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Thermal and ECLS Software

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ABSTRACT

This document contains the minutes of the 16th European Thermal and ECLS Software Workshop held at ESTEC, Noordwijk, The Netherlands on the 22nd and 23rd October 2002. 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 related documents.

Table 1: Printing History

Release	Date of issue	Reason
1.0	2002-10-30	Document creation
1.1	2002-12-06	Partial draft for internal distribution
1.2	2003-01-24	Completed final discussion section
1.3	2003-03-18	Updated after internal comments

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ESTEC, Noordwijk, The Netherlands
22nd-23rd October 2002

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1. Tuesday 22nd October: Morning Session

1.1. Welcome And Introduction

C. Stroom (ESTEC/TOS-MCV) explained that the main aim of the Workshop was to allow discussion of the tools sponsored by the Agency and to allow feedback between the users and the developers. (See Appendix A)

He had thought that this Workshop was one of the oldest run by the Agency but had subsequently discovered that the Antenna workshop was already in its 33rd year. He reminded everyone about the deadline for abstracts for the ICES conference in Canada in 2003.

1.2. Thermal Modelling Issues Concerning the Mechanically Pumped Two-Phase CO_2 Cooling for the AMS-2 Tracker

A. Woering (NLR) described the Alpha Magnetic Spectrometer payload which will be mounted on the exterior of the International Space Station. He then discussed the thermal control system and the various physical and software models which had been developed. (See Appendix B)

There were no questions.

1.3. SAVE: Simulation for Analysis and Validation of Energy for ATV

R. Ameziane (EADS-LV) presented the development of software for the management of energy systems on the ATV and its verification against the power requirements of the thermal control system. (See Appendix C)

R. Schlitt (OHB) asked whether there was software on the on-board computer for the control of the heat pipes, etc. R. Ameziane answered that the heat pipes and the power system were monitored by on-board software written in ADA in order to check that the thermal and electrical models matched.

O. Pin (ESTEC/TOS-MCV) asked whether the conversion from ESATAN to SABER involved any model reduction. He was told that there was no real reduction of the model itself but it was possible to compress radiative couplings if there were too many of them. O. Pin asked whether this was handled on a conductor or a node basis. R. Ameziane said that node reduction had to be done first in ESATAN because the ESATAN to SABER conversion only handled the reduction of radiative couplings.

1.4. Status of some ESA supported activities in thermal, thermo-hydraulic and ECLS analysis

O. Pin (ESTEC/TOS-MCV) briefly described various ESA initiatives which were already in progress, or which would start in the near future, relating to small tools, or to software not being

presented specifically at the Workshop. (See Appendix D)

R. Schlitt (OHB) asked about the vision for the next five years, and whether this would involve merging some of the tools. C. Stroom (ESTEC/TOS-MCV) felt that this was an issue which should be dealt with during the round table discussions. O. Pin said that any vision within ESA still had to reflect the expectations of the real world and commercial interests.

M. Molina (Carlo Gavazzi Space) asked about the short term results. He felt that it would be a great year with so many things going on, and that it would be interesting to be kept up to date with developments twice per year. He wondered whether it would be possible to distribute such information via e-mail or via a news letter. C. Stroom agreed that this was a good idea.

1.5. Modelling the VISTA Infrared Camera

N. Cavan (RAL) described the requirements of the VISTA infrared camera to be installed at the European Southern Observatory, how ESARAD and ESATAN had been used for the analysis, and gave feedback on obvious improvements to the tools which would have aided the process. (See Appendix E)

H. Peabody (Swales) commented on the request for the tools to be able to handle optical properties which were dependent on the angle of incidence of incoming rays. He noted that many people seemed to want it, but wondered whether it was really necessary. He also wondered whether there was enough reliable angle of incident dependent optical property data. N. Cavan said that the optical engineers working on the RAL team certainly wanted it. They had already had some of the data and had made measurements to obtain more. HP. de Koning (ESTEC/TOS-MCV) reminded everyone that this was similar to the requirements of the Bepi-Colombo mission, for modelling albedo fluxes on some planets which exhibited BRDF[1] type reflection. He wanted to be able to handle such optical properties in a generic way in future versions of ESARAD.

C. Stroom (ESTEC/TOS-MCV) wondered about the comment made about the excessively high and the negative temperatures seen in the cryogenic parts of the ESATAN model. He thought that a specific routine had been provided for the cryogenic modelling of the ISO satellite. J. Thomas (Alstom) explained that the routines had been for calculating temperature dependent properties, and were not related to the solvers themselves. These conductance functions had been used at RAL. C. Stroom remarked that the automatic conductor generation should be discussed later.

F. du Laurens (Alstom) said that he [as the Alstom support desk manager] was aware of most of these issues. The automatic conductor generation, mission requirements and improved pointing would be presented the following day. The fact that ESATAN could calculate temperatures less than zero kelvin was related to there being no explicit check for this in ESATAN in order to avoid constraints on the solvers. The user could always provide a check for such temperatures in the $VARIABLES1 block. O. Pin (ESTEC/TOS-MCV) wondered whether this would simply invert the imbalance because of the radiation terms, i.e. $(+2K)^4 = 16$

1. Bidirectional Reflectance Distribution Function

and $(-2K)^4$ = 16. C. Stroom said that the $VARIABLES1 code only needed to check the temperature of specific nodes. J. Thomas agreed that there was a need to look into this to see exactly why ESATAN didn't check for negative temperatures.

HP. de Koning had a remark about having a node number increment of 10 between successive rings on the cylinder: the user could have a FOR loop in the geometry definition file to build the shells with the desired node numbers, rather than building them all individually.

1.6. Thermal Analysis of Planck HFI

J. Fereday (RAL) presented details of the Planck High Frequency Instrument, the extreme requirements for the thermal control of the cryogenic and detector systems, and the issues which had needed to be addressed during the modelling and analysis. (See Appendix F)

F. Lamela (EADS CASA) asked whether Fourier analysis in the frequency domain had been considered to compensate for the calculation noise in the cryogenic part of the model. J. Fereday answered that the Fast Fourier Transform facilities of Excel were applied to the output data. F. Lamela went on to ask about the temperature difference in the time domain. He said that there was numerical noise in the 6-8 digit precision results produced by ESATAN and that the FFT might filter this noise rather than the noise in the real temperature variation. J. Fereday admitted that this had been recognised as a problem, but it had not been addressed.

M. Molina (Carlo Gavazzi Space) asked about the frequency band for the cryogenic temperature variation. He was told that there was a wide range with the fastest being about 1/3 of a second mean variation and the slowest being about 1000 seconds. These varied across the different parts of the spacecraft. M. Molina felt that a common working group should be established by ESA to look into these problems. Thermal engineers were suffering frustration compared to the structural analysists because they didn't have thermal modes, eigenfunctions, etc. which could be applied. Engineers were trying to apply 2^{nd} order derivatives to systems which didn't even have support for 1^{st} order derivatives. In this particular case he felt that the basic values should be enough and because they didn't have a derivative. He wondered about applying band pass filters. J. Fereday said that the LFI team had been investigating such an approach.

1.7. ESARAD v-5.1

F. du Laurens (Alstom) outlined the new features which were now available in ESARAD version 5.1. This version had been released at the end of June 2002. He went on to describe some tips on how to make the best use of these features. (See Appendix G)

H. Peabody (Swales) asked whether the model tree would be expanded automatically when the user used the new search feature, and was told that it would.

A. Robson (Astrium Ltd.) observed that very big spacecraft models tended to be divided into both internal and external models each of which generated their own ESATAN files and required their own supporting code. He wanted to know whether the new integrated process

would allow the user to import more than one set of ESARAD models into a single ESATAN model. J. Thomas (Alstom) said that this was possible: the analysis case definition allowed the user to specify any additional files which needed to be included in the ESATAN model. However, he warned that ESARAD couldn't check whether these included [ESATAN] files were correct. It was also possible to include external results as required. The analysis case template file only needed to be built once and then the ESATAN file could be regenerated every time using this template. Any external ESATAN or data files would be included automatically each time the ESATAN file was regenerated from the template.

1.8. Application of EcosimPro to Bio-regenerative Life Support Components

A. Rodriguez (ESTEC/TOS-MCT) described EcosimPro, a software package for modelling and simulating dynamic systems described by differential algebraic equations, ordinary differential equations and discrete events. He then presented the experience gained by using EcosimPro to model MELISSA[2], a closed loop microbial ecosystem. (See Appendix H)

There were no questions.

