

Appendix H

SYSTEMA-THERMICA Demonstration Part 1

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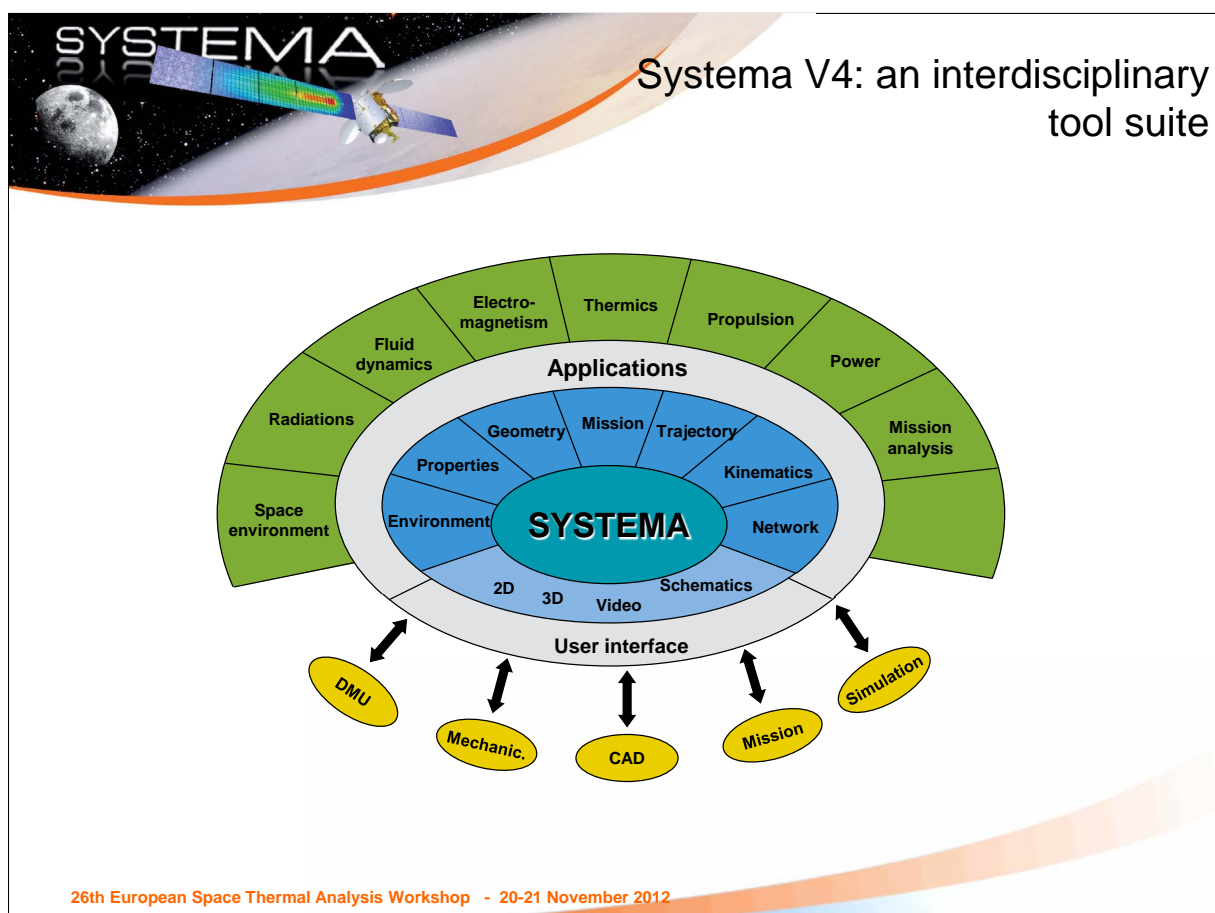
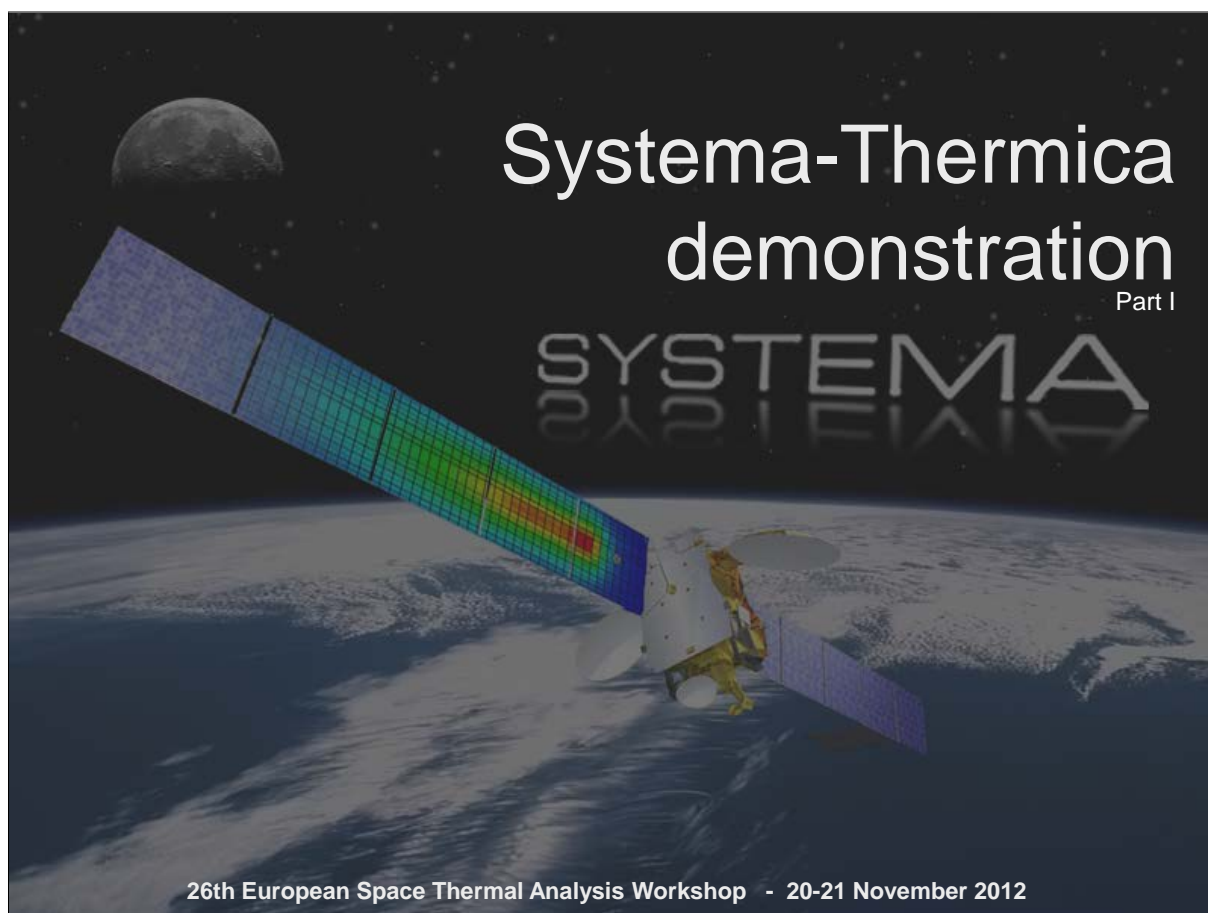
Abstract

