



# Exploration and Enduring Presence

Keeping space safe for operations at Earth and Beyond| June 2025

**ALVIN DREW**

Director for Space Sustainability,  
Space Operations Mission Directorate  
NASA Headquarters

# Purpose

**Manage the operational risks of in-flight collision and ground impact hazards to current and future NASA space missions.**

Improve understanding of **the orbital debris environment** and measures that can be taken to mitigate its effects and to control its growth.

Understand natural space environment phenomena such as **meteoroids and plasmas** and their associated risks to space missions in and beyond Earth's orbit.

Manage the risk of **in-space collisions** to NASA space missions and to their orbital environments.

# 1<sup>st</sup> Principles

## 1. Prevent.

- Preserve.
- Conserve.
- Cooperate.

## 2. Mitigate.

- Monitor.
- Assess.
- Avoid.

## 3. Remediate.

- Remove.
- Reuse.
- Recycle.

## 4. Indemnify.



# *NASA Mission Environments*



SPACE SUSTAINABILITY DIVISION

## *The Earth*







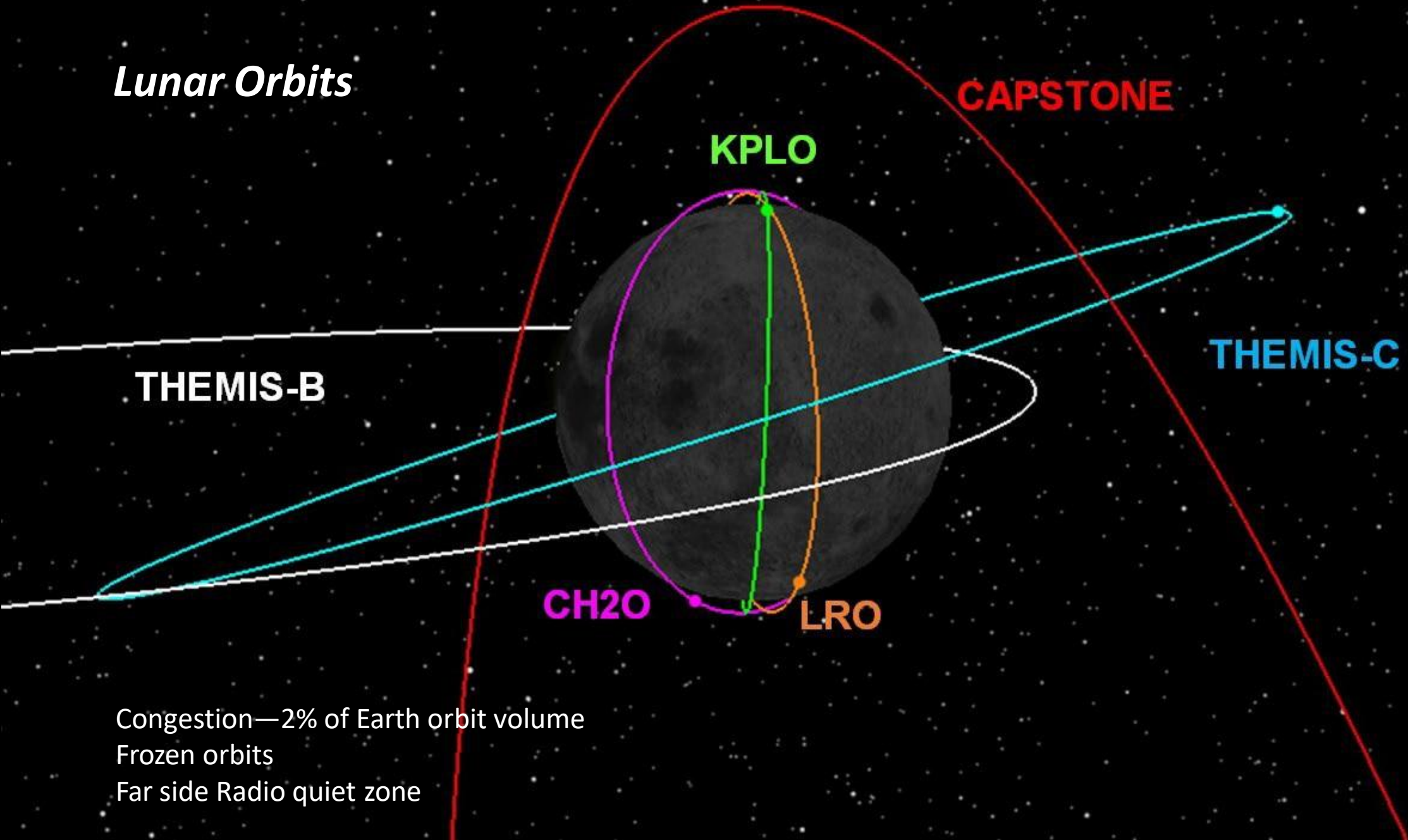
## *Earth's Surface and Atmosphere*

Ground impacts  
Atmospheric Effects





## *Lunar Orbits*



Congestion—2% of Earth orbit volume  
Frozen orbits  
Far side Radio quiet zone



## *Lunar Surface*

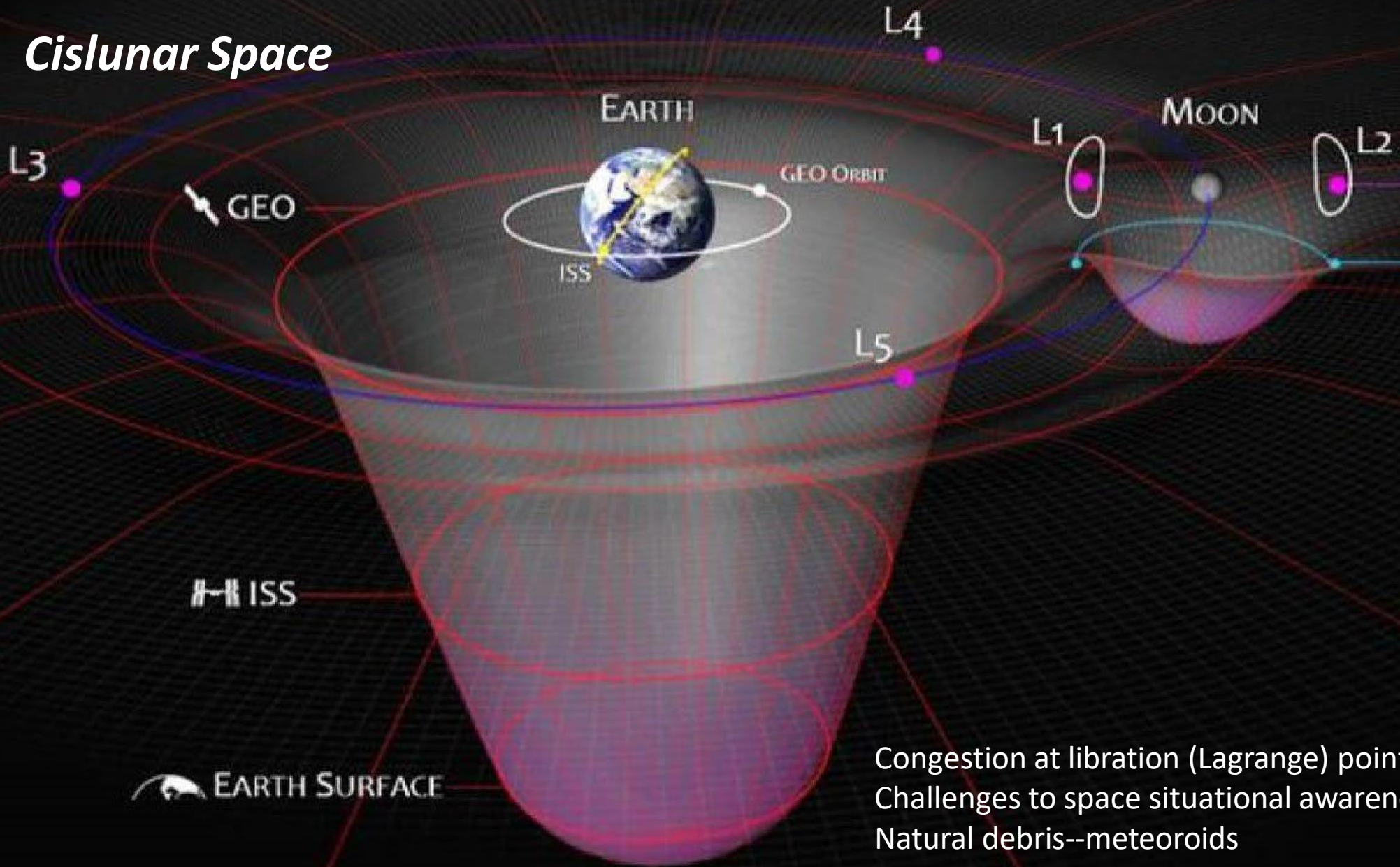
Debris impacts  
Meteoroids  
Radioactive fallout







