Industrializing Space for the Benefit of Earth

Jordan Croom
Jordan@varda.com
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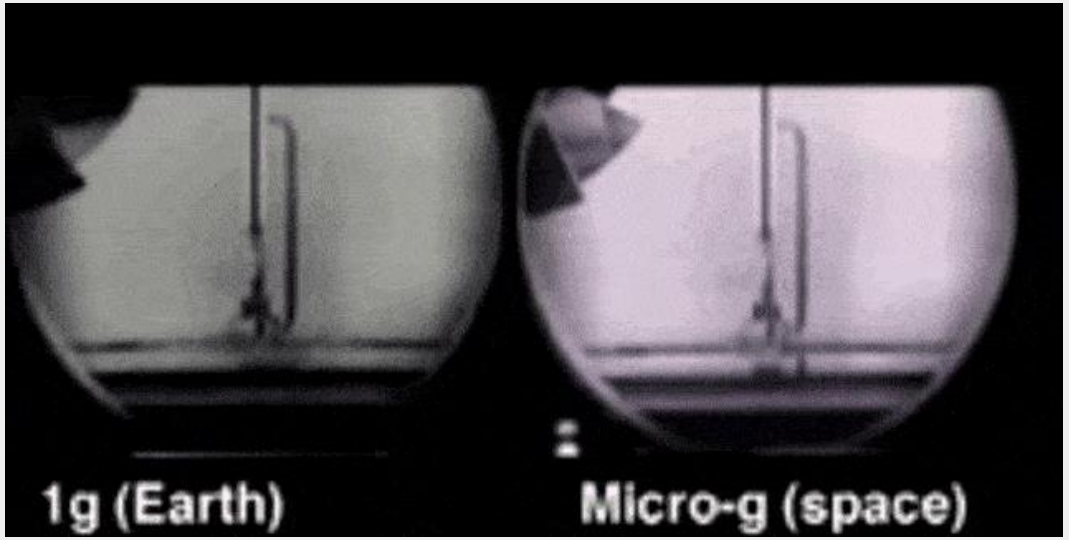
Microgravity Leads to Unique Chemical and Morphology Behavior

Earth Gravity

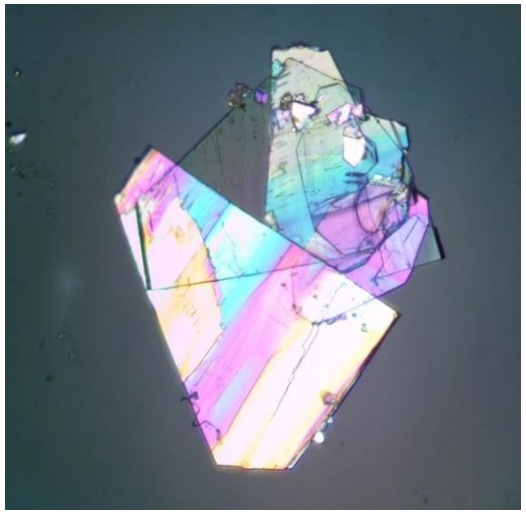
Microgravity

Microgravity Effects

Processing in a microgravity environment dramatically alters buoyancy, natural convection, sedimentation, phase separation and drives significant differences in transport-driven phenomena



Example Application: Pharmaceuticals



MICROGRAVITY IMPACT

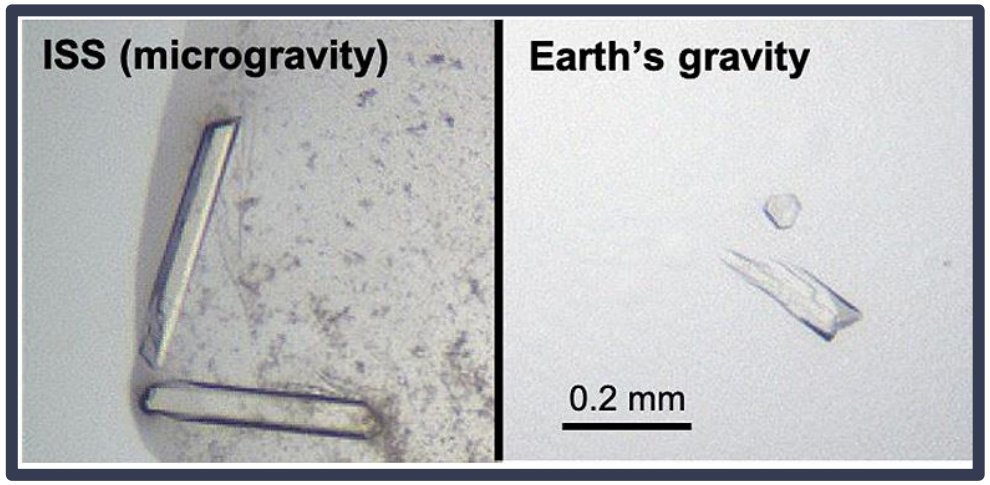
- Particle nucleation and growth kinetics
- More uniform particle size
- Novel crystal structures or morphologies
- Larger or smaller particles
- Fewer crystal defects

RANGE OF BENEFITS

- Enable new routes of administration
- Improved bioavailability and solubility
- Improved purity, reduced side effects, toxicity
- Extended shelf life
- Novel form discovery

KRAS Protein Crystals 0g vs 1g

“The problem was the internal orderliness of the crystals, they were disordered, so we couldn’t get very good data to resolve the structure…”



“…in microgravity, the movement of molecules during crystallization is slower and more ordered, resulting in a more uniform crystal.”

