OKAPI ORBITS

Making NewSpace Safer
Space Traffic Management

Introduction to the DMF-05 Activity

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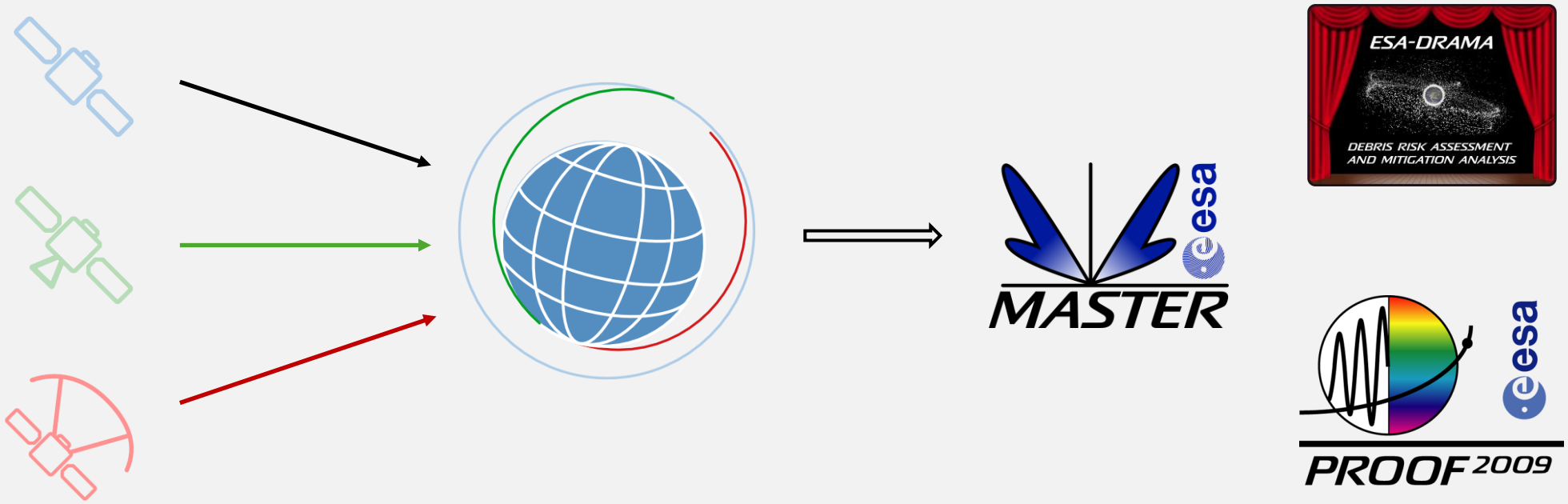
SST for Spacecraft Operations Workshop
May 2024

Debris Mitigation Facility
Rethinking DRAMA

Goal: One software to perform all debris-related mission analyses from a single mission definition.



Satellite | Mission phase(s) | Analyses

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Enabling complex analysis

Or

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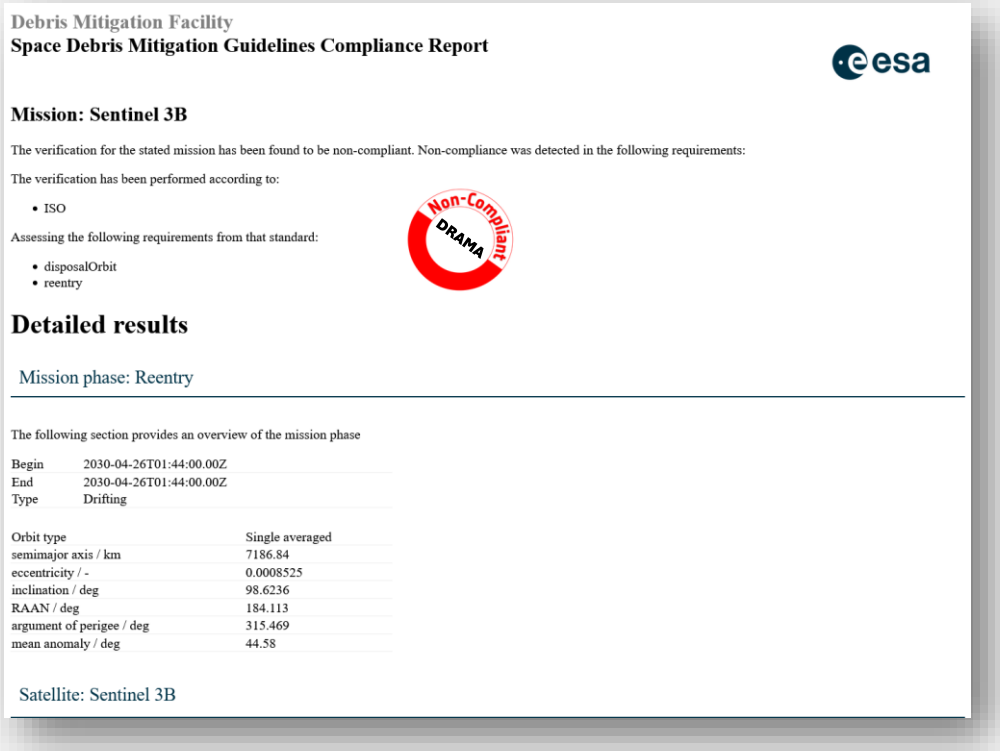
Paradigm shift in analysis setup:

