



Ground Control To Major Pharma: Drugs in Space

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Pharmaceutical innovation is replete with examples of researchers exploiting unusual environments to reveal insights that cannot be observed under standard laboratory conditions:

- Hypoxia chambers accelerated cancer research.
- Organ-on-chip systems improved human liver toxicity predictions.
- AI is transforming target discovery.

A small but increasingly well-financed group of companies (e.g. Varda Space Industries US\$187M Series C; Total Raised US\$329M) is confident that the next valuable research environment is not a specialized laboratory on Earth, but low Earth orbit (LEO).

Company	Key Technology / Platform	Focus Area	Missions Flown
Varda Space Industries	W-Series Re-entry Capsules	Small molecule & biologic crystallization	6
Redwire (SpaceMD)	PIL-BOX / Bio Fabrication Facility	Large-scale protein crystallization & 3D bioprinting	54
LambdaVision	Layer-by-Layer Manufacturing	Protein-based artificial retinas	9
Helogen	HEL-IOS Autonomous Platform	Regulated GMP-compliant space manufacturing for retinas	1
BioOrbit	BOX (Crystallization Platform)	Large-scale crystallization of protein drugs	0
Auxilium Biotechnologies	Microgravity Bioprinting	Kidney and liver tissue fabrication	2
Microgravity Pharmaceuticals	Microgravity Cell Production	Therapeutic T-regulatory cells	0

Central hypothesis: remove gravity and molecular properties and biology change.

Commercial implications: potentially profound.

You've Really Made the Grade: Some Advantages of Microgravity for Pharma R&D

A key value proposition of LEO for the pharmaceutical industry lies in the physical differences of a weightless environment, which allows for the creation of materials and data unattainable on Earth:

Precision Crystallization: In microgravity, the absence of convection currents, sedimentation and buoyancy leads to diffusion-based crystal

growth, resulting in larger, more uniform, and "pristine" crystals. This enables the discovery of new polymorphs (different structural forms of the same molecule) that may have better solubility, stability, and/or bioavailability.

Example: Varda Space Industries successfully crystallized the anti-HIV drug ritonavir (Form III) in orbit and successfully returned the crystals to Earth, proving they could survive the stresses of re-entry while maintaining their metastable form and enhanced drug formulation properties relative to terrestrial forms.

Example: Merck crystallized a high-concentration/low viscosity form of pembrolizumab that enabled subcutaneous delivery formulation with the potential to shift treatment from hours-long intravenous (IV) infusions to quick, patient-delivered subcutaneous injections.

3D Disease Modelling: On Earth, cell cultures often settle into 2D layers; in LEO, they form complex 3D structural architectures (organoids) that more closely mimic human biology. This may support more accurate drug screening and the modelling of diseases like Alzheimer's or cancer at greater speed given speeds at which organoids develop in space (hours) relative to Earth (weeks).

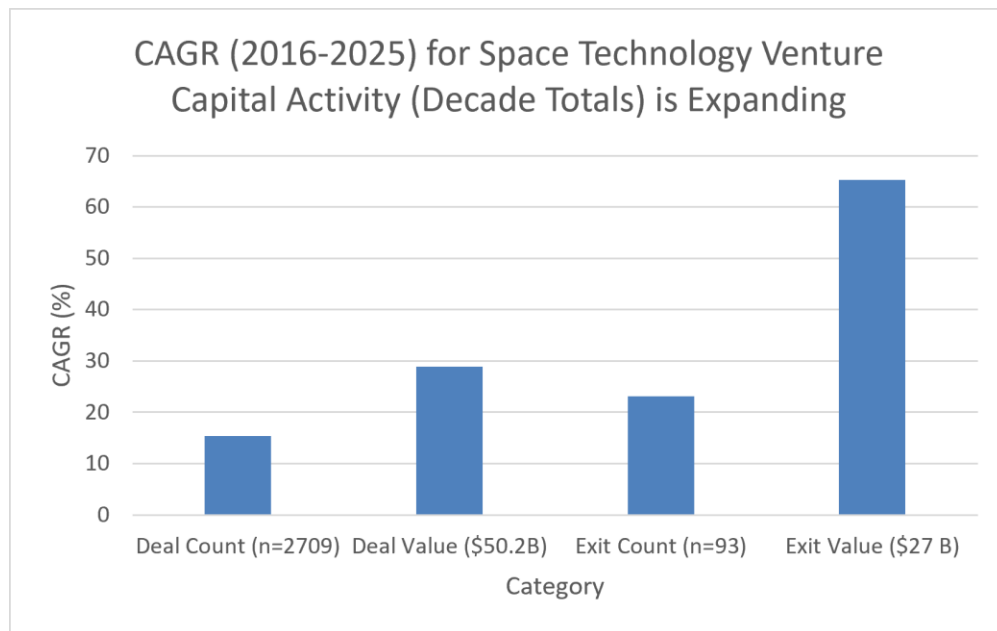
Example: Axonis Pharmaceuticals microgravity spheroids derived from mature neurons and astrocyte co-culture for neuron targeting gene therapies to treat neurological disorders.

