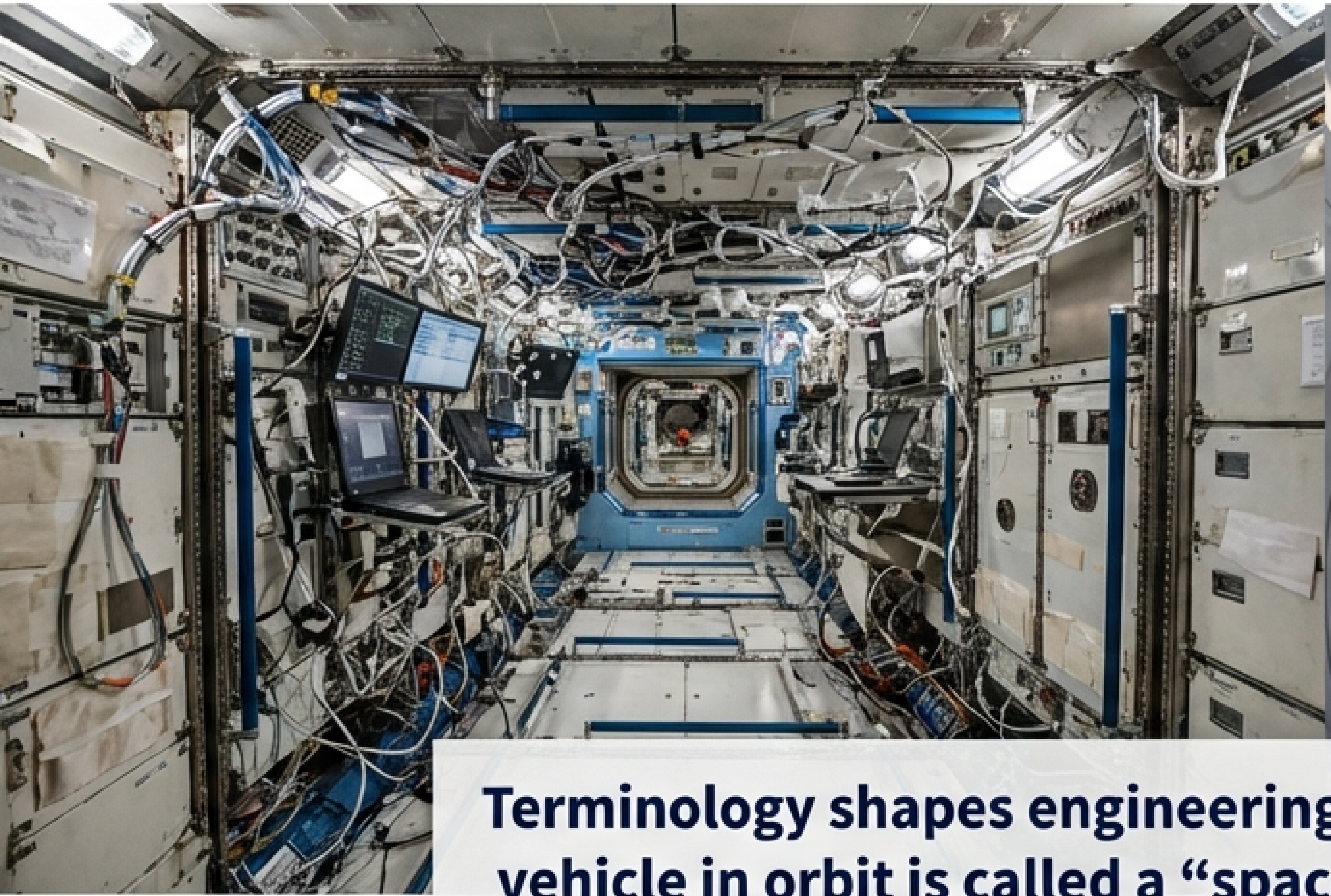
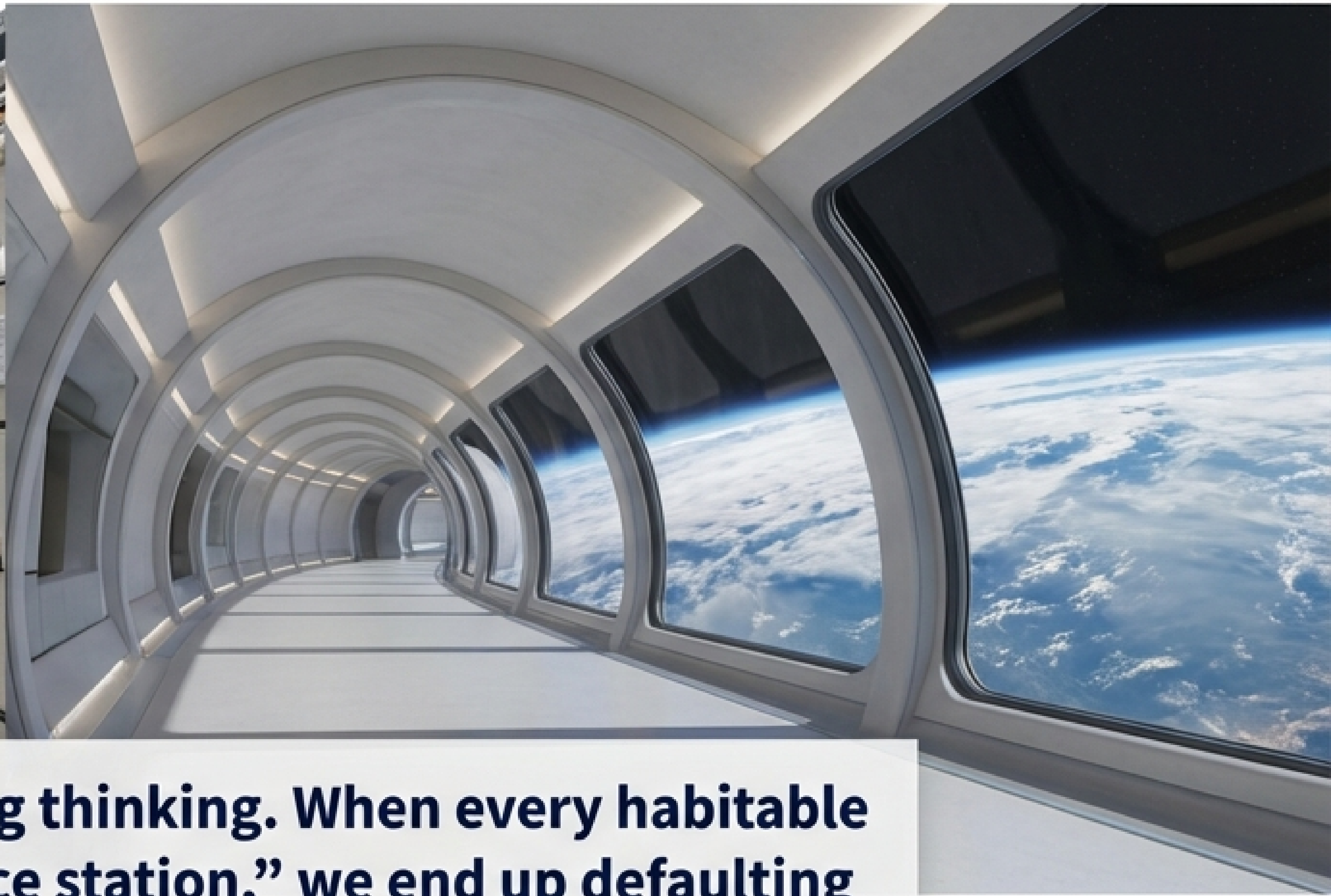
Our Future in Space is Trapped by a Word





Terminology shapes engineering thinking. When every habitable vehicle in orbit is called a "space station," we end up defaulting to proven station-like construction methods.

