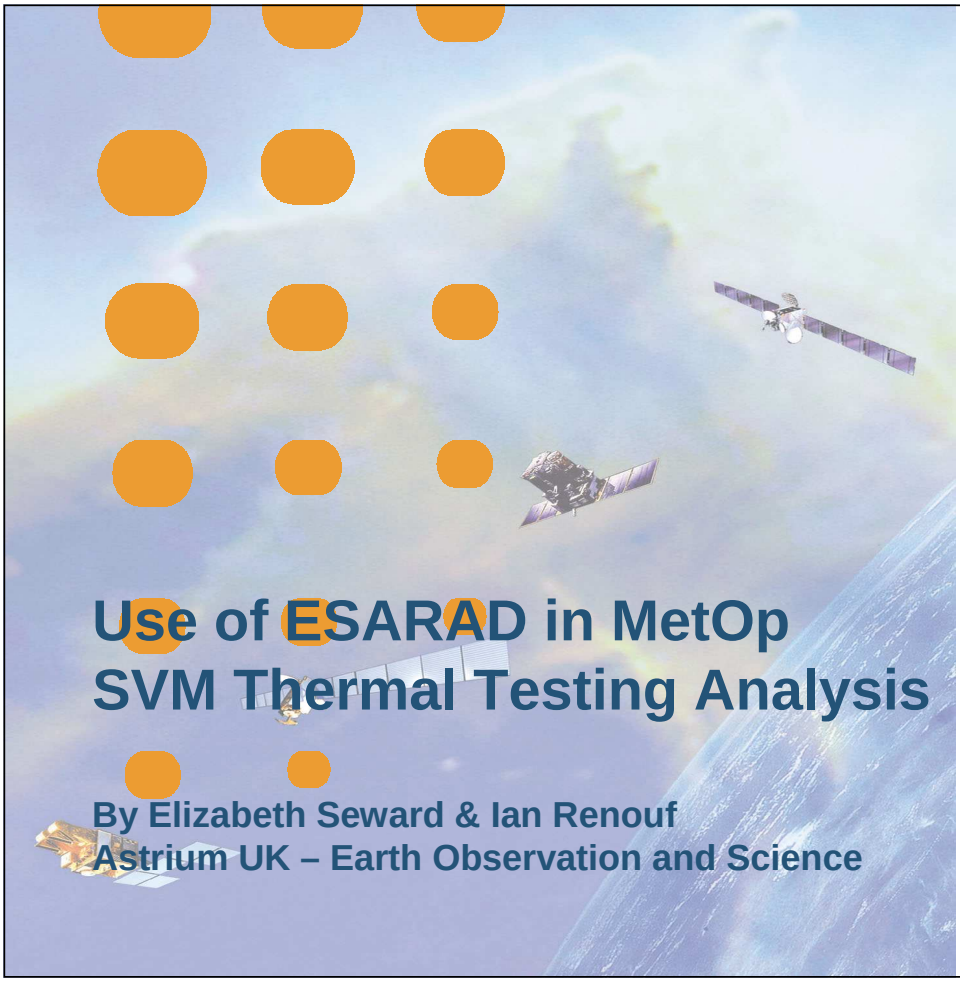


Use of ESARAD in MetOp SVM Thermal Testing Analysis

By Elizabeth Seward & Ian Renouf
Astrium UK – Earth Observation and Science

astrium

an EADS joint Company with BAE SYSTEMS

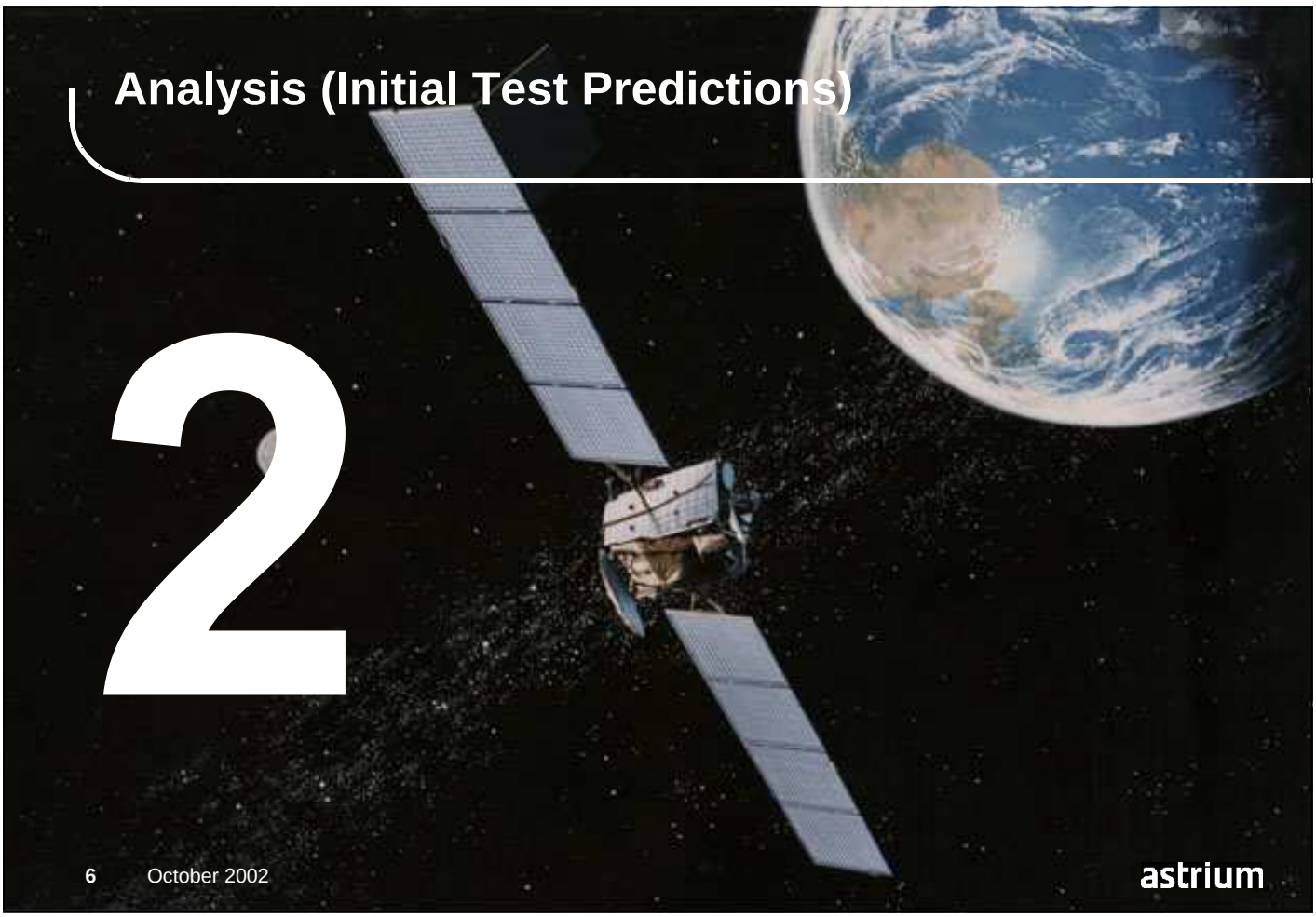
Summary

Objectives of Analysis

- Simulate the MetOp service module during TB/TV testing
- Use this model to define test specific hardware and test procedures
- Use the results of test to modify the model so that the results of the test correlate with the results of the analysis
- Transfer this correlated model to the flight analysis model and calculate final flight predictions

Initial Resources/Models

- Detailed model of MetOp SVM in ESARAD v3.2.7 in flight configuration
- Simple model of SIMLES chamber at INTESPACE in SYSTEMA
- Copy of ESARAD v3.2.7 running on HP Unix operating system



Analysis (Initial Test Predictions)

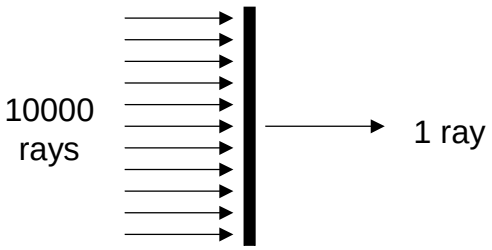
2

Initial ESARAD Test Model

- Strip down flight model to a test configuration
- Convert SIMLES model into ESARAD
- Put models together to create test model
- Add models to represent the test adaptors and simulators.