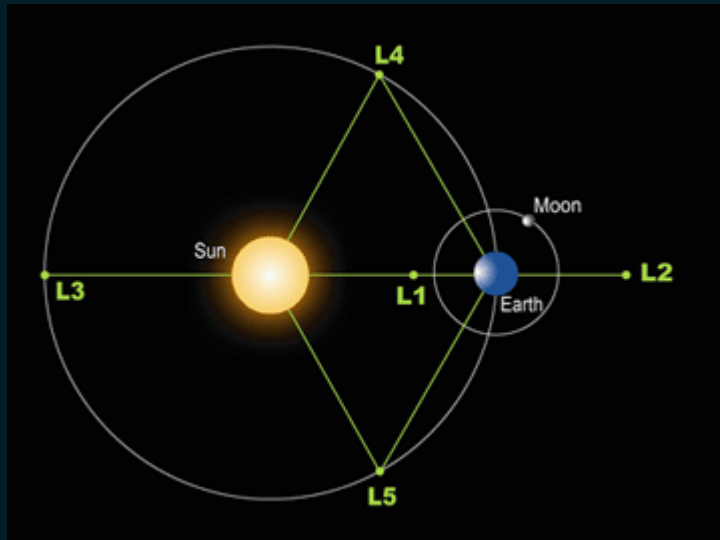
## *Cislunar Space*



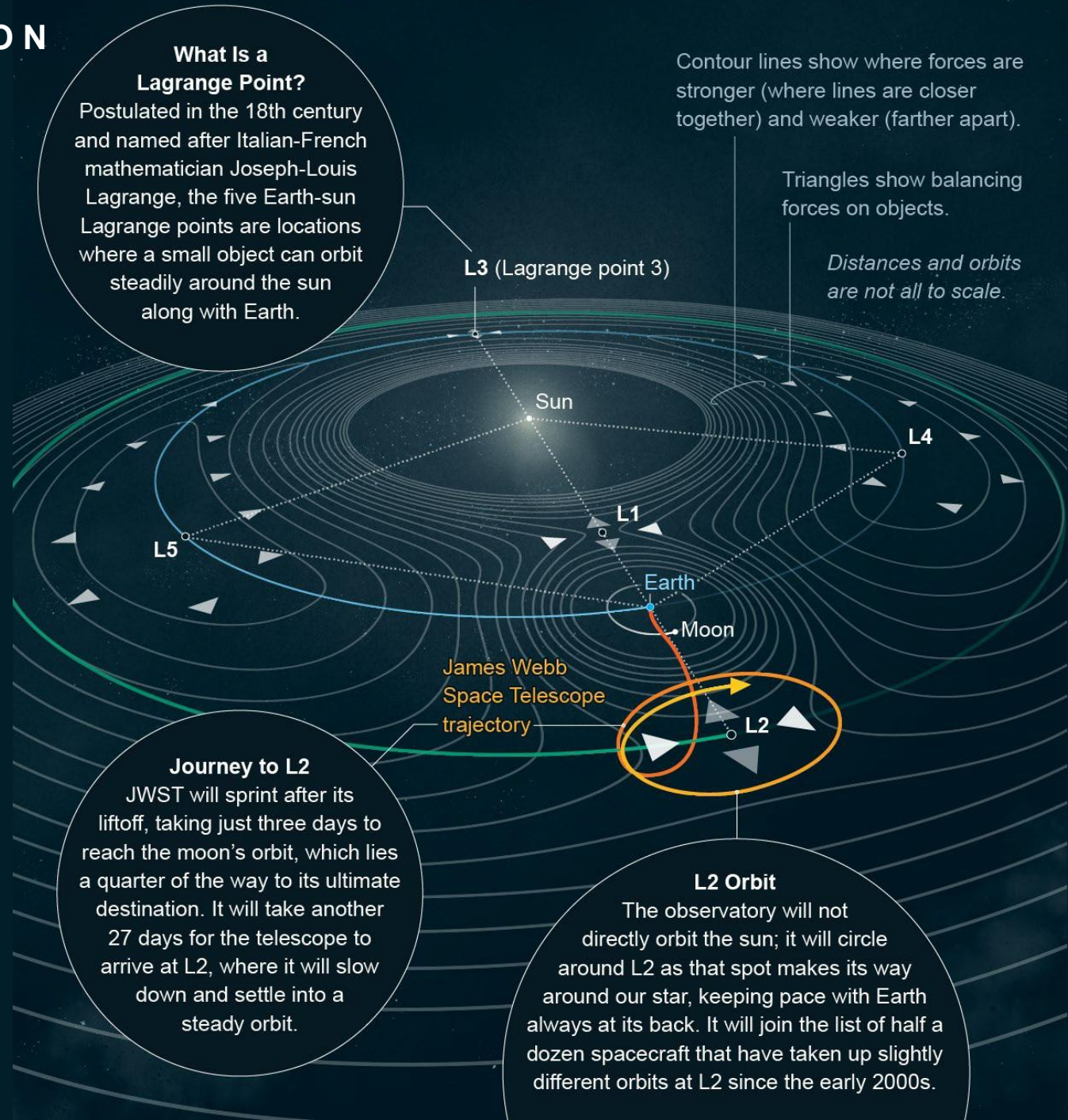
Congestion at libration (Lagrange) points  
Challenges to space situational awareness  
Natural debris--meteoroids