- **Mission-centric** instead of tool-specific definitions in DRAMA, MASTER, and PROOF
- Combined and shared inputs for multiple tools

Interaction between tools established

➢ CROC and CState are called, as part of workflows

Workflows allow to create complex processes:
compliance verification



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Space Debris Mitigation Guidelines Compliance Report

esa

Mission: Sentinel 3B

The verification for the stated mission has been found to be non-compliant. Non-compliance was detected in the following requirements:

The verification has been performed according to:

- ISO

Assessing the following requirements from that standard:

- disposalOrbit
- reentry

Non-Compliant DRAMA

Detailed results

Mission phase: Reentry

The following section provides an overview of the mission phase

Begin	2030-04-26T01:44:00.00Z
End	2030-04-26T01:44:00.00Z
Type	Drifting

Orbit type	Single averaged
semimajor axis / km	7186.84
eccentricity / -	0.0008525
inclination / deg	98.6236
RAAN / deg	184.113
argument of perigee / deg	315.469
mean anomaly / deg	44.58

Satellite: Sentinel 3B

Example of a compliance report

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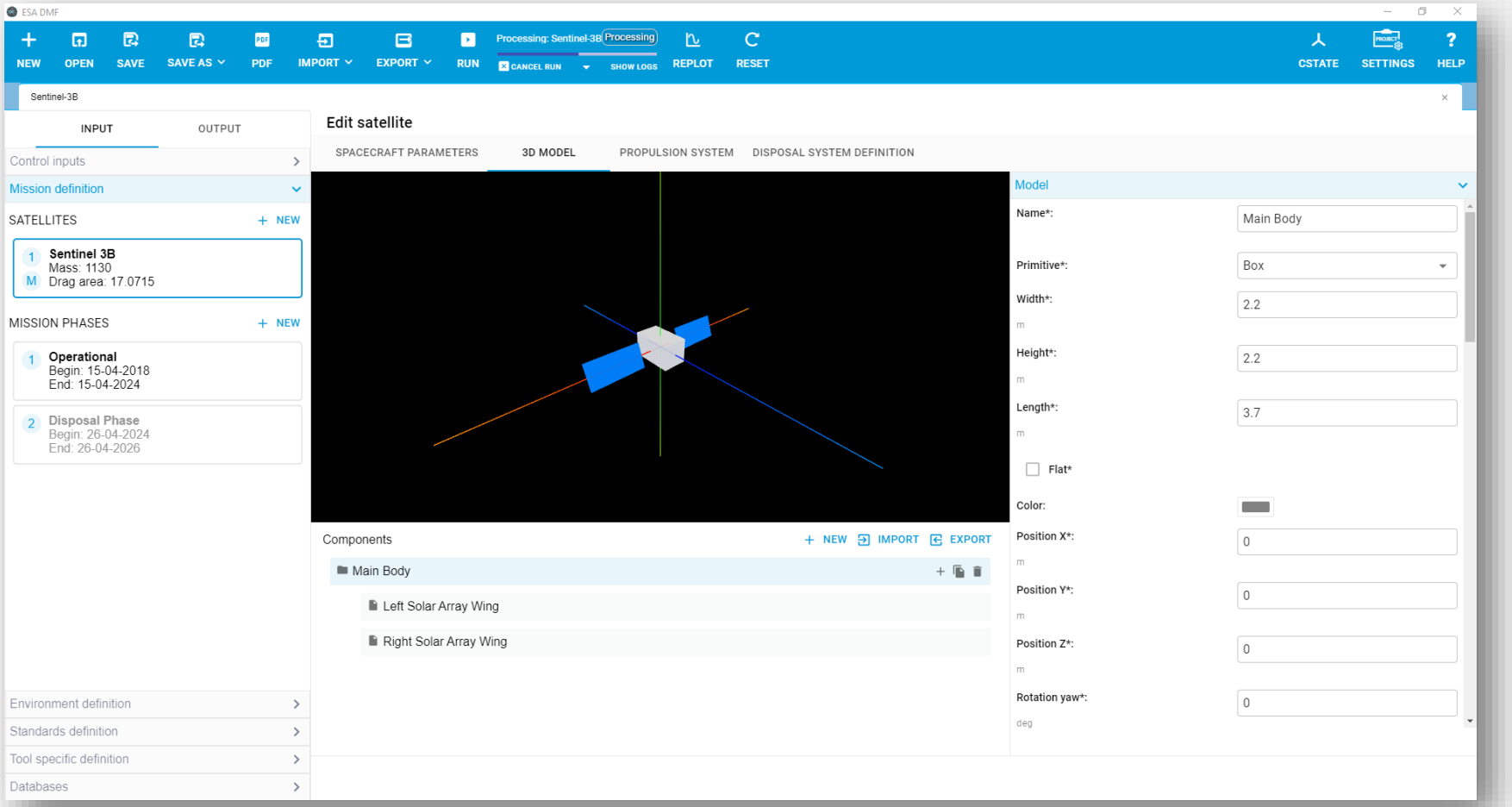
New User Interface



