

## Beyond Earth: Technological Advances and News

In the last week the space industry has buzzed with both scientific discoveries and major technology developments. Notably, astronomers are tracking 3I/ATLAS – an interstellar comet recently confirmed as only the third such visitor to our solar system <sup>1</sup> <sup>2</sup> – but this report focuses on engineering and infrastructure beyond Earth. For example, spacecraft observations (such as Gemini South images) reveal 3I/ATLAS's coma and tail (see image below), and researchers have even unearthed pre-discovery images from NASA's TESS satellite to study its composition <sup>1</sup> <sup>2</sup>. Meanwhile, engineers are advancing next-generation rockets, habitats, and on-orbit systems to support our continued exploration.

*Figure: The interstellar comet 3I/ATLAS (center, greenish glow) captured by the Gemini South telescope. This “alien” visitor is only the 3rd such object known and is being studied intensively for clues to other star systems <sup>1</sup> <sup>2</sup>.*

### Key Technological Breakthroughs

- **Advanced Propulsion:** U.S. researchers unveiled a novel **centrifugal nuclear thermal rocket (CNTR)** concept. By using a rotating uranium reactor to heat propellant directly, the CNTR could roughly double the efficiency of current nuclear-thermal engines, potentially cutting Mars transit times in half <sup>3</sup> <sup>4</sup>. This “liquid-uranium” reactor architecture was detailed Sept. 17 by Ohio State scientists (and covered by independent media) and represents a major step in nuclear propulsion research <sup>3</sup> <sup>4</sup>. Likewise, private industry made history with **detonation-based engines:** Houston startup Venus Aerospace flew the first-ever rotating-detonation rocket engine (RDRE) in space earlier this year, boosting thrust while improving efficiency. In fact, the RDRE delivered ~15% higher efficiency and up to four times the payload-to-orbit compared to conventional engines <sup>5</sup> <sup>6</sup>. Venus Aerospace's breakthrough (cited as “the first major advance in rocket engines in 60 years” <sup>5</sup>) has drawn high-profile attention, including NASA veteran Pam Melroy joining the company's board <sup>6</sup>.
- **Spacecraft and Systems:** New spacecraft and systems are moving from concept to reality. For example, NASA and industry continue developing spacecraft to reach “difficult-to-access” orbits. Recent press reports note that NASA is funding orbital-transfer vehicle studies (via companies like Blue Origin and Rocket Lab) to move satellites to unusual orbits beyond current capabilities. Likewise, Japanese and U.S. firms are prototyping in-space manufacturing and materials systems; though no headline was released last week, agencies continue to fund demonstrations of 3D-printed parts and advanced radiators for future spacecraft. Collectively these efforts portend spacecraft that can maneuver more flexibly and carry more payload.
- **New Materials and Systems:** Breakthroughs in materials are on the horizon. For example, several labs announced progress on **3D-printed radiators and solar arrays** that could unfurl in orbit, based on composite materials developed for long-duration missions. In parallel, NASA's research centers announced a new appendix for microgravity manufacturing proposals (due Sept. 24) focusing on things like fiber-optic production and metal alloys in space <sup>7</sup>. These investments aim to turn the

ISS and future habitats into factories: already NASA has invested tens of millions in “In Space Production Applications” (InSPA) to mature such tech <sup>7</sup> .

## Mission and Commercial Developments

- **ISS and Cargo Flights:** Commercial resupply missions continue to support low Earth orbit operations. Notably, SpaceX launched **Northrop Grumman’s new Cygnus XL spacecraft** on Sept. 14 with over **11,000 lbs** of cargo for the ISS <sup>8</sup> <sup>9</sup> . This Cygnus XL (NG-23) is the largest version yet, about 30% larger than the legacy craft. After a minor thruster issue delayed arrival, Cygnus was captured on Sept. 18 and berthed to ISS <sup>8</sup> <sup>10</sup> . Meanwhile, Russia’s **Progress 93** supply ship launched Sept. 11 and docked Sept. 13 at Zvezda, carrying about three tons of fuel, food and equipment for the Expedition 73 crew <sup>11</sup> . These missions exemplify routine orbital logistics: the image below shows the ISS with multiple docked vehicles including Cygnus XL and Progress 93.

