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Abstract

This document contains the minutes of the 20th European Thermal and ECLS Software Workshop held at ESA/ESTEC, Noordwijk, The Netherlands on the 4th and 5th October 2006. It is intended to reflect all of the additional comments and questions of the participants. In this way, progress (past and future) can be monitored and the views of the user community represented. The final schedule for the Workshop can be found after the table of contents. The list of participants appears as the final appendix. The other appendices consist of copies of the viewgraphs used in each presentation and any related documents.

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20th European Workshop on Thermal and ECLS Software
ESTEC, Noordwijk, The Netherlands

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10:00	**Status Update on STEP-TAS** Hans Peter de Koning, ESA/ESTEC, Netherlands
10:30	**New features of Baghera View** : extended reporting mechanism of thermal models with synchronisation based on XML and STEP-TAS Elisa Ciuti, CSTB, France
11:00	**Coffee break**
11:30	**Thermica V4** Timothée Soriano, Astrium, France
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14:30	**Closure** Harrie Rooijackers, ESA/ESTEC, Netherlands

Day 1

Wednesday 4th October 2006

1.1 Workshop Opening

M. Klein, the Head of the Thernal and Structures Division at ESA/ESTEC, opened the 20th edition of the workshop that had been founded by C. Stroom (retired). The workshop had always been an informal event with open discussions and was one way of helping to build and maintain the European space thermal community. He felt that it was very important to have and to support such a community.
Over the years the workshop had evolved to have a much wider scope. It was no longer limited to ESA sponsored thermal software, but now included presentations and discussions about R&D projects, non-ESA tools, ECLS software and lessons learned. The workshop had changed to satisfy the needs of the users. As a result, it had increased its attractiveness and was attended by a relatively large proportion of the community. The workshop was, without any doubt, a major event for the space thermal community.
The workshop offered the opportunity for exchange and discussion of ideas, especially concerning the on-going R&D work. There were clear trends in the work in progress, with effort being concentrated on `STEP-TAS`, involvement with ISO, model reduction, system-level tools, post-processing, the integration of tools, as well as R&D and the investigation of new methods required for new areas such as high stability thermal systems.
The workshop also allowed the European policy in the domain to be communicated to the participants, with harmonisation efforts across the agencies and industry focussing on data exchange and the sharing of ideas via the R&D pool. On the ECLS side, the development of `EcosimPro` had been a major contribution to the user community.

1.2 Welcome and Introduction

H. Rooijackers (ESA/ESTEC) welcomed everyone to the 20th edition of the workshop and mentioned that ESA would be offering a special workshop dinner to celebrate this important milestone. (See appendix A)
He explained the main aims of the workshop:

- to allow an exchange of views on the use of the thermal and ECLS analysis software
- to provide a forum for contact between the developers and the users
- to present new versions of the software and to solicit feedback from users

1.3 Status Update on STEP-TAS

HP. de Koning (ESA/ESTEC) gave a brief history of the STEP-TAS development, and described the current work and plans for the immediate future of STEP-TAS. Some effort was under way to subdivide the implementation of STEP-TAS into functionally related areas that would be reusable in other space fields. He explained that STEP-TAS was being prepared for submission to ISO. (See Appendix B)
J. Thomas (ALSTOM) asked whether there would be any significant differences between STEP-TAS version 5.3 and the version 6.0 that would be submitted to ISO. HP. de Koning said that the versions would have the same contents, but 6.0 documentation would be reformatted to conform to ISO requirements. Version 6.0 would include UML diagrams, but the protocol itself would be basically the same.
J. Thomas asked which version would be proposed for the US tools. HP. de Koning said that both the TRP activity for integration in the European tools and the separate development for the US tools should target the 6.0 version. Version 5.3 would be an intermediate documentation release. 6.0 would then be technically the same, but would have more diagrams and some reformatting of the Express schema. In the current planning, version 6.0 would be ready before the kick-off of the TRP activity.
H. Sdunnus (eta_max space) asked whether there was any cross link to the STEP-SPE development. HP. de Koning said that STEP-SPE was based on STEP-TAS version 5.2, so it was out-of-sync at the moment. However, part of the upgrade of TASverter to handle 6.0 would include a 5.2 to 6.0 converter. Before any formal submission of STEP-SPE to ISO, it would be necessary to decide whether to resync STEP-SPE with STEP-TAS version 6.0, or to keep STEP-SPE as completely separate and maintain a mapping between the two. Such a mapping would be quite simple, but the two standards would not be 100% compatible.
HP. de Koning explained that it was always difficult to synchronise everything in advance, and that this was one of the main problems with standards. Everyone wanted to make sure that their standard was mature enough to be submitted to ISO and would remain stable over long periods of time. ISO performed a systematic review of an ISO standard every five years, and in principle any changes or upgrades should be backwards compatible. He felt that this was important in the interest of long term archiving of models.

1.4 New Features of Baghera View: extended reporting mechanism of thermal models with synchronisation based on XML and STEP-TAS

E. Ciuti (CSTB) described the latest additions to Baghera View to allow improved documentation of models, and gave a live demonstration of the new features. In addition to the existing capability to compare model versions by superimposing them to see the differences, the reporting module had been extended to include a document template scheme and to provide documentation of the changes between model versions. (See appendix C)
There were no questions.