The SYSTEMA v4 project started in the mid 2000's and has successfully achieved its first goal: propose a new multi-physics software suite beyond on the v3 capabilities, in which new developments and evolutions becomes possible. Since the 2010's many new features and optimizations have been added and others are currently in development so to ease the process of thermal simulations from early phases to CDR, chamber test and in-orbit correlations.

Each year, the newly developed functionalities have been presented. This year's presentation is dedicated to an end-to-end use case covering the entire process from geometrical pre-processing to results post-processing, showing how the new SYSTEMA functionalities can ease thermal engineers work.

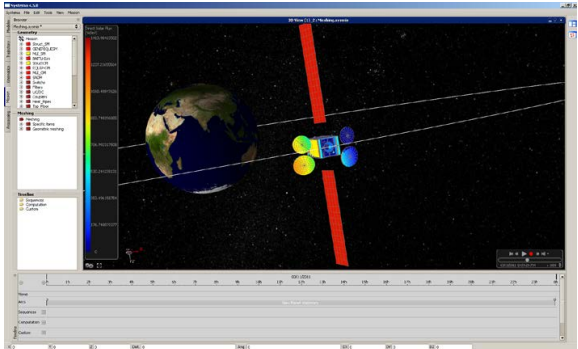
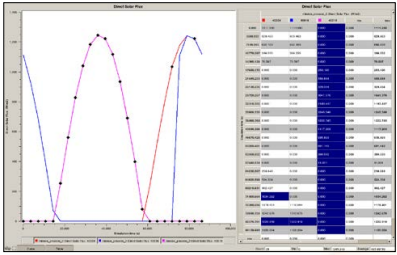
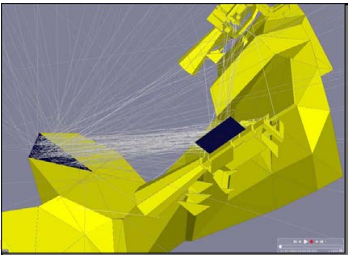
In particular, this first part covers:

- Geometry Management and Pre-processing
 - CAD geometry insertion and management
 - Import of Nastran model
 - Execution of Python script
 - Reverse orientation of multi-selection
 - Interactive geometry transformations
- Mission Settings and Management
 - Real Solar system management
 - Import of custom trajectories
 - Kinematics tree creation
 - Import of custom transformations
 - Mission's time-line and events management

