

MMOD modelling in an industrial context: **The use and application of MASTER**

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Overview:

I. MMOD Assessment process by OH B:

1. Project needs
2. General MMOD Analysis process
3. Detailed MMOD Analysis methodology

II. MMOD Modelling

1. Master use and comparison M2009 vs M8 outcome
2. Connection to Systema (stenvi files)

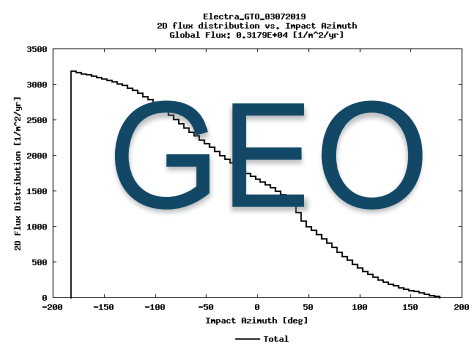
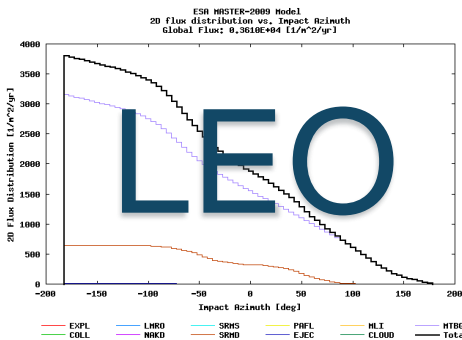
III. Conclusion: open discussion

1. MM models change? Why? [Results are weirder in new MASTER]
2. New Stenvi file format?

Project needs:

- OH B variety of missions: LEO, MEO, GEO, Exploration. Needs to study several MMOD environment and not only one type
 - LEO: 2 Observation satellites + CO2M
 - MEO: Galileo first generation satellites
 - GEO: Telecommunication satellites (H2SAT, Electra –orbit raising-) + Scientific (MTG)
 - Exploration: Plato, HERA

Exploration



- Project have specific needs for units or the whole satellite, to assess the PNF Lagrange L3 =>

MMOD Analysis process:

- Goal: check if the design is correct with regard of the studied subject
- These types of environment analysis interact with several disciplines:
 - Design
 - Thermal
 - Materials
 - Mission definition (orbit + Environment)
 - Interactions in two directions:
 - Defining the analysis
 - Flowing the outputs to the impacted subsystems
 - Loop if analysis show a design flow

Inputs

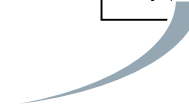
- Design: geometry STEP file
- Thermal: simplified list
- Materials: list with appropriate properties for the study
- Mission definition:
 - Orbit:
 - altitude and latitude
 - Local time and season
 - Environment:
 - MM models
 - Manmade debris
 - STENVI Files

Analysis

- Implementation into model
- Meshing
- Mission and Environment definition
- Numerical assessment
 - Ray-tracing
 - Surfaces orientation
- Sufficient iterations for confidence in results

Results

- Results adapted to project needs
- Comparison with requirements
- Check if analysis too conservative
- Identification of possible problems
- New loops if necessary
- PPT for intermediate results



MMOD Analysis Methodology

- Depending on the project state: PDR or CDR, we go more in details if needed
- Simplified process at early satellites stages: « MASTER + EXCEL »
 - Define Environnement with MASTER
 - Load MASTER ouput file in our own Excel tool
 - Make a first assesement for surfaces, for different BLEs, at different angles
 - Provide a first PNP
- Detailed assessment at advanced stages: “MASTER + SYSTEMA”
 - Defining the the meteoroids and orbital debris (M/OD) flux model from MASTER
 - Simplifying the spacecraft geometry within Systema
 - Computation of equipment vulnerability
 - Identifying structures and elements within the model
 - Defining the material parameters
 - Choosing the correct equations
 - Evaluating the Probability of No Penetration (PNP)

MMOD modelling: MASTER use and comparison

Comparison between M2009 and M8

- Target orbit

Target orbits (Singly Averaged Elements)							
Prop.	Start epoch	End epoch	SMA	ECC	INC	RAAN	AoP
<input type="checkbox"/>	2025 11 03 00	2026 03 23 00	42103.0	0.002	0.0	171.8	273.7

