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**February 2004**

**18th European Workshop on  
Thermal and ECLS Software**

**ESTEC, Noordwijk, The Netherlands**

**5-6 October 2004**

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## ABSTRACT

This document contains the minutes of the 18th European Thermal and ECLS Software Workshop held at ESTEC, Noordwijk, The Netherlands on the 5th and 6th October 2003. 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	2004-12-01	Document creation
1.1	2005-01-24	Draft for internal comment
1.2	2005-02-11	Initial release to participants

*The organisers would like to dedicate this workshop and the proceedings to Charles Stroom, who retired in 2004 from his role as head of the Thermal Analysis and Verification Section after thirty one years with the European Space Agency. Charles was the founder of the Workshop, organised many of the first seventeen, and was responsible for establishing the Workshop as the premier meeting place for the European space thermal analysis community.*

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## Final Programme

18th European Thermal and ECLS Software Workshop  
 ESTEC, Noordwijk, The Netherlands  
 5th-6th October 2004

### Tuesday 5th October 2004

09:00	Registration	
10:00	Welcome And Introduction Opening	Harrie Rooijackers, ESA/ESTEC, Netherlands Olivier Pin, ESA/ESTEC, Netherlands
10:20	Finite Element Based Analysis Tool for Re-entry Vehicle TPS Ablators	Tom van Eekelen, SAMTEC HQ, Belgium
10:45	EcosimPro Current Status and Future Improvements	Ramón Pérez Vara, Empresarios Agrupados, Spain
11:10	Capabilities of the Therm-OSS Tool	Matthias Haupt, Technical University Braunschweig, Germany
11:35	Coffee break	
11:50	ESATAN, FHTS, ThermXL and ESARAD - Product Status	Chris Kirtley, ALSTOM, UK
12:15	Feasibility of using a Stochastic Approach for Space Thermal Analysis	Matteo Gorlani, Blue Group, Italy
13:00	Lunch	
14:00	Automates Thermal Model Reduction for Telecom Spacecraft Walls	Frédéric Jouffroy, EADS ASTRIUM, France
14:25	Advances in the Thermal Analysis in the frequency domain Algorithms development, integrated software tools and post processing	Marco Molina, Carlo Gavazzi Space, Italy
14:50	LHP Transient Modelling using EcosimPro	Carmen Gregori, Empresarios Agrupados, Space
15:15	Designing for mK/ $\mu$ K revisited	Valter Perotto, Alenia Spazio, Italy
15:30	Coffee break	
16:00	GAETAN Usage at Alcatel Space	Karine Caire, Alcatel Space, France
16:25	Thermal Analysis of the Mechanical Structure of the Solar Telescope GREGOR	Thomas Bornkessel, Technical University Darmstadt, Germany
16:50	Modelling of Cryocoolers	Martin Linder, ESA/ESTEC, Netherlands
17:30	Social Gathering	
20:00	Dinner	

**Wednesday 6th October 2004**

09:00	Optimization of a Direct Condensing LHP Radiator with the Improved ALGOCAP Reinhard Schlitt, OHB System AG, Germany
09:25	Innovations in Thermica Marc Jacquiau, Astrium, France
09:50	Thermal and Radiative Modelling Julian Thomas, ALSTOM, UK
10:15	A Thermal Network Viewer Henri Brouquet, ALSTOM, UK
10:40	Coffee break
10:55	Modelling the Martian Surface Thermal Environment with ESATAN and ESARAD Bryan Shaughnessy, Rutherford Appleton Laboratory, UK
11:20	Data Exchange between CFD and ESATAN in the case of Natural Convection Christian Wendt, EADS Space Transportation, Germany
11:45	Development of an Interface Software for Patran/Thermal and ESARAD Cosmas Heller, Astrium Friedrichshafen, Germany
12:10	New version of BAGHERA STEP viewer based on open standard technologies Eric Lebegue, CSTB/GRAITEC, France
12:35	Interface between STEP-TAS format and Alcatel Space's CIGAL2 application (which works together with the CORATHERM solver) Christian Caillet, Open Cascade, France
13:00	Lunch
14:00	STEP-TAS and TASverter from the user's point of view David Alsina Orra, ESA/ESTEC, Netherlands
14:25	STEP-TAS and TASverter from the software developer's point of view Hans Peter de Koning, ESA/ESTEC, Netherlands
15:00	Workshop Close

# **1. Tuesday 5th October - Morning Session**

## **1.1. Welcome and Introduction**

H. Rooijackers (ESA) welcomed everyone to the workshop. He explained that the workshop was an opportunity for all three areas of the European space thermal community, namely ESA, the tool developers and the tool users, to exchange information and feedback. (See Appendix A)

O. Pin (ESA) introduced himself as the new head of the Thermal Analysis and Verification section at ESA, replacing Charles Stroom, who had retired earlier in the year, and who could be regarded as the father of some major European tools. It was he who had pushed for independent tools in Europe, had initiated many activities during his 31 years at ESA, and who had also founded the Thermal and ECLS workshop. For this reason, the staff of the Thermal Analysis and Verification section wanted to dedicate this workshop to him.

O. Pin emphasised that there would be no discussion of harmonisation during the workshop because ESA would be establishing the policy with the Harmonisation Steering Board in a meeting immediately after the workshop. All discussions on harmonisation policy would take place there.

## **1.2. Finite Element Based Analysis Tool for Re-entry Vehicle TPS Ablators**

T. van Eekelen (Samtech) explained the basics of heat protection systems based on ablation processes, and described the development of a software tool to model these processes. (See Appendix B)

H.P. de Koning (ESA) asked about the validation of the results, and how many parameters needed to be changed between runs. Did they start with measured properties, or did they need correlation with test results? T. van Eekelen said that EADS did the actual work, and not Samtech, so it was difficult to know exactly. One group would do tests, the other analysis. It could take months to qualify the material properties and select the appropriate values.

## **1.3. EcosimPro Current Status and Future Improvements**

R. Pérez (Empresarios Agrupados) presented recent developments of EcosimPro, including the replacement of the Smartsketch proprietary tool with their own code. (See Appendix C)

H. Rooijackers (ESA) understood that the new version would be available on Windows, Linux and Unix platforms, and asked whether it would be possible to exchange data between Windows and Linux versions. R. Pérez said that they were using ASCII for the data files, and the diagrams were encoded in ASCII XML, so there should be no problem in exchanging data across platforms.