1.5 SYSTEMA/Thermica V4

T. Soriano (Astrium) presented the new plug-in architecture of SYSTEMA, and the recent

developments of Thermica to be included in the current release. Thermica would also be the first plug-in for the SYSTEMA release in 2007.
A. Aguilar (Aguilar Consulting) asked whether it was possible to select a temperature distribution of the planet based on latitude and longitude, whether albedo could be modelled as non-isotropic, whether the refraction of materials was handled, and whether it was possible to model both 2D and 3D reflection. T. Soriano said that most of these features were already available in version 3 of Thermica. Temperature maps of the Earth could be provided via text files, although there was no means of visualising these maps, and so in complex missions it was hard to know if the correct properties were being used. Therefore this feature was being redefined in Thermica version 4 to use interactive maps so that the user could see the properties of the planet changing over time or latitude or longitude. This was planned to be available in the last quarter of 2007.
T. Soriano also wanted to improve the definition and handling of material properties. He wanted to have tabs that would allow interpolation in terms of temperature, incident angles and so on. He said that this would not be in the first full release, but would be included later.
HP. de Koning (ESA/ESTEC) wanted some clarification about the support for 95% of ESATAN in Thermisol: what was the missing 5%? Would this be included as the tool evolved? T. Soriano explained that these were mostly small differences. Each tool now lived its own life, and Thermisol would need to evolve to remain compatible. The 5% was made up of various ESATAN library routines that were not provided in Thermisol. ESATAN also supported multi-dimension arrays, but the Astrium users had only ever needed 1D and 2D arrays, so arrays with more than two dimensions were not supported in Thermisol. Any other differences were minor.
HP. de Koning wanted to know what evolution was planned for Thermisol in version 4. T. Soriano said that the basic functionality would be the same, but there would be changes to the output results file to use HDF5 instead of the current neutral files.
H. Brouquet (ALSTOM) asked about the compatibility comparison between Thermisol and ESATAN and wanted to know which version of ESATAN had been used. T. Soriano answered that the comparison had been based on ESATAN version 8.

1.6 ESARAD Status

J. Thomas (ALSTOM) presented the new features that had been made available in the releases of ESARAD since the last workshop, and described the current developments in performance and interactivity. He then gave a live demonstration of the new user interface, and the improved ways of creating the geometry using the new property sheets, points and directions. Other work planned for ESARAD version 6 included further interactivity improvements and expansion of the CAD handling. He was also hoping that they would be able to include some additional surprises, but he could not say any more at the moment! (See appendix E)
There were no questions.

1.7 SINAS: a generic tool for mapping lumped parameter temperatures to a finite element model for thermo-elastic analysis

S. Appel (ESA/ESTEC) described the principles behind SINAS, a tool that allowed the user to take the results of thermal analysis tools using lumped parameter networks and transfer them to thermo-elastic tools using finite element methods. SINAS was an old tool, and had not seen any

active development for some years, but it had been used recently on ESA projects, distributed via the ESA R&D pool, and was interesting for the current discussions about linking tools from the different disciplines. (See appendix F)
M. Gorlani (Blue Group) asked what happened if the model had high conductive connections as needed for radiators. Did SINAS handle this automatically? S. Appel said that SINAS also offered the possibility to handle constraints like NASTRAN MPCs [Multi-Point Constraints]. If the model had high coupling between nodes, the user could have numerical issues. MPCs allowed SINAS equations to treat the FE-node temperatures as being equal, or to apply other linear combinations. The constraints were introduced through Lagrange multipliers.
A. Aguilar (Aguilar Consulting) said that for the thermo-elastic analysis it would be necessary to change the rigid elements into bars to avoid additional spurious stresses. S. Appel agreed, but said that this only applied to rigid elements with non-zero length. In NASTRAN 2005 it was possible to add coefficients of thermal expansion [CTEs] to avoid this problem.
HP. de Koning (ESA/ESTEC) asked the audience whether it would be useful to have a set of academic test cases to use as benchmarks to check all sorts of tools and the mappings between tools. A. Aguilar said that NASTRAN and other CAD tools came with example models, and which could be recomputed. This had been completely tested as part of a previous converter, six years ago. HP. de Koning said that he was thinking more of test cases to be placed in the R&D pool as benchmarks. He wondered about NAFEMS benchmarks. S. Appel said that NAFEMS models addressed finite element only, and the thermal community needed correspondence with lumped parameter models.

1.8 ESATAN/TMG Demonstration

H. Brouquet (ALSTOM) outlined the ideas between linking ESATAN and TMG, two tools that had been established in their own areas for more than twenty years. He then gave a live demonstration of using ESATAN/TMG. He showed how ESATAN thermal nodes could be introduced to the TMG model. After solving, the ESATAN-calculated temperatures could be shown, not only on the original TMG model mesh, but also on other related meshes. (See appendix G)
HP. de Koning (ESA/ESTEC) asked what kind of finite element shapes could be imported. K. Duffy (MAYA) said that both linear and parabolic QUADs, TRIs and BEAMs were supported, as were TET, HEX and WEDGE solids.
S. Appel (ESA/ESTEC) noted that the demonstration had shown the generation of temperatures at FE-nodes and asked whether it was possible to generate cross-sectional temperature gradients. K. Duffy said that the demonstration hadn't shown all features, but on the map form it was possible to set a toggle to show transverse gradients, then select two groups of elements, and the tool would compute the mappings. S. Appel said that therefore the thermal meshes on each side did not have to correspond exactly. K. Duffy said that the tool could model the interior, to represent a honeycomb for example.
T. Soriano (Astrium) asked whether the calculation of radiative coupling was available in ESATAN/TMG. H. Brouquet said that TMG already provided radiative calculations itself, so ESATAN/TMG was not using ESARAD, or even the same radiative methods as ESARAD. ESATAN/TMG was intended to be used to supply temperatures for thermo-elastic analysis. It was still possible to use TMG for radiative calculations, or with ESARAD if in-orbit calculations are required.

