Appendix Q

Application of CADBench and ESATAN-TMS to the Advanced Closed Loop System

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Abstract

A recent addition to the ESATAN-TMS software is the CADBench tool for transferring a variety of CAD formats directly into the esatan geometry format. This presentation assesses the initial experience of this tool applied to the Advanced Closed Loop System (ACLS). The ACLS project requires the creation of a thermal geometry with a large number of components in a short time frame and as such is considered a good test for the capabilities of the new CADBench tool. This presentation will discuss the advantages, challenges and lessons learned in the initial application of this software tool in the frame of the ACLS project.


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James Mulcahy. Astrium Space Transportation. Bremen
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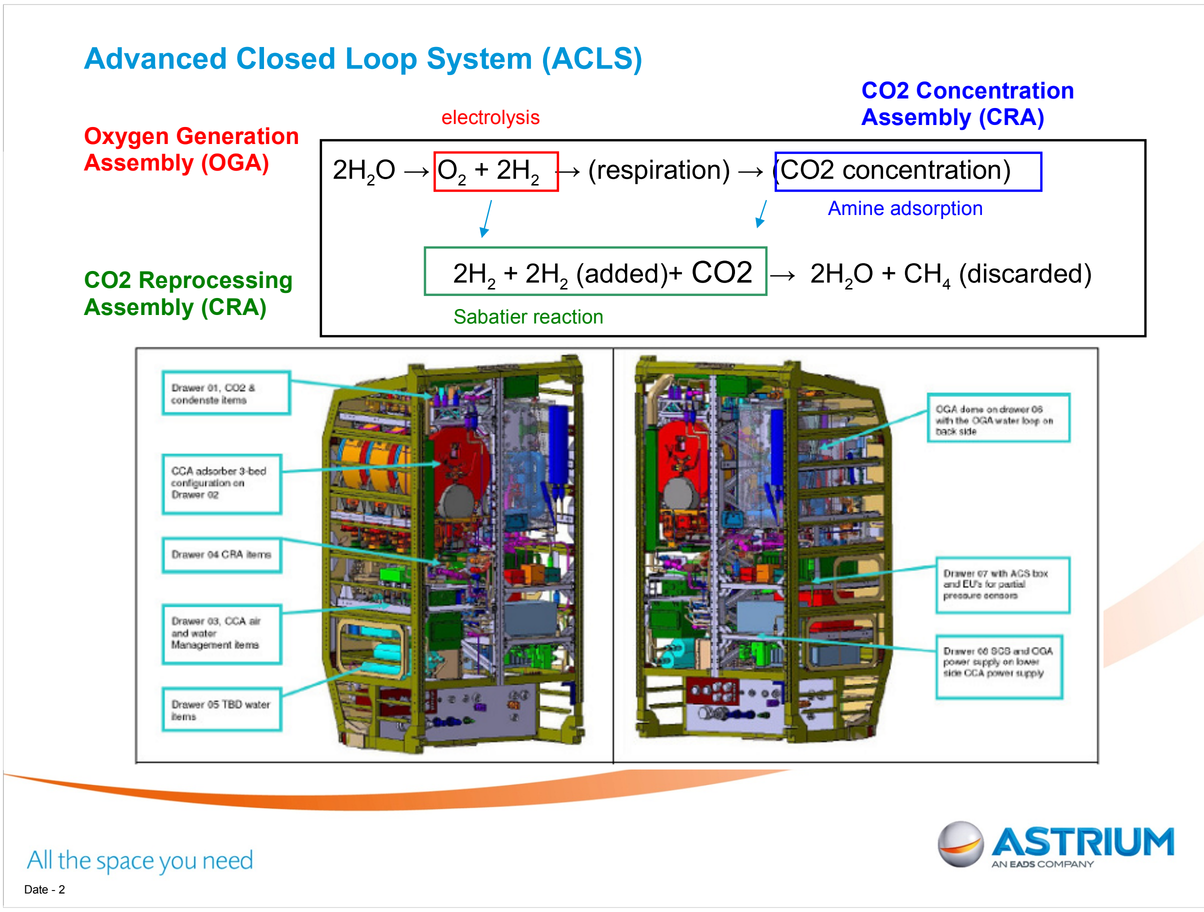


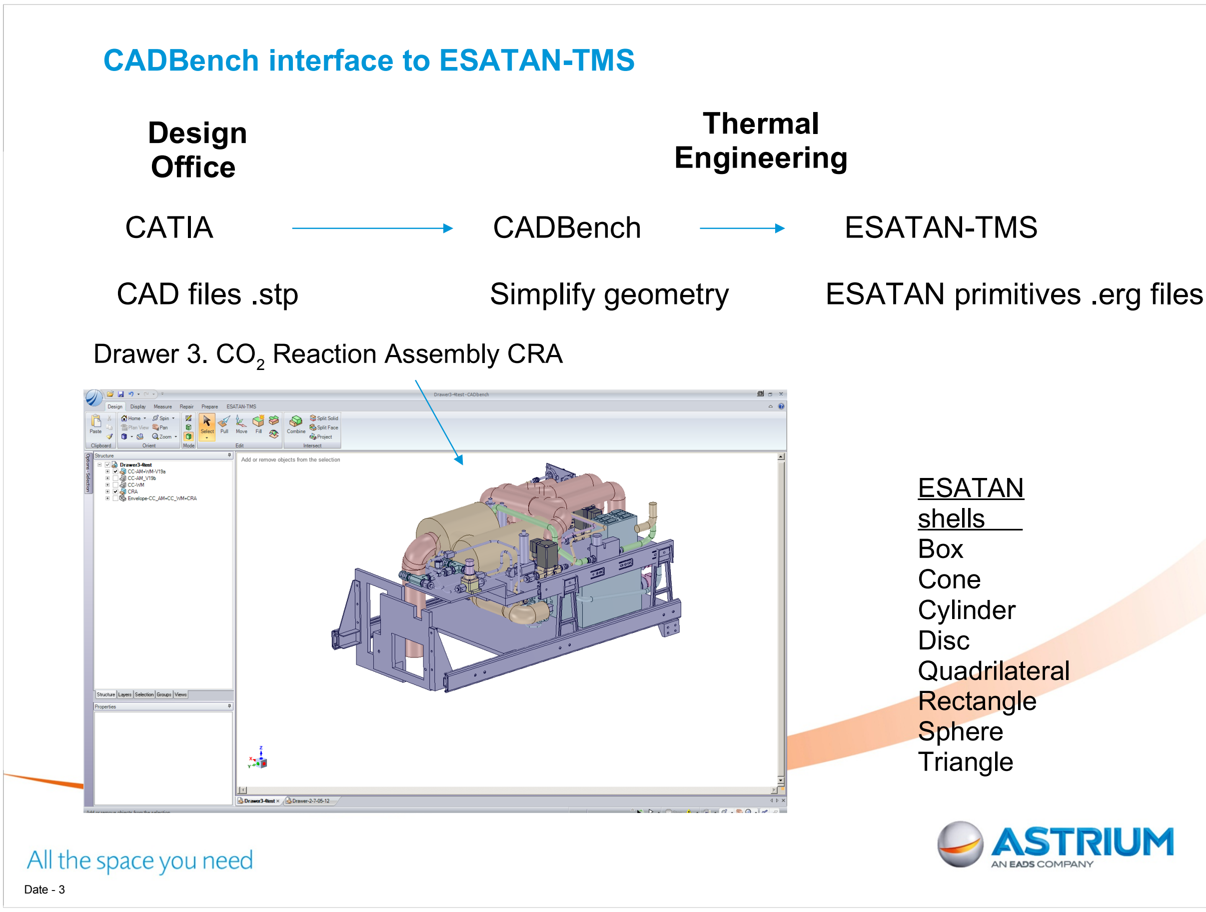
ACLS is double rack to be flown to the Columbus module of the ISS in the HTV June 2016. The system contains 8 drawers the most important 3 contain the CCA, CRA and the OGA. The remaining drawers contain the water management system WMS and various electronics.

The ACLS recycles CO2 taken from the ISS and produces O2. The system is not 100% mass efficient since it requires a source of H2 and discards methane produced in the reaction.

PDR is July 2012. CDR is July 2014.

Thermal Analysis of system poses problems as the geometry is complex and still undergoing revisions. Hundreds of components in system.

The use of CADBench was deemed necessary to enable rapid creation of GMM for thermal modelling.



CADBench is a plug in tool for ESATAN-TMS. The CADBench software is developed by SpaceClaim corporation. The company develops 3D software which is easy for engineers to use without needing to become CAD experts.

It allows the CAD geometry to be edited but does not include the full features of a program like CATIA.

For the thermal modeller these advanced CAD features are not required.

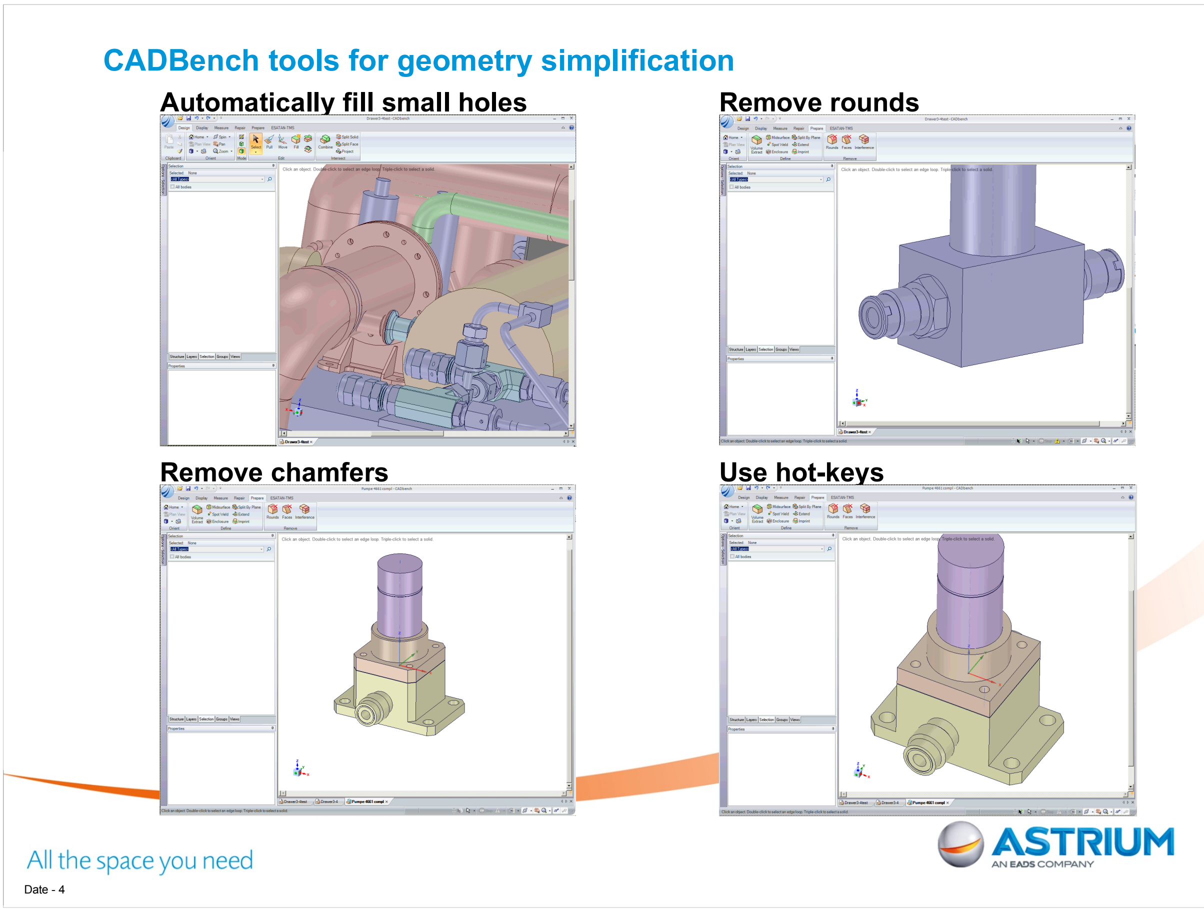
A number of automatic functions are included to rapidly simply the CAD model.

