Appendix D

First year using ESATAN-TMS
A newcomer's reflections

Edward Jones
(STFC Rutherford Appleton Laboratory, United Kingdom)

Abstract

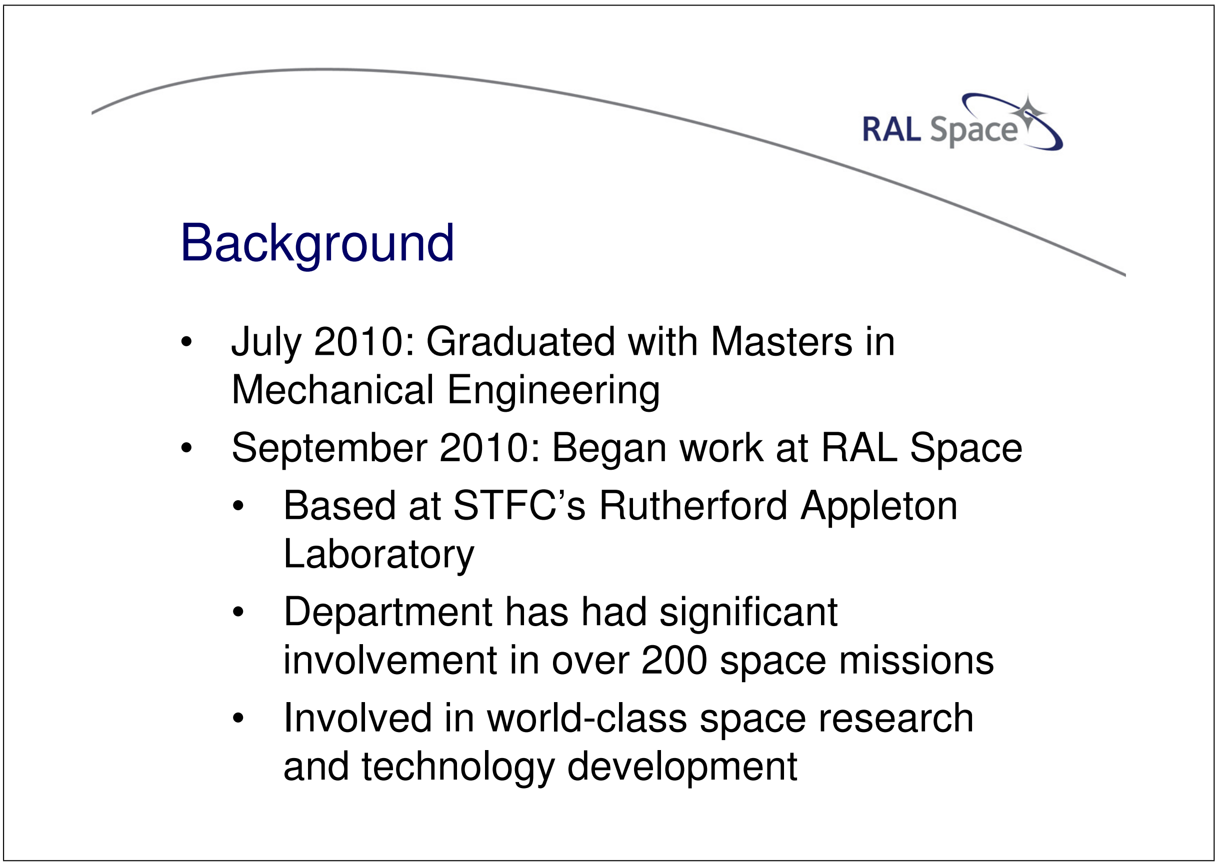
This presentation provides an overview of the experiences of a recent Mechanical Engineering graduate during his first year using the thermal analysis software ESATAN-TMS. An overview of the variety of different models that have been created and analysed within the software will be provided, along with the key successes (and many lessons learned) along the way. The ease, or otherwise, with which the software has been picked up will be described, and some areas for improvement of the software will be identified.

First year using ESATAN-TMS:
A newcomer's reflections

Edward Jones
(RAL Space, STFC Rutherford Appleton Laboratory, United Kingdom)

Overview

- Background
- Projects in ESATAN-TMS
  - Overview
  - Impressions of ESATAN-TMS
- Areas for improvement
- Overall Impression
- Q&A



I graduated with a Masters in Mechanical Engineering from the University of Leicester in July 2010. Although during my degree I covered two modules on Thermodynamics and Heat Transfer I had little experience of thermal modelling before starting work at RAL Space in September 2010.

RAL Space, based at STFC's Rutherford Appleton Laboratory, has had significant involvement in over 200 space missions, and is at the forefront of world-class space research and technology.

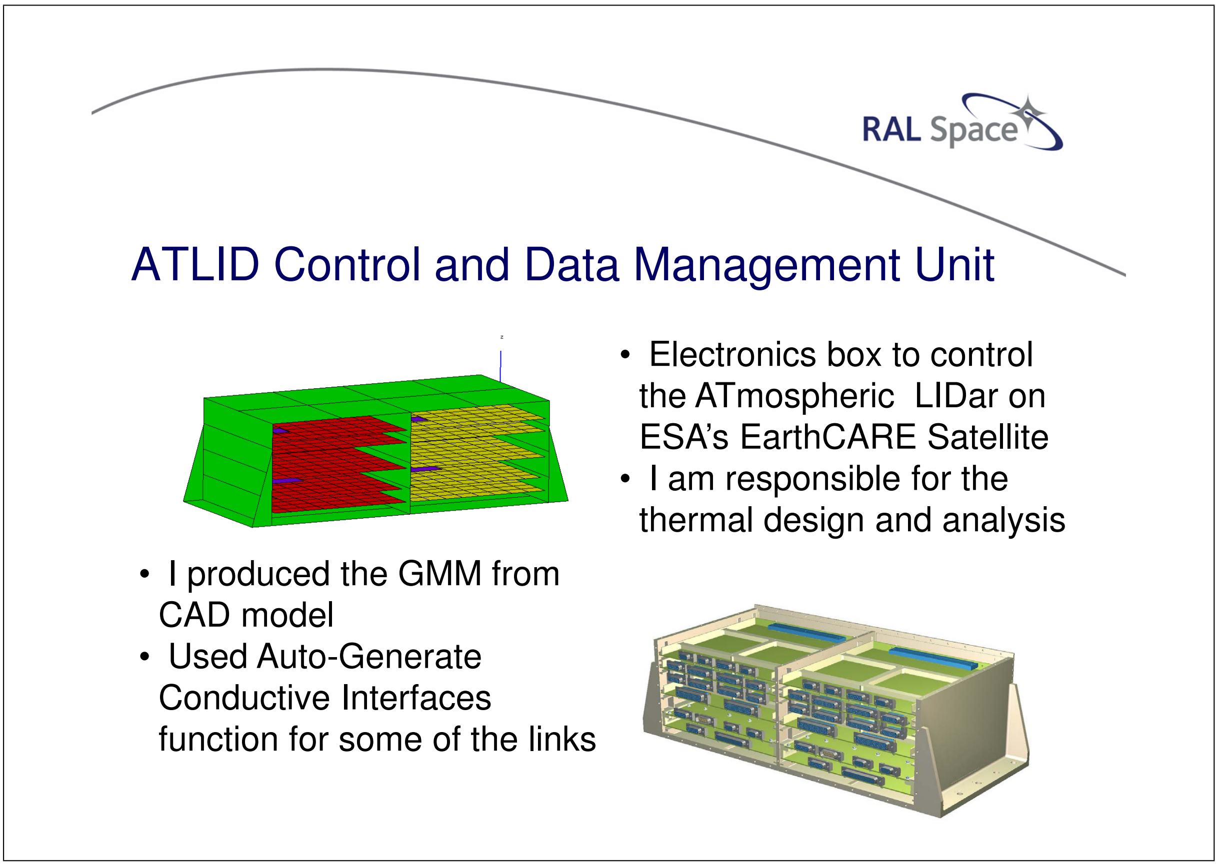
RAL Space

Background

- Work within the Thermal Engineering Group of RAL Space
- Attended beginners training course in ESATAN-TMS Feb 2011
- Worked on a number of projects
  - ATLID Control and Data Management unit
  - JWST MIRI Thermal shield
  - Urthecast ISS cameras

I work within the Thermal Engineering Group of RAL Space, and am involved in all aspects of thermal design, from initial analysis, detailed design, thermal testing and MLI manufacture. Since ESATAN-TMS is extensively used within the department, I attended the beginners' training course on ESATAN-TMS in February 2011.