Nanoencapsulation: Microgravity enables the production of targeted nanoencapsulated therapeutics with higher surface-area-to-volume ratios and more uniform diameters than terrestrial alternatives (approaching picometer dimensions).

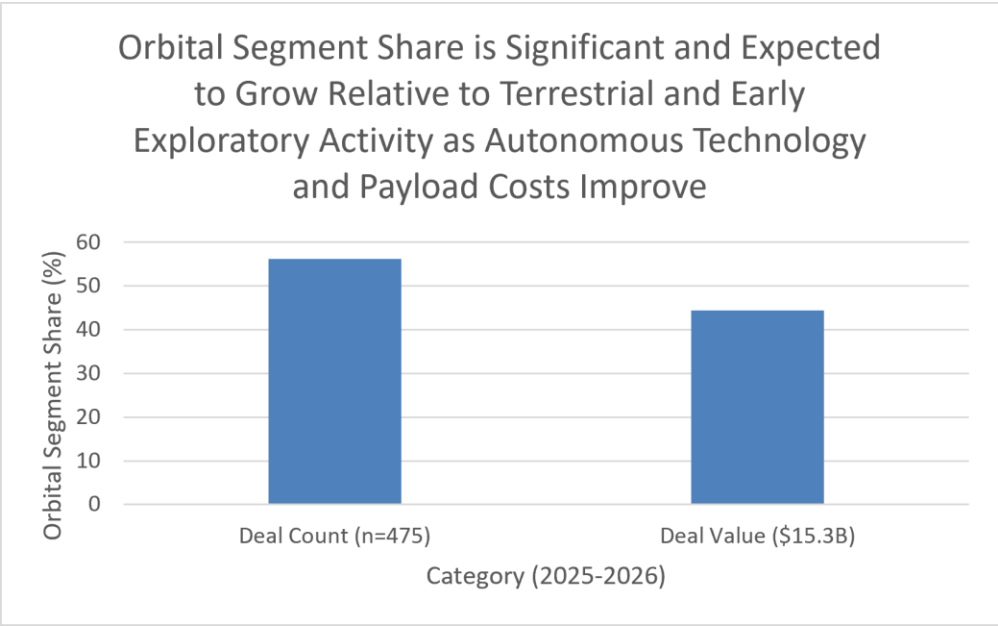
Example: Aphios Corp microgravity encapsulated Bryostatin-1 analogues for treatment of protein kinase-dependent diseases including various cancers, HIV and Alzheimer's disease.

Red Shift: Expanding Space Technology Venture Capital

In the first full decade since the launch of the full thrust Falcon 9 in 2015 space technology venture capital activity has expanded significantly...



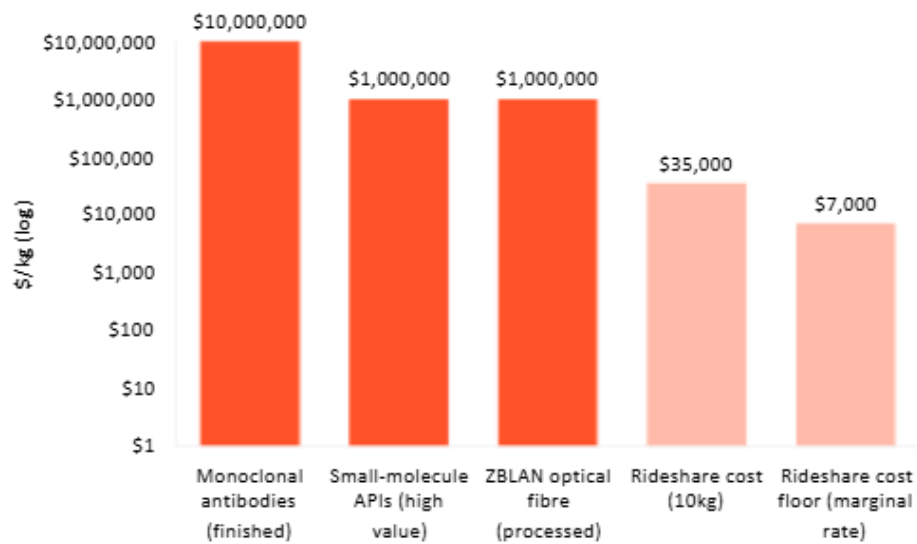
...and the orbital segment already captures a significant portion of the most recent years venture capital deal activity...