1.9. ESATAN/FHTS v8.7 & v8.8

ESATAN/FHTS version 8.7 was released in December 2001. F. du Laurens (Alstom) highlighted some outstanding issues with version 8.7, including the migration of licences from the old authorisation file scheme to the new FLEXlm licence system. He went on to describe the solver speed improvements and major new features of version 8.8, to be released shortly. (See Appendix I)

R. Schlitt (OHB) asked whether the solver improvements also related to two-phase systems in FHTS. J. Thomas (Alstom) said that there had been no mention of FHTS features because of the limited time for the presentation but a lot of work and feasibility studies relating to FHTS had been carried out in Alstom, with much work foreseen during the next year, especially in support of the @BUS platform. O. Pin (ESTEC/TOS-MCV) said that improvements had been made to the FGENFI solver to handle a fluid in pseudo-steady state. This had shown positive results in performance, but so far had only been implemented as a prototype. J. Thomas said that ESATAN/FHTS version 8.8 would handle absolute zero fluid flow, and more FHTS related changes were planned for future versions.

2. http://industry.esa.int/melissa/

2. Tuesday 9th October: Afternoon Session

2.1. Integrated thermal design and the thermal numerical tool box

J. van Es (NLR) presented the case for developing a simple thermal tool box for use in design studies, based on the experience of using ESATAN for several studies in the past. He provided some requirements for such an integrated tool. (See Appendix J)

M. Molina (Carlo Gavazzi Space) asked what kind of phase change material had been used for the design of the BIOFILTER experiment. J. van Es said that the material had been a type of paraffin, with an Alpha number of "ADK something", but he would really need to look it up. The phase change occurred at 5.9^{o}C. A. Rodriguez (ESTEC/TOS-MCT) asked whether the hysteresis of the melting point of the phase change material had been taken into account. He was told that the hysteresis had not been included in the model itself, but it had been accounted for as a safety factor in the design margins.

C. Stroom (ESTEC/TOS-MCV) wanted to know whether the MLI had been used in vacuum in the BIOFILTER experiment. J. van Es said that it was possible to experience problems in obtaining correct results when using MLI inside a pressurised box. The results could always be calculated for MLI in vacuum. He agreed that the vacuum was important.

C. Stroom remarked that the Open Source Software aspect of such a tool box should be asked during the round table discussion,

2.2. Thermal simulation in functional analysis

M. Jacquiau (Astrium SAS) described some of the areas where functional analysis required some level of thermal simulation, and the small tools and interfaces which had been developed to integrate them. (See Appendix K)

J. Persson (ESTEC/MSM-MCS) asked what was the difference between the power software tool and that described earlier by EADS. JP. Hulier (EADS LV) said that their software was intended for use in the pre-design analysis. M. Jacquiau said that their software was used in the preliminary design and also in the detailed design of some sub-systems. He admitted that it was similar to the EADS approach and worked with a description of the network. JP. Hulier wanted to confirm his understanding that the Astrium software was limited to 40-50 nodes. M. Jacquiau admitted that the CAT software was limited to 40-50 nodes. The solver being used was ESACAP. However, the Propulsion software used a different solver and also made use of components build by the user. JP. Hulier commented that this was a difference between the system and technological approaches.

2.3. ALGOCAP: Assessment of Thermo Hydraulic Algorithms for Capillary Pumped Loops and Loop Heat Pipes

D. Labuhn (OHB) presented the current results of an investigation into the application of

capillary pumped loops and loop heat pipes in spacecraft thermal control systems, and the issues encountered when trying to simulate such components using some of the current software tools. (See Appendix L)

There were no questions.

2.4. Use of ESARAD in MetOp SVM Thermal Testing Analysis

E. Seward (Astrium Ltd.) described how ESARAD 3.2.7 had originally been used for the analysis of the test configuration of the MetOp SVM in the SIMLES chamber and the problems which had been encountered. She went on to explain how the model had been updated to work with ESARAD 4.2.10, which problems had been resolved and which still remained. (See Appendix M)

HP. de Koning (ESTEC/TOS-MCV) was interested to know whether the problems with the transmissive surface used for modelling the chamber mirror were related to the use of diffuse rather than direct transmission. A. Robson (Astrium Ltd.) felt that they were related to the Monte Carlo method being used. HP. de Koning explained that ESARAD only supported diffuse transmission so this needed to be taken into account when modelling.

D. Gibson (ESTEC/TOS-MCV) commented that although Astrium had experienced problems with the correct positioning of user oriented parts of the model during animation via the GUI, it was possible but required working directly in the ESARAD language and applying some tricks[3].

2.5. ESA Harmonisation and User Survey

HP. de Koning (ESTEC/TOS-MCV) presented details of a harmonisation strategy being developed within ESA in order to provide better integration of tools and data across various disciplines relating to different space environments. He also described the results of a user survey which had asked users about their preferred options for such a harmonisation strategy, ranging from proprietary commercial systems to open source software, and from centrally coordinated development to a market driven approach. (See Appendix N)

Questions were deferred until the following round table discussion.

2.6. Round Table Discussion

C. Stroom (ESTEC/TOS-MCV) asked who wanted to start the discussion. He suggested starting with the issue of Open Source Software (OSS).

J. van Es (NLR) said that the success of OSS depended on the size of the active group of developers. He had seen examples where it had worked, and the product had improved because it became the storage for the knowledge of the contributors. He felt that ESARAD and

3. An example model and language files were sent to Astrium after the Workshop.

ESATAN tended to be used by “now and then” users, so using OSS to store knowledge could be important. He wanted to know how big the ESA software user base was. C. Stroom asked what he considered as examples of success. J. van Es said that the problem [with the space thermal community] was that the group was small, and that most of the companies within the group competed with each other. He was afraid that people wouldn’t share their knowledge. C. Stroom said that he really wanted as many users as possible to be involved in developing a generic, core tool kit, especially in this common area where companies could not claim to be in competition. J. van Es agreed in principle, but was not sure that a large company which spent money on a GUI for their people would be happy to share that effort. He said that many such users had their own tools which interfaced to ESATAN.

R. Schlitt (OHB) wondered whether OSS was really the future for software development. He felt that the first option [“hands off” approach with little coordination or harmonisation] would not be possible with OSS. C. Stroom said that the first option meant that ESA would not need to do anything. R. Schlitt asked whether a management board to support the second option [“harmonised” approach with coordination for the development of generic tool kit components] would include user representatives as well as ESA. C. Stroom said that one of the outcomes of the user survey had been that users felt that developers should not be in such a management board. F. du Laurens (Alstom) asked how the developers had responded to the survey. C. Stroom said that the problem was that they felt that they should be on such a board. He added that it could be that users felt that they had little influence on the current software development, and that restricting the membership of the board to users could provide the opportunity to change this. C. Stroom said that there was a balance between what software and features the users actually wanted to be developed, and how this development could be paid for. The available resources usually limited the choices. He felt that priorities [for feature development] should be given by the users, but the users were not usually in a position to determine how much the development would cost. Therefore it would be necessary to include the developers in the management board, but maybe they should not be able to vote on the priorities.

C. Stroom asked the audience whether people really wanted to share. He felt that there was such a large block of common functionality which everyone needed. He asked whether companies who had software which addressed this common functionality would be prepared to contribute it to help in building a common system. C. Ruel (Maya HTT) said that there was not enough money in such software to influence commercial companies. Users expected OSS to be free. Current software typically cost 1-10kEuro to produce, but this was a lot for “free” software. He didn’t feel that commercial companies had much incentive in providing “free” software.

C. Ruel wondered about the stability of the OSS code base. The infrastructure to allow users to incorporate changes into the code base would not work in the commercial environment used at Maya. C. Stroom said that there were different models which could be used, and gave the Linux kernel as an example. All changes were submitted to a central authority where they could be tested, validated and placed under configuration control. Another example was Apache, where the user downloaded the source, typed “configure” and could then build and install the software.

C. Ruel asked whether testing could be embedded in OSS thermal tools. C. Stroom said that testing would need to be included, because the community could not afford complete anarchy. He envisaged a system where ESA would handle the version control and testing via a central repository and users would be able to download the source code. All users would have access

to the release versions of the tools, such as “esakit-8.7” as well as any of the development versions. Any additional development by a particular user should be sent back to ESA, and there could be a vote on whether further resources needed to be spent to improve the quality of the changed or additional code before its integration into the repository.

C. Stroom commented that one of the findings from the survey was that code needed to be validated on both quality and robustness, so some scheme needed to be put in place to provide the means for producing robust, functional software. C. Ruel was concerned that if code was being received from many people, wasn’t there the risk that a lot of time and effort would be spent on evaluating all of the changes, deciding whether they were compatible with the existing code, etc. and wondered whether it would be easier to start code development from scratch. He asked whether this would prove to be an impediment to the development of new code, when so much effort would be spent on new code, and a lot of effort to evaluate the code, and in the end a lot of code being discarded or needing to be reworked before it could be integrated in the central code. C. Stroom argued that there would be overall cost reduction in avoiding duplication of code in all of the different tools currently being maintained, and that producing common software would not necessarily be cheaper than the cost of a single company producing its own tool. It should also be faster to redistribute the common software to the users as the development version would be available as well as the last released version. If a specific need arose for a specific project, that project could always clone the software in order to develop the features that it needed.

