

# **Beyond Earth: Deep Research on the Most Important Breakthroughs and News in Space and Aerospace from the Past 7 Days**

## **Introduction: The Accelerating Pace of Technological Realization**

The week of October 10-17, 2025, marks a significant inflection point in the space and aerospace sector, characterized by a decisive shift from theoretical concepts and experimental programs to the tangible realization of foundational technologies. The dominant narrative is no longer one of scientific discovery alone, but of industrialization and the methodical construction of the physical and logistical infrastructure required for a sustained off-world economy. This period's key developments underscore a maturation across the industry, where the focus has pivoted from the "what" to the "how"—the logistics, manufacturing, and transportation systems that will define the next era of activity beyond Earth.

Four pivotal trends have emerged this week, each signaling a systemic advance toward operational capability. First, the successful conclusion of SpaceX's Starship Version 2 test campaign represents a major de-risking of the world's most powerful launch system, moving the conversation around orbital-class reusability from a future possibility to a near-term engineering reality.<sup>1</sup> Second, the in-space manufacturing (ISM) value chain has been dramatically solidified through a landmark agreement between Varda Space Industries and Southern Launch, establishing the first high-cadence commercial pipeline for returning products manufactured in orbit—a previously missing and critical link for the sector's economic viability.<sup>3</sup>

Third, a fundamental paradigm shift in satellite production is accelerating, exemplified by the emergence of Apex Space's mass-production model. This approach, which mirrors the automotive industry's transition from bespoke coachbuilding to scalable assembly lines,

promises to radically alter the cost and deployment speed of future satellite constellations.<sup>4</sup> Finally, the convergence of terrestrial and space-based networks is becoming a technical reality, with projects like the ESA/Altice Labs '5G Nanosatellite' initiative demonstrating the potential for satellites to function as integrated nodes within a global communications fabric, rather than as isolated systems.<sup>6</sup>

Collectively, these events paint a picture of an industry in the midst of a profound transformation. The successful test of a super-heavy lift vehicle, the establishment of a reliable return-to-Earth supply chain, the industrialization of satellite manufacturing, and the physical assembly of the first human-rated deep-space vehicle in half a century are not disparate news items. They are interconnected components of an emerging ecosystem. This week's progress demonstrates that the foundational infrastructure for a robust cislunar economy is not just being planned; it is actively being built, tested, and validated.

## **Key Technological Breakthroughs: Forging the Tools for a New Era**

The past seven days have been marked by critical advancements in the core technologies that underpin access to and operations in space. Progress was not incremental but foundational, spanning the full spectrum from launch vehicle reusability and advanced materials to the validation of on-orbit manufacturing processes. These breakthroughs are not merely engineering achievements; they represent the forging of the essential tools required to build and sustain future space infrastructure.

### **Heavy-Lift Reusability: The Starship V2 Swan Song and V3 Prelude**

On October 13, 2025, SpaceX successfully conducted the eleventh Integrated Flight Test (IFT-11) of its Starship vehicle from the Starbase facility in Texas.<sup>7</sup> The mission served as the final flight of the "Version 2" (V2) vehicle design and achieved all of its primary test objectives, culminating in planned splashdowns of both the Super Heavy booster in the Gulf of Mexico and the Starship upper stage in the Indian Ocean.<sup>1</sup> This flight provided a wealth of data, effectively closing a significant chapter of the test campaign and paving the way for the more advanced "Version 3" (V3) vehicle.

The technical achievements of IFT-11 were substantial and demonstrated significant progress toward operational reusability. A key innovation was tested during the Super Heavy booster's

landing sequence. The booster initiated its landing burn by igniting 13 of its Raptor engines—a dramatic increase from the three-engine burns used in earlier tests—before throttling down to a three-engine configuration for the final moments before splashdown.<sup>1</sup> This complex maneuver validates a more robust and redundant landing profile, which provides a greater margin for engine-out scenarios and is a critical step toward the high-energy returns required for future attempts to "catch" the booster with the launch tower's mechanical arms.

Equally critical was the successful in-space relight of a single Raptor engine on the Starship upper stage.<sup>1</sup> This capability is non-negotiable for future missions, as it is required to perform the final de-orbit burn for a precision return to Earth or to execute orbital maneuvering and interplanetary injection burns. The test effectively demonstrated the engine's reliability after exposure to the vacuum of space.

Furthering the program's aggressive testing philosophy, SpaceX engineers intentionally removed select heat shield tiles from the Starship's hull.<sup>2</sup> This stress test was designed to expose the vehicle's most vulnerable areas to the intense heat of atmospheric reentry, allowing engineers to gather invaluable data on thermal limits and potential failure modes. This approach significantly accelerates the design validation process for the vehicle's reusable thermal protection system. The mission also successfully demonstrated operational capabilities, including the deployment of eight Starlink satellite simulators in suborbital space and the execution of a dynamic banking maneuver during reentry to test guidance algorithms for future precision landings.<sup>1</sup>

The successful conclusion of the V2 test series provides a high-confidence data set that directly informs the transition to the larger and more capable Starship V3, expected to begin flights in 2026. The V3 iteration is designed for operational payload missions, including Starlink deployments and, most importantly, on-orbit propellant transfer—the key enabling technology for crewed missions to the Moon and Mars.<sup>4</sup>

## **Advanced Materials for Propulsion: ESA's Phoebus Project**

The European Space Agency (ESA), in partnership with ArianeGroup and MT Aerospace, reported significant manufacturing and testing progress on the Phoebus project. This ambitious initiative aims to replace the metallic cryogenic propellant tanks on the Ariane 6 upper stage with significantly lighter Carbon-Fiber Reinforced-Plastic (CFRP) alternatives.<sup>11</sup> A successful outcome for this project would represent a major materials science breakthrough, directly enhancing the performance and competitiveness of Europe's flagship launch vehicle.