The software has a built in converter that takes geometry and produces ESATAN-TMS geometry. The translator has shape recognition functionality.

Only ESATAN-TMS shells will be recognised. If the components do not consist of these shells then the shape will be approximated by triangulation.

ESATAN-TMS can be launched automatically from CADBench to view exported geometry.

For the PDR in July Thermal Analysis will be carried out on a single drawer. The CRA which is on drawer 3 was selected.

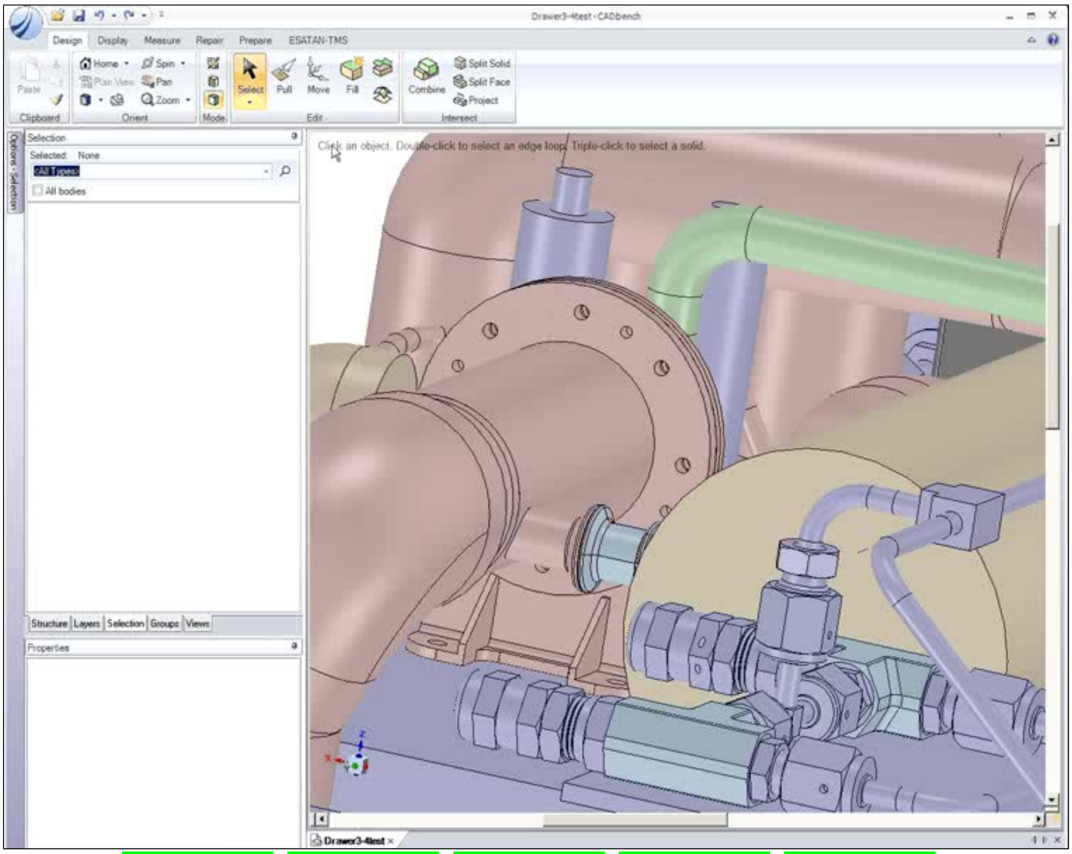


CADBench includes a number of tools for automatically removing features that are unwanted in order to simplify the geometry.

1 Small holes which have no effect on radiation couplings can be removed. Note that in selecting a hole, you can also select to remove all holes of the same diameter.

2. 3. Chamfers and rounds (fillet) can also be removed. Again selection can be based on all rounds of similar diameter, or all surfaces with the same area.

4. Editing is sped up through the use of keyboard hot-key. For example all the previous functions, Filling holes, chamfers or rounds (fillets) can all be done by selecting and typing F on the keyboard.



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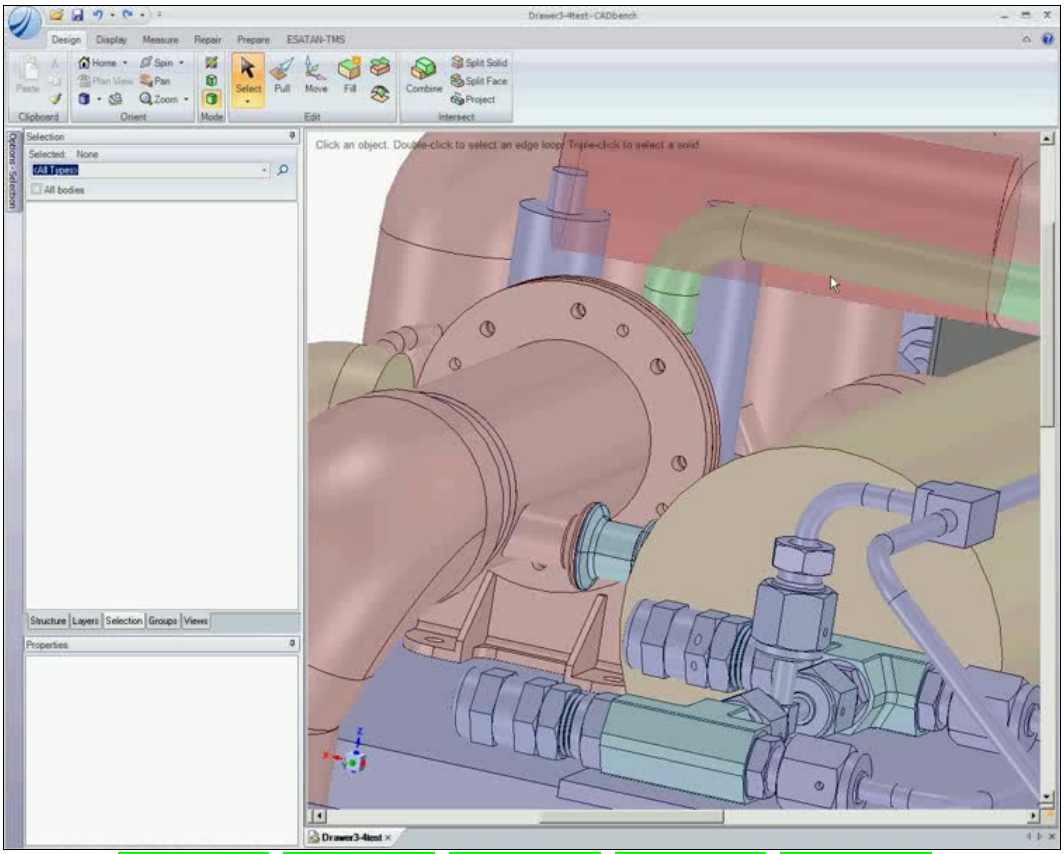

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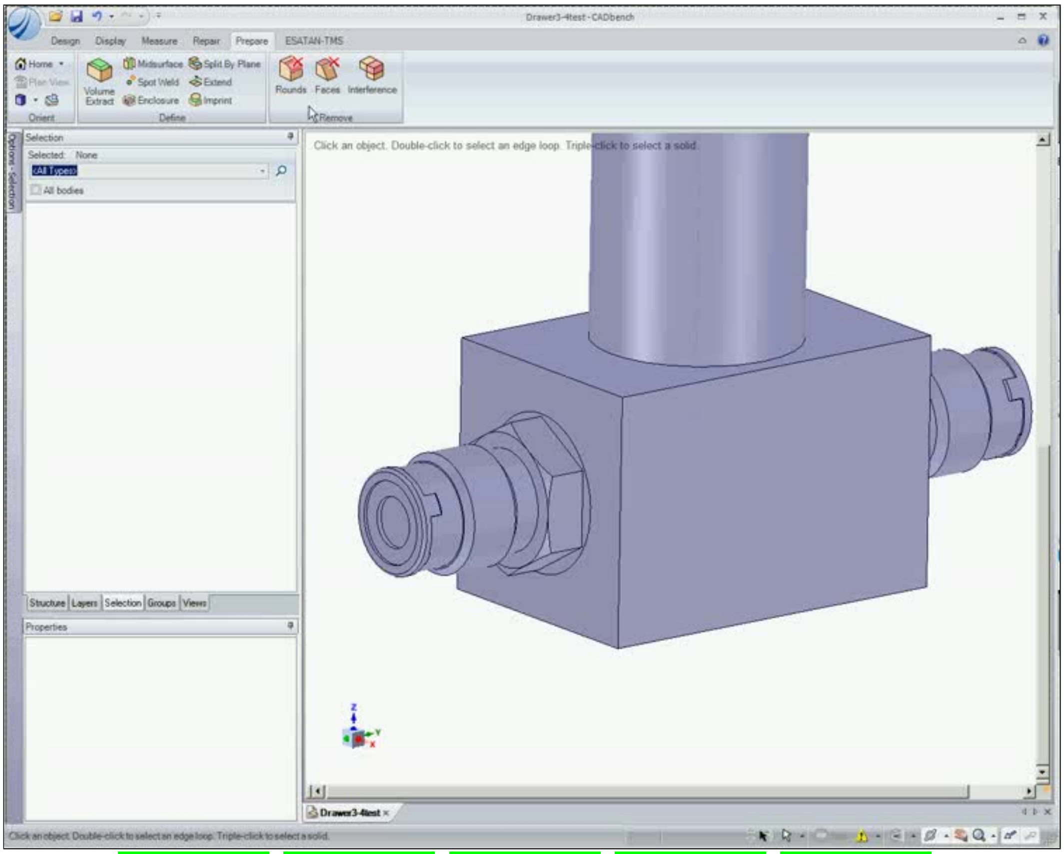