Albert Chan, Frederick National Lab, Space Crystals and the Search for a Cancer Cure: Using Microgravity to Improve Protein Crystallization (issnationallab.org), February 27, 2023

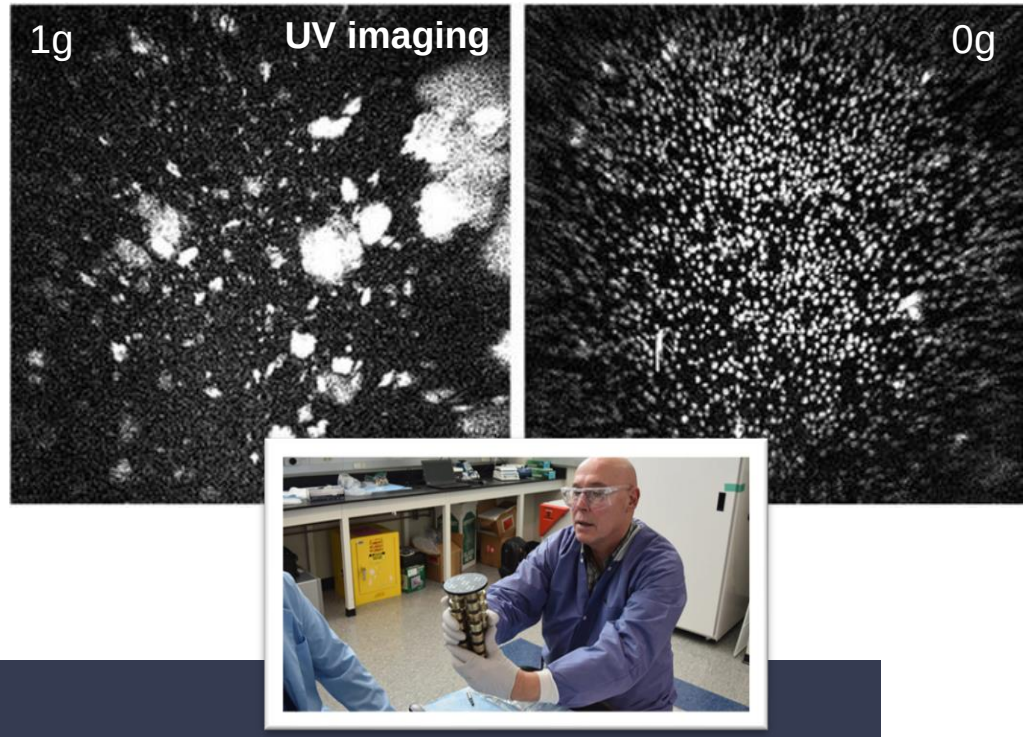
Keytruda® IV to Subcutaneous Injection

CONDUCTING A DIFFERENT KIND OF PROTEIN CRYSTAL GROWTH EXPERIMENT

The study aims to grow a crystalline suspension of millions of tiny uniform crystals.

“The more you minimize movement within the solution and rely solely on the ability of the molecules to one by one come together and build the crystal lattice, the more likely you’ll get a highly ordered, pure crystal.”

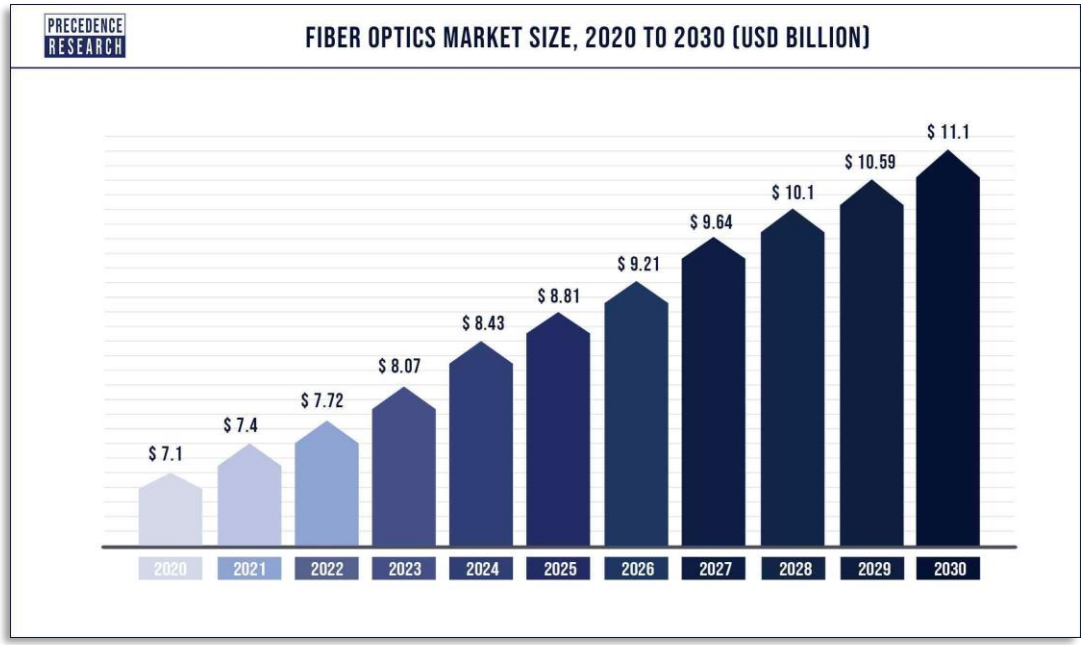
– Matt Truppo, Merck & Co.



