Demisability analysis of
Solar Array Drive Mechanism

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Introduction

- 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
  - Magnetorquers
  - Balance masses
  - Optical payloads

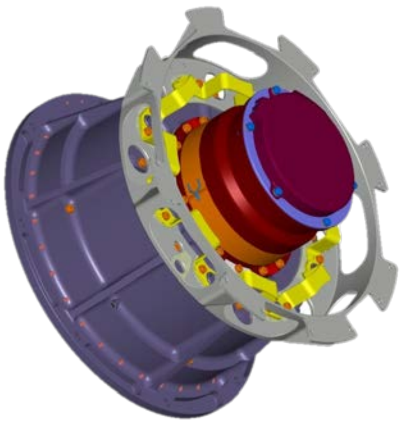
Introduction

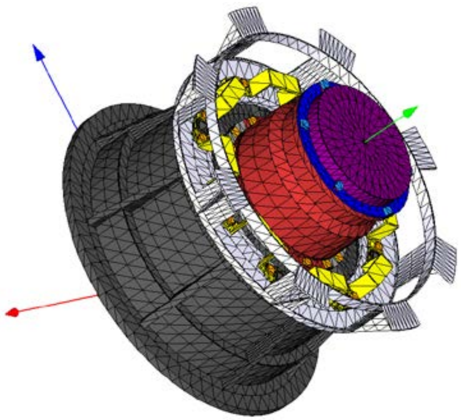
- Within ESA's "*High Fidelity Re-Entry Simulations on Critical Spacecraft Platform Equipment*" project:
  - Model and perform analysis of SADMs demise process during atmospheric re-entry
  - Assess the impact of D4D modifications on demisability

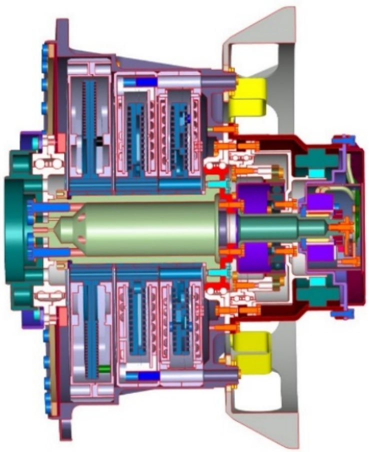
Baseline: Model

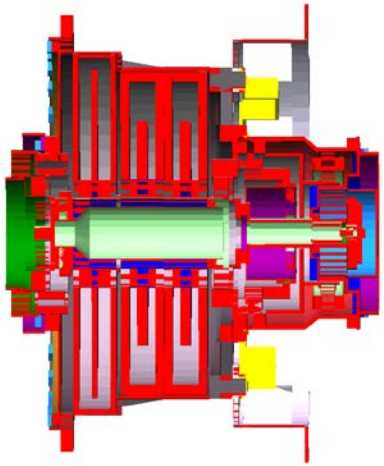
CAD model
(provided by RUAG)

