Towards Space Mining: Thoughts and Opportunities

SMRID 2025 – 15 May 2025

René Laufer, Professor and Head of Space Systems
Luleå University of Technology – Kiruna Space Campus

Can we keep it simple?

CHALLENGES

- Technical
- Economic
- Legal and Regulatory
- Operational and Logistical
- Ethical and Sustainability

Image: ChatGPT

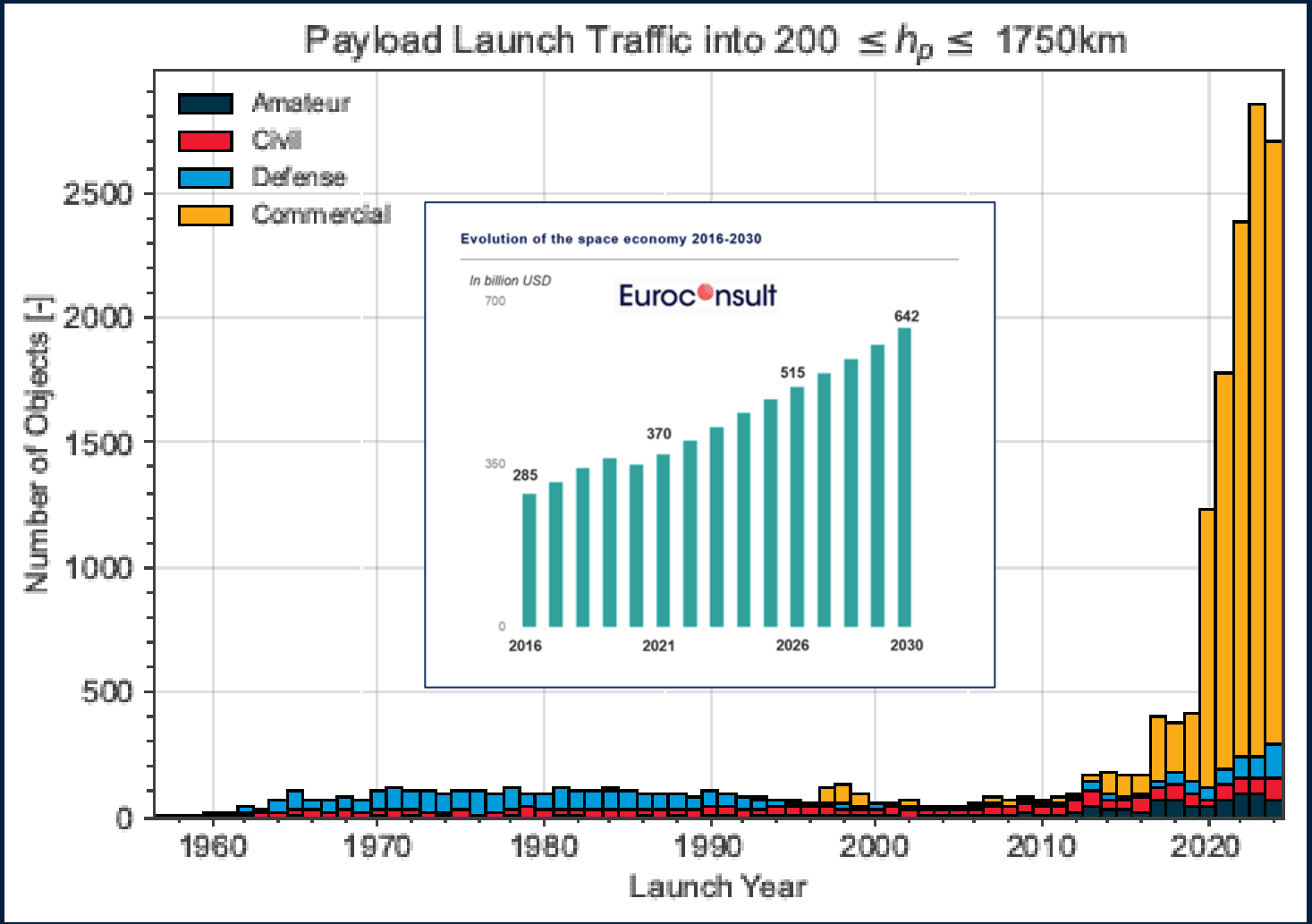
BENEFITS

- Resources for Space Activities and Exploration
- Economic Opportunities
- Reducing Environmental Impact on Earth
- Strategic Advantage

Remind me what is out there!