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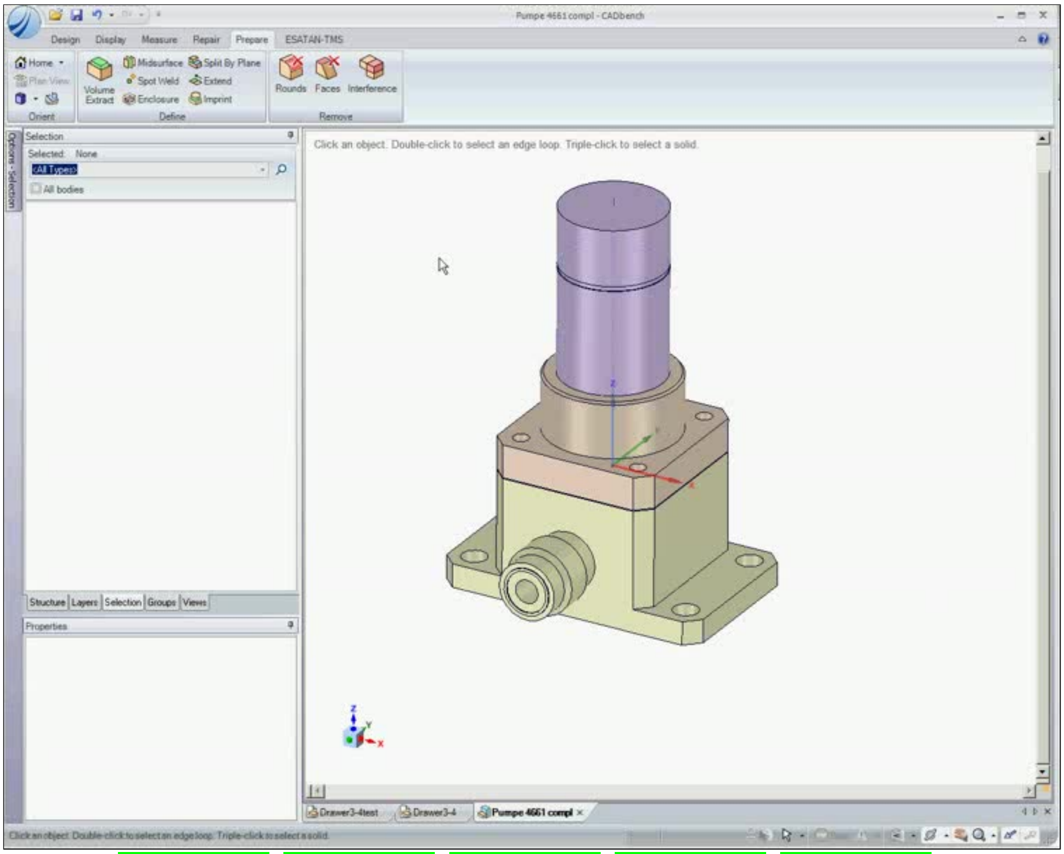

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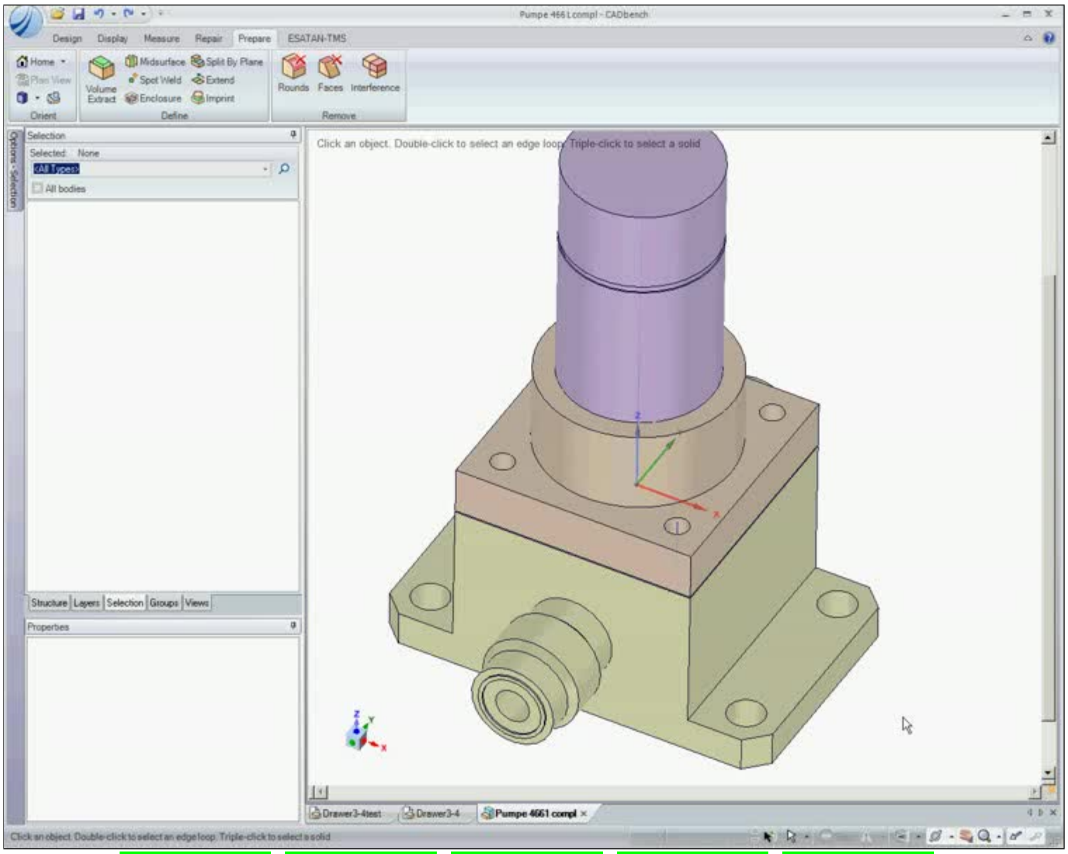

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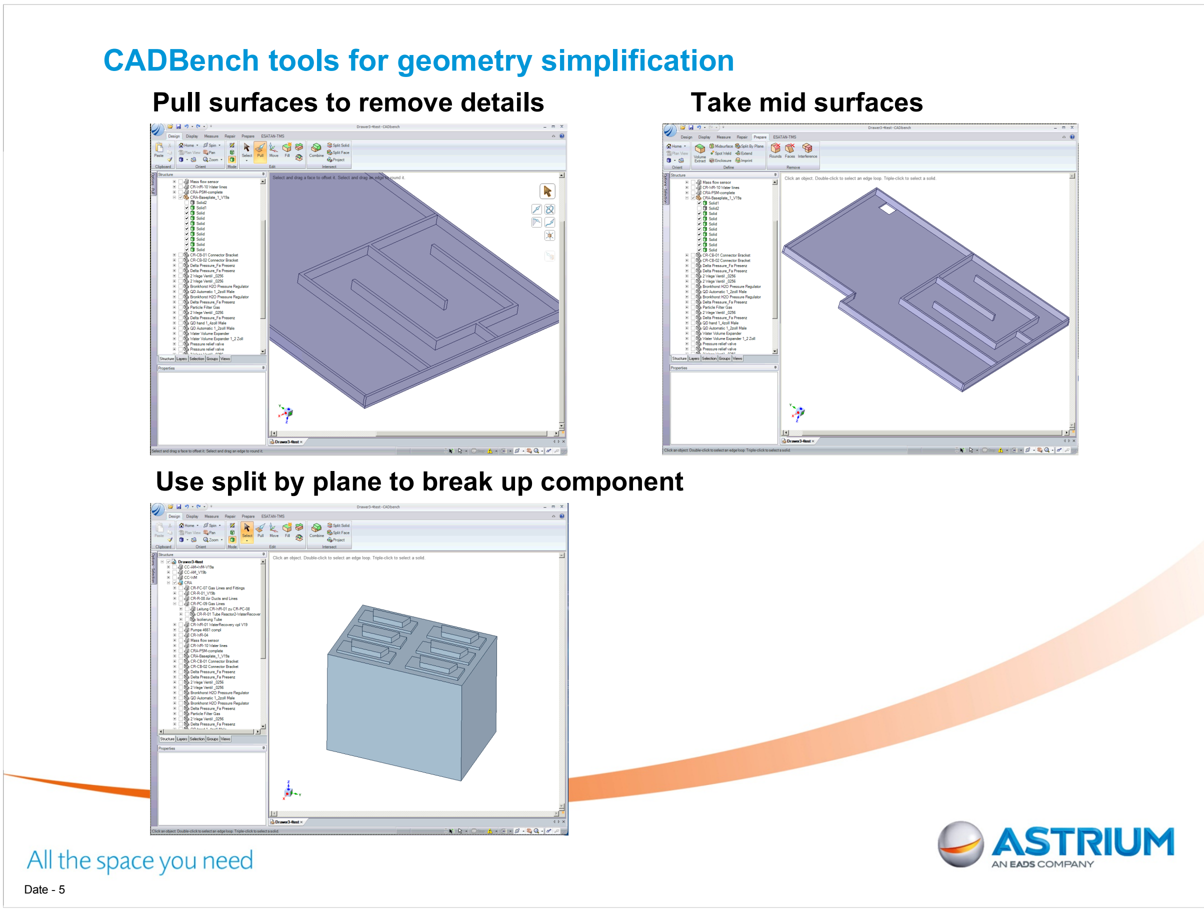
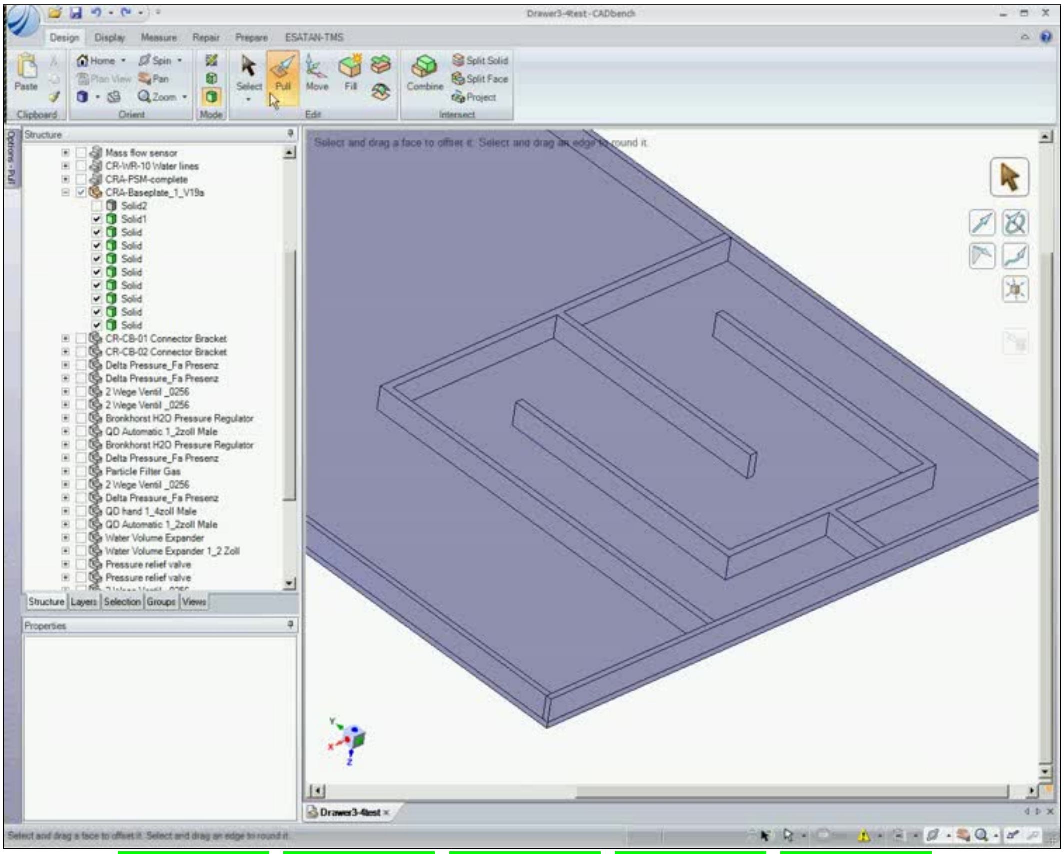