C. Stroom returned to the question of money. He said that some resources would be needed to start such a project. The figure of 1-10kEuro would not really cover development, but he felt that the cost of software maintenance would probably prove to be more of a problem. Commercial software vendors always had to consider maintenance. He said that the business model for moving to OSS development would also need to address the long term running and maintenance of the software. He emphasized that the cost of maintenance of software went up as the software grew older. He gave the example that ESATAN was already 20 years old, and it would need to be maintained for another 10 years before it could be replaced. J. Thomas (Alstom) was quick to point out that any replacement for ESATAN did not necessarily have to be an OSS version. C. Stroom agreed, but said that ESATAN was in need of an overhaul, but it was not clear how this should be achieved.

F. Lamela (EADS CASA) wondered about the French position on OSS development. He had experience with a Belgian company called SamTech developing a “new NASTRAN”. This new software was being used by many French companies, so he wondered whether there was a requirement to use this particular software. He wanted to know what other companies were doing who were currently using NASTRAN. He said that the “new NASTRAN” users wouldn’t see details of the meshing and surface properties: they would see a CATIA view only, and then produce data for import into Excel. This was one software product aimed at a specific manufacturing application where the user did not need to know anything about the internals of the calculations. HP. de Koning (ESTEC/TOS-MCV) confirmed that SAMCEF was the only real competitor to NASTRAN in Europe, and that it was used a lot in the non-linear domain. There were other OSS projects in Europe, such as OpenCASCADE. SAMCEF used this OSS internally, e.g. to provide the geometric engine. He went on to say that everyone had to take the French position to be that given by the French delegation to ESA. HP. de Koning stressed that there was also a large difference between the provision of software for the structural and thermal

areas. NASTRAN type tools commanded a huge market involving tens of thousands of seats, but the thermal tools had a much smaller market.

HP. de Koning felt that the second point which F. Lamela had made, that of hiding the details of model construction and calculation, would be more difficult to achieve. It wasn't always possible to rely on "point and shoot" type software systems: the users had to think about how to achieve what they wanted, what assumptions were made by the tools, etc. Users needed to have access to the details in order to perform verification of models. He agreed that people were more exposed to the internal workings of software than they should or needed to be, but access to the internals was still required for parametric studies, etc. There was a need for a scripting interface to many tools in order to get at the internals. He had big doubts that "point and click" systems would suffer from the limitation imposed by lack of user access to the internals.

F. Lamela argued that most structural engineers were only interested in the spacecraft as a series of panels. The user passed the length of both sides of the panels to CATIA, the panel could be meshed automatically, etc. He suggested that five parameters could be used to represent most thermal models. The user should only have to provide the software with these parameters in order to get a result. The meshing and calculation could all be hidden inside the software. For example the user should only need to give the diameter of a hole in a panel for the software to be able to produce the results in the GUI, or to be able to generate reports automatically. HP. de Koning said that this related to the automatic idealisation of the model and the extraction of the results from the model. Engineers could use procedures to advantage for achieving this. NASTRAN could afford to offer these features because of the large user community, but it was difficult for companies to justify spending the effort to achieve this if there were only a hundred users of their tool.

C. Ruel was worried that if people were able to download the source code, they could always develop their own GUIs or enhancements if they didn't like what the central version offered, and that this would lead to the existence of incompatible versions. This is what had happened to other tools, such as SINDA, and the different versions tended to grow. HP. de Koning agreed that this was an argument against distributing source code. He said that ESATAN could have been distributed with source code, but by not doing so any differences between the various sites running ESATAN had been avoided. With OSS, a different approach had developed over the last 4 or 5 years, and that this was based on trust. The idea was that if you participated in the software development along with others, then you would get back more than you put in. However, if people hijacked the development for their own ends, there was the risk that chaos might ensue, but in practice the development community would not tolerate this. C. Ruel asked how the situation could be policed effectively. C. Stroom answered that it usually came down to self control. He had access to the sources for the Linux kernel, and in theory could modify them for his own needs, but so far he hadn't been tempted to do so. Anyone who did make changes outside the main development stream usually found that the next upgrade couldn't be applied without re-modifying the new sources to reflect the user's own changes, and that this soon became prohibitive.

C. Stroom felt that 20 years previously the thermal software community had been amateurs when it came to software development. A lot of experience had been gained over that time, and the situation was now different. Maintaining software was a costly business and now everyone realized this. He was sure that all of the companies represented at the workshop realized this.

However, most of the people at the workshop didn't come from software companies. All they wanted were tools to help the thermal design process. Most people used the tools as they were, and only if they needed a specific feature would they even consider writing code of their own. He felt that people simply didn't have the time or money to dedicate to writing such code. HP. de Koning commented that the growth of the Internet and Web technologies had enabled easy cooperation between different groups no matter where they were in the world. This was very different from 20 years ago when sharing programs and data involved sending tapes, lengthy delays, etc. C. Stroom repeated that chaos could only result if there were users who forked their own versions of the software.

C. Ruel said that TMG had hundreds and thousands of customers and not just in the aerospace sector, so they had lots of requirements from different parts of the market. C. Stroom observed that even large companies had disappeared. Look at EUCLID and ASKA. However the engineers still required tools in order to make satellites. C. Ruel said that Maya had funding from the Canadian Space Agency and the intellectual property rights (IPR) of all code developed for the CSA was shared. If Maya went out of business, then the CSA would have access to the source code. C. Stroom admitted that this was true in theory, but said that if a company such as Maya or Alstom disappeared then the concentration of all of that company's knowledge would disappear too. R. Schlitt suggested that ESATAN and ESARAD could be marketed along with NASTRAN. J. Thomas (Alstom) said that they had probed MSC about this in the past, but that MSC hadn't shown any interest in doing so.

C. Stroom was under the impression that users didn't want to have a list of prescribed tools. HP. de Koning agreed and said that stability needed to come from the provision of good interfaces. Different tools could then use those interfaces. He said that the standardising on particular tools had never worked.

F. Lamela introduced the differences between working in the commercial and the scientific satellite markets. Their @BUS work provided for 200 hours to be spent in England and 100 hours to be spent in Germany, and such pressure would not leave them with enough time to write a report on the results obtained. He said that tools must introduce minimum cost to the engineering process. The time taken to discretize a model need to be reasonable, but this was an area which needed to be fixed in software. He felt that there were issues of innovation and communication. He felt that there wasn't enough communication about the existing developments in the standard software and was worried about how this would work with innovative software being developed as OSS. If he needed to add functionality to such innovative software, how would he be able to discover whether someone else was already working on it? He said that most companies didn't give away information.

F. Lamela was also interested to know how people could manage the cases of low prices and tight schedules which were normally presented in proposals. For example, he was interested in good software to help in the calculation of antenna characteristics. However, structural engineers took one week to calculate what they needed whereas the thermal people took three months. C. Stroom asked whether F. Lamela wanted a marketing tool or an analysis tool. Was he really interested in a tool to help in winning bids? Was he looking for a nice tool which could provide approximate results quickly but which would not be reliable for detailed models? C. Stroom explained that he had visited JPL, where there was a CDF[4]. Engineers from all disciplines sat together in the CDF to make the design for a new satellite. All NASA sites

competed on bidding for the satellite as part of a competitive ITT. The successful bid came from JPL, with the CDF. However, the question then arose of what to do once the bid had been won. Should JPL continue with the design which had been produced by the CDF for the bid? In fact, the CDF had been used to produce a design specifically to win the bid. Once it had been won, this design was discarded and the real design started again. C. Stroom felt that if the goal of the tool was to be able to convince the marketing manager that a radiator would need to be 300kg and handle 300W then this was fine. However, it was important to know the level which the users expected for this tool.

R. Schlitt said that the important word which had been mentioned during the discussion was "communication". He was in favour of the harmonisation meetings, but stressed that it was important to have user involvement at the beginning of any development work. He felt that it was necessary to have users take part in more discussions. He suggested two meetings per year. However he recognised the problems involved in organising such meetings. He already had a problem of how to discuss loop heat pipe technology with software developers and users when there was no spare money to enable such meetings. He went back to the communication issue and said that every year there was a new version of the software and users were not always fully aware of the new features and improvements. C. Stroom agreed that communication was important and that there should be users and ESA representatives on any software management board, but he wanted ideas on exactly how this should be achieved. Yes, there were the yearly meetings and other things which would be of interest to users. Users also had their own "wish lists" for new features, but usually they had no time to communicate these requirements when they needed them most. C. Stroom felt that it would take more than just a news letter to keep them informed of all new developments. R. Schlitt admitted that they had problems with software, but they never saw some of the developers (e.g. Alstom) in order to discuss solving them, whereas some other developers visited regularly.

C. Stroom said that the space thermal tools had only about 10% of the market compared to some other tools, and had only a small budget for development and maintenance. Therefore it was necessary to know how to prioritise in order to make best use of the budget. R. Schlitt thought that there must be a lot of money around if all tools such as THERMICA, CORATHERM, etc. were taken into account. What was needed was some way of harmonising the money spent on the different tools. HP. de Koning stressed that this was the whole point. In Europe the user community was too small to warrant so many parallel tools and developments. He felt that in the future, Europe would need to pool all of these resources together.