- Performed for:
 - MASTER 2009
 - MASTER 8
 - Grün model – Grün distribution
 - Grün model – Taylor distribution
 - Divine-Staubach model (Grün distribution)
 - Divine-Staubach model (Taylor distribution)

First Comparison Analysis

Master 2009

Debris Sources

Select all

Explosion fragments Collision fragments LMRO

NaK droplets SRM slag SRM dust

Paint flakes Ejecta MLI

Population Clouds

Population clouds Refresh

25730

Meteoroid Sources

Meteoroids

Core population Asteroidal population A population

B population C population Select all

Meteoroid Streams

No seasonal streams (averaging)

Jenniskens-McBride

Cour-Palais

Master 8 Grün – Grün

Debris Sources

Condensed

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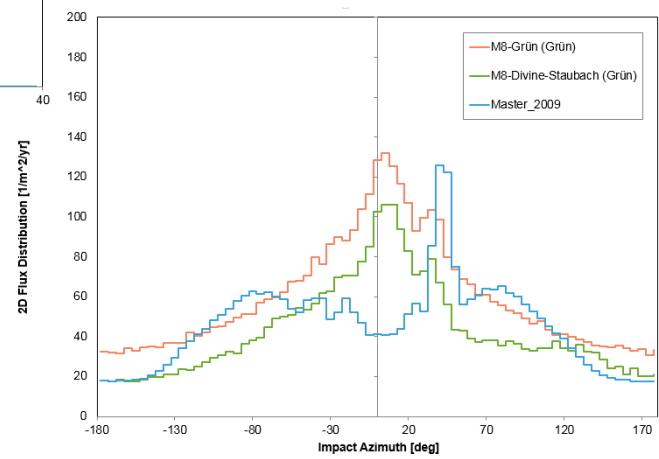
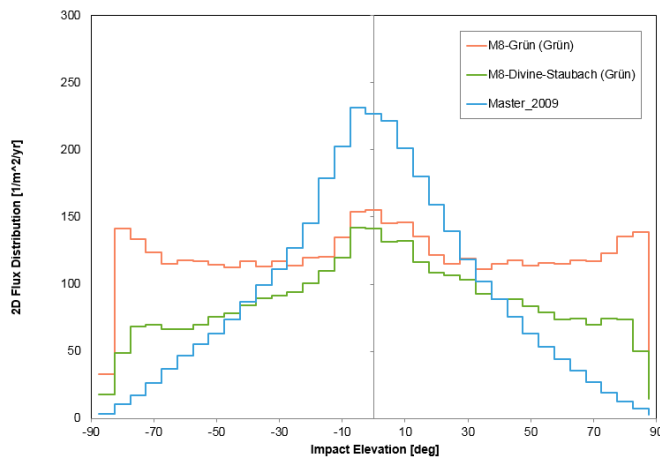
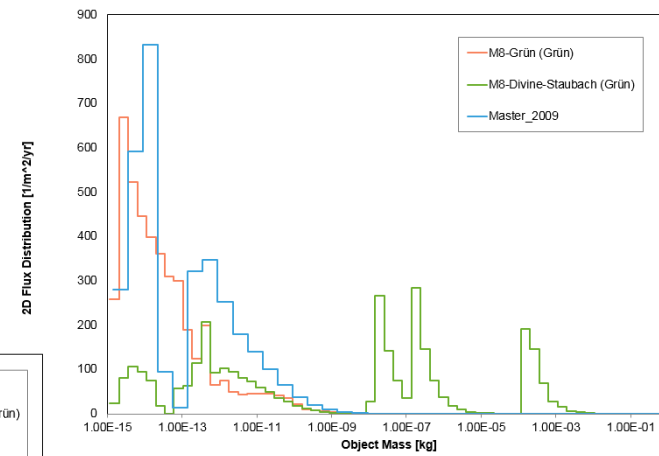
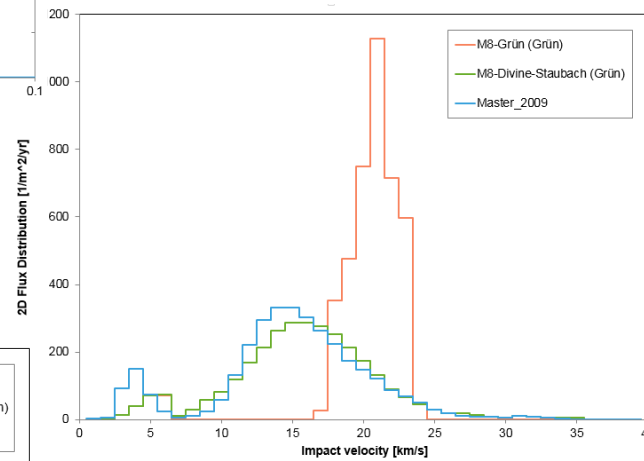
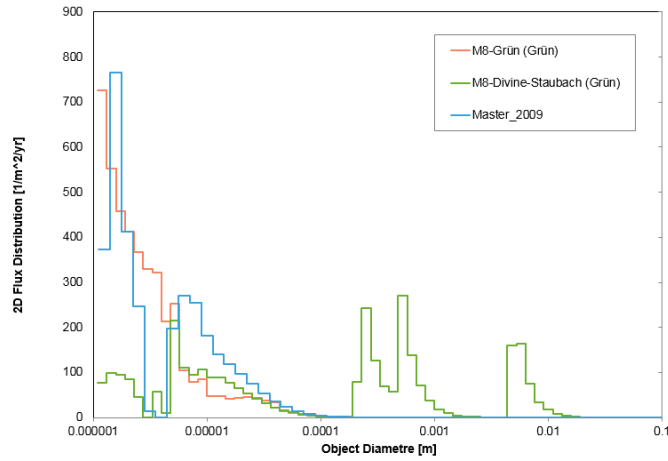
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Suggestions of change from ESOC