# Sun-Earth Nodes



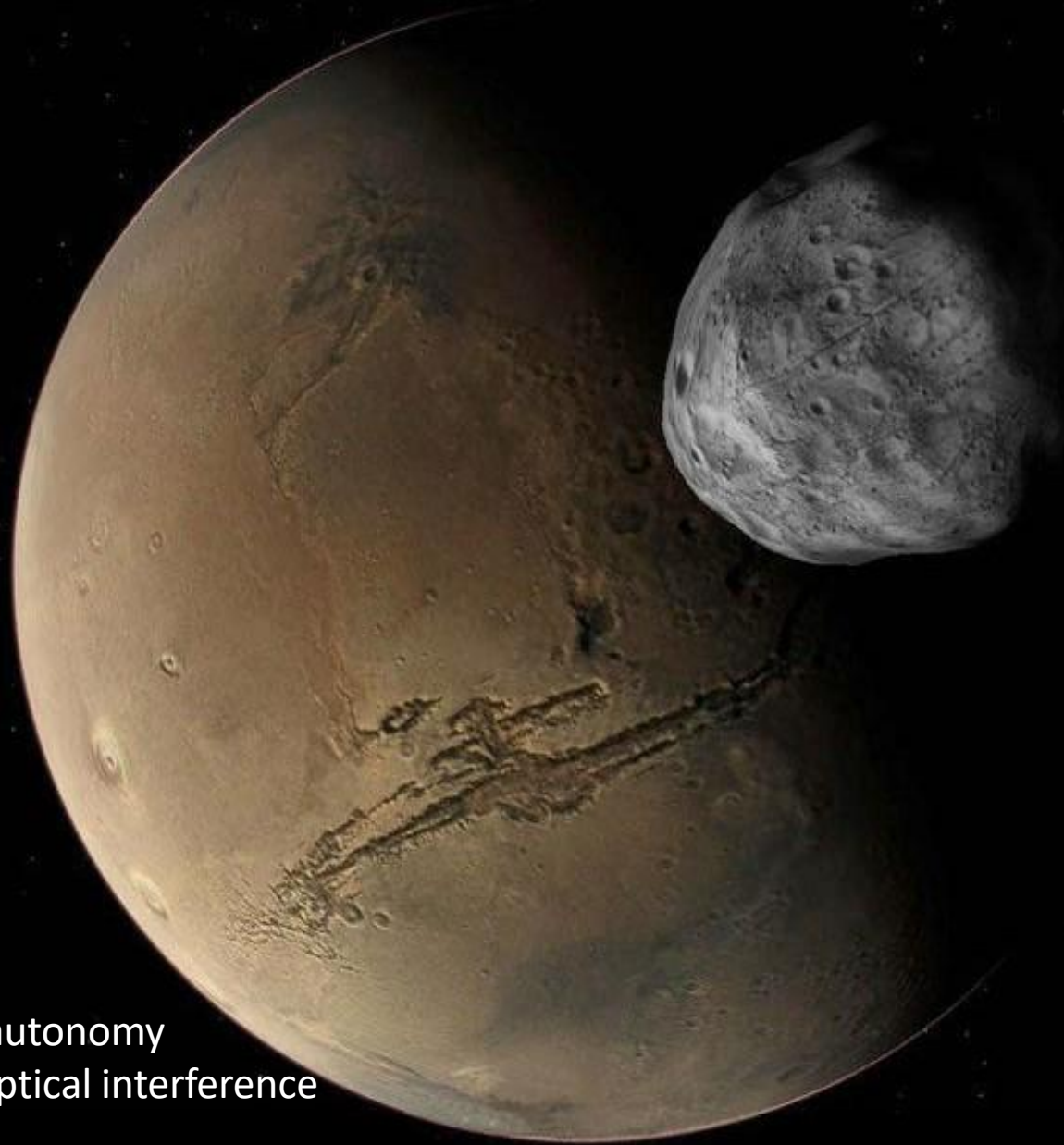
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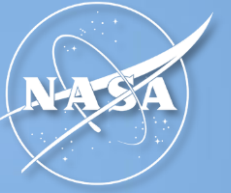