The primary technical challenge of the project lies in the containment of liquid hydrogen, which must be stored at a temperature of  $-253^{\circ}\text{C}$ , just 20 degrees above absolute zero.<sup>11</sup> At

such extreme temperatures, conventional CFRP composites can become brittle and develop micro-cracks. The challenge is compounded by the fact that hydrogen is the smallest molecule in the universe, allowing it to leak through imperfections that would contain other propellants. The Phoebus team has had to develop novel composite weaves and proprietary resin formulations specifically designed to maintain their integrity and impermeability under these harsh conditions.<sup>11</sup> The project also faced the challenge of measurement, as no off-the-shelf devices existed to accurately measure minuscule hydrogen leak rates at such cryogenic temperatures, requiring the development of new sensor technologies.<sup>11</sup>

Recent progress indicates the project is moving from small-scale demonstrators to full-scale test articles. A 2,600-litre, 2-meter diameter hydrogen test tank completed its initial manufacturing steps at MT Aerospace in Germany in September 2025 and is on schedule for completion by December 2025. This tank is slated for a rigorous test campaign beginning in April 2026 at a new, specially designed facility in Trauen, Germany, where it will be cryogenically loaded and pressurized to its structural limits to precisely map the onset of material stress.<sup>11</sup> In parallel, a full-scale 3.5-meter diameter liquid oxygen tank demonstrator has also reached the final phases of production, demonstrating the viability of the technology for both of Ariane 6's cryogenic propellants.<sup>13</sup>

The strategic importance of this project cannot be overstated. Successfully developing and qualifying CFRP cryogenic tanks could save several tonnes of mass on the Ariane 6 upper stage. This mass reduction translates directly into increased payload capacity, allowing the launcher to carry heavier satellites to geostationary transfer orbit or to send scientific missions on more ambitious interplanetary trajectories. This performance enhancement is a critical element in ESA's strategy to ensure Ariane 6 remains competitive in a global launch market increasingly defined by performance and cost-efficiency.

## **On-Orbit Manufacturing: From Fabrication to Analysis**

A crucial milestone for the future of in-space manufacturing and assembly was achieved this week with the return of the first metal part 3D-printed aboard the International Space Station (ISS). The component, produced by a metal 3D printer developed by an ESA-led consortium including Airbus, has arrived at ESA's European Space Research and Technology Centre (ESTEC) in the Netherlands for comprehensive terrestrial analysis.<sup>14</sup>

The true significance of this achievement lies not just in the successful printing operation in orbit, but in the "closing of the loop" through detailed ground-based testing. Scientists and materials engineers at ESTEC will now conduct a battery of microstructural and mechanical tests, comparing the space-printed part directly against an identical control sample manufactured on Earth.<sup>15</sup> This comparative analysis will provide the first definitive, empirical

data on how the microgravity environment affects the metallic grain structure, layer adhesion, porosity, and overall tensile strength of a 3D-printed component.

The technology employed for this demonstration was carefully selected for the unique challenges of the ISS environment. The printer utilizes a wire-based deposition process, where a stainless-steel wire is melted by a high-power laser. This method is inherently safer and more easily contained in microgravity than powder-based systems, which risk contaminating the station's atmosphere. The entire process takes place within a sealed, nitrogen-purged box to safely manage the extreme melting temperatures of over \$1,200\$ °C and to prevent the metal from oxidizing during fabrication.<sup>15</sup>

This achievement represents a foundational step toward validating on-orbit manufacturing as a viable technology for long-duration spaceflight. If the analysis confirms that space-printed parts are of equal or even superior quality to their terrestrial counterparts—potentially benefiting from the absence of gravity-induced defects—it will unlock transformative capabilities for future missions. The ability to print tools, spare parts, and even large structural components on demand would drastically reduce the mass of supplies that must be launched from Earth, increasing mission autonomy and resilience, particularly for crewed expeditions to the Moon and Mars.<sup>18</sup>

<b>Vehicle/System</b>	<b>Company/Agency</b>	<b>Key Technological Milestone This Week</b>	<b>Propulsion System Focus</b>	<b>Strategic Implication</b>
<b>Starship</b>	SpaceX	Successful completion of IFT-11, demonstrating advanced 13-engine landing burn, in-space engine relight, and heat shield stress testing.	Methane-Oxygen Full-Flow Staged Combustion (Raptor)	De-risks the path to full, rapid reusability for super-heavy lift, setting the stage for V3 operational flights and lunar missions.
<b>Ariane 6 Upper Stage</b>	ESA / ArianeGroup / MT Aerospace	Progress on Phoebus project: manufacturing	Advanced Materials (CFRP) for Cryogenic	Aims to increase Ariane 6 payload

		of a 2,600-litre CFRP liquid hydrogen test tank nearing completion.	Propellant Tanks (Liquid Hydrogen/Oxygen)	performance by reducing upper stage mass, enhancing competitiveness in the GTO market.
<b>ZERO</b>	Interstellar Technologies (Japan)	Company profile raised by partnership with Toyota, highlighting a focus on manufacturing efficiency for its upcoming orbital rocket.	Liquid Biomethane-Oxygen Gas Generator Cycle (COSMOS)	Establishes a new, potentially disruptive entrant in the small-to-medium satellite launch market, backed by world-class manufacturing expertise.

## Mission and Commercial Developments: The New Economics of Space

The past week has highlighted a profound evolution in the business and operational models governing the space sector. From the industrialization of satellite production to the convergence of space and terrestrial communications networks, commercial entities and government agencies are pioneering new economic frameworks. These developments are driven by technological innovation and are, in turn, creating new markets and capabilities that are reshaping the strategic landscape.

