C.R.A.F.T.

Construction & Rapid Assembly Factory Terminal

Building the First Factories in Space

White Paper — February 2026

Authors: Harper Dammann Smith & William Fahie

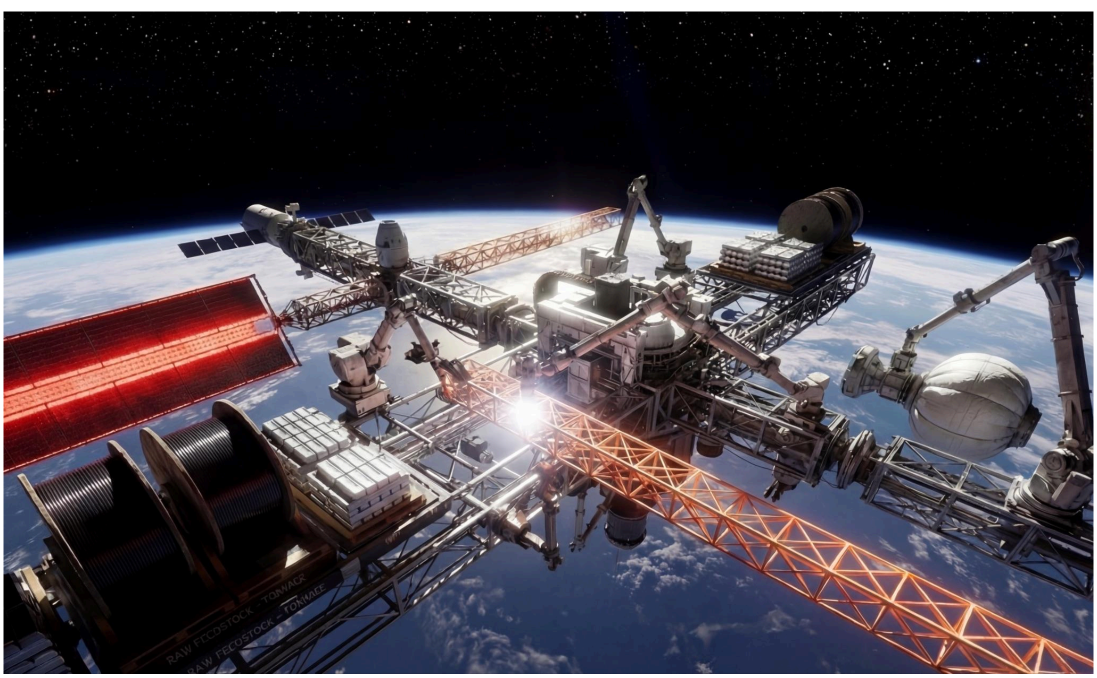
Introduction

When the first pioneers crossed the oceans to settle new frontiers, they didn't carry finished houses on their backs — they brought the tools to build them from the earth beneath their feet. We believe the expansion to space is no different; to become a multi-planetary species, we must stop launching the structures we live in and start manufacturing in-situ.

This paper lays out the case for C.R.A.F.T. — an autonomous orbital manufacturing terminal that mass-produces pressurised habitats and structural modules directly in Low Earth Orbit (LEO). SpaceX has solved the transportation problem. Starship will push launch costs toward $100/kg and eventually $10/kg. But every habitat, every station module, every large structure we put in space is still built on Earth, stuffed inside a rocket fairing, and launched as mostly empty air.

A typical ISS module weighs 14 tonnes and encloses $106m^3$ of pressurised volume. That's 14 tonnes of mass budget to ship a hollow tube. Why waste all that space? We believe in a different approach: launch dense feedstock, manufacture in orbit. Instead of building bespoke aerospace structures on Earth and shipping them through narrow fairings, we bulk-launch raw aluminium and manufacture structural modules autonomously in LEO. For the same launch mass, in-orbit manufacturing produces 5–13× more habitable volume than prefabricated rigid modules.

The space economy is projected to reach $1.8 trillion by 2035 (McKinsey/WEF). The ISS retires in 2030 with no adequate replacement ready. NASA has funded four commercial station programmes. Every one of them is constrained by the same bottleneck: you can't build a habitat bigger than the rocket that carries it. **C.R.A.F.T. will remove that constraint.**



Founding Theses

1. Launch costs are about to collapse, and nobody has a supply chain ready for it. Starship targets 100–150 tonnes to LEO at $100–500/kg near-term, potentially $10/kg at maturity. This changes the economics of everything — but only if you have something useful to do with cheap mass-to-orbit.
2. Prefabricated modules are fundamentally inefficient for space habitation. You're paying to launch a structural shell, thermal protection, and micrometeoroid shielding that together enclose a volume of nothing. The mass-to-volume ratio of ISS modules is 137–252 kg/m³. Dense aluminium feedstock, manufactured in orbit into pressure shells, achieves 5–40 kg/m³.

