Identifying 50 Recyclable Objects in Upper Earth Orbit

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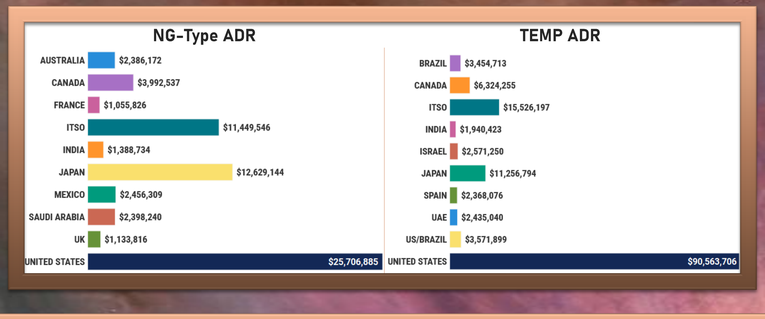
In-Situ Aluminum Recycling

Take high-value debris from upper Earth orbit & deliver to the moon at regular intervals, providing multiple benefits:

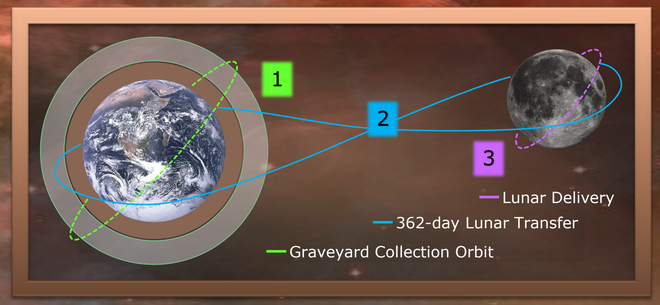
- Save upmass on raw materials for ISAM, specifically additive manufacturing.
- Prepare a Lunar foothold to reclaim and reuse all 'waste' aluminum, starting with debris in Earth orbit and reaching from old rovers to mined regolith.
- Eliminate pollution caused by end-of-life deorbit.
- Provide a new revenue stream to existing Active Debris Removal (ADR) servicers when delivering to a recycling collection orbit.



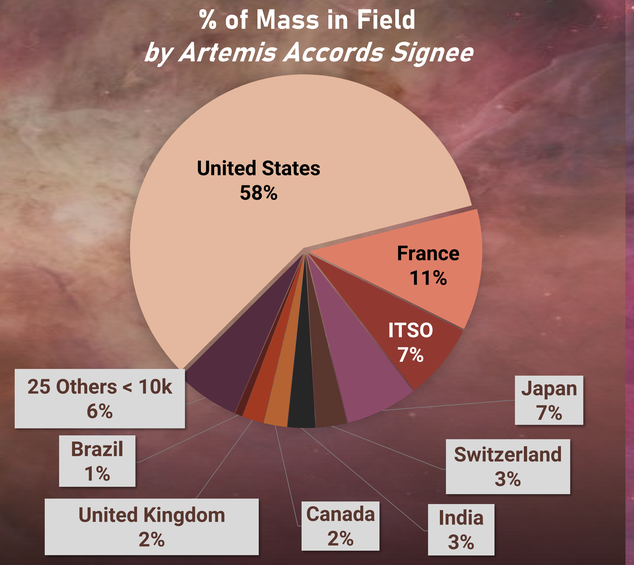
Modeling Mission Vehicles

Two of the seven ADR vehicles modeled for this work are analyzed here. First, a model imitating current-state capability of a Northrop Grumman MEP or MEV (NG-Type). Second, a theoretical vehicle extrapolated to max payload (TEMP), based on NASA expected performance of the Gateway PPE if modified for orbital maneuvers while maintaining payload capacity for even the largest object in this debris field (6,000 kg).

The NG-type was able to collect less mass over the lifetime of the model than the TEMP, resulting in less potential value for recycling. The above bar charts showing value of just the top 50 items collected under each ADR model further emphasize the importance of international collaboration, not just for ADR technology but also to maximize cheaper ISRU materials from recycling.