1.9 A system for solving fully coupled thermal-structural problems using TMG and NASTRAN

K. Duffy (MAYA) described a framework for coupling TMG and NASTRAN to provide analysis results where thermo-elastic distortion could affect the thermal control system. Each tool was used to solve a quasi-steady state problem, was loosely coupled to the other using a Meshed based Parallel Code Coupling Interface [MpCCI], and communicated the results via output files. (See appendix H)
S. Appel (ESA/ESTEC) had noted that in the graph shown, the maximum displacement within the dish was 2mm, and wanted to know the overall size of the dish. K. Duffy admitted that he did not know - he had not been involved in modelling this particular case - but thought that the dish was of the order of a metre or so in diameter. S. Appel said he was surprised that a 2mm deformation of a 2m dish had resulted in such a large change in the radiative conductors. K. Duffy agreed that normally there would not be such a deformation, but this was an example model to demonstrate the coupling of the tools.
J. Etchells (ESA/ESTEC) expressed concern about the overhead needed as the coupled solution stepped between the two tools each time. The conductor matrix wouldn't change between steps, but the radiative coupling matrix would. Therefore the tool would need to recompute the matrix at each iteration and this would be a large overhead. K. Duffy agreed that it took a lot of computation.
HP. de Koning (ESA/ESTEC) asked about the convergence per iteration, and how many switches back and forth between the tools were required. K. Duffy said that the coupling was quite weak, so convergence didn't take many iterations.
M. Huchler (Astrium Satellites) asked whether the recalculation of the radiative exchange factors was automatic. K. Duffy confirmed that they were calculated automatically. Once the results had been obtained from NASTRAN, TMG needed to refresh itself and put the new values in the matrix.
J. Kanis (Dutch Space) asked whether the fluxes were recomputed. K. Duffy said that they were, and it was a heavy computation. HP. de Koning asked whether there was a new computation each timestep. K. Duffy confirmed that there was because the tools did not store information between runs, and so had to regenerate each run from the new input data.
S. Appel imagined that, in principle, the deformation could be used to switch a conductive path on, or off, if there was some bending like in a thermal switch. K. Duffy said it would probably be possible to model this using the MpCCI system, but they had not considered it. There would need to be some way to feed back the pressure within such a switch. They had not implemented such a system, but it would be feasible.
S. Appel asked whether it was correct to say that the difference between using MSC/MARC and ABAQUS compared to TMG and NASTRAN were the typical space features, such as on-orbit fluxes, etc. K. Duffy said that the main difference was that MSC/MARC and ABAQUS did not handle dissimilar meshes. S. Appel admitted that MSC/MARC and ABAQUS did not handle fluxes either.

1.10 ESATAN Thermal Suite Status

C. Kirtley (ALSTOM) described the ESATAN Thermal Suite, emphasising that the licence scheme meant that anyone who had a licence for ESATAN was also entitled to run ESATAN/FHTS, ThermXL and ThermNV. He highlighted the various releases of the different tools since the last workshop, and the new features available in each release. He explained the new parametric case handling within ESATAN and the new GUI to make it easier to use the parametric case handling for sensitivity analysis. (See appendix I)

R. Patricio (Active Space Technologies) asked whether it would be possible to have a parameter case where different entities were set to different values. C. Kirtley said that it was possible to set anything via the parameter file. The GUI on top of the parameter file had been specifically designed to support sensitivity analysis, so its user interface only suppored a subset of the parameter handling language, but the parameter file itself was more flexible.
H. Rooijackers (ESA/ESTEC) asked about the parametric model: if there was a second parameter case, was this run on top of the first case, or from the nominal model? C. Kirtley said that if the user specified INITIAL state, then the parametric case would be rerun from the initial state, and using FINAL state would use the results from the previous run as the starting point.
J. Kanis (Dutch Space) said that the CSV output would give problems if there were more than 256 columns. C. Kirtley said that the output itself was not restricted to 256 columns, but users post-processing in Excel would be limited to 256 columns. Excel could not handle more than 256 columns, although the next version of Excel [2007] would handle a maximum of 16384 columns. J. Kanis suggested that ALSTOM should offer routines to split the output into multiple files. C. Kirtley said that in the example shown he had simply specified `'T*'` as the output parameter, but it would be possible to split the output into smaller and separate files by giving a subset to each output call. HP. de Koning (ESA/ESTEC) said that the general CSV handling could be added to the CSV module. J. Kanis said that DutchSpace already had a routine to split a CSV file into multiple files. C. Kirtley admitted that `ESATAN` could have done that, but it had not been done, because they felt that the output routines were flexible. J. Thomas (ALSTOM) commented that users could raise this as a feature request because ALSTOM did review the currently open feature requests when considering which features to add. He said that users could also output to GFF format, which was now the ALSTOM default for post-processing via `ThermNV`, as this did not suffer from the 256 column limit.

1.11 Presentation of the Open Frontier Framework as a Platform for Space Engineering Tools

H. Sdunnus (eta_max space) described the Open Frontier framework that had been developed to support the new `ESABASE`/Debris module, and the experiences of using the open source methodology for producing a non-commercial tool for ESA. He was not sure that the intended community was large enough to support and contribute to a pure open source model. (See appendix J)
O. Pin (ESA/ESTEC) asked whether `ESABASE` on PC meant that it was available on PC/Windows or PC/Linux. H. Sdunnus said that it was currently available for Windows, but there was a beta-release of a Linux version that was not yet operational.
HP. de Koning (ESA/ESTEC) clarified the situation with the ESA Open Source Software licence. ESA had obtained the appropriate licence for `Expressik`, (the product of an ESA activity), and there were discussions about improving the formulation of the licence for more general use. The aim was to have two licences: one to provide open access to the whole world, much like the LGPL, and the other to provide a community open source licence where the source would be restricted to *"persons and bodies of ESA member states"*. These were under development, but were progressing very slowly. The first draft had been available two years ago, but it was still not finished. There were lots of opinions about how to go about it, and a lack of information within the higher level bodies that had to make the decisions. There were conflicting views from different software developers. He hoped that the situation would be resolved within the next half year. It was still the intention for Open Frontier to be released as global open source software.

J. Thomas (ALSTOM) asked whether there would be any possibility of a short term solution with a short term licence to allow particular projects to continue, such as the ALSTOM CAD interfaces. HP. de Koning said that he had a specific licence for Expressik, so it could be done. However, what was really wanted was a generic licence where the name of the product could simply be filled in, and to avoid rediscussing everything for each product, but this was not yet available. One problem was that in the ESA General Clauses and Conditions Rev. 6, "Open Source Code" was defined as source code which ESA will distribute to members of the public free of charge. So the possibility of Open Source Software for a fee, and/or Open Source Software for a restricted community, had not been taken into account. This had lead to a big legal discussion which was taking a long time. However, it was expected that short term solutions for specific products would be available on a case by case basis.