...with year-on-year growth in space manufacturing registering the second highest tally (276%) next to space debris and tracking operations according to a detailed [Pitchbook](#) analysis.

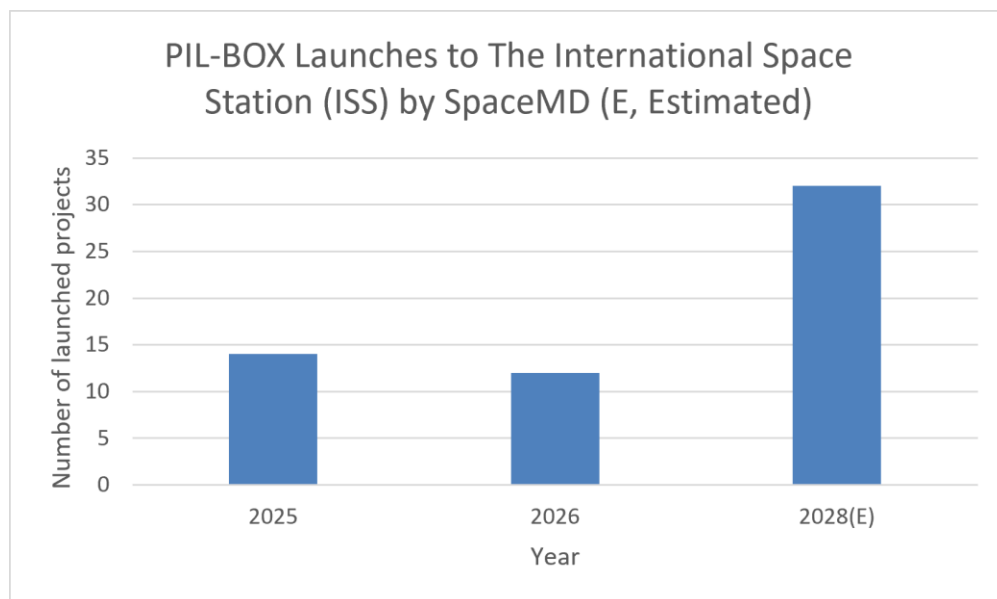
Economic Viability: Low Mass, Medium Throughput and High Value Products

Microgravity derived product values relative to Falcon 9 Rideshare launch costs indicate economic viability for relatively low mass and high value therapeutics...



From Berenberg's Aerospace and Defence – More Than a Moonshot: launching space cover (September 2, 2026)

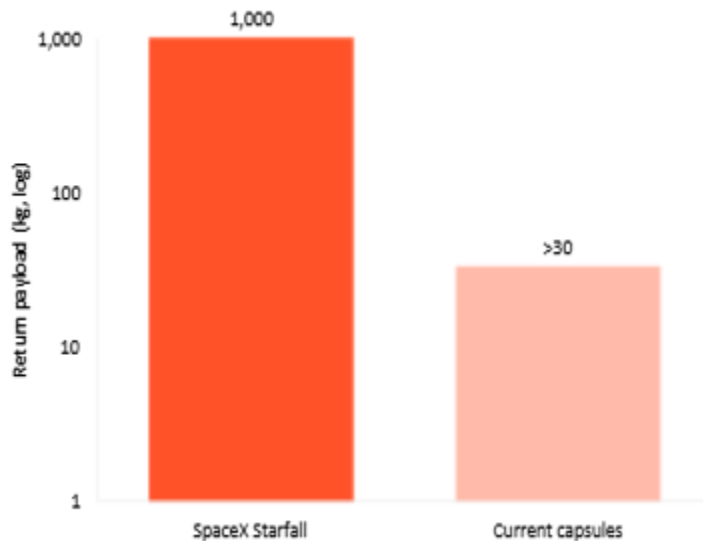
...and platforms that can achieve multiple molecule launches can drive economic growth by enhancing throughput...



...with autonomous platforms that can achieve floor pricing (weight thresholds) and multiple pharmaceutical projects that can utilize terrestrial manufacturing to scale on orbitally derived seeds becoming high revving recurring revenue engines relative to in-orbit bulk manufacturing and structure-based research.