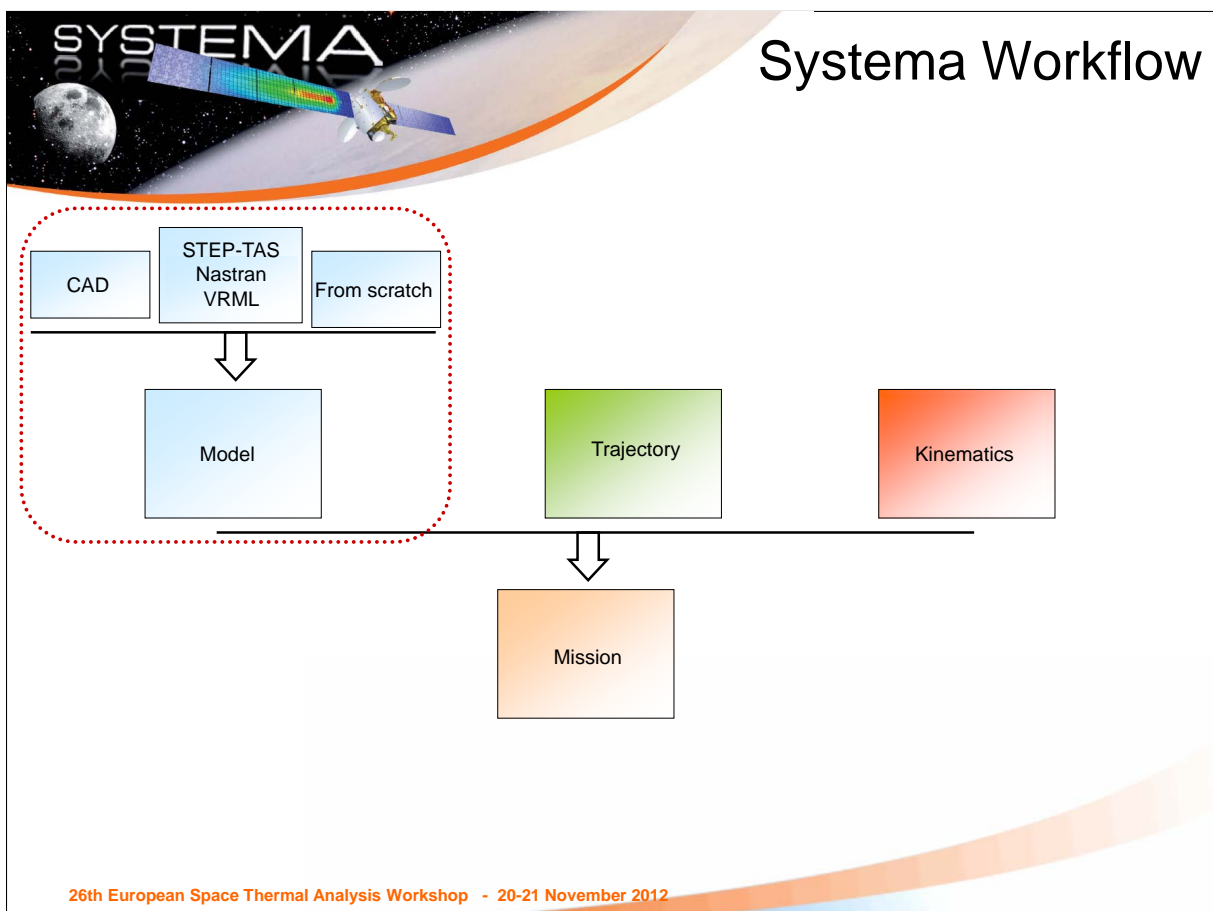


Systema v4.5.1 – current status

- Python scripting
- Timeline is available in both the Trajectory & Mission module
- Curve & table view for post-processing
- Ray display

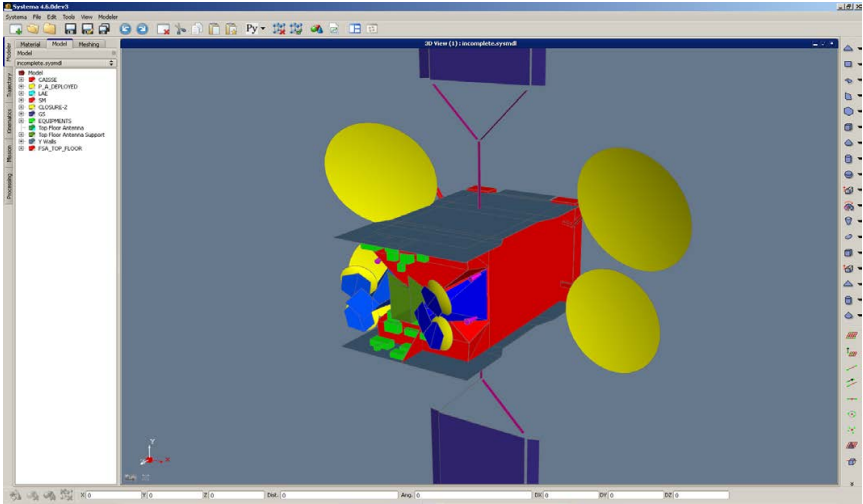
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SYSTEMA

Demonstration

- Loading of the reference model



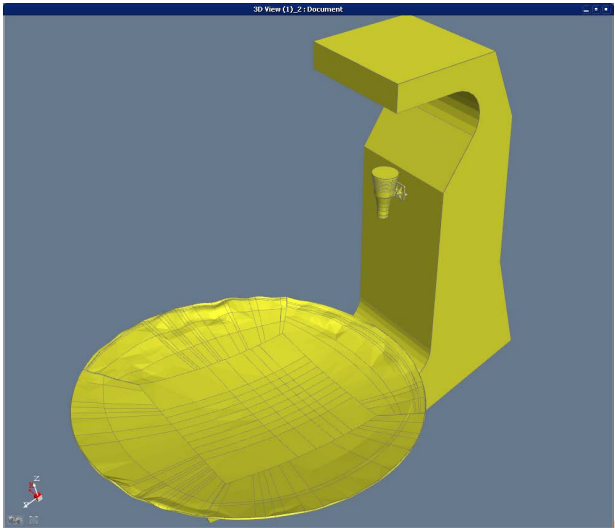
- We will work on a typical Telecom satellite

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SYSTEMA

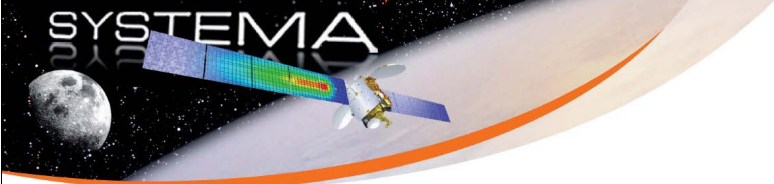
STEP-AP203

- Systema manages STEP files in import

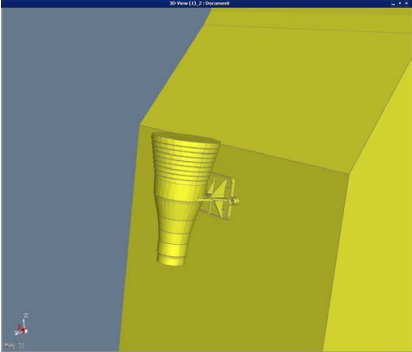
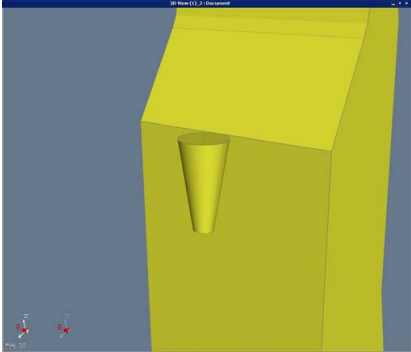


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STEP-AP203



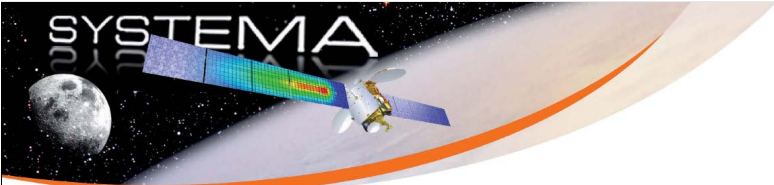
- Simplifications can be done directly in the framework