C. Stroom wondered whether there was a need to pay users for their rôle in requirements gathering, ECSS involvement, etc. All users seemed to want data exchange, but none of them had the time or money to be able to contribute to defining the requirements. H. Peabody (Swales) felt that the funding was key to the development process, and said that a company would drive development as long as there was a task to be completed and a need to have a new software feature in order to complete that task. However, if there was no clear project or task to which such development could be charged then the company was unlikely to pay. It wasn't always possible for developers to work on what they wanted to work on. He went on to say that the idea of OSS was great, but if the users didn't have the time or resources to put into the development, then it wouldn't work. C. Stroom admitted that this was true to a certain extent.

4. Concurrent Design Facility

The Apache model for OSS development wouldn't work for the space thermal community. H. Peabody argued that Apache had a lot of users in comparison to the thermal community. HP. de Koning commented that OSS didn't necessarily mean free of charge. H. Peabody admitted this, but countered by saying that if his company wouldn't pay [his time and resources] then how could he contribute to any OSS development. C. Ruel felt that this was a key point: a developer needed resources in order to work. C. Stroom argued that since people were already developing a lot of tools on their own, these resources were available, but were not coordinated. He said that a lot of components were already available as OSS: there were systems for ray-tracing, scripting, etc. HP. de Koning said that a lot of OSS development was about gluing existing components together rather than developing everything from scratch. C. Stroom said that without being able to work in terms of smaller components, any changes to software required a major overhaul of the code. Rewriting a system such as ESATAN or ESARAD was not really a development problem, but more of a maintenance problem in the long term.

C. Ruel wondered whether it would be possible to issue contracts to maintain OSS code. HP. de Koning said that there were different models available for developing and maintaining software. People could pay to join a board which oversaw any development work, or people could buy services which could pay for development. Therefore issuing contracts to maintain code was a serious possibility.

J. van Es was concerned about the issues of giving any software away. He wondered whether it would be possible for ESA to sub-contract thermal analysis and then provide a bonus if any tools developed by the company were contributed to the common software base. In the future, people should be encouraged to generate tools for the common software base as part of project work. C. Stroom commented that this was basically what HP. de Koning had said: the company should pay for development, and then contribute it to the community for the common good. H. Peabody didn't think that it would be as easy as that. It had taken him four years to develop ThermPlot but Swales owned it, Goddard had some rights to it. He was not the owner.

C. Stroom observed that the discussion seemed to have become stuck on OSS, and wondered whether there were any other topics.

E. Werling (CNES) asked about using SYSTEMA as a solution to the common software base. HP. de Koning admitted that SYSTEMA and THERMICA formed one of the major tool kits. However it was a good example of what was meant by duplicate effort. It would be better if all effort could be brought together in the interests of the user community as a whole in order to provide common tools.

E. Werling observed that the Harmonisation report had mentioned a user group with ESA responsibility and wondered what form this would take. HP. de Koning answered that there was no real name for such a group. E. Werling asked whether anything had already been planned. HP. de Koning said that it could be that one of the recommendations to be made in the Harmonisation road map would be to form such a group, There would be a meeting in the middle of December to consider the options. L. Maresi (ESTEC/IMT-THH) said that, provided some consensus could be reached, information from the Workshop could be used to help with the recommendations to the meeting in December for the development of a common tool kit. C. Stroom said that ESA had to deliver the documents one month before the meeting, so time was tight.

R. Schlitt commented that the “tool kit” under discussion was currently without form and it was necessary to define what was actually wanted or needed, what primitives should be provided, etc. C. Stroom asked who would be prepared to participate, and he meant really participate rather than just provide vague support.

S. Dolce (ESTEC/TOS-MCT) was prepared to give an example where in a project, if the phase A/B design suggested the use of Loop Heat Pipes [LHP] using ESATAN/FHTS, if nothing was already available on the market then the project would consider developing its own. He felt that it would be a good idea to have a list of desired technologies to be supported, and that this list should be made public so that users could contribute and be involved in the decision making. At the ESA level such a list would show whether there was a need for ESATAN-II, and ESA would know that they would have to make it available. The same held true for the harmonisation group, or for French companies: if they needed LHP technology support, they needed to go through the same process. If it was not possible to have such a scheme to help direct common development, then model exchange between the different tools would be essential. HP. de Koning agreed, but said that the data exchange was an independent issue. S. Dolce argued that data exchange had been discussed for years, but projects weren’t prepared to wait five years for an ideal solution: they needed solutions now, and were prepared to develop their own if necessary.

J. Thomas informed everybody that ALSTOM maintained just such a list of Feature Requests on its web site, although access to it was restricted for a variety of reasons. These Feature Requests had been produced after discussions with customers, or from comments during previous workshops, etc. He said that he had collected two pages of Feature Requests from this Workshop alone! He wondered whether there was enough interest to make the Feature Request List available to a wider public, although he said that there were some aspects of confidentiality, etc. which would need to be discussed. He went on to say that ALSTOM had adopted the policy that development work should be 100% driven by the direct project requirements or by items on the Feature Request List. Therefore, developments shouldn’t really be a surprise to the users. He wondered whether even more transparency was needed in order to improve the requirements process.

S. Dolce felt that there had to be some link between the needs of the users and projects and the way of reacting to them quickly. J. Thomas said that there were some differences between general user requirements and specific project requirements, and it was necessary to balance the two. If a particular feature request would only be useful to one or two companies than it would be hard to justify doing the development with general development money. However, Alstom were open to discussing requirements with any company or project which had specific needs and which was prepared to pay for their implementation.

S. Dolce wondered whether the drawback to the current proposal was that until some consensus was reached by the delegation it would be difficult to make any progress. HP. de Koning argued that trying to prioritise Feature Requests at the European level would be valid for all products. He felt that there was a need to do this across the community and not just at the vendor level. He admitted that there was a certain level of commercial conflict of interest. He stressed that people who shared the common environment needed to put things into it as well as get the benefits out of it. The question was how to do this without exchanging software. A request for a new feature to be added to ESARAD would probably apply to THERMICA as well. The

difference between the commercial approach and the harmonised approach meant that different groups would gain from each. The question was how to find a middle ground in which all parties can benefit.

M. Heuts (Dutch Space) asked what the users were actually interested in. Most companies were interested in tools which enabled the engineers to work in an efficient manner, and it didn't really matter which tool that was. Dutch Space wouldn't invest in tools if it could work with existing tools. He agreed with the harmonisation effort if the goal was to work efficiently, but if he needed to spend lots of money in order to participate, then he wouldn't take part because at the moment he could work with the existing tools. C. Stroom forecast that the current situation which had existed for twenty years wouldn't continue for another twenty. Therefore there was a need to do something before current expertise was lost. For example, ESATAN had been written using F77 and in the future there would be fewer developers with experience of F77, and less support from vendors. The aim of the harmonisation wasn't for the short term, but looking to the three to five year time frame. M. Heuts said that he would be prepared to participate on a part-time basis to help achieve such a goal.

P. van Leijenhorst (Dutch Space) said that it was necessary to ensure that the effort went in the right direction. Participation should not necessarily involve paying, but it would mean that there would be a better consensus in how to use the R&D money, and more people to help convince the delegates about what was needed. C. Stroom said that participation would take time and that "Time is Money". He said that a set of crosses on a list or survey wasn't enough to build consensus. He knew that the user community had a wide range of varying opinions, and that it would be necessary to find the common goals and requirements of the users. He stressed that if the users were not involved in making the decisions, they would probably be unhappy with some of the results which came out of them.

H. Peabody felt that it would be beneficial for users if someone could provide a web site where users could store information on new technologies, LHP, software requirements, etc. He compared this with the Visual Basic bulletin board, where users could search a knowledge base for answers to their own questions. C. Stroom agreed that these were valuable suggestions, and something like this had been envisaged for the now-defunct Thermal Mailing List. H. Peabody said the difference was that the information needed to be searchable. C. Stroom wondered about effort required to keep such a web site up to date. H. Peabody said that there must be a lot of people who had home grown software that nobody else ever found out about.

C. Marechal (CNES) reminded everyone about the GAETAN development. At the beginning the users had been involved in the requirements and design, but had only contributed financially when they had been obliged to, such as when the software was changed for them, or when the users had new needs which the software didn't meet. There had been user group meetings every two months to allow for feedback, but these had collapsed after only three meetings because the software worked to do what they wanted. C. Stroom admitted that there had been a similar experience with an ESA software board which had met four times and then hadn't really worked any more. What he had learned was that user involvement really needed to be set up differently. This was what a suitable web site might be able to offer. People rarely had spare time and resources so the number of physical meetings could be reduced, having them as additional sessions within workshops for example. He felt that it was important to use the user interest more efficiently.

