Expanding our Planetary Defense Umbrella to Cislunar Space

Jan Osburg (josburg@rand.org)
Peter Garretson (garretson@afpc.org)

9th IAA Planetary Defense Conference , May 2025

Image: NASA

Exploring Planetary Defense for the Moon (PD-M)

- **"Planetary Defenses Are Better Than Ever!" – for Earth.**
- **Over the coming decades, more and more infrastructure and people will be on the Moon, putting them at risk from celestial impacts as well.**
- **More research is needed to understand key differences:**
  - Lunar impact consequences are different from those on Earth.
  - Lunar impact mitigation is different from mitigation on Earth.
  - For smaller objects (<15m or so), Lunar impact likelihood is different from Earth surface impact likelihood.
- **But: many existing PD capabilities can be used for PD-M.**

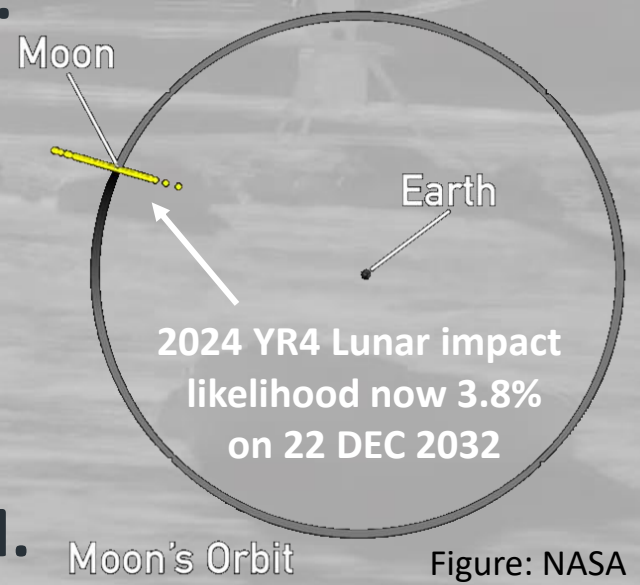


Figure: NASA

Image: Lockheed-Martin

Impact Consequences

- **Direct impact effects:**
  - Penetration of pressure vessels
  - Destruction of hardware
- **For impactors beyond typical micrometeoroid size:**
  - Cratering (example: 5kg object → 9m diameter crater)
  - Generation of ejecta that impact elsewhere (example: 5kg object → 75t of regolith ejected)
  - For high-energy impactors: generation of orbital debris affecting Cislunar space
  - Triggering of Moonquakes
- **Where to draw the line between micrometeoroid mitigation and PD-M – sizes that cause cratering?**