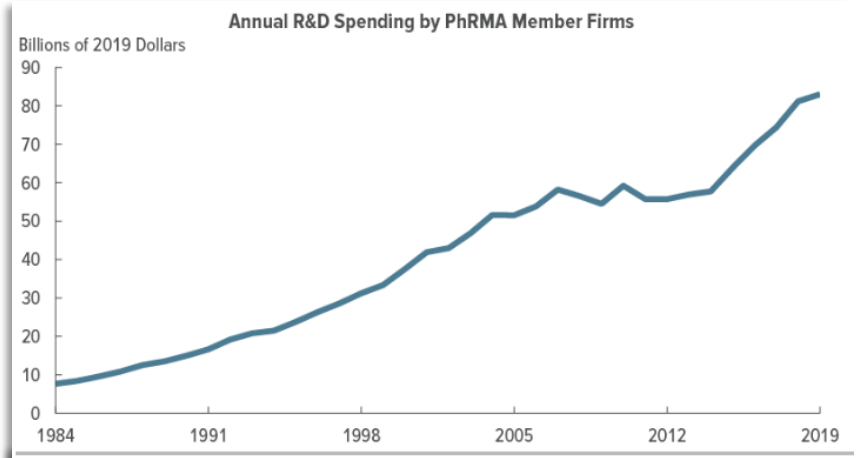
“Conducting experiments in microgravity allows us to test unique preparations and make primary discoveries that we can then apply to drug development on the ground and onward to manufacturing” - Paul Reichert, 2018

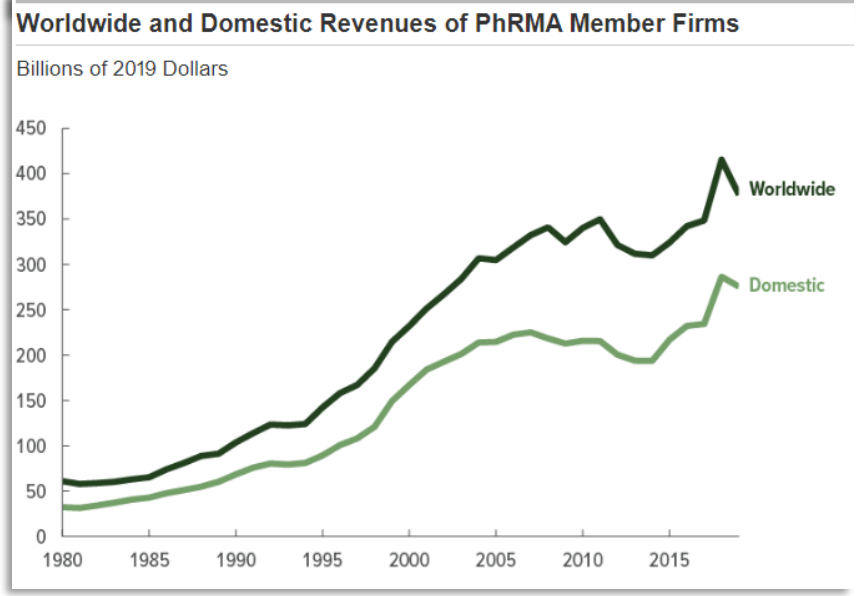
Paul Reichert, Merck & Co.’s immunotherapy drug Keytruda®; https://www.issnationallab.org/reshaping-drug-delivery-millions-of-crystals-at-a-time/ March 26, 2018 - https://www.nature.com/articles/s41526-019-0090-3

In-Space For-Earth



https://www.precedenceresearch.com/fiber-optics-market



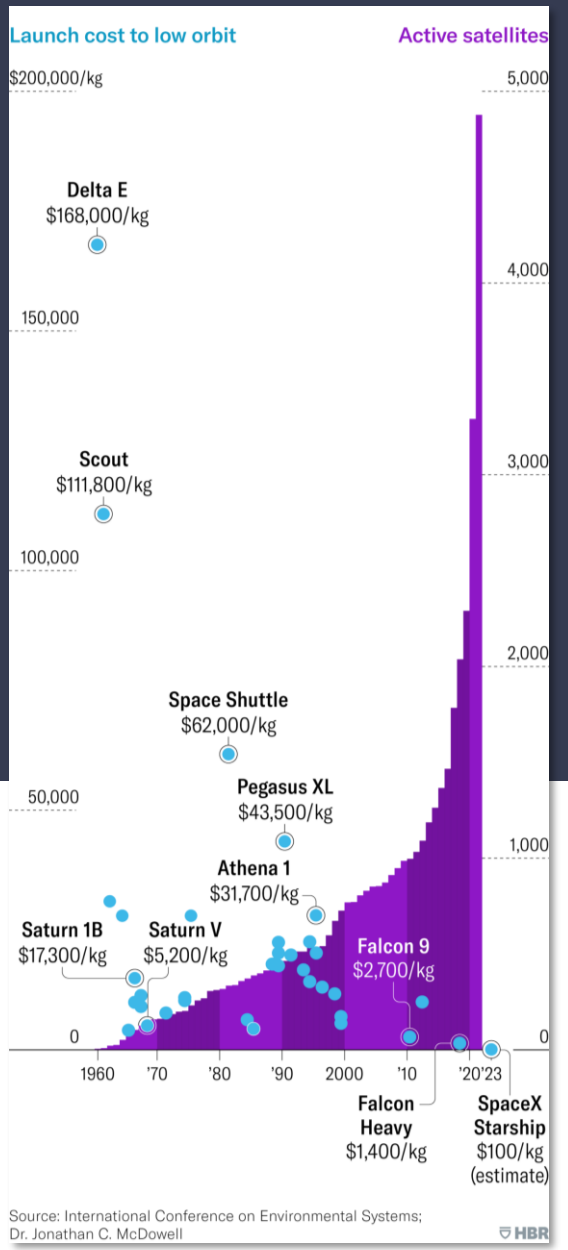


Data source: Congressional Budget Office, using data from PhRMA, *2019 PhRMA Annual Membership Survey*, Table 4 (PhRMA, 2019), https://tinyurl.com/ycvneve7 (PDF, 2.15 MB).
See www.cbo.gov/publication/57025#data.

Why Now?

Significant progress from the commercial space industry makes building and launching spacecraft cheaper and more reliable than ever.

