Demisability analysis of Solar Array Drive Mechanism

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The casualty risk for any re-entry shall not exceed $10^{-4}$

- One way of reducing the on-ground casualty risk is by limiting the number of fragments surviving until ground.

- The fragments which survive a re-entry are often from recurring spacecraft components.
  - Propellant tanks, reaction wheels, solar array drive mechanisms, magnetic torquers, balance masses and optical payloads

- Within ESA’s “High Fidelity Re-Entry Simulations on Critical Spacecraft Platform Equipment” project:
  - Model and perform analysis of SADMs demise process during atmospheric re-entry
  - Assess the impact of D4D modifications on demisability
Previous SADMs used in SCARAB

CarbonSat

Sentinel-2

Sentinel-3
Initial re-entry conditions for component

CleanSat reference trajectory

Initial Temperature = 300 K

- 96 km
- 87 km
- 78 km
- 69 km
- 60 km
Assessment of baseline model

Real-time Animation
[flight direction to the right; view from zenith to nadir]

CritSPE, ESA Contract No. 4000121149/17/NL/GLC/as
Assessment of baseline model
Assessment of baseline model

Commonly surviving sub-components

Graph: 
- Casualty Area [m^2]
- Release Altitude [km]
- Most Probable Casualty Area
- Baseline results

Demisability analysis of SADM
24th of October 2018, Clean Space Industrial Days
Identify critical sub-components for Baseline

Release altitude $78 \pm 2$ km

Frequency of sub-component surviving

- Actuator bearing: 100%
- Potentiometer shaft: 100%
- Harmonic drive: 100%
- Main shaft: 31%
- Solar array interface: 26%
- Front bearing: 31%
Together with manufacturer feasible D4D modifications were identified

Open SADM

- Removed parts of the main housing assembly, the idea is to expose the SADM interior to the flow earlier.

Open SADM w/ aluminum actuator

- Keeping the open SADM design and in addition changing some Actuator components material to aluminum (from titanium) thereby reducing the heat required for complete demise ($Q_{demise}$).
- Actuator components which were changed:
  - Actuator housing
  - Potentiometer shaft
  - Potentiometer housing

*The wall thickness of the modified sub-components has NOT been changed
Evaluation of design modifications
Summary

• Baseline model **demise above if released above 87 km**

• Critical sub-components surviving have been identified:
  - Actuator bearing, Potentiometer shaft, Harmonic Drive, Main shaft, Solar array interface and Front bearing

• D4D modification (1): Open SADM
  • Demise for release altitudes above 87 km
  • Tendency to generate more fragments for release altitudes above 67 km. (Larger casualty area on average)
  • Similar “most probable” Casualty Area distribution to the baseline model.

• D4D modification (2): Open SADM w/ Aluminium Actuator
  • Tendency to generate more fragments for release altitudes below 69 km.
  • Minimum demisable altitude around 78 km.
Thank you for listening!

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Extended work

Typical fragmentation altitudes during re-entry simulation with SCARAB

![Diagram showing typical fragmentation altitudes during re-entry simulation with SCARAB. The graph illustrates the relationship between altitude and velocity, with a shaded region indicating the main break-up region.](chart.png)
SADM - Initial release conditions:

Extended work

*SAD* release altitude

*SADM* release temperature

*only thermal fragmentation simulated*