired orbit and time of launch while accompanied by other passengers on board, lowering the total cost of the launch.
- And the Rideshare Configuration, where ISAR is responsible for finding and allotting the most suitable launch for a customer's mission and they hop on board with other passengers.

This flexibility is highly sought after by customers in a market where flexibility can often be hard to come by in launch service offerings. This is especially the case with 'New Space' startups that naturally seek affordable and reliable access to space for their business models.

IV. IMPACT ON THE EUROPEAN SPACE INDUSTRY

ISAR's commitment to leveraging advanced engineering and manufacturing processes, vertical integration, and a customer-centric approach has positioned it as an innovative and central player in the satellite launch market. Through the

provision of both flexible and economical launch solutions, ISAR enhances market competitiveness and presence for its customers, consequently spurring the industry forwards and directly contributing to the dynamic and sustainable growth of the European space ecosystem.

Following its maiden test flight, the introduction of the Spectrum launch vehicle to the commercial market is poised to significantly impact the European space industry. This can be considered as particularly critical given the aforementioned current challenges faced by the industry, such as limited launch capacity and the need for alternatives amidst geopolitical and competitive pressures. ISAR's planned high cadence launch services will increase the frequency of satellite deployments, thus enabling quicker and more efficient access to space for European entities. By adopting such a customer-centric approach/ commercialisation strategy, ISAR fosters a vibrant space ecosystem in Europe; supporting new space startups and established players alike, ultimately facilitating the growth of a diverse and dynamic space industry. Such an ecosystem is essential for driving innovation, creating new business opportunities, and ensuring the long-term sustainability of the European space sector.

By focusing on advanced engineering and manufacturing processes, ISAR also seeks to drive technological innovation within the European space sector. ISAR's previously highlighted extensive use of cutting-edge practices in automation, serial production, additive manufacturing, rapid prototyping, and in-house testing sets new standards for aerospace efficiency and cost-effectiveness. And these innovations not only reduce the time and costs associated with building critical systems, but also explicitly position Europe as a whole as a leader in pioneering space technologies.

ISAR's contribution to the development of the European space ecosystem is also greatly supported and enhanced by the involvement of regional institutions, such as the European Commission and the European Space Agency (ESA), both of which are actively supporting commercial launch providers like ISAR to enhance Europe's autonomous and sovereign space access. Through ISAR's entry into the European commercial launch services market, it directly contributes to this strategic goal by providing independent and reliable launch capabilities. Such regional autonomy is crucial for ensuring that Europe is able to maintain its competitive edge and also reduce dependence on non-European launch providers.

V. CONCLUSION

The European space industry is at a critical juncture, one characterised by rapid growth and an increasing demand for efficient and cost-effective access to space. Within this

dynamic and competitive environment, ISAR has emerged as a key player, poised to redefine the landscape of space access in Europe through its innovative Spectrum launch vehicle.

The analysis presented in this paper highlights ISAR's strategic benefits, technical innovations, and operational efficiencies. The ability to provide high cadence launch services is absolutely crucial for accelerating market competitiveness and presence, particularly for satellite constellation projects that require coordinated and timely deployments.

Moreover, ISAR's impact on the European space industry specifically is extensive. Through the provision of a reliable and cost-effective alternative to existing launch services, ISAR directly addresses critical challenges faced by the region, such as limited launch capacity and the need for alternatives amidst geopolitical and competitive pressures. The company's focus on advanced engineering and manufacturing processes is a testament to technological innovation in aerospace and is positioning Europe as a leader in cutting-edge space technology. Such strategic and technological initiatives have been designed intentionally to support long-term growth and development across the European space industry.

In conclusion, ISAR and its Spectrum launch vehicle offer significant strategic benefits that enhance market competitiveness and presence for its customers. And through a multitude of innovative developments and customer focused strategic approaches, ISAR's contributions are set to drive the future of satellite launch services in Europe, consequently shaping the landscape of space access and fostering a vibrant space sector.

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