SCARAB model



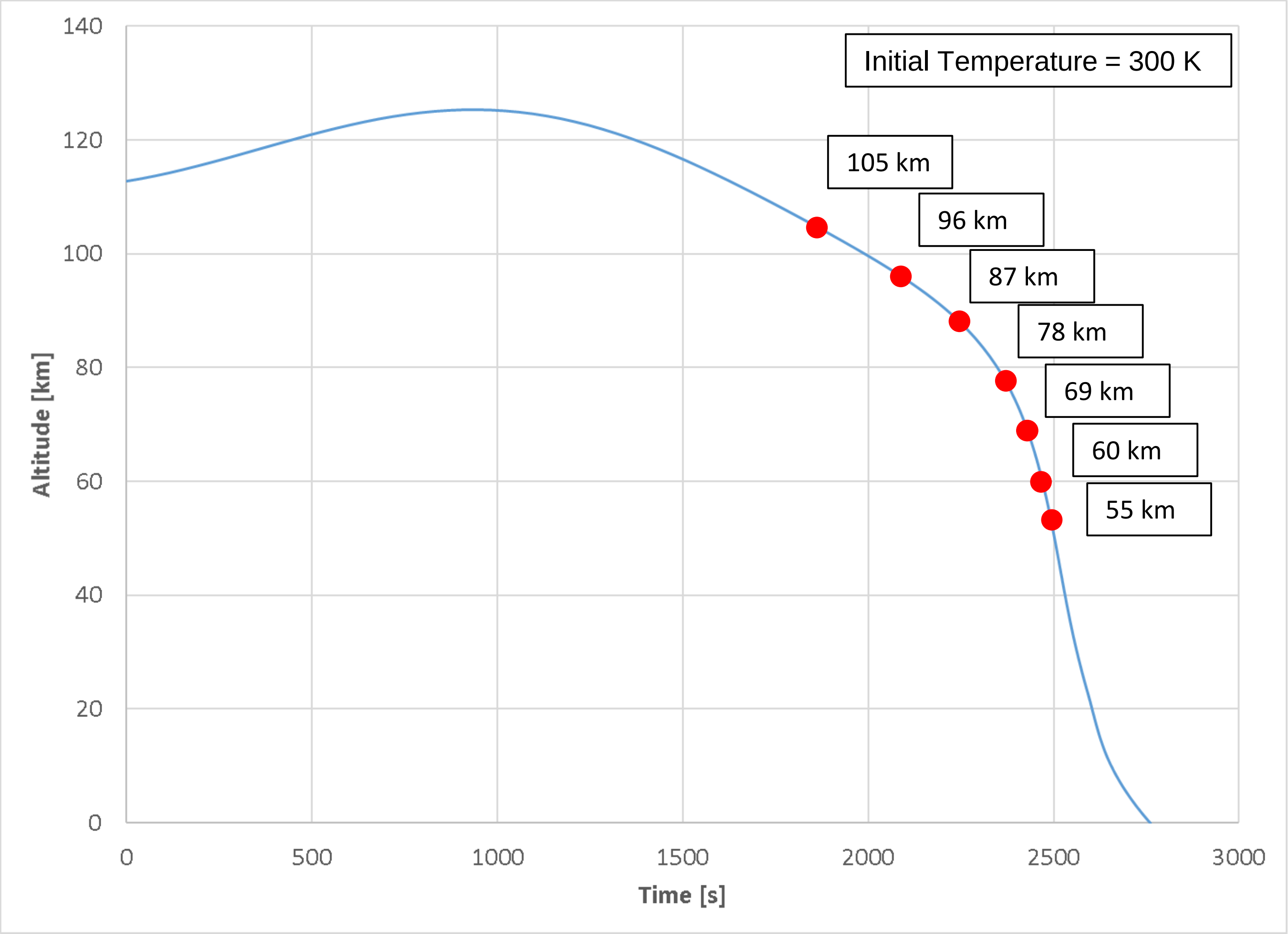




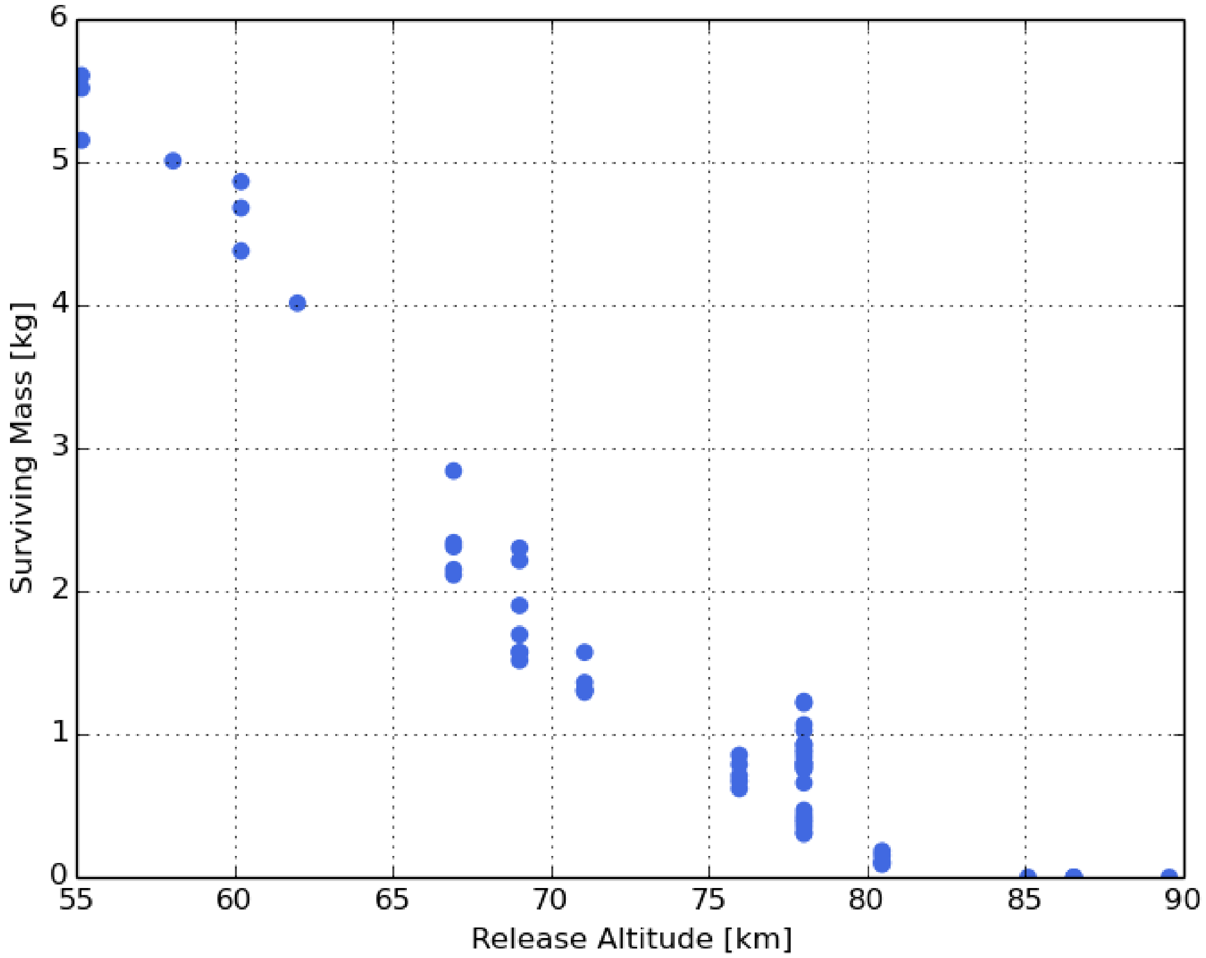


Baseline: Initial conditions

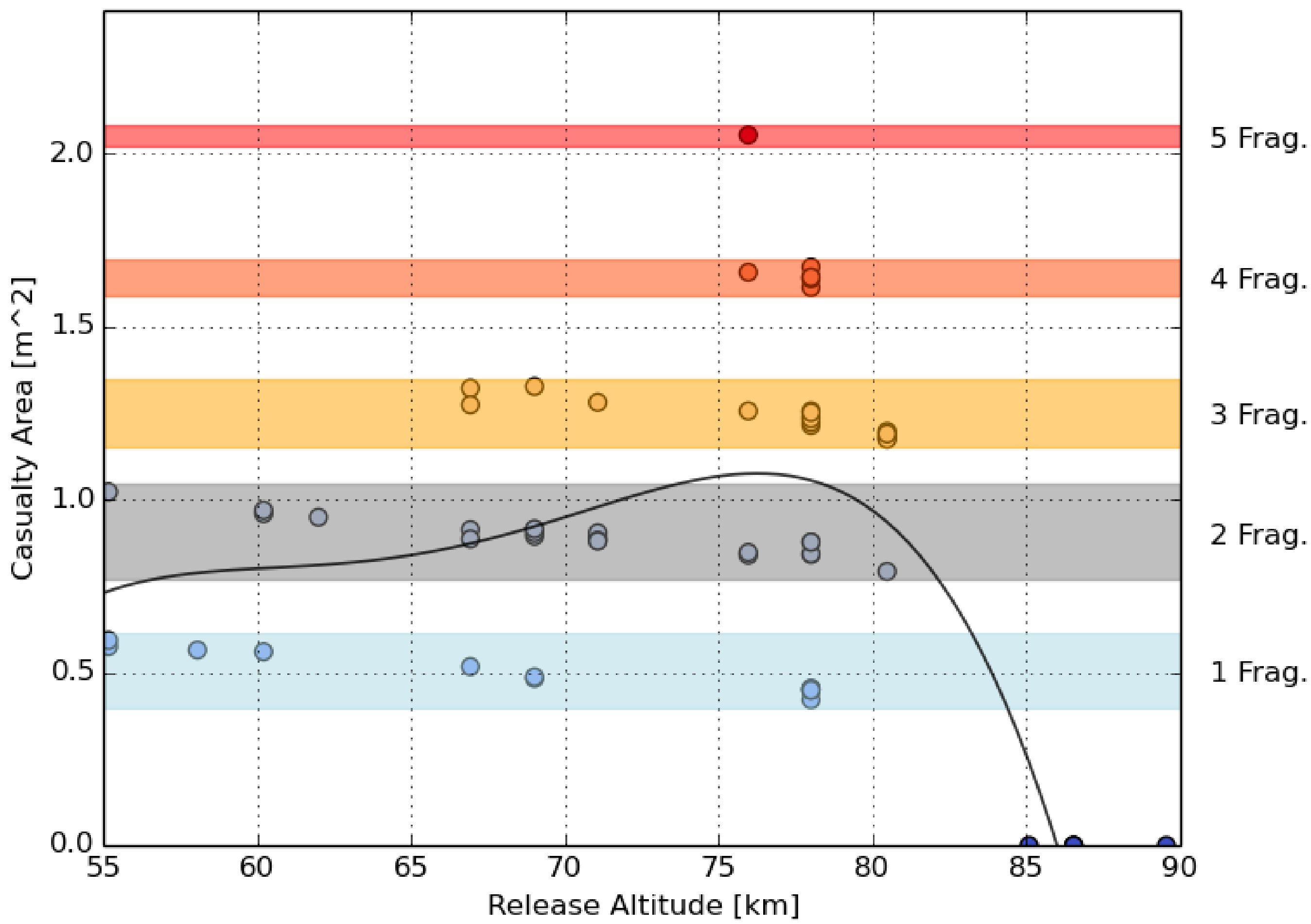
CleanSat reference trajectory



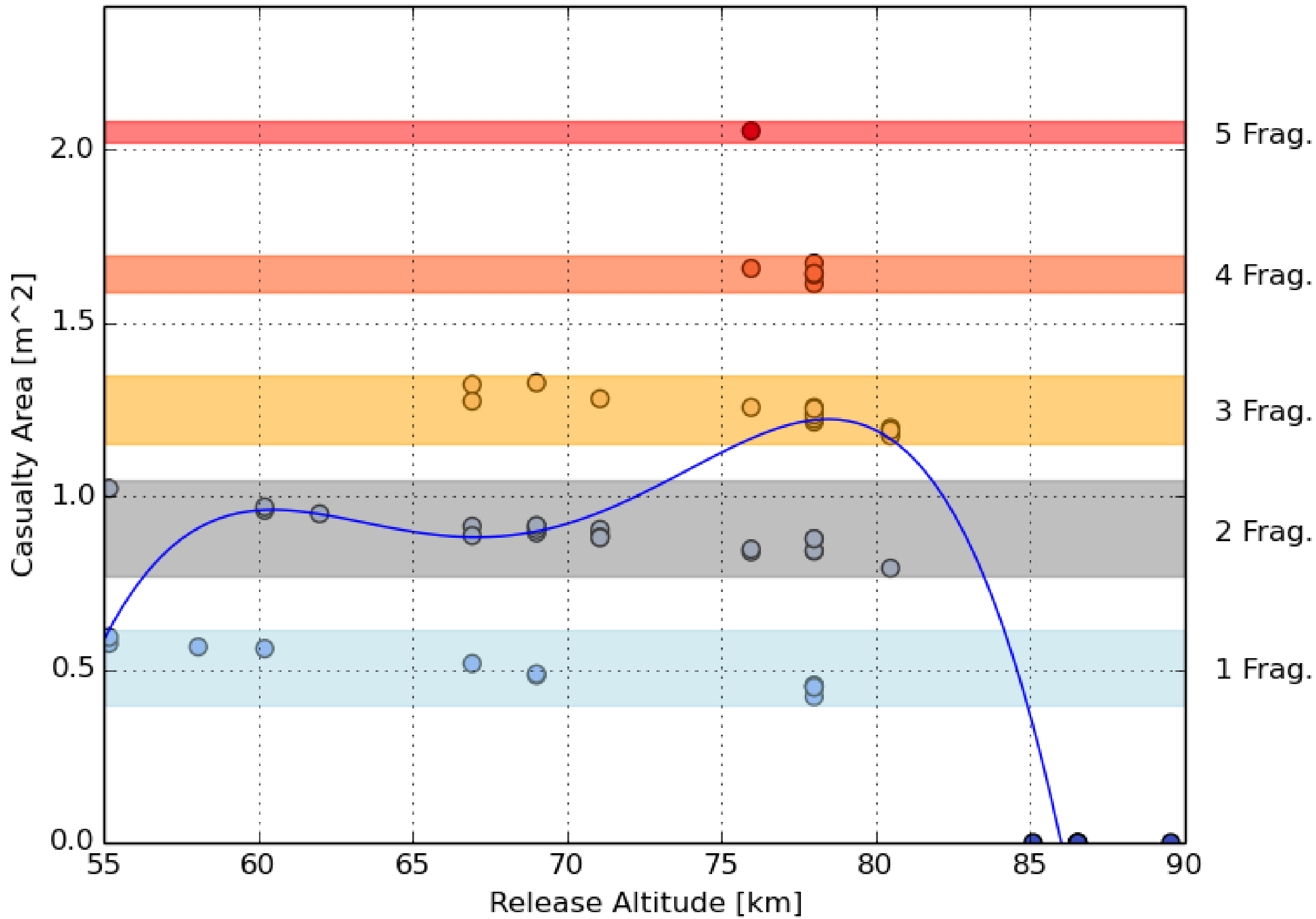
Baseline: Results
Surviving Mass



Baseline: Results
Casualty Area