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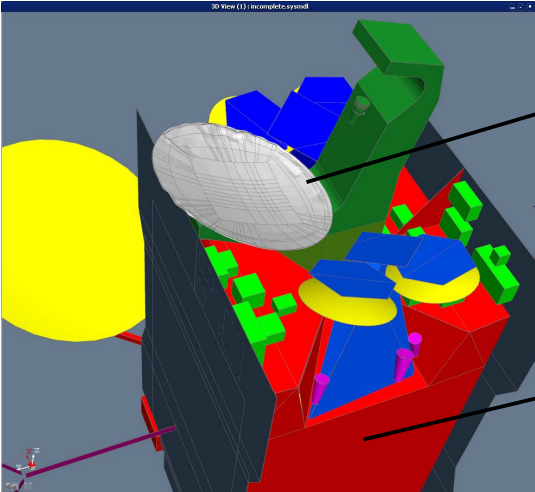
- Computation can be made directly on the STEP
- Or the STEP can be converted into Systema's model

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STEP-AP203



- Mixing of models from different sources



Imported from CAD

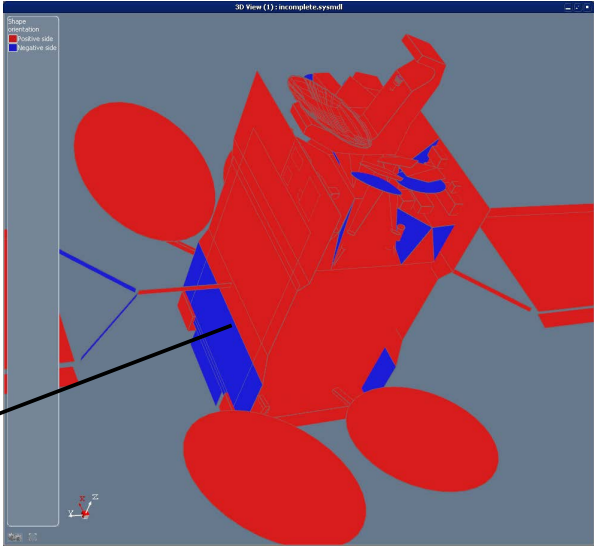
Systema's native shapes

- Adaptation using transformations

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Model checking

- Shape orientations are easy to check out and modify using the 3D



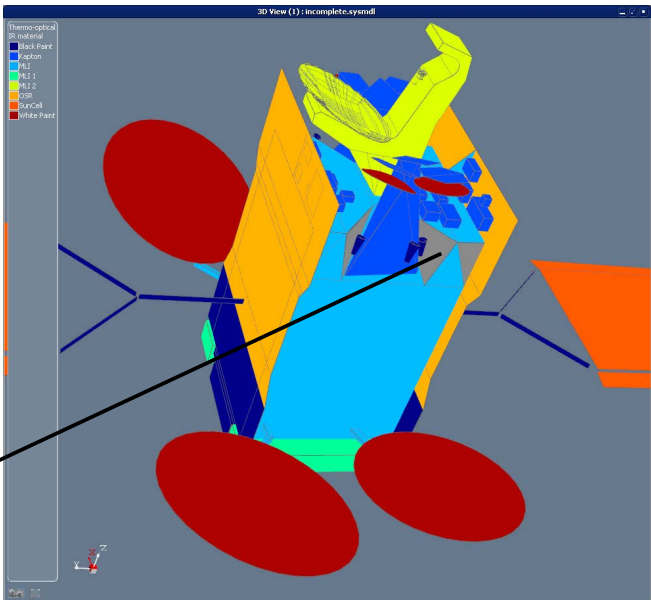
Shape orientation discrepancies

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The image shows a 3D model of a satellite in a software window titled '3D View (1): incomplete.sysmell'. The satellite has several large red surfaces and some blue surfaces. A legend on the left indicates 'Shape orientation' with 'Positive side' in red and 'Negative side' in blue. A black arrow points to a blue surface, with the text 'Shape orientation discrepancies' next to it.

Model checking

- As shape orientations, the different materials can be displayed
 - Materials & physical properties can be set in the browser view

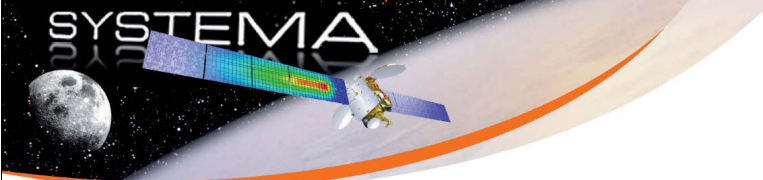


No material is defined

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The image shows a 3D model of a satellite in a software window titled '3D View (1): incomplete.sysmell'. The satellite has various colored surfaces: red, blue, yellow, orange, and green. A legend on the left lists materials: 'Thermo-optical', 'Black Part', 'Vacuum', 'AL1', 'AL2', 'AL3', 'AL4', 'AL5', 'AL6', 'AL7', 'AL8', 'AL9', 'AL10', 'AL11', 'AL12', 'AL13', 'AL14', 'AL15', 'AL16', 'AL17', 'AL18', 'AL19', 'AL20', 'AL21', 'AL22', 'AL23', 'AL24', 'AL25', 'AL26', 'AL27', 'AL28', 'AL29', 'AL30', 'AL31', 'AL32', 'AL33', 'AL34', 'AL35', 'AL36', 'AL37', 'AL38', 'AL39', 'AL40', 'AL41', 'AL42', 'AL43', 'AL44', 'AL45', 'AL46', 'AL47', 'AL48', 'AL49', 'AL50', 'AL51', 'AL52', 'AL53', 'AL54', 'AL55', 'AL56', 'AL57', 'AL58', 'AL59', 'AL60', 'AL61', 'AL62', 'AL63', 'AL64', 'AL65', 'AL66', 'AL67', 'AL68', 'AL69', 'AL70', 'AL71', 'AL72', 'AL73', 'AL74', 'AL75', 'AL76', 'AL77', 'AL78', 'AL79', 'AL80', 'AL81', 'AL82', 'AL83', 'AL84', 'AL85', 'AL86', 'AL87', 'AL88', 'AL89', 'AL90', 'AL91', 'AL92', 'AL93', 'AL94', 'AL95', 'AL96', 'AL97', 'AL98', 'AL99', 'AL100'. A black arrow points to a blue surface, with the text 'No material is defined' next to it.