1. Surfaces can be pulled to remove features.

2. For thin surfaces where thickness is negligible a midsurface can be taken between two planes. This will result in a single surface imported into ESATAN.

3. One of the main issues is that in CADBench components are identified as single 3D object. To aid shape recognition it is necessary to split components into many smaller objects that are recognised ESATAN TMS shells



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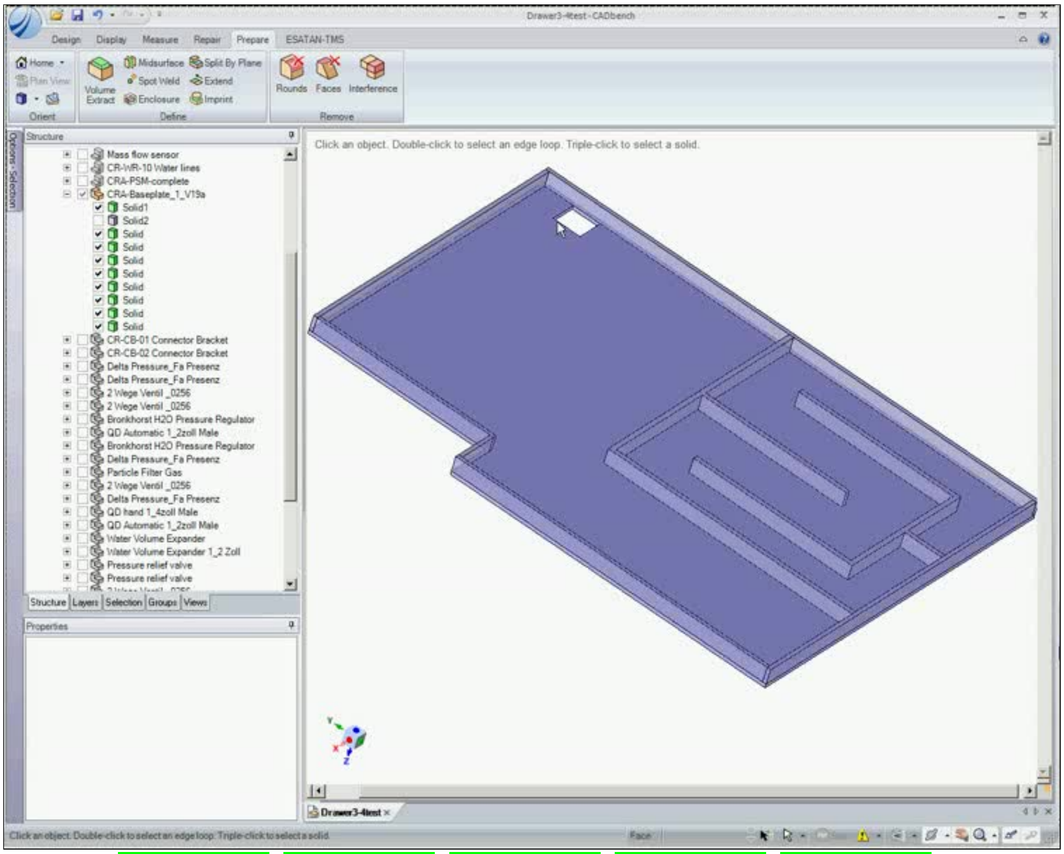

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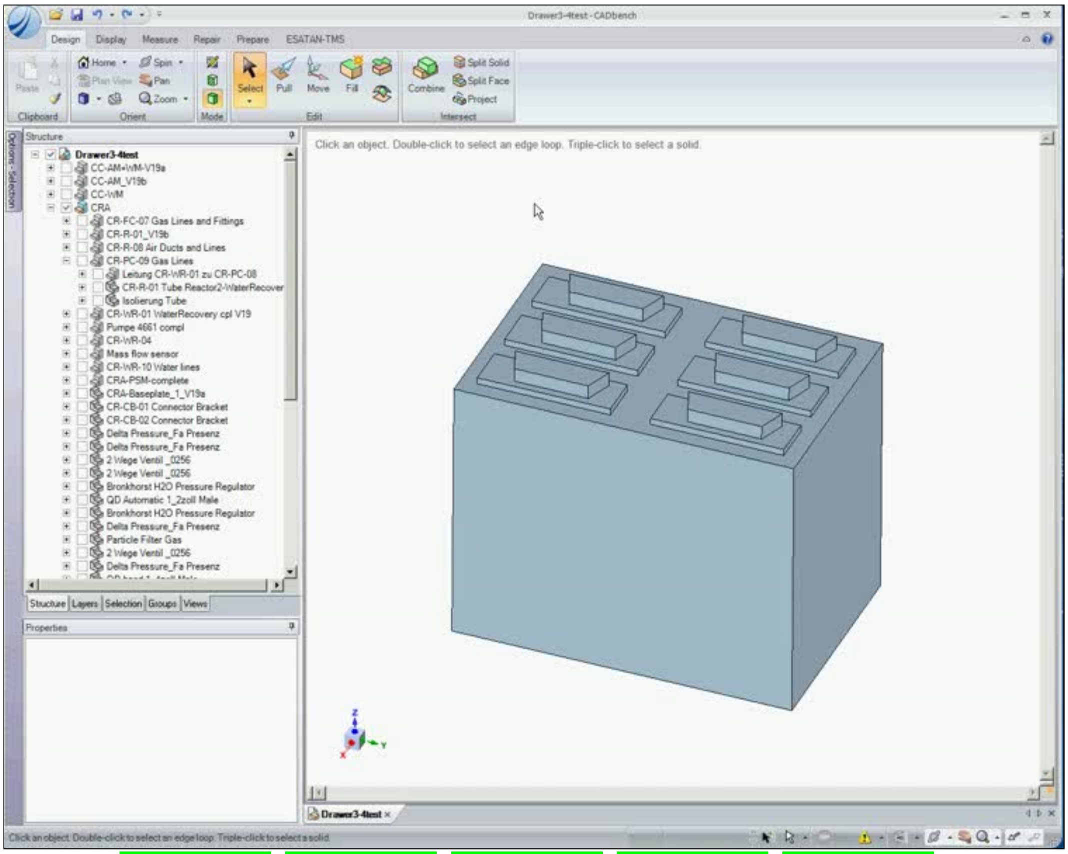

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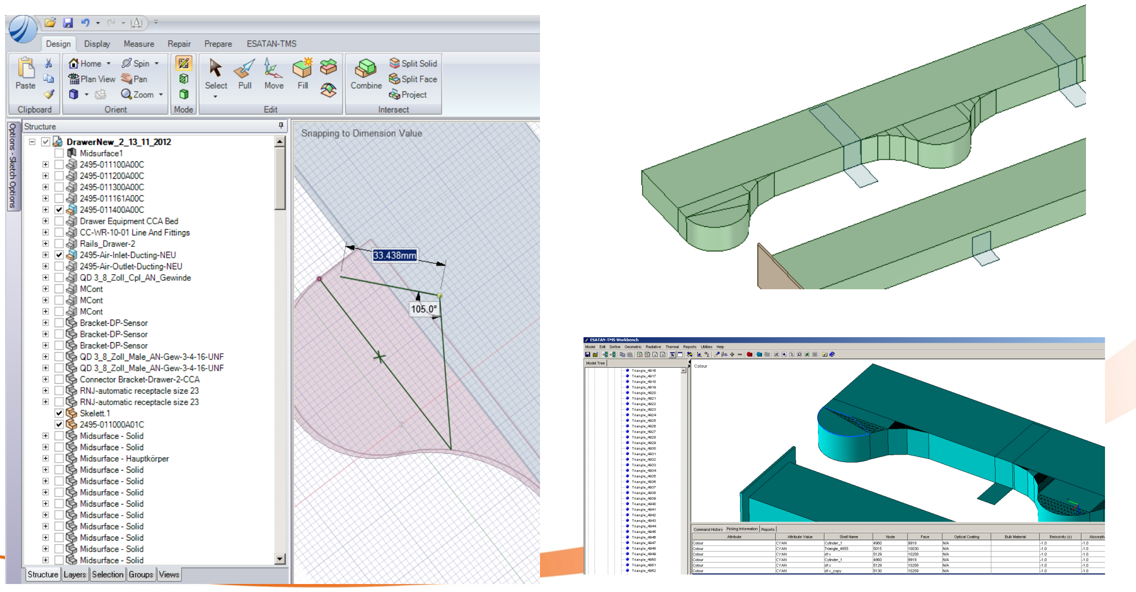
CADBench tools for geometry creation

Sketching dialog is not present in CADBench, however can create geometry with hotkeys. Press L to create line, C to create circle etc.



