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ADVISORY COUNCIL

In support of the United Nations Programme on Space Applications

Strategies for Cis-Lunar Space Traffic Management

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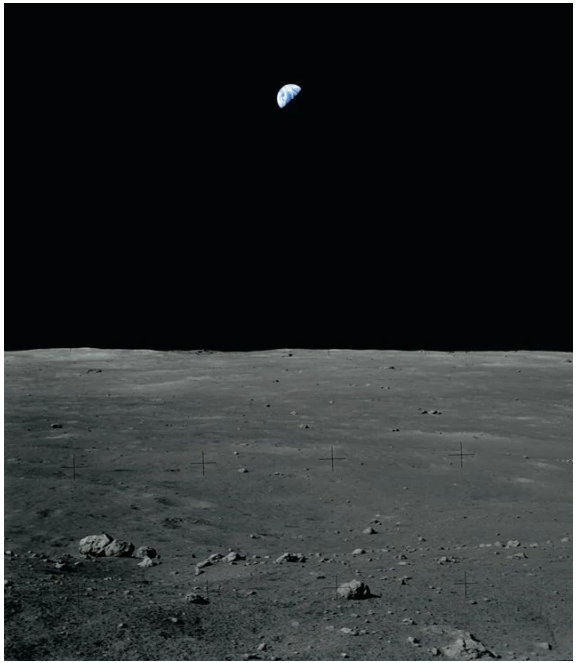
Overview: Introduction

- With the rise in popularity of smaller satellites, cheaper access to orbit, and a renewed interest in Lunar exploration, our **space sustainability efforts must evolve beyond Earth orbit.**

- Through this presentation we seek to encourage the international space community towards the formation of legal guidelines and promote the required technical investment for ensuring a sustainable environment beyond the Earth.

- Our work presented here outlines recommendations for satellite operators planning end-of-life scenarios for Cis-Lunar operations



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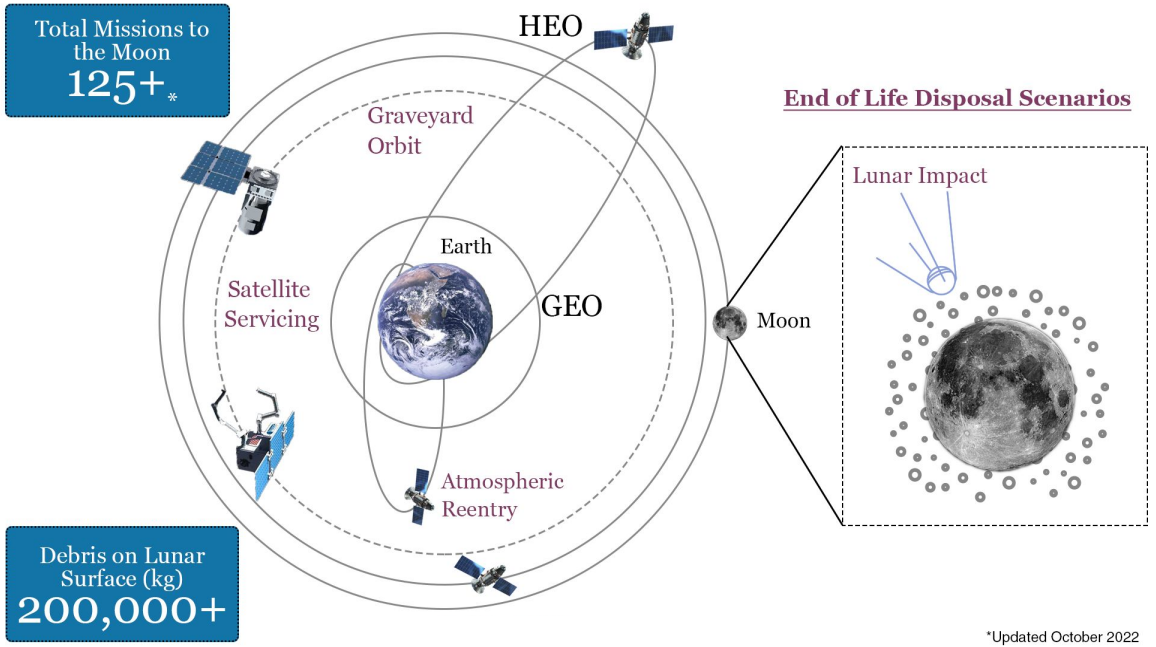
Overview: End-of-Life Scenarios

Our work explores the considerations for 4 end-of-life scenarios for Cis-Lunar traffic

1. Graveyard Orbit
2. Lunar Impact
3. Atmospheric Re-entry
4. Satellite Servicing

With over 125 mission and 200 Tons of human-made objects on the Moon, the guidelines towards proper disposal of Cis-Lunar traffic is an imperative issue.



*Updated October 2022

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Graveyard Orbit Disposal

The introduction of a graveyard orbit may offer a low-cost option for Cis-Lunar satellite operators would be for the long term storage of spacecrafts. Having traditionally been used for Geostationary Orbit operations, the possibility for such parking spaces can be explored in two classes of orbits.

1. Heliocentric Orbits
2. Earth/Lunar-centric Orbits e.g. Periodic Orbits / Cycler Orbits

Recommendations:

- Exploring the possibility of defining a new class of graveyard orbits for the Moon.
- Establishing guidelines which would govern how these orbits would be utilized in a responsible and equitable manner, while minimizing the potential for conflicts and collisions.
- Establishing guidelines for disposal, as well as allowing for considerations concerning satellite servicing and life extension.