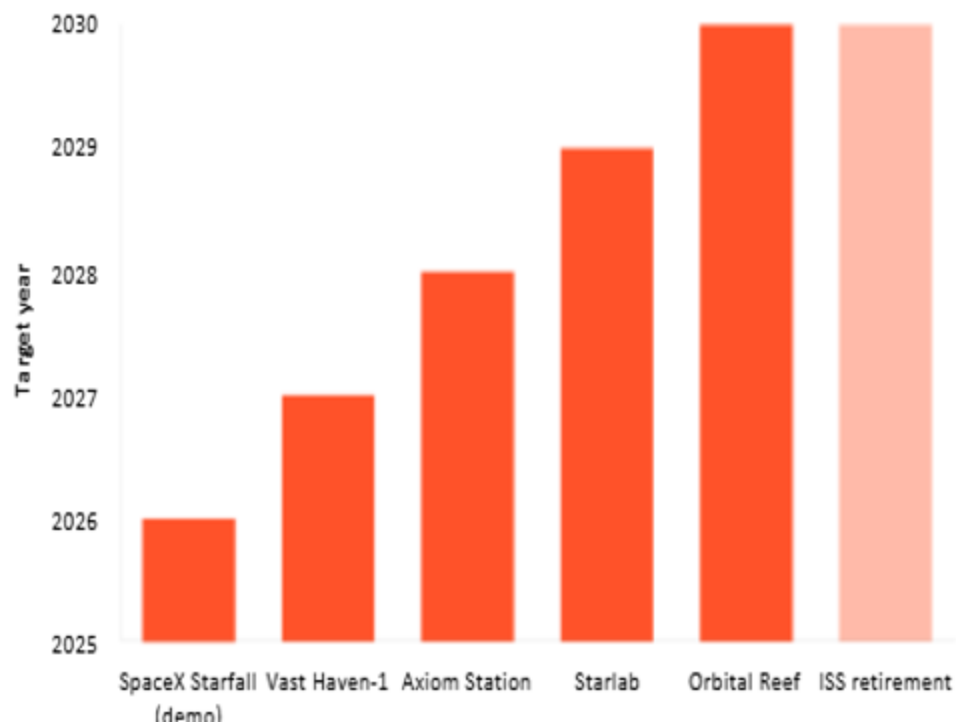
My Ship Knows Which Way to Go: In With the New, Out With the Old

Advances in re-entry capsule payload capacity like SpaceX's Starfall will help autonomous platform players drive economic growth and market share...



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...particularly as new station-based systems come on-line for commercial use and as the ISS undergoes decommissioning...



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The Papers Want To Know Whose Shirts You Wear: LEO Partnerships

Given the very recent development of autonomous systems much of the pharma and biotech collaboration in LEO-based therapeutics research has been focused on the ISS following the early work by Merck and Eli Lilly...

<u>Company</u>	<u>Platform/Partner</u>	<u>Research Focus</u>
United Therapeutics	Varda Space Industries	Formulations for rare pulmonary diseases
AstraZeneca	ISS National Lab	Immunotherapy and vaccine development
Sanofi	ISS National Lab	Immunotherapy and vaccine development
Novartis	ISS National Lab	General biopharma R&D
GlaxoSmithKline Bristol Myers Squibb	ISS National Lab	Drug discovery and delivery technologies
Burjeel Holdings	Axiom Space	Space-medicine program for diabetes
ExesaLibero Pharma	Redwire (SpaceMD)	Licensing for molecules targeting TRPC developed in PIL-BOX
Space LiinTech	Voyager Technologies	Advancing protein crystallization techniques
Axonis Therapeutics	ISS National Lab	3D human brain organoids for gene therapy

From GlobalData, AlphaSense

...however, mature companies like Varda Space Industries, and emerging companies such as Helogen, SpacePharma and Ambrosia Space Manufacturing are quickly demonstrating the viability of station-independent business models.