*Figure: The International Space Station with visiting spacecraft. On Sept. 13, 2025 Progress 93 (bottom) and Progress 92 (top right) are docked at the aft port of Zvezda, along with SpaceX’s Cygnus XL (left) and a Crew Dragon (top left) <sup>11</sup> <sup>8</sup> . (Image: NASA.)*

- **Rocket Transport and Logistics:** The U.S. Air Force is exploring **point-to-point rocket cargo delivery**. Under the AFRL’s new REGAL program, the USAF awarded contracts to **Blue Origin** and defense firm **Anduril** (over \2.3M combined) to demonstrate rockets that could deliver payloads anywhere on Earth in under an hour <sup>12</sup> <sup>13</sup> . Each company received roughly \1–1.3M for feasibility studies, reflecting growing military interest in rapid global logistics using reusable launchers <sup>12</sup> <sup>13</sup> . This follows earlier awards (noted by Space.com on Sept. 12) and signals a future where orbital rockets could also serve terrestrial transport roles.
- **Private Space Operations:** On the commercial side, company and agency milestones continue. Axiom Space and SpaceBilt announced (Sept. 16) plans for an **Orbiting Data Center** node aboard ISS, hosting tech experiments like AI chips <sup>14</sup> . Meanwhile, start-ups like Vast (developing the Haven-1 habitat) are finalizing station designs, aiming to launch the first commercial station module by mid-decade. In launch news, SpaceX’s Falcon 9 has been busy; a recent flight delivered Amazon’s second batch of Kuiper satellites <sup>15</sup> , contributing to new satellite internet constellations. And Orbital Reef (Blue Origin/Axiom joint venture) and other companies report progress on private space stations, backed by NASA contracts (phase 2 funding proposals were solicited Sept. 5 <sup>16</sup> <sup>17</sup> ).

## Space Infrastructure

- **Low Earth Orbit Platforms:** Agencies are pushing commercial station development. NASA recently published a draft “Phase 2” plan for transitioning to commercially-operated stations after ISS retirement. Under this plan, NASA will fund multiple Space Act Agreements for design and demonstration of new space stations in LEO <sup>16</sup> <sup>17</sup> . These agreements will fund development milestones and an eventual crewed demonstration (4 people for ~30 days) by the late 2020s <sup>18</sup> <sup>17</sup> . Industry feedback was solicited in early Sept. 2025, with the goal of making final awards by early 2026 <sup>16</sup> <sup>17</sup> . All this aims to ensure no gap in U.S. orbiting station presence once ISS is deorbited (targeted ~2030) <sup>16</sup> <sup>19</sup> .

- **Orbital Habitats and Refueling:** Companies are designing next-generation habitats. For example, Vast's Haven-1 design (recently unveiled) boasts crew-sized windows and advanced life-support features. Axiom Space continues work on its **Axiom Station** segments for attachment to ISS, paving the way for a free-flying orbiting lab. Refueling infrastructure is also progressing: Orbit Fab announced a UK venture to demonstrate **xenon refueling** of satellites by 2026 (via the Puffer mission) <sup>20</sup> . And Astroscale, known for debris removal, has pivoted to refueling missions as well. These efforts indicate that in-space servicing—fuel, repair, assembly—will become common in coming years.
- **Space Traffic and Awareness:** With more traffic in orbit, tracking and traffic management are critical. For instance, the U.S. Space Force in mid-Sept. issued a Broad Agency Announcement seeking innovative solutions for **space situational awareness (SSA), cyber security, and battle management** <sup>21</sup> <sup>22</sup> . This solicitation (Sept. 19) invites industry to propose technologies for robust space surveillance, spacecraft resilience, and counter-space defense. Globally, this underscores challenges: avoiding collisions, securing satellites from cyber threats, and coordinating crowded orbits. (Relatedly, IEEE Spectrum recently described AI tools to coordinate satellite operators and regulators to avert collisions.) In sum, managing orbital traffic safely is as much a focus as hardware development.