Master 8 Grün – Grün

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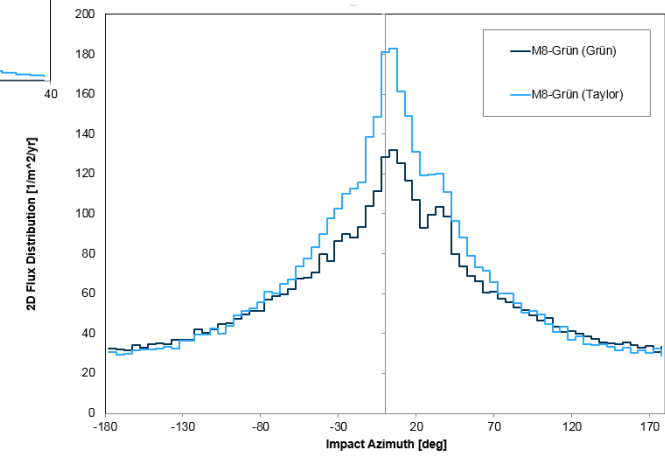
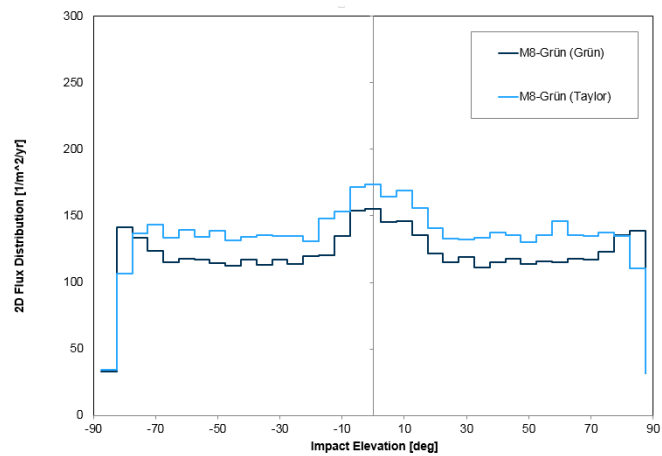
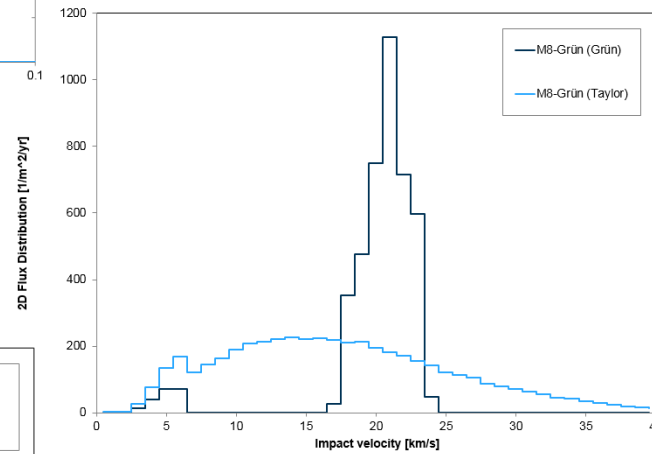
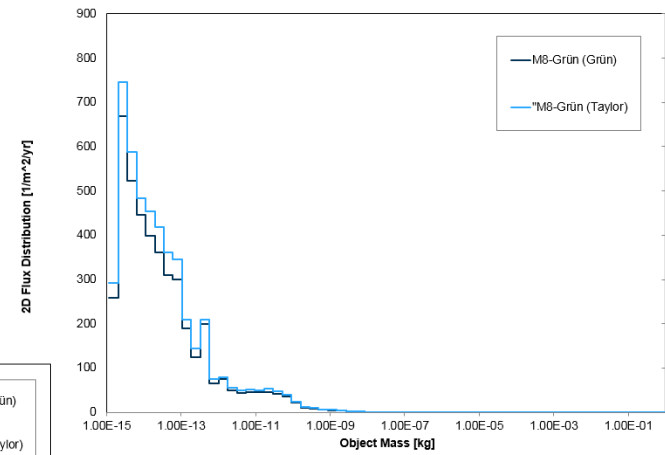
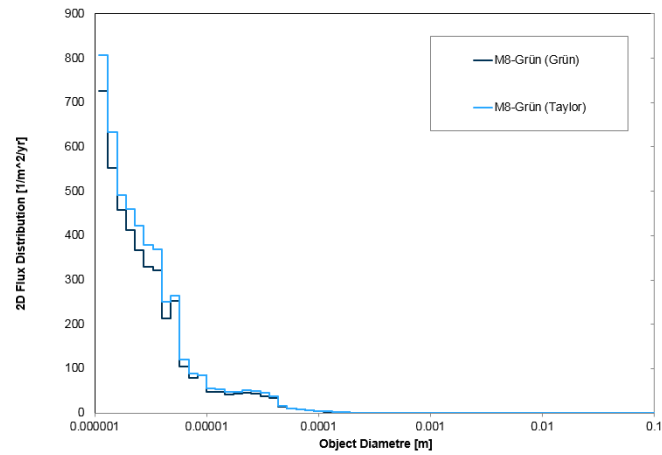
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Second Comparison Analysis