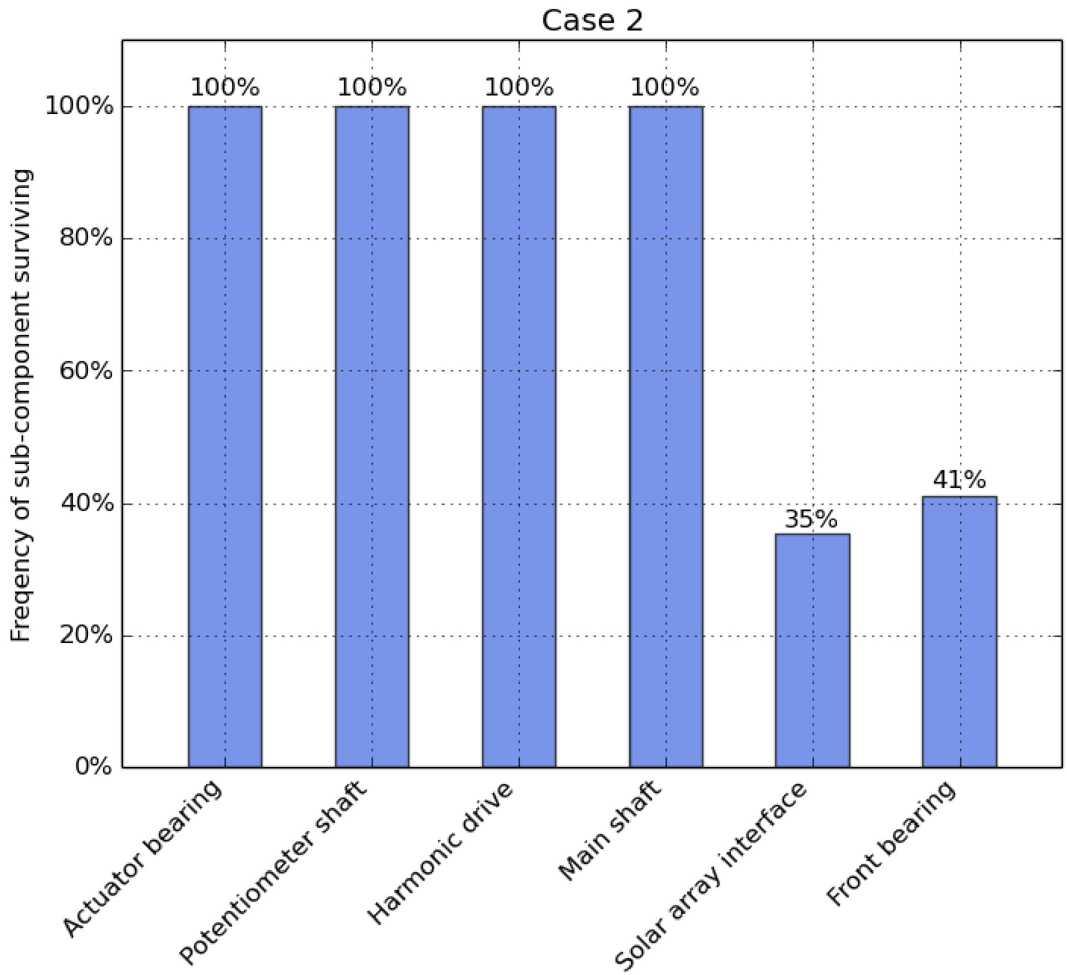


Baseline: Results
Casualty Area



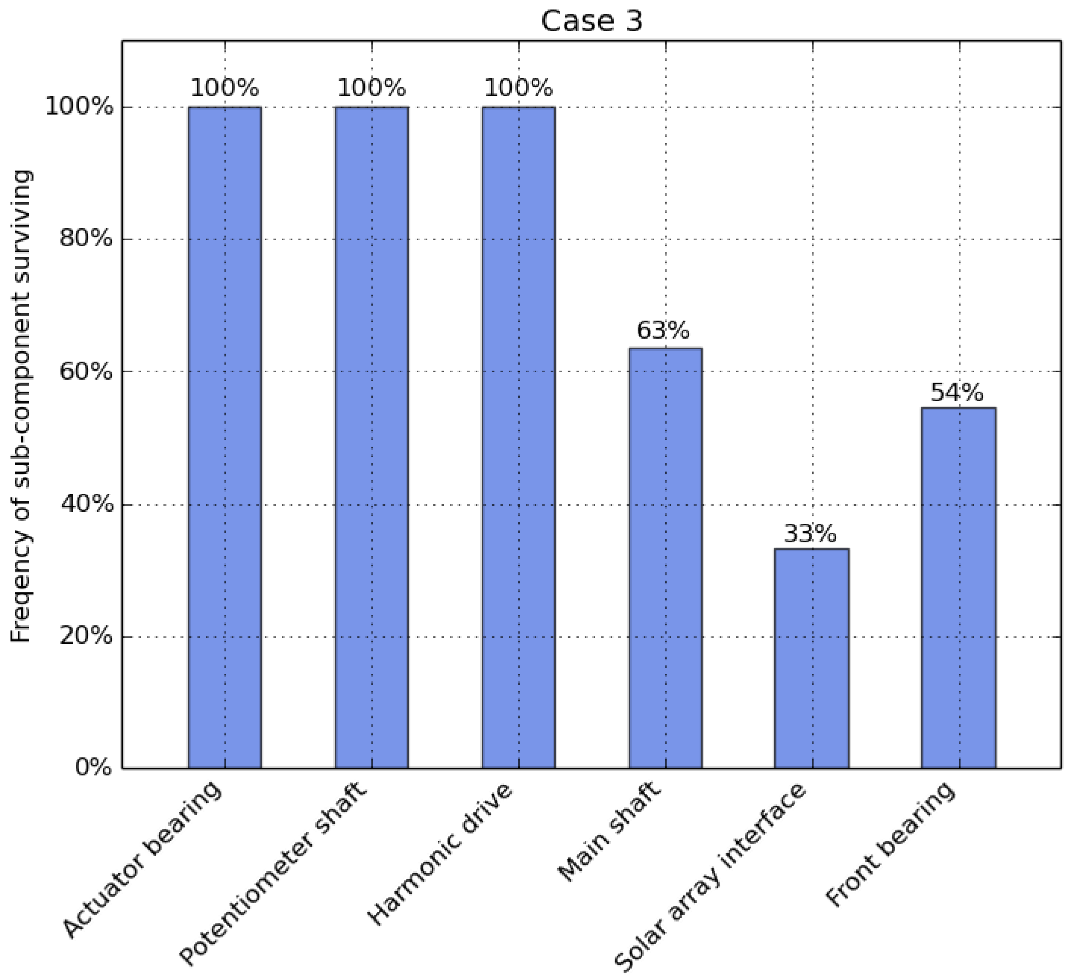
Baseline: Results
Critical Sub-components

Critical sub-components for 69 ±2 km

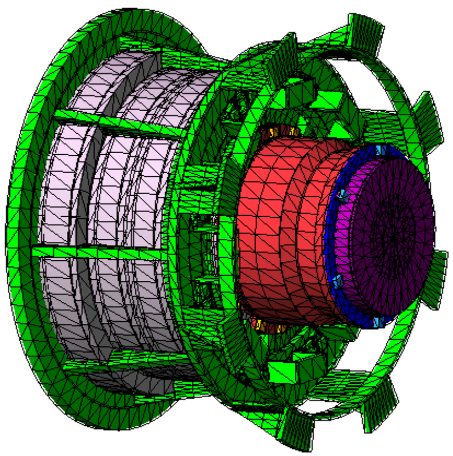


Baseline: Results
Critical Sub-components

Critical sub-components for 78 ±2 km

