OHB'S APPROACH TO SPACE ENVIRONMENT MODELLING: MMOD IMPACTS AND RE-ENTRY

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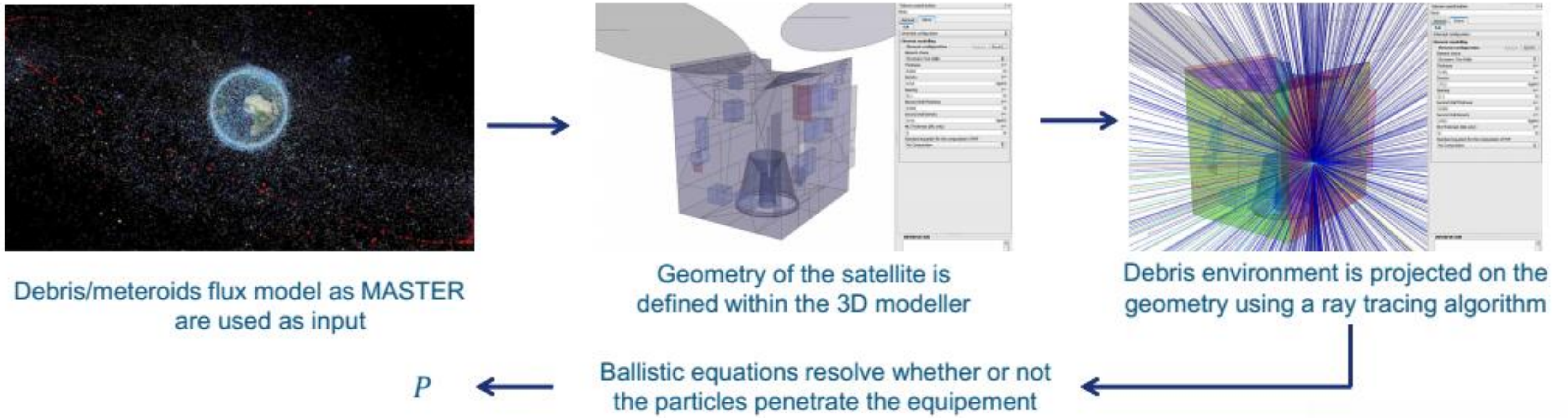
INTRODUCTION

OUTLINE

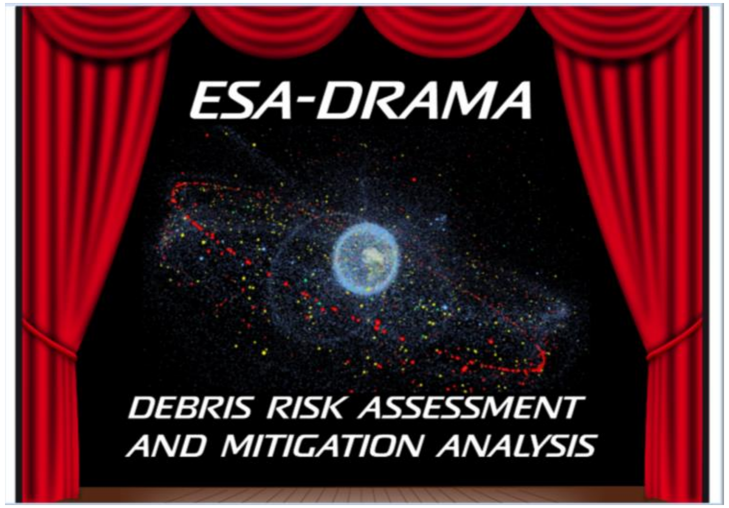
- **Methodology of Analysis in OHB**
- **Environmental Models for MM**
  - Grün model correction at 1 AU
  - MEM3 output as StenviFile for interplanetary mission (>1AU)
- **DSMC simulations for Re-entry**
  - Orion Case
  - Spacecraft Case
- **Conclusions**