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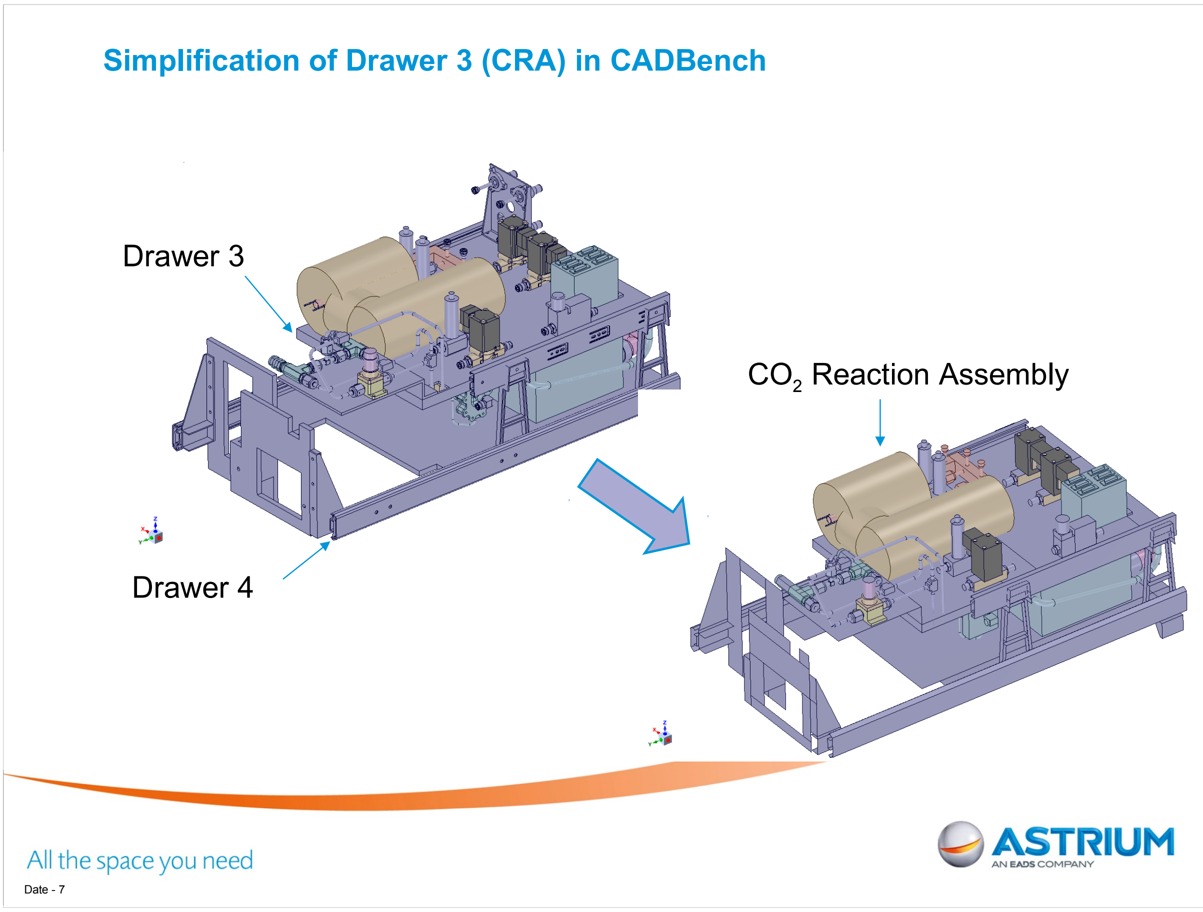
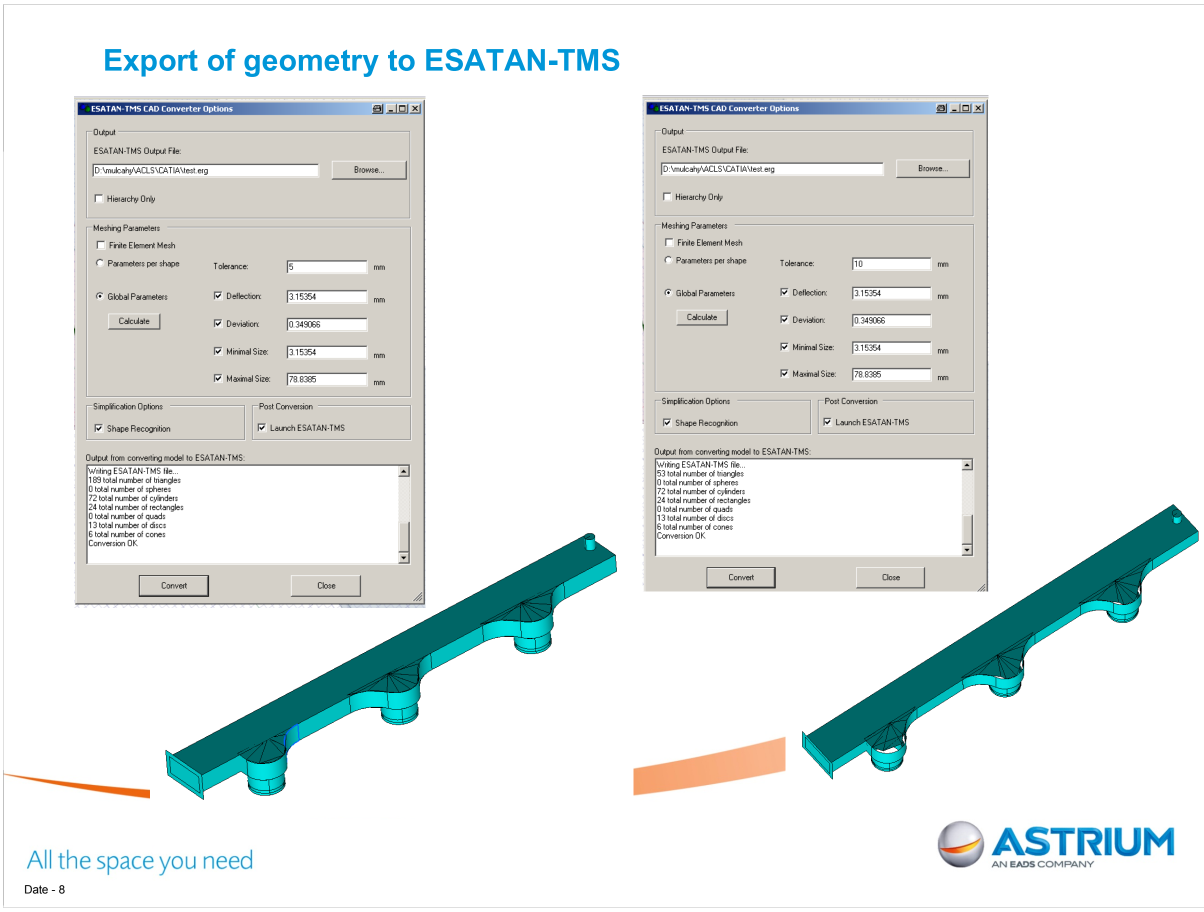
The CADBench tool seems tailored to edit existing CAD files rather than create new geometry. The geometry dialog box is not present in the GUI of the current CADBench version but it is possible to draw in the model by entering sketch mode and using hotkeys to instruct the software to draw a line or circle. The geometry can then be created by selecting points in the GUI.

Seems more a bug than a feature. But it‘s a useful bug. Allows shapes which will not be reconized automatically to be approximated.



Gas lines omitted initially from model building to simplify construction and focus on heat dissipating components that are connected to the heat plate. These can be added at a later date.

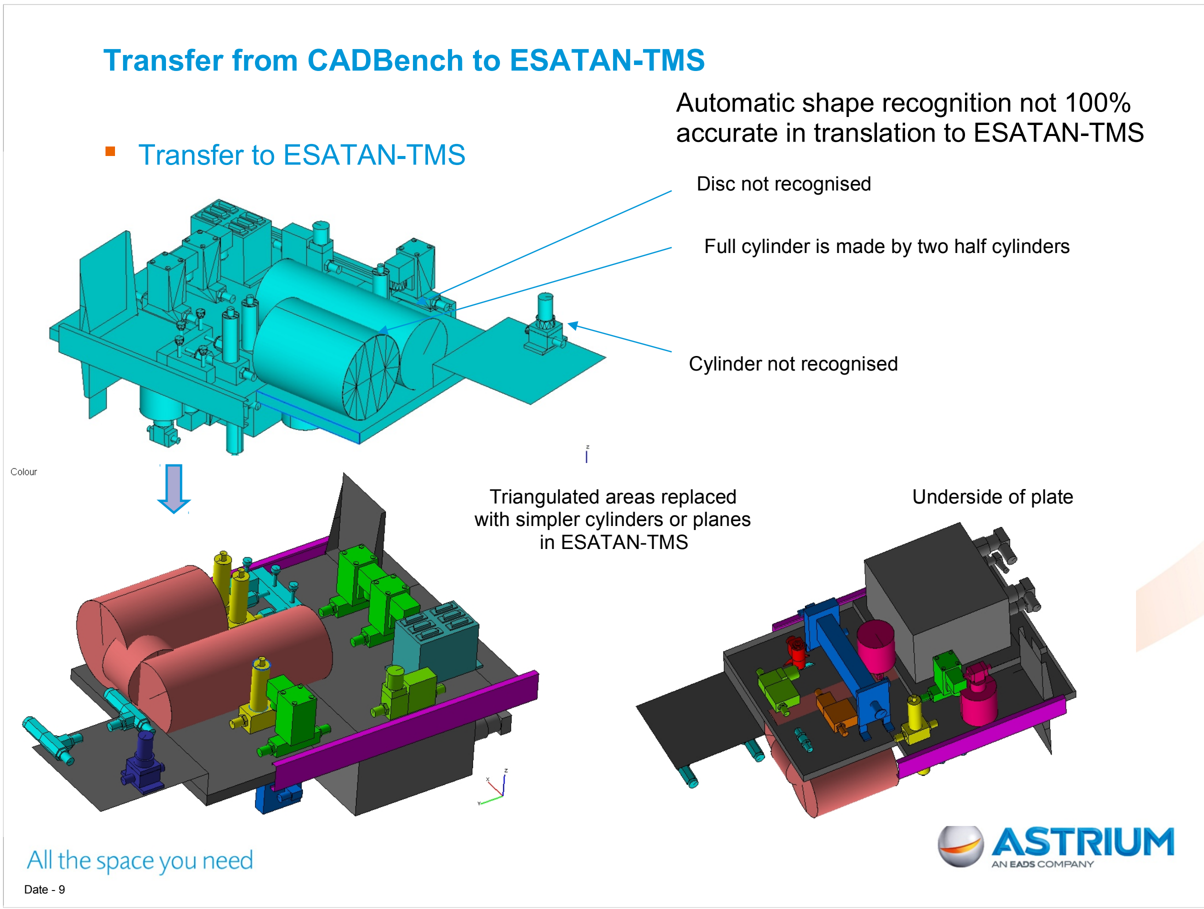
Only radiation and conduction are considered. No conduction through gas. The heat removed by convection at the cold plate attached to the base-plate is considered.



Exported dialog box provides a variety of parameters for varying how CADBench converts CAD file to erg.