Dinosaurs became extinct because they didn't have a space program. - Larry Niven

The Imperatives for Becoming a Spacefaring Species are No Longer Speculative.

Survival

Stephen Hawking warned we must become a spacefaring species to survive. Some estimate the window is under 40 years.

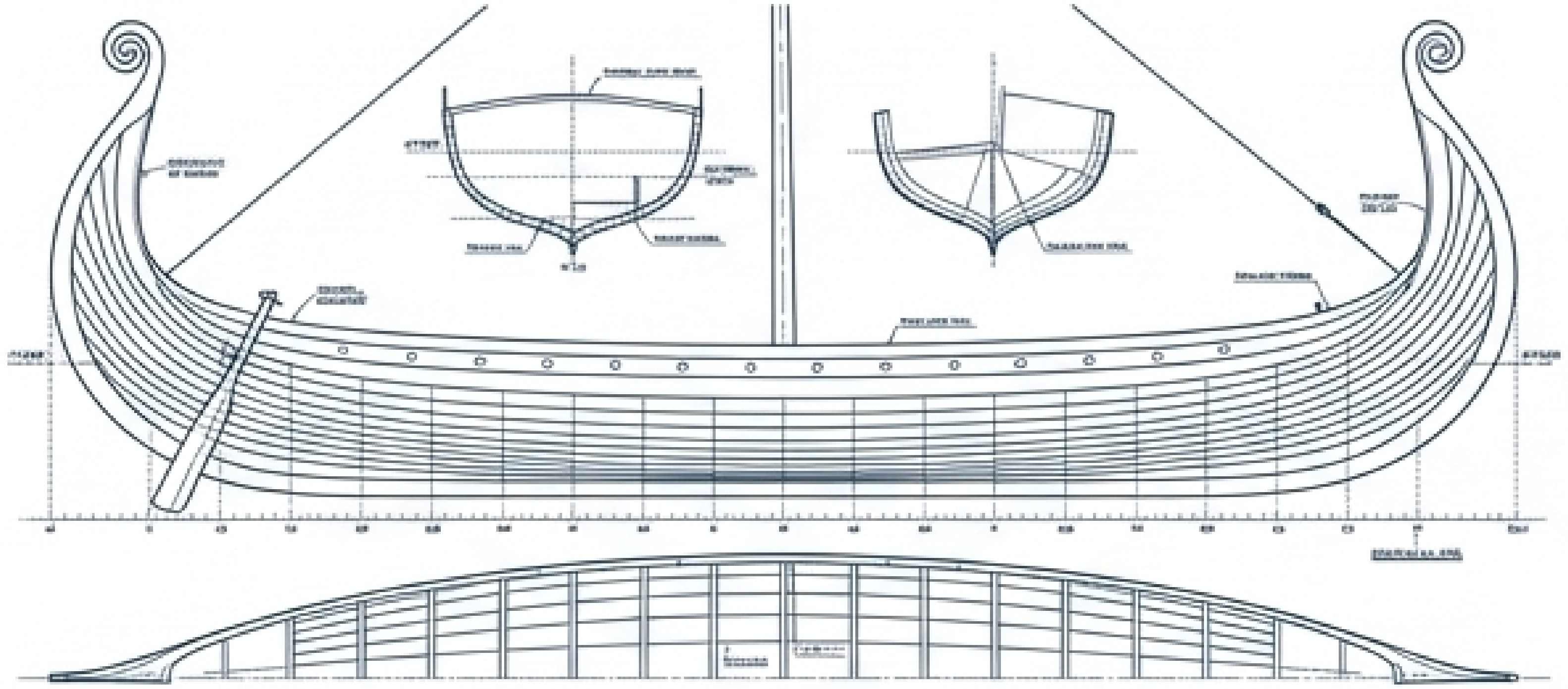
Economy

Gerard O'Neill's vision of shifting heavy industry to orbit is becoming reality. Startups are already proving the value of in-space manufacturing and data centers.

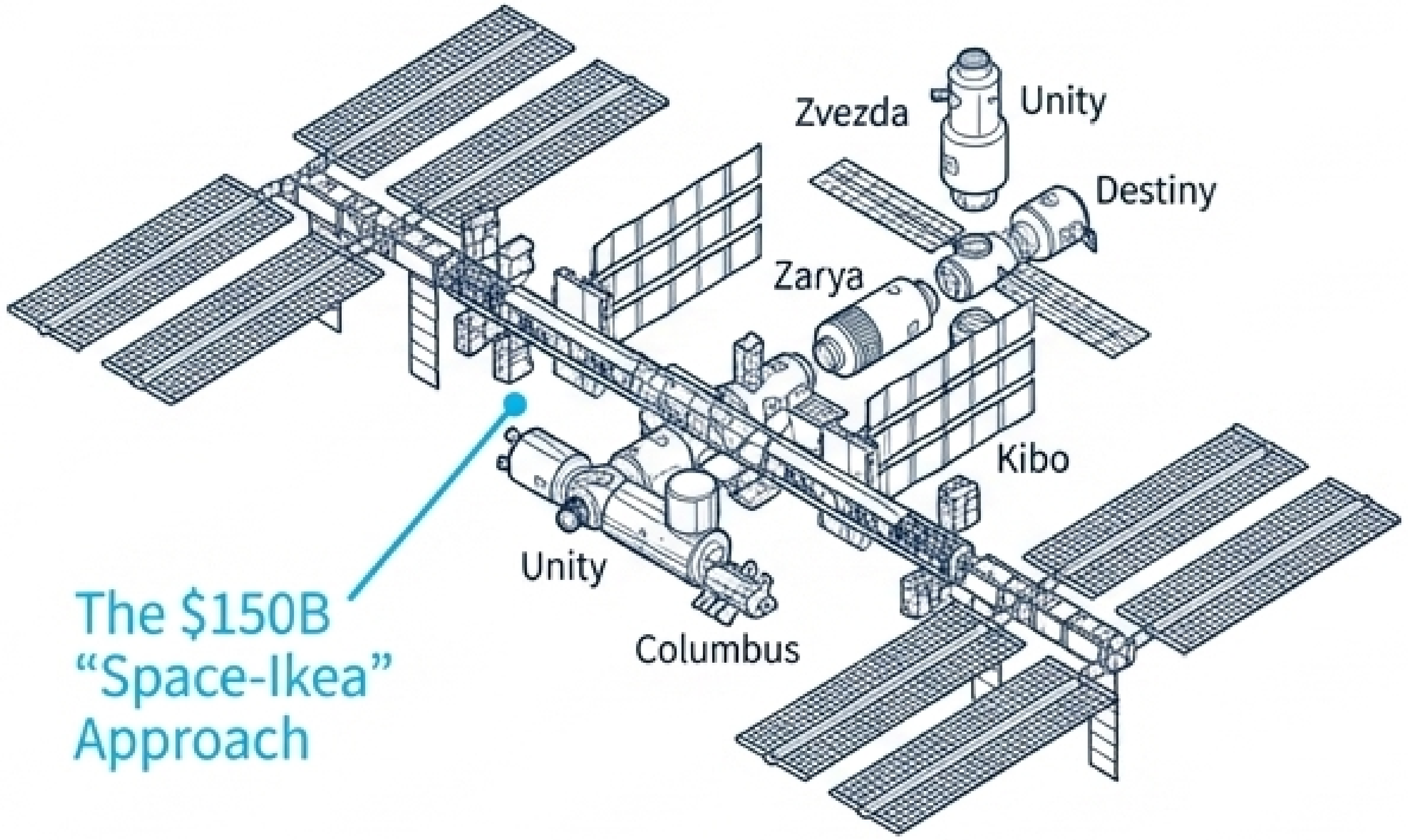
Exploration

Beyond survival and economics, expanding our presence in space offers adventure and meaning for future generations.