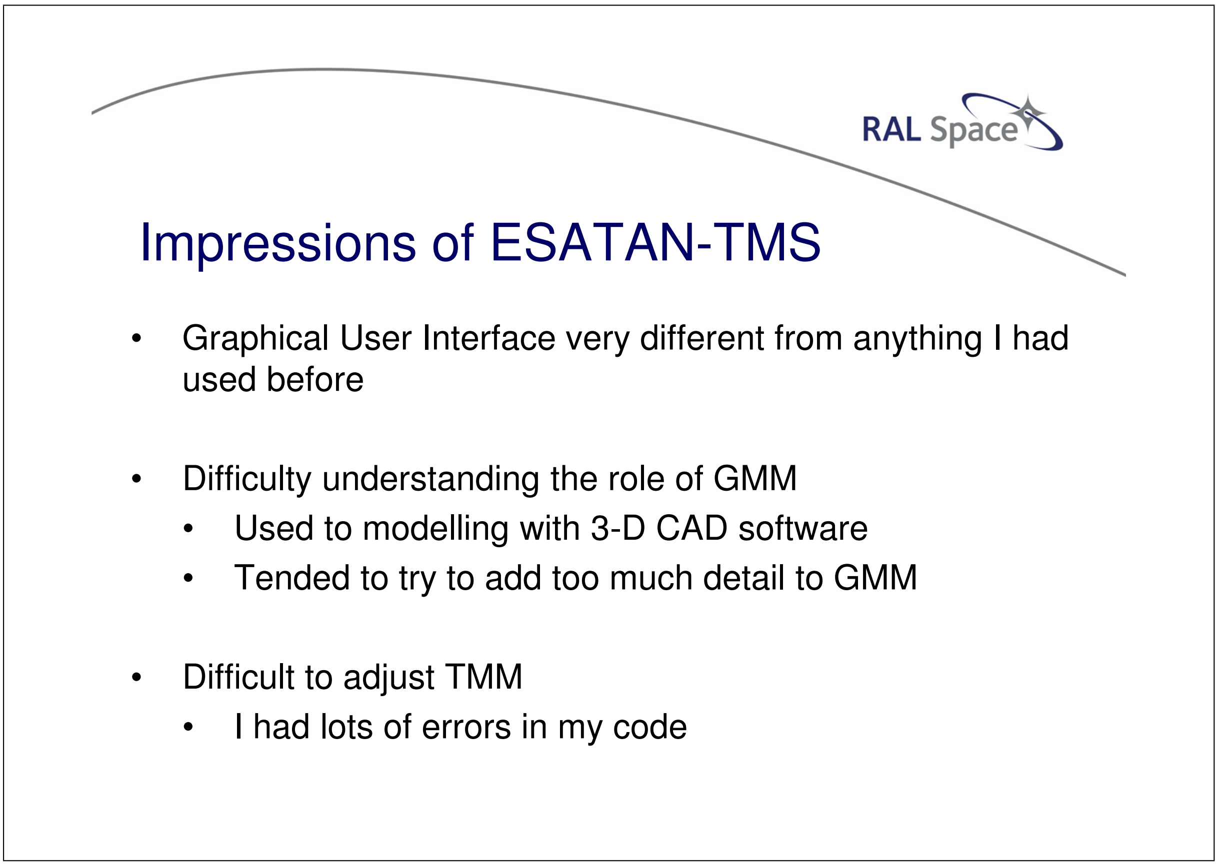
During the past year working for RAL Space, I have been involved in a number of different projects. The three main projects that I have worked on, however, have been the ATLID CDM unit, the MIRI heat shield and the Urthecast ISS cameras project. Each of these projects has required extensive modelling within ESATAN-TMS, and each has allowed me to explore the features of ESATAN further.



Before beginning work on my first project, the ATLID Control and Data Management Unit, I used the tutorials provided within the manuals to learn how to use ESATAN-TMS. After completing the set examples within the tutorials, I moved on to trying to modify the models in order to reinforce my understanding of thermal analysis and ESATAN-TMS.

After spending a week working on the tutorials, I was ready to begin the modelling of the ATLID Control and Data Management Unit. This is the electronics box which controls the Atmospheric LIDar on ESA's EarthCARE satellite, and I was responsible for the thermal design and analysis of the unit.

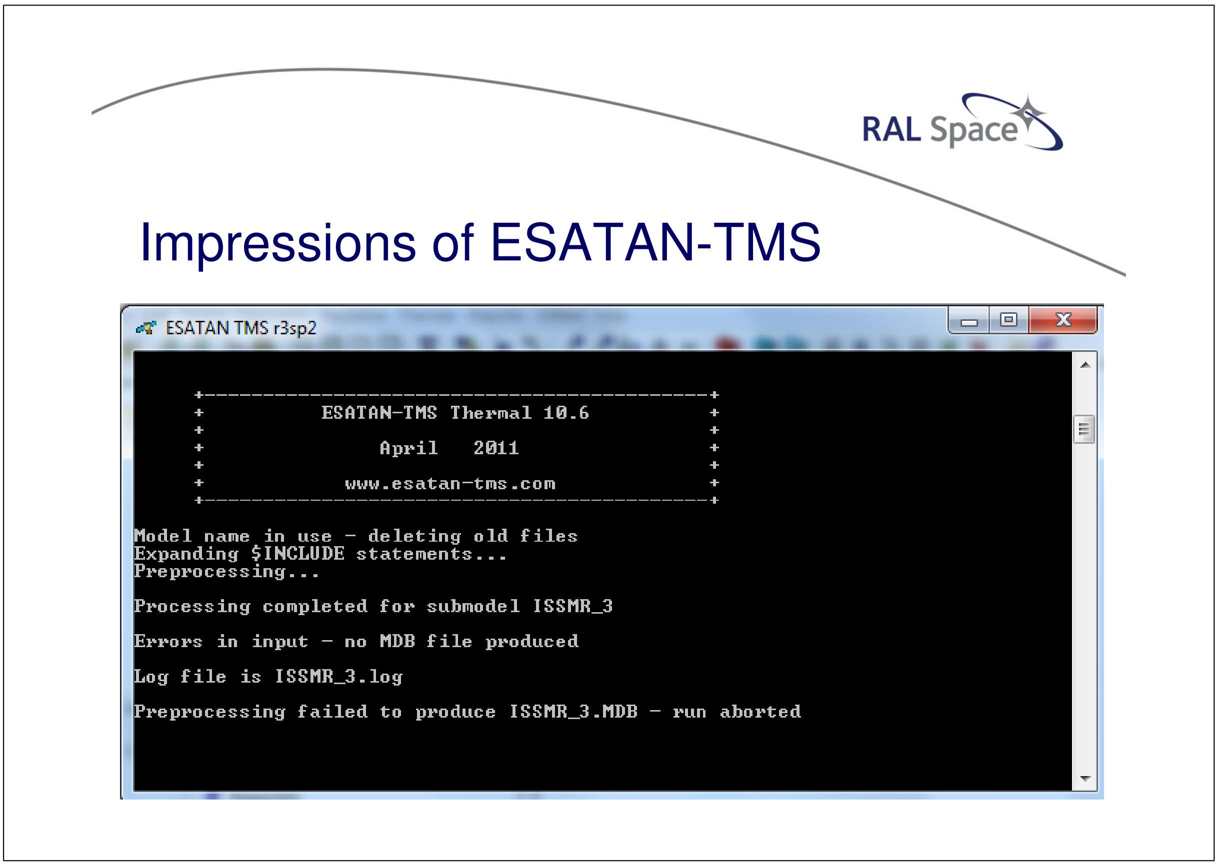
I produced the GMM from the CAD model, and used a coarse node definition for the metal work of the unit and a finer node definition for the PCBs, since were the key areas of interest. Although I used the Auto-Generate Conductive Links function to generate some of the links within the model, a large portion of the links were coded directly within the TMM.