### Disrupting Satellite Procurement: The Apex Mass-Production Model

Apex Space, a Los Angeles-based startup founded in 2022, is aggressively scaling a manufacturing strategy that represents a fundamental departure from traditional satellite production. The company is focused on the high-rate production of standardized, yet configurable, satellite buses in the 100-500 kg class, with the stated goal of reducing delivery times from the industry standard of 12-24 months to just a few months.<sup>4</sup>

The core of Apex's business model is the principle of productization over customization. Rather than designing each satellite bus as a unique, bespoke project, Apex offers three core product lines—the 100 kg class Aries, the ESPA Grande class Nova, and the 500 kg class Comet.<sup>20</sup> Customers can select a base model and then choose from a menu of pre-engineered configuration packages for power, propulsion, communications, and avionics. This approach is supported by a transparent, fixed-pricing structure published on the company's website, eliminating the lengthy and complex custom quoting process that has long characterized the aerospace industry.<sup>5</sup>

This product-centric approach is enabled by a manufacturing philosophy inspired by the automotive industry. Inside its 50,000-square-foot "Factory One," Apex is implementing an assembly line model designed for scalable production, a stark contrast to the traditional, labor-intensive clean-room assembly of one-off spacecraft.<sup>5</sup> To support this model, the company is pursuing aggressive vertical integration, with a goal of increasing its in-house component manufacturing from the current 50% to over 90%. This strategy is intended to reduce reliance on a complex and often slow-moving supply chain, thereby gaining greater control over cost, quality, and production schedules.<sup>5</sup>

The strategic implications of this model are significant. By commoditizing the satellite bus, Apex allows customers—whether commercial constellation developers or government agencies—to shift their financial and engineering resources away from the complexities of spacecraft platform development and focus instead on their core mission: the payload and the data services it provides. This has the potential to dramatically lower the barrier to entry for new space applications and accelerate the deployment of next-generation LEO constellations for communications, Earth observation, and national security.<sup>24</sup>

## **The Convergence of Networks: 5G from Low Earth Orbit**

A pioneering initiative by Portugal's Altice Labs and the European Space Agency (ESA) has entered its second phase, advancing the development of a "5G Nanosatellite" with a planned launch in 2027.<sup>6</sup> This project is a prime example of the ongoing convergence of the space and telecommunications industries, aiming to create a bidirectional 5G terminal in LEO that can seamlessly integrate with terrestrial networks.

A key technical aspect of the project is its strict adherence to the 3rd Generation Partnership Project (3GPP) standards for Non-Terrestrial Networks (NTN). This is a crucial design choice, as it ensures the satellite can function as a standard 5G node—either as User Equipment (UE) or a base station (gNB)—allowing it to interoperate with existing and future terrestrial 5G infrastructure without proprietary protocols.<sup>6</sup> This standards-based approach is the foundation for creating a true hybrid network.

The satellite's terminal is built upon a flexible and powerful technology stack, utilizing a Software Defined Radio (SDR) running on an AMD Radio Frequency System-on-Chip (RFSoc).<sup>6</sup> This hardware choice combines processing, FPGA capabilities, and data converters on a single chip, reducing complexity and allowing for in-orbit software updates to adapt to evolving 5G standards. This flexibility is critical in a rapidly developing field.

The architecture is designed to provide persistent connectivity, a significant improvement over traditional satellite operations that are often limited to short communication windows when passing over specific ground stations. By leveraging a network of ground stations and implementing standard 5G handover and roaming features, the satellite can maintain an almost continuous data link as it orbits the Earth.<sup>6</sup>

The strategic potential of this technology extends far beyond providing simple "satellite internet." It enables a unified, global communications fabric where a user's device could roam seamlessly between a terrestrial 5G tower and a satellite link without interruption. This capability could be transformative for the Internet of Things (IoT), autonomous transportation, disaster response, and providing reliable, high-bandwidth connectivity to the most remote regions of the planet.

## **National Security in LEO: The Proliferated Warfighter Architecture**

On October 15, a SpaceX Falcon 9 rocket launched the T1TL-C mission for the U.S. Space Development Agency (SDA), successfully deploying another 21 satellites into low Earth orbit. These satellites, manufactured by Lockheed Martin, are the latest additions to the Tranche 1 Transport Layer of the Proliferated Warfighter Space Architecture (PWSA).<sup>28</sup>

The PWSA represents a fundamental strategic shift in U.S. military space philosophy. It moves away from the traditional reliance on a small number of large, expensive, and potentially vulnerable satellites in higher orbits. Instead, the PWSA is based on a large, "proliferated" constellation of smaller, more affordable, and interconnected satellites in LEO. This architecture is designed for resilience; the loss of one or even several satellites does not cripple the network, which can dynamically reroute data through its mesh of remaining

nodes.<sup>28</sup>

The architecture is composed of distinct but interconnected layers. The Transport Layer, which is currently being deployed, serves as a low-latency, high-bandwidth data communications backbone in space, akin to a military-grade internet. It is designed to provide tactical data links directly to warfighters on the ground, at sea, and in the air. This is complemented by other planned layers, such as the Tracking Layer, which will consist of satellites equipped with advanced sensors for missile warning and tracking.<sup>28</sup>

The SDA's acquisition strategy is as innovative as its architecture. The agency is heavily leveraging the speed and cost-efficiency of the commercial space industry, contracting with companies like SpaceX for frequent launches and with a diverse set of manufacturers, including Lockheed Martin and York Space Systems, for the satellite buses.<sup>28</sup> This approach allows for rapid deployment and technology refreshment cycles. The PWSA is the Pentagon's tangible response to the challenges of a contested space domain, aiming to provide a persistent, resilient, and globally accessible information network that will fundamentally alter how the U.S. military conducts operations.