## 1.4. Capabilities of the Therm-OSS Tool

M. Haupt (TU-Braunschweig) described the current status of Therm-OSS, a tool to demonstrate the use of open source software components to handle the full thermal analysis chain from mission specification, radiative analysis of simple geometrical models, the solution of the thermal mathematical model and even visualisation and post-processing of results. (See Appendix D)

M. Molina (Carlo Gavazzi Space) said that the end user interest in open source software was driven by the learning time. He asked for an estimate of the learning time required before an ordinary thermal user would be able to work with Therm-OSS. M. Haupt said that ESATAN was a relatively simple solver and that Therm-OSS was a more complex system, but with an architecture which allowed more flexibility and functionality than ESATAN and ESARAD. He felt that it would be necessary to divide the target users into developers and end-users and ask what the end-users expect. Therm-OSS had been designed for someone in between the full software developer and the thermal end-user. If Therm-OSS allowed the end-user to build the geometry and then push a button to get the results, it was not difficult to hide the details.

M. Molina asked how often new versions of the open source components were released, and whether these versions were related to debugging or development. M. Haupt said that some releases were intended to eliminate errors, but others were for development purposes. For example, a recent release of the k3d software had some changes to the architecture.

C. Heller (EADS) asked about the verification of the tool. M. Haupt said that the calculation with the lumped parameter solver had been checked against NASTRAN. The linear and non-linear solver and the OHB example had been checked against ESATAN. C. Heller asked about the radiative calculations. M. Haupt said that Therm-OSS had used TOPIC, which had a lot of restrictions, but an investigation was in progress into the use of RenderPak which would handle irradiance, etc.

H.P. de Koning (ESA) emphasised that Therm-OSS had been intended as a study and exploration. The main interest had been to discover what components were available to the software engineer developing a tool rather than the thermal engineer, and to provide techniques and a possible architecture for future development. M. Haupt said that after gaining experience during the year's development he would like to rewrite everything. The architecture was fine, but some details of the implementation could be better.

## 1.5. ESATAN, FHTS, ThermXL and ESARAD - Product Status

C. Kirtley (ALSTOM) described recent developments across the range of ALSTOM tools and the expected release schedule. (See Appendix E)

H. Rooijackers (ESA) had noted that the oct-tree handling introduced into ESARAD had resulted in a factor of three speed improvements for some models, and asked whether there were any guidelines on expected speed improvements for particular types of models. C. Kirtley said that the speed improvement depended on the actual bounding box and the geometry. If the geometry included a large projection, such as an antenna, then the oct-tree handling allowed a



coarser mesh to be used where there were no shells, leading to better performance. The speed improvement varied depending on the model, but so far had been between 2 and 3 times as fast on average, possibly even 4.

## 1.6. Feasibility of using a Stochastic Approach for Space Thermal Analysis

M. Gorlani (Blue Group) presented details of a study into the use of stochastic techniques for space thermal analysis. (See Appendix F)

M. Molina (Carlo Gavazzi Space) said that the optimization of the algorithms to use stochastic methods looked promising. He had noted the remark on the Phase-A study described, and wondered why the standard approach had failed. M. Gorlani said that the database used had not been tailored for EUSO and many configuration problems had not been considered, such as the exact configuration of the ISS. The stochastic method had taken these configuration options into account.

M. Molina said that he was suspicious of the effect of the roll angle. He asked how the thermal engineer should approach the conflict between the -15 and +15 degrees of roll angle. V. Perotto (Alenia) said that Alenia had made the initial database, but it had not been tailored for EUSO. The database had been created by running thousands of test cases involving the ISS with cubes attached in various locations to estimate the fluxes. There had been no cube which corresponded with EUSO, so the database was inadequate for EUSO. Even so thanks to the stochastic methods, they had still been able to find the worst cases for EUSO. However, he noted that it would not always be possible to have such a detailed database available for Phase-A studies.

M. Molina noted that in Phase-A studies it might be necessary to scan all combinations of beta angles, etc. How did the engineer know which optimization tool to select? M. Gorlani said that this functionality was already embedded in ST-ORM<sup>1</sup>, which had been one reason why ST-ORM had been selected. The user could run a series of Monte Carlo simulations to calculate the response of the system over a range of values, but then needed to set up the physical runs.

O. Pin (ESA) said that this [study of Stochastic Methods] activity fitted with the ESA strategy to develop methodologies and algorithms to improve thermal analysis rather than develop software. He felt that this was a better use of funding for the overall benefit of all thermal engineers in the ESA states in general. He emphasised the fact that all thermal engineers in the ESA states had a right to benefit from ESA funded studies and he invited people to download the report once it was made available.

C. Kirtley (ALSTOM) noted that there had been 60 runs with 15 shots. What did this mean? Did it mean 15 parallel processes? M. Gorlani said that they were able to run 4 analysis runs in parallel, and this was independent of the number of shots. The example had shown different Monte Carlo simulations, each one with 15 shots, but it could have been run using only 5 shots.

C. Kirtley said that ALSTOM would be interested in supporting stochastic methods for the benefit of users if that is what users wanted. The question was: what licence scheme was needed

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1. ST-ORM is the **S**tochastic **O**ptimization and **R**obustness **M**anagement tool from EASi in Germany

by ST-ORM to support it? M. Gorlani said that it depended only on the CPU. ST-ORM didn't delay the CPU, so 15 licences allows 15 simultaneous runs. HB asked how many licences would be required for 100 analyses. M. Gorlani said that they had used 4 or 5 CPUs at a time, so they had only required 4 or 5 licences.

P. Sahlin (EASi Engineering) said that they were interested in working with the space community and had been following the evaluation with interest. They had started cooperation with the software developers and had a joint proposition for ALSTOM and Astrium on the rapid introduction of stochastic methods into their tools. The first step, during the autumn and winter would allow the evaluation of ST-ORM and to overcome any initial problems. They would provide access and ST-ORM licences for ESARAD, ESATAN and Thermica and would run workshops on how to work with ST-ORM, the theory behind it, etc. The first result will be a joint workshop with ALSTOM in Leicester at the end of October. A similar workshop would be held with Astrium, but no date had been arranged. The second step would be to agree on a joint pricing and licensing scheme with each software developer.

## **2. Tuesday 5th October - Afternoon Session**

### **2.1. Automated Thermal Model Reduction for Telecom S/C Walls**

F. Jouffroy (EADS) described the algorithms and use of a tool, developed over ten years, for providing fast computation of results using a reduced thermal model generated from the highly detailed thermal model of a spacecraft required for other types of analysis. (See Appendix G)

S. Appel (ESA) said that the slide had shown a nice set of equations relating to the reduced system, but he didn't understand the load vector  $P(i)$ . Did this depend on the temperature of the eliminated nodes? F. Jouffroy said that the condensed nodes were introduced into the matrix and the whole system was solved, but then only a subset of the couplings were extracted. S. Appel said that the reduced model power vector included the radiative fluxes from the eliminated nodes and therefore it was dependent on the temperature of the nodes which had been taken out. F. Jouffroy admitted that there was a trick in the method which allowed it to be independent of the eliminated condensed nodes. S. Appel felt that not only the condensed nodes, but also the detailed nodes needed to be taken into account, but it would be better to discuss this separately later.