My first impression of ESATAN-TMS was that the Graphical User Interface was very different from anything I had used before. Throughout my degree I had predominantly used 3D CAD software in which the philosophy for creating models was to produce a 2D sketch and then extrude this to create the 3D geometry. The process of creating flat areas to build up a 3D geometry was very different.

This experience I had had with 3-D CAD software meant that to begin with I had difficulty in understanding the role of the GMM. My instinct was to try to add too much detail, such as modelling the PCB stiffeners and Connectors within the GMM. With experience, and by reviewing models created by other members of the department, I am now much better at simplifying the geometry.

Initially I found it quite difficult to successfully modify the TMM. Within the ATLID project I had to write a large amount of the TMM code within a text editor, and as a result made lots of errors within my code.



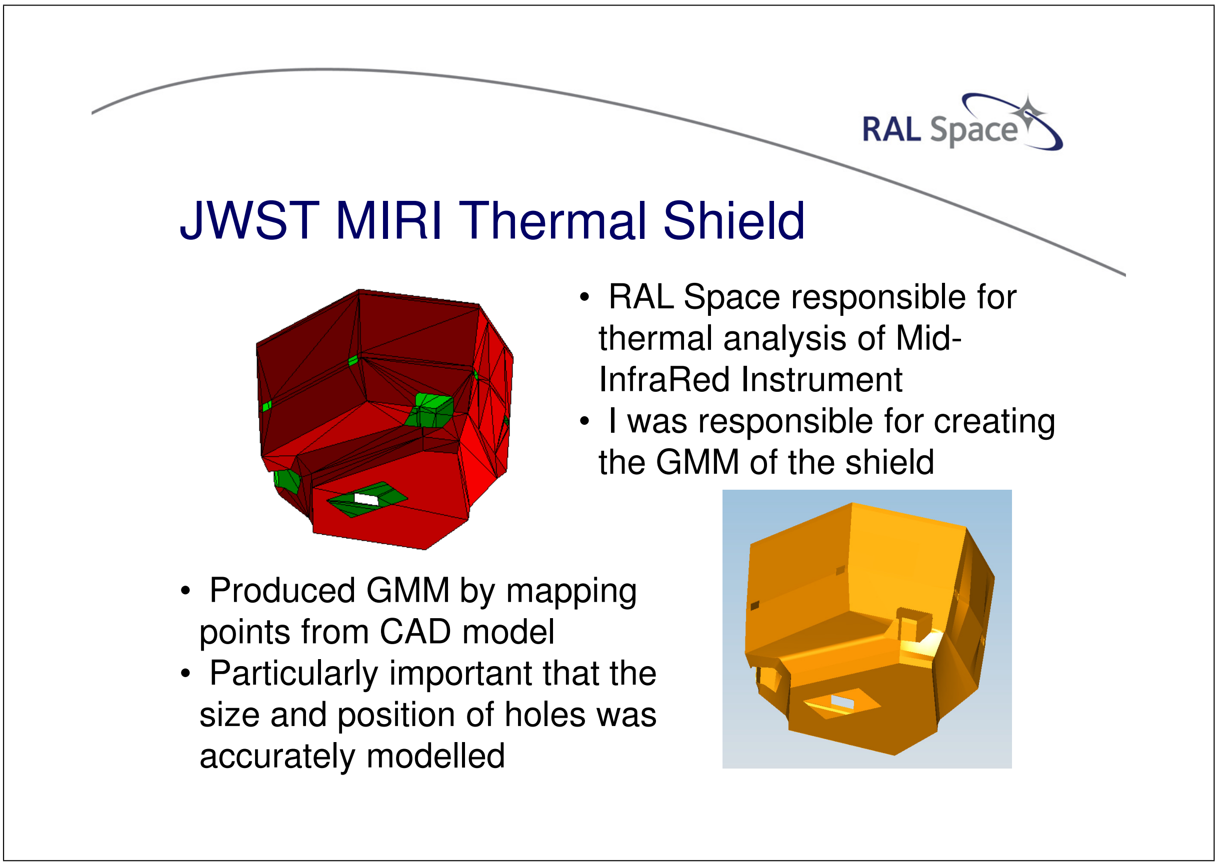
It seemed that every time I tried to preprocess the code it would fail and if I had a pound for every time that I saw the ’run aborted’ message within the DOS screen I would be a very rich man! The majority of the problems I had were syntax errors; either forgetting to include a semicolon where it was needed or including one where it wasn’t; or forgetting to ensure that I had 6 spaces before commands within the Execution Block.

RAL Space

Impressions of ESATAN-TMS

- Graphical User Interface very different from anything I had used before
- Difficulty understanding the role of GMM
  - Used to modelling with 3-D CAD software
  - Tended to try to add too much detail to GMM
- Difficult to adjust TMM
  - I had lots of errors in my code
  - Little explanation of reason for failure to preprocess