1.12 Day Closure

H. Rooijackers (ESA/ESTEC) reminded everyone that this was the 20th edition of the workshop, and that ESA were marking the occasion by providing cocktails and a special dinner later that evening.

He emphasised that the success of the workshop was down to the participants. There had been a total of 468 registered participants for the 20 workshops, and 9 of the top 10 attendees were also at this workshop. The founder of the workshop, C. Stroom (retired), had not registered for the first one, and had not been present for the first day of the current workshop, so he had tumbled down the list. H. Rooijackers awarded certificates for joint third place to HP. de Koning (ESA/ESTEC) and J. Sørensen (ESA/ESTEC) for attending 17 workshops. Another certificate for second place went to V. Perotto (Alcatel Alenia Space) for attending 18 workshops. First place, and a bottle of champagne, went to H. Rathjen (Astrium GmbH) for attending 19 workshops!

H. Rathjen said that he remembered attending the first workshop, but had missed one due to other commitments relating to Ariane. He even remembered attending the first ESATAN release workshop, with John Turner, that had been held two years before the first thermal workshop.

Day 2

Thursday 5th October 2006

2.1 Migration of existing thermal models into new software versions

S. Kasper (Jena-Optronik) described some basic modelling guidelines used at Jena Optik, and some issues encountered with material properties when models created for ESARAD version 5.6 were processed in ESARAD version 5.8. He outlined the consequences in the generated ESATAN models. (See appendix K)
HP. de Koning (ESA/ESTEC) asked whether this problem concerning the different material thickness on two sides of a shell had been discovered through usage, or by reading the ESARAD release notes. S. Kasper answered that they had not wanted to change the model, and had discovered the problem when trying to use the new version, and had identified the cause with the help of ALSTOM support.
J. Thomas (ALSTOM) apologised to the ESARAD users for the issue with the changes in capacitance. Adding a GENMOR statement in the $VARIABLES1 block would help to avoid the problem. HP. de Koning agreed, but noted that ESATAN would still overwrite the values from the $INITIAL block. H. Brouquet (ALSTOM) answered that the material properties could be set in the $LOCALS block, where they would not be overwritten.
S. Kasper said that it was not difficult to have multiple versions of ESARAD installed, and either switch versions as required, or even change the models.

2.2 Introduction to NX TMG Space Thermal

K. Duffy (MAYA) presented details of a new version of TMG to interface to the next generation of NASTRAN. The user interface and other key parts of TMG had been rewritten from scratch to remove inconsistencies, and to work with the new, as yet unpublished, interface to the new NASTRAN. (See appendix L)
F. Koorevaar (Dutch Space) said that when he had looked at TMG five years ago it had not been as sophisticated in certain areas as other tools. Optical properties had not been good enough then for what he needed: was specular reflection now available? At that time, the radiative exchange factor calculation had involved matrix inversion: had this been replaced by raytracing? K. Duffy said that specular reflection was now handled. There were now three methods for calculating the RADKs. Two of these were viewfactor methods: one used Gebhart factors and matrix inversion, and the other used a radiosity matrix of black body viewfactors and was known as Oppenheim's

scheme. This was a disjoint method that bypassed the matrix inversions and handled specular reflection. The third method had only been introduced recently and used a Monte Carlo raytracing and hemicube method to calculate viewfactors and RADKs.

2.3 Thermal Model Reduction with Stochastic Optimisation

M. Gorlani (Blue Group) described a method for considering a condensed model of an instrument in both hot and cold cases, coupled with an in-house stochastic analysis tool to provide confidence in any intermediate cases, to help produce a reduced model for inclusion at system level. This process had reduced the original model by 80% to just 15 nodes. (See appendix M)
S. Appel (ESA/ESTEC) wanted to clarify that in both the detailed and the reduced models the heat exchange with the environment and the internals were similar, and that the stochastic approach to try all combinations of conductors in the reduced models had lead to the same behaviour. M. Gorlani said that the model reduction had only considered the GLs and had been easy to do in this type of model. He had some experience of reducing a radiative model by hand, and then leaving the GLs to keep the reduced models. In this case the model reduction had been limited to GLs and not GRs. The condensed model had only considered GLs, and then care had been taken to ensure the correspondence of results with the reduced model. There had been no change between the condensed node and the reduced node.
S. Appel asked whether in the end they had created a reduced model with GLs that behaved the same as the original. M. Gorlani confirmed that the temperatures had been the same, to within the required uncertainty. S. Appel asked whether the reduced model was generic, or was specific to the hot or cold case. M. Gorlani said that the stochastic optimisation of the parameters was limited to the GLs for the specific hot and cold cases, but the reduced model was valid within the hot and cold case extremes.
A. Aguilar (Aguilar Consulting) asked how this method was able to guarantee the Second Law of Thermodynamics, and that the model still had physical meaning. He wanted to know how it was possible to obtain the same correlation with random values. M. Gorlani stressed that the limits for the parameters had been given by the real hot and cold cases, and that they had verified the heat exchange between the sensors and the nodes on interest. A. Aguilar asked how they could be sure that the heat exchanges could not be outside the accepted ranges. M. Gorlani said that the two extreme levels of GLs had been given by the real hot and cold cases, and he was therefore confident that all other values had to lie between these extremes.
A. Aguilar asked how they could guarantee that there were no spurious values not seen in reality. M. Gorlani stressed that the extreme GLs had come from the real hot and cold cases. They had correlated the results from the condensed model and the reduced model, and had achieved similar heat results for both hot and cold cases. A. Aguilar said that if one GL calculation had relied on the thermal path length or area, this would alter the conductivity matrix. How could they be sure of a match? M. Gorlani said that the model was relatively simple so it would have been possible to do this by hand. However, it had been necessary to apply this for a whole range of different materials, and hand calculations would be open to a whole class of mistakes, so it had been better to use the stochastic technique.
V. Perotto (Alcatel Alenia Space) noted that the process used specific GLs from the condensed group nodes, and asked whether the reduced model gave new GLs or kept the same set. M. Gorlani replied that the reduced model kept the same set of GLs, but with new values.
J. Etchells (ESA/ESTEC) had noted that the acceptance criteria had involved keeping the root-sum-square to less than two degrees, and asked whether this applied to steady state, or to

transient? M. Gorlani answered that it only applied to the steady state.