### **2.2. Advances in Thermal Analysis in the Frequency Domain**

M. Molina (Carlo Gavazzi Space) described one approach being taken to estimate the thermal stability of highly sensitive spacecraft instruments which require not only that the temperature be restricted to a narrow range, but also that the rate of change of temperature is constrained. (See Appendix H)

H. Rooijackers (ESA) asked whether the algorithm shown had involved a Laplace transformation. M. Molina said that the Laplace transformation had been used to convert from

the time to the frequency domain. H. Rooijackers asked why he had not used a Fourier transform. M. Molina said that he had not been working with periodic variation so he had not needed a Fourier transform. The step function could be handled using Laplace, and did not require a lot of terms to do so, but could not be handled as easily using a Fourier transform.

M. Gorlani (Blue Group) noted that the equilibrium conditions were used as a starting point, but wondered whether they were then discarded. M. Molina said that the linearisation holds around the equilibrium point, so the function depended on the equilibrium point. M. Gorlani said that the temperature was really temperature deviation. M. Molina said that the gain was a dimensionless term, so by multiplying by the temperature it was possible to get the temperature deviation. M. Gorlani wondered whether it would be possible to use the eigenvalues or eigenvectors directly. M. Molina said that the system was always stable by definition, but admitted that some improvement to the method would be possible.

### **2.3. LHP Transient Modelling using EcosimPro**

C. Gregori (Empresarios Agrupados) presented the experiences of modelling a loop heat pipe component using EcosimPro. (See Appendix I)

V. Perotto (Alenia) noted that there were a number of elements to describe the loop, and asked whether there was an element to describe the capillary isolators. C. Gregori said that the model didn't have such an element because the model assumed homogeneous flow, so it was not necessary to separate the fractions. She still wanted to evaluate the advantages and disadvantages of the current model, but there were various ideas in development.

C. Kirtley (ALSTOM) said that there are various effects in capillary devices. He wondered how the start-up phase was detected, when the heat load was enough for the flow rate. C. Gregori said that it was possible to see the void fraction in the wick, and how much coupling there was with the liquid, and to calculate the capillary pressure. C. Kirtley asked whether it was possible to calculate the drying out of the wick, and C. Gregori confirmed that it was possible.

### **2.4. Designing for mK/ $\mu$ K revisited**

V. Perotto (Alenia) revisited his presentation from the previous workshop and discussed how the results of test cases that had been run during the year discounted the initial findings from Alenia which had been reported at the previous workshop. (See Appendix J)

O. Pin (ESA) thanked V. Perotto for the clarification. He had now proven that the original test case presented no issues for ESATAN, but obviously it wasn't possible to say the same for all possible models. A study was required. The question now was whether we really understood what the problems actually were. M. Molina (Carlo Gavazzi Space)'s presentation had shown another way around the problem. It was important to collect the user requirements from GAIA, LISA, etc. to find out exactly what problems needed to be addressed. O. Pin said that ESA had started working on this area even though it was difficult to find the time.

H.P. de Koning (ESA) commented that it might not be the absolute temperature as such, but

temperature gradients of milli- and micro-kelvin which might be the issue. For the solvers it would be important to have an accurate transfer of results from the radiative analysis to the thermal solver. Which parameters would be critical?

E. Werling (CNES) said that even if you obtained results, how could you verify them? O. Pin said that GAIA had asked this question, and this was exactly why this analysis was required. E. Werling said that there were some micro-kelvin projects, but these involved relative values. The difficulty was linked to the verification aspects rather than any specific requirements. The 3 milli-kelvin range gave difficulties.

M. Molina said that following his approach it was possible to work the other way round: first validate the model and then linearise. This is what he was trying to do with the LTP. M. Gorlani (Blue Group) said that there were still problems with absolute temperatures for frequency analysis, and that it was important not to discard information during the linearisation.

## **2.5. GAETAN usage at ALCATEL Space**

K.Caire (Alcatel) described how the complete thermal analysis process at Alcatel was now based around GAETAN, and outlined the benefits of the approach. (See Appendix K)

O. Pin (ESA) had an observation, not on GAETAN itself, but related to post-processing. The ESATAP project had started at the beginning of the year. There had been a user survey of requirements, and the project was busy with the architectural design phase, with a PDR to be held the week after the workshop. The planned delivery date for ESATAP was currently September 2005.

## **2.6. Thermal Analysis of the Mechanical Structure of the GREGOR Solar Telescope**

T. Bornkessel (TU- Darmstadt) presented the requirements for the GREGOR Solar Telescope and how the analysis had been performed using ANSYS. (See Appendix L)

C. Heller (EADS) asked whether it was possible to calculate specular reflection in ANSYS. T. Bornkessel said that ANSYS handled diffuse reflection only. They had no access to any other software - only ANSYS - but with some effort it had been possible to achieve the required results and demonstrate the design requirements.

## **2.7. Modelling of Cryocoolers**

M. Linder (ESA) described one approach to modelling cryocooler elements in ESATAN models using physical fit functions in order to avoid polynomial fit functions based on experimental data. (See Appendix M)

E. Werling (CNES) asked whether the algorithm presented could be implemented as a module in ESATAN. M. Linder said that, in principle, it was not necessary to have a complete module

because everything could be handled via a single equation. Therefore this equation could be expressed in the model directly.

E. Werling asked whether there were any plans for pulse tube equations. M. Linder answered that further work was required on the single stage pulse tube shown using results provided by Air Liquide. More work would be required to extend the method to handle multi-stage coolers.

G. Theurer (EADS) asked where the empirical values had come from which had been used in the equations. M. Linder said that they had been calculated using empirical measurement data, therefore they provided the characteristic for that particular cooler only. He had needed about 20 data points. There was a dependence on the sink temperature and the cold tip temperature therefore fewer data points were required than for a complete polynomial fit. G. Theurer asked whether there had been any comparison with the fit function results. M. Linder said that this had not yet been done. The fit function was only accurate to within 5%.

C. Kirtley (ALSTOM) said it would be possible to introduce the equation into a \$ELEMENT in ESATAN. M. Linder agreed, because the equation could be parameterised to give a general element. O. Pin (ESA) said it would be easier to provide the equation as a subroutine if no nodes were required. G. Theurer said it would be easy to use the equation within \$VARIABLES1.

### **3. Wednesday 6th October - Morning Session**

#### **3.1. Optimization of Direct Condensing LHP Radiator using ALGOCAP**

R. Schlitt (OHB) described how the ALGOCAP tool had been used with ESATAN to model the AMS instrument payload on the ISS, and how the different requirements of the two tools had been addressed. (See Appendix N)

F. Jouffroy (EADS) asked how the synchronisation of the two models was handled. Were they run from the same ESATAN execution? R. Schlitt said that they switched off the ESATAN model while calculating the low level model using ALGOCAP, then use the temperature and switch the model back on. The temperatures of the low-level and high-level models compared quite well.