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From Crossing to Tracking

The objective of the activity is to integrate and extend ESA's PROOF capabilities into the DMF framework to support mission designers in the detectability and trackability guideline requirements verification.

- ✓ Preparation of functional integration of ESA's PROOF into the DMF user-interface framework;
- ✓ Extend the functionality of PROOF to assess if and how well one or multiple spacecraft can be catalogued*. Support in mission design in terms of trackability, but also allow calibration of break-up events and provide estimates on catalogue accuracies for DRAMA's ARES module;
- ✓ Extension of the detection model to account for complex spacecraft models.

Debris Mitigation Facility New Use Cases in DMF-05

Four main use cases:

1. Object trackability analysis,
2. Population trackability analysis,
3. Ares preset generation,
4. Light pollution analysis.

Use case ID	UC-01
Summary	A user wants to determine the trackability of the designed space object
Users	**Sensor operator**; space mission designer

Use case ID	UC-02
Summary	A user wants to determine the trackability of a population of objects orbiting Earth
Users	**Sensor operator**

Use case ID	UC-03
Summary	A user wants to create a new space surveillance network pre-set
Users	**Sensor operator**, space mission designer

Use case ID	UC-04
Summary	Assess the visible magnitude of a given space mission
Users	Space Mission Designer

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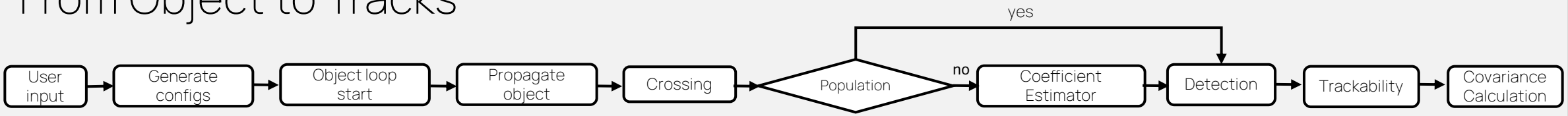
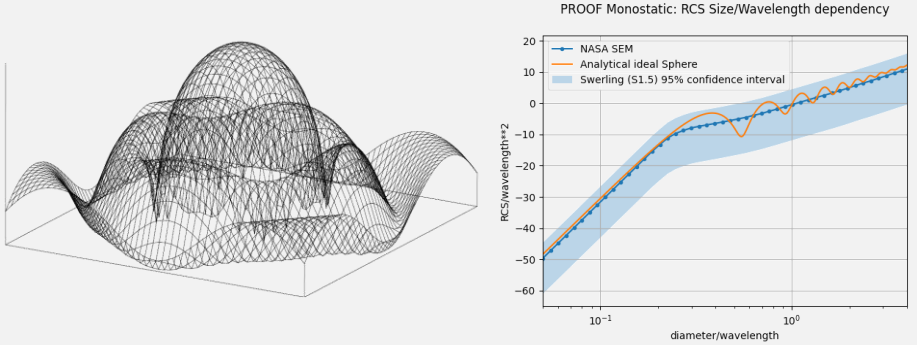
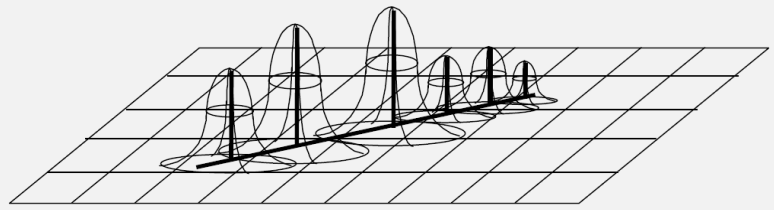
From Object to Tracks