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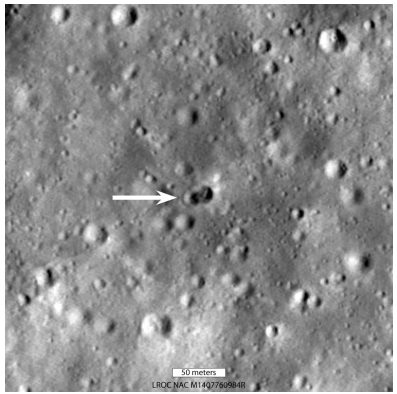
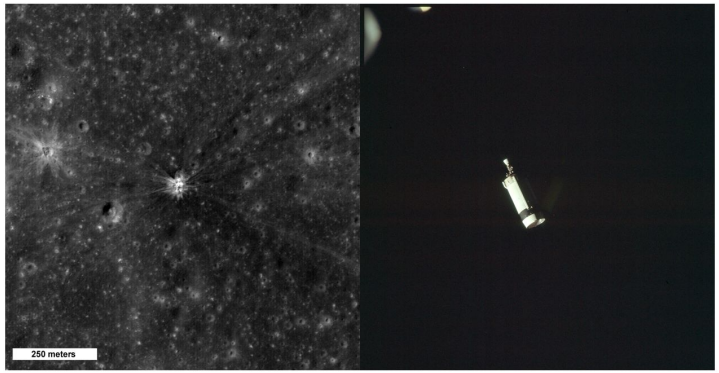
Lunar Impact Disposal

At present the Lunar surface has approximately 200,000+ kilograms of human-made spacecraft remnants. While this disposal strategy is effective for clearing orbits, however contaminates the lunar surface and endangers historically relevant sites.



Rocket body impact near Hertzprung Russel crater, June 2022



Left: Apollo 14 S-IVB Impact Crater
Right: Apollo 14 S-IVB stage in orbit

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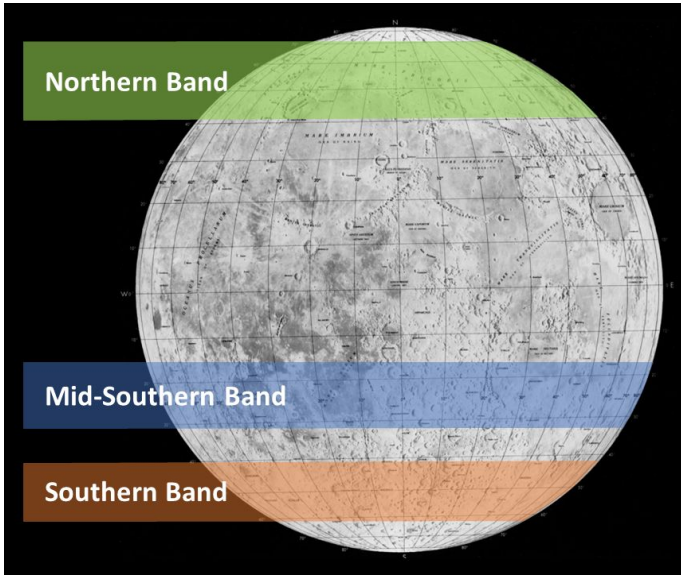
Lunar Impact Disposal

Recommendations:

- End-of-Life disposal on the Lunar surface would be a disruptive and unsustainable long-term solution
- Defining safety zones for lunar surface disposal to safeguard future human activity and preserve historically and scientifically relevant sites.
- Regulations should be established to for scenarios regarding human-made objects returning to the Earth-moon system on unexpected trajectories to prevent collisions and minimize risks to surface and orbital assets



Lunar latitude belts for artefact preservation
R. Armellin, P. Di Lizia, G. Di Mauro, M. Rasotto, and M. Landgraf

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Earth Atmosphere Disposal

The Earth's atmosphere allows for deorbiting spacecrafts to be nearly or completely destroyed. For missions in the Cis-Lunar regime, this disposal option would be viable for human exploration related spacecrafts. While an effective strategy, comes with disposal at extremely high velocity, and pose risks to orbiting satellites.

Recommendations:

- Revision of current atmospheric disposal guidelines to ensure proper disposal of spacecrafts. Similar to Lunar surface, defining disposal zones and re-entry corridors would be required for returning spacecrafts
- Extend current atmospheric disposal guidelines to include spacecrafts returning from beyond GEO, to have the required hardware for such a disposal maneuver while minimizing risk.

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Satellite Servicing & Active Debris Removal

Capable satellite servicing in Cis-Lunar orbit will involve the maintenance, repair, and refueling of functional satellites, as well as the removal of non-functional or end-of-life satellites and other debris within the region.

Recommendations:

- Extension of current satellite servicing and debris removal guidelines for operations in the Cis-Lunar environment, encompassing current challenges in satellite servicing, such as ownership, repair, refuelling, etc.
- Encourage development of guidelines pertaining to autonomy, accessibility, and mission life extension in the Cis-Lunar environment.
- Encourage transparency and confidence-building measures to make the operation of Active Debris Removal less risky and thus reduce licensing costs.

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Conclusions

While there is no elegant way of disposal of satellite missions, steps need to be taken to ensure the sustainable use of our orbital environment continues for future generations.

General Recommendations

- Promote shared responsibility between the public and private sectors, a proactive legal framework that incorporates a public-private partnership approach needs to be defined.
- Improve space domain awareness capabilities beyond GEO to enable tracking and monitoring of satellites through investment into ground based and space based monitoring infrastructure.
- Create internationally agreed upon guidelines for satellite end-of-life disposal, debris mitigation, satellite servicing, refuelling, and retrieval operations within the Cis-Lunar domain.
- Establish guidelines regarding sharing orbits, spacecraft duration in a certain orbit, and method of disposal by assigning values to various orbit families in the region.

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THANK YOU

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