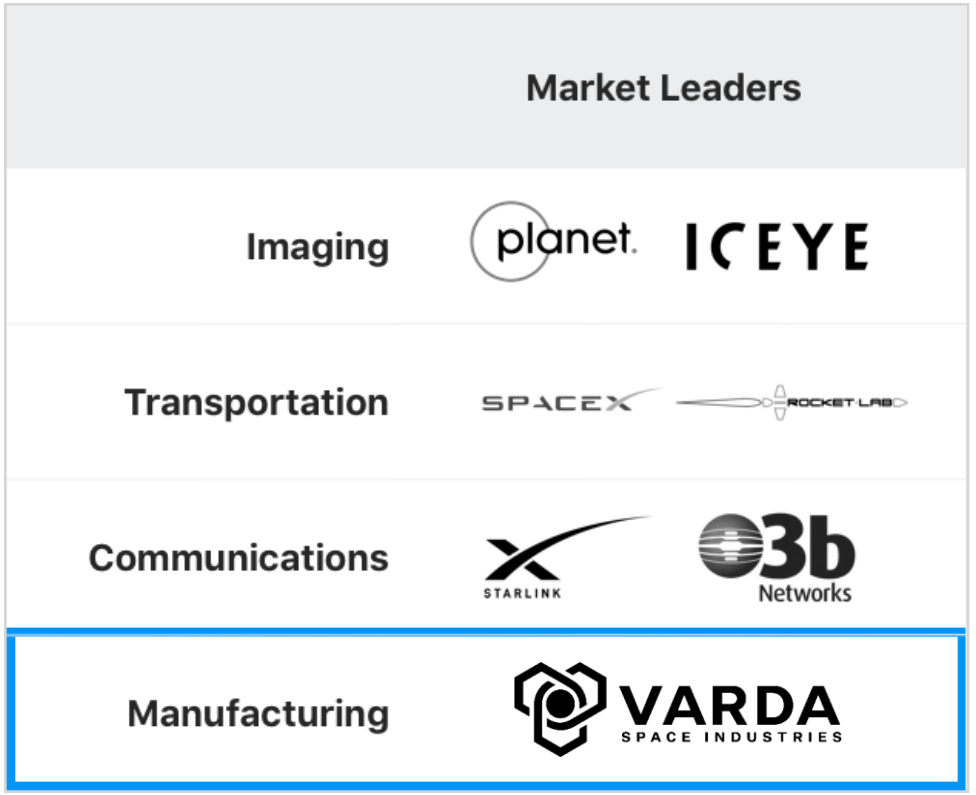
Microgravity is now economically viable for material production.



Building a sustainable economy in space

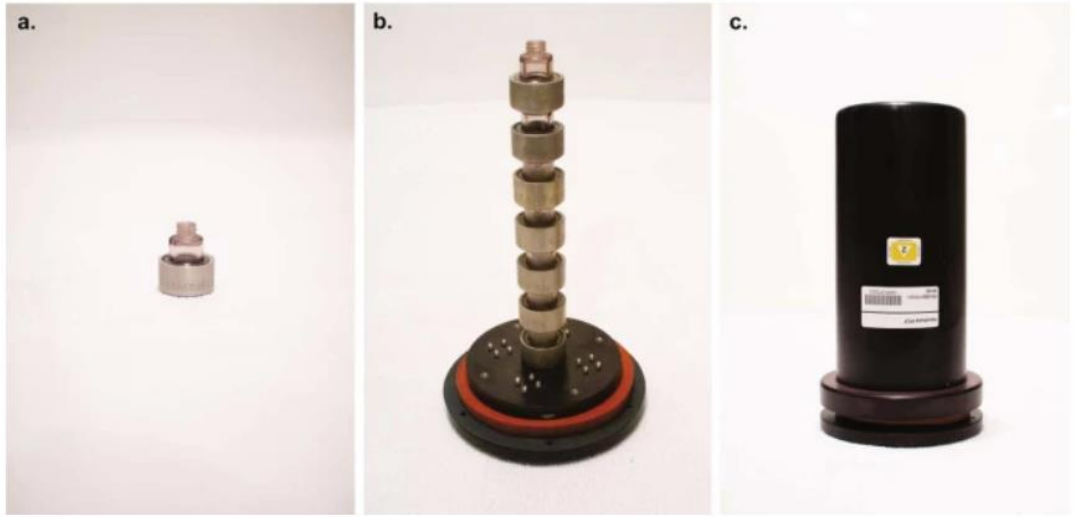
Now, space manufacturing can be done profitably

We can cheaply send things up *and down*. Zero gravity opens a whole world of materials you can manufacture profitably.



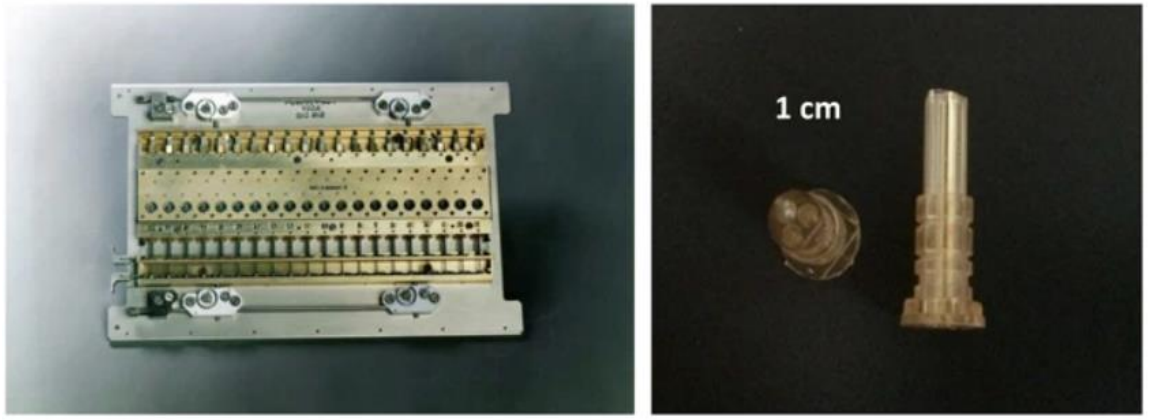
What do orbital manufacturing devices look like?