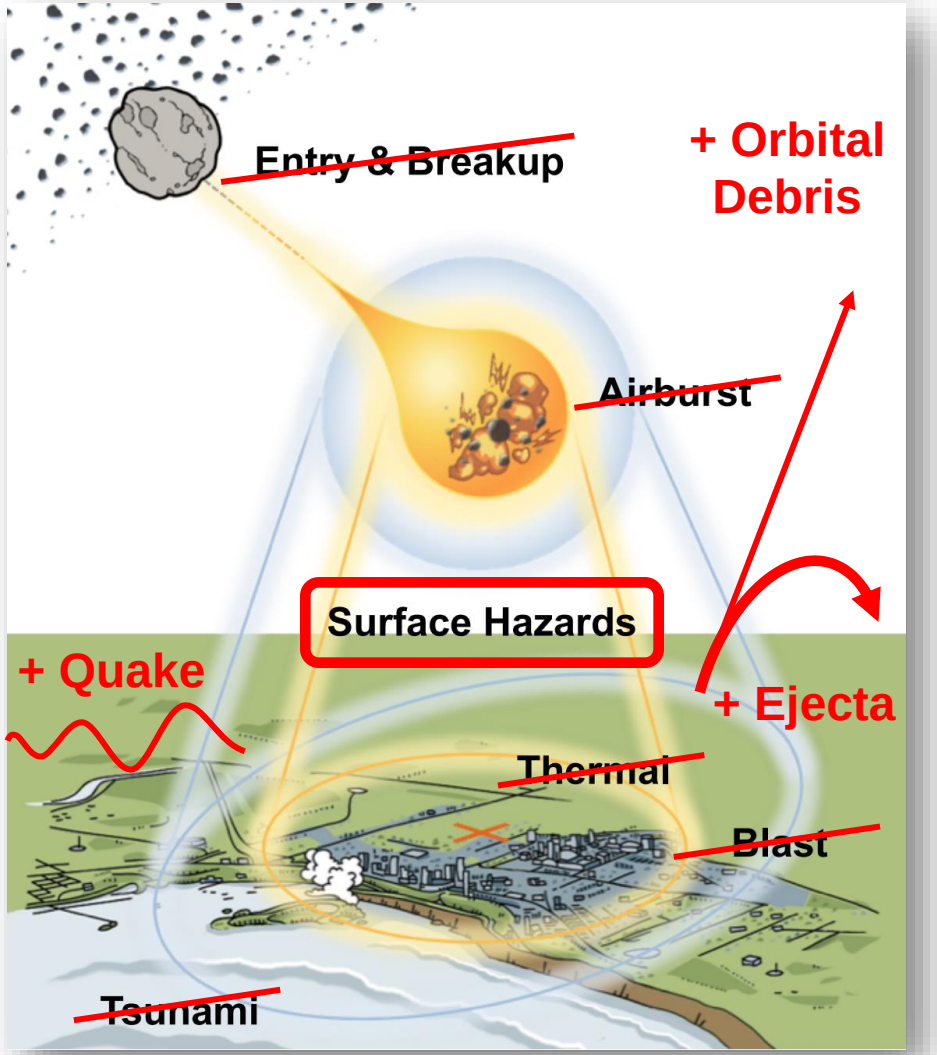
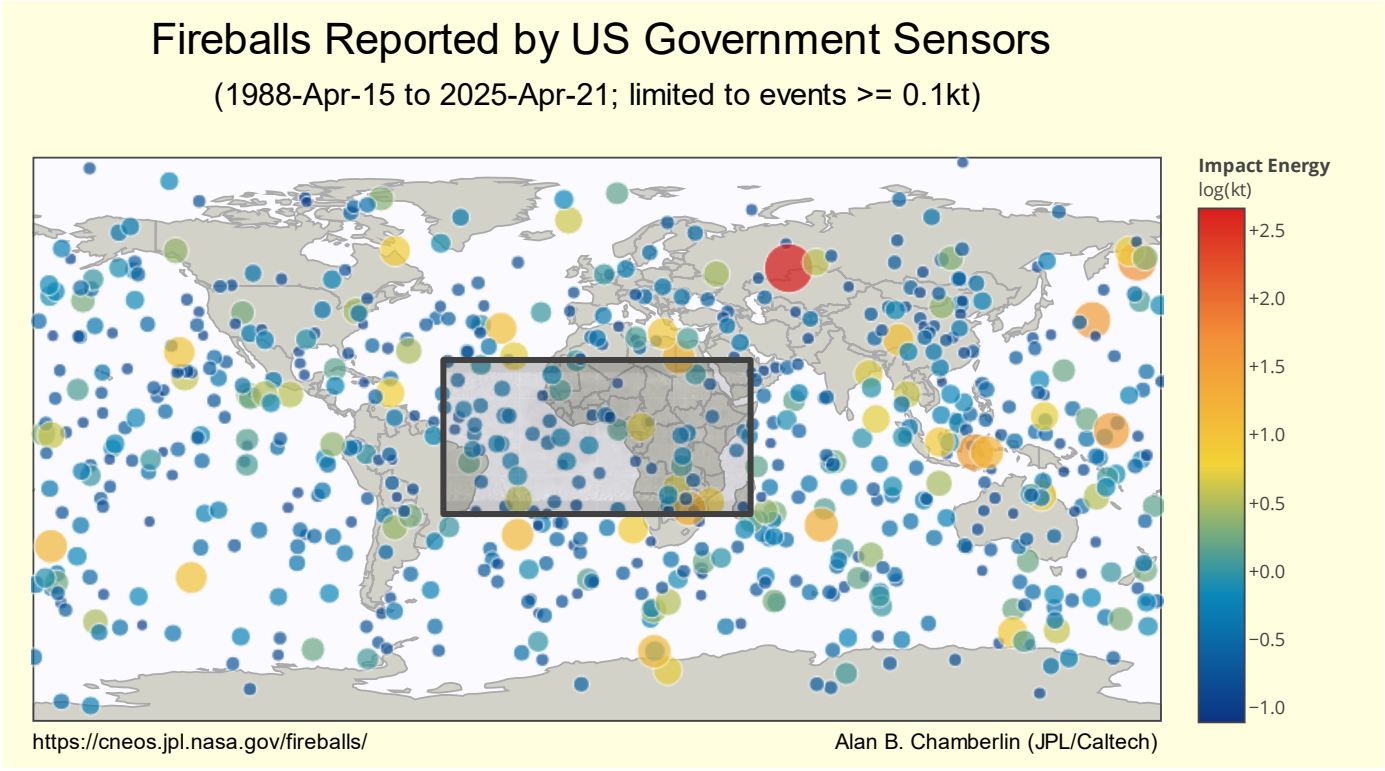


Image: NASA

Impact Likelihood

- Same general flux of objects for Earth and Moon
- Impactor size and frequency is inversely related
- Impactors smaller than 10-15m are of no concern for Earth
- Even much smaller impactors are of concern for the Moon
- However, low density of critical infrastructure on the Moon



Figures: NASA/JPL CNEOS, AZ State U

BOTTOM LINE: Lunar infrastructure and astronauts are at risk from impacts of objects above typical micrometeoroid size. This points to the need for PD-M.

Next Steps for PD-M

Research

- **Further investigating the effects of impacts on Lunar infrastructure, including dependence on size/energy**
- **Defining a size/energy threshold between micrometeoroid mitigation and PD-M**
- **Calculating impact likelihoods for relevant object sizes**
- **Defining a "PD-M Scale" that captures the impact risk of a given object**
- **…**

Looking forward to many papers on the topic at PDC 2027!

Capabilities

- **Quick win:**
  - Add Lunar impact probability from JPL Small Body Database to CNEOS Close Approach tables and similar products
- **Additional actions:**
  - Expand scope of PDCO, ESA SSO, IAWN & SMPAG to also cover PD-M
  - Upgrade impact monitoring systems such as SENTRY and NEODyS to also look for impacts with the Moon
  - Inject PD-M into Moon mission plans
  - Develop PD-M specific mitigations
  - …

Image: NASA