E. Werling remarked that there was a document - a strategy paper by ESA - which could be sent to industry for comment. C. Stroom pointed to the ECSS web site where it was possible for a user to be sent notification when a document had been added to the web site. HP. de Koning said that there was already an initial version of a Thermal web site, and he wanted to build on this site to provide a discussion forum.

R. Schlitt said that as far as user involvement was concerned, if the users could see that they would save time and money by using new developments in the software, and being able to guide those developments, then the users would be more interested. He said that he often saw RFQ and ITT documents but he didn't usually know how such initiatives would affect him directly.

C. Stroom said that he wanted to make a form of business case for any new form of development. He felt that there should be real milestones, and if these were not reached then the development should be abandoned, but it was important that the whole community should make this business case together. Everyone in the user survey had said that ESA should take the lead, but he felt that users still needed to participate. HP. de Koning said that the December delegation would comment on any proposals, so users should ensure that the delegates were aware of their positions.

V. Perotto (Alenia) observed that the current situation had been created by a number of boundary conditions. One of these was the lack of confidence of the users in the developers and ESA in providing software to address users needs. He gave the specific example of lack of progress on the data exchange problem. He felt that if he could present something to his management or to the delegation that something was actually being done, then he might be able to change their attitudes.

HP. de Koning remarked that the data exchange question would be handled during a presentation on the following day. V. Perotto had already heard about the initiative to provide conversion between ESARAD and THERMICA, and he could inform his management that things were moving again. If his management could be convinced that ESA could provide results within six months, then they could use their own resources and effort in a more efficient way. HP. de Koning said that ESA had already taken measures to ensure progress on data exchange. ESA had taken responsibility for developing the converters. An alpha version was already available, and he was hoping to be able to distribute the converters free of charge before Christmas.

V. Perotto went back to considering the problems of selling a common tool kit to management. He said that a user might want to present a bit of an existing tool to ESA as part of the common tool kit, but it might be difficult to obtain management authorisation to do so. If users were allowed to participate, what would each company offer? He felt that authorisation would be hard to get because it wasn't clear whether the company would actually get any compensation for the effort.

H. Peabody said that it would be helpful to know exactly what tools were already being used. There might be a problem of actually distributing existing tools, but it was often useful to know that a particular tool was out there. C. Stroom agreed. He said that collecting such information depended on the amount of available ESA manpower, and he admitted that maybe ESA should do more.

A. Crutcher (FSC Ltd.) gave a developer's perspective on user involvement. As the ThermXL developer, they had offered two seminars to end users to discuss requirement and development, but in the end only one person had been interested. He felt that end user involvement had to be simple to use, such as a Web based discussion board. However, he was not entirely convinced about end-user involvement in general. What currently happened was that ESA funded some development and at the end of it the users criticized the result, but he felt that this might be the only way of working because "design by committee" was rarely successful. He felt that there should be a small executive committee which should put forward ideas, try to deliver these to the users, and take any criticism

A. Crutcher admitted that the OSS idea sounded quite good but gave Red Hat Linux as an example of a value added OSS product which had to be bought even though the component parts could be downloaded for free elsewhere. HP. de Koning felt that this model was fine if people were prepared to pay for additional services or maintenance. A. Crutcher emphasised that OSS systems were inherently different to packages such as EcosimPro. He felt that many end-users would have difficulties to build all of the tools from scratch, or to incorporate ray tracers, etc. and that they wouldn't all be able to put all of the components together. HP. de Koning admitted that this was true: end-users wouldn't necessarily be able to build the tools because it really needed to be done by software engineers. However, he said that there were examples of such systems out there, and gave OpenCASCADE as an example of a large OSS system with many contributors.

C .Caillet (OpenCASCADE) explained that there had been 18 Meuro of investment in the OpenCASCADE system, initially by Matra Datavision, before it had been converted to an open source system under the control of a daughter company. This company now sold services in software engineering on how to use the open source software. The business model had been built entirely on these services. The services included integration and technical support provided to customers.The sale of these services provided the money needed to improve the product, investment in research and development and extending the platform base. Some funding also came from European and French research initiatives. There would be a presentation on the SALOME system the next day: this was an integration of CAD with numerical simulation. Nine partners had spent 540 man years in its development. He agreed that maintenance of software cost a lot and that it was a big issue. The company had to ensure that there was an on-going customer maintenance project with general bug fixing for the whole community, and a system of charging customers with support contracts for fixing specific bugs rapidly to enable them to continue working. This resulted in a sharing of costs and benefit across the whole user community.

R. Schlitt returned to the issue of user involvement: he said that the software developer had to convince the customer to buy a particular software product. A. Crutcher wondered what would happen if a company offered software as OSS, what terms and conditions would apply, and whether these would apply worldwide. HP. de Koning said that the software could be restricted to a user community group. C. Stroom commented that there were already systems available with restricted access, such as the various environment models developed for SPENVIS[5]. However, he didn't know how the different access models to the common tool kit would work in practice.

5. Space Environment Information System. See http://www.spenvis.oma.be/spenvis/

3. Wednesday 23rd October: Morning Session

3.1. Use of TSS as a neutral format for geometry model conversions: an alternative to STEP-TAS

H. Peabody (Swales) presented the problems of trying to share model data with different project groups and the different software systems which they use. With no current consensus on a common format for data exchange between tools, and with TSS providing a superset of the facilities available in other tools, he had produced a series of converters for translating models to and from the TSS format. He described the additional conversion tricks which were required. (See Appendix O)

N. Cavan (RAL) asked whether the conversion process conserved any model hierarchy and was told that it did. H. Peabody said that ESARAD reported everything using global coordinates whereas TSS used staged coordinate systems. The ESARAD converter had been written first, and it should really be revisited to apply the knowledge gained writing the other converters. The converter had an option for trimming surface names, but this could result in a problem of nesting in ESARAD, so the software had to keep track of all trimmed names.

J. Persson (ESTEC/MSM-MCS) asked whether TSS would become the replacement for TRASYS. He was interested to know whether a TSS model of the International Space Station existed. H. Peabody said that TSS had been designed as the replacement for TRASYS. He didn't know why NASA had chosen TRASYS to model the ISS because he knew that NASA converted the model to TSS in order to view it. The conversion from TSS to TRASYS and back was a simple one. J. Persson wondered whether it would be possible to use the ISS model in TSS and convert it to ESARAD. H. Peabody said that it was probably possible although he hadn't tried it.

C. Stroom (ESTEC/TOS-MCV) referred back to the viewgraph on the neutral formats and said that TSS was effectively proprietary software and therefore could not be controlled. This was one of the arguments for a true neutral format. H. Peabody admitted that the TSS format could be changed without warning, but so far it had proved to be very stable. C. Stroom felt that import and export should really be handled by the tool supplier, and not by reverse engineering the required data formats. However, he admitted that the TSS converters worked, and European efforts to work with STEP-TAS were still incomplete.

3.2. CIGAL2: An open source pre/post-processing tool for CORATHERM and other software activities

JP. Dudon (Alcatel) described the userof CORATHERM in Cannes, and the design of a new tool, CIGAL2, based on open source components to integrate the various pre- and post-processing needs of the thermal engineers. (See Appendix P)

S. Appel (ESTEC/TOS-MCV) asked whether he had understood the last slide correctly to mean that some interpolation was needed to map thermal node temperatures to the finite element

nodes. JP. Dudon said that this was only necessary to fit the meshing and that when the finite element node corresponded to the finite difference node the thermal calculations on the finite difference meshing could use EQUIVALE. S. Appel said that this implied that the system used the finite difference conduction matrix on the finite element nodes. JP. Dudon agreed and said that finite difference tools were used to calculate local temperatures on small nodes and these were then used for the final temperatures of the finite element mesh. S. Appel said that with an initial fine lumped parameter mesh and a final finite element mesh it would be easier to make a mapping. JP. Dudon agreed that such an approach would make it easier to get the final mapping.

HP. de Koning (ESTEC/TOS-MCV) noted that the example had achieved $\pm 2^{o}$ accuracy in the condensed model compared with the full main model. He asked whether there had been a similar check on the heat balances if nodes were grouped. T. Basset (Alcatel) said that it had. HP. de Koning said that it would be useful to have an indication of the accuracy and constraints of the reduced model. JP. Dudon replied that this would be a parameter which would be taken into account in the future.

E. Werling (CNES) suggested that the a STEP-TAS converter needed to be added to the framework. JP. Dudon admitted that it was already in the planning. E. Werling said that this was important, because it would enable communication and interchange with other tools such as THERMICA and ESARAD.

3.3. TMG: New Technologies and Modelling Approaches

C. Ruel (Maya HTT) presented a comprehensive overview of the capabilities of TMG, outlined some of the algorithms being used, and described some new features which would be available in the next release. (See Appendix Q)

H. Peabody (Swales) asked when the new version would be available. C. Ruel said that IDEAS-10 would be released at the beginning of 2003, but some of the features which he had described were already available in IDEAS-9. HP. de Koning (ESTEC/TOS-MCV) asked whether these features would be available in both FEMAP-TMG and IDEAS-TMG and was told that they would.