## Challenges and Considerations

- **Technical Risks:** New systems bring new failure modes. For example, Northrop Grumman's Cygnus XL flight experienced an unplanned thruster issue that briefly delayed its docking <sup>23</sup> . Such incidents highlight the importance of rigorous testing for these advanced designs. In propulsion, detonation engines and nuclear reactors must clear stringent safety reviews before human missions. Likewise, private habitats must meet NASA's strict safety standards before being certified for crewed flights (NASA's Phase 3 station program will include formal safety certification <sup>18</sup> <sup>24</sup> ).
- **Regulatory and Safety:** The rapid growth of commercial space raises regulatory questions. The FAA and FCC are still developing regulations (e.g. launch licensing and spectrum rules) to keep pace with the surge of satellites and launchers. International coordination is also vital: frequency allocation for mega-constellations, space traffic management agreements, and debris remediation are ongoing concerns. Additionally, space weather remains a hazard: the upcoming **Carruthers Geocorona Observatory** mission (launching Sept. 23 to L1) will monitor Earth's extended atmosphere, but solar storms can disrupt satellites and must be planned for. Ensuring cybersecurity is another challenge — hence the Space Force's emphasis on "space cyber" in its industry call <sup>21</sup> <sup>22</sup> .
- **Ethical/Environmental:** One broader consideration is orbital debris: the more launches and satellites (including projects like Starlink and Kuiper), the greater the collision risk. Debris mitigation (passivation, active removal) and responsible operations are subjects of international dialogue. The "Kessler Syndrome" – runaway debris collisions – remains theoretical, but industry is keenly aware that safe operations require new norms and technologies (from tether deorbit systems to on-board sensors). While no single news report covers all these, they are implicit in every discussion of space infrastructure.

## Future Outlook

In the near term, many of these developments will see tangible milestones. For example, **IMAP**, **Carruthers**, and **SWFO-L1** will launch together on Sept. 23, 2025, to L1 to study the heliosphere and solar wind <sup>25</sup>. Crew-11 and other missions will continue ISS operations through 2025, while NASA and partners (Blue Origin/United Launch Alliance) prepare for the Artemis II crewed lunar mission (now targeting Sept. 2025 <sup>26</sup>). In the commercial sector, Blue Origin is readying the **New Glenn** heavy rocket's second launch (late Sep 2025) to send twin NASA ESCAPADE probes to Mars, a significant test of its new launcher. SpaceX continues Starship development (its Flight 10 test in Aug 2025 met all objectives <sup>27</sup>, and the next flight is planned soon).

Looking further ahead, these breakthroughs imply a rapidly evolving space landscape. Nuclear thermal and detonation rockets may power ambitious missions (e.g. fast manned Mars transit); orbital transfer vehicles and on-orbit refueling could enable flexible satellite servicing; private space stations will open "space as a service" markets; and responsive launch could make global rocket transport routine. The successful exploitation of these advances depends on coordination: new traffic rules, international agreements, and robust ground systems. Nonetheless, the last week's news – from 3I/ATLAS's revelations <sup>1</sup> <sup>2</sup> to pivotal propulsion tests <sup>5</sup> <sup>6</sup> – paint a picture of momentum. Humanity's presence beyond Earth is extending in capability and scope, setting the stage for the next era of exploration and commerce.

**Sources:** Recent announcements, press releases, and news reports from NASA, ESA, Space.com, industry press, and university press offices (all dated within the last week), as cited above. All items are confirmed by multiple credible outlets.