Model checking



- Complex checking using Python
- I want to verify that my node numbering is within my specifications

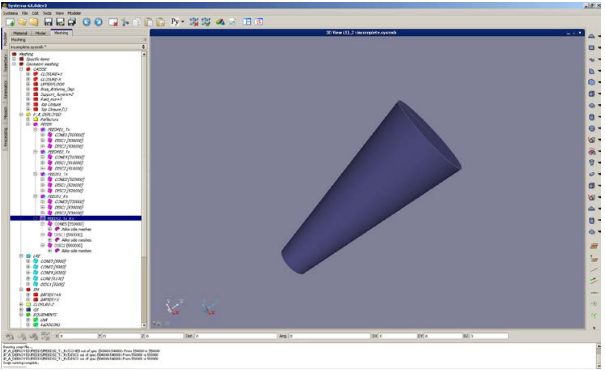
Text file

GS: [7500-8800]
 Reflectors: [5000-5700]
 Feeds: [500000-540000]

```

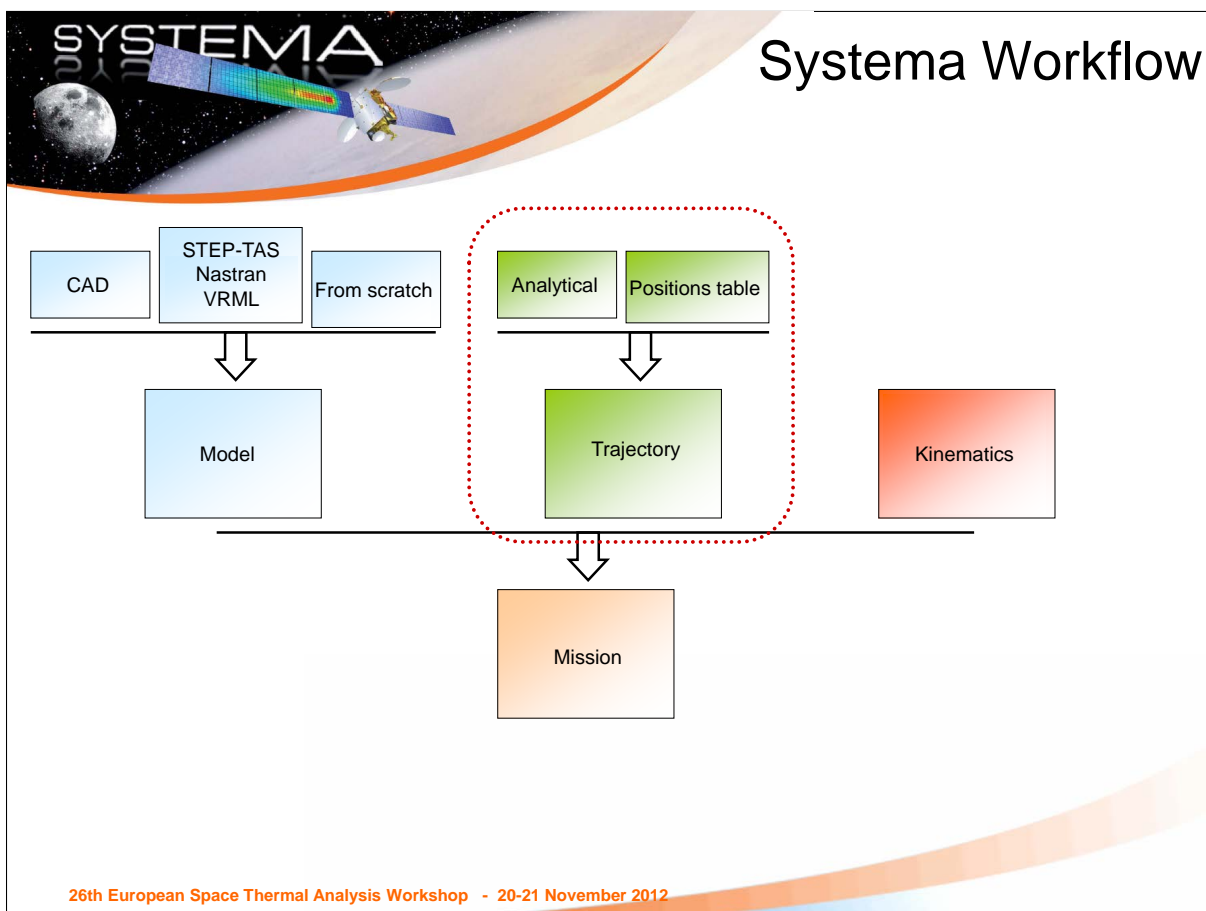
1 # Import modules
2 import sys
3 import os
4 import re
5 import math
6 import numpy as np
7
8 # Define the geometry
9 def define_geometry():
10     # Create a list of nodes
11     nodes = []
12     # Add nodes to the list
13     for i in range(1, 1000000):
14         nodes.append(i)
15     return nodes
16
17 # Main function
18 def main():
19     # Define the geometry
20     nodes = define_geometry()
21     # Print the number of nodes
22     print(len(nodes))
23
24 # Call the main function
25 if __name__ == '__main__':
26     main()
      
```