## **Emerging Launch Contenders: Japan's Interstellar Technologies**

Japan's private space sector is witnessing the rise of a credible new competitor in the orbital launch market with Interstellar Technologies (IST). The Hokkaido-based startup is making significant strides in the development of its ZERO orbital rocket, targeting a maiden flight in 2027, and is backed by a strategic partnership that could prove decisive.<sup>4</sup>

A cornerstone of IST's strategy is its deep collaboration with Toyota Motor Corporation. IST is explicitly leveraging Toyota's world-renowned manufacturing expertise, particularly the Toyota Production System, to streamline its rocket production processes, enhance quality control, and drive down costs.<sup>4</sup> This application of automotive mass-production principles to aerospace manufacturing is a powerful approach to achieving the cadence and cost-efficiency required to compete in the modern launch market.

The ZERO rocket itself is a two-stage vehicle designed to deliver payloads of up to 1,000 kg to LEO. Its "COSMOS" engine is particularly noteworthy for its use of liquid biomethane as fuel, derived from local agricultural waste.<sup>31</sup> This choice is not only technically sound but also positions the company as a provider of sustainable launch services, a factor of growing importance in the global market.

The company's progress is backed by robust financing. IST has successfully raised a total of \$166M, including a recent \$44.7M Series F funding round led by Woven by Toyota, the

automotive giant's venture arm.<sup>33</sup> This strong financial position, combined with its unique technical and manufacturing strategy, establishes IST as a serious new entrant in the highly competitive small-to-medium launch segment, poised to challenge established players like Rocket Lab and serve the growing Asian space market. The emergence of IST signifies a major maturation of Japan's commercial space ecosystem and introduces a formidable new international competitor to the global launch landscape.

The interplay between these commercial and mission developments reveals a powerful, self-reinforcing cycle of disruption. The dramatic reduction in launch costs and increased flight frequency, pioneered by SpaceX, created the necessary market conditions for large LEO constellations to become economically feasible.<sup>36</sup> This newfound viability, in turn, generated a massive demand for a new satellite manufacturing paradigm, as the traditional, slow, and expensive bespoke model proved incapable of supplying satellites at the required scale and price point. Apex Space's mass-production model is a direct and innovative response to this specific market demand, aiming to become the key supplier for these next-generation constellations.<sup>5</sup> Finally, the ability to rapidly build and deploy hundreds of satellites, enabled by the synergy of low-cost launch and mass-produced buses, provides the technological foundation for new military architectures like the SDA's PWSA, which would be impossible to implement otherwise.<sup>28</sup> This creates a powerful feedback loop where cheaper launch enables mass-produced satellites, which enables new architectures, which further drives demand for both launch and satellites. The events of this week provide a clear snapshot of all the key components of this disruptive cycle actively accelerating in unison.

## **Space Infrastructure: Building the Platforms for Off-World Operations**

This week saw critical progress in the development of the physical infrastructure that will support future operations in Earth orbit and beyond. Key milestones were achieved in the logistics of in-space manufacturing, the strategic leadership of commercial space station development, and the assembly of humanity's next deep-space exploration vehicle. These developments are not isolated; they represent the foundational layers of a burgeoning off-world economy.

## **The Return Leg: Solidifying In-Space Manufacturing Logistics**

Varda Space Industries, a leader in the nascent field of in-space manufacturing, signed a landmark contract with Australian launch and re-entry provider Southern Launch. The agreement facilitates 20 additional spacecraft returns to the Koonibba Test Range in South Australia, with missions scheduled through 2028.<sup>3</sup> This development is a pivotal moment for the entire ISM sector, as it establishes the first routine, high-cadence commercial pipeline for bringing products manufactured in orbit back to Earth.

This agreement moves the industry beyond one-off technology demonstration missions and into the realm of scheduled, operational logistics. Varda plans to leverage this capability to ramp up to a near-monthly return cadence by 2028, a tempo necessary to support a viable commercial enterprise.<sup>3</sup> Varda's business model is predicated on leveraging the unique microgravity environment to produce high-value materials, particularly novel pharmaceutical crystals, that are difficult or impossible to create on Earth.<sup>39</sup> While the manufacturing process in space is the core value proposition, a reliable, licensed, and frequent re-entry capability is the absolute lynchpin of their economic model. This contract with Southern Launch secures that critical "return leg" of the supply chain.

The deal also carries significant geopolitical weight, cementing South Australia's position as a global leader and a trusted location for commercial re-entry operations.<sup>42</sup> The ability to offer safe, land-based returns is a unique and valuable niche in the global space economy. While much of the industry's focus has historically been on the challenges of reaching orbit and operating there, this agreement underscores the critical importance of mastering the logistics of returning valuable products. It marks a major step in maturing the end-to-end business of in-space manufacturing from a scientific curiosity into a sustainable commercial industry.

## **The Post-ISS Era: Commercial Space Station Strategy**

On October 15, Axiom Space, the front-runner in the race to build a commercial successor to the International Space Station, announced a significant leadership transition. Dr. Jonathan Cirtain was appointed as the company's new Chief Executive Officer, succeeding Tejpal Bhatia, who had held the position for the preceding six months.<sup>44</sup> This change in leadership at such a critical juncture offers insight into the company's strategic priorities as it moves toward hardware manufacturing and on-orbit assembly.

Dr. Cirtain's professional background is deeply rooted in engineering and government space programs. A physicist by training, he spent nearly nine years at NASA's Marshall Space Flight Center in key scientific and management roles and later held senior executive positions at BWX Technologies, a firm with extensive expertise in nuclear technologies and advanced manufacturing.<sup>45</sup> This profile contrasts with that of his predecessor, who came from a business development and revenue-focused background, having previously worked at Google

before joining Axiom as Chief Revenue Officer.<sup>47</sup>

This leadership change strongly suggests a strategic pivot for Axiom, placing a renewed emphasis on technical execution and the deep, intricate partnership with NASA. As Axiom transitions from the design and private astronaut mission phase to the far more complex challenge of manufacturing, launching, and integrating its station modules, installing a CEO with a strong NASA and advanced technology pedigree is a clear signal. It serves to reassure NASA, which will be Axiom Station's anchor tenant, that the formidable engineering and safety challenges are the company's paramount focus, especially as the 2030 retirement date for the ISS approaches.<sup>48</sup> This move underscores the symbiotic relationship between the agency and its designated commercial successor, highlighting that technical credibility and mission assurance are the most valuable currencies in this next phase of development.