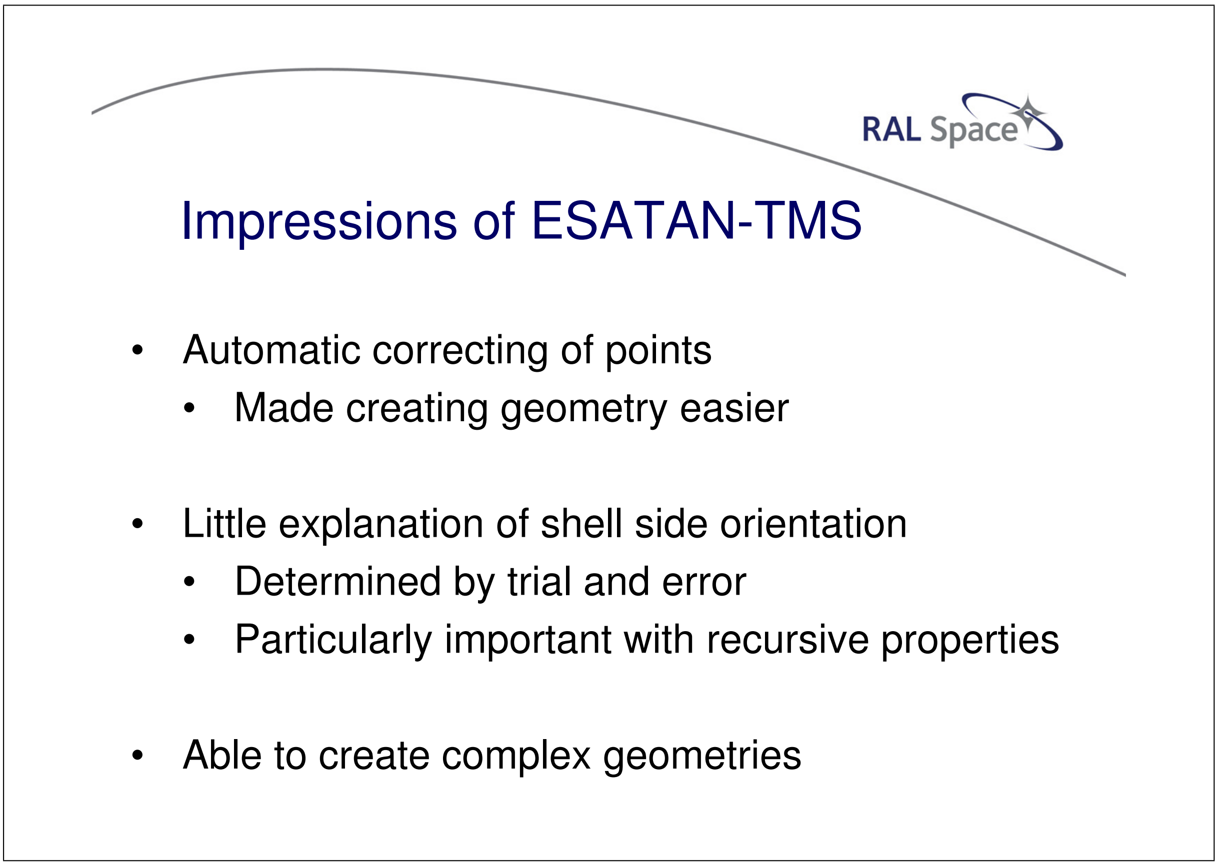
I found that the error messages given within the log files gave no clear explanation of the causes of the file not pre-processing, and there was no detail within the user manuals about potential causes of the errors. I therefore found it very difficult to debug my code, and think that if there had been a clear description within the user manual or training guide of the possible causes of certain common error messages then I would have been able to save a lot of time during this project.



The second project that I worked on was the Thermal shield for the Mid-InfraRed Instrument on the James Webb Space Telescope. The instrument's Optical module fits inside the shield. The geometry and apertures must be accurately represented to ensure the correct radiative boundary conditions.

RAL Space was responsible for the thermal design, as well as for the Assembly, Integration and Verification testing of the instrument. I was responsible for creating the GMM of the thermal shield.

I created the GMM from the CAD geometry by mapping points from the CAD model into ESATAN-TMS. I then used these points to define shells to create the geometry. It was important that the geometry was accurately mapped, but a minimal number of shells used in order to reduce the complexity of the model once it was combined with the MIRI GMM. It was particularly important that the positions and sizes of the holes within the shield were accurately modelled, since these had to coincide with features on the instrument.

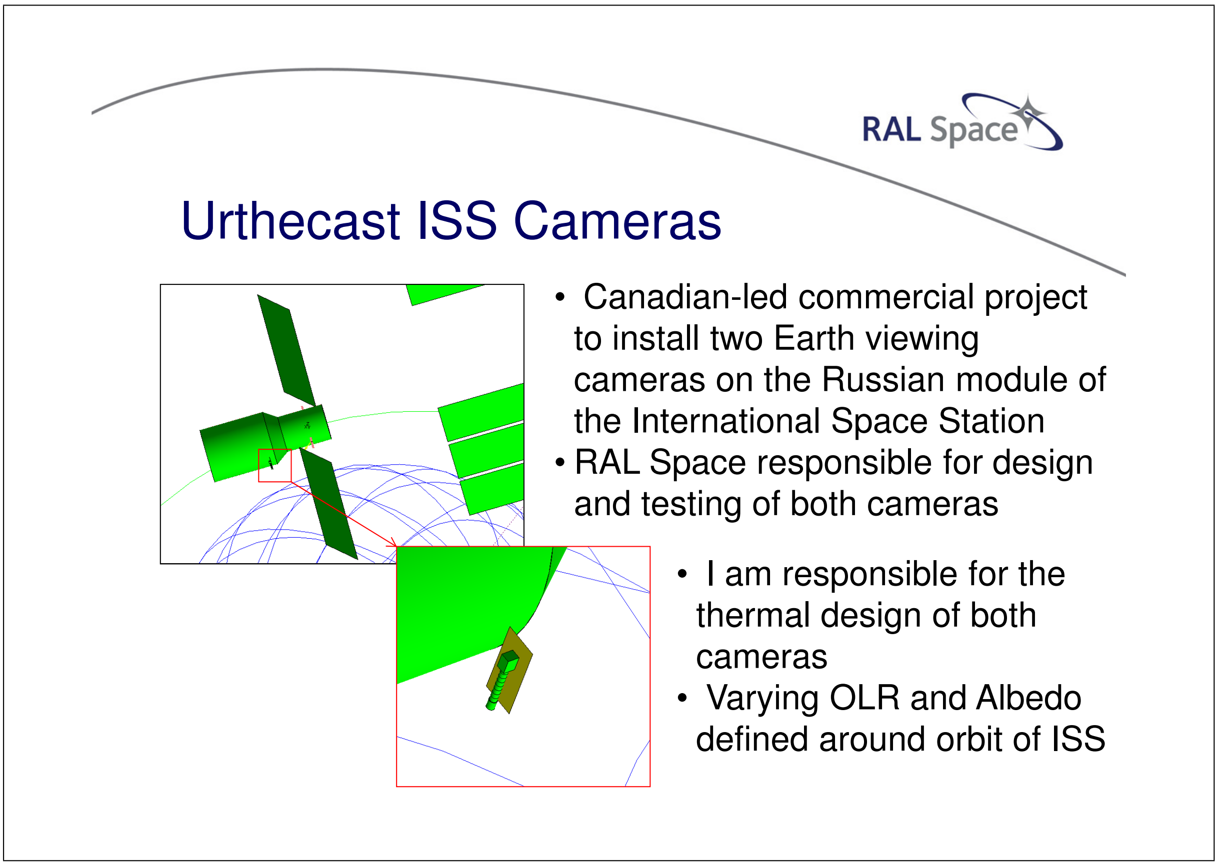


As may be seen, the MIRI thermal shield was a significantly more complex geometry than the ATLID unit, and therefore this greatly increased my understanding of the features of GMM creation within ESATAN-TMS.

I was particularly impressed with the automatic creating of points, when the points originally selected were not compatible due to, for example, not being in-plane or not being perpendicular. Since ESATAN-TMS specified the translation that had been applied to the point, it was possible for me to work out whether it was an error in inputting the co-ordinates of the point, or if the wrong choice of shell had been chosen i.e. two triangles should be used rather than a single quadrilateral. This made it easy for me to create an acceptable geometry, without incompatible shells.