3.4. SYSTEMA/THERMICA version 4: overview of the new capabilities

M. Jacquiau (Astrium SAS) described the current capabilities of the SYSTEMA framework, and detailed the latest developments within THERMICA and related applications. (See Appendix R)

C. Ruel (Maya HTT) asked about the tolerance used for the automatic detection of contact between shells. M. Jacquiau said that the user could tune the tolerance value used during the detection of contact between edges. C. Ruel wanted to know whether the user could specify the contact resistance. M. Jacquiau answered that the contact resistance could be given by the user.

H. Peabody (Swales) asked whether THERMICA could handle surfaces with thermal nodes on both sides. M. Jacquiau said that he hoped to be able to offer this in the future, but for the

moment it was still necessary to use two surfaces, one for each node.

E. Werling (CNES) asked whether the full SYSTEMA suite would be offered as a commercial package. M. Jacquiau said that a decision would be taken soon. He explained that some specific applications were already available commercially, but the complete framework was different. It was easy to exchange data models between the different applications within SYSTEMA. He wanted to commercialise SYSTEMA but there were still some commercial and technical issues which needed to be discussed.

J. Thomas (Alstom) asked whether THERMICA version 4 was already operational within Astrium. M. Jacquiau (Astrium SAS) said that some of the GUI parts were already being used, all of the batch processes were available internally, and there were even a few external users of the batch version. He explained that all of the new features came from the needs of projects within Astrium.

3.5. ESATAN/FHTS and ESARAD: A View on the Near Future

J. Thomas (Alstom) presented details of new and improved areas of functionality within ESARAD, currently being used in-house at Alstom, most of which would be available in the next industrial release. He described how these features would lead to better integration between the tools. (See Appendix S)

H. Peabody (Swales) was interested in the conductor generation facility, and asked whether it would support having two nodes connected to one side. J. Thomas said that he didn't know the answer off-hand, but would try to provide an answer via e-mail. H. Peabody remarked that there had already been some discussions and issues about conductor generation. HP. de Koning (ESTEC/TOS-MCV) said that the algorithm needed to be independent of the meshing. F. du Laurens (Alstom) said that the algorithm would identify the connect lines but the user could turn some off or add others.

H. Peabody asked whether the STEP-TAS interface was working on Unix, because it was needed for GSS-ATX. HP. de Koning said that the next presentation would address this, so the question could be asked again then if necessary.

3.6. TASverter: Thermal Analysis for Space model converter

S. Appel (ESTEC/TOS-MCV) and HP. de Koning (ESTEC/TOS-MCV) described the TASverter initiative to provide data exchange capabilities in the short term while problems with the development of industrial libraries for integration in the main tools were being addressed. (See Appendix S)

D. Charvet (Astrium SAS) asked whether the converter between ESATAN and SINDA was already available. HP. de Koning said that it was, but only from SINDA85 to ESATAN. It was a two pass converter. The first converted SINDA to its ESATAN equivalent. In the second pass, the converter detected which units were being used, and tried to map to MORTRAN by converting SINDA library routines to the ESATAN equivalent. This conversion was extendible

to user routines. The converter was able to resolve most of the MORTRAN but the user still had to do a lot by hand. The data blocks were converted completely.

S. Dolce (ESTEC/TOS-MCT) asked about the verification of the converters: was this a visual inspection, or some intrinsic check? HP. de Koning said that there was a large suite of test cases - currently there were 200 for the TRASYS and 50 for the SYSBAS conversions - and these applied to all shapes and optical properties. For the TASverter itself there was no visual check, and the user needed to see the model in the sending and receiving tools. However, he was confident that the test suites handled all cases. The tool vendors would also have access to the test suites. J. Persson (ESTEC/MSM-MCS) asked how the test cases defined successful conversion. HP. de Koning explained that they had to be some level of inspection although it was possible to use reference definitions to provide some automatic comparison. He admitted that the first time the case was run, the comparison had to be made by hand. The full test suite was available for regression testing against the reference cases.

J. Thomas (Alstom) asked about the source code for the converters: would it be available as open source and could the vendors make changes to it. HP. de Koning said that the converter suite was a prime candidate for release as open source software because it was in the interest of the community as a whole and nobody had a competitive edge which needed to be protected.

E. Werling (CNES) noted the availability of the converter between THERMICA and ESARAD as being the end of the year, and wondered when the other converters would be validated. HP. de Koning said that the test suites were already available, and he was confident in the tools because some large industrial models had also been converted. However, he was interested in users trying their own models. E. Werling asked whether the tools would be available at the start of next year. HP. de Koning said that he wanted to start a full verification campaign involving CNES, Alstom and the other vendors.

3.7. ThermXL v2 and Beyond

J. Thomas (Alstom) demonstrated the latest features of ThermXL using a prepared example, and described future developments. (See Appendix S)

J. Persson (ESTEC/MSM-MCS) commented that he hadn't seen whether ThermXL supported time-profile data, like those handled in the ESATAN $ARRAYS block. J. Thomas said that ThermXL was built on top of Excel, so it was possible to use any Excel function within the spreadsheet and to apply a function to a particular cell. He demonstrated on screen that the user could define any data cell to be dependent on a set of other data cells, such as those containing time dependent data. The user could then write a Visual Basic macro to interpolate the data within these cells as needed. He explained that there was an example in the ThermXL tutorial which demonstrated this. Version 3 of ThermXL would get rid of the need for some of this by providing a specific INTERP function. O. Pin (ESTEC/TOS-MCV) added that ThermXL provided equivalent mechanisms to the $VARIABLES2 block in ESATAN. He said that if time varying variables had not been available then ThermXL would have been useless. HP. de Koning (ESTEC/TOS-MCV) remarked that because the whole spreadsheet was recalculated at every time step it was possible to refer to individual variables during the time marching.

E. Werling (CNES) wanted to know about the relative speed of ThermXL compared to ESATAN. J. Thomas explained that ThermXL had never been intended as a replacement for ESATAN as it could only handle small models. There was an Excel limit of 255 columns in the spreadsheet, and this meant that ThermXL could handle a maximum of 254 nodes. He admitted that the more complexity the user added into the spreadsheet, the more work Excel had to do to recalculate it every time, so the calculation became slower. However, he stressed that the tool had never been aimed at handling large models.

4. Wednesday 23rd October: Afternoon Session

4.1. ALTAN application for Bepi-Colombo thermal analyses

V. Perotto (Alenia) described aspects of the Bepi-Colombo mission which could not be modelled using the existing tools - namely directional reflectivity, the finite size of the sun, and non-uniform planet temperature -and the software which had been developed to handle these problems. (See Appendix S)

There were no questions.

4.2. Last Developments in and around GAETAN

C. Marechal (CNES) described the changes to the GAETAN software which had been made since it had been presented at a previous Workshop, and also gave some details of CONDOR, an internal CNES tool to help find dimensioning cases for given orbit parameters. (See Appendix S)

S. Dolce (ESTEC/TOS-MCT) asked for a more detailed explanation of the semi-automatic model reduction available in GAETAN. C. Marechal said that he had already given a presentation on the model reduction feature at the Workshop three or four years ago. E. Werling (CNES) explained that it was a physical method, and that all thermal flux analysis and heater data could be taken into account. He stressed that this involved an energetic and physical approach and was not based on stochastic methods. S. Dolce asked whether the reduced model was a physical representation of the original model. E. Werling gave the example of the INTEGRAL spectrometer which had yielded a factor of 100 model reduction. He confirmed that the physical meaning of the model was retained. He explained that this was why the algorithm was only semi-automatic, in order to keep the physical meaning and to allow the user to define the appropriate node groups.

4.3. NASA Space Environment Specification

HP. de Koning (ESTEC/TOS-MCV) gave a brief news bulletin that a new Space Environment Specification was available from NASA and that it might form a useful foundation from which many projects would be able to draw common definitions.

The complete reference for the document is:[6]

NASA/TM-211221, Anderson, B.J. and Justus*, C.G. and Batts*, G.W., Guidelines for the Selection of Near-Earth Thermal Environment Parameters for Spacecraft Design, George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812, National Aeronautics and Space Administration Washington, DC 20546-0001, Prepared by Engineering Systems Department, Engineering Directorate *Computer Sciences Corporation, October 2001, pp. 32, Format(s): PDF 1885k.

4.4. CAD-FE integration using Open Source Software

C. Caillet (OpenCASCADE) described the design requirements for an open source framework for building numerical simulation tools, and how the SALOME system had been developed and was currently being used. (See Appendix S)

HP. de Koning (ESTEC/TOS-MCV) said that the OpenCASCADE framework was already available as open source software. He asked whether SALOME would also be available. C. Caillet said that SALOME had not yet been industrialised: it was still being built and tested.