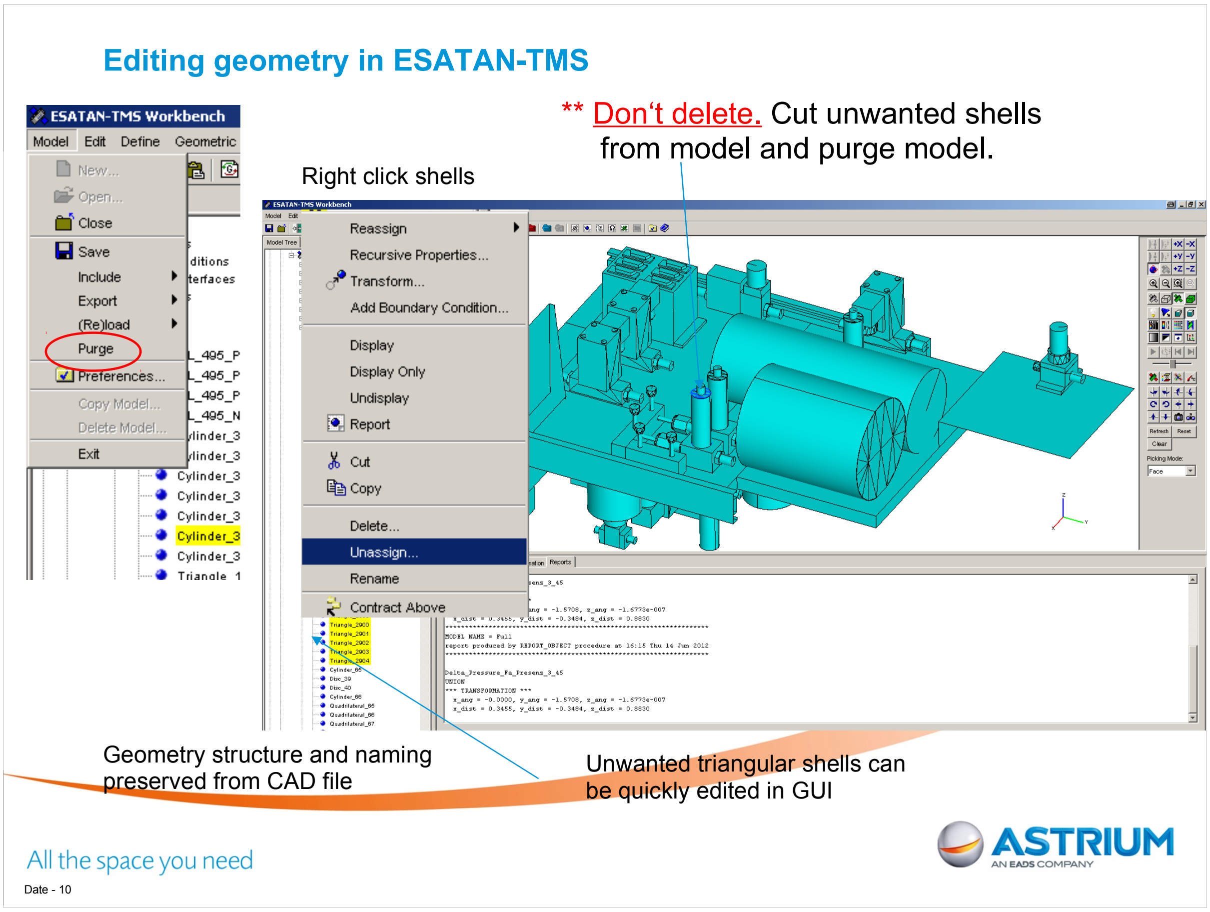
Shape recognition works for simple primitives most of the time. There is an issue with trinagulating some discs and cylinders.

Unknown shapes are triangulated. There is a trade off between accurately capturing shape and having excessive shells.



Automatic generation of ESATAN-TMS shells use shape recognition algorithm. Some issues with unecessary triangulation of standard primitives, discs and cylinders in particular.

This requires some manual editing of the ESATAN-TMS geometry to reduce the number of shells. Too many shells in the GUI in ESATAN can cause memory problems, increases radiation coupling calculation etc.

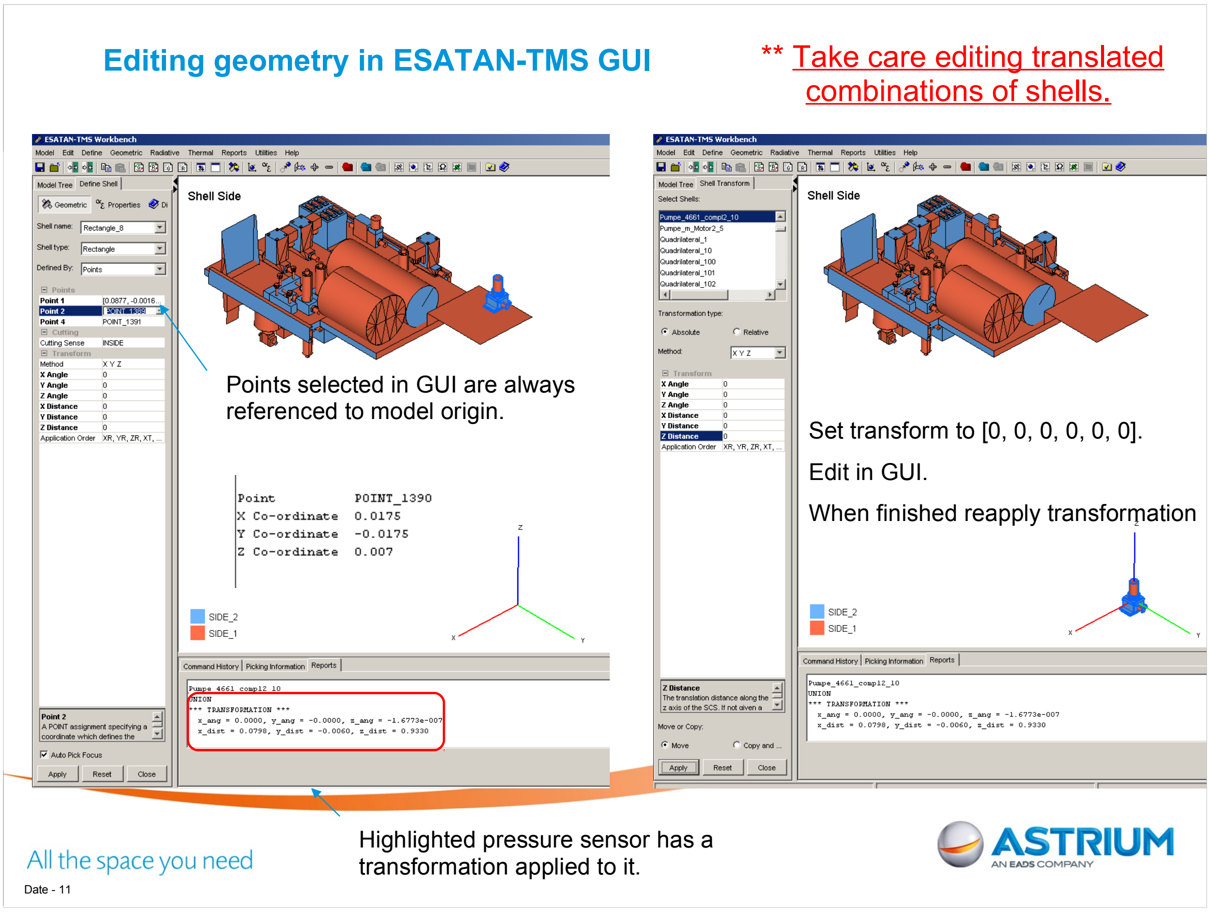


The geometry structure is preserved from the CAD file.

The triangulated shape provides points from which simpler shells can be created in ESATAN-TMS. Then the triangles can be removed.

Deleting shells directly in the GUI is very slow and for large numbers of shells it can cause the software to freeze or crash. The work-around for this problem is to cut unwanted shells from the model and past the shells outside the model. Unassign achieves the same effect. Then purge the model. The purge function is found under Model – menu at the top right of the GUI.

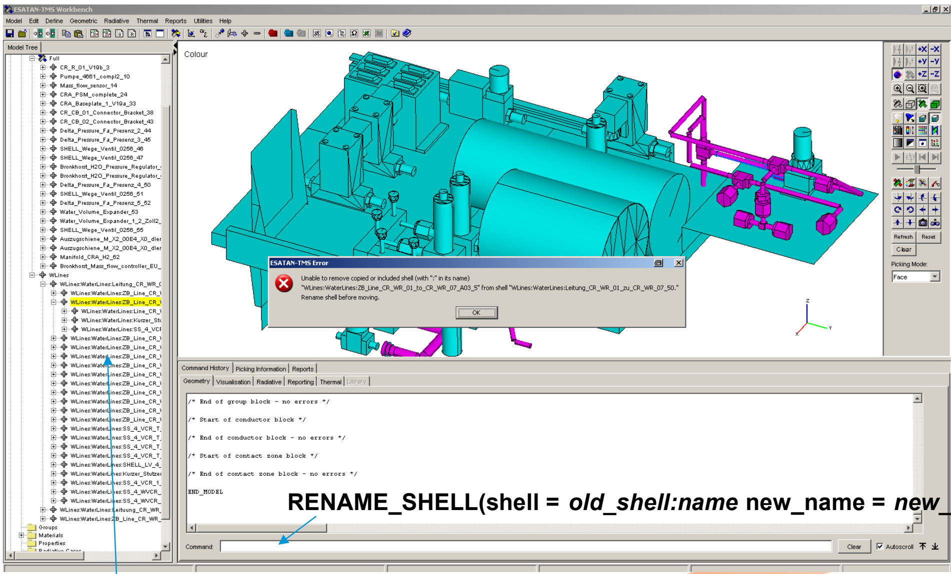
Purging removes all shells not assigned to the model.



When using selecting geometry points for editing the model in the ESATAN-TMS GUI. The point values returned are defined by the absolute x, y and z distance from the model origin. When editing combinations of shells which have a translation applied to them this will result in geometric errors. The workaround is to record the translation of the combination. Set it back to the origin. Edit the combination as desired in the GUI and then re-apply the original translation.

Updating geometry by using Include Geometry, Include Model

The text file .erg where the geometry is saved can be edited directly in ESATAN-TMS



RENAME_SHELL(shell = *old_shell:name* new_name = *new_shell_name*);

To avoid shell naming conflict. Newly included geometry is prefaced with new_shell_name:

This can create problems later on as shown in error message

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It is desirable to be able to work on separate components at different times and then import them into an overall ESATAN-TMS model at different times.

When translating geometry from CADBench ESATAN-TMS names the created shells sequentially as they are created, rectangle_1, rectangle_2 etc.

These shells are often defined in terms of real points which are also named sequentially and will also conflict.

ESATAN-TMS avoids problems by prefacing shells with Shell name and a colon. Why colon. Cannot normally name shells with colon in them. Cannot copy. Have to first rename.