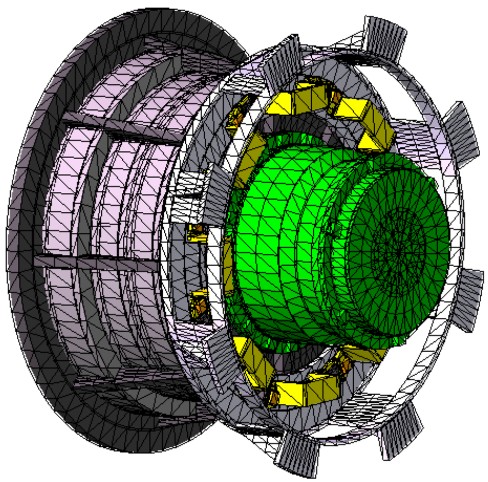


Open SADM



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

Open SADM w/ aluminum actuator

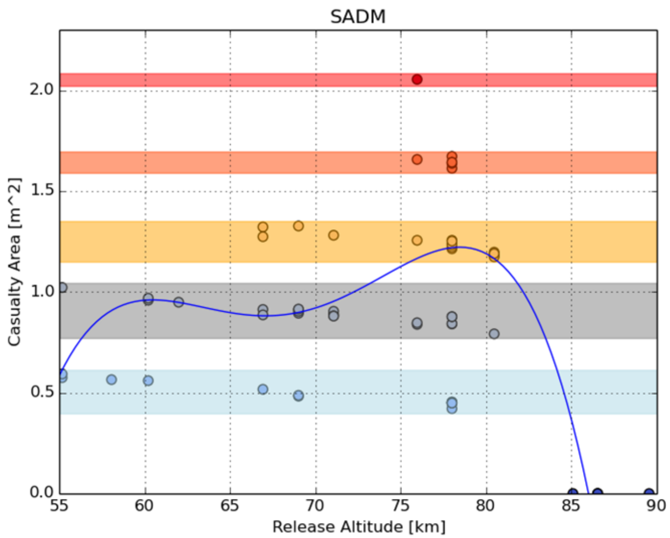


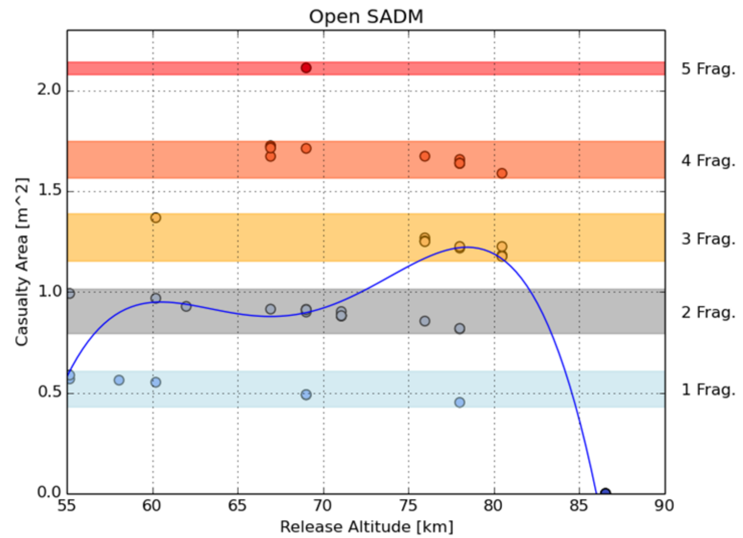
The wall thickness of the modified sub-components has* ***NOT* *been changed*