2.4 ThermNV Status

J. Thomas (ALSTOM) described the evolution of ThermNV as the ESATAN results post-processor since the previous workshop. He demonstrated the support for node grouping, network layout and report generation. He showed the new calculator capabilities, and how even derived attributes could be shown in reports. He explained the report template and batch feature for use with the new ESATAN parametric analysis cases. (See appendix N)
S. Appel (ESA/ESTEC) acknowledged that ThermNV version 3.0 now looked to be quite complete. He wondered whether it could handle ESATAN models produced using ESATAN/TMG which had many nodes, and whether it would be possible to display the geometry as well. J. Thomas said that to display the results on the geometry the user would really need to use ESARAD. ALSTOM were currently looking at whether it would be possible to provide batch mode visualisation in ESARAD in order to show the results of parametric studies. The basic answer was that the user would need to use ESARAD to show the results on the geometry, and not ThermNV.
S. Appel said that being able to create and select groups was a nice feature, but he was worried that it would be too difficult for models that contained thousands of nodes. J. Thomas admitted that this was an important point, but stressed that even if a model contained 5000 nodes there was usually only a small subset of nodes that were really of interest. ThermNV also grouped nodes based on sub-model hierarchy, so that would simplify the initial network. ThermNV also offered the “bin” which was not a means of deleting groups and nodes, but a means of removing them from the display. He said that ThermNV version 3 (or possibly 3.2) would allow the user to load the model directly into the “bin”, and then each node of interest could be brought out of the “bin” onto the display for inclusion in reports. The big question being considered at the moment was how to store all of that data, and ALSTOM were investigating the use of HDF5.
G. Jahn (Astrium GmbH) asked whether it was possible to use ThermNV with ESATAN version 8. J. Thomas said that there had been no changes in the GFF handling, so this should still work. H. Brouquet (ALSTOM) confirmed that the GFF had not changed at all, so it would be possible to read version 8 results in ThermNV.

2.5 GAETAN 5: a complete environment for thermal analysis

H. Pasquier (CNES) presented the advances made in GAETAN version 5. New CONDOR and GENETIK modules were available for identifying the extreme design cases over a mission and to optimise the search for thermal dimensioning cases. The user interfaces had been redesigned to use XML and guide the user so that invalid input parameters were avoided. As well as ESARAD and ESATAN, since 2005 GAETAN now also supported Thermica and Thermisol. (See appendix O)
D. Sukmawanto (Verhaert Space) had noticed that GAETAN supported the use of Peltier elements, and wondered which capabilities were handled. H. Pasquier said that some standard Peltier elements were available. E. Werling (CNES) explained that there was a choice of single or multi-stage Peltier modules, and the user was able to supply some inputs for some of the parameters. D. Sukmawanto asked which parameters were supported. E. Werling said that he could provide the user manual. The annex showed what was handled in the Peltier elements.
H. Rooijackers (ESA/ESTEC) asked for some indication of the size of models handled. H. Pasquier said that there was no maximum size really. It was possible to have big models.

E. Werling said that the current version supported 500 nodes, but this could be extended. H. Rooijackers said that he had noticed some of the presentations talking about FE models with half a million nodes. E. Werling said that the user needed to maintain some engineering sense. He was the boss in his group, and he insisted on models with fewer than 500 nodes. He had seen no such large models within CNES in his 20 years there, except for the space station models. M. Imhof (CNES) said that Alcatel used GAETAN and had a model with a million conductors and thousands of nodes that had been handled successfully. E. Werling explained that GAETAN was just a pre- and post-processor for ESATAN, so if the model worked in ESATAN, then it would work in GAETAN.

2.6 TCDT: an environment for preliminary thermal analysis and design

M. Gorlani (Blue Group) described the background and history of the Thermal Concept Design Tool. A. Tosetto (Blue Group) gave a live demonstration of the tool, and showed how it could be used for radiator sizing for a given internal heat dissipation, and how to add heaters to maintain a stable temperature range for the orbit conditions. (See appendix P)
O. Pin (ESA/ESTEC) wanted to offer some clarifications about the TCDT. The background for the tool had been a specific requirement by the Concurrent Design Facility [CDF] in ESTEC, where engineers from different disciplines interacted using Excel files. Therefore the tool needed to be compatible with Excel. At the time when the TCDT had been proposed, the other thermal tools had suffered from a lack of interactivity, but this had since been addressed in these tools, so there was now some overlap between the TCDT and the other tools. The priority for ESA had been to please its customer, the CDF. The CDF would use the tool to start with, and ESA would verify the tool internally. The intellectual property rights [IPR] would be transferred to ESA, and ESA planned to make the TCDT available, free of charge, probably at the end of 2006, after it had been verified, as a binary distribution via the R&D pool Exchange server. O. Pin had successfully negotiated to make the TCDT available to ESA member and associate states, including Canada. If there was sufficient interest in the tool, then ESA would maintain it and decide how to proceed further.
M. Huchler (Astrium Satellites) asked whether there were any particular hardware requirements to run the TCDT, or specific version of Excel. What about the language used on the machine? M. Gorlani said that the tool had been tested on Windows2000 and WindowsXP with both Office2000 and OfficeXP.
C. Theroude (Astrium) commented that the tool was clearly intended for preliminary design. Such design required connection to other tools for the mechanical design and so on, but only thermal aspects had been shown. M. Gorlani said the connection to other tools worked by exchanging Excel files. There were no specific links for different tools. HP. de Koning (ESA/ESTEC) explained that pre-formatted Excel worksheets were used to connect to other disciplines because this was part of the inherent CDF datamodel.