→



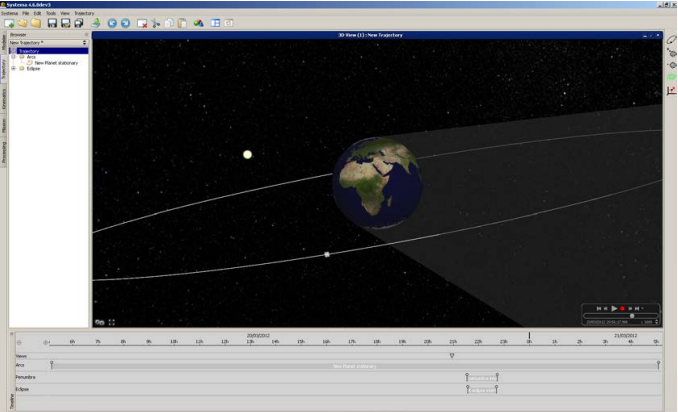
Returns and displays the out-of-spec meshes

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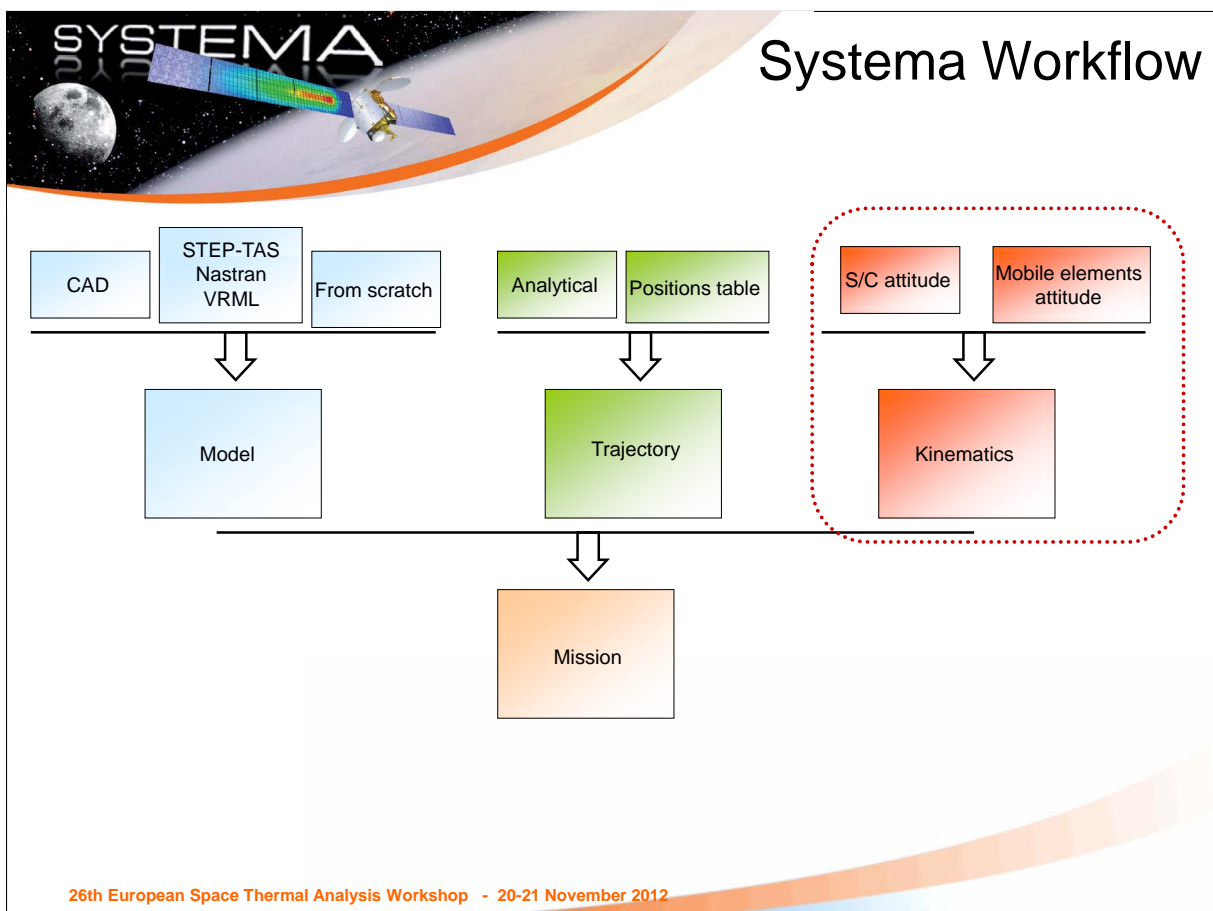


Trajectory

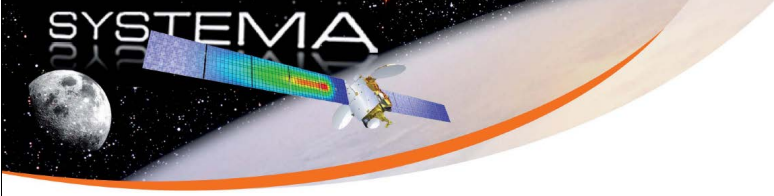
- Systema allows the user to easily define its trajectory
- Sun-synchronous, geo-stationary & general keplerians orbits are available
- Display of eclipses



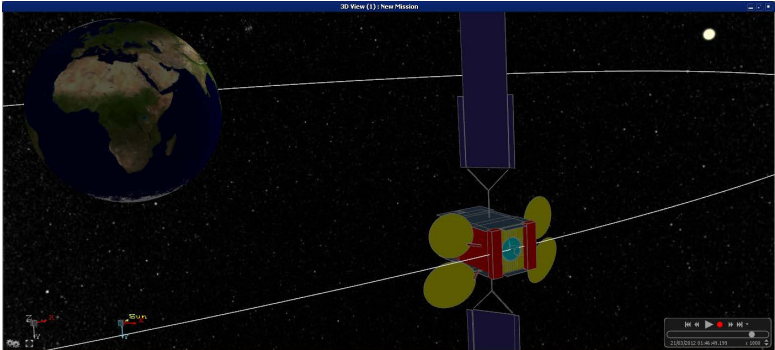
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Kinematics