Fig. 1



HH-PCF hardware: **a** 1 ml polysulfone bottle with aluminum cap. **b** Base plate with one tower of 7 × 1 ml polysulfone bottles with aluminum caps and orange gasket for sealing. **c** Outer aluminum cover, which covers the base plate. *Below: Astronaut with crystallization device*

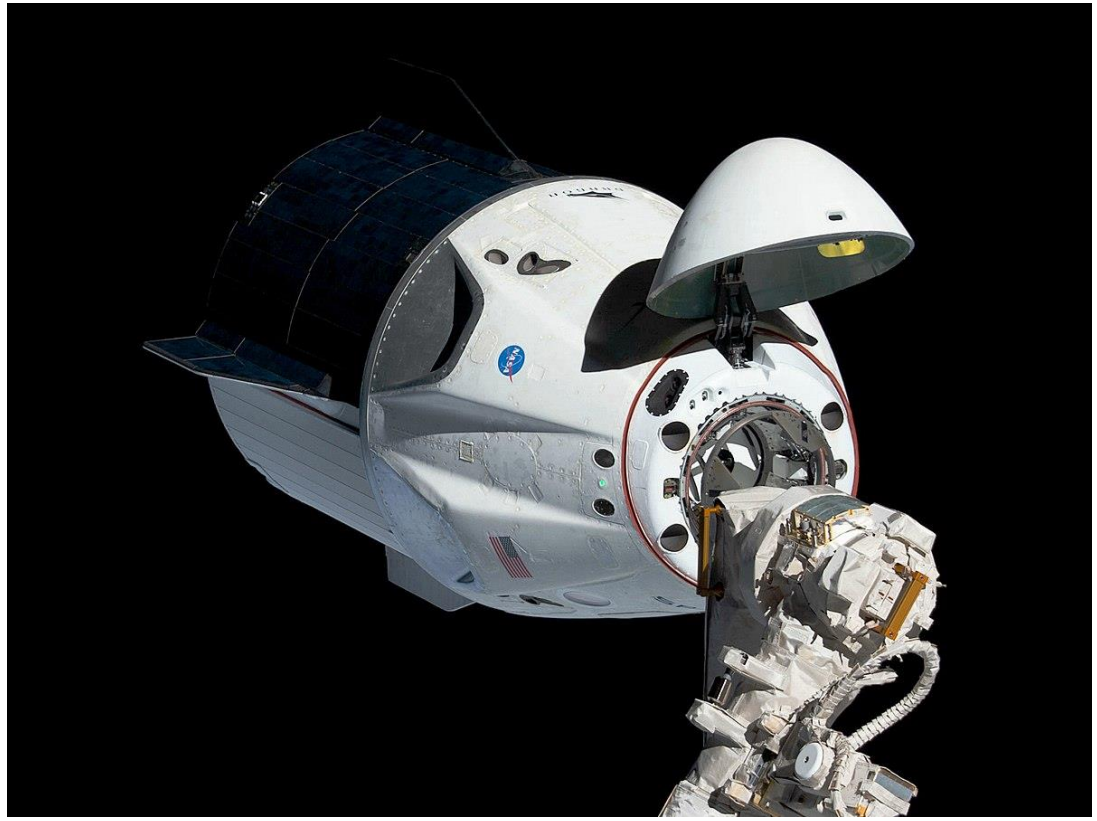
ISS Astronaut for scale. NASA



Second generation VDA. The image on the left contains 20 vapor diffusion experiment chambers (three of these trays were contained in one space shuttle incubator for a total of 60 vapor diffusion experiments. The image on the right shows a triple barrel syringe used for each experiment chamber.

Made In Space Fiber Optic draw apparatus on the International Space Station

Why Not the ISS?



>$220M/launch
~$120k/kg powered cargo round trip
Significant additional integration fees
<175 kg commercial cargo available per year
Booked years in advance

$130k/hr
Max 25 hrs per company per year
Payloads must be human safe

Business Implications

Given:

- Sending humans to space in still wildly expensive.
- Orbital processing steps don’t require human supervision.
- In-Space For-Earth markets are dramatically larger than In-Space For-Space (for now)

The best way to create an economically motivated in-space production economy:

- Focus on developing technologies that are produced in space, but that create value on Earth
- Remove humans from any process where it’s at all possible
- Perform only the required processing and analysis steps in orbit

Company Overview

TEAM:

- Founded in 2020 by Will Bruey (CEO, formerly SpaceX) and Delian Asparouhov (Chairman, Founders Fund)
- Team of 60+ engineers, operators and scientists from prominent space, materials and biopharma companies

SPACEX BLUE ORIGIN

INVESTMENT:

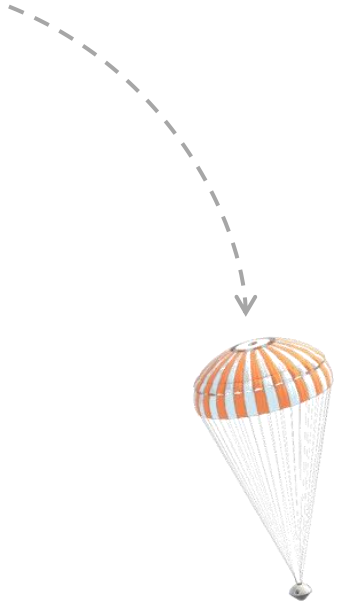
- Raised $50M+ from world leading venture capital firms

LUX FOUNDERS FUND GENERAL CATALYST khosla ventures

PARTNERS:

U.S. AIR FORCE · AIR FORCE NUCLEAR WEAPONS CENTER · UNITED STATES NAVY · TEST RESOURCE MANAGEMENT CENTER · DEPARTMENT OF DEFENSE · Ames Research Center