Problems (1): Transmissive Surfaces

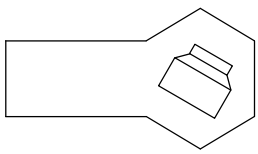
Effect of transmissive surface in Monte-Carlo raytracing solution



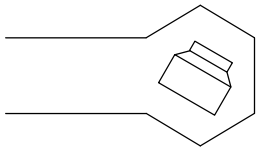
Result: Highly inaccurate solar flux results for model

Problem

Use 2 models



Model to calculate radiative couplings 'With Mirror'



Model to calculate solar fluxes 'No Mirror'

Solution

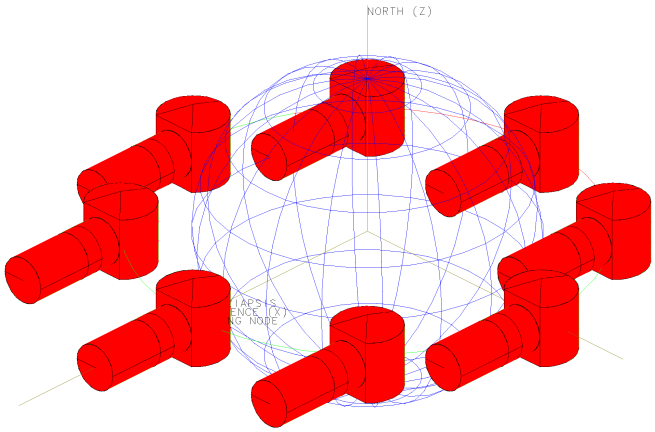
Problems (2): Transient Simulation

Problem:

- How to simulate the rotation of the spacecraft for the transient test phases

Solution:

- Assemble the SVM and SIMLES with the SVM as the moving body and orientated towards the Planet
- Put the model in a sun oriented orbit with the chamber mirror pointed towards the Sun
- Set the orbit parameters so that the orbit is equatorial, with a time period equal to the rotation period of the satellite in the test chamber



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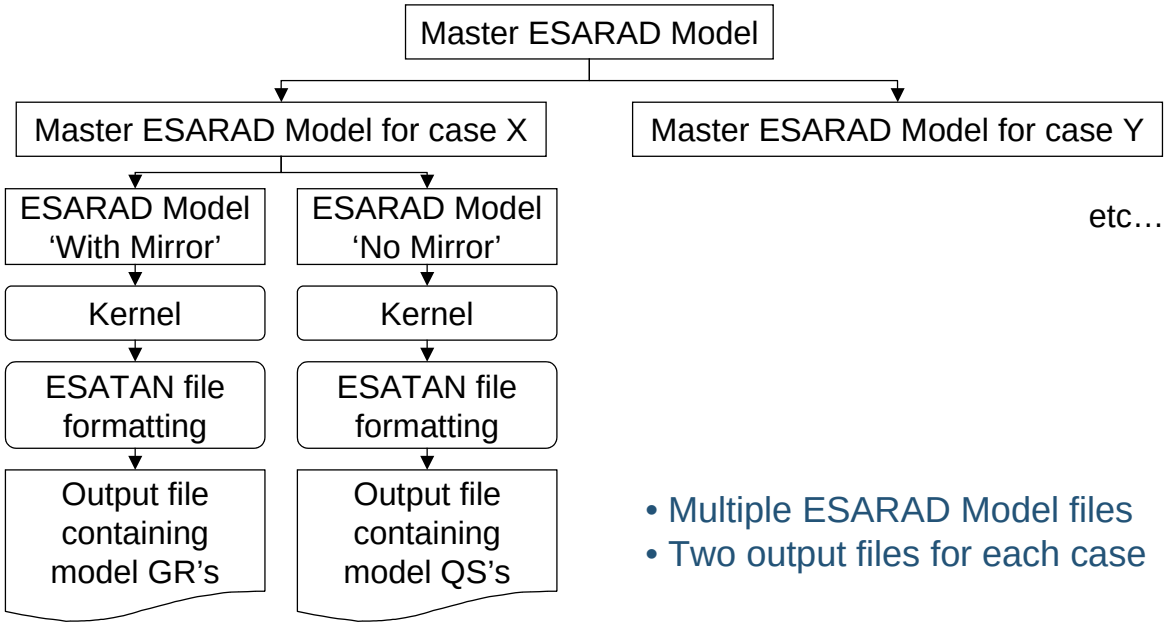
Final Model Structure