We Build Space Stations Like Lashing Rowboats Together, Not Like Shipbuilding

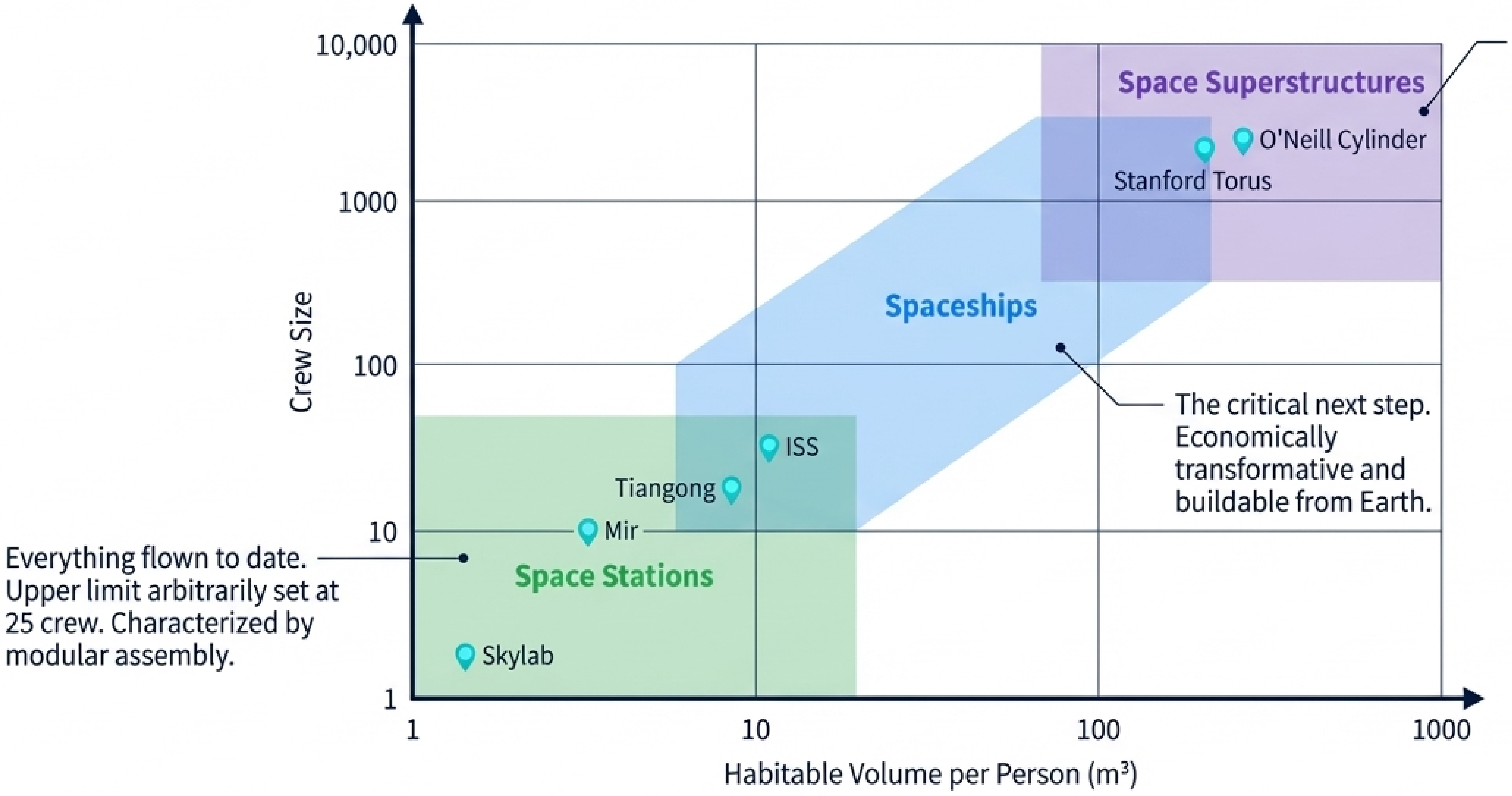


Viking

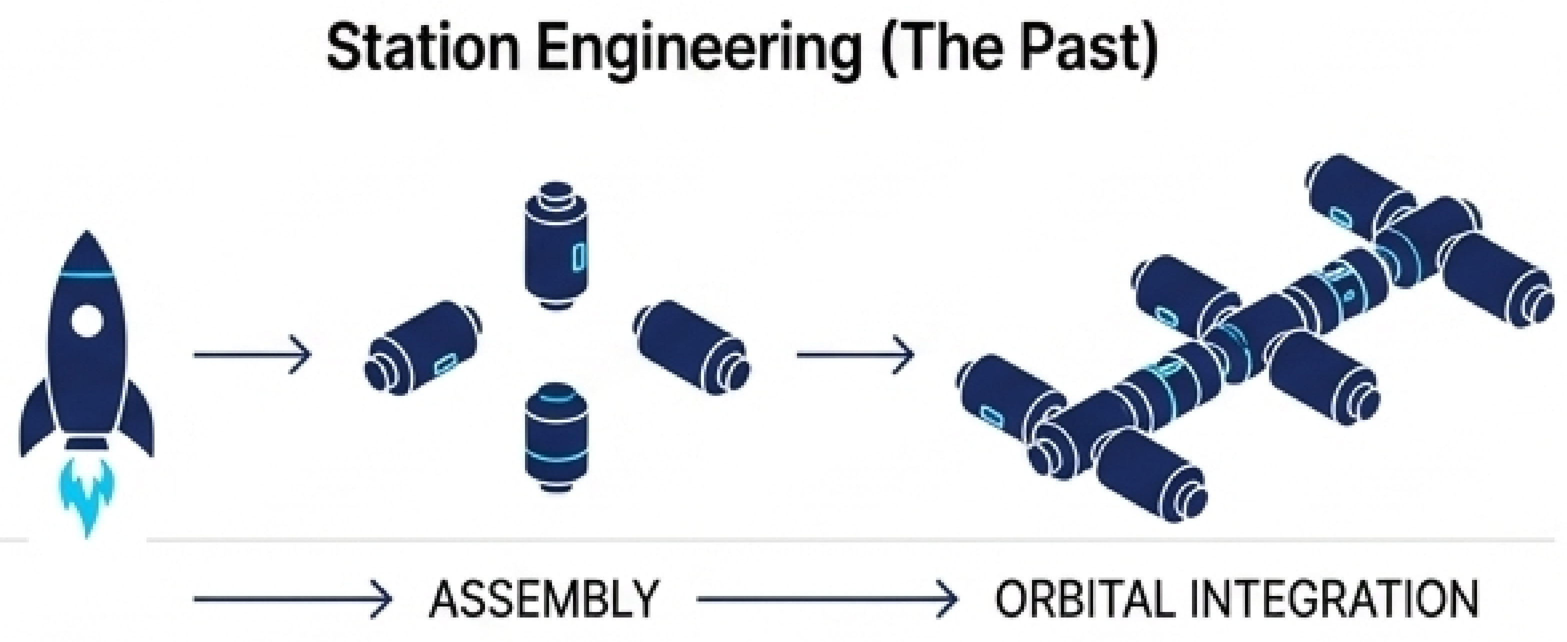


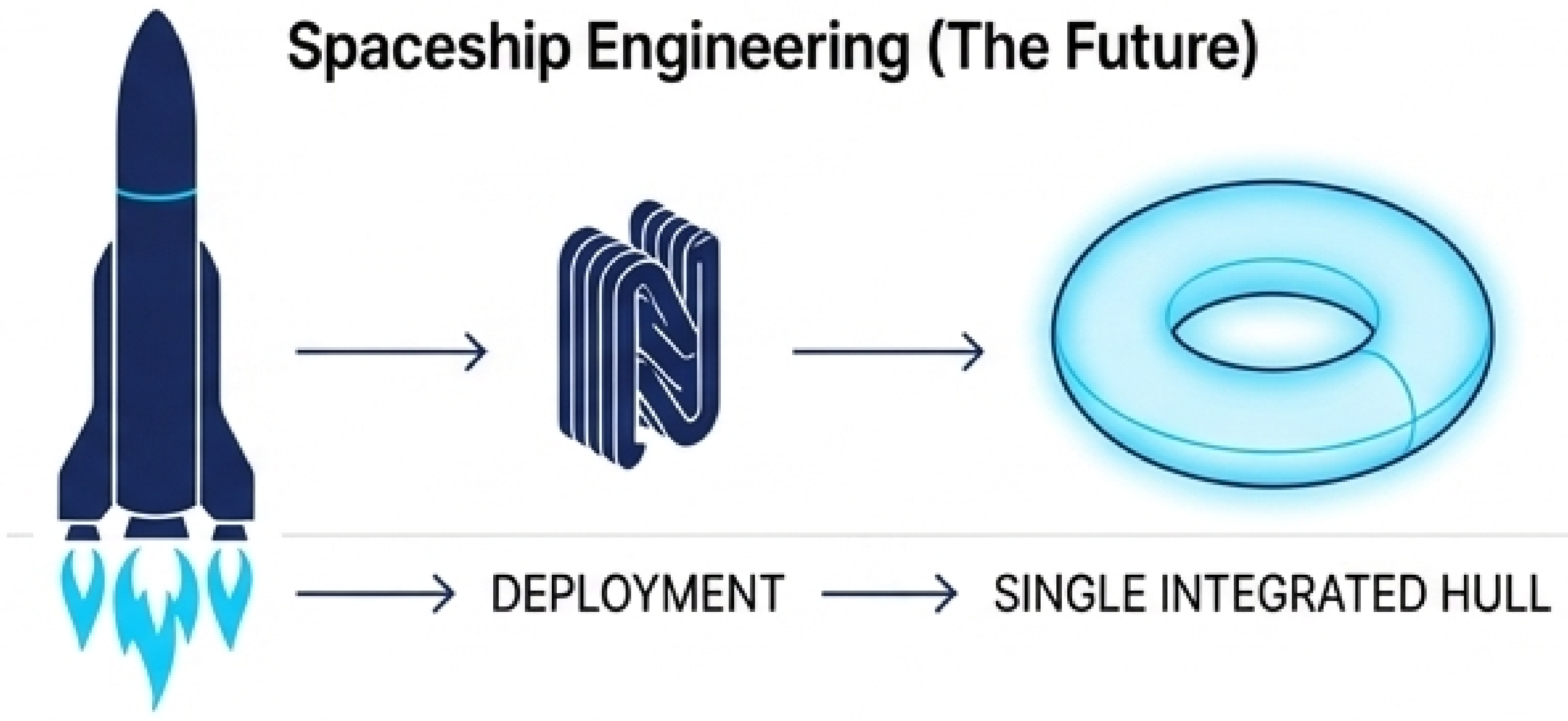
- The Romans and Vikings didn't build vessels for hundreds by combining rowboats. Yet this is essentially how we built the ISS, requiring over 40 launches to house just seven astronauts.
- An 11th-century longship carried a crew of 30-40. Our modern benchmark struggles to support thirteen.
- This flawed modular design is the direct result of thinking in terms of "stations".

A New Taxonomy Reveals the Path Forward: A Map of Our Future in Orbit.



“Spaceships” Are Defined by a Different Construction Philosophy: Monolithic Hulls





Space Stations

Assembled in orbit from many small, rigid modules. Costly, complex, and cumbersome.

Spaceships

Manufactured on Earth as a single, monolithic hull. Launched in one or a few launches. Uninterrupted interior volume.

Space Superstructures

Require materials sourced from the Moon or asteroids (ISRU) for construction.