3. The core manufacturing technologies already work in space. NASA proved polymer 3D printing on the ISS in 2014. ESA proved metal 3D printing in 2024. Orbital Matter proved vacuum printing in open space in 2024. Electron beam welding, friction stir welding, and inflatable structures are all flight-demonstrated. The gap isn't any single technology — it's integrating them into a factory.
4. There is a specific, near-term market. The ISS retires in 2030. NASA's CLD programme is spending $2.1B over five years on commercial station development. Four station programmes need habitable volume. All of them are constrained by Earth-based manufacturing timelines and fairing diameters.
5. Nobody else is doing this at the right scale. Existing in-space manufacturing companies are either making small components, manufacturing products to return to Earth, or still in the lab. Zero companies have demonstrated autonomous large-scale structural manufacturing in orbit.

The Problem: Shipping Air

Every space station ever built has been shaped by the cylinder it rode to orbit in. The ISS was assembled from modules constrained to the Space Shuttle's 4.6-metre payload bay. Thirty years later, the fundamental architecture hasn't changed: build a rigid tube on Earth, fill it with equipment, stuff it inside a fairing, launch. **60–80% of launched mass is a structural shell enclosing empty space.**

Now compare that to dense feedstock. Aluminium has a density of 2,700 kg/m³. A Starship carrying 150 tonnes of aluminium billets fills just 56 m³ of its 1,000 m³ payload bay — 5.6% of the available space. In this scenario, the rocket is mass-limited, not volume-limited. Every kilogram goes toward material that will become structure.

The Market

The International Space Station is 916m^3 of pressurised volume, 42 launches, two decades of assembly, ~$150 billion total cost. It will be deorbited into the South Pacific by early 2031. NASA's plan is to hand off to commercial operators. The Commercial LEO Destinations (CLD) programme awarded ~$415M to develop replacements.

Planned Station Capacities

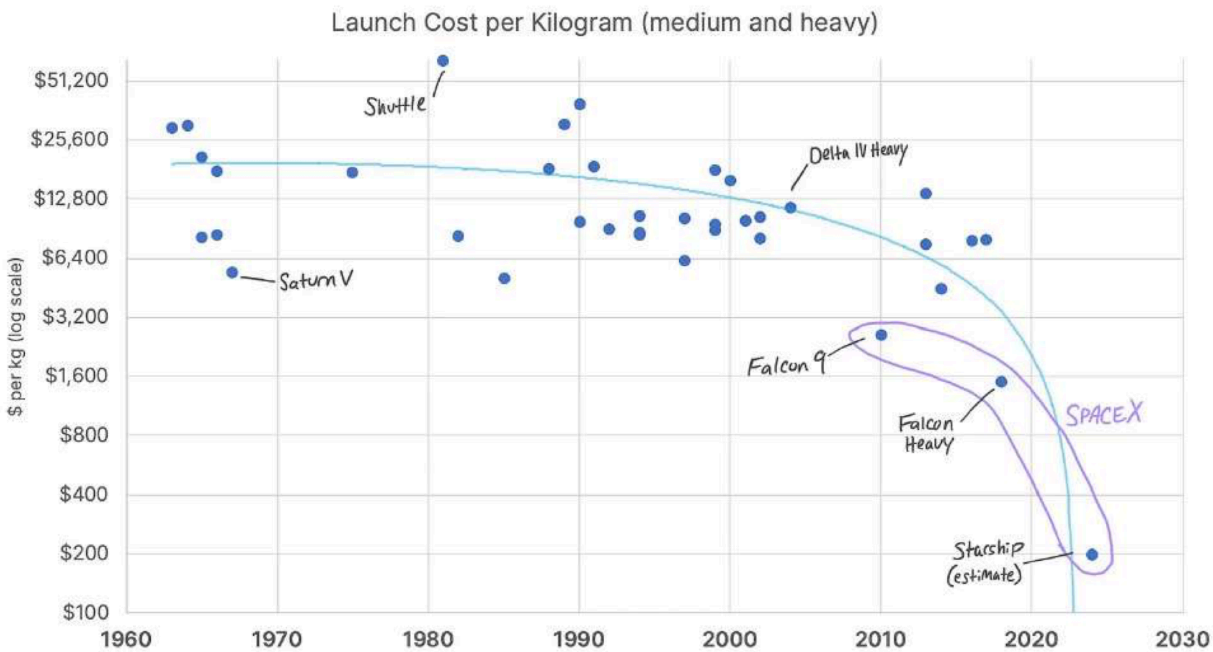
Station	Volume	Crew	Status
ISS (Retiring)	916 m^3	6–7	Deorbit 2031
Starlab (Voyager/Airbus)	340–450 m^3	4–8	Target 2028
Axiom Station	TBD	4+	First module ~2027
Vast Haven-1	45 m^3	4	Target Q1 2027
Tiangong (China)	340 m^3	3–6	Operational now