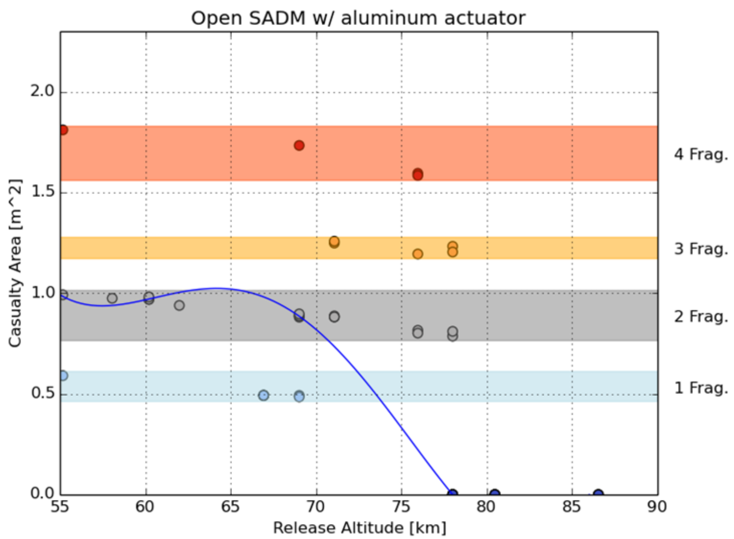
Keeping the open SADM design and in addition changing some Actuator components material to aluminum (from titanium) thereby reducing the heat required for complete demise (Q_{demise}). Actuator components which were changed:

- Actuator housing
- Potentiometer shaft
- Potentiometer housing

D4D: Results
Casualty Area

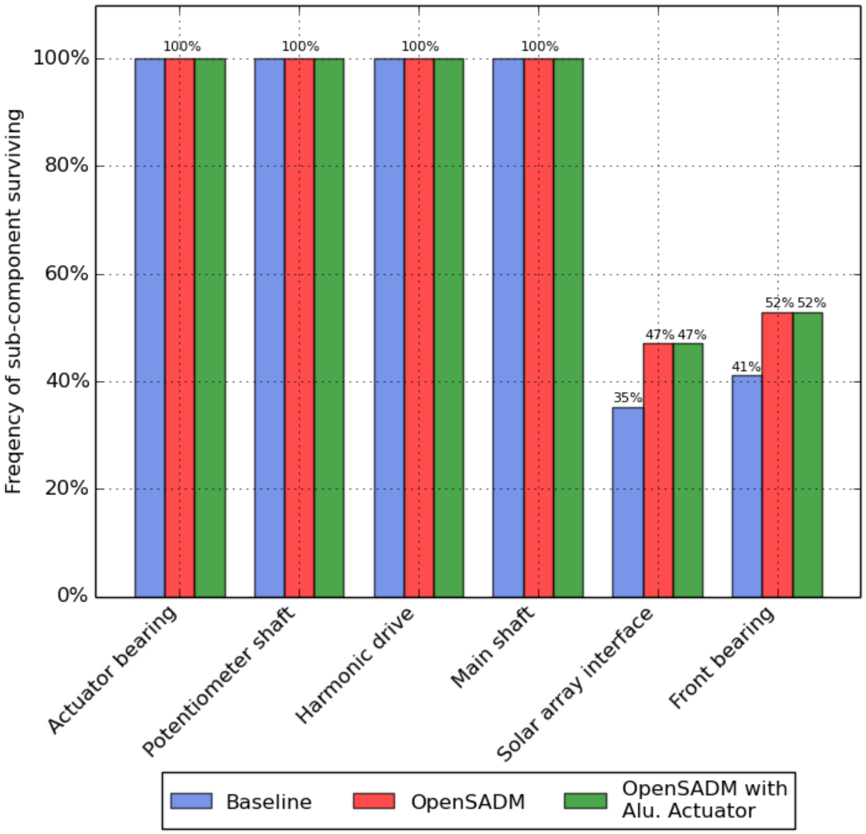




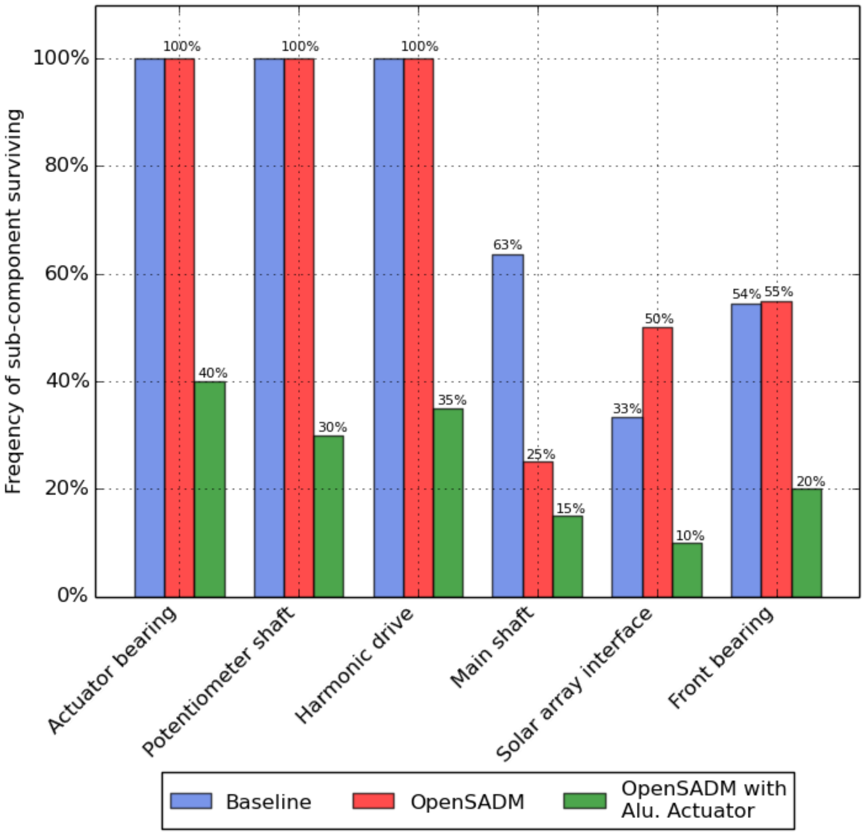


D4D: Results
Critical Sub-components

Case2 ($69 \pm 2\ km$)



Case3 ($78 \pm 2\ km$)



Baseline: Summary

- Release altitude **demise above 87 km**
- Release altitude **between 80 km – 55 km** result in **multiple ground fragments**. *(Casualty Area dependent on number of ground fragments)*
- Critical sub-components surviving:
  - Actuator bearing
  - Harmonic Drive
  - Potentiometer shaft
  - Main shaft
  - Solar array interface
  - Front bearing

D4D: Summary

- D4D modification (1): Open SADM
  - Complete 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.