- Multiple ESARAD Model files
- Two output files for each case

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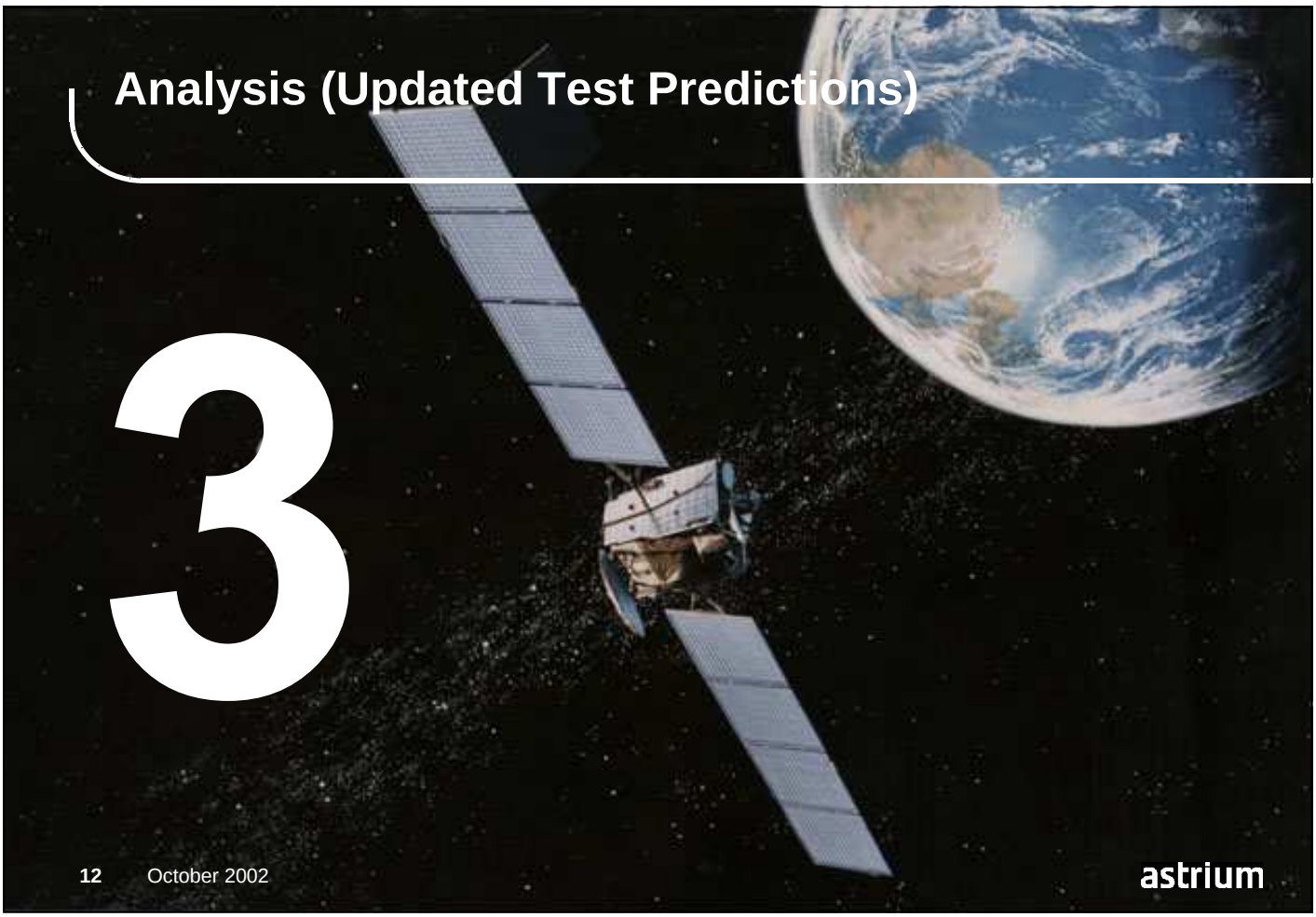
Update to ESARAD v4.2.10

Upon the release of ESARAD v4.2.10 the model was modified to work in the new version. The following actions were performed

- The geometry modified to work fully compliant with the new version
- The Kernel was updated and run in the new version
- The ESATAN file formatting was updated and run in the new version
- The output from the ESARAD v4.2.10 was checked and verified against the results from v3.2.7



Analysis (Updated Test Predictions)

3

Update Model to Final Test Specification

- 12 months later the model needed updating due to changes to the test specification, and to prepare to perform test correlation
- v4.3.2 of ESARAD now in use

Upon running the ESARAD files it is discovered that they no longer produce an output for radiative couplings and solar flux

An investigation is launched to uncover the problem.