Varda's Approach

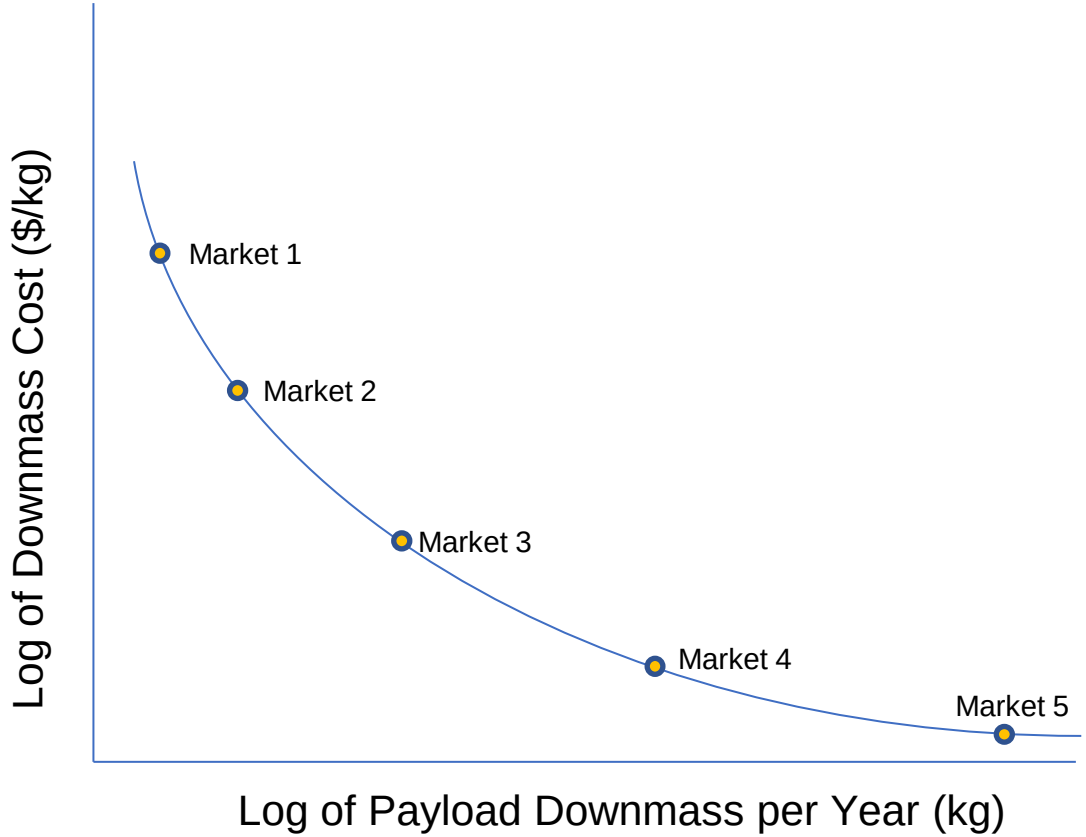


Low recurring cost even excluding reuse
Functionally unlimited rideshare launches
Available with little notice
No requirements for astronaut safety
Control our own destiny

Implications for the Future

Conditions
- Every mission is cashflow positive
- Serving large, mature markets on Earth
- Varda's Incentive: Launch as often as possible

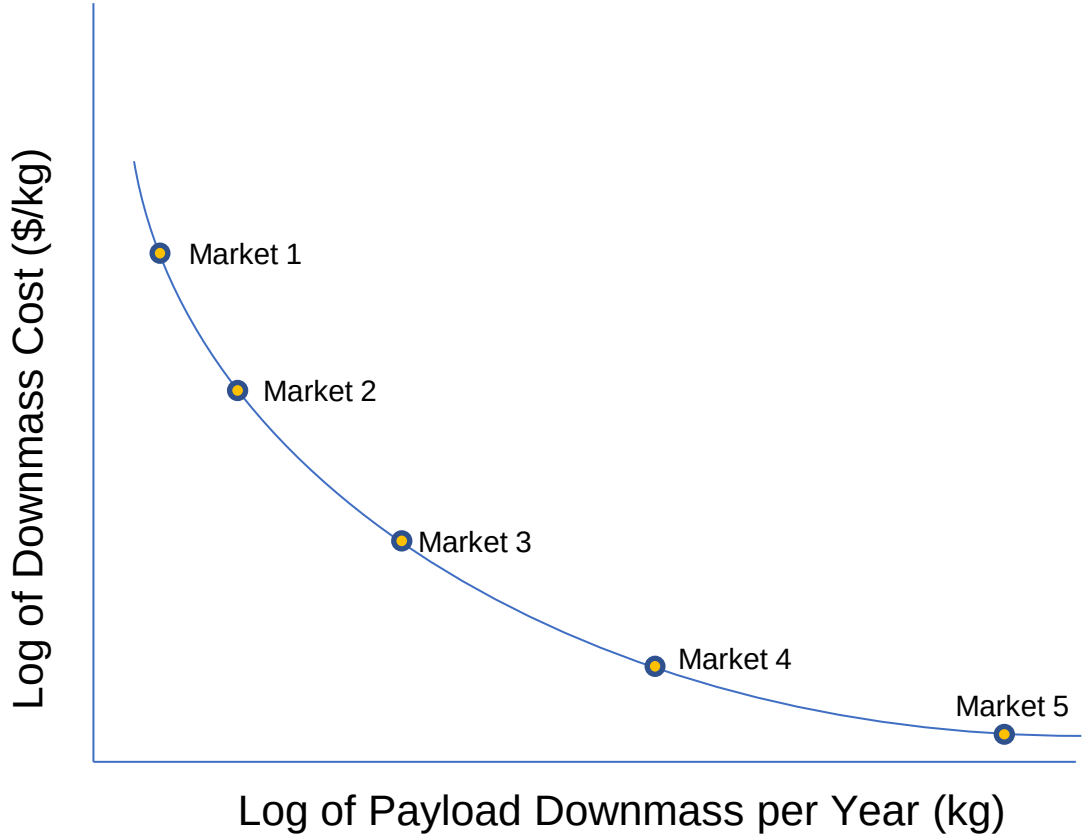
Results
- Drive next phase of exponential growth in launch cadence and reduction in launch costs
- Reduced costs unlock new use cases with even higher volumes and masses
- Increased economic activity makes space-for-space businesses viable
- Humanity permanently expands into the solar system



