6th International Space Debris Re-entry Workshop – Final remarks and future steps

ESA Space Debris Office

15/01/2025

Whilst burning … wrap-up conclusions

- **Materials models:** missing some materials characterisation; missing impact on the atmosphere and inclusion in climate models (e.g. AlO and small particles effect); define new models not only temperature dependent; models should be well calibrated; catalicity is required to rebuild PWT test with glass materials, emissivity and radiation are key to improve demise observability; oxidation effect considered via emissivity; complex models and few simulations Vs simple models and many simulations; missing new material models in risk assessment tools like DRAMA; uncertainties in CFRP behaviour (dispersion when melting starts, ball fire, further breakup once weakened?)

- **Uncertainties:** in-situ measurements for atmosphere calibration is needed; missing procedures for air-traffic (required air traffic density models) affected by space debris -> informing asap regardless the uncertainty; largest uncertainties come from space weather and atmosphere modelling; gap of knowledge on SC attitude during re-entry; for atmospheric uncertainties rarefied regime is critical; break-up altitude uncertainties (depending on SC design, type of connections…etc)

- **Types of re-entry predictions tools:** MC simulations with simple tools Vs High fidelity tools; uncertainties max and min required for meaningful MC simulations; too conservative; ablation model depends on the type of re-entry; probability of a re-entry to happen in a specific area and debris footprint still unknown; break-up models improvement

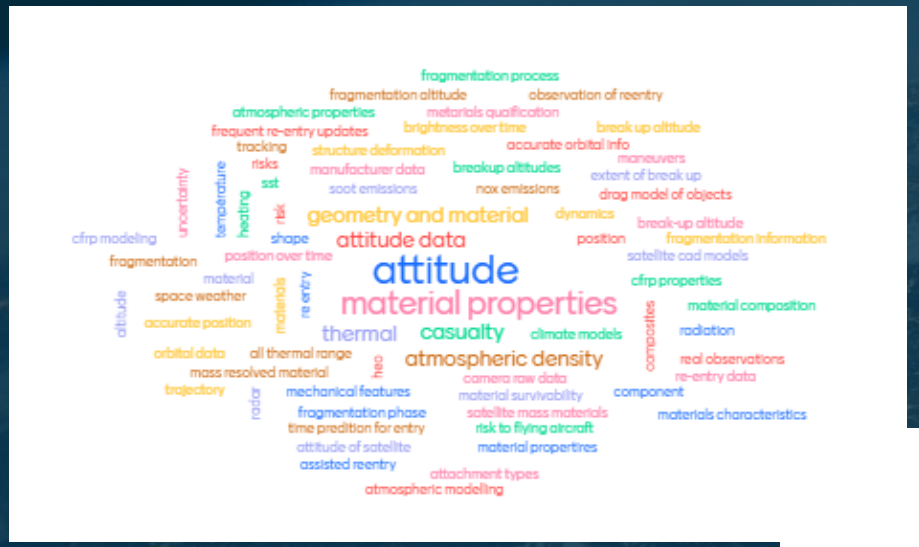
Whilst burning … wrap-up conclusions

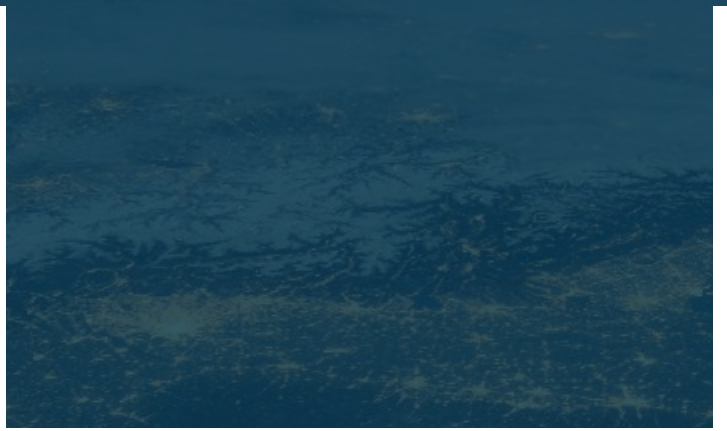
- **Re-entry physics:** joints modelling is missing (thermo-mechanical-chemical response); simple tests preferred to understand first how forces and temperatures are coupled and then to understand oxidation under different pressure conditions; realistic BC assessment; knowledge gap in the oxidation role in demise/break-up; trajectory simulations and SC attitude data required; interest in free-molecular heating of rarefied flow (beginning of fragmentation); integral heat and forces data are required to understand break-up altitude; NMSIS atmospheric model is of very low accuracy; space weather parameters instead density?