Simultaneous a review of the procedure for running the model is performed to see if a more efficient solution exists

Update ESARAD Kernel File

- A review of the Kernel file shows that it is a v3 kernel for a standard orbital analysis that has been modified to work in v4.
- The Kernel file is seen to contain code that adds no value to the model or performs unnecessary tasks that slow down the analysis and could be at fault for the problem
- Kernel file is rewritten to specifically to run the test analysis with all unnecessary code removed

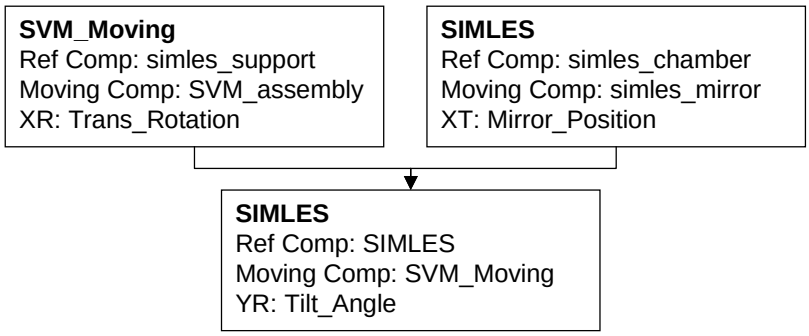
Conclusion:
Model still does not work but model will run in half the time when the problem is found

Implementation of multiple ‘ASSEMBLY’ commands

- **Techniques learnt from other programs shows that multiple ‘ASSEMBLY’ commands can be stringed together to provide a model with multiple degrees of freedom that can be controlled by user defined code in the Kernel**

New Top Level Model Structure

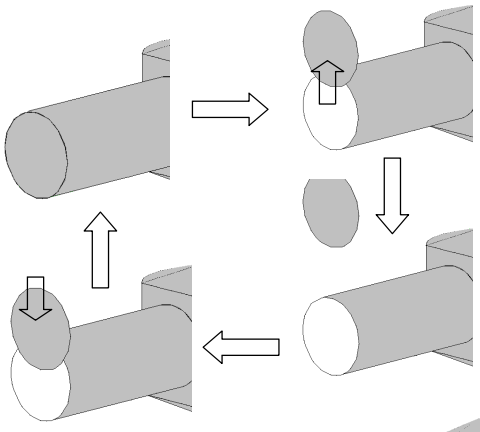
Where:
Trans_rotation, Mirror_Position & Tilt_Angle are REAL variables



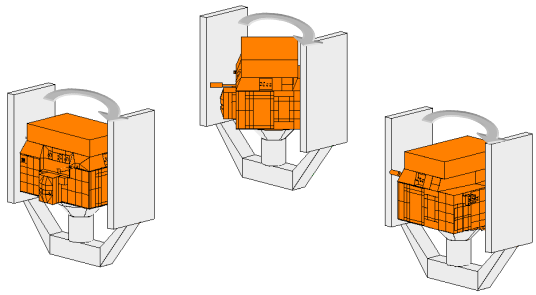
Conclusion:
The model now generates results. The problem appeared to lie with the planet orientation of the SVM