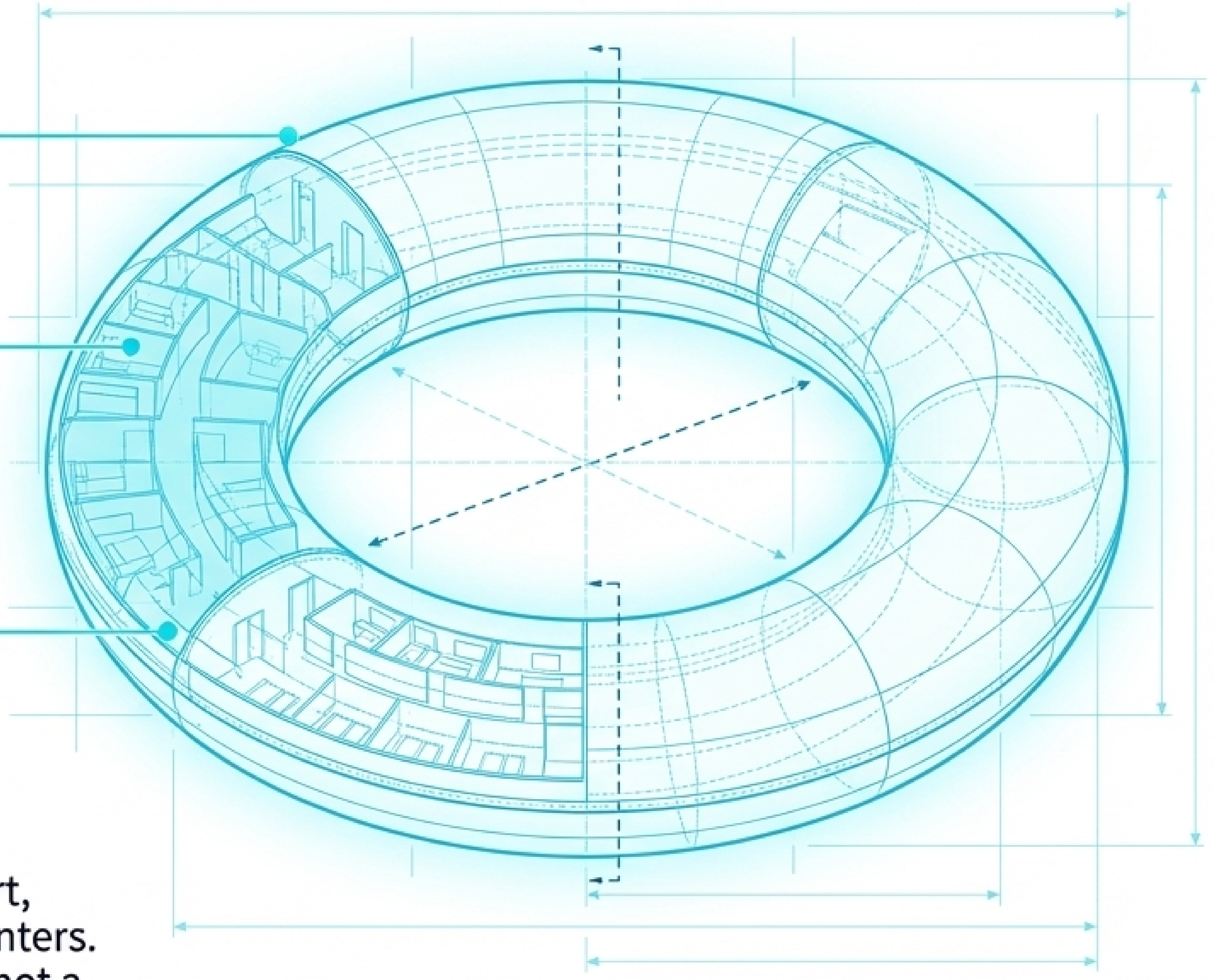
Core Insight: Spaceship engineering is a discipline distinct from spacecraft engineering, avoiding the trap of starting with hyper-modularity in the hull design.

Our Target: Defining the "Ideal Spaceship".

Crew Capacity
70 persons
(an order of magnitude increase over the ISS).

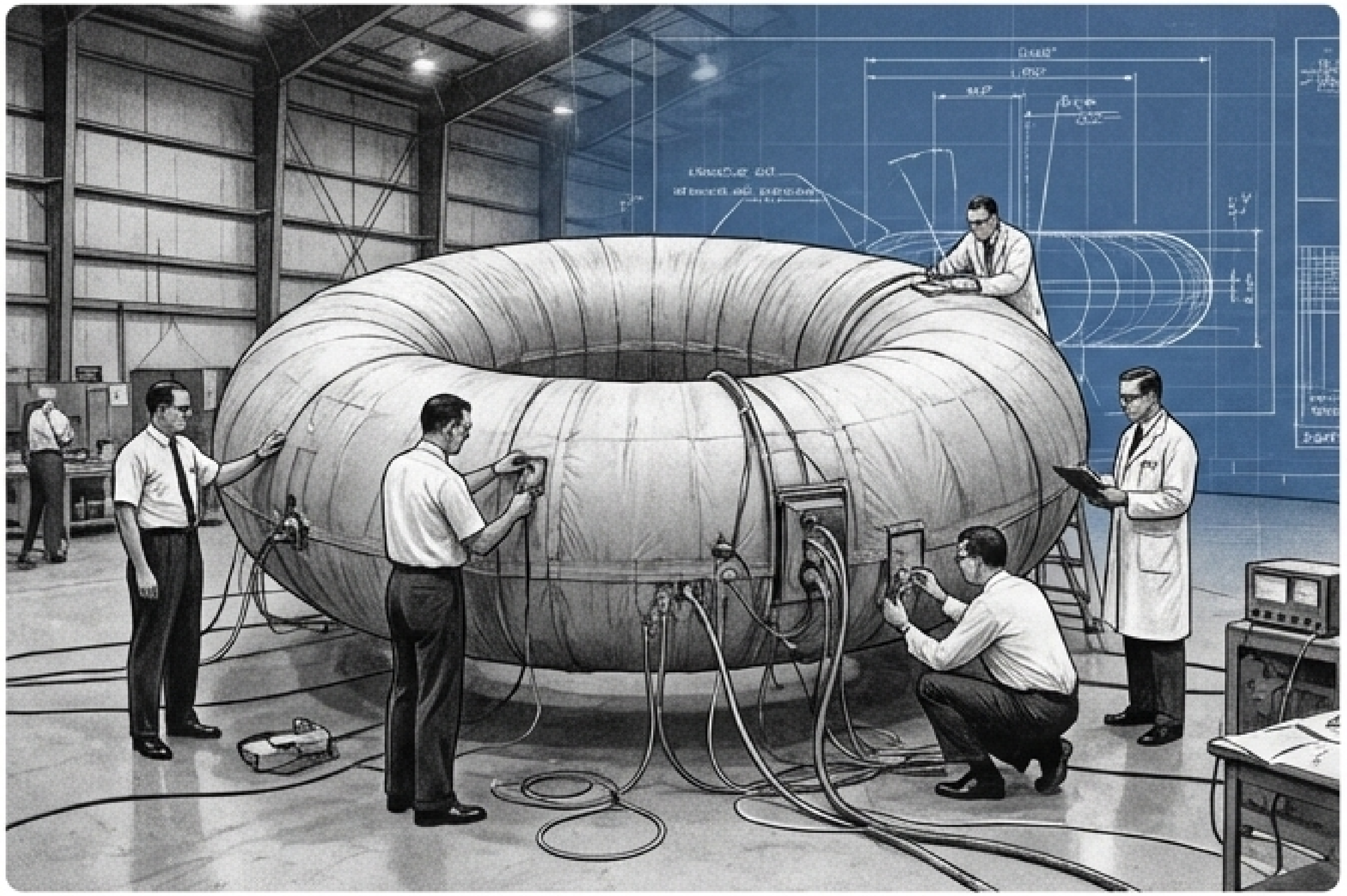
Comfort
90 m³ of habitable volume per person
(on par with Skylab, the best-in-class for comfort).

Total Volume
6300 m³
(remarkably close to Wernher von Braun's original wheel concept).



A monolithic hull spacious enough for human comfort, in-space manufacturing, and potential space data centers. Artificial gravity is a potential downstream upgrade, not a mandatory initial feature.

The Path to the Ideal Spaceship Was First Charted in the 1960s: Inflatables.



Engineers at NASA Langley in the 1960s pioneered monolithic inflatable concepts, sidestepping the hyper-modular “tin-can” approach. Their analysis promised dramatically lower cost and complexity.

Estimated cost:

Two orders of magnitude cheaper than the ISS

(adjusted to ~$1B in 2025).