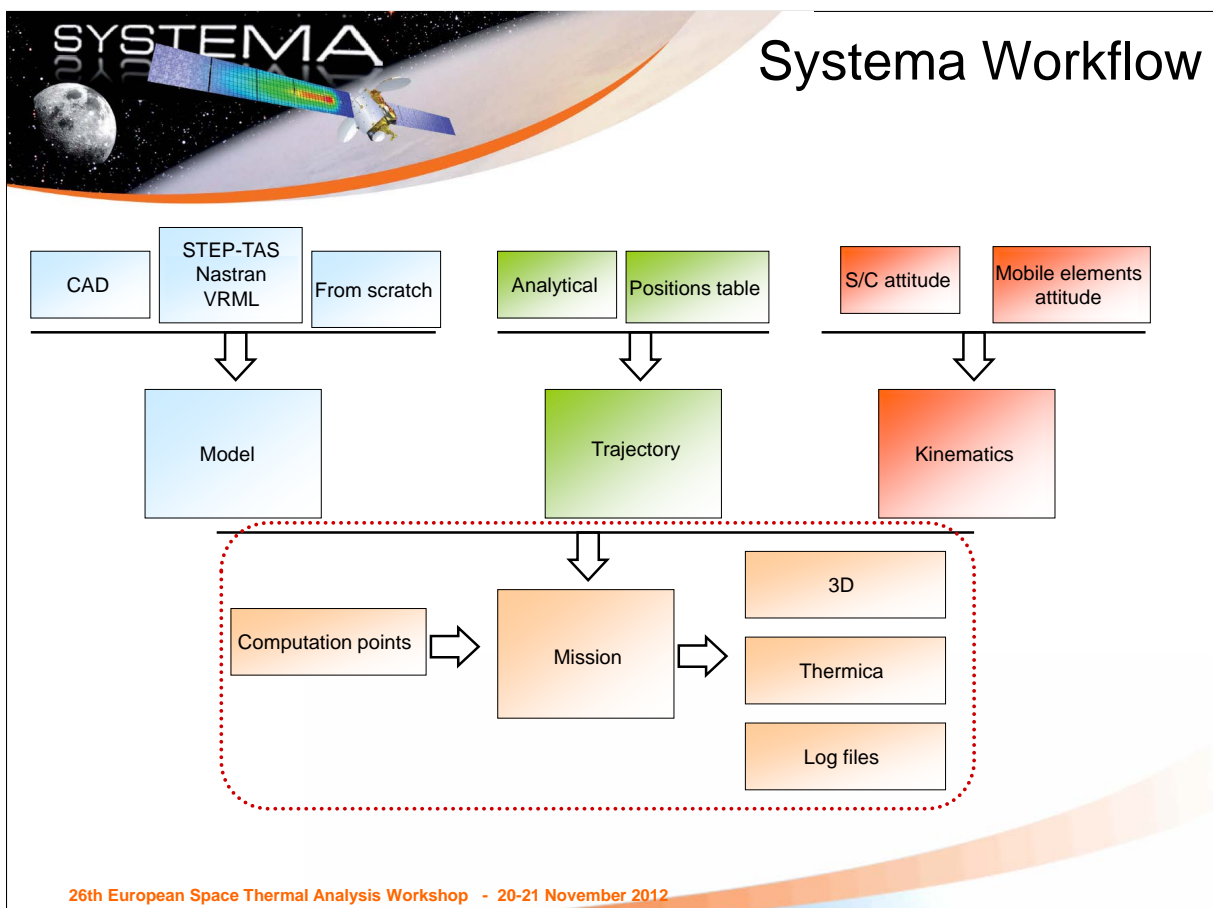
- Definition of the S/C attitude
- Definition of the orientation of the GS



Correct orientation of the S/C and its solar arrays

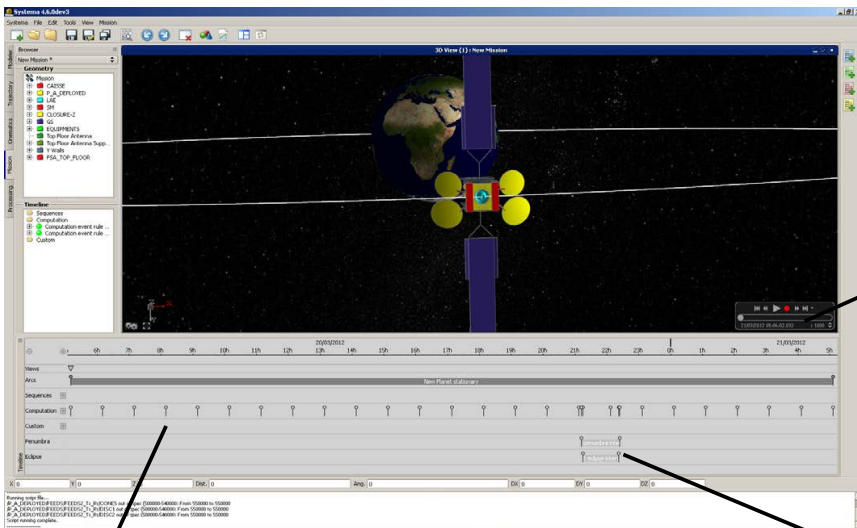
- Pointing laws to planets, sun, velocity vector ; linear rotations ; attitudes defined by tabulated data are available

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Mission

- The mission scenario can be set up within seconds



Real-time visualization

Computation points

Eclipse interval

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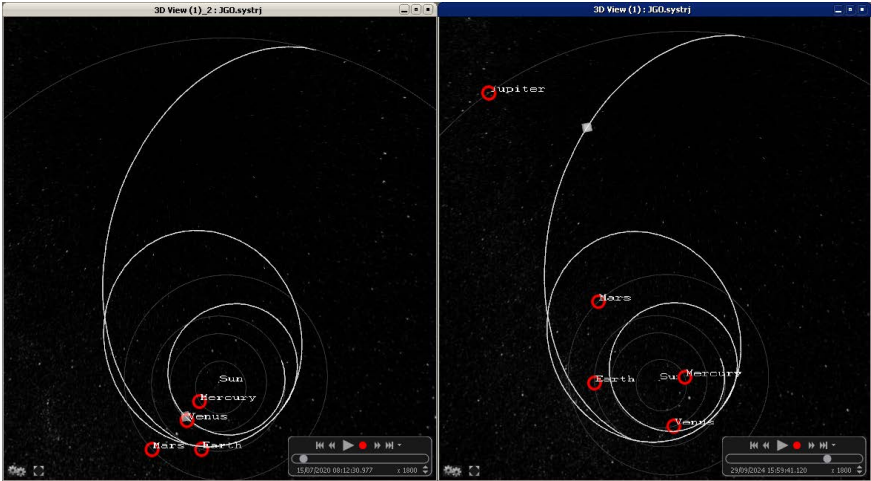
Systema Framework... In a nutshell