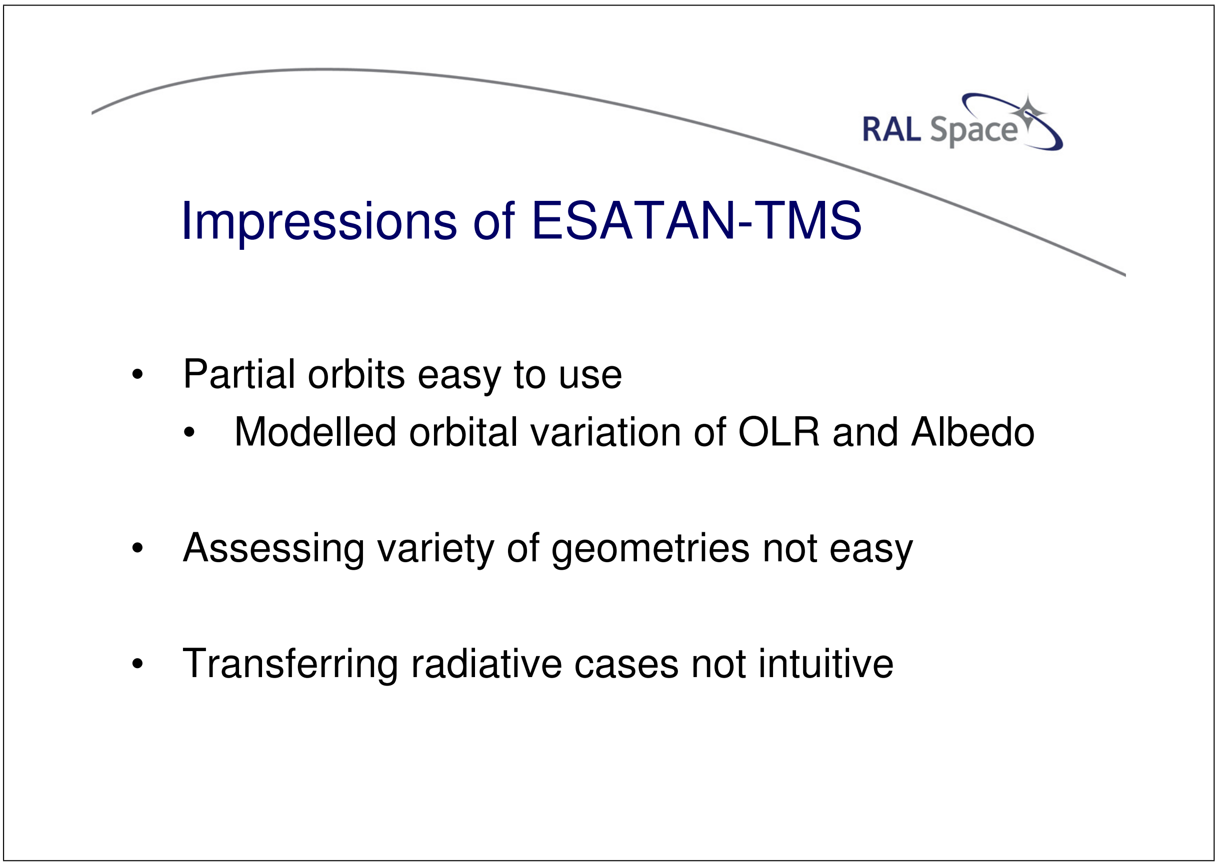
I did find it very difficult when specifying shells to work out which would be side 1 and which would side 2. At first I had to determine this by trial and error, before realising that the diagrams within the help are orientated with Side 1 facing forwards. A clearer, easier method for defining side 1 and side 2, or else the is particularly important now that the recursive shell property function has been included within ESATAN-TMS.

Finally I was impressed by how it is possible to create complex geometries by building up discrete geometric shapes. I feel that this process of building up the GMM forces the user to consider how best to simplify the geometry, and hence to create efficient models. Though this creation process makes it more difficult to produce complex geometries, I do think it serves a useful purpose.



The final project that I am going to talk about is the Urthecast ISS project. This is a Canadian-led commercial project to install two Earth-viewing cameras on the International Space Station. These cameras will provide a continuous feed to a freely accessible website. RAL Space is responsible for the design, manufacture and testing of both of the cameras, and I am responsible for the thermal design of both cameras.

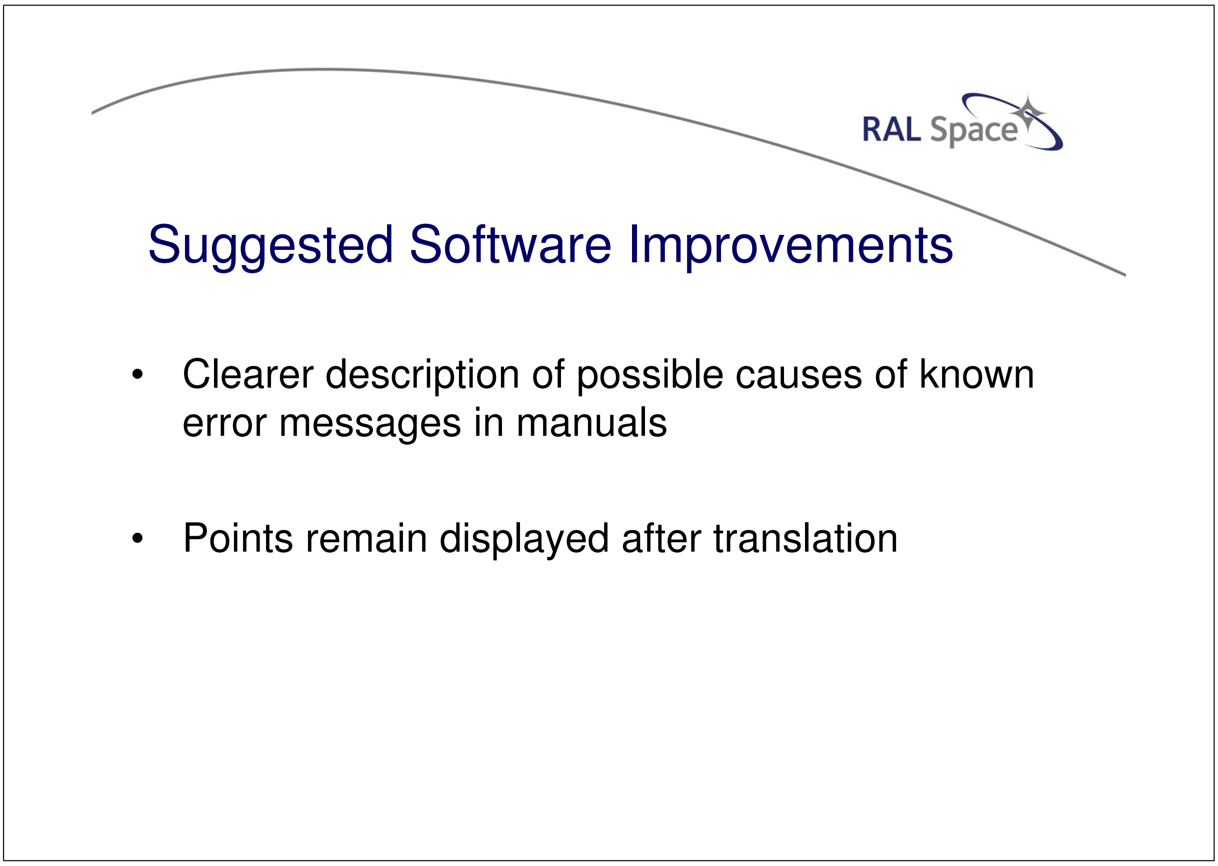
This is the first project that I have worked on which requires orbital modelling, and the hot and cold case orbits of the ISS are defined as having a changing OLR and albedo around the orbit. I therefore have to model a complex geometry with a complex orbit definition.