2.7 ESATAP: a postprocessor environment of thermal analysis

F. Brunetti (DOREA) described the goals of ESATAP for generic postprocessing, and explained the architecture as a series of building blocks of common components that could be connected together to provide what the user needed. ESATAP could extract results data from STEP-TAS files for display as 2D or 3D plots, as text documents or as HTML. (See appendix Q)

O. Pin (ESA/ESTEC) clarified the history and decisions behind ESATAP. He said that anyone new coming into the business now would think that there were a lot of tools, GAETAN, ThermPlot, ThermNV, ESATAP, etc. but he stressed that ESATAP was a purely post-processing tool. ESATAP was targeted at industrial projects in phase C/D. It had been intended for large models rather than small ones, so effort had been spent to support traceability and scalability. ThermNV was the most similar tool for small models, but it had not existed when the ESATAP project had begun.
Verification and validation would be handled by Alcatel in Toulouse. There was a large test suite, and ESATAP would be benchmarked against GAETAN results. Complex test cases existed as a reference for ESATAP. These tools needed to manage large amounts of data, so verification would be important.
O. Pin said that as far as distribution was concerned, the IPR would remain with ESA, and current planning involved a community open source model, so the distribution scheme might not necessarily follow a pure open source approach. He said that the approach for the maintenance of ESATAP would be similar to the one adopted for the TCDT: it would first be made available via the R&D pool, and then ESA would see what happened.

2.8 Therm3D: a new tool for 3D thermal modelling

JP. Dudon (Alcatel Alenia Space) presented details of Therm3D, a tool designed to speed up the conductive modelling process. It allowed the import of geometry models from a variety of tools and calculated basic conductive couplings. The experience of Equivale had been applied to allow the reduction of thousands of FEM nodes into a smaller thermal lumped parameter network. (See appendix R)
There were no questions.

2.9 Workshop Close

H. Rooijackers (ESA/ESTEC) thanked all of the presentors for sharing their developments and experience, and all of the participants for taking the time and trouble to attend. He hoped to see everyone at the next workshop.

Appendix A

Welcome and Introduction

Harrie Rooijackers
(ESA/ESTEC, The Netherlands)

Appendix B

Status Update on STEP-TAS

Hans Peter de Koning
(ESA/ESTEC, The Netherlands)

Appendix C

New features of Baghera View : extended reporting mechanism of thermal models with synchronisation based on XML and STEP-TAS

Elisa Ciuti
(CSTB, France)

Appendix D

SYSTEMA/Thermica V4

Timothée Soriano
(Astrium, France)

Appendix E

ESARAD Status

Julian Thomas
(ALSTOM, United Kingdom)

Appendix F

SINAS: Generic tool for mapping lumped parameter temperatures to a finite element model for thermo-elastic analyses

Simon Appel
(AOES, The Netherlands)

Appendix G

ESATAN/TMG Demonstration

Henri Brouquet
(ALSTOM, United Kingdom)

Appendix H

A system for solving fully coupled thermal-structural problems using TMG and NASTRAN

Kevin Duffy
(MAYA, Canada)

Appendix I

ESATAN Thermal Suite Status

Chris Kirtley
(ALSTOM, United Kingdom)

Appendix J

Presentation of the Open Frontier Framework as a Platform for Space Engineering Tools

Holger Sdunnus
(eta_max space GmbH, Germany)

Appendix K

Migration of existing thermal models into new software versions

Stefan Kasper
(Jena-Optronik GmbH, Germany)

Appendix L

Introduction to NX TMG Space Thermal

Kevin Duffy
(MAYA, Canada)

Appendix M

Thermal Model Reduction with Stochastic Optimisation

Matteo Gorlani
(Blue Group, Italy)

Appendix N

ThermNV Status

Julian Thomas
(ALSTOM, United Kingdom)

Appendix O

GAETAN 5: A complete environment for thermal analysis

Hélène Pasquier
(CNES, France)

Appendix P

TCDT: An environment for preliminary thermal analysis and design

Matteo Gorlani
Andrea Tosetto
(Blue Group, Italy)

Appendix Q

ESATAP: A postprocessor environment of thermal analysis

François Brunetti
(Dorea, France)

Appendix R

A new tool for 3D thermal modeling

Jean-Paul Dudon
(Alcatel Alenia Space, France)

Appendix S

List of Participants

Aguilar, A.
Aguilar Aerospace
Avda El Ferrol 19 piso 1 puerta 4
28020 Madrid
SPAIN
Tel: +34 657762559
Email: info@adolfo-aguilar.com

Appel, S.
ESA/ESTEC
ESA/ESTEC D/TEC-MCV
p.a. Keplerlaan 1
2201 AZ Noordwijk
NETHERLANDS
Tel: +31 71 5654013
Email: Simon.Appel@aoes.com

Brouquet, H.
ALSTOM Aerospace
Cambridge Road
LE8 6LH Leicester
UNITED KINGDOM
Tel: +44 116 284 5748
Email: henri.brouquet@power.alstom.com

Brunetti, F.
DOREA
Résidence de l'Olivet, Bat.F 75 Chemin de l'Olivet
6110 Le Cannet
FRANCE
Tel: +33 4 93 69 07 48
Fax: +33 6 64 69 17 00
Email: francois.brunetti@dorea.fr

Bsibsi, M.
NLR
Space Division
voorsterweg 31
8315PR Marknesse
NETHERLANDS
Tel: +31 527248628
Fax: +31 527248210
Email: bsibsim@nlr.nl

Bunte, K.
eta_max space GmbH
Richard-Wagner-Str. 1
38106 Braunschweig
GERMANY
Tel: +49 531 3802 432
Email: k.bunte@etamax.de

Checa Cortes, M. E.
ESA/ESTEC
TEC-MCT
Keplerlaan 1
2200AG Noordwijk
NETHERLANDS
Tel: +31 71-5656606
Email: Elena.Checa@esa.int