4.5. Final Discussion and Conclusions

L. Maresi (ESTEC/IMT-THH) had put together a series of viewgraphs based on the earlier session on Harmonization and the Round Table discussion. These needed further discussion to ensure consensus. (See Appendix Y)

C. Stroom (ESTEC/TOS-MCV) started the discussion with point 1 (general consensus was expressed on the role of ESA for defining standards for data exchange). He explained that the work on data exchange had been a major priority and would remain so in the near future. Data exchange needed to be based on open standards. Standards needed to be of high quality, stable and should never be based on a proprietary definition. The latter point was important to ensure that the standards did not fall under the control of one company. STEP was therefore the best solution.

S. Dolce (ESTEC/TOS-MCT) said that standards should be made available quickly. In Europe, there was a constant need to exchange thermal models between different tools. Developing a perfect standard and solution for this problem might still take a significant amount of time. It was important to focus on quality but flexibility and short-term availability should also be taken into account.

C. Stroom explained that developing standards was never fast. He said that the earlier presentation by H. Peabody (Swales) had been a good indicator of the number of issues that had to be solved up front before it was possible to define workable standards. It was indeed a meticulous task. The same remarks could be expressed for the ECSS standards. In many cases

6. The URL to this document which was shown at the Workshop is no longer valid. The document is currently available at http://trs.nis.nasa.gov/archive/00000581/

an initial plan involved 2 years to establish a standard, but in reality it taken far longer. C. Stroom said that he understood the frustration of the users who wanted to have a solution for data exchange in a short-term. On the other hand addressing only the short-term could lead to the non-availability of a long-term and more efficient solution.

S. Dolce said that TASverter was a good initiative because it would provide a solution for exchanging thermal models in the short-term. HP. de Koning (ESTEC/TOS-MCV) explained that ESA recognised the need for a short-term solution and this was exactly why the development of TASverter had been initiated. He admitted that from the users' point of view no significant progress had been made since the establishment of the STEP-TAS protocol in December 1996, 6 years previously. He was the first one to be disappointed by the lack of progress given his direct involvement during this time, both in industry and now at ESA. He pointed out that software vendors generally considered the need to interface their tools with standards as a second priority. There was also the fact that the technology chosen at that time had been quite complicated, with an approach that had been more academic than industrial. Now that lessons had been learnt he was confident that a more industrial type of environment could be used for the development of STEP-TAS and STEP-NRF.

C. Stroom had two additional remarks. Apart from the fact of using more efficient software technology it was clear that all efforts of the past had not been wasted. For example TASverter was based on the STEP-TAS protocol definition. He also explained that the project had suffered from two and a half years of delay because of the very poor performance of the main Contractor. The activity had lacked focus and in many times promised deliveries had not been made. He felt that this was one of the good reasons to go to an OSS distribution model to ensure that the overall development would not be jeopardised by the poor performance of a single company.

C. Caillet (OpenCASCADE) agreed with HP. de Koning on the fact that STEP had been a bit of a "University type" development. It was important to focus on a relevant subset for users. For example, CAD was not fully covered in Salomé but a reasonable subset was available. It was also important that the users themselves were involved by providing test cases to software vendors and by making sure that their needs were considered. Users needed to push and not wait for the standards to be available.

H. Peabody (Swales) said that as a user he did not care too much about how to go from tool A to tool B. To answer a previous comment made by C. Stroom he said that TSS was not a proprietary format but an ASCII fixed format. He remarked that in any case there would be a need to update STEP-TAS/NRF when new functionality was needed, for example for sub-modelling. HP. de Koning replied that sub-modelling was already supported in the STEP-TAS/ NRF data models. The current problem had not been in the standards themselves but in their implementation.

P. van Leijenhorst (Dutch Space) said that, in his opinion, priority should be given to the development of a solution for data exchange. He was in favour of option 1, data exchange and nothing more. The tool kit was not a priority. HP. de Koning agreed that there was a general consensus for having data exchange as a first priority. However, providing a solution for data exchange was not contradictory with the development of a tool kit. ESA should produce a stable and effective data exchange component but the tool kit could be addressed as a further step.

C. Stroom asked P. van Leijenhorst about his expectations for the next 5 years and was told that he wanted a working solution for data exchange. He had no further expectations. C. Stroom explained that ESA considered data exchange as a matter of first priority and that parallel activities such as TASverter would also be carried out internally at ESA to ensure that a backup would be available. He didn't believe, however, that just adding six extra people to the team would necessarily produce quicker initial results. He had been able to allocate one and a half engineers with relevant expertise to work on data exchange at ESA, and he felt that activities were back on track and ESA would deliver as promised.

HP. de Koning (ESTEC/TOS-MCV) said that users had to realise that work would need to start a long time in advance if a tool kit was wanted. It would probably take one year or more for the preparatory work. It was therefore necessary to address data exchange and the tool kit in parallel - and starting now - but still focusing on the immediate need to deliver working protocols for data exchange.

C. Stroom said that one of ESA's goals was to develop long-term solutions for thermal analysis tools and that we were at the beginning of a necessary review with users. He was therefore interested to hear what the users in the room would ask for once the data exchange protocols had been made available. P. van Leijenhorst said that all he wanted was not to have the same discussion on data exchange next year.

H. Peabody said that users had to realise that it was not possible to produce something perfect from the start. It was up to the users to assess whether a converter was right. The only way to have working solutions for data exchange was to have full involvement of the users. He was therefore of the opinion that STEP-TAS/NRF and associated converters should be released now and users could then detect any possible problems with the protocol and converters and help in their consolidation. HP. de Koning and C. Stroom agreed.

C. Stroom proposed to move to point 2 (the age of the current software tools and the increasing maintenance costs were major drivers for new development).

P. van Leijenhorst disagreed with the statement. The existing software tools were adequately doing what they were supposed to do. S. Dolce thought the contrary, and that there was a need for improvement.

C. Stroom gave the example of the requirements for Bepi-Colombo to explain that the development cost of existing tools could inhibit the availability of new critical functionality.

V. Perotto (Alenia) said that all requirements for thermal analysis tools originated from missions requirements in one way or another. If new functionality was requested for a mission then this should be implemented in the set of thermal analysis tools.

HP. de Koning said that a related issue was the need to support scientific missions which had very strong requirements for detailed analysis and verification. These scientific missions brought up a new class of required functionality. The age of the existing tools resulted in increased implementation costs, and this had an adverse impact on the availability of this new functionality. Another good example of new issues to be addressed related to the new generation of high power satellites. The analysis tools had to be scalable, for example, in order

to support 20000 node models and benefit from modern high-performance computing.

C. Stroom said that he would modify the formulation of point 2. He then moved the discussion to point 3 (Tool kit would be funded through ESA TRP/GSTP) which was more a statement than a point for discussion and to point 4 (user shall be involved). Everyone agreed that the involvement of the users was necessary. Points 5, 6 and 7 were then re-stated. C. Stroom said that the presentation about OpenCASCADE / Salomé had shown the feasibility of the open source approach outlined in point 7 (some users prefer turn-key solution. Is this possible with an OSS approach? -Yes). There were no further comments on points 5, 6 and 7.

C. Stroom presented point 8 (the effort required to move the users from the tools used daily to a new environment seems to be the major barrier to overcome). He insisted on the fact that tools were part of the work flow and modelling environments and there was therefore a natural tendency for the users to avoid modifying the tools and hence work flow and environment unless this was not an absolute necessity. However, retaining backwards compatibility of tools was also a major obstacle to their evolution and this had to be considered.

S. Dolce asked more specifically what were the conclusions of point 8. Was there any way to change this? HP. de Koning said that any new development would need to be accompanied by a migration path for existing tools. C. Stroom explained that running projects needed to be supported and it was clear that they would not change tools.

S. Dolce said that this was related to earlier discussions that had taken place during the Workshop. There had been 2 or 3 versions of ESARAD recently but it was necessary to guarantee access to the same version during the course of a project. A project could not always afford the CCNs and RIDs which would be issued by industry as a result of a change in the version of ESARAD specified in the original contracts.

C. Stroom said that no commercial tool vendors would support more than two or three versions. If problems were found it was not possible to implement corrections in older versions as this would be prohibitive in cost. This was one of the additional advantages of the OSS approach because it was possible to re-compile a tool for own use.

C. Caillet (OpenCASCADE) said that you should change tools only when starting a new project and not during the course of the project. E. Werling (CNES) commented that typical space projects lasted for 8 to 10 years. C. Caillet said that in the typical life cycle in the automotive industry was in the order of 4 to 5 years.The aeronautical industry also encountered long life cycles and there was the need to address tool and model migration. This came back to the already-discussed need for efficient data exchange. It was also necessary to retrieve data for later use. For instance, computations still had to be carried out for Concorde more than 30 years after the original development.