#### **3.2. Innovations in Thermica**

M. Jacquiau (Astrium) presented the latest developments in Thermica, including importing CAD geometry, the provision of an ESATAN-compatible solver in Systema, and the automated calculation of conductive links. (See Appendix O)

R. Schlitt (OHB) noted that M. Jacquiau had talked to the project managers concerning the import of CAD models, but had not talked to the structural engineers, and had not considered NASTRAN itself. Why not pre-process the NASTRAN model into a thermal model? Why introduce a new model? M. Jacquiau said that the classical approach had been retained because

this is how they were working already. The thermal people at the system level wanted this in their software, the Thermica end-users wanted this capability, but different companies have different structural analysis tools. He admitted that R. Schlitt was right in that only one model was really needed, but the two model solution had been chosen. Sometimes two solutions were better than one.

S. Appel (ESA) remarked that the geometry required by the structural engineer was not usually the same model required by the thermal engineer. The thermal engineer wants only the outer surfaces, MLI, etc. The structural engineer wants the load carrying part of the geometry. These are not usually the same. Even if the thermal engineer used PATRAN, there would still be a difference in the required geometry. R. Schlitt argued that if they used the same model it would simplify work. One source model was a lot better than a series of modified models.

O. Pin (ESA) asked what happened when the CAD model was updated. How was it reprocessed? M. Jacquiau said that there was no easy way to reprocess automatically. If the CAD model changed, the user could import both the CAD and thermal models and see the changes in the visualisation. The thermal model still needed to be updated by hand.

M. Molina (Carlo Gavazzi Space) asked about the error in the calculation of the conductive links. Did this relate to the finite element method, or the finite volume method? M. Jacquiau said that both methods had similar levels of error. M. Molina said that he would have expected to see symmetry across the axis. M. Jacquiau said that he hadn't investigated too closely because the actual error was so small. The conductive links had been calculated using double precision, but the geometry was defined using only single precision. H.P. de Koning (ESA) agreed that if this had been a test case then the results should have been absolutely symmetrical.

A. Torres (CASA) asked how the CAD definitions of individual units and equipment were handled rather than the full space craft model. M. Jacquiau said that all data came from the design office, and the tests had involved the entire CAD file. He didn't know how the design office assembled individual units into the overall CAD model. A. Torres said that there had been some examples of complex shapes. Were these re-meshed? M. Jacquiau said that they were all re-meshed into the standard surfaces, and the user could re-mesh further if required.

O. Pin remarked on the statement about the price increase in the solvers. He said that the statement wasn't true: ESATAN now used FlexLM to enforce licence use, so it was more strict than it had been before. The cost of the licence had not increased. M. Jacquiau replied that he had repeated what his purchase office had told him. O. Pin said that the cost of a licence had not changed in 4 years. J. Thomas (ALSTOM) said that there were some fluctuations in the Sterling/Euro exchange rate, but the Sterling price had remained unchanged. M. Jacquiau said that he would need to verify the figures. C. Kirtley (ALSTOM) said that the figure might relate to total number of network licences, rather than price per licence.

C. Kirtley asked about the new multi-timestep feature in the solver. How did the user choose which boundaries to use? M. Jacquiau said that the solver could auto-detect errors on small surfaces, etc. The user specified the accuracy required, globally, on all nodes. C. Kirtley asked whether all other nodes were treated as boundary nodes and whether they were decoupled. M. Jacquiau said that the solver decoupled the boundary nodes and interpolated from the last temperature value. C. Kirtley commented that ESATAN had multi-timestep handling on one of

the fluid routines to handle the fluid and thermal interpolation.

### **3.3. Thermal and Radiative Modelling**

J.Thomas (ALSTOM) described and demonstrated the use of the analysis case in ESARAD and how the template files could be modified to bring in additional non-geometric nodes, links, and other user-defined logic. (See Appendix P)

### **3.4. A Thermal Network Viewer**

H. Brouquet (ALSTOM) demonstrated ThermNV, the new thermal network results viewer available with ESATAN. (See Appendix Q)

M. Molina (Carlo Gavazzi Space) recommended that the developers at ALSTOM should sit down with some SINAPS users to get feedback on the network viewer. ThermNV provided a graphical user interface, so why use numbers to represent flow? Why not use line thickness to show the flow. It wasn't possible to read numbers for anything other than a simple network model. M. Molina appreciated that ThermXL was integrated with Excel, but asked why ThermNV used tables which then required an interface to Excel. J. Thomas (ALSTOM) said that it was possible to cut and paste the tables directly into Excel, so a dedicated interface to Excel was not strictly necessary. ALSTOM would be looking at this and other issues as they already had a huge list of feature requests. ALSTOM were keen to give the alpha version to people in order to have comments. J. Thomas said that they had not been able to cross check the interface with that of SINAPS. A. Goizel (RAL) asked whether it was also possible to cut and paste the report layout, etc. H. Brouquet said that it was possible: the table and time row could be pasted directly into Excel.

### **3.5. Modelling the Martian Surface Thermal Environment with ESATAN and ESARAD**

B. Shaughnessy (RAL) described some of the additional factors which needed to be taken into account when modelling the Martian surface environment, including diffuse solar radiation, dust storms and convection. (See Appendix R)

H.P. de Koning (ESA) asked how they had handled the transmission through the atmosphere. Had they used MODTRAN? B. Shaughnessy said that they had been calculated using ESATAN subroutines written in f77. A specific atmosphere module had been written especially for them in order to calculate the diffuse fluxes and the surface temperatures. H.P. de Koning asked how they had handled the different alpha values. B. Shaughnessy said that they had found it adequate to use the alpha values corresponding to the solar wavelengths. They had seen no evidence of how JPL had handled these issues for their landers.

### **3.6. Data Exchange using CFD and ESATAN in the case of Natural Convection**

C. Wendt (EADS) described an approach for coupling the results of CFD and ESATAN analyses to handle convective effects in a cavity within the body of the Ariane5 ESC-A launcher. (See Appendix S)

J. Persson (ESA) asked whether test verification was available for this type of modelling. C. Wendt said that they compared against a correlated ESATAN model. Both gave the same wall temperatures and heat fluxes. There would be a ground test in the week following the workshop.

K. Duffy (MAYA) asked how they achieved convergence between the CFD and ESATAN models: buoyancy terms had been introduced which required iteration back and forth between the tools. C. Wendt agreed that this was the case. For the LOX tank membrane the same heat fluxes and conditions applied, so the models were the same. K. Duffy asked how the models were synchronised. Were all of the nodes treated as boundary nodes? C. Wendt said that they used steady state ground analysis models and other compound models. They assumed that the heat conduction related to linear flow as long as the temperatures didn't vary too much. The flow needed to have the same shape.