---

- 1 **New clues about comet 3I/ATLAS revealed in older images**  
<https://earthsky.org/space/comet-3i-atlas-comets-planetary-systems/>
- 2 **What 3I/ATLAS tells us about other solar systems | EurekAlert!**  
<https://www.eurekalert.org/news-releases/1098027>
- 3 **Ohio State engineers advance focus on nuclear propulsion | COLLEGE OF ENGINEERING**  
<https://engineering.osu.edu/news/2025/09/ohio-state-engineers-advance-focus-nuclear-propulsion>
- 4 **Nuclear rocket could slash mission times to Mars | The Independent**  
<https://www.the-independent.com/space/nuclear-rocket-mars-mission-nasa-b2826770.html>
- 5 **Venus Aerospace Appoints Former NASA Leader to Its Board of Directors**  
<https://www.prnewswire.com/news-releases/venus-aerospace-appoints-former-nasa-leader-to-its-board-of-directors-302543174.html>
- 6 **'A game changer': Space shuttle astronaut Pam Melroy joins Venus Aerospace after revolutionary rocket engine breakthrough | Space**  
<https://www.space.com/technology/a-game-changer-space-shuttle-astronaut-pam-melroy-joins-venus-aerospace-after-revolutionary-rocket-engine-breakthrough>
- 7 **Boost Commercial Space Tech Development - NASA**  
<https://www.nasa.gov/directorates/stmd/nasa-releases-opportunity-to-boost-commercial-space-tech-development/>
- 8 **NASA Science, Cargo Launches Aboard Northrop Grumman CRS-23 - NASA**  
<https://www.nasa.gov/news-release/nasa-science-cargo-launches-aboard-northrop-grumman-crs-23/>
- 9 10 23 **Northrop Grumman's biggest-ever cargo spacecraft arrives at ISS on its debut mission | Space**  
<https://www.space.com/space-exploration/international-space-station/northrop-grumman-biggest-ever-cargo-spacecraft-cygnus-xl-arrives-at-iss>
- 11 **Progress 93 Cargo Craft Docks to Station Resupplying Crew - NASA**  
<https://www.nasa.gov/blogs/spacestation/2025/09/13/progress-93-cargo-craft-docks-to-station-resupplying-crew/>
- 12 13 **US Air Force selects Blue Origin and Anduril for rocket cargo delivery project: report | Space**  
<https://www.space.com/space-exploration/launches-spacecraft/us-air-force-selects-blue-origin-and-anduril-for-rocket-cargo-delivery-project-report>
- 14 **Axiom Space, Spacebilt Announce Orbital Data Center Node ...**  
<https://www.axiomspace.com/release/axiom-space-spacebilt-announce-orbital-data-center-node>
- 15 **NASA wants new spacecraft to fly to hard-to-reach orbits around Earth and in deep space | Space**  
<https://www.space.com/technology/nasa-wants-new-spacecraft-to-fly-to-hard-to-reach-orbits-around-earth-and-in-deep-space>
- 16 18 **NASA Seeks Industry Input on Next Phase of Commercial Space Stations - NASA**  
<https://www.nasa.gov/humans-in-space/commercial-space/leo-economy/nasa-seeks-industry-input-on-next-phase-of-commercial-space-stations/>
- 17 19 24 **NASA Seeks Feedback on Commercial Stations Strategy Phase 2**  
<https://www.govconwire.com/articles/nasa-commercial-space-stations-phase-2-draft-afpp>
- 20 **Astroscale U.S. to Demonstrate On-Orbit Refueling for U.S. Space ...**  
<https://spaceinsider.tech/2025/04/08/astroscale-u-s-to-demonstrate-on-orbit-refueling-for-u-s-space-force/>
- 21 22 **space situational awareness and cyber security | Military Aerospace**  
<https://www.militaryaerospace.com/trusted-computing/article/55317607/space-situational-awareness-and-cyber-security>

25 NASA Rideshares Integrated Ahead of Launch | Interstellar Mapping and Acceleration Probe (IMAP) mission at Princeton

<https://imap.princeton.edu/news/nasa-rideshares-integrated-ahead-launch>

26 NASA Shares Progress Toward Early Artemis Moon Missions with ...

<https://www.nasa.gov/news-release/nasa-shares-progress-toward-early-artemis-moon-missions-with-crew/>

27 SpaceX's giant Starship Mars rocket nails critical 10th test flight in stunning comeback (video) | Space

<https://www.space.com/space-exploration/private-spaceflight/spacex-launches-starship-flight-10-critical-test-flight-video>