## **Gateway to Deep Space: Artemis 2 Assembly Milestone**

In a tangible and visually compelling sign of progress for human deep-space exploration, NASA moved the Artemis 2 Orion spacecraft into the iconic Vehicle Assembly Building (VAB) at Kennedy Space Center on October 16.<sup>50</sup> The spacecraft, which has been named 'Integrity' by its four-person crew, is now poised for integration with its massive Space Launch System (SLS) rocket.

This move from the Launch Abort System Facility to the VAB marks the beginning of the final assembly phase for the first crewed vehicle destined for deep space since the Apollo program. Over the coming weeks, technicians will carefully lift and stack the Orion capsule atop the fully assembled SLS rocket, physically completing the vehicle that will carry three NASA astronauts and one Canadian Space Agency astronaut on a ten-day journey around the Moon.<sup>50</sup>

The next phase of work inside the VAB will be dominated by a series of complex, integrated tests that are uniquely crew-centric. A key upcoming event is the Countdown Demonstration Test (CDDT), during which the Artemis 2 astronauts will don their flight suits, board the powered-on capsule, and run through a complete simulated countdown. This critical test will validate procedures, communications, and life support systems and will include drills for emergency egress from the launch pad.<sup>50</sup> Following the work in the VAB, the fully stacked vehicle will roll out to the launch pad for a full Wet Dress Rehearsal (WDR), where the rocket will be loaded with cryogenic propellants.

This milestone keeps the Artemis 2 mission firmly on track for its launch window, which is scheduled to open in February 2026.<sup>50</sup> The physical assembly of the Artemis 2 vehicle is a powerful symbol of progress in NASA's ambitious plan to establish a sustained human

presence at the Moon. It represents the culmination of years of design, manufacturing, and component-level testing, and decisively shifts the program's focus toward final integrated testing, flight operations, and the return of humans to the lunar environment.

The infrastructure developments of the past week reveal a significant divergence in the models being pursued for LEO versus deep space. In LEO, a commercially driven, competitive model is taking shape. NASA is acting as a catalyst and an anchor customer, providing seed funding to multiple private companies like Axiom Space with the long-term goal of purchasing services in a competitive marketplace.<sup>46</sup> The leadership change at Axiom reflects the intense pressures of this commercial environment, where satisfying the anchor tenant and demonstrating a viable business case are paramount.<sup>52</sup> In stark contrast, the model for deep space remains a government-led, internationally collaborative enterprise. The Artemis program, while utilizing a vast network of commercial contractors, is fundamentally a traditional, government-integrated and operated architecture. The meticulous process of moving the Orion spacecraft into the VAB for stacking is a hallmark of this government-managed approach.<sup>50</sup> This bifurcation is logical: the business case for LEO is diversifying across research, manufacturing, and tourism, while the impetus for lunar exploration is currently driven by national strategic goals, scientific discovery, and international prestige. The industry is thus evolving along two parallel tracks, with LEO infrastructure becoming a private-sector-led domain where government is one of many customers, while cislunar and deep-space infrastructure remains a government-led endeavor for the foreseeable future.

## **Challenges and Considerations: Navigating the Path Forward**

Despite the significant technological and commercial progress witnessed this week, the path to a fully realized space economy is fraught with substantial challenges. These hurdles span the technical, economic, and regulatory domains and will require concerted effort and innovation to overcome.

### **Technical and Manufacturing Scalability**

A recurring theme across this week's most significant advancements is the challenge of scaling from successful prototypes to reliable, high-rate production. For SpaceX, the

successful IFT-11 flight of Starship V2 is a monumental achievement, but the true test will be in establishing a manufacturing and refurbishment cadence for the V3 vehicle that enables the frequent, low-cost flights upon which its entire business model depends. This involves mastering not only the technology of the vehicle itself but also the complexities of supply chain management, quality control at scale, and workforce training for an unprecedented production rate.<sup>10</sup> Similarly, Apex Space's disruptive business model hinges on its ability to execute its automotive-style assembly line for satellite buses. Transitioning from building initial units to producing dozens or hundreds per year without sacrificing reliability is a formidable manufacturing challenge.<sup>5</sup>

Fundamental materials science hurdles also persist. The ESA's Phoebus project, while promising, underscores the difficulty of working with advanced materials under extreme conditions. While demonstrators have proven the concept of CFRP cryogenic tanks, the long-term reliability and performance of these structures under the repeated stress and thermal cycling of multiple launch campaigns have yet to be proven at full scale.<sup>11</sup>

## **Economic Viability and Market Demand**

The long-term economic sustainability of next-generation space infrastructure remains a critical question. For commercial LEO destinations like Axiom Station, the primary challenge is closing the business case. While NASA has committed to being an anchor tenant, it is uncertain whether the demand from other sectors—such as private research, in-space manufacturing, and space tourism—will be sufficient to cover the immense operational costs and generate a profit, particularly after the ISS is deorbited.<sup>53</sup> The recent and rapid CEO change at Axiom may reflect investor and stakeholder pressure to solidify this long-term business plan and secure a broader customer base.<sup>52</sup>

In the launch sector, the impending operational status of Starship, combined with the entry of new competitors like Japan's Interstellar Technologies, raises the prospect of market saturation. While increased competition and capacity are beneficial for customers, driving down prices, they also create a fiercely competitive environment. There is a tangible risk of a launch market glut, particularly in the small-to-medium payload class, which could lead to financial instability, consolidation, and the failure of less competitive players.<sup>4</sup>

## **Regulatory and Safety Complexities**

The growth of new commercial space activities is outpacing the development of the regulatory frameworks needed to govern them safely and efficiently. The Varda-Southern Launch agreement for 20 re-entry missions is a commercial triumph, but it also highlights the complexities of the international regulatory environment for atmospheric re-entry.<sup>3</sup> Scaling these operations will require a streamlined, predictable, and internationally recognized process for licensing and airspace management, a regime that is still in its infancy.