The orbit variation of the ISS is defined within the standard by beta angle, which is the angle between the solar vector and the orbital plane. Around the orbit there is a variation in OLR and albedo specified, so I used the partial orbit function within ESATANTMS to model each period of constant OLR and Albedo. I calculated the Earth temperature that would be required for each value of OLR, and determined the initial and final true anomaly for each case from the period of the orbit. Since there were 4 worst cases specified, 2 Hot and 2 Cold, and three different values of OLR and Albedo for each case, a total of 12 different radiative cases were created. I was very impressed with the ease with which this potentially complicated orbit scenario could be modelled through the use of partial orbits, though it would have been easier if it had been possible to directly specify the Earth IR.

Since the geometry of the cameras and their associated radiators have not yet been fully defined it is necessary to assess a number of different geometries and orientations. In my experience modelling different geometries within ESATAN-TMS is not easy. Having to create a separate model for each change of geometry does not seem particularly easy to me, especially since the process of transferring the analysis and radiative cases between models is not intuitive.

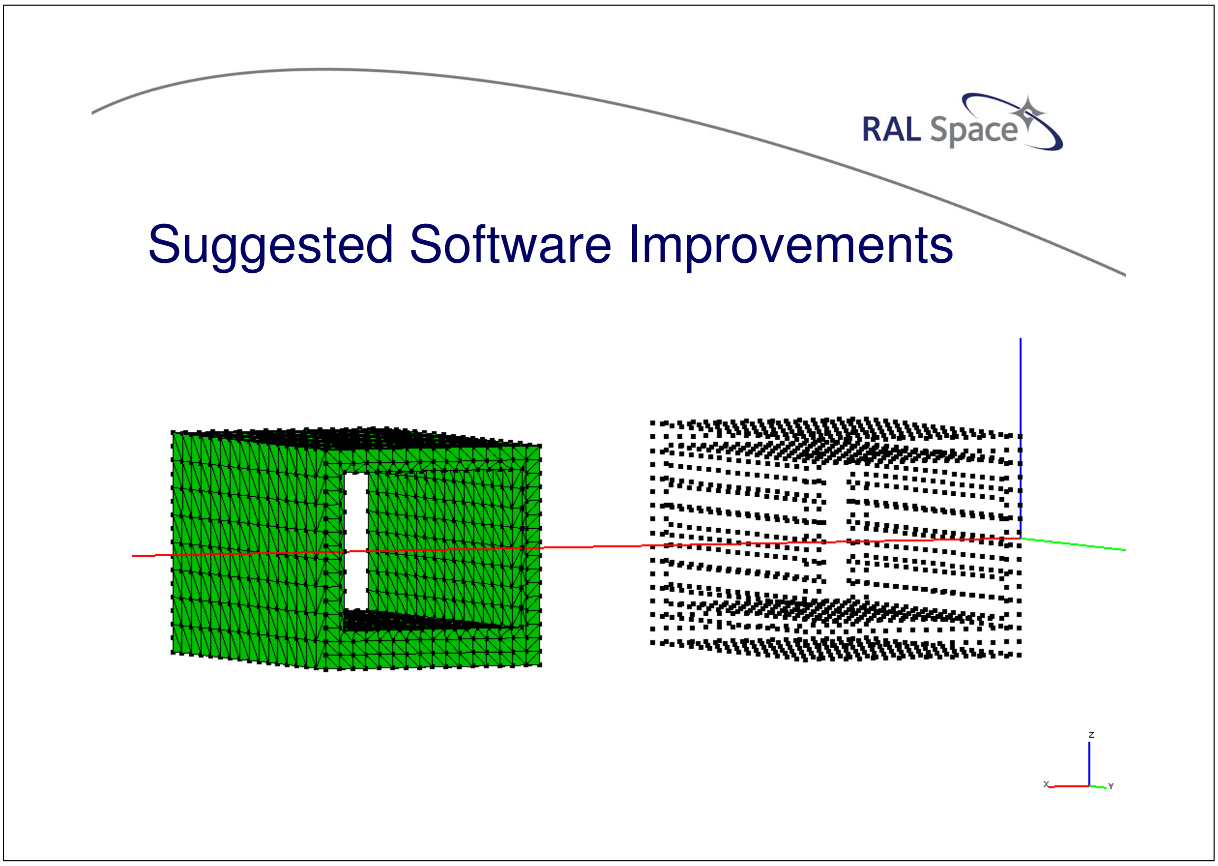
Currently it is necessary to either go through the process of defining the radiative cases within the GUI for each model, or else to find the appropriate part of the log file relating to the definition of the radiative case and then paste that into the command line. With 12 radiative cases for each model this makes for quite a cumbersome process. Therefore a simpler method of transferring the radiative cases between models would be very useful.



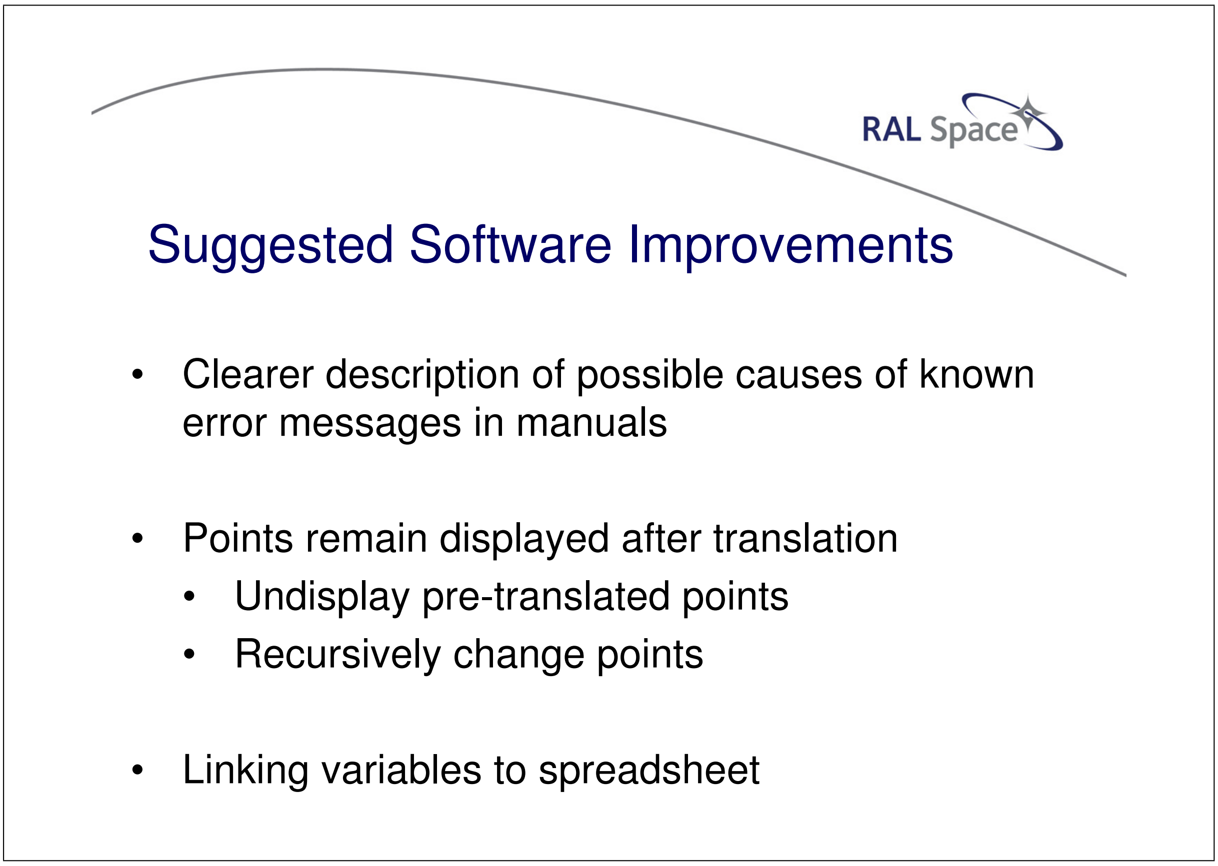
Through the work that I have completed using ESATAN-TMS over the past year, I have identified a few areas that I feel would benefit from improvement.