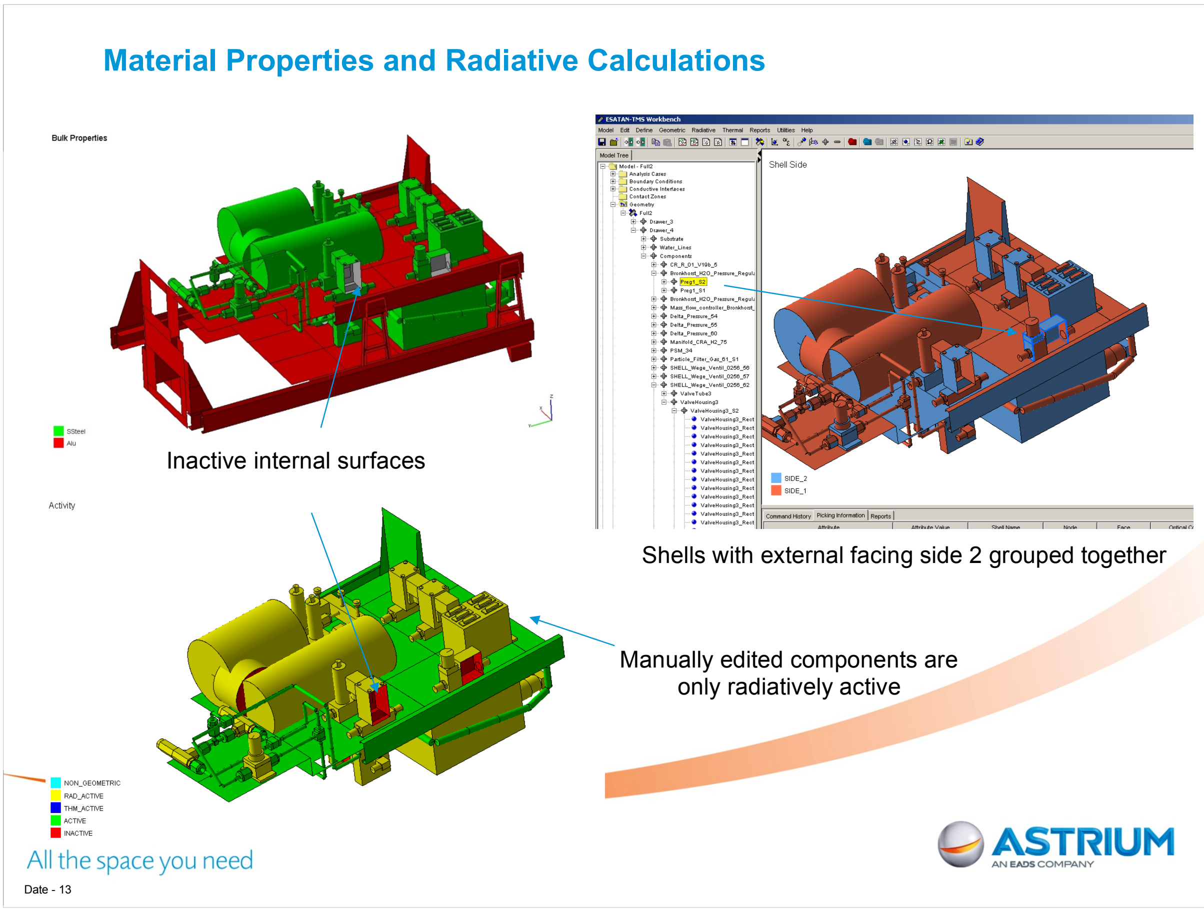
Naming becomes very long.

It is possible but far too time consuming to change the shell names in the GUI.

One effective way to deal with this issue is to edit the .erg text file directly using a find and replace function to change the shell names. The .erg file is much bigger and contains more informaton than the .sysbas file used in THERMICA and therefore not as easy to manually edit.

Its also possible to enter in commands directly to the command window. So a list of name changes can be prepared in a text file and the commands can be copied all together into the command window.

Including model seems to be initially less problematic. However I have seen errors and crashes when building cumulatively, i.e. including a model which itself includes a model. Java runtime error about inaccessible memory.



Shells can easily have material and thermo-optical properties applied to them. Each shell has a two sides and each of these sides can have different properties.

When importing geometry some shells will have side 1 facing out and others will have side 2 facing out. For the radiation calculation it is necessary to have the inner surfaces inactive.

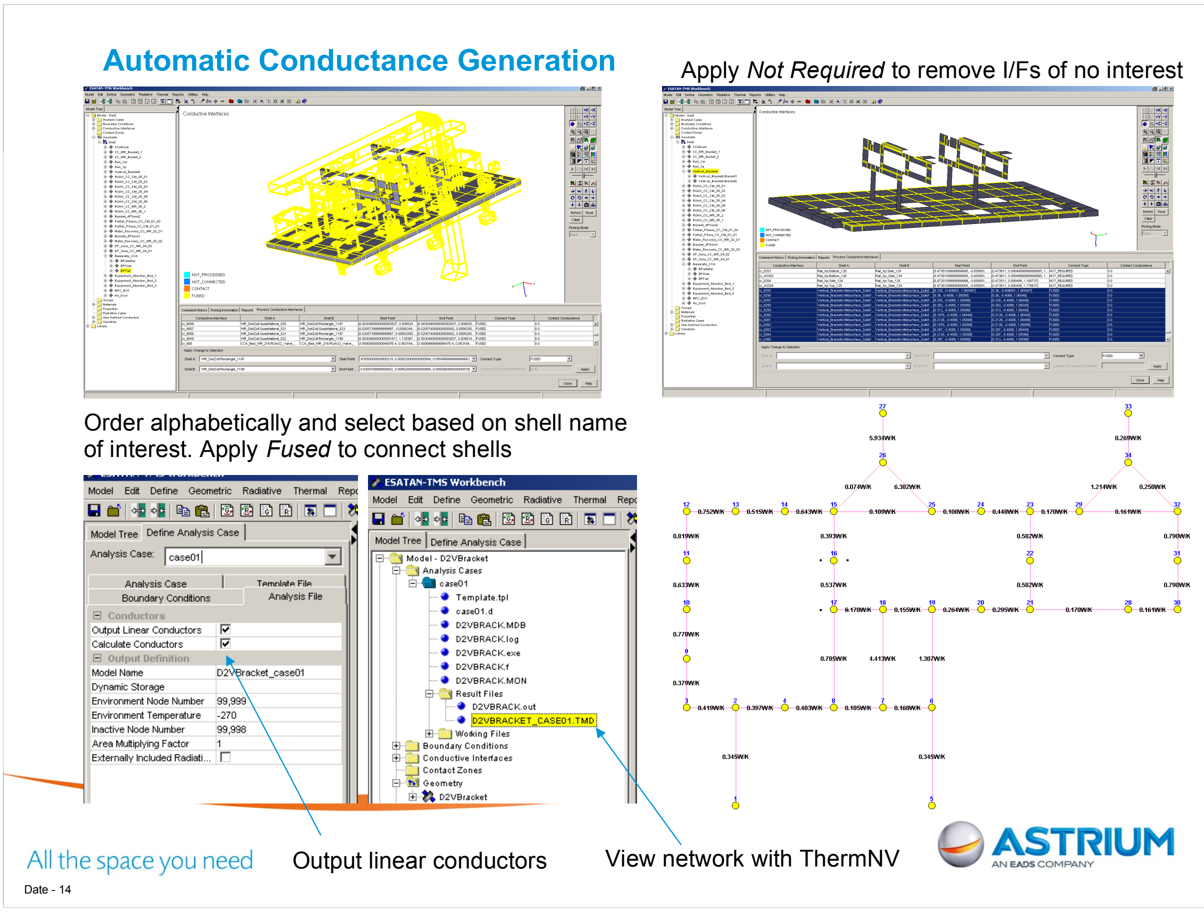
Shell activity can be corrected by visual checking and editing.

Ideally a solution where the shell can be selected and the side automatically reversed would be very useful. This was mentioned in a presentation last year

However it is worthwhile to group together in the model tree, shells with side 2 facing externally. This makes it much easier to change entire groups of shell properties later on rather than having to manually pick each shell.

Can take care when initially importing the geometry from CADBench to correct it so that side 1 is always facing out.

Multiple radiation cases can be run for example with different emissivities and the model can be run with these separate cases.



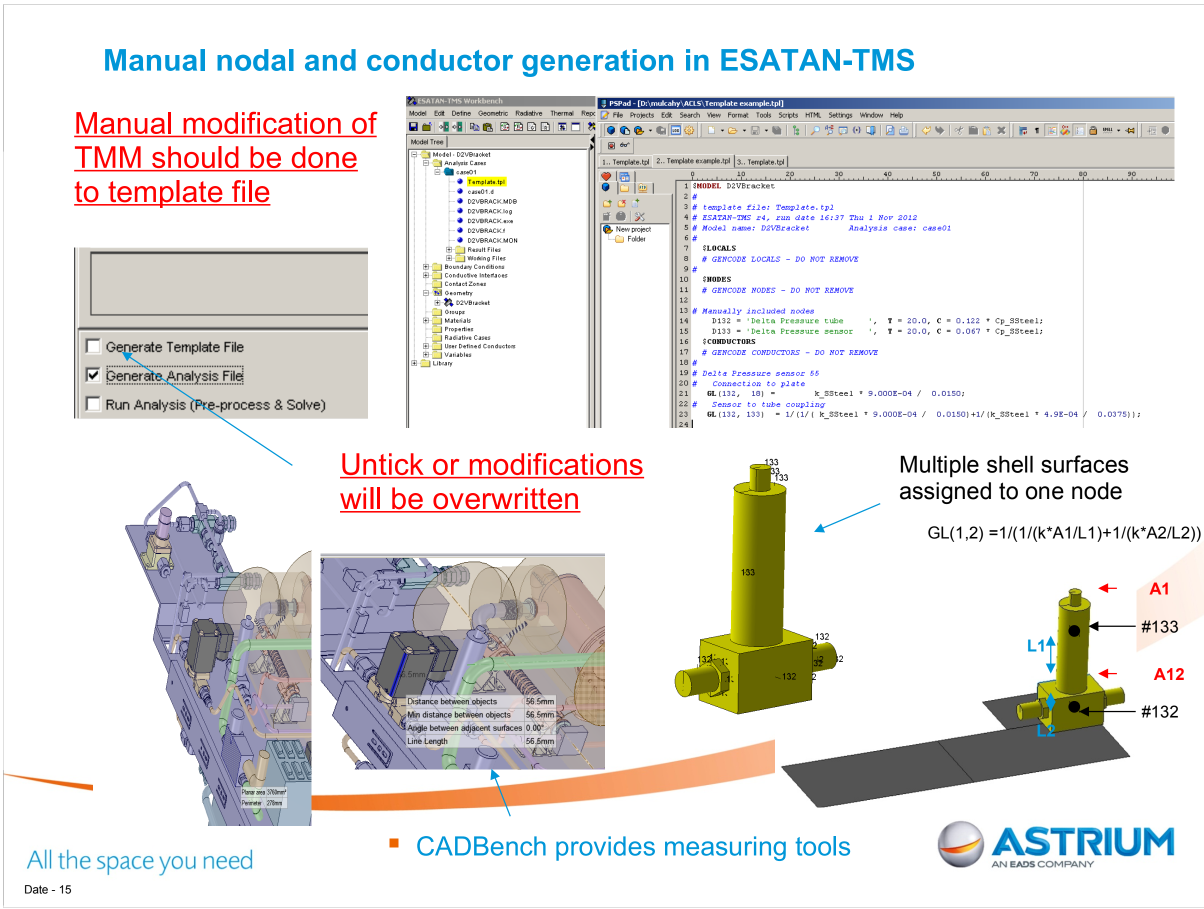
ACG initially detects all planar I/Fs. This makes visualisation difficult. Apply Not Required to all but I/F of interest to remove display from the GUI.