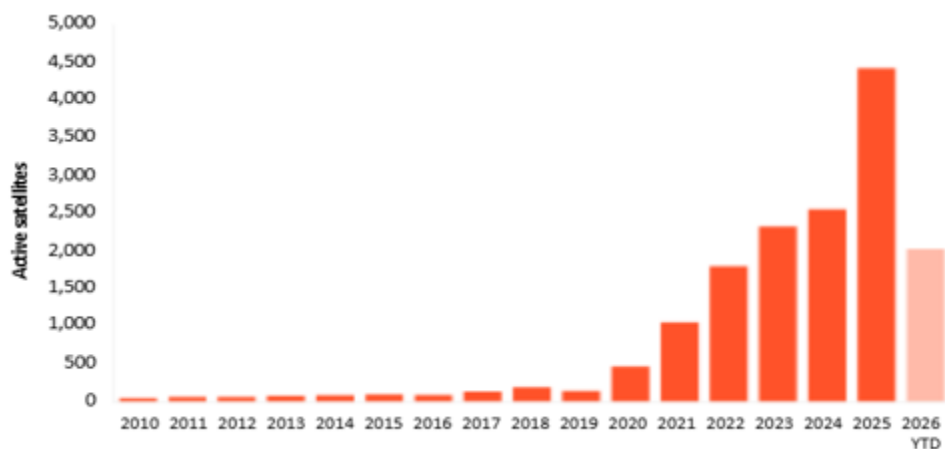
The autonomous partnerships are an emerging area and many of the partnership details are not publicly known. SpaceMD and ExesaLibero

Pharma have established a royalty-based partnership based on sales of LEO-derived products and this type of approach may be the best way to support autonomous and station-based LEO drug manufacturing given the high costs for launch and re-entry of a given program.

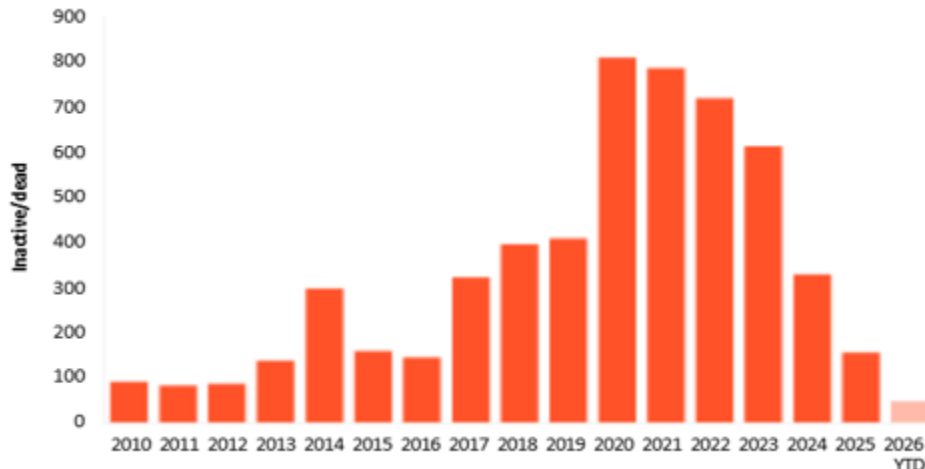
Your Circuits Dead There's Something Wrong: An Interesting Risk Profile

Historically launch and re-entry risks were quite significant, but those risks are coming down with advances in technology for both of those technical aspects. An interesting developing risk because of improved launch survival and orbital zone is related to the sheer number objects in LOE, both dead and alive...

Active Satellites Per Launch Year



Inactive/Dead Satellites Per Launch Year



In 1978 Donald Kessler described a self-sustaining chain reaction of collisions, debris formation and more debris collisions (Kessler Syndrome). This risk is limited by orbital band, but some bands could become unusable if overcrowded:

- 700 to 1000 km band (sun-synchronous Earth observation) – can maintain debris over centuries and currently has more than 27,300 trackable debris objects;
- 550 km band (Starlink) – atmospheric drag removes debris within a couple of decades, but Starlink collision avoidance manoeuvres increased almost 3-fold to 144,000/6 months from H1 2024 to H1 2026.

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Take Aways From This Short Piece

Microgravity manufacturing of therapeutic crystals has a demonstrable impact on drug product characteristics that can support better therapeutic index, patient access, indication expansion and life-cycle management for high value programs;

Large Pharma companies have been at the forefront of the space drug discovery race and biotechnology companies now are establishing partnerships with innovative manufacturing companies to gain access to the previously prohibitive environment;

The ISS has been the workhorse for microgravity drug research but is planned for decommissioning in 2030 with possible extension to 2032;

New station-based platforms are expected to come on-line in the next decade, but these may be smaller with more limited commercial capacity for an ever-growing number of potential applications;

Autonomous drug manufacturing **start-ups are raising** significant capital to develop the non-station-based market and have already demonstrated re-entry recovery of improved therapeutic forms of existing compounds;

Advances in launch, manufacturing and re-entry technology are set to **expand bot autonomous and station-based capability** and to drive down costs; Increased active and inactive satellite loads may impact orbital based risk profiles and mitigation strategies for LEO-based manufacturing.

The stars look very different today...