METHODOLOGY OF ANALYSIS IN OHB

MASTER + SYSTEMA DEBRIS AND DRAMA



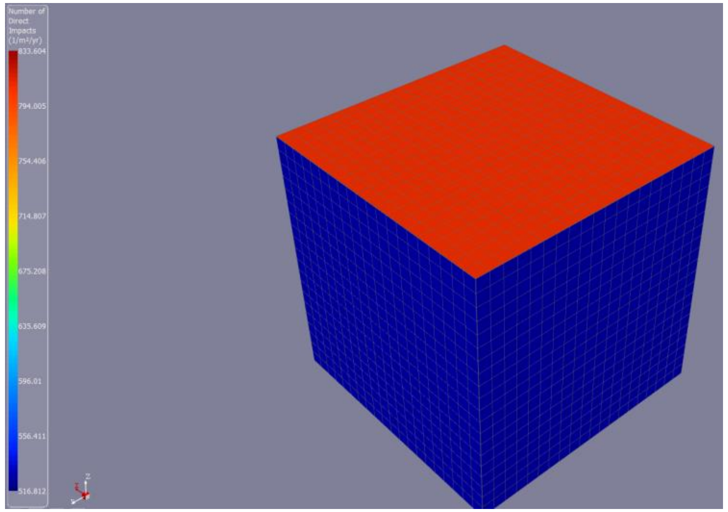
- **General workflow of MMOD Analysis**
  - Defining the debris/meteoroids flux model from MASTER
  - Simplifying the geometry of the satellite with Systema 3D Modeller
  - Identifying the structures and elements within the model
  - Identifying sensitive units
  - Defining the structural parameters such as materials, thicknesses, and standoff distances
  - Choosing the correct equations for the PNF calculation