From my difficulties in getting the TMM to pre-process successfully, I think that it would be very useful to have descriptions of the causes of the most commonly encountered error messages, along with an overview of the key syntax for the models, within the training manual. As many computer programs move away from coding, and more into Graphical User Interfaces, it becomes more important to have this since new users may have less experience in coding, and particularly in using FORTRAN. Had these descriptions been within the user manual, I would have saved a considerable amount of time during the ATLID project.

Though I have not used it extensively I have been impressed with the CAD convertor for importing complex geometries. One of my colleagues needed to model a double sided concave mirror, and through the CAD convertor was able to import a good representation of the geometry into the GMM. The major disadvantage I see with the CAD convertor, however, is the heritage of points after a translation is performed.

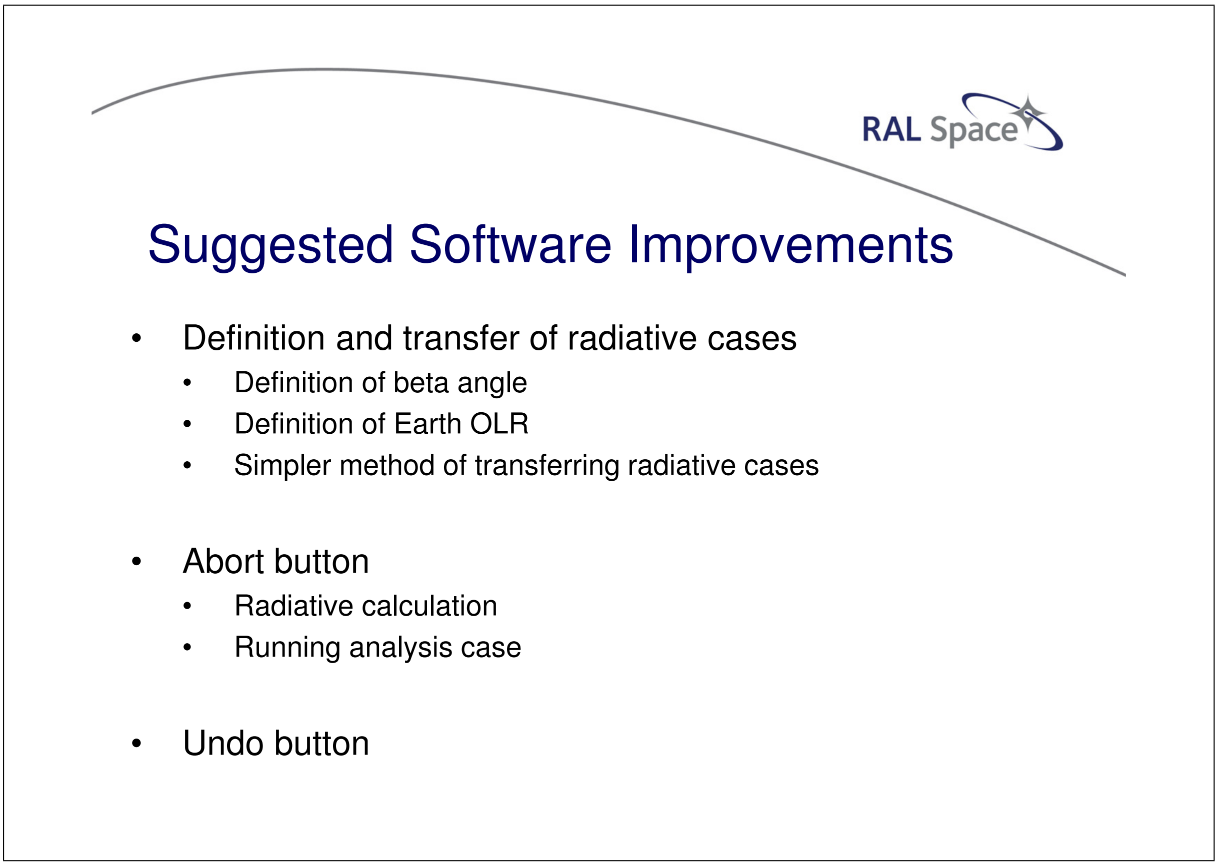


As may be seen in this simple geometry that I imported, after a translation the original points remain displayed within the GMM. This not only makes the GMM untidy, but could get very confusing if the CAD convertor is used to import a number of different geometries into a single model. Currently it is not possible to undisplay individual points; the user has only a selection between displaying all points or none. If it were possible to either automatically undisplay all pre-translated points or else to select points to undisplay, I think that this would make the CAD convertor a significantly better tool and the GMM tidier.



In addition to the ability to undisplay selected points, I think that it would be useful to be able to recursively change point co-ordinates. If a geometry has been defined through user defined points, and then the dimensions of the geometry change, it would be useful to be able to redefine one of the co-ordinates of a number of points simultaneously.

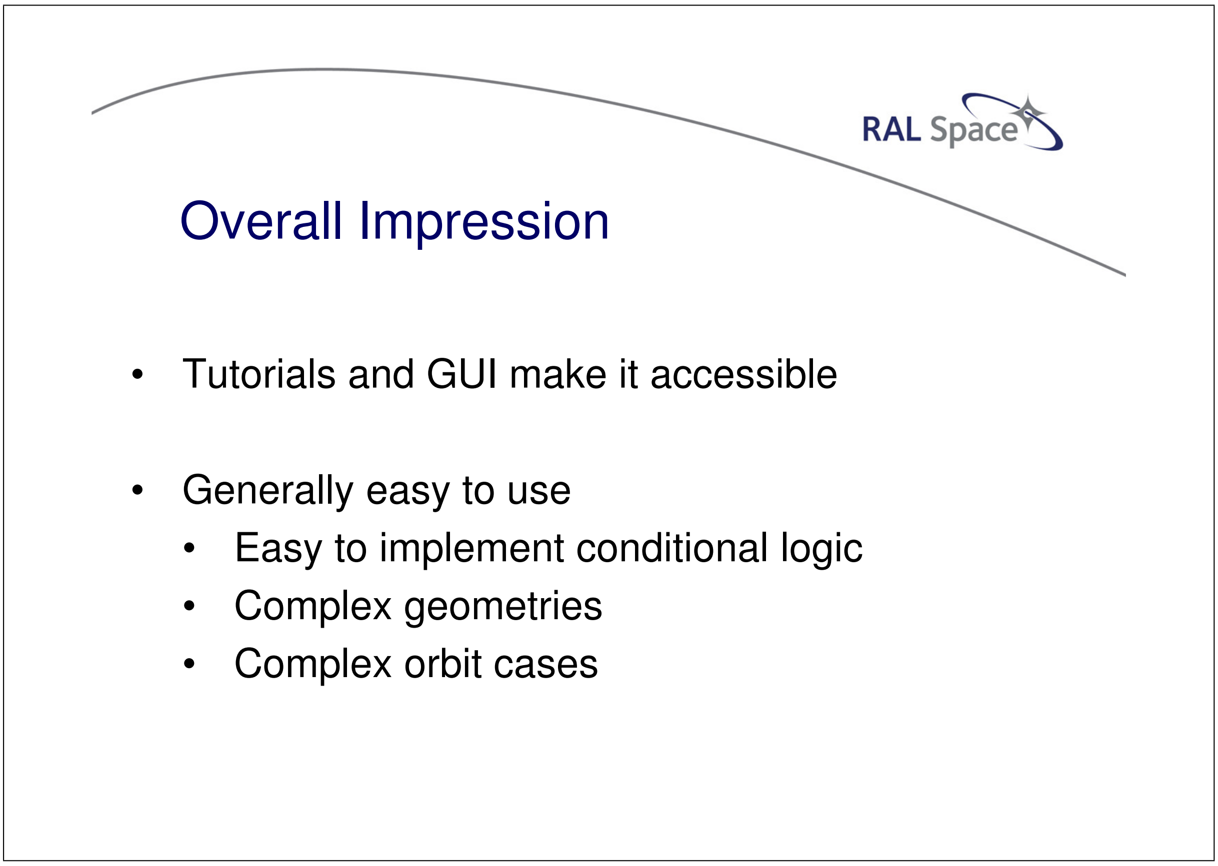
Another potential improvement that I have identified for the software, from parallels to CAD programs that I have used, is the ability to link points or variables to a spreadsheet. These variables could be reloaded periodically, and updates to the geometry identified. This would improve the link between CAD packages and ESATAN, allowing changes in geometry to be easily updated within ESATAN, and would also make it easy to keep a track of the variables used within the models.