Am I out of time?

In that case:
Thank you for listening! ☺

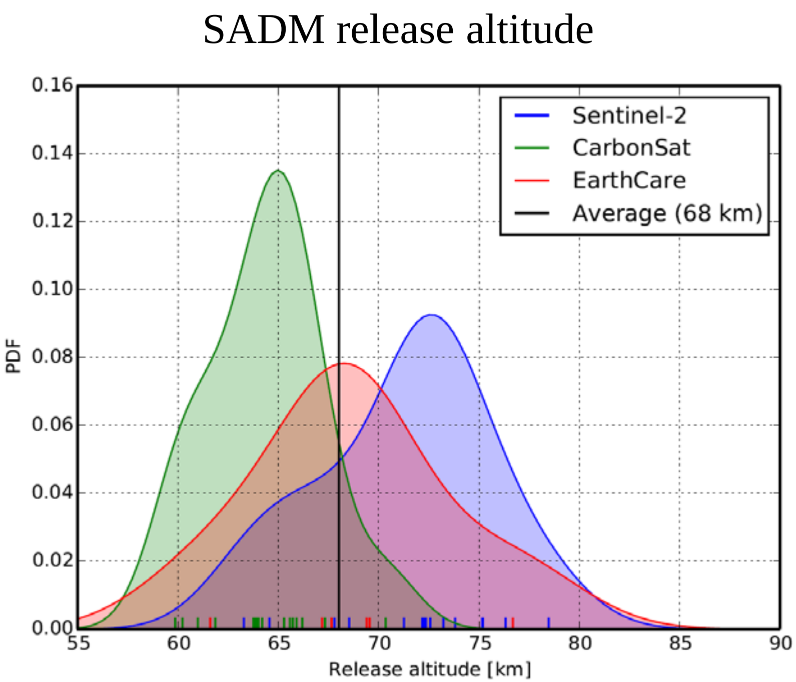
Extended work

- How many simulations are enough?

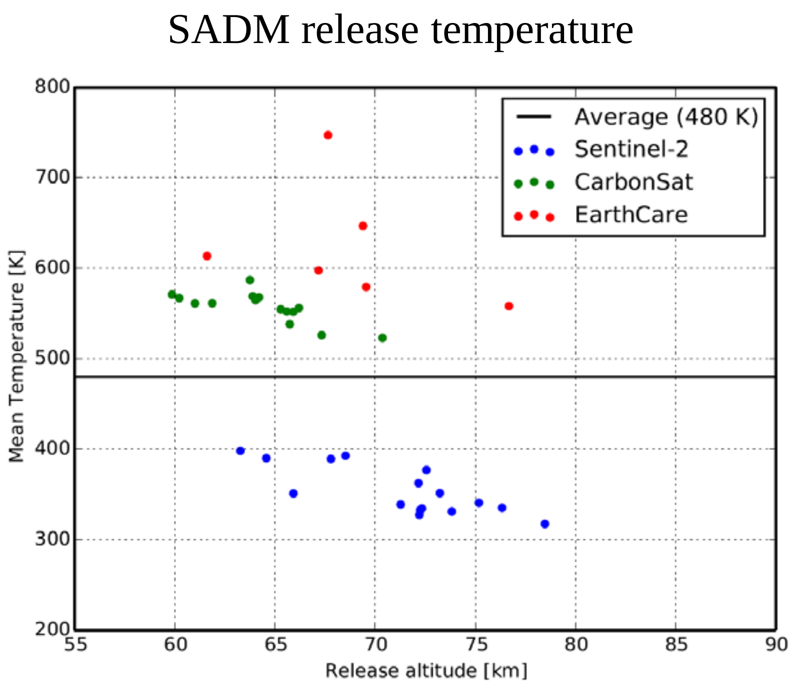
“With limited number of simulations, how do we ensure that our results are representative of the full output space?”

  - Can I reduce my input space?
  - When does my results converge?

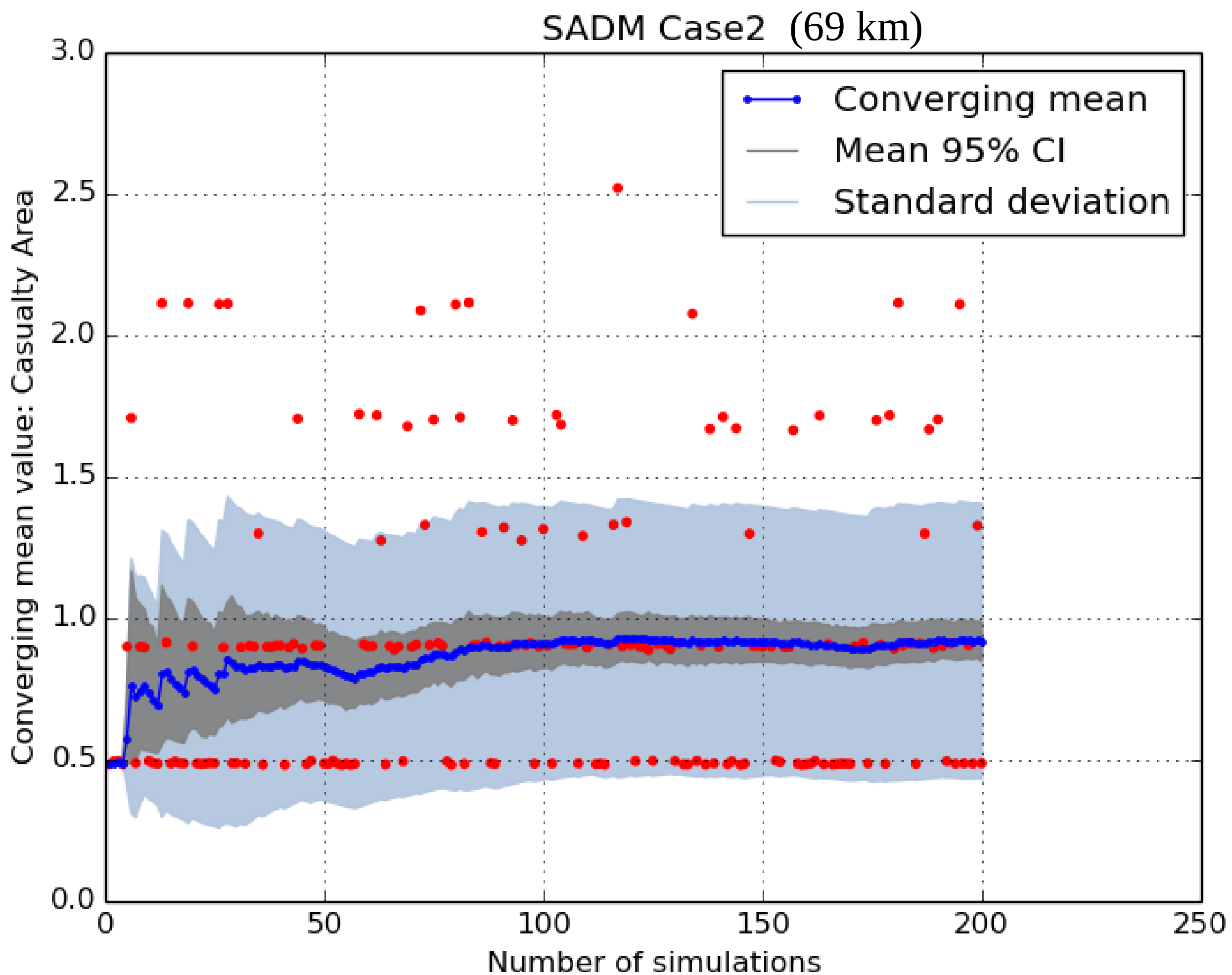
SADM - Initial release conditions:



*only thermal fragmentation simulated



Extended work



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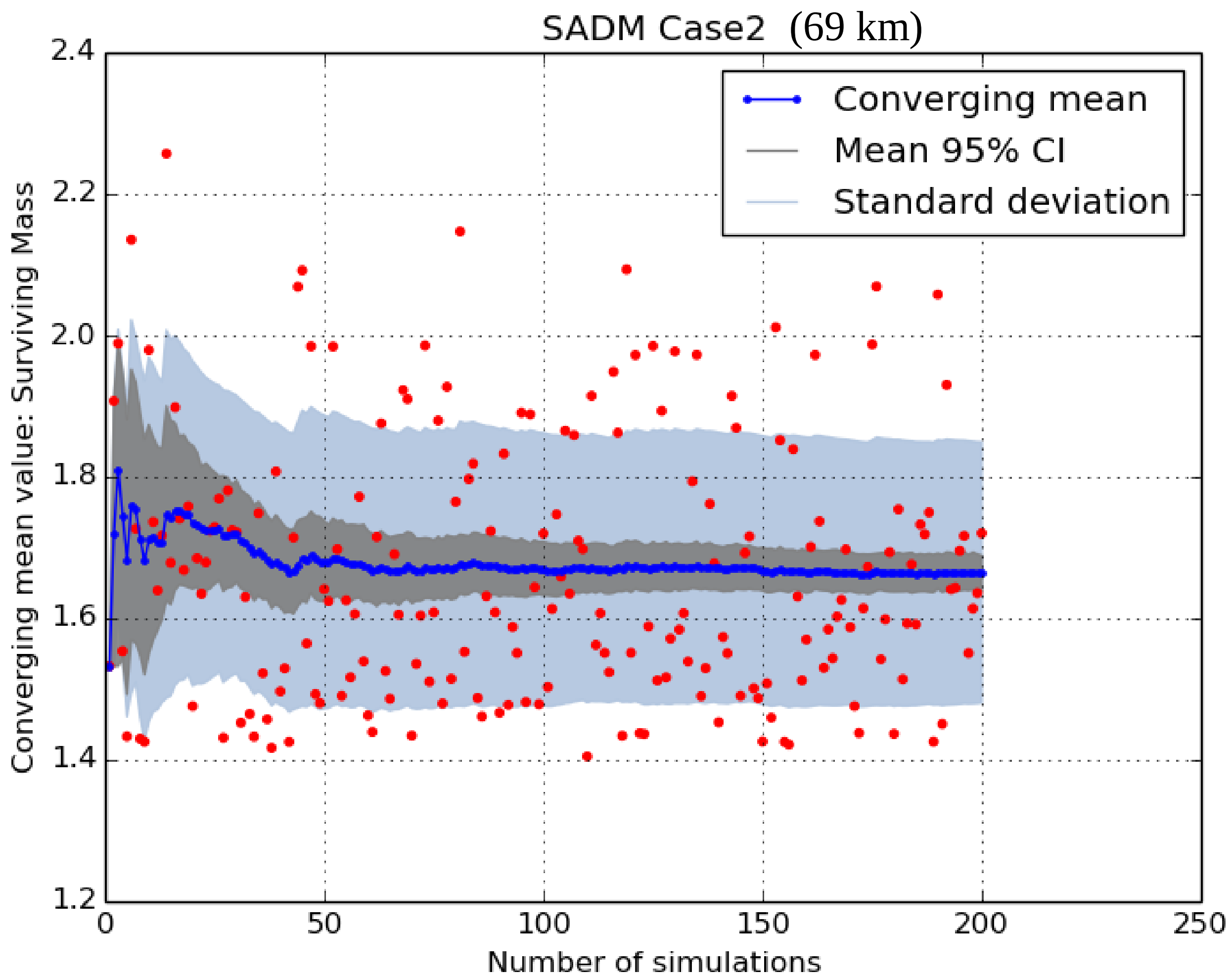
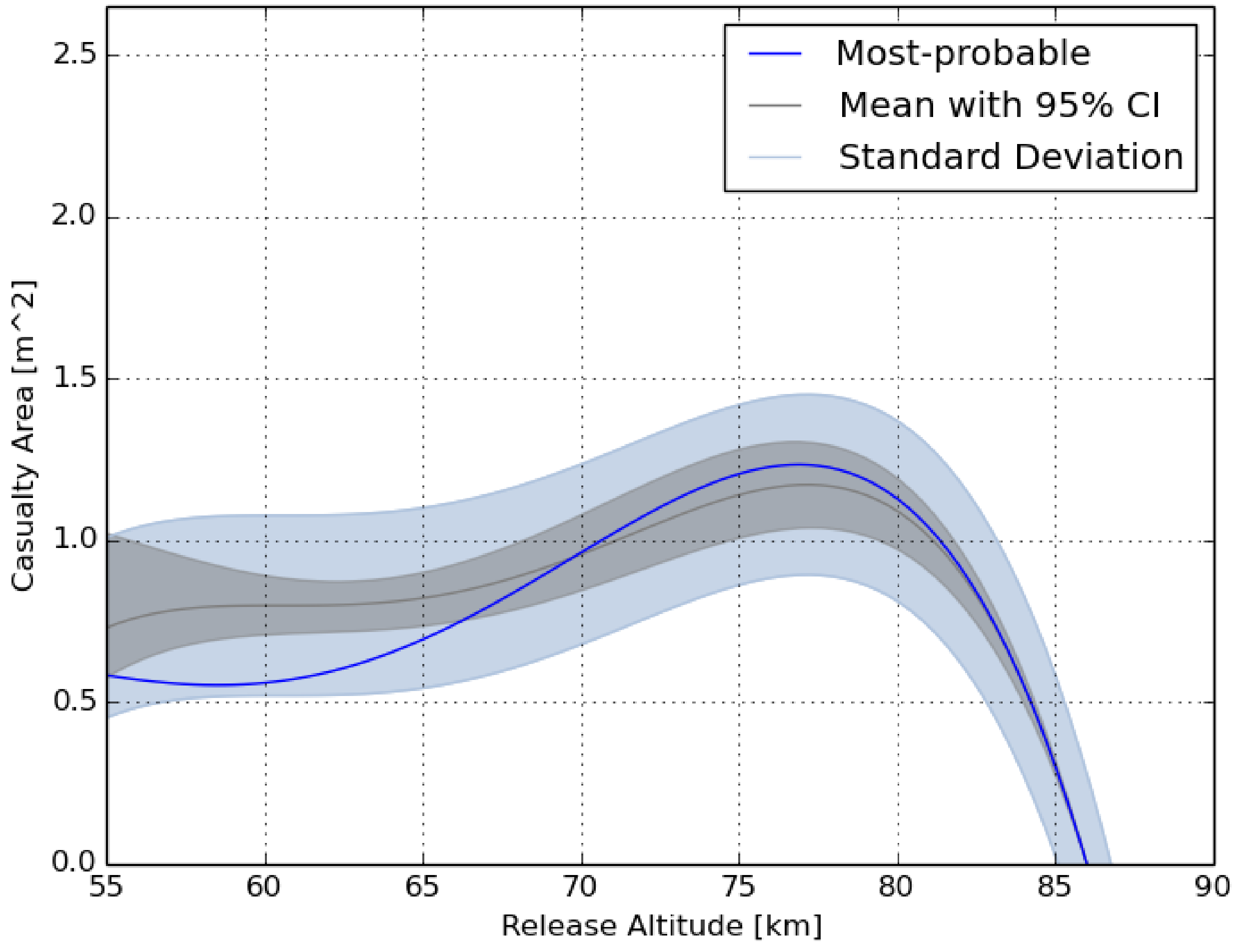
Extended work