Even with unlimited capital, adding a habitat module to any of these stations takes 3–5 years. Thales Alenia builds Axiom's modules. Airbus builds Starlab's. These are multi-year aerospace programmes for each individual module. That timeline is fine if you're building one station. It breaks the moment you need to scale. C.R.A.F.T. will sell manufactured pressurised volume as a commodity. Per-cubic-metre pricing. The customer doesn't wait 3 years to build and ship a module — they order volume from our factory already in orbit.

The economics of space have always been defined by launch cost. Everything follows from what it costs to put a kilogram in orbit.

Vehicle	Payload to LEO	Cost per kg	Fairing Diameter
Space Shuttle	27,500 kg	~$54,500	4.6 m
Falcon 9	22,800 kg	~$2,720	4.6 m
Falcon Heavy	63,800 kg	~$1,400	5.2 m
Starship (near-term)	100–150,000 kg	~$100–500	8.0 m
Starship (mature)	150,000 kg	~$10–50	8.0 m

We are approaching a threshold where it will be cheaper to launch bulk material and manufacture in orbit than to build bespoke aerospace hardware on Earth and ship it.



Credit: Max Olson; The Future of Space, Part I: The Setup.

Credit: SpaceX

The Technology

A common objection: “can you actually manufacture in space?” The answer is yes, and it’s been proven repeatedly. What hasn’t been done is put the pieces together into a single integrated system at scale.

1. 3D printing in microgravity: NASA and Made In Space flew the first 3D printer to the ISS in November 2014. Redwire’s Additive Manufacturing Facility has since produced over 200 parts on the ISS. In January 2024, ESA sent the first metal 3D printer — it produced stainless steel components via directed energy deposition at 1,400°C.
2. Manufacturing in vacuum: Orbital Matter demonstrated a vacuum-compatible 3D printer on its Replicator CubeSat in July 2024, printing a 50 cm beam at 580 km altitude. This proved the concept that you don’t need a pressurised module to manufacture in orbit.
3. Electron beam welding: ThinkOrbital has miniaturised electron beam tools for autonomous orbital construction. Vacuum is ideal for electron beam processes — no shielding gas, no oxidation, high power density.
4. Inflatable structures: Bigelow’s BEAM module has been on the ISS since 2016 — nine years, no penetrations, radiation protection comparable to aluminium. Sierra Space’s LIFE habitat burst-tested at 27% above NASA’s 4× safety requirement.

The gap isn’t any single technology — it’s integrating them into a factory.

Competition

The in-space manufacturing sector is active but fragmented. Nobody is building large-scale structural manufacturing that stays in orbit and produces habitable volume at scale.

Company	Funding	Focus	Difference from C.R.A.F.T.
Redwire	Public (~$1.5B cap)	ISS printing, solar arrays	Components, not structures
ThinkOrbital	~$3.5M	EBM welding tools	Closest; very early stage
Orbital Matter	~€1.2M	Vacuum 3D printing	R&D demo, tiny scale
Orbital Composites	~$6.6M	Composite antennas	Antennas, not habitats
Space Forge	~$30M	Semiconductor materials	Materials for Earth return

The Mission

- Phase 1: Ground Demo (3 months). Demonstrate metal 3D printing and structural joining in simulated conditions. Sign LOIs.
- Phase 2: Rideshare Demo (18–24 months). Launch a 3D printer inside an inflated test volume on a Starship rideshare. Print a structural component in orbit.
- Phase 3: First Factory (3–5 years). Deploy the first C.R.A.F.T. manufacturing terminal in LEO. Deliver pressurised volumes to customer stations.
- Phase 4+: Scale. Cislunar manufacturing for Gateway, lunar surface habitats, and Mars transit habitat production.

Our vision: Reaching LEO from Earth's surface takes ~9.4 km/s of delta-v — about 62% of the total needed to reach the lunar surface. Manufacturing in LEO means the hardest part of the journey is already done for every structure headed to the Moon or Mars.

"We believe it's a failure of humanity if we're not multiplanetary by the end of the century. Before you can support civilisation on another planet, you need to support one in orbit. Before you can support one in orbit, you need to be able to build things there."

We'll see you in LEO :)

harper@arksen.com | williamfahie@outlook.com