Whilst working on the orbit definitions for the Urthecast ISS cameras project, I have identified a couple of areas in which the definition and transfer of the radiative cases could be improved. One of the sources that I have read about orbital modelling for thermal analysis suggested that considering orbits in terms of Beta angle offers an easier way for defining the worst case hot and cold cases to consider. Since the hot case is the maximum absolute beta angle and the cold case is the minimum, considering the orbit in this way removes the complexities of variation due to precession of the orbit. I think that it would be useful if it were possible to define the orbit inclination, the solar declination and the beta angle to be considered, and for ESATAN-TMS to then automatically align the orbit to achieve this beta angle. The other improvements, which I have already mentioned, are the ability to directly define the Earth OLR value and a simpler method of transferring radiative cases between different models.

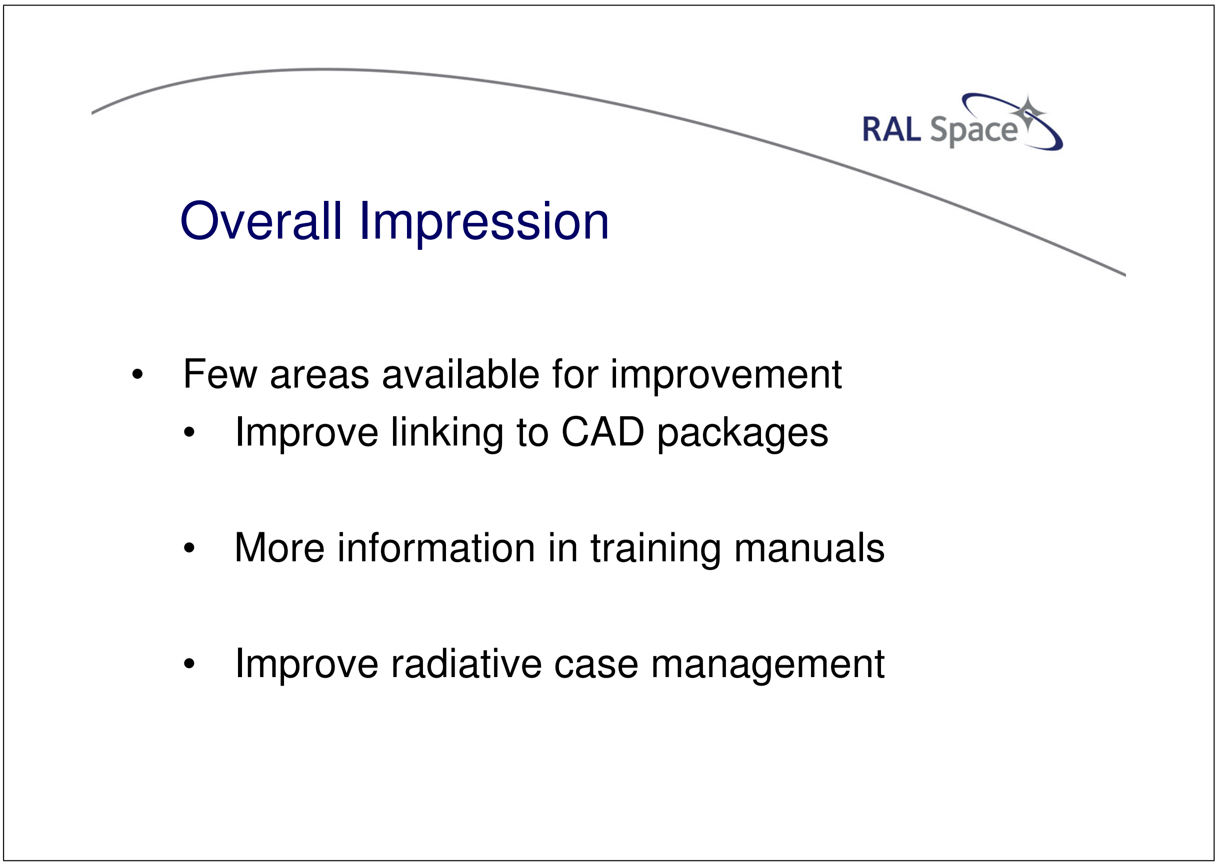
Another feature that I think would be a useful addition to the software is an abort button, to stop the radiative calculation and the analysis cases running. As the models I have produced have got larger and more complicated, the time taken for these two actions has increased. It is annoying when you realise shortly after pressing the pre-process and solve button, that you have forgotten to regenerate the analysis file, or after executing the radiative case, realising a change you should have made to the GMM, and then having to wait for the program to produce results that are of no use to you. The current method I adopt for aborting in these cases is to close the DOS window, but this is rather a dramatic method. An abort button to safely stop the process would reduce the time wasted after making a mistake.

The final feature that I often wish ESATAN-TMS had is an undo button. After changing the wrong variable or unassigning the wrong shell it would be very useful to be able to undo the action. This was something I was particularly keen for after trying to return to a previous geometry and using the reload geometry function. This resulted in my analysis cases disappearing from the screen and the radiative cases being deleted, and so at that time I desperately wanted to press cntrl+Z and have it all reappear!



Despite these few areas for improvement, overall I am impressed with ESATAN-TMS. The user interface means that it is a very accessible program, and with the tutorials it is easy to begin creating simple models. I was able to produce an initial model of the ATLID unit within a week of starting to use the program.

I find the program generally easy to use, and since a large portion of the model may be generated through the GUI, it is easy to initially set up the different elements of the model. It is easy to include complex transient cases, such as heater control through the use of conditional logic, and whilst being simple enough to pick up quickly, it is powerful enough to model complex geometries and orbital cases.



To summarise, the few areas that I feel would benefit from improvement are an improved linking to CAD packages, more information within the training manuals about common errors made by new users, and improvements to the definition and management of radiative cases.

Thank You

Any Questions?