Furthermore, the very success of the new space economy exacerbates one of its greatest threats: orbital debris. The deployment of large, proliferated constellations, whether for commercial broadband or for national security applications like the PWSA, significantly increases the density of objects in LEO. This raises the statistical probability of collisions and the potential for a cascading debris-generating event, as described by the Kessler Syndrome. This reality adds urgency to the international effort to develop and implement effective space traffic coordination and debris mitigation strategies.<sup>55</sup>

## **Future Outlook: Strategic Implications and Near-Term Projections**

The technological and commercial advancements of the past week provide a clear vector for the space industry's near-term trajectory. The convergence of these developments is not merely accelerating progress but is fundamentally reshaping the economic and strategic landscape, creating the tangible foundations for a robust and sustainable cislunar economy.

### **Projected Developments (12-24 Months)**

Based on the current momentum and stated program goals, several key milestones can be projected for the coming 12 to 24 months. The successful conclusion of the Starship V2 test program strongly indicates that the first orbital flights of the operational Starship V3 are highly probable during 2026. These initial missions will likely focus on deploying Starlink satellites and conducting the first in-space propellant transfer demonstrations, a critical capability for the Artemis lunar missions.<sup>4</sup> The Varda-Southern Launch contract signals the beginning of routine commercial returns from orbit; following the W-4 and W-5 missions scheduled for late 2025, a quasi-monthly cadence of pharmaceutical and materials returns is expected to be established by 2028, marking the operational start of a true in-space manufacturing industry.<sup>3</sup> In the launch sector, Japan's Interstellar Technologies is on a credible path toward a maiden

flight of its ZERO rocket in 2027, which will introduce a significant new international competitor to the small-to-medium launch market.<sup>30</sup> Finally, the assembly and testing of the Artemis 2 vehicle will culminate in its crewed circumlunar mission in 2026, marking humanity's physical return to the lunar environment for the first time in over 50 years.<sup>50</sup>

## **Transformative Impact on the Space Economy**

The single most powerful driver of change in the space economy is the impending operational status of a fully and rapidly reusable Starship. The "Starship Effect" will be felt across every segment of the industry. Its projected low cost and massive payload capacity will fundamentally alter the economic calculations for satellite deployment, directly enabling the business models of companies like Apex Space that rely on mass production. It will also serve as the logistical backbone for military architectures like the SDA's PWSA and will be the primary enabler for the construction of large-scale commercial space stations like Axiom Station.

The combination of this low-cost, heavy-lift capability (Starship), human-rated deep-space transportation (Artemis/Orion), and developing commercial hubs in LEO (Axiom) represents the three essential pillars of a true cislunar economy. The events of this week are remarkable because they demonstrate tangible, concurrent progress on all three of these foundational fronts.

For decades, the expansion of the space economy has been constrained by a persistent "chicken-and-egg" problem: there was no compelling business case for ambitious in-space activities without access to cheap and reliable launch, and simultaneously, there was no market to support the development of such a launch system without a clear source of in-space demand. The progress detailed this week indicates that the industry is decisively breaking out of this stalemate. The launch capability, spearheaded by SpaceX's aggressive development of Starship, is materializing at a rapid pace.<sup>1</sup> This impending supply of affordable access to orbit is, in turn, creating and validating the very demand it needs. The business models of Varda for in-space manufacturing and Apex for mass-produced satellites are only viable in a world with frequent, affordable launch and return capabilities.<sup>5</sup> The SDA's proliferated architecture is similarly dependent on this new reality.<sup>28</sup> We are witnessing the simultaneous and synergistic creation of both supply and demand, a clear signal that the space economy is entering a new, expansionary, and transformative phase.

### **Works cited**

1. Starship's Eleventh Flight Test - SpaceX, accessed October 17, 2025, <https://www.spacex.com/launches/starship-flight-11>

2. Elon Musk's SpaceX nails 11th Starship Super Heavy flight, hits all test targets, accessed October 17, 2025, <https://www.indiatoday.in/science/story/spacex-starship-super-heavy-launched-on-11th-test-flight-elon-musk-moon-mars-mission-2802656-2025-10-14>
3. Southern Launch + Varda Space sign contract for a further 20 ..., accessed October 17, 2025, <https://news.satnews.com/2025/10/16/southern-launch-var-da-space-sign-contract-for-a-further-20-spacecraft-returns-to-the-koonibba-test-range/>
4. Aviation Week & Space Technology, accessed October 17, 2025, <https://aviationweek.com/AWST>
5. Apex revenue, funding & news | Sacra, accessed October 17, 2025, <https://sacra.com/c/apex/>
6. Business News - Portugal: Altice Labs, ESA aim for 5G terminal working 24/7 in low earth orbit - Lusa, accessed October 17, 2025, <https://www.aman-alliance.org/Home/ContentDetail/96064>
7. What's Happening in Space Policy October 12-18, 2025 - SpacePolicyOnline.com, accessed October 17, 2025, <https://spacepolicyonline.com/news/whats-happening-in-space-policy-october-12-18-2025/>
8. Industry News Archives - AIAA - Shaping the future of aerospace, accessed October 17, 2025, <https://aiaa.org/news/industry-news/>
9. Starship Super Heavy launch on October 14: What is Elon Musk ..., accessed October 17, 2025, <https://www.indiatoday.in/science/story/starship-super-heavy-launch-on-october-14-what-is-elon-musk-trying-to-achieve-2801369-2025-10-11>
10. Getting even bigger: What's next for SpaceX's Starship after Flight 11 success | Space, accessed October 17, 2025, <https://www.space.com/space-exploration/launches-spacecraft/getting-even-bigger-whats-next-for-spacexs-starship-after-flight-11-success>
11. Phoebus: keeping the smallest molecule in the Universe contained - ESA, accessed October 17, 2025, [https://www.esa.int/Enabling\\_Support/Space\\_Transportation/Future\\_space\\_transportation/Phoebus\\_keeping\\_the\\_smallest\\_molecule\\_in\\_the\\_Universe\\_contained](https://www.esa.int/Enabling_Support/Space_Transportation/Future_space_transportation/Phoebus_keeping_the_smallest_molecule_in_the_Universe_contained)
12. Phoebus project advances composite hydrogen tank testing for Ariane 6 - Space Daily, accessed October 17, 2025, [https://www.spacedaily.com/reports/Phoebus\\_project\\_advances\\_composite\\_hydrogen\\_tank\\_testing\\_for\\_Ariane\\_6\\_999.html](https://www.spacedaily.com/reports/Phoebus_project_advances_composite_hydrogen_tank_testing_for_Ariane_6_999.html)
13. ESA - Phoebus: keeping cool with oxygen - European Space Agency, accessed October 17, 2025, [https://www.esa.int/Enabling\\_Support/Space\\_Transportation/Future\\_space\\_transportation/Phoebus\\_keeping\\_cool\\_with\\_oxygen](https://www.esa.int/Enabling_Support/Space_Transportation/Future_space_transportation/Phoebus_keeping_cool_with_oxygen)
14. ESA - Press Releases - European Space Agency, accessed October 17, 2025, [https://www.esa.int/Newsroom/Press\\_Releases/\(lang\)/en/\(year\)/2025](https://www.esa.int/Newsroom/Press_Releases/(lang)/en/(year)/2025)
15. First metal 3D printed part from space returns for testing, accessed October 17, 2025,