## *Mars Orbits*



Congestion  
Communications delays--autonomy  
Radio-frequency + laser-optical interference  
Mars' moons



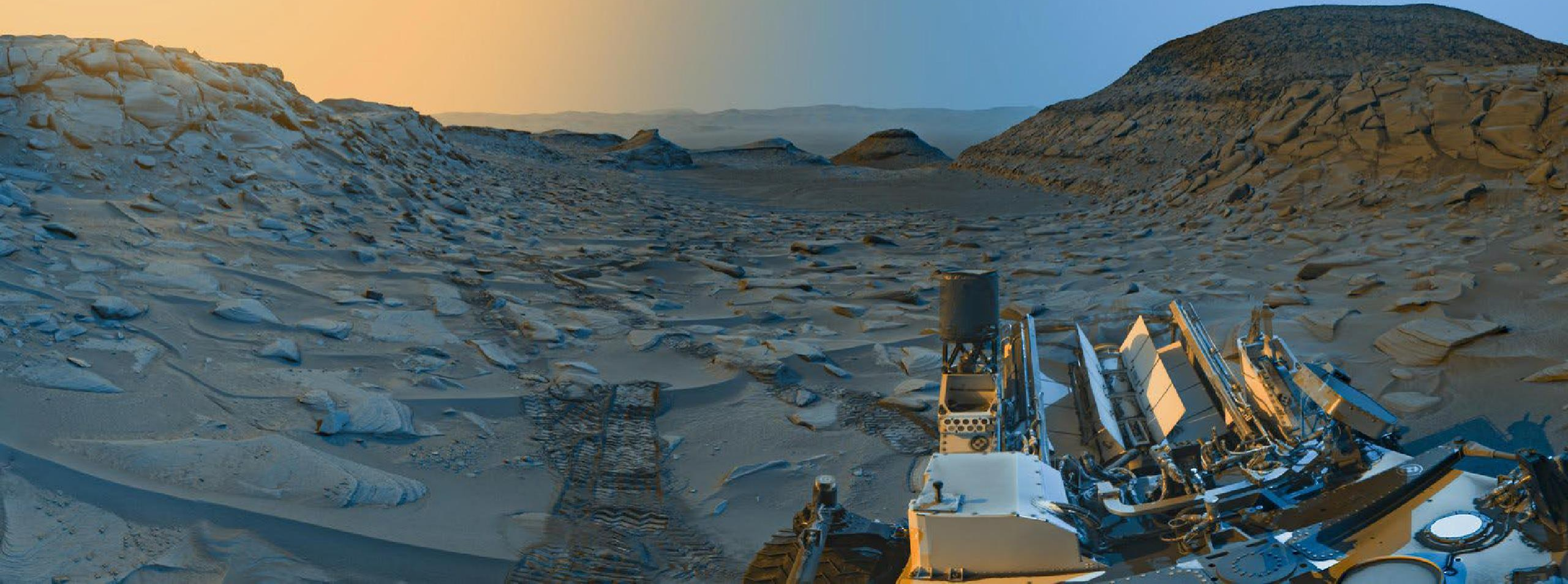