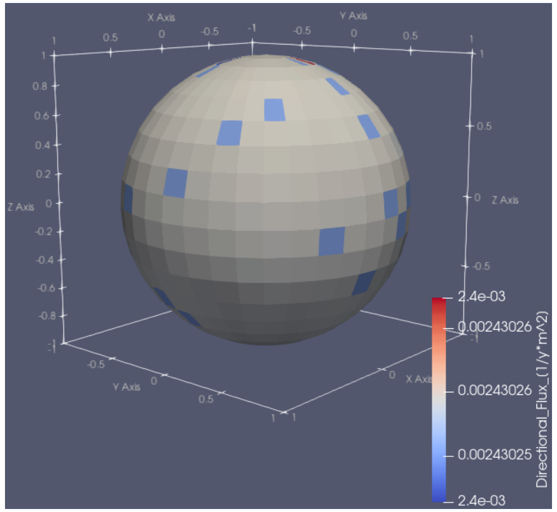


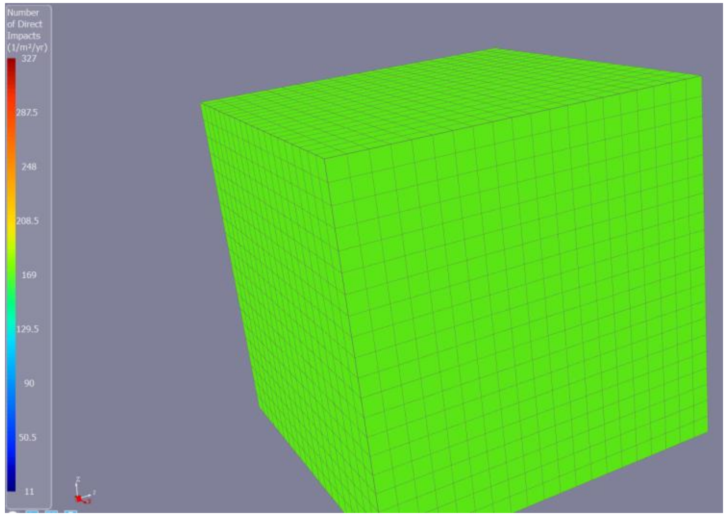
GRÜN MODEL CORRECTION AT 1 AU

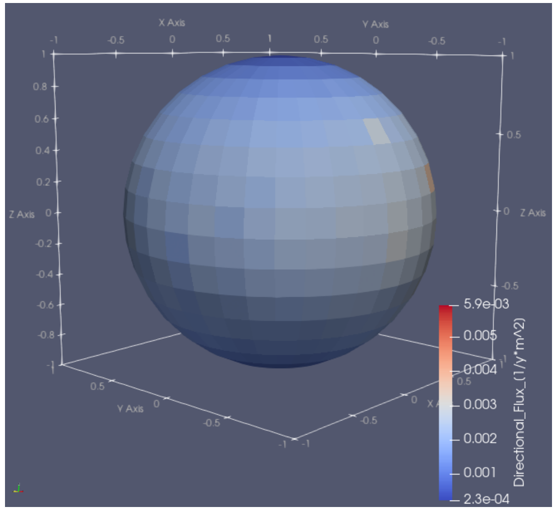
NEW STENVI FOR SYSTEMA DEBRIS

- **Double Correction for Polar Bins**
  - Grün model isotropic flux
  - MASTER particle fluxes directional distribution is given as bins of azimuth and elevation with constant increases in angle → Decreased cell bin size at the poles → less flux → MASTER correction
  - SYSTEMA places the cell of a mesh in the centre of sphere representing the environment. It then creates a ray coming from each of the environment's cells and checks whether it hits other components beforehand. As the cells towards the poles are smaller, the density of rays coming is higher







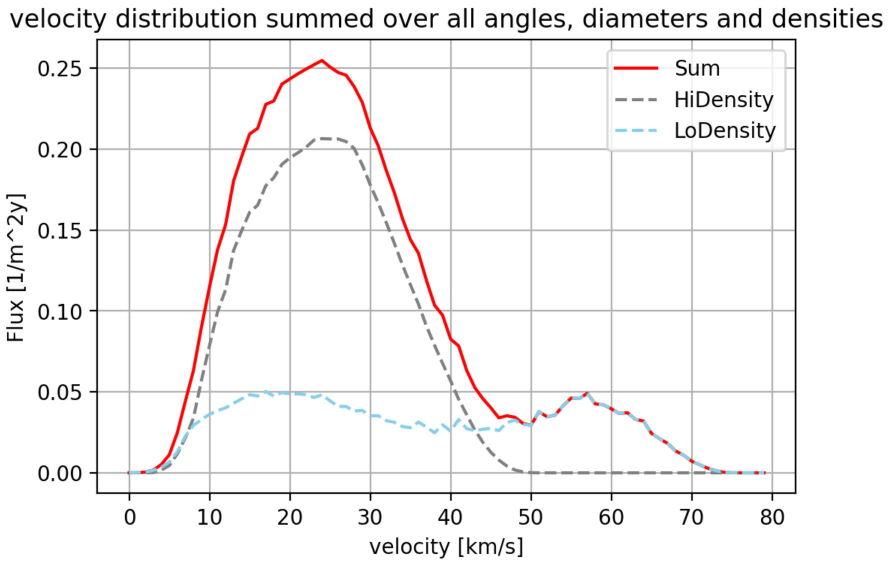


INTERPLANETARY MISSIONS (>1AU)

MEM3 TO STENVI

- **Output: MASTER vs MEM3**
  - MASTER: 6-dimensional dependence → azimuth, elevation, speed, (fixed) density, particle diameter and latitude
  - MEM3: 3-dimensional dependence → azimuth, elevation, speed
- **Missing Dependences Modelling**
  - Fractions of flux per density for combined and reduced density bins
  - MASTER, by default creates one bin for the latitude
  - Original Grün model to calculate flux fraction per diameter for a given density

$$g(m) = (c_4 m^{\gamma_4} + c_5)^{\gamma_5} + c_6(m + c_7 m^{\gamma_6} + c_8 m^{\gamma_7})^{\gamma_8} + c_9(m + c_{10} m^{\gamma_9})^{\gamma_{10}}$$