- <https://3dprintingindustry.com/news/first-metal-3d-printed-part-from-space-ret-urns-for-testing-237244/>
16. Behind the scenes of the first metal part to be 3D-printed aboard the ISS - Airbus, accessed October 17, 2025, <https://www.airbus.com/en/newsroom/stories/2024-09-behind-the-scenes-of-the-first-metal-part-to-be-3d-printed-aboard-the-iss>
  17. Behind the scenes of the first metal part to be 3D-printed aboard the ISS | Military Aerospace, accessed October 17, 2025, <https://www.militaryaerospace.com/home/article/55139092/behind-the-scenes-of-the-first-metal-part-to-be-3d-printed-aboard-the-iss>
  18. In-Space Manufacturing: Technologies, Challenges, and, accessed October 17, 2025, <https://www.mdpi.com/2504-4494/9/3/84>
  19. www.mdpi.com, accessed October 17, 2025, <https://www.mdpi.com/2504-4494/9/3/84#:~:text=Future%20advancements%20i n%20this%20field,components%20in%20space%20%5B8%5D.>
  20. Apex - Satellite Buses, accessed October 17, 2025, <https://www.apexspace.com/>
  21. Apex Space: Transforming Satellite Bus Manufacturing for the Future of Space Exploration, accessed October 17, 2025, <https://www.satnow.com/news/details/3306-apex-space-transforming-satellite-bus-manufacturing-for-the-future-of-space-exploration>
  22. Satellite Bus Models - Aries - Apex Space, accessed October 17, 2025, <https://www.apexspace.com/products>
  23. Configure Your Bus - Apex Space, accessed October 17, 2025, <https://www.apexspace.com/order-now>
  24. Apex Satellite: Cutting-edge And Reliable - Robo Earth, accessed October 17, 2025, <https://www.roboearth.org/apex-satellite/>
  25. News & Blog Posts - Apex Space, accessed October 17, 2025, [https://www.apexspace.com/blog/news?9bb19008\\_page=2](https://www.apexspace.com/blog/news?9bb19008_page=2)
  26. Altice Labs and European Space Agency to Launch 5G Terminal into Space by 2027, accessed October 17, 2025, <https://www.alticelabs.com/blog/altice-labs-and-european-space-agency-to-launch-5g-terminal-into-space-by-2027/>
  27. 5G Nanosatellite | ESA CSC - European Space Agency, accessed October 17, 2025, <https://connectivity.esa.int/projects/5g-nanosatellite>
  28. SpaceX launches 2nd batch of satellites for Space Development Agency following weather scrub - Spaceflight Now, accessed October 17, 2025, <https://spaceflightnow.com/2025/10/14/live-coverage-spacex-to-launch-2nd-batch-of-satellites-for-space-development-agency-constellation/>
  29. Interstellar Technologies - Wikipedia, accessed October 17, 2025, [https://en.wikipedia.org/wiki/Interstellar\\_Technologies](https://en.wikipedia.org/wiki/Interstellar_Technologies)
  30. Interstellar Books Customers for its First ZERO Launch - Payload Space, accessed October 17, 2025, <https://payloadspace.com/interstellar-books-customers-for-its-first-zero-launch/>
  31. ZERO | Interstellar Technologies Inc., accessed October 17, 2025, <https://www.istellartech.com/en/launch/zero>