% of Mass in Field
by Artemis Accords Signee

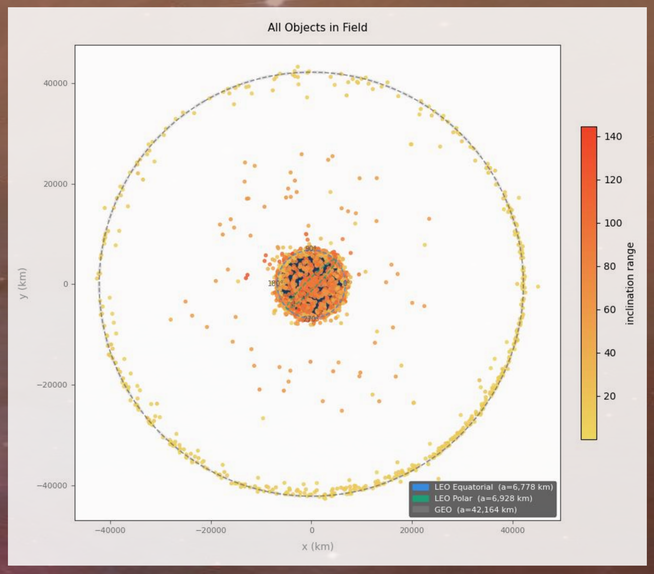


Survey of Recycling Candidates

Space objects were included as candidates under the following criteria:

1. Launched before 01-Jan-2006,
2. Large or Medium RCS,
3. Assigned to a member of the Artemis Accords,
4. Semi-major axis greater than 6,800 km.

Our database prioritizes logging object mass data to the highest confidence level of recyclable content onboard, which is **Dry Mass** (DM). Confidence levels decrease to on-orbit fuel use estimates (DF), after Beginning-of-Life (BOL), and sometimes least-confidence values of Launch Mass (LM) are the best available data. This effort is ongoing; about 40% of the current field is rated DM-level.



This figure is a 2D display of the entire recycling candidate field, viewing on Earth-centered equatorial plane; inclination is indicated with heatmap color, and argument of perigee corresponds to angular position.

Below are the top 50 recycling candidates selected by the two ADR vehicles.

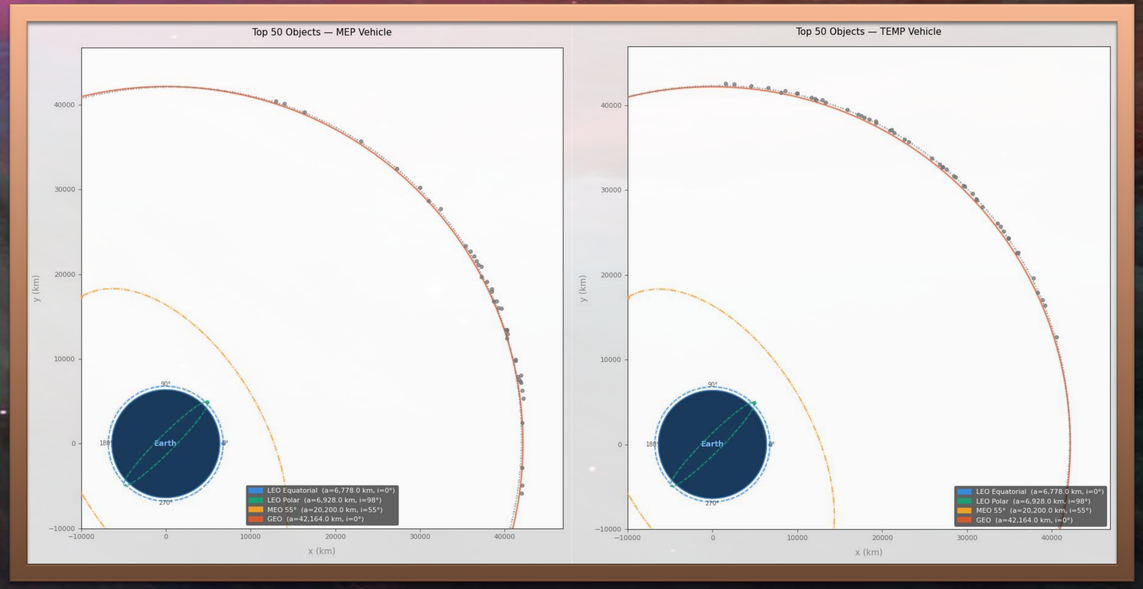
Ongoing Work

Today's debris selection model uses a general estimate of 38% aluminum by mass. This data is being refined to include more precise alloy mass values, with help from NASA research libraries and Gunter's Space Page.

As more ADR vehicles are designed and deployed, and as infrastructure for the Lunar Base progresses, it will be exciting to integrate these new systems into the analysis performed here and better refine the projected return on investment for ADR raise-to-recycle operations as a viable alternative to deorbiting debris.

Currently, design and testing is being performed on an aluminum recycling reactor that will operate on the Lunar surface, with help from labs at NASA Glenn Research Center and Marshall Space Flight Center.

Plans to integrate with existing space systems for in-space additive manufacturing are also under development. Please reach out to us if you think we can develop crosscutting lunar surface technologies together!



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Background Image: Orion Mosaic © NASA, ESA / M. Robberto / Hubble.

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