Resource Type	Use	Sources
Water (H_2O)	Fuel, life support, shielding	Moon, asteroids, Mars
Iron/Nickel/Cobalt	Structural materials	Asteroids, Moon
Platinum Group	Electronics, Earth markets	Metallic asteroids
Rare Earths	High-tech, clean energy	Asteroids
Helium-3	Theoretical fusion fuel	Moon
Hydrogen/Oxygen	Fuel, life support	Ice, hydrated minerals
Carbon Compounds	Organics, fuels	Carbonaceous asteroids
Regolith	Construction, shielding	Moon, Mars

Demand for Materials in Space – Example: Low Earth Orbit



Estimated number of objects in orbit as of August 2024 (with about 9300 active payloads):

- ~54000 objects larger than 10 cm
- ~1.2 million objects from 1 – 10 cm
- >130 million objects larger than 0.1 cm

Example: Satellite Constellations

- SpaceX Starlink): ~42000, currently over 7000 (Internet, USA)
- Amazon Kuiper: >3000 (Internet, USA)
- Guowang: ~13000 (Internet, China)
- Qianfan: ~13000 (Internet, China)
- E-Space: ~116000 (Internet, France)

Source/Images: ESA Space Environment Report (2025-03-31), Euroconsult

Demand for Materials in Space – Example: Low Earth

Let's take a step back
...and think about it.

s in orbit
t 9300

m
cm
1 cm

onstellations

- SpaceX Starlink): ~42000, currently over 7000 (Internet, USA)
- Amazon Kuiper: >3000 (Internet, USA)
- Guowang: ~13000 (Internet, China)
- Qianfan: ~13000 (Internet, China)
- E-Space: ~116000 (Internet, France)

Source/Images: ESA Space Environment Report (2025-03-31), Euroconsult

Let’s think about… sustainability as an enabler?


Image: PAP, 2025


Image: ChatGPT

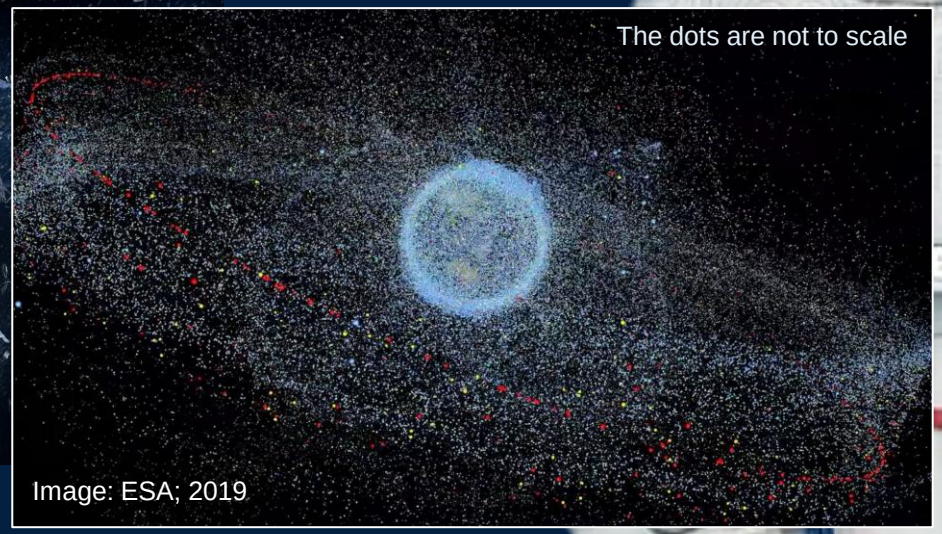


Image: ESA; 2019

Images: GettyImages, dreamstime

Let’s think about… reducing environmental impact


Image: ESA-David Ducros

PNAS RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES OPEN ACCESS

Metals from spacecraft reentry in stratospheric aerosol particles

Daniel M. Murphy[a,b,1], Maya Abou-Ghanem[a], Daniel J. Cziczo[b], Karl D. Froyd[a,c], Justin Jacquot[b], Michael J. Lawler[a,c], Christopher Maloney[a,c], John M. C. Plane[d], Martin N. Ross[e], Gregory P. Schill[a], and Xiaoli Shen[b]