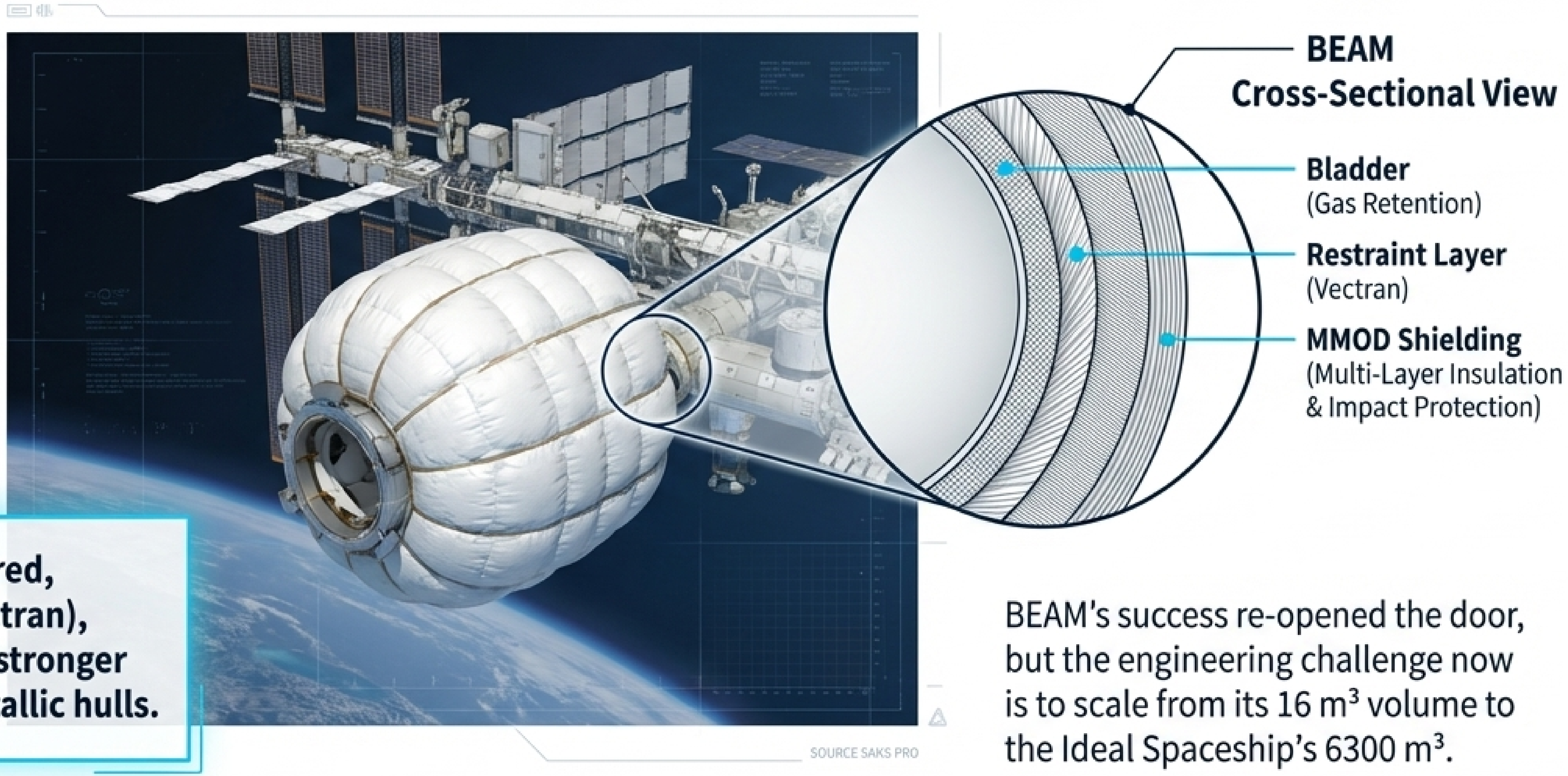
Launch requirements:

Roughly ten times fewer launches than the ISS.

This work was abandoned in the pivot to Apollo, but the principles remain valid.

Inflatable Technology is Not a Relic; It's Flight-Proven and Outperforms Metal.

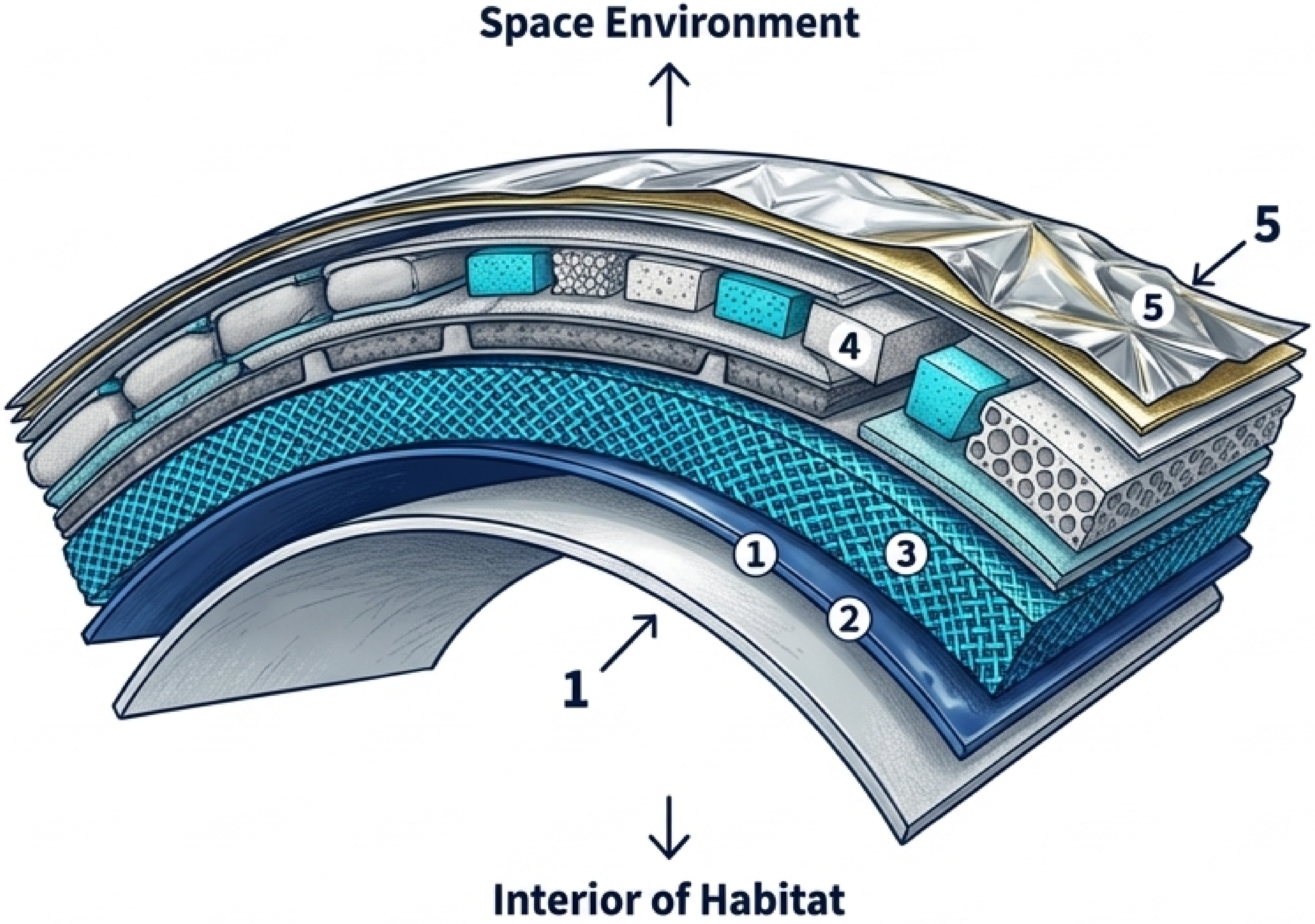
In 2016, NASA tested the BEAM module on the ISS, reinvigorating the case for inflatables.