Ciuti, E.
CSTB
MOD-EVE
290 route des Lucioles
6904 SOPHIA-ANTIPOLIS
FRANCE
Tel: +33 4 93 95 64 38
Fax: +33 4 93 95 67 33
Email: elisa.ciuti@cstb.fr

de Koning, H. P.
ESA/ESTEC
D/TEC-MCV
Keplerlaan 1
2201 AZ Noordwijk
NETHERLANDS
Tel: +31 71 5653452
Email: Hans-Peter.de.Koning@esa.int

Dudon, JP.
alcatel alenia space
research Dpt
100 bd du midi - bp 99
6156 cannes la bocca
FRANCE
Tel: +33 4 92 92 67 13
Email: jean-paul.dudon@alcatelaleniaspace.com

Duffy, K.
MAYA Heat Transfer Technologies Limited
4999 Ste. Catherine West, #400
H3Z1T3 Montreal
CANADA
Tel: +1 514 369 5706
Email: kevin.duffy@mayahtt.com

Etchells, J.
ESA/ESTEC
Keplerlaan 1
2200 AG Noordwijk
NETHERLANDS
Tel: +31 715658503
Email: James.Etchells@esa.int

Fagot, A.
DOREA
Résidence de l'Olivet, Bat.F 75 Chemin de l'Olive
6110 Le Cannet
FRANCE
Tel: +33 8 70 25 64 05
Fax: +33 6 64 69 17 00
Email: alain.fagot@dorea.fr

Gerbier, Nathalie
SILOGIC
ASC
6 rue Roger Camboulives
31036 Toulouse
FRANCE
Tel: +33 5-34-61-92-92
Fax: +33 5-34-61-92-22
Email: nathalie.gerbier@silogic.fr

Gibson, D.
ESA/ESTEC
D/TEC-MCV
Keplerlaan 1
2201 AZ Noordwijk
NETHERLANDS
Tel: +31 71 5654013
Email: Duncan.Gibson@esa.int

Gorlani, M.
Blue Group
Engineering
Via Albenga 98
10090 Cascine Vica (TO)
ITALY
Tel: +39 0119504211
Fax: +39 0119504216
Email: m.gorlani@blue-group.it

Gregori, C.
Iberespacio
Magallanes,1
28015 Madrid
SPAIN
Tel: +34 914441515
Fax: +34 914451764
Email: mgx@iberespacio.es

Guijt, H.
TERMA BV
Space
Schuttersveld 9
2316XG Leiden
NETHERLANDS
Tel: +31 715240800
Fax: +31 715143277
Email: hg@terma.com

Heuts, M.
Dutch Space
Newtonweg 1
2333 CP Leiden
NETHERLANDS
Tel: +31 715245781
Email: m.heuts@dutchspace.nl

Huchler, M.
Astrium Satellites
Mech., Therm., Fluidics Analysis & Test
88039 Friedrichshafen
GERMANY
Tel: +49 7545 8 2967
Fax: +49 7545 18 2967
Email: markus.huchler@astrium.eads.net

Imhof, M.
SILOGIC
6 rue Roger Camboulives
31100 Toulouse
FRANCE
Tel: +33 534619292
Email: marie.imhof@silogic.fr

Jahn, G.
Astrium GmbH
Thermal Analysis and Test - ASG22
Claude-Dornier-Strasse
88090 Immenstaad
GERMANY
Tel: +49 7545-83472
Fax: +49 7545-8183472
Email: Gerd.Jahn@astrium.eads.net

Jouffroy, F.
Astrium
Analyses et tests mécaniques et thermiques
31 rue des Cosmonautes ZI du Palays
31402 TOULOUSE
FRANCE
Tel: +33 5 62 19 94 97
Fax: +33 5 62 19 77 44
Email: frederic.jouffroy@astrium.eads.net

Kanis, J.
Dutch Space
AS$E
Newtonweg 1
2333CP Leiden
NETHERLANDS
Tel: +31 71 5245827
Fax: +31 71 5245499
Email: j.kanis@dutchspace.nl

Kasper, S.
Jena-Optronik
Optics & Mechanics
Pruessingstrasse 41
7745 Jena
GERMANY
Tel: +49 3641 200 176
Fax: +49 3641 200 220
Email: stefan.kasper@jena-optronik.de

Kirtley, C.
ALSTOM Aerospace
Cambridge Road
LE8 6LH Leicester
UNITED KINGDOM
Tel: +44 116 284 5653
Email: chris.kirtley@power.alstom.com

Klein, M.
ESA/ESTEC
Keplerlaan 1
2200 Ag Noordwijk
NETHERLANDS
Tel: +31 71 565 3994
Fax: +31 71 565 6142
Email: Michel.Klein@esa.int

Knight, P.
ALSTOM Aerospace
Cambridge Road
LE8 6LH Leicester
UNITED KINGDOM
Tel: +44 116 284 5659
Email: peter.knight@power.alstom.com

Koorevaar, F.
Dutch Space
AS & E
newtonweg 1
2333CP Leiden
NETHERLANDS
Tel: +31 715245849
Email: f.koorevaar@dutchspace.nl

Lebègue, E.
CSTB
MOD-EVE
290, route des Lucioles - BP 209
6904 SOPHIA-ANTIPOLIS
FRANCE
Tel: +33 4 93 95 64 23
Fax: +33 4 93 95 67 33
Email: eric.lebegue@cstb.fr

Leroy, S.
DOREA
Résidence de l'Olivet, Bat.F 75 Chemin de l'Olive
6110 Le Cannet
FRANCE
Tel: +33 8 70 59 65 47
Fax: +33 6 64 69 17 00
Email: sandrine.leroy@dorea.fr

Loetzke, H.
German Aerospace Centre DLR
Systems Conditioning
Rutherfordstr. 2
D-12527 Berlin
GERMANY
Tel: +49 3067055617
Fax: +49 30670558617
Email: horst-georg.loetzke@dlr.de

Münstermann, R.
Astrium Space transportation
Hühnefeldstr. 1-5
28361 Bremen
GERMANY
Tel: +49 421-539-5011
Fax: +49 421-539-285011
Email: rolf.muenstermann@space.eads.net