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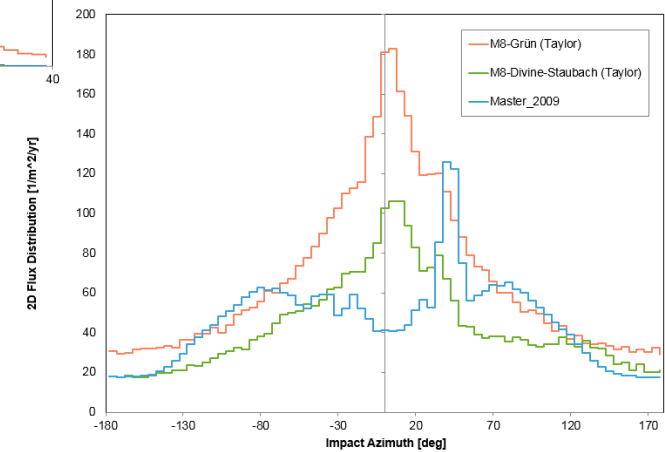
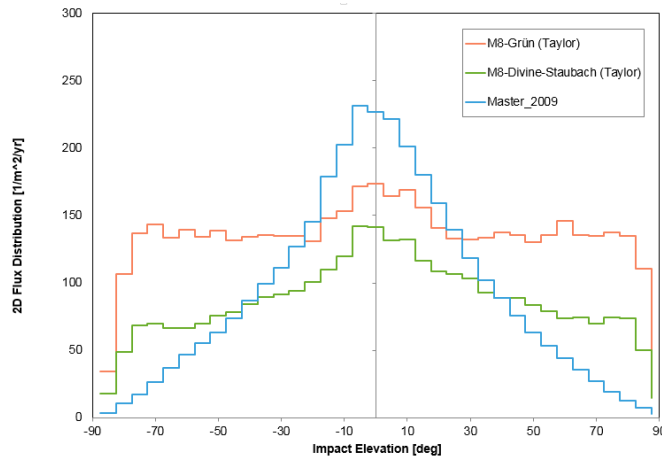
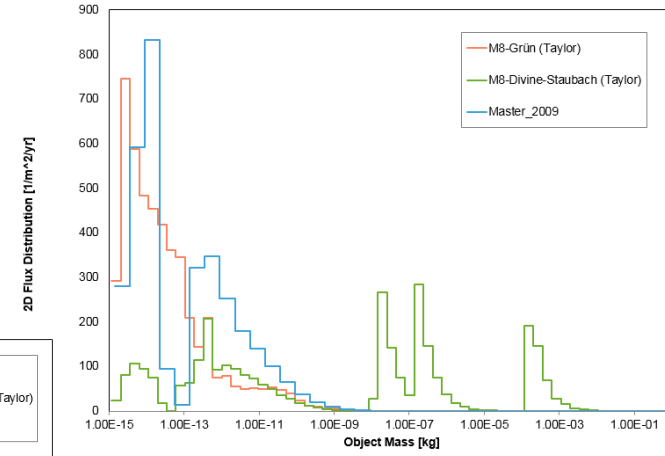
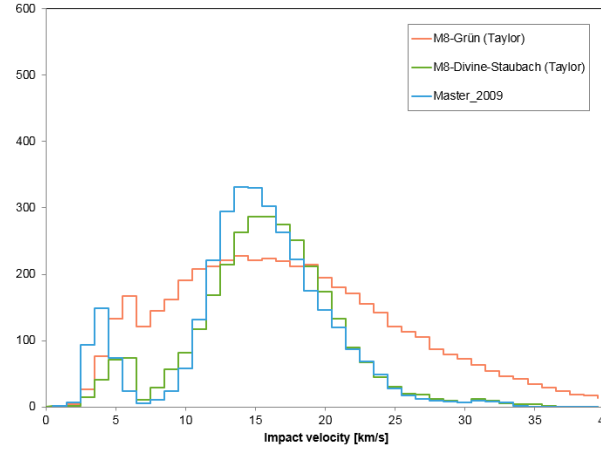
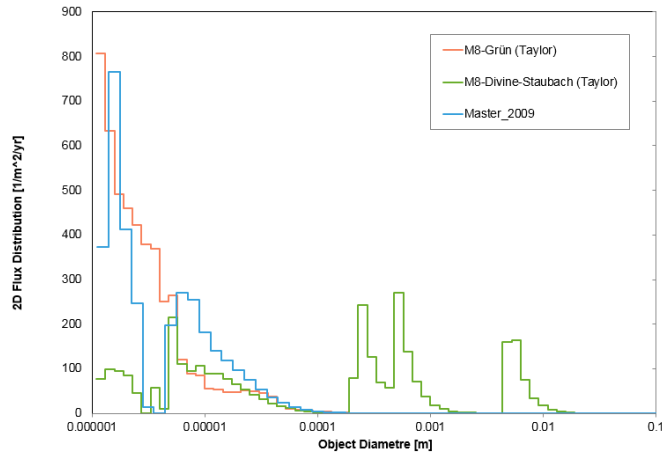
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Impact risk assessment