Extended work

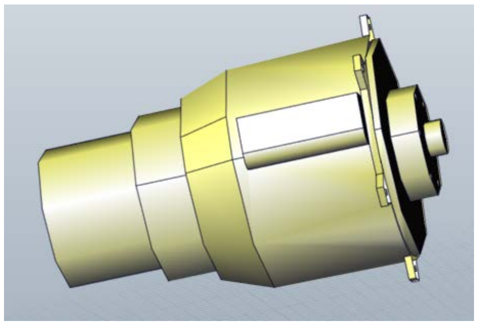


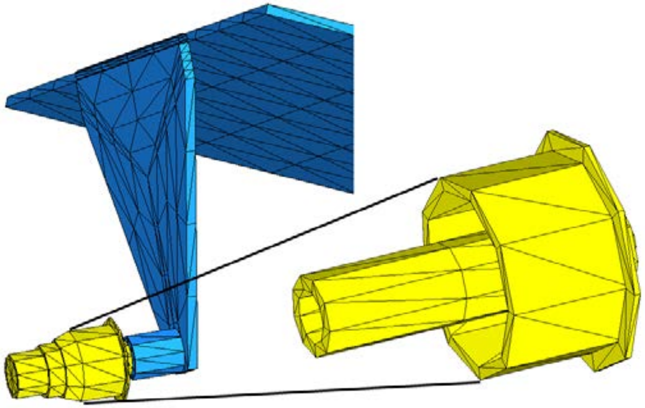
Thank you for listening!

Questions?

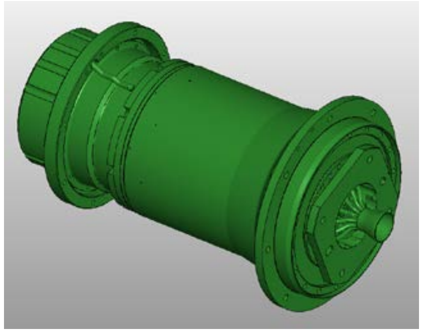
Previous SADMs used in SCARAB

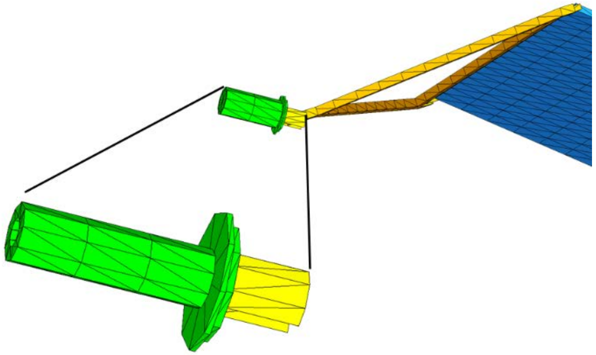
CarbonSat



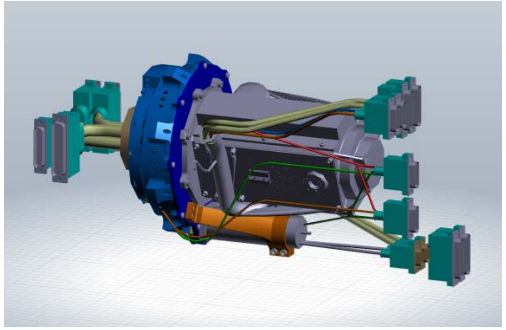


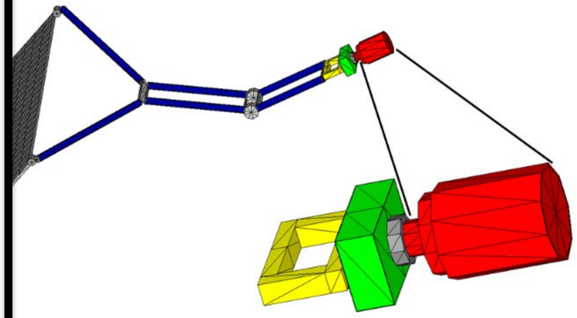
Sentinel-2



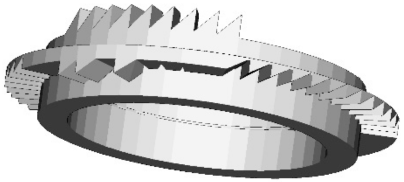


Sentinel-3

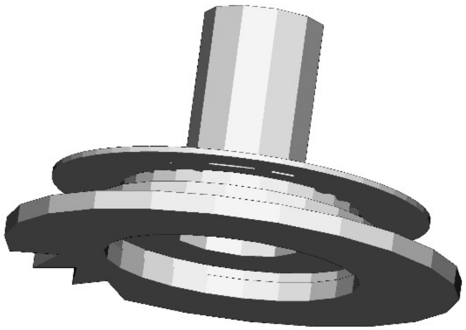




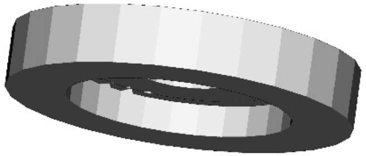
Surviving fragments Case3-1 ($78 \pm 2\ km$)



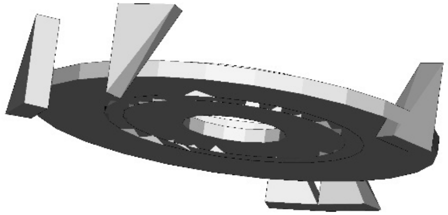
Actuator bearing



Potentiometer shaft + Actuator bearing + Harmonic drive



Solar array interface + Front bearing



Front bearing

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Baseline: Results
Casualty Area