Visualisation of ‘ASSEMBLY’ actuations

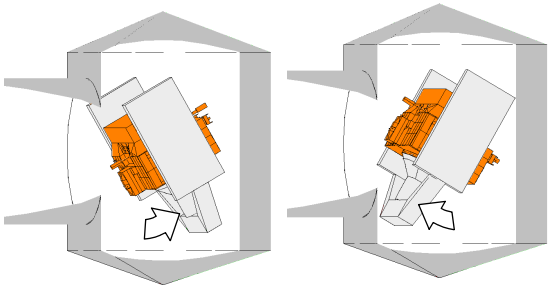
SIMLES Assembly



SVM Moving



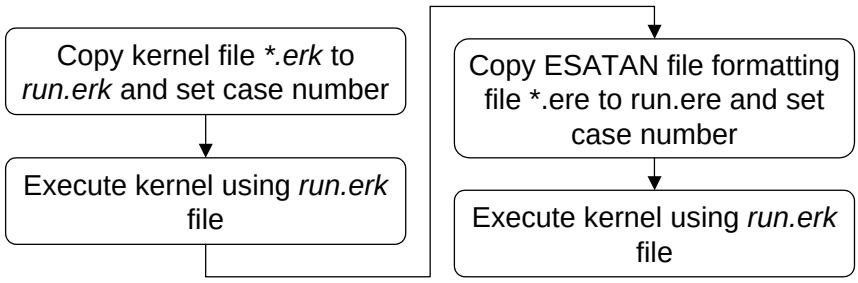
SIMLES



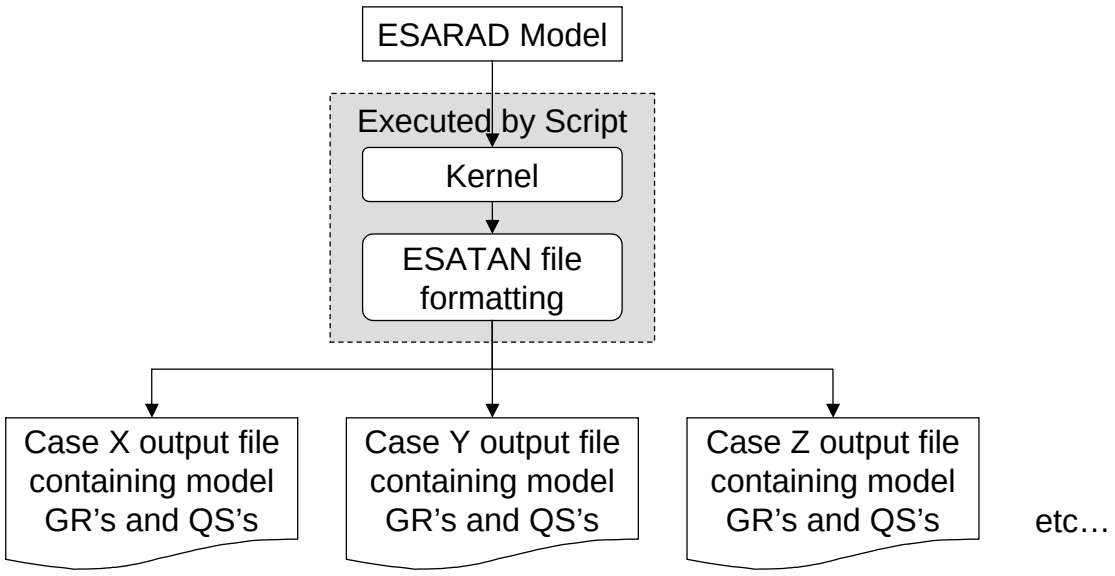
Addition of Script to Run Analysis Cases

- **Astrium UK defines its ESARAD kernels for multiple cases in a single file, switches are embedded in the file to run the parameters desired for each case.**
- **Experience of UNIX has shown that short script files can be used to run models. Implementation of a script allows any case or combination of cases can be set to run sequentially very quickly (and accurately).**
- **By combining these 2 techniques together we now have a system that runs as many ESARAD cases for a model as we like, whilst using and producing the minimum number of files and data.**

Script file logic



New Final Model Structure



- Simple model structure
- One output file for each case

Verification: Checking Steady State Fluxes

- The fluxes from the v4.3.2 run were compared to the values from v4.2

Case 1.1
Hot Fixed

Nodes	Original	V4.3.2	Difference	Percentage Difference
11171	20.926	20.649	-0.2779	1.33%
11401	2.279	2.274	-0.0056	0.25%
11412	3.207	3.215	0.0079	0.25%
11415	5.356	5.360	0.0042	0.08%
11452	3.564	3.559	-0.0050	0.14%
11455	7.685	7.675	-0.0096	0.13%
13312	28.142	28.142	-0.0005	0.00%
13314	11.847	11.798	-0.0486	0.41%