C. Stroom said that, related to the last point, he had been surprised that archiving data had not been identified as an important aspect during the user survey. S. Dolce said that the long life cycle of space projects was a fact of life and that there was therefore the need to keep backwards compatibility and to support more than one version. C. Stroom repeated that this would prove far too costly in practice. He expected that the software cost would triple. H. Peabody agreed and said that for ThermPlot he was concentrating on interfacing with the most recent version

revision of the other tools.

S. Dolce said that he did not want to re-experience what had happened during the METOP project. Moving from ESARAD 3.2.7 to version 4.2 had been a significant issue for both industry and ESA. C. Stroom said that he fully understood the issue but that with the current resources it would simply be impossible to support more than one version of the tools. H. Peabody suggested to S. Dolce that maybe the best approach was simply to wait before upgrading.

J. Thomas (Alstom) explained that in practice users usually had more than 1 year to carry out a migration. He also pointed out that this was sometimes a significant constraint for Alstom. For instance ESARAD 3.2.7 used ORACLE but there was no longer any ORACLE expertise within the development team.

E. Werling said that it was currently possible to use the current and the previous versions and that in his opinion this was satisfactory. Only in some particular cases was it necessary to work with older versions.

C. Stroom moved to points 9, 10 and 11. There were no comments.

E. Werling wanted to return to point 1. He said that CNES had agreed, in principle, to support STEP-TAS, STEP-NRF, STEP-SPE and STEP-AP/203. However 6 years had passed without having a reliable STEP-TAS. He felt that something needed to be done from the management point of view and that lessons should be drawn to ensure that the situation would be corrected in the future. In particular, the validation of these protocols required a complex industrial organisation with vendors, industry and agencies and it was necessary to define this in detail. Concerning point 2, he agreed with the statement made. Concerning point 3, he said that something was required to replace ESABASE but he had some doubts about the need to develop a tool kit for thermal control analysis. This was obviously linked to point 8 (migration from existing tools). Moving users from ESABASE would not be a problem. However moving the thermal control engineers from their existing tools would be more difficult because of the development environments which had been put in place around these tools. He was of the opinion that it would be more sensible to build around the existing tools, with the idea of capitalising on more than 20 years of know-how and past effort, rather than re-build everything from scratch.

C. Stroom said that his position on this matter was related to point 5. To be competitive this had to be considered and this could conflict with what E. Werling had just said.

E. Werling then moved to point 4. He said CNES agreed with having a web site in place but this was not sufficient. What was necessary was to have thorough discussions with users during working meetings. He thought that users should also be involved when defining the strategy of thermal analysis tools. H. Peabody agreed that the user should always drive the process of tool development. Software vendors were always more efficient when replying to user's requests. J. Thomas also agreed.

E. Werling asked whether something more practical could be put in place for the current Thermal and ECLS Software Workshop. Or whether it might be useful to hold an additional

workshop in Toulouse consisting of a 2 day meeting involving 40 or 50 invited participants. Some round-table discussions could be set-up to capture high-level user requirements with the objective of formalising them. C. Stroom said that any suggestions were welcomed.

E. Werling insisted that there was a real problem of communication between software developers and users.

J. Thomas, taking the example of Bepi-Colombo, said that they were about to start upgrading ESARAD. But unfortunately they had not been made aware until very recently of the user's needs.

M. Jacquiau (Astrium SAS) had some comments on point 5. He wanted to explain the philosophy followed for THERMICA and SYSTEMA. A lot of components of THERMICA were common components of SYSTEMA. In practice, this meant that developments for THERMICA could be shared with others, as part of the SYSTEMA framework. HP. de Koning commented that Astrium was a special case because it was one company for which sharing was possible given the overall volume of their activities.

C. Stroom wanted to come back to the issue of the requirements for Bepi-Colombo that had not been correctly addressed. He admitted that there had been a period during which the quality of the tools was lower. V. Perotto asked C. Stroom why the information had not been provided to his section. C. Stroom explained that in some cases the information was available but in other cases it was not. He also reflected on the fact that it was generally difficult to convince the projects to support developments if there were no benefits to the project in the short-term.

HP. de Koning said that what had happened for Bepi-Colombo was a very good illustration of potential problems that could occur when a company played a double role. Astrium were competing for the mission and were also software vendors. Solutions needed to be found to overcome such potential conflicts of interest.

4.6. Workshop Close

C. Stroom (ESTEC/TOS-MCV) thanked everyone for their participation, and closed the Workshop.

Appendix A: Welcome and Introduction

Welcome and Introduction

C. Stroom
ESTEC/TOS-MCV

Appendix B: Thermal Modelling Issues Concerning the Mechanically Pumped Two-Phase CO_2 Cooling for the AMS-02 Silicon Tracker

Thermal Modelling Issues
Concerning the
Mechanically Pumped Two-Phase CO_2 Cooling
for the
AMS-02 Silicon Tracker

A. Woering
NLR

Appendix C: SAVE: Simulation for Analysis and Validation of Energy for ATV

SAVE:
Simulation for Analysis and
Validation of Energy
for ATV

R. Ameziane
EADS - Launch Vehicles

Appendix D: Status of some ESA supported activities in thermal, thermo-hydraulic and ECLS analysis

Status of some
ESA supported activities in
thermal, thermo-hydraulic
and
ECLS analysis

O. Pin
ESTEC/TOS-MCV

Appendix E: Modelling the VISTA Infrared Camera

Modelling
the
VISTA
Infrared Camera

N. Cavan
RAL

Appendix F: Thermal Analysis of Planck HFI

Thermal Analysis
of
Planck HFI

J. Fereday
RAL

Appendix G: ESARAD v-5.1

ESARAD
v-5.1

F. du Laurens d'Oiselay
Alstom

Appendix H: Application of EcosimPro to Bio-regenerative Life Support Components

Application of EcosimPro
to
Bio-regenerative Life Support Components

A. Rodriguez
ESTEC/TOS-MCT

Appendix I: ESATAN v8.7 & 8.8

ESATAN
v8.7 & 8.8

F. du Laurens d'Oiselay
Alstom

Appendix J: Integrated thermal design and the thermal numerical tool box

Integrated thermal design
and the
thermal numerical tool box

J. van Es
NLR

Appendix K: Thermal simulation in functional analysis

Thermal simulation
in
functional analysis

M. Jacquiau
Astrium SAS

Appendix L: ALGOCAP: Assessment of Thermo Hydraulic Algorithms for Capillary Pumped Loops and Loop Heat Pipes

ALGOCAP: Assessment of Thermo Hydraulic Algorithms for Capillary Pumped Loops and Loop Heat Pipes

D. Labuhn
OHB

Appendix M: Use of ESARAD in MetOp SVM Thermal Testing Analysis

Use of ESARAD
in
MetOp SVM
Thermal Testing Analysis

E. Seward
Astrium Ltd.

Appendix N: ESA Harmonisation and User Survey

ESA Harmonisation

and

User Survey

HP. de Koning
ESTEC/TOS-MCV

Appendix O: Use of TSS as a neutral format for geometry model conversions: an alternative to STEP-TAS

Use of TSS
as a neutral format for
geometry model conversions:
an alternative to STEP-TAS

H. Peabody
Swales Aerospace

Appendix P: CIGAL2: An open source pre/post-processing tool for CORATHERM and other software activities

CIGAL2: an open source pre/post-processing tool for CORATHERM and other software activities

JP. Dudon
Alcatel

Appendix Q: TMG: New Technologies and Modelling Approaches

TMG:
New Technologies
and
Modelling Approaches

C. Ruel
Maya HTT

Appendix R: SYSTEMA/THERMICA version 4: Overview of the new capabilities

SYSTEMA/THERMICA
version 4:
Overview of the
new capabilities

M. Jacquiau
Astrium SAS

Appendix S: ESATAN/FHTS and ESARAD: a View on the Near Future

ESATAN/FHTS and ESARAD:
a View on the Near Future

J. Thomas
Alstom

Appendix T: TASverter: Thermal Analysis for Space model converter

TASverter:
Thermal Analysis for Space
model converter

S. Appel
ESTEC/TOS-MCV

Appendix U: ThermXL v2 and Beyond

ThermXL v2
and Beyond

J. Thomas
Alstom

Appendix V: ALTAN application for Bepi-Colombo thermal analysis

ALTAN application
for
Bepi-Colombo
thermal analysis

V. Perotto
Alenia Spazio

Appendix W: Last developments in and around GAETAN

Last developments
in and around
GAETAN

C. Marechal
CNES

Appendix X: CAD-FE integration using Open Source Software

CAD-FE integration
using
Open Source Software

C. Caillet
OpenCASCADE

Appendix Y: ESA Harmonisation, User Survey and Discussion Summary

ESA Harmonisation,
User Survey
and
Discussion
Summary

L. Maresi
ESTEC/IMT-THH

Appendix Z: List of Participants

List of Participants

16th European Workshop on
Thermal and ECLS Software

22-23 October 2002
ESTEC, Noordwijk, Netherlands

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