Pasquier, H.
CNES
BPI 1716 - 18 avenue Edouard Belin
31401 TOULOUSE Cedex 9
FRANCE
Tel: +33 561283544
Email: helenem.pasquier@cnes.fr

Patricio, R.
Active Space Technologies
R Pedro Nunes
3030-199 Coimbra
PORTUGAL
Tel: +351 239700333
Fax: +351 239700301
Email: ricardo.patricio@activespacetech.com

Pauw, A.
NLR
ASSP
PO Box 153
8300 AD Emmeloord
NETHERLANDS
Tel: +31 527 248273
Fax: +31 527 248210
Email: pauw@nlr.nl

Perotto, V.
Alcatel-Alenia Space - Torino
Thermal Control
strada Antica di Collegno 253
10146 Torino
ITALY
Tel: +39 0117180609
Fax: +39 0117180239
Email: valter.perotto@aleniaspazio.it

Persson, J.
ESA/ESTEC
TEC-MCT
Keplerlaan 1
2200 AG Noordwijk
NETHERLANDS
Tel: +31 71 565 3814
Email: Jan.Persson@esa.int

Pin, O.
ESA/ESTEC
D/TEC-MCV
Keplerlaan 1
2201 AZ Noordwijk
NETHERLANDS
Tel: +31 71 5655878
Email: Olivier.Pin@esa.int

Rathjen, H.R.
Astrium GmbH
TE52
Postfach 28 61 56
28361 Bremen
GERMANY
Tel: +49 421 539-4173
Fax: +49 421 539-5582
Email: harold.rathjen@space.eads.net

Romera Perez, J.A.
ESA/ESTEC
TEC-MCT
Keplerlaan, 1
2200 ag Noordwijk
NETHERLANDS
Tel: +31 71 5653979
Fax: +31 71 5656142
Email: jose.antonio.romera.perez@esa.int

Rooijackers, H.
ESA/ESTEC
ESA/ESTEC D/TEC-MCV
p.a. Keplerlaan 1
2201 AZ Noordwijk
NETHERLANDS
Tel: +31 71 5653453
Email: Harrie.Rooijackers@aoes.com

Santoni, M.
Galileo Avionica
Electrooptical Products Design & Development
Via Einstein 35
50013 Campi Bisenzio
ITALY
Tel: +39 055 8950796
Email: massimo.santoni@galileoavionica.it

Sdunnus, H.
eta_max space GmbH
Richard-Wagner-Str. 1
38106 Braunschweig
GERMANY
Tel: +49 531 3802 422
Fax: +49 531 3802 401
Email: h.sdunnus@etamax.de

Shaughnessy, B.
RAL
Thermal Engineering Group
Chilton
OX11 0QX Oxfordshire
UNITED KINGDOM
Tel: +44 1235 445061
Email: b.m.shaughnessy@rl.ac.uk

Sørensen, J.
ESA/ESTEC
TEC-EES
Keplerlaan 1
2200AG Noordwijk
NETHERLANDS
Tel: +31 71 565 3795
Fax: +31 71 565 4999
Email: john.sorensen@esa.int

Soriano, T.
Astrium satellite
31 rue des cosmonautes
31402 Toulouse Cedex 4
FRANCE
Tel: +33 5 62 19 91 76
Email: timothee.soriano@astrium.eads.net

Stroom, C.
retired
Gerrit van der Veenstraat 169-hs
1077 EB Amsterdam
NETHERLANDS
Tel: +31 20-662.5533
Email: charles@stremen.xs4all.nl

Sukmawanto, D.S.
Verhaert Space
Mechanical system engineering
Hogenakkerhoekstraat 9
9150 Kruibeke
BELGIUM
Tel: +32 3-2501454
Email: danang.sukmawanto@verhaert.com

Supper, W.
ESA/ESTEC
Keplerlaan 1
2200 Ag Noordwijk
NETHERLANDS
Tel: +31 71 565 4735
Fax: +31 71 565 6142
Email: Wolfgang.Supper@esa.int

Tan, G.B.T.
ESA/ESTEC
TEC-MCT
Keplerlaan 1
2201AZ Noordwijk
NETHERLANDS
Tel: +31 71-5654016
Email: Gijsbert.Tan@esa.int

Theroude, C.
Astrium
31 rue des Cosmonautes
31402 Toulouse
FRANCE
Tel: +33 5 62 19 68 85
Email: christophe.theroude@astrium.eads.net

Thomas, J.
ALSTOM Aerospace
Cambridge Road
LE8 6LH Leicester
UNITED KINGDOM
Tel: +44 116 284 5607
Email: julian.thomas@power.alstom.com

Tonellotto, G.
ESA/ESTEC
TEC-MCT
Keplerlaan 1
2201AZ Noordwijk
NETHERLANDS
Tel: +31 7156 54817
Fax: +31 7156 56142
Email: giulio.tonellotto@esa.int

Tosetto, T.A.
Blue Group
via Albenga 98
10098 Rivoli
ITALY
Tel: +39 0119504211
Fax: +39 0119504216
Email: a.tosetto@blue-group.it

van Bentlem, R.C.
NLR
PO BOX 153
8300AD Emmeloord
NETHERLANDS
Tel: +31 0527 248231
Fax: +31 0527 248210
Email: bentlem@nrl.nl

Veughs, P.
LTAS – Infographie
Département d'Aérospatiale et Mécanique
B52, Chemin des Chevreuils 1
B4000 Liège 1
BELGIUM
Tel: +32 4 366 92 13
Fax: +32 4 366 91 41
Email: Pierre.Vueghs@ulg.ac.be

Vey, S.
ESA/ESTEC
Keplerlaan 1
2200 AG Noordwijk
NETHERLANDS
Tel: +31 71 565 8309
Email: Sylvain.Vey@esa.int

Werling, E.
CNES
DCT/TV/TH
18, avenue Edouard Belin
31401 Toulouse Cedex 9
FRANCE
Tel: +33 561273083
Fax: +33 561273446
Email: Eric.Werling@CNES.FR