Constructed from layered, Kevlar-like fabrics (Vectran), BEAM was found to be stronger than the ISS's own metallic hulls.

BEAM's success re-opened the door, but the engineering challenge now is to scale from its 16 m^3 volume to the Ideal Spaceship's 6300 m^3.

The Anatomy of a Modern Inflatable Shell.



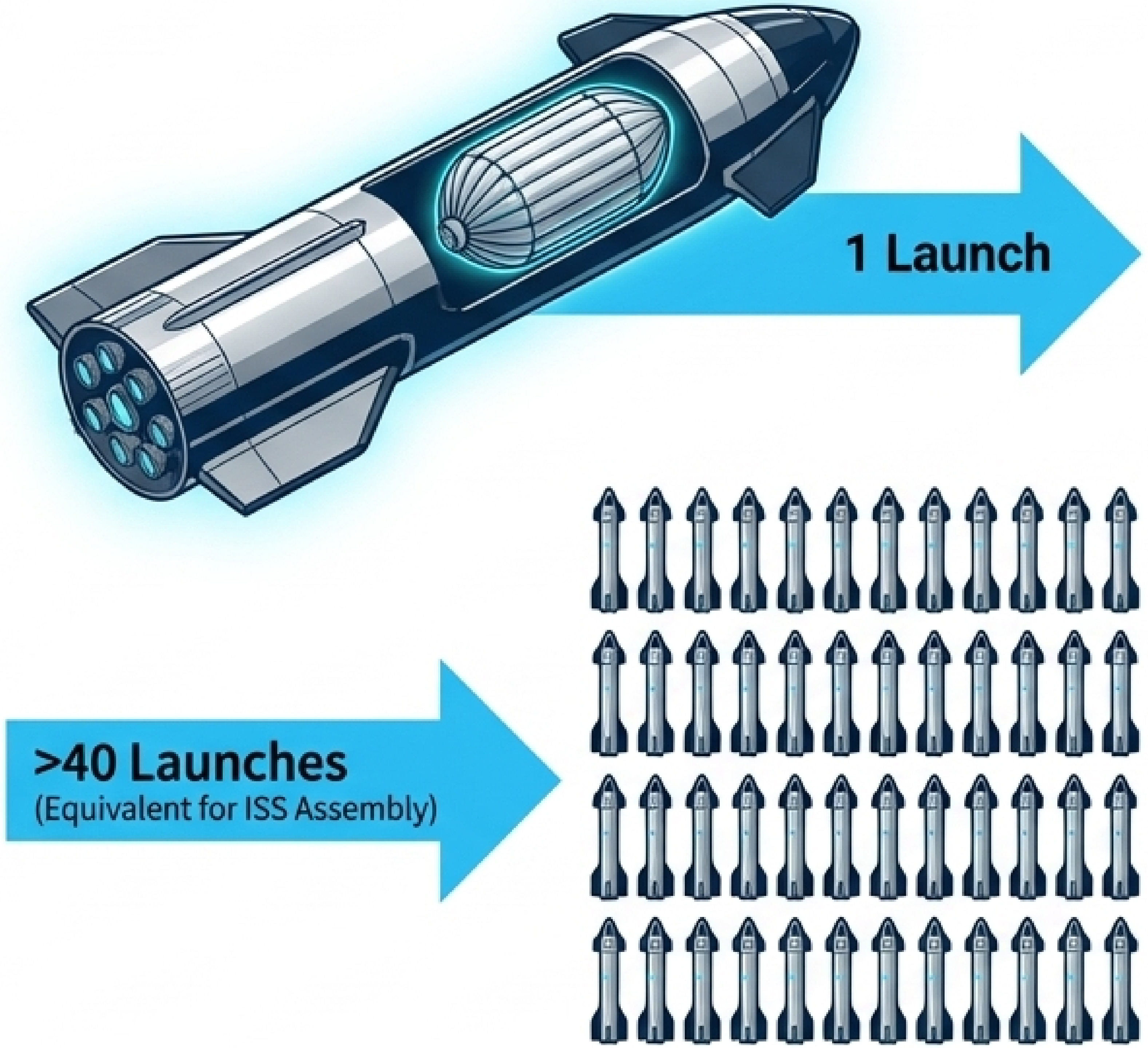
1. **Inner Liner:** The primary interior surface of the habitat.
2. **Bladder Layer:** The airtight gas barrier that contains the breathable atmosphere.
3. **Restraint Layer:** The primary structural and load-bearing layer, made of high-strength woven fabric.
4. **MMOD Protection Layer:** Shielding against micrometeoroids and orbital debris.
5. **Thermal Protection (MLI) Layer:** Multi-Layer Insulation to manage extreme temperatures in space.

The Engineering Case: Mass, Volume, and **Launch Feasibility**.

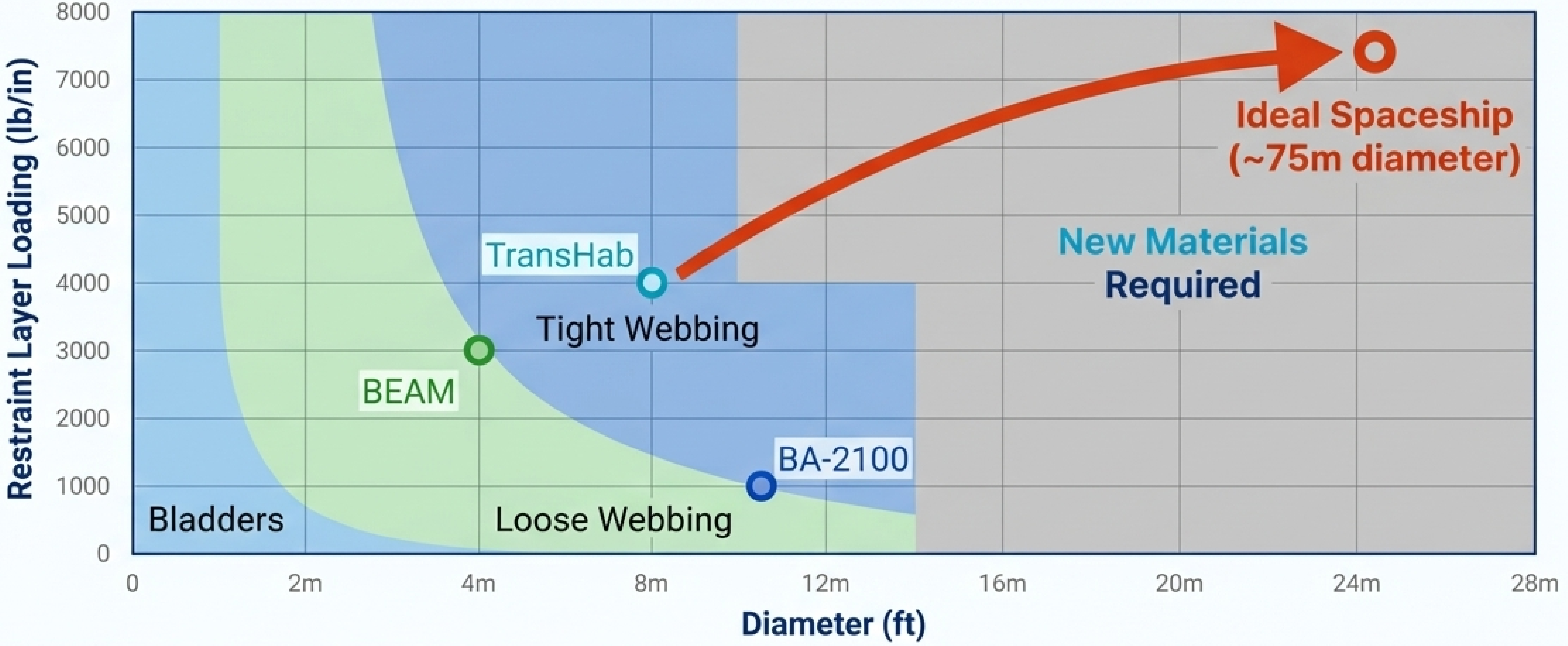
METRIC	TransHab (1990s Tech)	BEAM (2016 Tech)	Ideal Spaceship Goal
Packed Density (kg/m^3)	122	157	**<100 (Target)**
Compression Ratio	3.12:1	1.78:1	**>6.3:1 (Target)**