M. Gorlani (Blue Group) assumed that the model didn't use GFs. C. Wendt said that they used GRs, even for the case nodes. GFs were one way conductors, and as there was no gas flow in the tubes the heat flow could be in both directions. A. Rodriguez (ESA) said that the model should really use GFs and calculate the mass flow rate to ensure positive flow.

### **3.7. Development of Interface software between PATRAN/Thermal and ESARAD**

C.Heller (EADS) described the development of software to allow the transfer of a geometrical model created by PATRAN into ESARAD so that radiative exchange factors and environmental fluxes could be calculated and then transferred back to PATRAN/Thermal for use in thermal analysis, temperature mapping and thermo-distortion analysis. (See Appendix T)

S. Appel (ESA) asked whether they were using PATRAN fields for the interpolation from the thermal to the structural mesh. He said that PATRAN allowed 3d fields, and these could be used to get the temperatures. C. Heller said that they hadn't decided whether to use PATRAN fields or to use other methods for interpolation. They still had to talk to the structural people. He said that they only had temperatures on edge nodes, so this could lead to problems. S. Appel asked whether the same geometry was used for both models. C. Heller said that the automatic GL calculation was handled by P/Thermal so everything inside the model was calculated.

H.P. de Koning (ESA) said that he had been at TFAWS earlier in the year and so had MSC, the developers of PATRAN. They had discussed that PATRAN was going to support STEP-TAS. He felt that this would be a more efficient route for EADS to follow than a custom interface. He made a plea for everyone to use open standards and not to implement tool-to-tool data exchange.



It would be better to do it once and to get it right than to have dedicated effort per tool combination. In PATRAN 5 to be released in 2005 all of the “thermal” primitive shapes would be supported so PATRAN could also be used to build thermal models. C. Heller said that he was aware of the STEP-TAS interface in PATRAN, so generating the geometry in PATRAN was easy, but radiative exchange factors were not yet supported.

J. Thomas (ALSTOM) commented that the malformed sphere problem shown during the presentation related to the use of a second order quadrilateral mesh that didn’t map to the first order mesh used by ESARAD. If the quadrilateral mesh were converted to use triangles then the model exchange should work. C. Heller acknowledged that the curved quadrilateral elements gave “point not in plane” problems for ESARAD and agreed that splitting these quadrilaterals into two triangles would probably solve the problem. He argued that support for second order primitives in the radiative tools would also solve the problem.

### **3.8. New version of BAGHERA STEP viewer based on open standard technologies**

E. Lebegue (Graitec) presented the latest developments in BAGHERA, and demonstrated its use to visualise STEP files. (See Appendix U)

### **3.9. Interface between STEP-TAS and Alcatel Space’s CIGAL2 application (which works with the CORATHERM solver)**

C. Caillet (Open Cascade) described the development of a STEP-TAS interface for CIGAL2 and outlined some of the problems encountered and the solutions which had been used to address them. (See Appendix V)

S. Appel (ESA) commented that CIGAL2 used certain primitives for which support was not yet complete. C. Caillet admitted that the support for the CIGAL primitive conversion to and from STEP-TAS was not yet complete.

R. Schlitt (OHB) asked whether loop heat pipes would be included in the schema in the future. C. Caillet said that for ARTES-8 it would be necessary to handle all of the elements which existed in both Astrium and Alcatel tools.

## **4. Wednesday 6th October - Afternoon Session**

### **4.1. STEP-TAS and TASverter from the user’s point of view**

D. Alsina (ESA) presented the capabilities of the TASverter tool and the use of the different options for converting user models. (See Appendix W)

O. Pin (ESA) drew everyone’s attention to the fact that the CIGAL2 reader and writer were

currently being developed by Alcatel with the help of Open Cascade. He wanted to generalise the scheme so that the other readers and writers were handled by the developers, so the Thermica reader and writer would go to Astrium and the Esarad reader and writers would go to ALSTOM. A prototype of an ESATAN to STEP-TAS converter had still to be discussed.

M. Jacquiau (Astrium) asked whether the community could expect that the deliveries for ESA space projects would now be in STEP-TAS format. O. Pin said that this would be a topic under discussion at the Harmonisation Steering Board meeting the following day.

R. Schlitt (OHB) expressed concerns about maintaining data exchange across future versions of the tools. H.P. de Koning (ESA) said that this would be addressed in the following presentation.

## **4.2. STEP-TAS and TASverter from the software developer's point of view**

H.P. de Koning (ESA) described the underlying principles and architecture of STEP-TAS and TASverter and what options were open to software developers in creating conversion tools. (See Appendix X)

A. Fagot (Dorea) said that additional libraries had been mentioned in the scope of the new integration of CIGAL and STEP-TAS, and wanted to know what was available in TASverter. H.P. de Koning said that additional libraries were now used to load a run-time protocol specific dictionary which could be used by all tools. ESA would provide an example of how to add new readers and writers and then it would be up to individual companies to publish their own readers and writers.

## **4.3. Workshop Close**

H. Rooijackers (ESA) had heard various comments that holding the workshop “early in October” was too soon after the summer break, but there had still been enough presentations and questions to exceed the programme time. There had been some interesting discussions, even in the coffee and lunch breaks. There had been an exchange of information between developers and users, there had been some inspiring application demonstrations, and we had even seen some coupling between structural and thermal analysis. He expected these topics to return. He hoped that the next workshop would be as easy to organise. He thanked the presenters, because preparing presentations took a lot of work, and thanked the other participants for taking part. He hoped to see everyone again at the next workshop.

## **Appendix A: Welcome and Introduction**

### **Welcome and Introduction**

**H. Rooijackers**  
ESA/ESTEC



**Appendix B: Finite Element Based Analysis Tool For Re-entry Vehicle TPS  
Ablators**

**Finite Element Based  
Analysis Tool  
For  
Re-entry Vehicle  
TPS Ablators**

**T. van Eekelen**  
SAMTECH s.a.



## **Appendix C: EcosimPro Current Status and Future Improvements**

### **EcosimPro Current Status and Future Improvements**

**R. Pérez Vara**  
Empresarios Agrupados





## **Appendix D: Capabilities of the Therm-OSS Tool**

### **Capabilities of the Therm-OSS Tool**

**M. Haupt**  
TU-Braunschweig



## **Appendix E: ESATAN, FHTS, ThermXL and ESARAD - Product Status**

### **ESATAN, FHTS, ThermXL and ESARAD Product Status**

**C. Kirtley**  
ALSTOM



## **Appendix F: Feasibility of using a Stochastic Approach for Space Thermal Analysis**

### **Feasibility of using a Stochastic Approach for Space Thermal Analysis**

**M. Gorlani**  
Blue Group



## **Appendix G: Automated Thermal Model Reduction for Telecom S/C Walls**

### **Automated Thermal Model Reduction for Telecom S/C Walls**

**F. Jouffroy**  
EADS Astrium





**Appendix H: Advances in the Thermal Analysis in the frequency domain:  
Algorithms development, integrated software tools and post-  
processing**