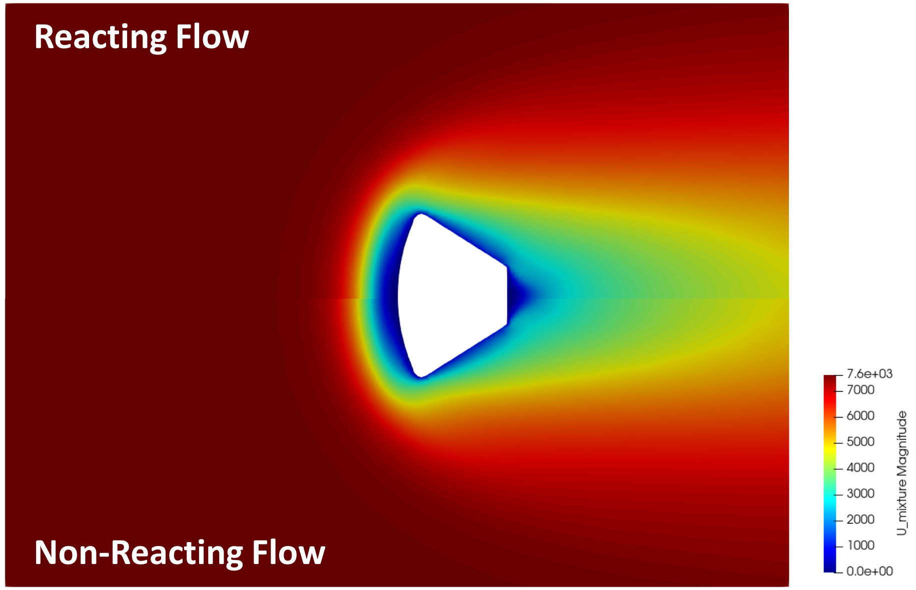


DSMC SIMULATIONS FOR RE-ENTRY

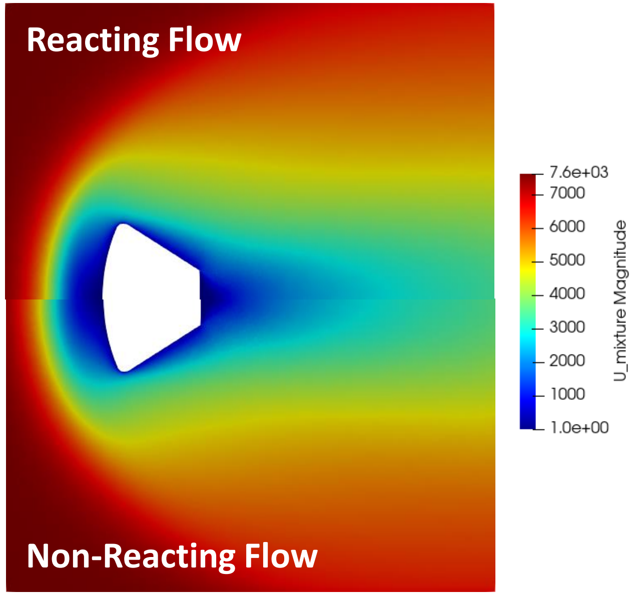
ORION MODELLING AND ANALYSIS

- **Orion case with OpenFOAM dsmc+ and SPARTA**
  - **Compare OpenFOAM dsmc+ with existing litterature**