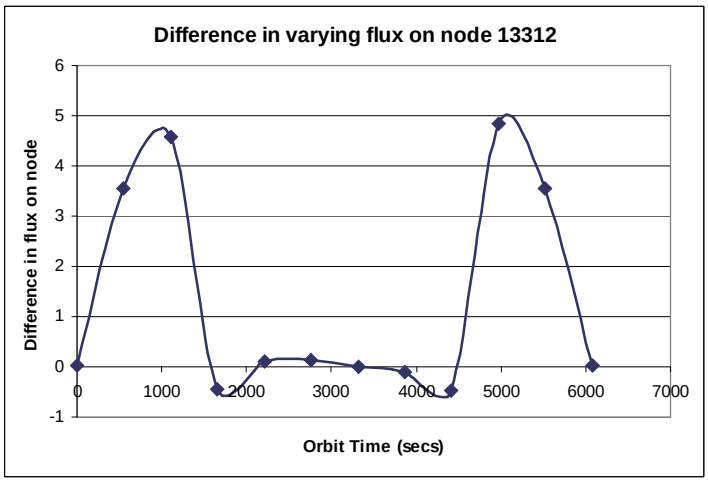
- The comparison was repeated for the other steady state cases with similar results

Verification: Checking Transient Fluxes

- Again the fluxes from the v4.3.2 run were compared to the values from v4.2

Case 1.2
Hot Transient
Node 13312

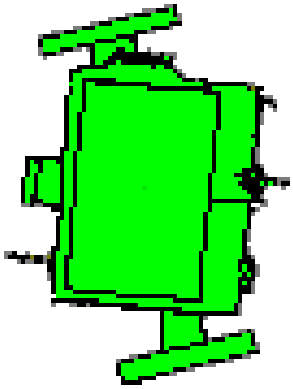
Original	V4.3.2	Diff	% Diff
88.393	88.410	0.0164	0.02%
70.433	73.975	3.5417	5.03%
28.169	32.741	4.5722	16.23%
3.812	3.359	-0.4535	11.89%
0.299	0.394	0.0953	31.84%
0.660	0.779	0.1191	18.04%
0.746	0.753	0.0071	0.96%
0.286	0.182	-0.1032	36.12%
4.236	3.767	-0.4696	11.08%
27.844	32.699	4.8549	17.44%
70.447	73.988	3.5417	5.03%
88.393	88.410	0.0164	0.02%



This variation in the fluxes is due to the different kernel files

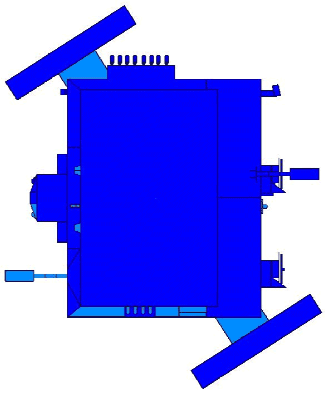
Verification: Visualisation of Kernel

In these animations, support structure is rotated around the SVM



Old Kernel

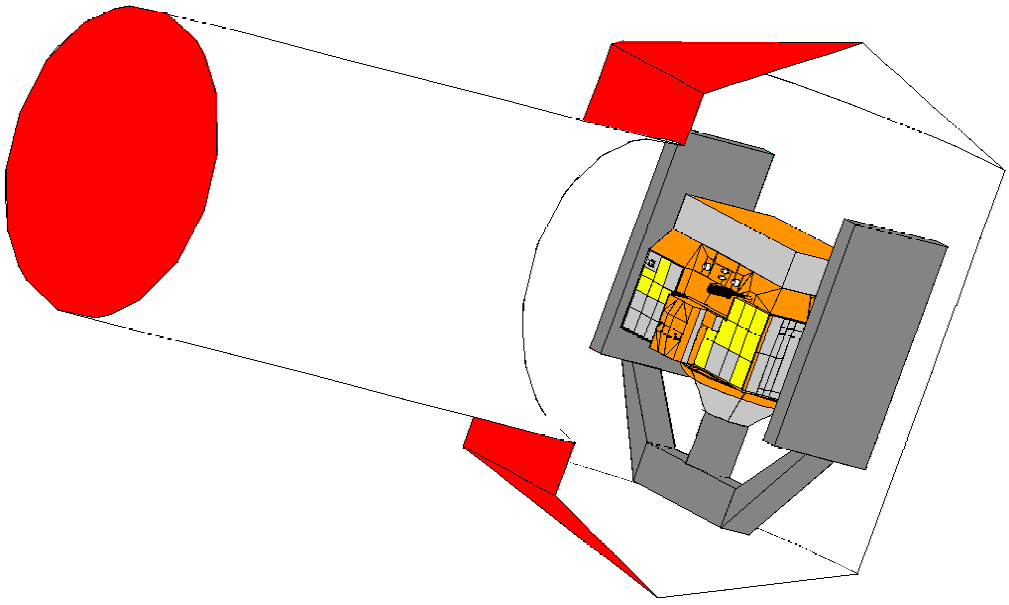
- The wobble seen is due to the a slight variation in step angle when the SVM is Earth pointing and its rotation axis is not perpendicular to the pointing direction