- Easy interfacing
 - With CAD
 - With NASTRAN
 - With AOCS tools
 - Using Python
- Gives integral access to the data
 - In 3D
 - With the time line
 - Using Python
 - As textual information
- A powerful mission creation
 - Can be created with a snap of the fingers
 - Complete trajectory & kinematics management

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Additional slide Trajectory

- For complex trajectories, possibility to use tabulated data
- Full & real-size solar system

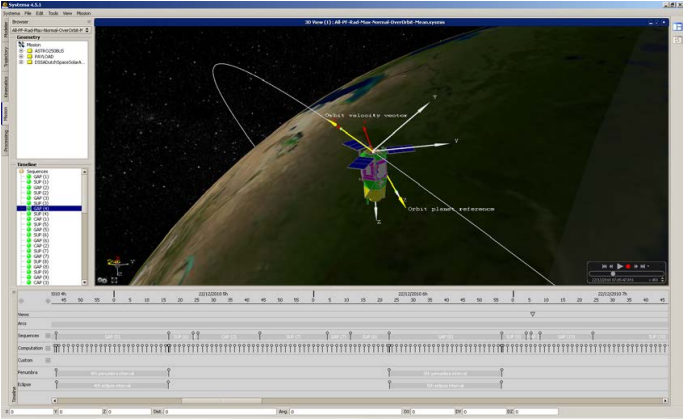


Jupiter Ganymede Orbiter example trajectory – Venus flyby (left) – Jupiter approach (right)

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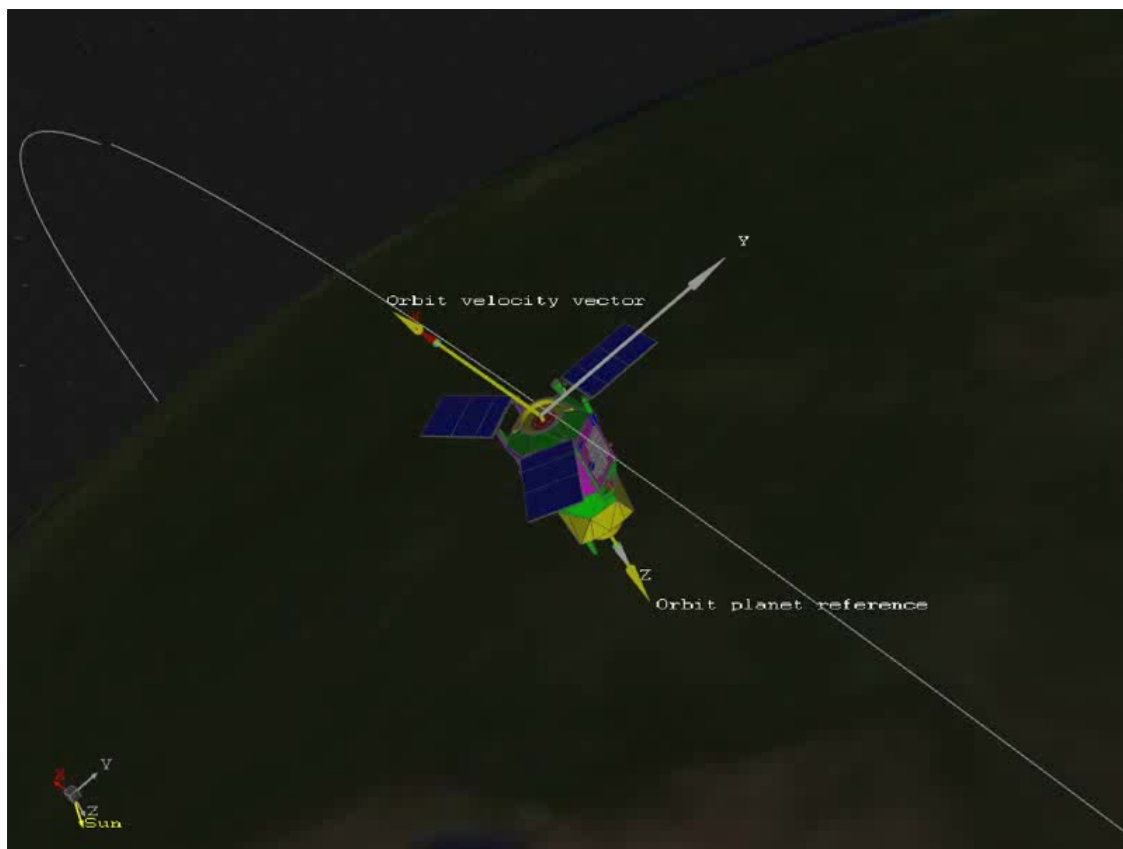
Additional slide Sequences

- To create complex mission plan
- Typically, for an EO satellite
 - Acquisition period
 - Charging (Solar arrays pointing the Sun)
 - Waiting (Earth pointing)



[Cf video](#)

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Slow

Normal

Fast

Play/Pause

Stop



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 maxime.joliet@astrium.eads.net
 anne.millet@astrium.eads.net



THERMISOL - Applications

THERMISOL has been used, validated and optimized on many projects. Thanks to 5 years of intense use in Astrium, convergence optimizations were finely tuned. Here are examples of the THERMISOL special features.

Automatic time-step adjustment

SCRANKAUTO provides an automatic time-step based on minimum and maximum error specifications

ERRMIN = 0.01; ERRMAX = 0.01;

The new solution is plotted in the following graph :



Automatic time-step adjustment

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