Realizing the Future

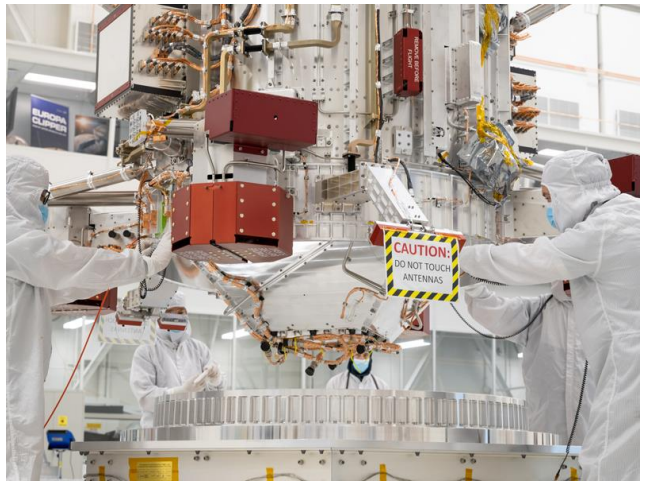
Needs

- Large, reusable launch vehicles (e.g. Starship, Terran, Stoke)
- Rocket and reentry vehicle reflights with minimal refurbishment or inspection
- Autonomous orbital factories
- Regular, dependable launches and payload slots
- Regularization of launch (FAA) and communications (FCC) licensing, and operations (Air Force)
- Regularization of reentry licensing (currently FAA part 450)
- Commercial launch and reentry facilities



Paradigm Shifts

FROM

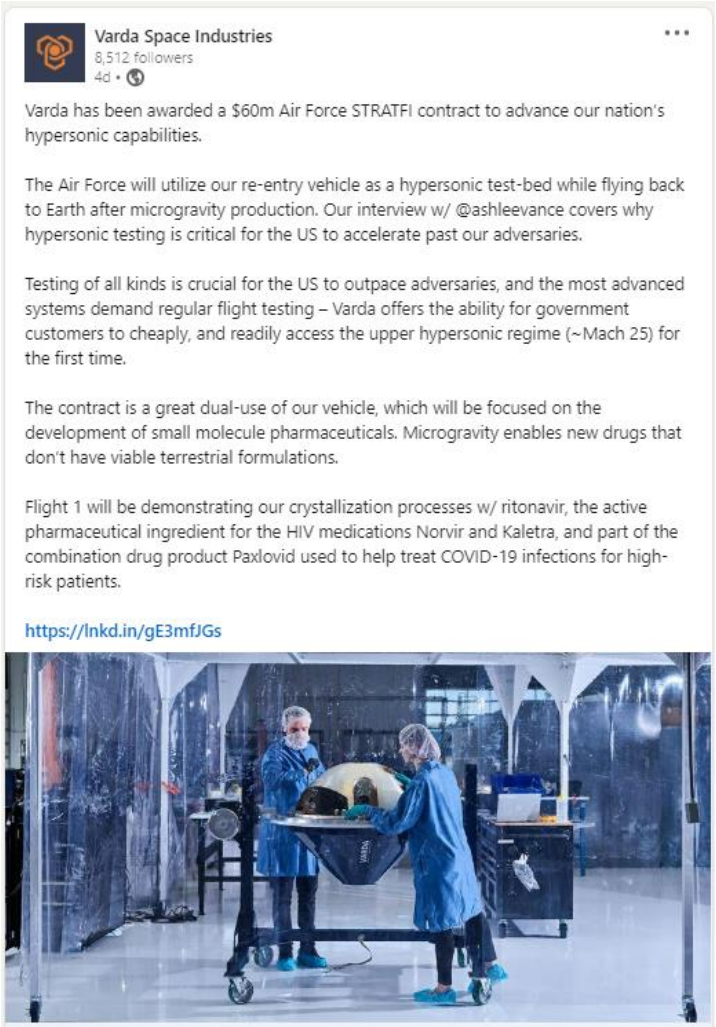


TO

Progress Thus Far

"Ritonavir Form III: A Coincidental Concurrent Discovery." Crystal Growth & Design (2022).

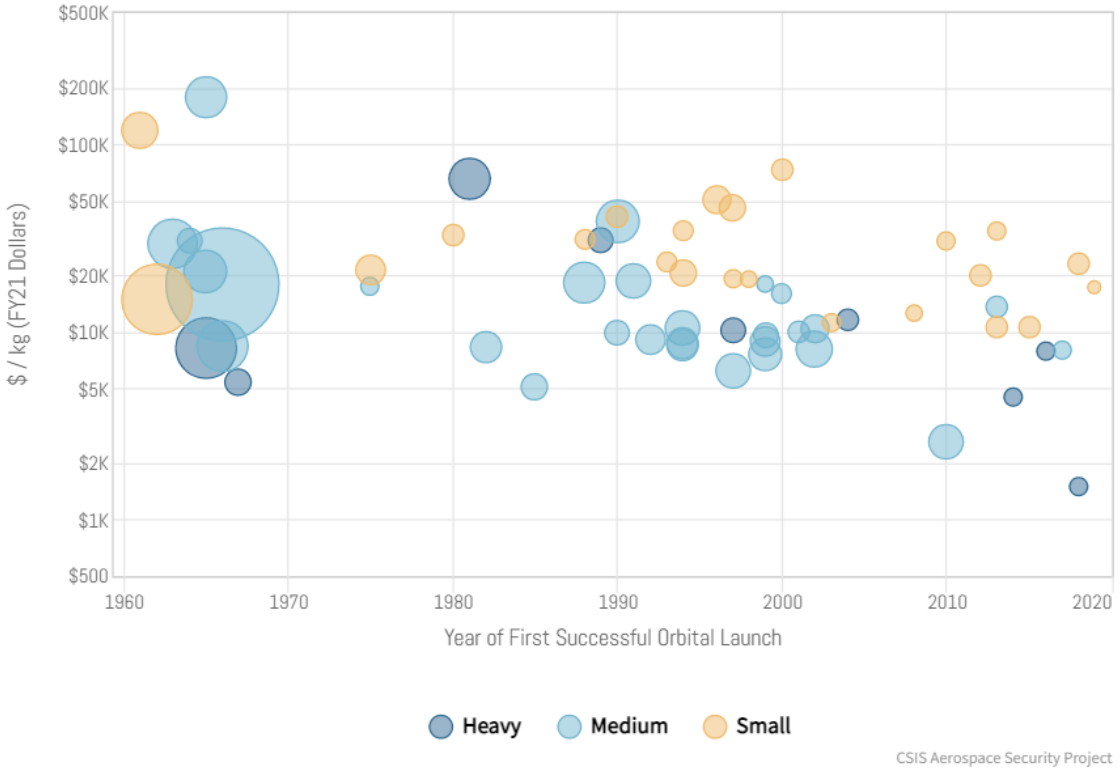
Mission 1 Flight Vehicle Completed Qual
Launching in June