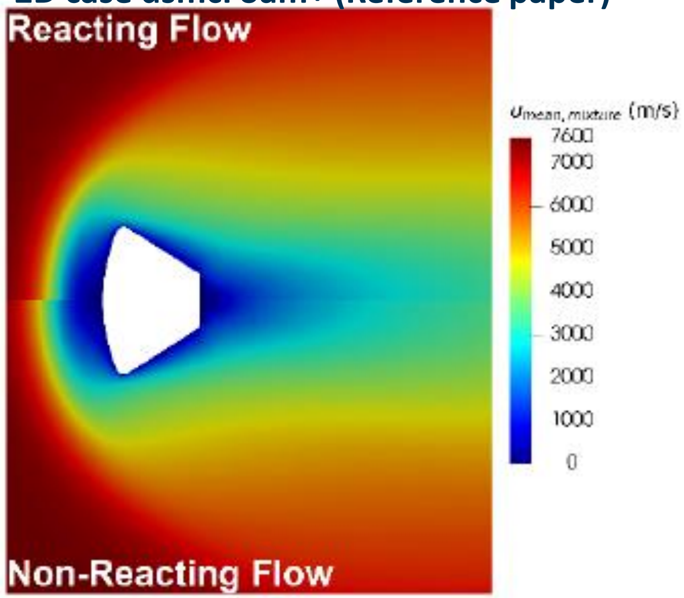
3D case dsmcFoam+



2D case dsmcFoam+



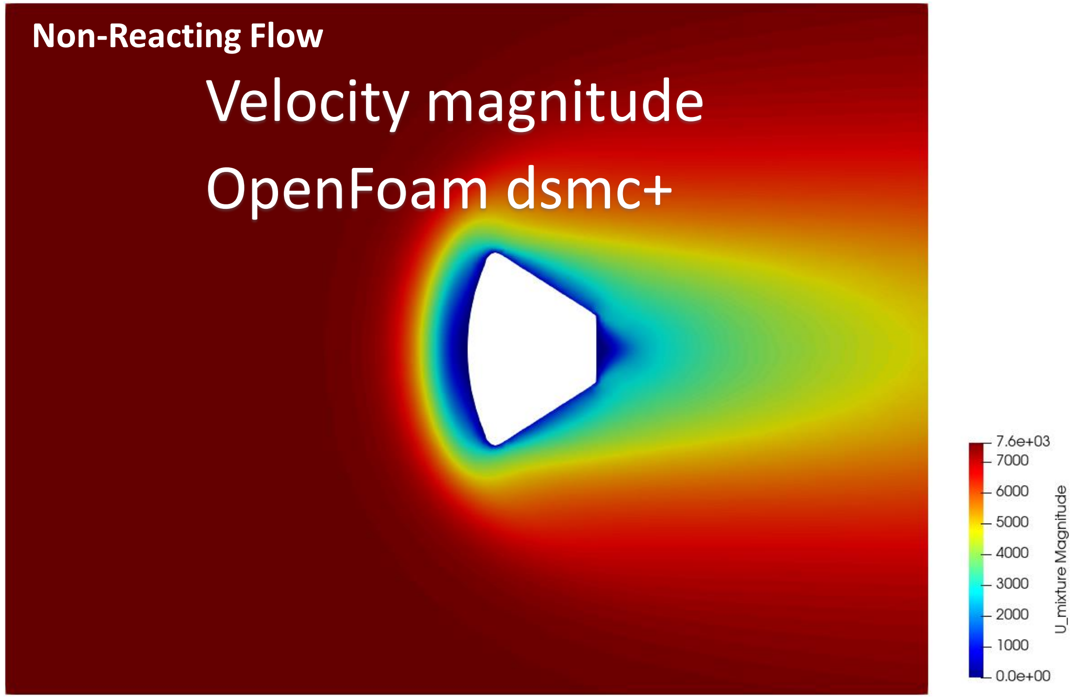
2D case dsmcFoam+ (Reference paper)