Risk of failure assessed by using:

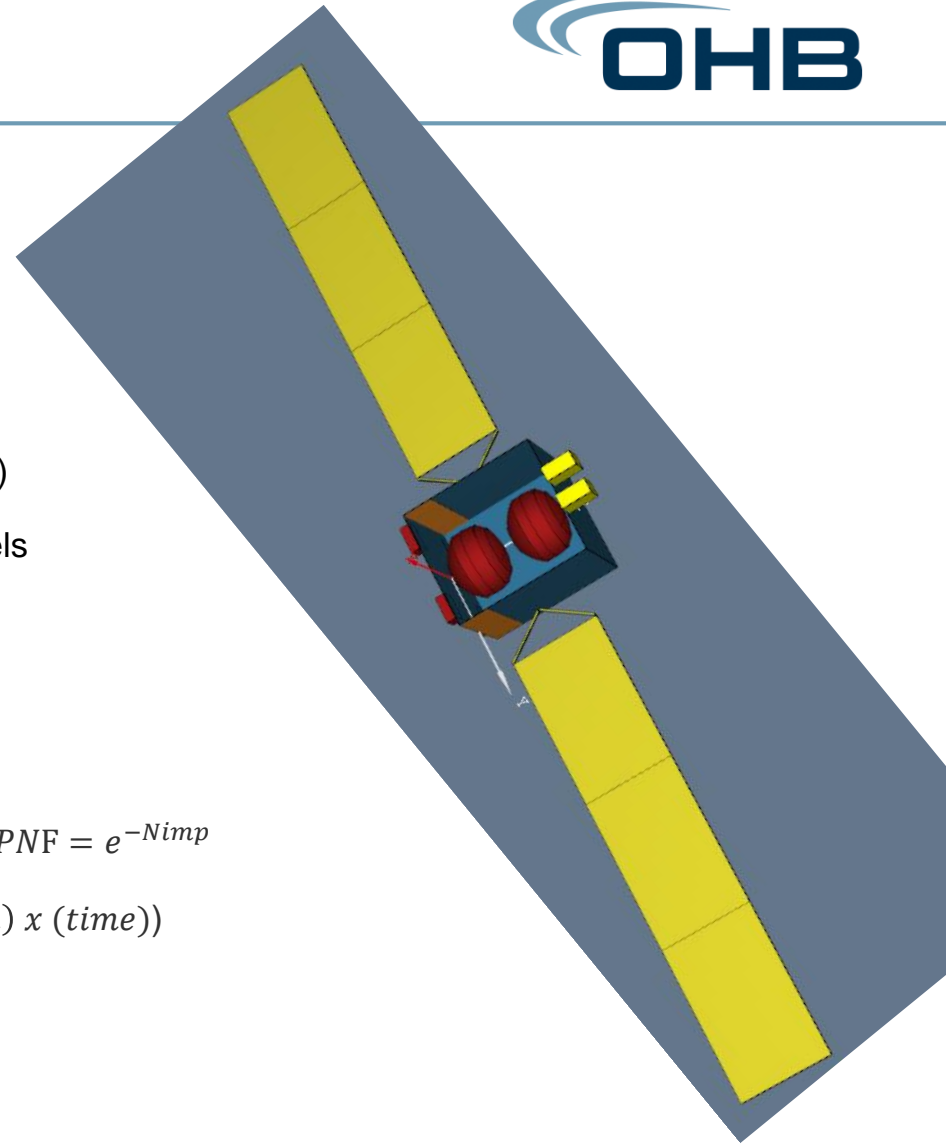
- Spacecraft information (geometry, trajectory...)
- Ballistic limit equations (stablishing the failure criteria)
- Directional collision fluxes derived from MMOD models

Measure of risk : Poisson statistics relations

$$P_{imp} = 1 - e^{-N_{imp}} \rightarrow PNF = e^{-N_{imp}}$$

$$(N_{imp} = (flux) \times (area) \times (time))$$

- Link with MASTER?



Link with MASTER: Stenvi files

- First difficulty: how to define the BIN?

#-----< Definition of the output spectrum >-----

#	Bin	Min	Max	
AZIMUTH	18	-180.0	180.0	Azimuth [deg]
ELEVATION	18	-90.0	90.0	Elevation [deg]
VELOCITY	2	0.5	20.5	Velocity [km/s]
DIAMETER	40	0.1E-04	0.1E+02	Diameter [m]
LATITUDE	1	0.0	360.0	Argument of True Latitude [deg]
DENSITY	200	0.0	5.0	Density [g/cm ³]

- How the link with the “different years scenarios” is performed?
- Stenvi only provides Lower border and Uppers Borders, averaged in time
- Some information are lost afterwards in the simulation (exact distribution according to the particles sizes)

Conclusion: open discussions

Micrometeoroids and Debris assessment

- The **use of MASTER 2009 is recommended** until the MASTER 8 Divine-Staubach model patch is released and a more **exhaustive investigation on the Grün model** has been performed
 - An **exchange with ESA/ESOC** about the MASTER new version investigation was performed
 - The use of Grün model with **Taylor distribution is recommended**
- **Why change of the MM models? Not stable in new MASTER**
- Use of new orbits such as Lagrange Points, exploration... **How reliable is the tool? Limitations?**

Link with Systema: STENVI files, open for discussions

- Some questions remains open: different years scenarios, averaged values, information lost later