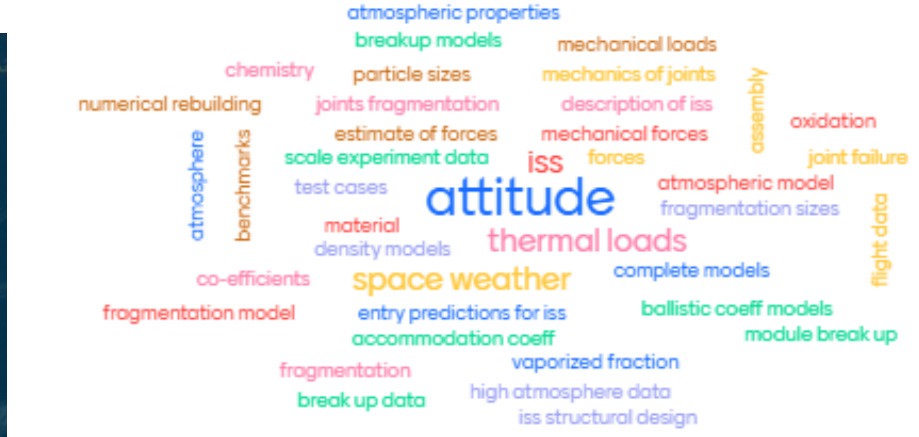
- **Wind-tunnel tests** to support modelling validation, measuring deformations and temperatures…simulating different flow conditions. Caution to extrapolate with in-flight conditions, especially with velocity; to support emissivity characterisation at wide temperature range -> simple test**S** strategy; PWT accurate spectra measurements; can reproduce flight conditions in boundary layer (one point)

- **Observations:** in different ranges of the spectrum -> lidar, from airborne observation campaigns feasibility -> expected brightness modelling; OD as precise as possible (distribution along the orbit) and attitude data; fuse data from different sources; observations with arcsec accuracy and long arc; data sharing function capability is missing -> OPEN SOURCE Sharing platform?; re-entry predictions (OD) complexity Vs precision trade-off; transponder on-board; operational systems: to foster communication between re-entry experts and operators; L0 to L2 data products -> high temporal resolution, TM and HK, CCSDS format, real-time raw data, drag coefficient, geometry information, attitude, manoeuvre information, reflectivity information

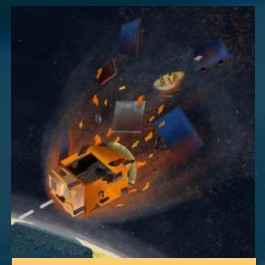
….and the winner dataset is…?







Future steps (1/2)



6ISDRWS

January 2025

March 2025

Planned Whitepaper release

April 2025

Norsat-TD re-entry

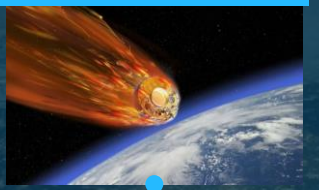
May 2025

Planned datasets release

June 2025

Sep 2025

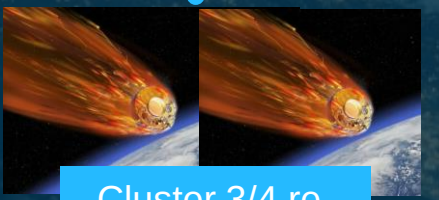
Cluster 1 re-entry



Oct 2025

TUBIN re-entry

Sep 2026



Cluster 3/4 re-entries

January 2027

Future steps (2/2)

Why scientific white paper?

- Re-entry are going to happen. While mitigating their risks, how can we make use of their inevitable end?
- Based on today's discussions, we take stock of what is on offer and what the community needs are
- See where the re-entry community's need overlap with on-going and new activity proposals

Why not release all data at once?

- Legal rights and obligations ☺
- Based today's exchanges, identify the most relevant bits for a wide community where possible.
- Curation will take time and effort

Thanks!