New Kernel

- The kernel file moves the SVM by a defined angle each time

Visualisation of Final Model



MetOp SVM in the simles chamber

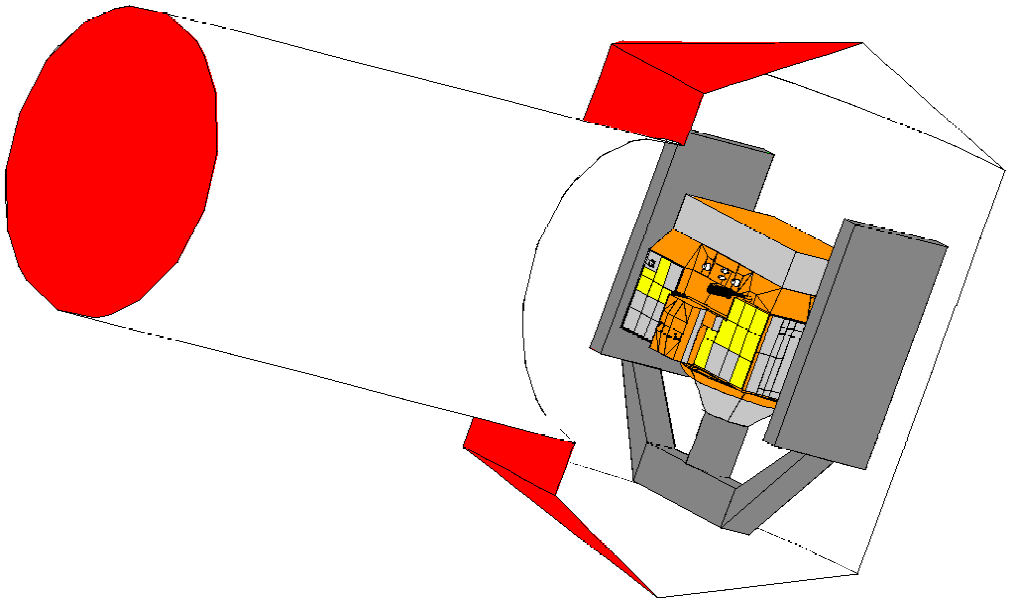
Achievements

- **The model works and generates the correct results**
- **The number of models has been reduced**
  - From 10 down to 1
- **The file/model structure to run the model for all cases has been simplified**
  - A single model makes it much easier to implement and control geometry changes
- **It is now much easier to make modifications to the model and re-run cases as desired**
  - The time taken and effort required to run the model is greatly reduced
- **This solution has been proven to be compatible with ESARAD v5**
  - The same problem should not occur in future

Outstanding Issues

- ESARAD has not yet been shown to handle transmissive surfaces in a way that will produce results in an acceptable computation time.
- It is not possible to visualise transient ESARAD kernel runs that use pointing defined by user code in the kernel file in the same way as predefined ESARAD pointing. i.e. you can not visualise the complete orbit in the same orientation as that used to generate results.
- Experience has shown that there are normally compatibility issues when ESARAD (and ESATAN) are upgraded to the new versions that normally require small modifications to be made to the models. How can the occurrence and effect on projects of these problems be reduced in future?

Questions?



MetOp SVM in the simles chamber