$60M Hypersonics R&D Contract

Jordan@Varda.com

Kilogram to space, and back from space



Pricing Policy Available for Commercial Activities associated with NRA NNJ13ZBG001N Focus Area 3			
Resource	**Reimbursable Value**	**Annual ISS Resources**	**Maximum allowed per company per year**
Upmass (Passive Cargo)	$20,000 per kg	175 kg	50 kg/single CTBE[1]
Trash Disposal (Passive Cargo)	$20,000 per kg	175 kg	50 kg
Downmass (Passive Cargo)	$40,000 per kg	125 kg	35 kg
Conditioned Cargo (Round Trip)	$90,000 per kg	Based on NASA availability	--
Powered Cargo (Round Trip)	$120,000 per kg	Based on NASA availability	--

Table A: Pricing Policy for Commercial Activities associated with NRA NNJ13ZBG001N Focus Area 3
Credits: NASA

Based on NASA rates, a 300kg* spacecraft to orbit, and back to Earth will cost around $18 million dollars**

Estimated size of a small satellite bus and some form of processing equipment

****This estimate is high compared to current commercial offerings***

Now with humans

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ISS Crew Time	$130,000 per hr	90 hrs	25 hrs

Table A: Pricing Policy for Commercial Activities associated with NRA NNJ13ZBG001N Focus Area 3
Credits: NASA

The addition of one mission of "ISS Crew Time", "Integration and Basic Services" will add in $10m to our $18m 300kg mission, not including the vehicle needed to get our crew to and from the station.

Seats on Russian Soyuz, SpaceX's Dragon, and Boeing's Dreamchaser cost between $50m and $65m each.

https://oig.nasa.gov/docs/IG-20-005.pdf

Pricing Policy for Private Astronaut Missions[1] Associated with NRA NNJ13ZBG001N Focus Area 4		
Resource	**Reimbursable Value**	**Description**
ISS Baseline Capabilities	N/A	No cost for baseline on-orbit resources such as life support, visiting vehicle power, crew laptops and tablets, and data downlink (~12 GB per person, per day for video, pictures, email, etc.).
Food	$2000 per person, per day	Rate for food and beverages from NASA (free-flight and/or docked). Upmass and trash disposal not included.
Crew Provisions	$40 - $1,500 per person, per day	Estimated rate for clothing, hygiene products, office supplies, sleeping bags, and other crew supplies. Cost will vary depending on type and quantity of crew supplies procured through NASA. High end estimate reflects all supplies procured through NASA. Upmass and trash disposal not included.
Upmass/Disposal	$88,000 - $164,000 per person, per day	Estimated rate for pre-staging food and crew provisions on ISS, as well as disposing of pre-staged items on NASA vehicles. Cost will vary depending upon quantity of items flown and disposed of on NASA vehicles.
Integration and Basic Services	$4,800,000 per mission	Estimated cost for NASA integration, mission planning and execution, Human Space Flight Communications & Tracking Network support, and NASA provided equipment to support the visiting vehicle spacecraft.
ISS Crew Time	$5,200,000 per mission	Base cost for ISS crew time to support visiting vehicle operations, logistics support, and on-orbit familiarization for Private Astronaut Mission crew.
Below are the resources that could be required from NASA to conduct private astronaut mission specific commercial activities. The pricing reflects full reimbursement for the value of NASA resources and is consistent with the pricing policy for Commercial Use Activities.		
Upmass (Passive Cargo)	$20,000 per kg	Rate for passive cargo flown on NASA vehicles. Maximum upmass available per mission is based on nominal supply rates for comparable ISS crew and current availability.
Trash Disposal (Passive Cargo)	$20,000 per kg	Rate for passive cargo disposed on NASA vehicles. Maximum available per mission is based on nominal rates for comparable ISS crew and current availability.
Downmass (Passive Cargo)	$40,000 per kg	Rate for passive cargo returned on NASA vehicles. Downmass is an overly constrained resource and requires a unique assessment.
ISS Crew Time	$130,000 per hr	Rate for NASA crew time. Hours may be limited and are based on NASA availability for the timeframe requested.
Stowage	$700 per CTBE[2], per day	Rate for stowage of items left on orbit. On-orbit stowage is an overly constrained resources and requires a unique assessment.

[1]Pricing does not include reimbursable value for crew training, transportation, medical, integration for unique hardware or services, usage of NASA facilities, or services at Kennedy Space Center.

[2]In the form factor of single Cargo Transfer Bag Equivalent (CTBE). Unit for size of bag used to transport cargo from visiting vehicles, such as SpaceX, Northrop Grumman, or H-II Transfer Vehicle (HTV), to the International Space Station. Dimensions are 19 in x 16.25 in x 9 in (48.3 cm x 41.3 cm x 22.9 cm). Weight limit is 60 lbs (27.2 kg).