32. ZERO by Interstellar Technologies Inc.: Lowering the Cost of Access to Space From Japan - DigitalCommons@USU, accessed October 17, 2025, [https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=6054&context=smalls\\_at](https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=6054&context=smalls_at)
33. Interstellar - 2025 Funding Rounds & List of Investors - Tracxn, accessed October 17, 2025, [https://tracxn.com/d/companies/interstellar/\\_W2Xcfj\\_IZ1js1SB9Yj-i5n9iLXYIkryE6gFrxyTE5nY/funding-and-investors](https://tracxn.com/d/companies/interstellar/_W2Xcfj_IZ1js1SB9Yj-i5n9iLXYIkryE6gFrxyTE5nY/funding-and-investors)
34. Interstellar - 2025 Company Profile, Team, Funding & Competitors - Tracxn, accessed October 17, 2025, [https://tracxn.com/d/companies/interstellar/\\_W2Xcfj\\_IZ1js1SB9Yj-i5n9iLXYIkryE6gFrxyTE5nY](https://tracxn.com/d/companies/interstellar/_W2Xcfj_IZ1js1SB9Yj-i5n9iLXYIkryE6gFrxyTE5nY)
35. Interstellar Technologies raises USD 61.8 million in Series F funding to develop ZERO rocket - SPEEDA Edge, accessed October 17, 2025, <https://sp-edge.com/updates/52421>
36. SpaceX sends 28 Starlink satellites to low Earth orbit in predawn launch - Spaceflight Now, accessed October 17, 2025, <https://spaceflightnow.com/2025/10/15/live-coverage-overnight-launch-planned-for-28-more-starlink-satellites/>
37. SpaceX Starlink 311 launch and Falcon 9 first stage landing, 16 October 2025 - YouTube, accessed October 17, 2025, <https://www.youtube.com/watch?v=CelqY5JXmEM>
38. Southern Launch and Varda Space Industries sign contract for a further 20 spacecraft returns to the Koonibba Test Range, accessed October 17, 2025, <https://www.southernlaunch.space/news-feed/southern-launch-and-var-da-space-e-industries-sign-contract-for-a-further-20-spacecraft-returns-to-the-koonibba-test-range>
39. Varda Space Industries - Wikipedia, accessed October 17, 2025, [https://en.wikipedia.org/wiki/Varda\\_Space\\_Industries](https://en.wikipedia.org/wiki/Varda_Space_Industries)
40. Varda Space Industries, accessed October 17, 2025, <https://www.factoriesinspace.com/var-da-space>
41. Varda Space Industries : Medicine in Microgravity - Manufacturing Outlook, accessed October 17, 2025, <https://www.mfg-outlook.com/healthcare-manufacturing/var-da-space-industries-medicine-in-microgravity>
42. 20 new space missions to touch down in SA - Premier of South Australia, accessed October 17, 2025, <https://www.premier.sa.gov.au/media-releases/news-items/20-new-space-missions-to-touch-down-in-sa>
43. South Australia cements global leadership in commercial spacecraft returns - SASIC, accessed October 17, 2025, <https://sasic.sa.gov.au/news/south-australia-cements-global-leadership-in-commercial-spacecraft-returns/>
44. Axiom Space Appoints Dr. Jonathan Cirtain as CEO and President, accessed October 17, 2025, <https://www.axiomspace.com/release/jonathan-cirtain-ceo>

45. Axiom Space President Jonathan Cirtain Appointed CEO - GovCon Wire, accessed October 17, 2025, <https://www.govconwire.com/articles/axiom-space-president-jonathan-cirtain-ceo>
46. Axiom Space hires NASA, BWXT vet as CEO - Washington Technology, accessed October 17, 2025, <https://www.washingtontechnology.com/companies/2025/10/axiom-space-hires-nasa-bwxt-vet-ceo/408856/>
47. Axiom Space's Chief Revenue Officer tapped as new CEO - Spaceflight Now, accessed October 17, 2025, <https://spaceflightnow.com/2025/04/25/axiom-spaces-chief-revenue-officer-tapped-as-new-ceo/>
48. NASA prepares to say goodbye to the ISS after 25 years in orbit as commercial space stations take over, accessed October 17, 2025, <https://timesofindia.indiatimes.com/science/nasa-prepares-to-say-goodbye-to-the-iss-after-25-years-in-orbit-as-commercial-space-stations-take-over/articleshow/124573724.cms>
49. NASA Seeks Industry Input on Next Phase of Commercial Space Stations, accessed October 17, 2025, <https://www.nasa.gov/humans-in-space/commercial-space/leo-economy/nasa-seeks-industry-input-on-next-phase-of-commercial-space-stations/>
50. Orion spacecraft arrives at VAB ahead of stacking for Artemis 2 ..., accessed October 17, 2025, <https://spaceflightnow.com/2025/10/17/orion-spacecraft-arrives-at-vab-ahead-of-stacking-for-artemis-2/>
51. NASA Accelerates Artemis 2 by Two Months - AmericaSpace, accessed October 17, 2025, <https://www.americaspace.com/2025/03/22/nasa-accelerates-artemis-2-by-two-months/>
52. Axiom Space ejects CEO after six months, installs NASA veteran as replacement - Reddit, accessed October 17, 2025, [https://www.reddit.com/r/space/comments/1o8bvcr/axiom\\_space\\_ejects\\_ceo\\_after\\_six\\_months\\_installs/](https://www.reddit.com/r/space/comments/1o8bvcr/axiom_space_ejects_ceo_after_six_months_installs/)
53. Commercial Space Stations - Meegle, accessed October 17, 2025, [https://www.meegle.com/en\\_us/topics/space-commercial/commercial-space-stations](https://www.meegle.com/en_us/topics/space-commercial/commercial-space-stations)
54. It seems like commercial space stations are way behind their original initial launch date. : r/spaceflight - Reddit, accessed October 17, 2025, [https://www.reddit.com/r/spaceflight/comments/1o8bjod/it\\_seems\\_like\\_commercial\\_space\\_stations\\_are\\_way/](https://www.reddit.com/r/spaceflight/comments/1o8bjod/it_seems_like_commercial_space_stations_are_way/)
55. Policy Challenges Of Commercial Space Stations - Beyond Earth Institute, accessed October 17, 2025, <https://beyondearth.org/wp-content/uploads/2023/01/Commercial-Space-Station-Paper.pdf>
56. Starlink satellites: Facts, tracking and impact on astronomy - Space, accessed

October 17, 2025, <https://www.space.com/spacex-starlink-satellites.html>  
57. Space - Stanford Emerging Technology Review, accessed October 17, 2025,  
<https://setr.stanford.edu/technology/space/2023>