Use ordering options in dialog under main GUI to get only shells and components of interest.

Ensure output linear conductors is applied. Leave node number as 0 on nodes that you want automatically calculated.

It can be seen that when using the split by plane tool in CADBench you need to be thinking about how you want your nodal network to look when the geometry is ESATAN-TMS

A case needs to be run to generate the TMD file to view the nodal network in ThermNV. Might be nice to not have to run the model to view the conductor matrix.



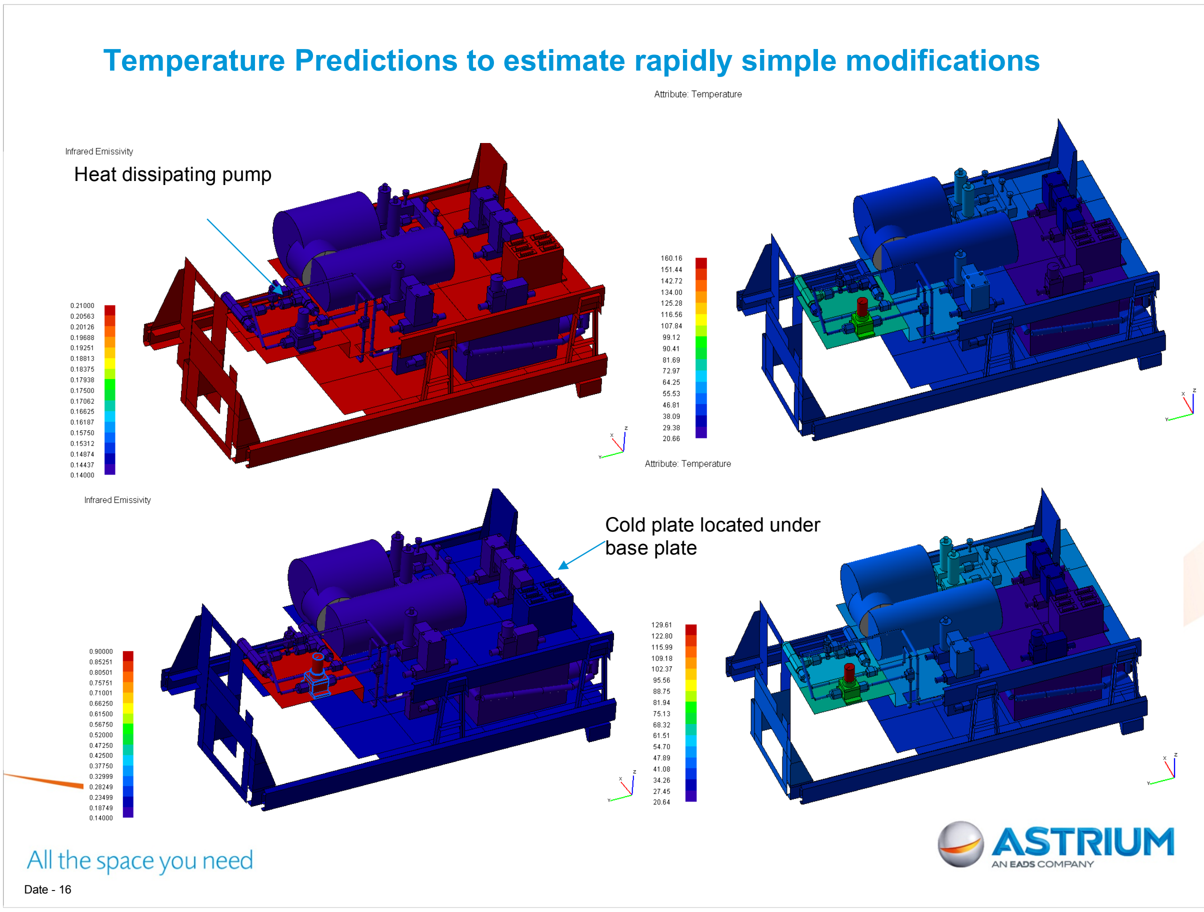
ESATAN-TMS calculates node capacitance and conductors for thin shells only not solid components

Certain parts such as the base plates can be quickly modelled but others such as solid valves must be evaluated manually and input into the thermal model.

Capacitance based on volume and conductor based on areas and lengths measured in CAD file.

When adding manual modifications to the TMM, these should be added to a template file not the analysis file.

Otherwise any changes in the GUI such as a new radiation calculation will overwrite the manual changes in the analysis file. When modifying the template manually, ensure that when you rerun analysis the box for generating a new template file is **not ticked** or the template will be overwritten.



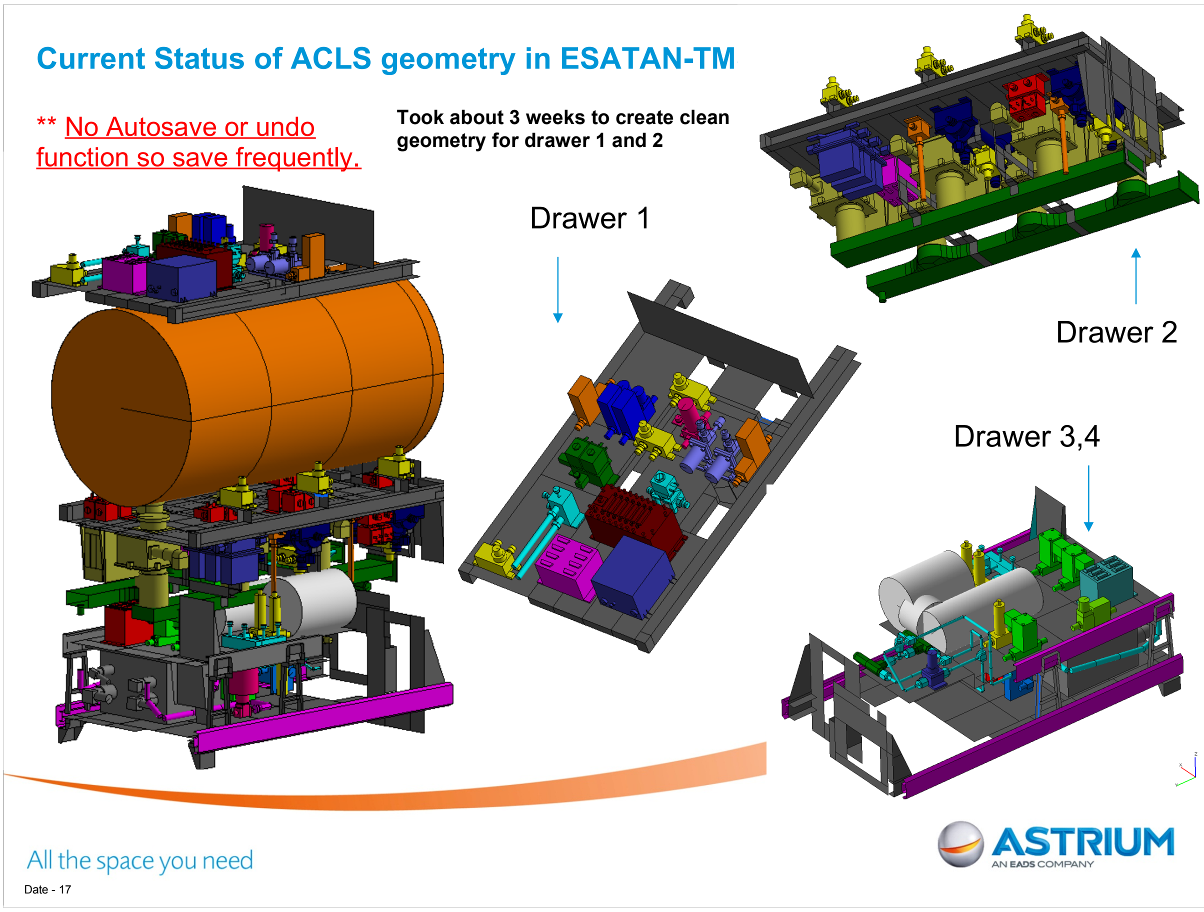
Initial analysis carried out assumed the outer insulated surface of the CRA (CO2 reaction Assembly) was at 45 celcius.

The full ACLS rack will be crowded with other heat dissipating components so a relatively warm surrounding radiative sink temperature of 40 C was taken.

The coldplate maintained components relatively cool. Although a water pump located far from the cold plate dissipating 14W was found to reach relatively high temperatures.

A quick measure for mitigating the hotspot was to investigate modifying the surface emissivity of the pump and its surroundings. This did drop temperatures by 30 C.

Further measures can be investigated relatively quickly in ESATAN-TMS, e.g. adding radiator surface to pump, changing material of pump adapter, increasing plate thicknesses, adding thermal straps etc.



The current status of the ACLS geometry in ESTAN-TMS is highlighted. Drawer 3 4 has been run as a steady state thermal model. Drawer 1 and 2 are ready to begin radiative calculations.

There is a definite improvement in productivity with experience. Initial to create the geometry of drawer 3 and 4 took about a month. To create drawers 1 and 2 which have more components took about three weeks.

Conclusions

- The CADBench plug-in is very effective for taking 3D CAD files and converting to Thermal Geometric Models.
- The software has a learning curve but a user can quickly learn how to simplify CAD files to get clean geometry for thermal radiation calculations.
- Design changes can be rapidly transferred to thermal models.
- The ESATAN-TMS software helps automate calculations in some areas while allowing the user direct access to the TMM for solutions not easily implemented in the GUI.
- The ACLS model proved a good task for investigating the abilities of the current software. Outlining it's advantages and highlighting remaining challenges.

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For the ACLS drawer 4 analysed the project took ~ 6 weeks to go from CAD data to first thermal analysis results. This time included the user becoming familiar with the CADBench software.

The deadlines for this project are challenging with final design on the layout of the system still undergoing changes.

CADBench and ESATAN-TMS gives us the ability to work directly from CAD files as they are updated. This allows the thermal analysis to respond much more rapidly to changes.

Work can be performed concurrently rather than waiting for a frozen design to be set before beginning thermal analysis. Its also useful to be able to suggest specific design changes based on thermal analyses before becoming too far along the design path.