## *Mars Surface*

Ground impacts

Meteoroids

Radioactive fallout





# Prevention

In-space assembly

Persistent/Aggregate platforms

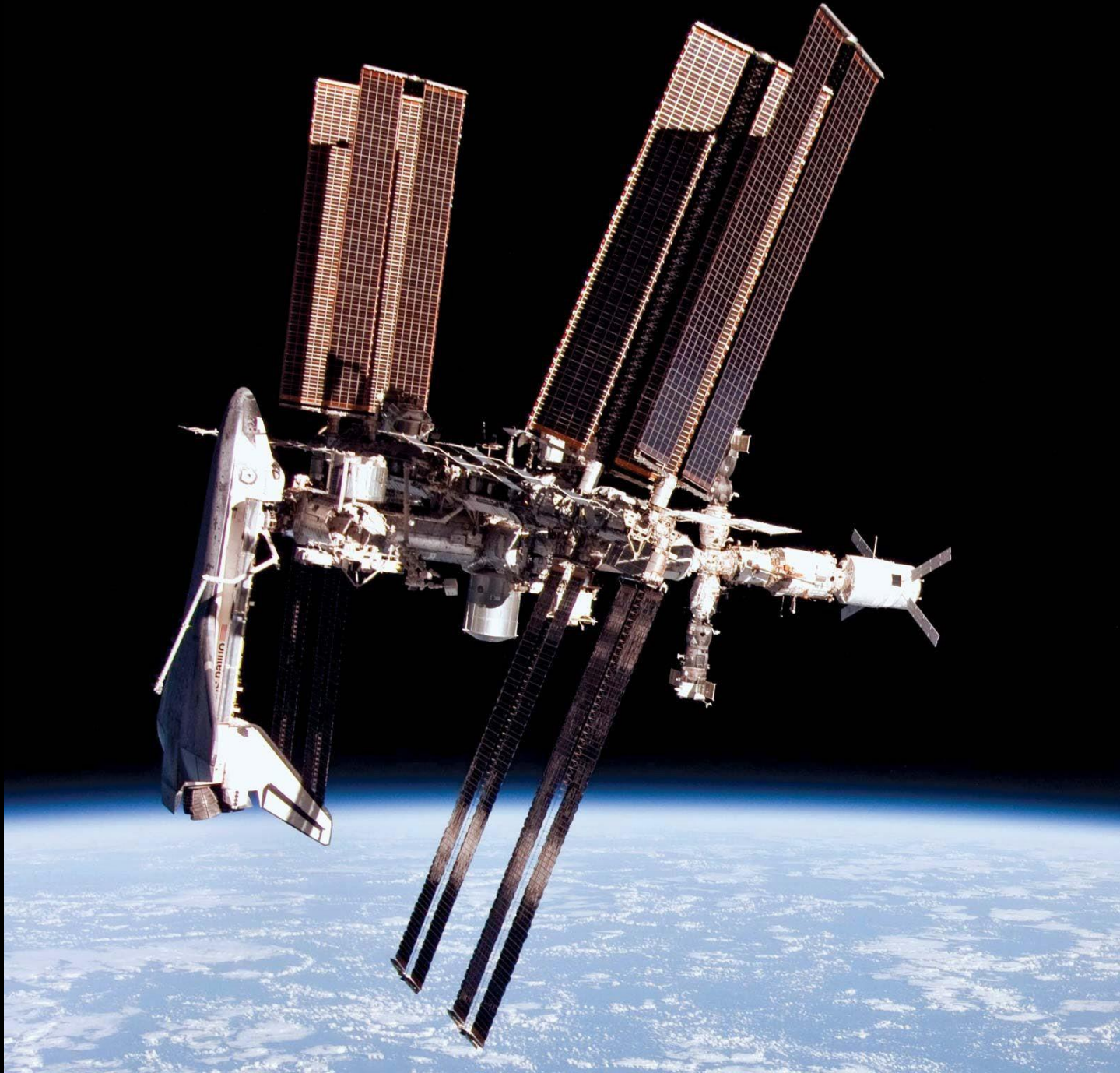
In-space servicing:

Installation/Un-installation/Relocation

Replenishment of consumables

Repair & Replacement

Active/Direct disposal



# Management & Mitigation

$4\pi$  steradian custody of all potentially lethal objects out to 500kmiles

Lethal nontrackable debris and micro-meteoroids characterization

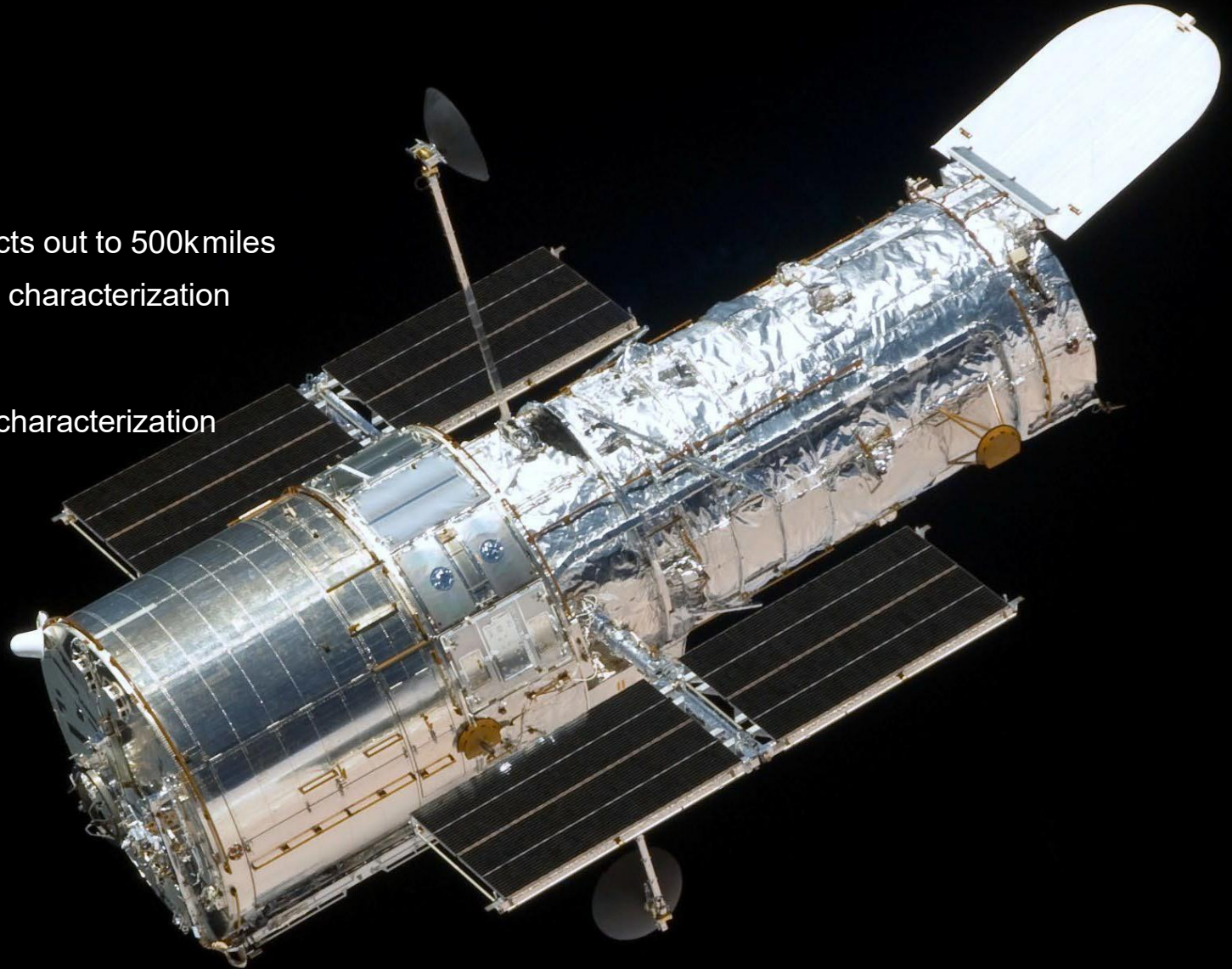
Low-SW&P Controlled and/or targeted disposal

Real-time reverse-engineered atmospheric drag characterization

Non-Keplerian trajectory prediction

Autonomous collision avoidance

Portable space surveillance





# QUESTIONS?

[www.nasa.gov/directorates/space-operations/](http://www.nasa.gov/directorates/space-operations/)