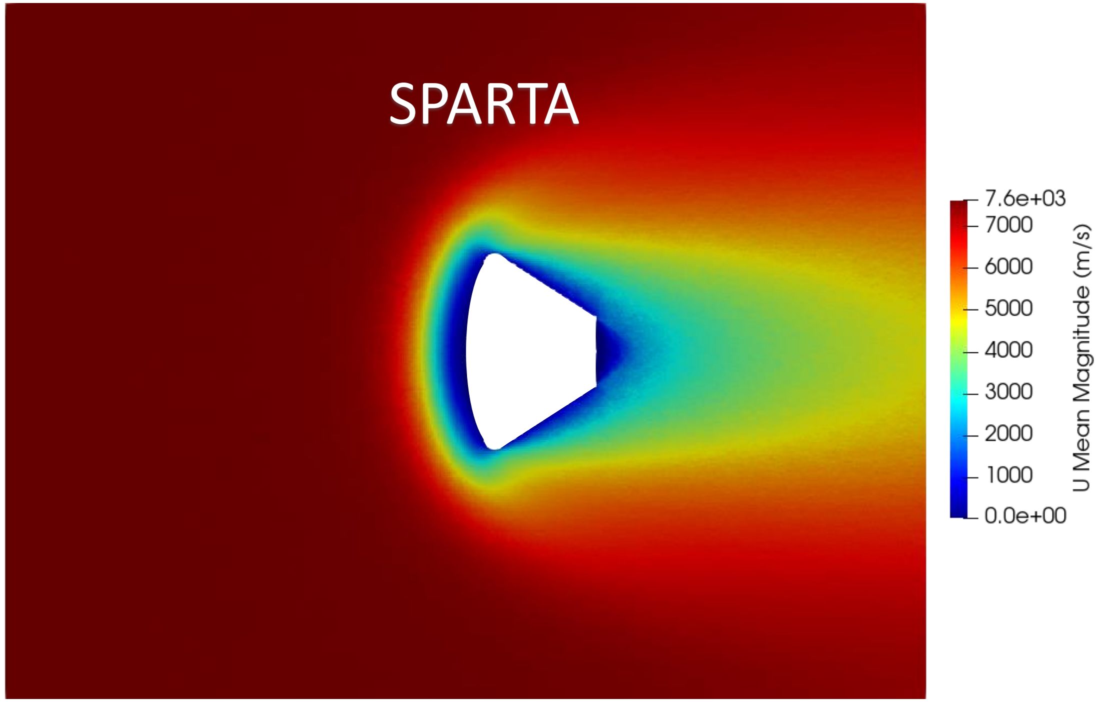


DSMC SIMULATIONS FOR RE-ENTRY

ORION MODELLING AND ANALYSIS

- **Non reacting flow OpenFOAM dsmc+ vs SPARTA (OHB own simulations) for 3D case**