**Advances in the Thermal Analysis  
in the frequency domain:  
Algorithms development,  
integrated software tools  
and post-processing**

**M. Molina**  
Carlo Gavazzi Space



## **Appendix I: LHP Transient Modelling with EcosimPro**

### **LHP Transient Modelling with EcosimPro**

**C. Gregori de la Malla**  
Empresarios Agrupados



## **Appendix J: Designing for milli- and micro-kelvin revisited**

**Designing  
for  
milli- and micro-kelvin  
  
revisited**

**V.Perotto**  
Alenia Spazio



## **Appendix K: GAETAN Usage at Alcatel Space**

### **GAETAN Usage at Alcatel Space**

**K. Caire**  
Alcatel Space





**Appendix L: Thermal Analysis of the Mechanical Structure of the Solar Telescope GREGOR**

**Thermal Analysis of the  
Mechanical Structure  
of the  
Solar Telescope  
GREGOR**

**T. Bornkessel**  
TU Darmstadt



## **Appendix M: Modelling of Cryocoolers**

### **Modelling of Cryocoolers**

**M. Linder**  
ESA/ESTEC



**Appendix N: Optimization of a Direct Condensing LHP Radiator with the Improved ALGOCAP**

**Optimization of a  
Direct Condensing  
LHP Radiator  
with the  
Improved ALGOCAP**

**R. Schlitt**  
OHB System



## **Appendix O: Innovations in Thermica**

### **Innovations in Thermica**

**M. Jacquiau**  
EADS Astrium





## **Appendix P: Thermal and Radiative Modelling**

### **Thermal and Radiative Modelling**

**J. Thomas**  
ALSTOM



## **Appendix Q: Thermal Network Viewer**

**Thermal  
Network  
Viewer**

**H. Brouquet**  
ALSTOM



**Appendix R: Modelling the Martian Surface Thermal Environment with  
ESATAN and ESARAD**

**Modelling the  
Martian Surface Thermal Environment  
with  
ESATAN and ESARAD**

**B. Shaughnessy**  
Rutherford Appleton Laboratory



**Appendix S: Data Exchange between CFD and ESATAN in the case of Natural Convection**

**Data Exchange  
between  
CFD and ESATAN  
in the case of  
Natural Convection**

**C. Wendt**  
EADS Space Transportation





**Appendix T: Development of an Interface Software for Patran/Thermal  
and ESARAD**

**Development of an  
Interface Software for  
Patran/Thermal  
and  
ESARAD**

**C. Heller**  
EADS Astrium



**Appendix U: New version of BAGHERA STEP viewer based on open standard technologies**

**New version of  
BAGHERA STEP viewer  
based on  
open standard technologies**

**E. Lebegue**  
CSTB/GRAITEC



**Appendix V: Interface between STEP-TAS format and Alcatel Space's  
CIGAL2 application**

**Interface between  
STEP-TAS format  
and  
Alcatel Space's  
CIGAL2 application**

**C. Caillet**  
Open Cascade



## **Appendix W: STEP-TAS and TASverter from the user's point of view**

### **STEP-TAS and TASverter from the user's point of view**

**D. Alsina Orra**  
ESA/ESTEC





**Appendix X: STEP-TAS and TASverter from the software developer's  
point of view**

**STEP-TAS and TASverter  
from the  
software developer's  
point of view**

**HP. de Koning**  
ESA/ESTEC



## **Appendix Y: List of Participants**

### **List of Participants**

**18<sup>th</sup> European Workshop on  
Thermal and ECLS Software**

**5-6 October 2004  
ESTEC, Noordwijk, Netherlands**

**ESTEC Conference Bureau**  
P.O.Box 299, 2200AG, Noordwijk, NL

Tel: +31 71 565 5005

Fax: +31 71 565 5658

Email: [esa.conference.bureau@esa.int](mailto:esa.conference.bureau@esa.int)



**Alsina Orra, D.**

ESA/ESTEC  
TEC-MCV  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 6645  
Fax: +31 71 565 6142  
Email: alsina@thermal.esa.int

**Appel, S.**

ESA/ESTEC  
TEC-MCV  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 4329  
Fax: +31 71 565 6142  
Email: simon@thermal.esa.int

**Barbagallo, G.**

ESA/ESTEC  
TEC-MCT  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 3731  
Fax: +31 71 565 6142  
Email: guido.barbagallo@esa.int

**Basset, Th.**

Alcatel Space  
100 Boulevard de Midi  
BP 99  
06156 Cannes la Bocca  
FRANCE  
Tel: +33 4 92 92 67 29  
Fax: +33 4 92 92 78 70  
Email: thierry.basset@space.alcatel.fr

**Bellet, F.**

Open CASCADE.  
Immeuble ARIANE  
4, Rue René Razel,  
91400 Saclay  
FRANCE  
Tel: +33 1 69 35 44 54  
Fax: +33 1 69 35 44 93  
Email: francis.bellet@opencascade.com

**Bornkessel, T.**

TU Darmstadt  
Soderstrasse 44  
64287 Darmstadt  
GERMANY  
Tel: +49 6151163178  
Fax:  
Email: bornkessel@fnb,tu-darmstadt.de

**Brand, O.**

OHB-System AG  
Universitaetsallee 27-29  
28359 Bremen  
GERMANY  
Tel: +49 421 2020 722  
Fax: +49 421 2020 610  
Email: brand@ohb-system.de

**Brouquet, H.**

ALSTOM  
Cambridge Road  
Whetstone  
Leicester LE8 6LH  
UNITED KINGDOM  
Tel: +44 116 284 5748  
Fax: +44 116 284 5464  
Email: henri.brouquet@power.alstom.com

**Brunetti, F.**

DOREA  
Res de l'Olivet, Bat F  
75 ch de l'Olivet  
6110 Le Cannet  
FRANCE  
Tel: +33 6 64 80 01 28  
Fax: +33 6 64 69 17 00  
Email: francois.brunetti@dorea.fr

**Caillet, C.**

Open CASCADE.  
Immeuble ARIANE  
4, Rue René Razel,  
91400 Saclay  
FRANCE  
Tel: +33 1 69 35 44 63  
Fax: +33 1 69 35 44 93  
Email: christian.caillet@opencascade.com