Mass estimates for a 6300 m^3 hull using existing material technology:

- With TransHab materials: ~195 tons (2 Starship launches).
- With BEAM materials: ~487 tons (5 Starship launches).
- The goal is a next-generation shell light enough for a single Starship launch (<100 tons).

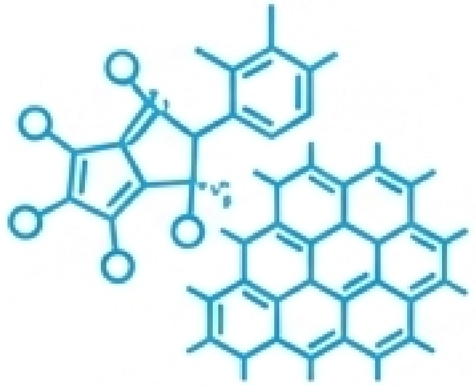


The Core Engineering Hurdle: Scaling the Restraint Layer



- The restraint layer is the main **load-bearing** component.
- As the diameter of the structure increases, the load on the restraint layer's fabric increases significantly.
- Current "tight webbing" designs (like on TransHab) are **proven up to ~8m diameters**. The Ideal Spaceship requires a diameter of ~75m.
- This leap in scale likely requires **novel materials**, **new weave patterns**, or both, especially for non-cylindrical (toroidal) geometries.

An Invitation: The Engineering Challenges to Unlock the Future.



Challenge 1: Shell Density

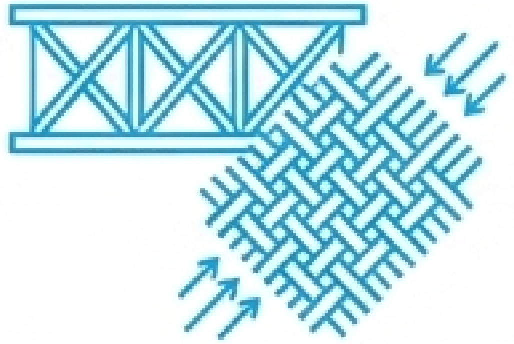
Develop a multilayer shell with half the pressurized density of TransHab materials.

Enable a ~6300 m³ hull to mass under 100 tons, fitting within a single Starship launch.

Challenge 2: Advanced Packaging

Engineer a method to fold a large, wheel-shaped hull to achieve a >6.3:1 compression ratio.

Allow the stowed structure to fit within Starship's ~1000 m³ payload fairing.

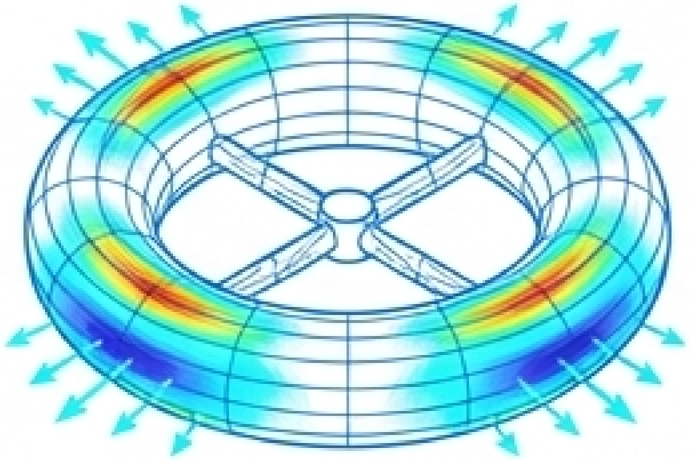


Challenge 3: Restraint Layer Scaling

Create materials and weaves that can handle the increased structural loads of a ~75m diameter inflatable.

Overcome the primary physical barrier to building spaceship-scale structures.

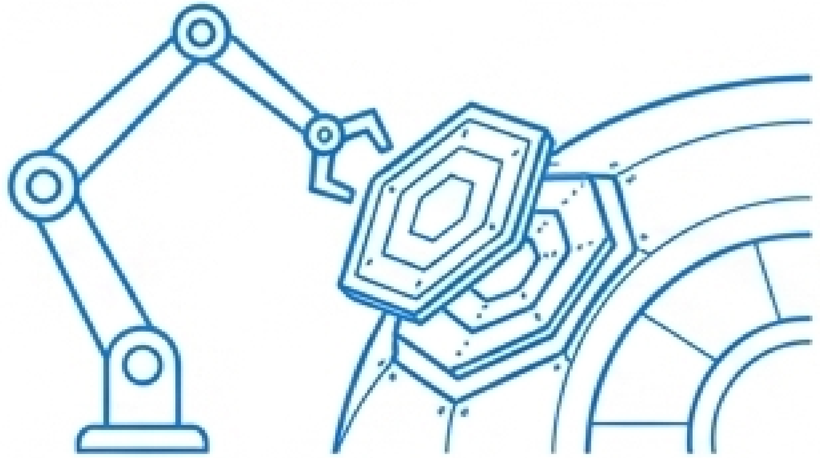
An Invitation: Solving for Geometry and Mission Architecture.



Challenge 4: Restraint for Toroidal Geometries

Goal: Design and model restraint layers specifically for wheel-shaped structures.

Outcome: Understand and mitigate the unique stress distributions and failure modes that differ from well-understood cylindrical modules.



Challenge 5: MMOD Protection Architecture

Trade-off: Should MMOD be a heavy, integrated layer (as in TransHab), or should a lighter hull be launched first, with modular Whipple shield panels robotically assembled in orbit on a subsequent mission?

From Tin Cans to Vast Habitats.

A spaceship is a distinct class of orbital structure between today's stations and tomorrow's superstructures. Achieving this requires a return to the philosophy of monolithic, inflatable hulls pioneered decades ago. The engineering challenges are clear, defined, and solvable.

"The next wave of spaceship engineers will decide whether humanity's future in orbit remains cramped in tin cans or grows into vast, city-sized habitats."