Edited by Mark Thiemens, University of California, San Diego, CA; received August 3, 2023; accepted Septem

Large increases in the number of low earth orbit satellites are projected in the coming decades [L. Schulz, K.-H. Glassmeier, *Adv. Space Res.* 67, 1002–1025 (2021)] with perhaps 50,000 additional satellites in orbit by 2030 [GAO, Large constellations of satellites: Mitigating environmental and other effects (2022)]. When spent rocket bodies and defunct satellites reenter the atmosphere, they produce metal vapors that condense into aerosol particles that descend into the stratosphere. So far, models of spacecraft reentry have focused on understanding the hazard presented by objects that survive to the surface rather than on the fate of the metals that vaporize. Here, we show that metals that vaporized during spacecraft reentries can be clearly measured in stratospheric sulfuric acid particles. Over 20 elements from reentry were detected and

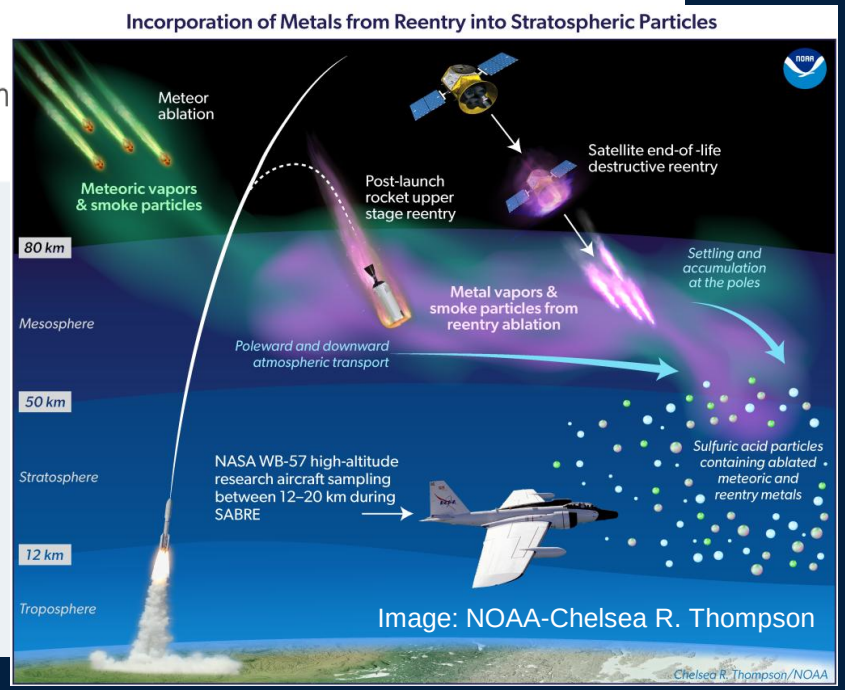


Image: NOAA-Chelsea R. Thompson

Let’s think about…. enabling in-space manufacturing


Image: ChatGPT

- Utilisation of space mined and spacecraft materials
- Transfer of supply for space activities from Earth to space!
- Commercial space activities & exploration as anchor customer
- Utilising green propellants and reusable launchers
- Reducing launches and de-orbiting

Like to talk more about Space Mining?

We are LTU and you know where to find us!

Creaternity Aerospace Lab and Space Circular Economy

- Prof. Anna Öhrwall Rönnbäck (Luleå), Prof. René Laufer (Kiruna)

Asteroid Engineering Lab and Space Systems

- Prof. Mikael Granvik, Prof. René Laufer (both Kiruna)


LULEÅ
UNIVERSITY
OF TECHNOLOGY