- Definition of object orbit and properties
- Definition of sensor network
- Complex radar, optical and laser performance models are used to determine detectability
- Detections are grouped into tracklets and used to calculate a covariance using orbit determination algorithms.
- An initial covariance is propagated for a user-specified duration using consider parameters that account for drag and SRP uncertainty.
- Statistics are also calculated:
  - Percentage of total observations and crossings for each object in population run modes.



Radar performance model: 2-way radiation pattern



Optical performance model: Object's signal over pixel

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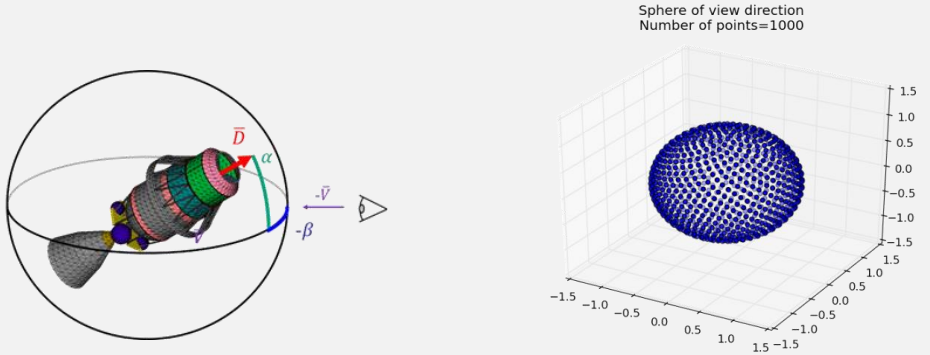
Properties and detection databases

Coefficient Estimator

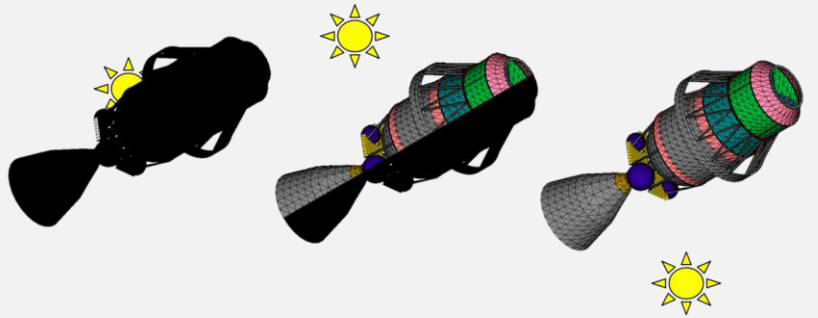
The main purpose of the detection database is to pre-compute illumination, radar, and reflector visibility and store them as detection coefficients for several view angles.

The goal is a simple interface to get attitude dependent detection properties for complex geometries in DMF:

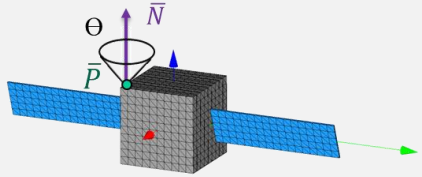
- Radar equivalent area database
- Surface visibility (optical) and its reflection properties (diffuse and specular) database
- Retro-reflector database



Discretization of complex model and mapping in sphere coordinate system



Simulation of expected illumination conditions on trajectory



Placement of retro-reflector position on complex 3D model

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Properties and detection databases

- The ARES run mode requires additional processing of the propagated covariance.
- For the radial, tangential, and normal components of the covariance matrix, a polynomial fitting takes place.
- Coefficients of the polynomials are determined using curve fit functionality.

$$\sigma_j = c_j \cdot 10^{a_j \cdot \Delta t}, j \, \epsilon \, (U, W)$$

$$\sigma_V = c_V \cdot (b_V + \Delta t)^{a_V}$$

Functions for the radial (U), along-track (V) and normal (W) uncertainties, ARES technical note.

Thanks for your attention!