**Caire, K.**

Alcatel Space  
26 Avenue J-F Champollion  
BP 1187  
21037 Toulouse Cedex 1  
FRANCE  
Tel: +33 5 34 35 52 31  
Fax: +33 5 34 35 62 40  
Email: karine.caire@space.alcatel.fr

**Carvalho, B.**

Active Space Technolgies  
Urb. D. João, Lt. 3 9ºESQ AT  
3030-020 Coimbra  
PORTUGAL  
Tel: +31 625135966  
Fax: +31 715656635  
Email: bruno.carvalho@activespacetech.com

**Checa Cortes, E.**

ESA/ESTEC  
TEC-MCT  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 6606  
Fax: +31 71 565 6142  
Email: elena.checa@esa.int

**Crampé, F.**

SILOGIC  
6 rue Roger Camboulives  
BP1133  
31036 Toulouse  
FRANCE  
Tel: +33 534 619 385  
Fax: +33 534 619 222  
Email: frederic.crampe@silogic.fr

**De Koning, H.P.**

ESA/ESTEC  
TEC-MCV  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 3452  
Fax: +31 71 565 6142  
Email: hans-peter.de.koning@esa.int

**Dolce, S.**

ESA/ESTEC  
TEC-MCT  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 4673  
Fax: +31 71 565 6142  
Email: silvio.dolce@esa.int

**Dudon, J.P.**

Alcatel Space  
100 Boulevard du Midi  
BP99  
06156 Cannes la Bocca  
FRANCE  
Tel: +33 4 92 92 67 13  
Fax: +33 4 92 92 69 70  
Email: jean-paul.dudon@space.alcatel.fr

**Duffy, K.**

MAYA HTT  
4999 Ste. Catherine West, Suite 400  
Montreal H3Z1T3  
CANADA  
Tel: +1 5143695706  
Fax: +1 5143694200  
Email: kevin.duffy@mayhatt.com

**Etchells, J.**

ESA/ESTEC  
TEC-MCV  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 5803  
Fax: +31 71 565 6142  
Email: james.etchells@esa.int

**Fagot, A.**

DOREA  
Res de l'Olivet, Bat F  
75 ch de l'Olivet  
6110 Le Cannet  
FRANCE  
Tel: +33 6 79 24 10 88  
Fax: +33 6 64 69 17 00  
Email: alain.fagot@dorea.fr

**Gibson, D.**

ESA/ESTEC  
TEC-MCV  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 4013  
Fax: +31 71 565 6142  
Email: duncan.gibson@esa.int

**Giunta, D.**

ESA/ESTEC  
TEC-ETC  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 3863  
Fax: +31 71 565 4596  
Email: domenico.giunta@esa.int

**Goizel, A.S.**

Rutherford Appleton Laboratory  
Chilton,  
Didcot  
Oxfordshire, OX11 0QX  
UNITED KINGDOM  
Tel: +44 1235445210  
Fax: +44 1235445848  
Email: a.goizel@rl.ac.uk

**Gorlani, M.**

Blue Group  
Via Albenga, 98  
10098 Cascine Vica  
Rivoli (TO)  
ITALY  
Tel: +39 0119504211  
Fax: +39 0119504216  
Email: m.gorlani@blue-group.it

**Gregori de la Malla, C.****Empresarios Agrupados**

G. Quevedo, 2 planta  
28015 Madrid  
SPAIN  
Tel: +34 914441500  
Fax:  
Email: mgx@iberspacio.es

**Haupt, M.****IFL / TU Braunschweig**

Hermann-Blenk-Str. 35  
D38108 Braunschweig  
GERMANY  
Tel: +49 531 391 9917  
Fax: +49 531 391 9904  
Email: m.haupt@tu-bs.de

**Heller, C.****EADS Astrium GmbH**

88039 Friedrichshafen  
GERMANY  
Tel: +49 75 458 2280  
Fax: +49 75 458 3881  
Email: cosmas.heller@astrium.eads.net

**Heuts, M.****Dutch Space BV**

Newtonweg 1  
2333CP Leiden  
NETHERLANDS  
Tel: +31 71 5245781  
Fax: +31 71 5245499  
Email: m.heuts@dutchspace.nl

**Imhof, M.****SILOGIC**

6 rue Roger Camboulives  
BP1133  
31036 Toulouse  
FRANCE  
Tel: +33 534 619 292  
Fax: +33 534 619 222  
Email: marie.imhof@silogic.fr

**Jacquiau, M.****EADS Astrium**

31 av des Cosmonautes  
ZI du Palays  
31402 TOULOUSE  
FRANCE  
Tel: +33 5 62 19 54 77  
Tel: +33 5 62 19 77 90  
Email: marc.jacquiau@astrium.eads.net

**Jouffroy, F.****EADS Astrium**

31 rue des cosmonautes  
31402 Toulouse cedex  
FRANCE,  
Tel: +33 5 62 19 94 97  
Fax: +33 5 62 19 77 44  
Email: frederic.jouffroy@astrium.eads.net

**Kirtley, C.****ALSTOM**

Cambridge Road  
Whetstone  
Leicester LE8 6LH  
UNITED KINGDOM  
Tel: +44 116 284 5653  
Fax:  
Email: chris.kirtley@power.alstom.com

**Knight, P.****ALSTOM**

Cambridge Road  
Whetstone  
Leicester LE8 6LH  
UNITED KINGDOM  
Tel:  
Fax:  
Email: peter.knight@power.alstom.com

**Koorevaar, F.****Dutch Space**

Newtonweg 1  
2333 CP Leiden  
NETHERLANDS  
Tel: +31 715245799  
Fax:  
Email: f.koorevaar@dutchspace.nl

**Lebegue, E.****CSTB/GRAITEC**

290 route des Lucioles  
BP 209  
06904 SOPHIA-ANTIPOLIS  
FRANCE  
Tel: +33 4 93 95 64 23  
Fax:  
Email: eric.lebegue@cstb.fr

**Linder, M.****ESA/ESTEC**

TEC-MCT  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 4463  
Fax: +31 71 565 6142  
Email: martin.linder@esa.int

**Loetzke, H-G.**

DLR

Rutherfordstr. 2

D-12489 Berlin

GERMANY

Tel: +49 30 6705 8617

Fax: +49 30 6705 5617

Email: horst-georg.loetzke@dlr.de

**Marechal, C.**

CNES

Avenue e. Belim 18

31044 Toulouse Cedex 9

FRANCE

Tel: +33 5 31 27 37 50

Fax: +33 5 61 27 34 46

Email: christophe.marechal@cnes.fr

**Mareschi, V.**

Alenia Spazio spa

Strada Antica di Collegno 253

10146 Torino

ITALY

Tel: +39 011 7180294

Fax: +39 011 7180239

Email: vmaresch@to.alespazio.it

**Molina, M.**

Carlo Gavazzi Space

Via Gallarate 150

20151 Milano

ITALY

Tel: +39 02 38048259

Fax: +39 02 3086458

Email: mmolina@cgspace.it

**Ordóñez Inda, L.**

ESA/ESTEC

TEC-MCT

P.O. Box 299

2200AG Noordwijk

NETHERLANDS

Tel: +31 71 565 6159

Fax: +31 71 565 6142

Email: luis.ordonez.inda@esa.int

**Pailles, O.**

INCKA

85 avenue Pierre Grenier

92100 BOULOGNE

FRANCE

Tel: +33 1 58 17 12 36

Fax: +33 1 58 17 12 25

Email: olivier.pailles@incka.net

**Pérez Vara, R.**

Empresarios Agrupados

c/ Magallanes 3

28015 Madrid

SPAIN

Tel: +34 914441537

Fax:

Email: rpv@empre.es

**Perotto, V.**

Alenia Spazio spa

Strada Antica di Collegno 253

10146 Torino

ITALY

Tel: +39 011 7180215

Fax: +39 011 7180239

Email: vperotto@to.alespazio.it

**Persson, J.**

ESA/ESTEC

MSM-MCS

P.O. Box 299

2200AG Noordwijk

NETHERLANDS

Tel: +31 71 565 3814

Fax: +31 71 565 6279

Email: jan.persson@esa.intl

**Pin, O.**

ESA/ESTEC

TEC-MCV

P.O. Box 299

2200AG Noordwijk

NETHERLANDS

Tel: +31 71 565 5878

Fax: +31 71 565 6142

Email: olivier.pin@esa.int

**Rathjen, H.**

EADS-ST/BRE - TE52

Hünefeldstr. 1-5

28199 Bremen

GERMANY

Tel: +49 421 539 4173

Tel: +49 421 539 5288

Email: harold.rathjen@space.eads.net

**Robson, A.**

EADS Astrium

Gunnelswood Road

Stevenage SG1 2AS

UNITED KINGDOM

Tel: +44 14 3877 4358

Fax: +44 14 3877 8913

Email: andrew.robson@astrium.eads.net



**Romera Perez, J.A.**

ESA/ESTEC  
TEC-MCT  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 3979  
Fax: +31 71 565 6142  
Email: jose.antonio.romera.perez@esa.intl

**Rooijackers, H.**

ESA/ESTEC  
TEC-MCV  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 5656  
Fax: +31 71 565 6142  
Email: harrie@thermal.esa.int

**Sahlin, P.**

EASi Engineering GmbH  
Norr Mälarstrand 80, 1 tr  
112 35 Stockholm  
SWEDEN  
Tel: +46 8 650 77 34  
Fax:  
Email: petter.sahlin@easi.de

**Schaefer, J.**

University of Stuttgart  
Pfaffenwaldring 27  
70569 Stuttgart  
GERMANY  
Tel: +49 7116852482  
Fax: +49 7116853706  
Email: schaefer@isd.uni-stuttgart.de

**Schautz, M.**

ESA/ESTEC  
TEC-EPB  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 715653836  
Fax: +31 715654994  
Email: max.schautz@esa.int

**Schlitt, R.**

OHB - System AG  
Universitätsallee 27-29  
D-28359 Bremen  
GERMANY  
Tel: +49 421 2 637  
Fax: +49 421 2 610  
Email: rschlitt@ohb-system.de

**Schmidt, H.P.**

DLR - German Aerospace Center  
Institute of Space Simulation  
51147 Köln  
GERMANY  
Tel: +49 2203 601 2175  
Fax: +49 2203 61474  
Email: hp.schmidt@dlr.de

**Sdunnus, H.**

eta\_max space GmbH  
Richard-Wagner-Strasse 1  
38106 Braunschweig  
GERMANY  
Tel: +49 531 3802 423  
Fax: +49 531 3802 401  
Email: hsdunnus@etamax.de

**Shaughnessy, B.**

CCLRC  
Chilton Didcot  
Oxfordshire OX11 0QX  
UNITED KINGDOM  
Tel: +44 1235445061  
Fax: +44 1235445848  
Email: b.m.shaughnessy@rl.ac.uk

**Sorensen, J.**

ESA/ESTEC  
TEC-EES  
P.O. Box 299  
2200AG Noordwijk  
NETHERLANDS  
Tel: +31 71 565 3795  
Fax: +31 71 565 4999  
Email: john.sorensen@esa.int

**Stroom, C.**

ESA/ESTEC (retired)  
Amsterdam  
NETHERLANDS  
Tel:  
Fax:  
Email: charles@stremen.xs4all.nl

**Theurer, G.**

EADS-ST  
88039 Friedrichshafen  
Friedrichshafen  
GERMANY  
Tel: +49 754589769  
Fax: +49 754584429  
Email: Georg.Theurer@space.eads.net

**Thomas, J.**

ALSTOM

Cambridge Road

Whetstone

LE8 6LH

UNITED KINGDOM

Tel: +44 116 284 5607

Fax:

Email: julian.thomas@power.alstom.com

**Tonello, G.**

ESA/ESTEC

TEC-MCT

P.O. Box 299

2200AG Noordwijk

NETHERLANDS

Tel: +31 715654817

Fax: +31 715656142

Email: giulio.tonello@esa.int

**Torres, A.**

EADS CASA

G. Quevedo, 2 planta

28015 Madrid

SPAIN

Tel: +34 914441502

Fax:

Email: ato@iberspacio.es

**Van Baren, C.**

SRON - Space Research Organisation Netherlands

Sorbonnelaan 2

3584CA Utrecht

NETHERLANDS

Tel: +31 30 253 5621

Fax: +31 30 254 0860

Email: c.van.baren@sron.nl

**Van Eckelen, T.**

Samtech s.a.

Rue des Chasseurs-Ardennais 8

Angleur-Liege

B-4031

BELGIUM

Tel: +32 43616969

Fax: +32 43616980

Email: tom@samcef.com

**Van Leijenhorst, P.**

Dutch Space

Newtonweg 1

2333CP Leiden

NETHERLANDS

Tel: +31 71 5245799

Fax:

Email: p.van.leijenhorst@dutchspace.nl

**Weimer, L**

EADS Astrium GmbH

An der B31

88039 Friedrichshafen

GERMANY

Tel: +49 75458 3916

Fax: +49 75458 4912

Email: lars.weimer@astrium.eads.net

**Wendt, C.**

EADS-ST/BRE

Hünefeldstr.1-5

28199 Bremen

GERMANY

Tel: +49 421 539 4606

Fax: +49 421 539 5582

Email: christian.wendt.space.eads.net

**Werling, E.**

CNES

18 Avenue E. Belin

31401 TOULOUSE Cedex 09

FRANCE

Tel: +33 561273083

Fax: +33 561273446

Email: eric.werling@cnes.fr