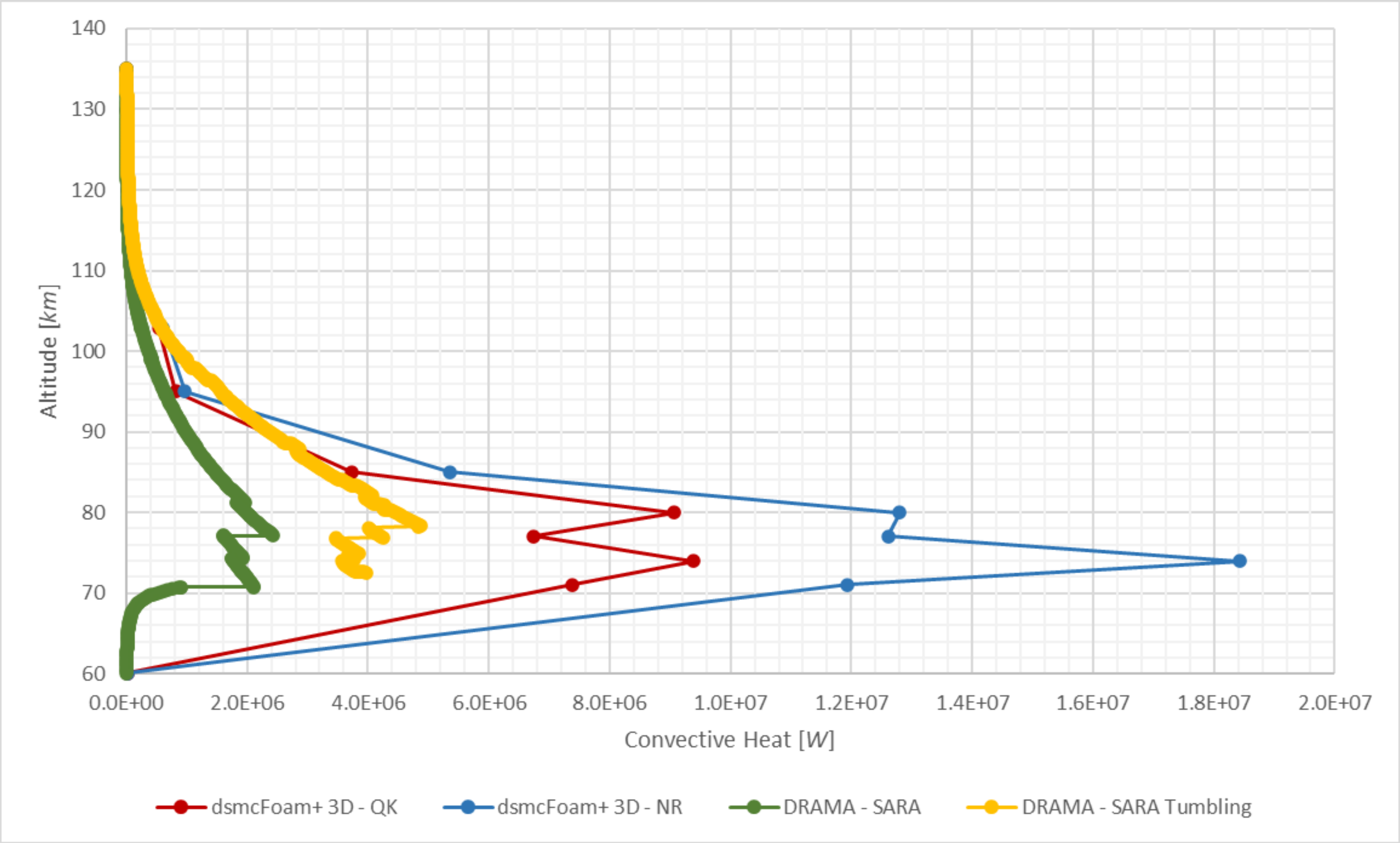




DSMC SIMULATIONS FOR RE-ENTRY

SPACECRAFT MODELLING AND ANALYSIS

Convective Heat Comparison



Deviation results with DRAMA-SARA

Altitude, km	dsmcFoam+ 3D - QK (%)	dsmcFoam+ 3D - NR (%)
135	60.20	61.01
130	69.71	71.50
120	102.22	107.34
110	129.49	141.97
103	118.76	146.22
95	28.88	54.06
90	55.12	95.07
85	152.23	262.32
80	354.75	641.39
77	317.58	680.53
74	428.97	938.33
71	581.39	1268.94
60	263.77	300.75

CONCLUSIONS

OHB ANALYSIS ROADMAP

- **Further Steps:**
  - Extend the current model using a hybrid DSMC-CFD approach like hy2Foam to simulate the full range of flow regimes, enhancing realism in different atmospheric layers.
  - Perform full re-entry simulations with deformable mesh ablation models
  - Include tumbling dynamics during re-entry to improve accuracy on thermal loads and interaction with atmospheric particles.
  - Investigate the pollution effects of chemical releases during re-entry, particularly on the ozone layer, integrating with ablation models for a comprehensive evaluation.

THANK YOU!

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