ESA Harmonisation & User Survey

Thermal and Space Environment Analysis Tools and Interfaces

Hans Peter de Koning (ESA D/TOS-MCV)

Charles Stroom (ESA D/TOS-MCV)
Éamonn Daly (ESA D/TOS-EMA)
John Sørensen (ESA D/TOS-EMA)
Luca Maresi (ESA D/IMT-THH)

Background on the disciplines

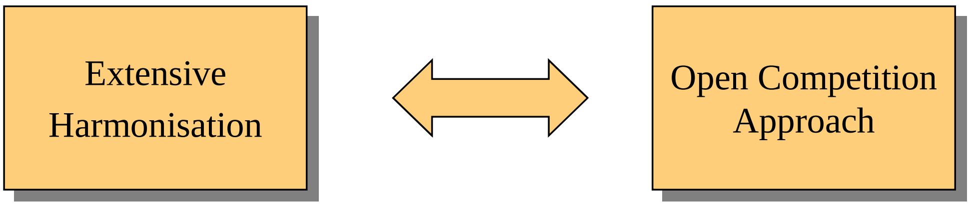
- The domain comprises:
  - → Spacecraft thermal control: managing internal and external heating and cooling as well as temperature ranges for spacecraft parts
  - → Space environmental effects: high energy radiation, plasmas, small sized debris and meteoroids
- During all mission phases
- Different disciplines, different models, however sharing common needs:
  - → Spacecraft shape (external surfaces) and material properties
  - → Orbit trajectory, attitude, pointing, rigid body kinematics
  - → Shared solution algorithms (e.g. ray-tracing)
  - → Similar needs to exchange data with CAD and other engineering disciplines
- It is space-specific (i.e. no terrestrial equivalent):
  - → Thermal: radiation dominated (vacuum); limited convection (vacuum, zero gravity); wide temperature ranges and thermal cycling
  - → Space environment: energetic particles, atomic oxygen, space debris, contamination, ...

Software tools are fundamental for all engineering analysis

- For design, development, verification and in-orbit operations
- Many tools are in actual use:
  - → Fully commercial (NASTRAN, Mentor Graphics, etc.); wide range of applications; many users
  - → Space-specific tools (thermal, space environment); very specific; limited number of users (number of sites in Europe ~100 max, in US few hundred, rest of world ?)
  - → In-house developments; often to complement other tools in use, or to capture specific company expertise
- PDE (product data exchange) of models, results, material and other data, is an ever growing concern:
  - → To support multi-disciplinary design and development, collaborative engineering
  - → To support efficient data exchange between partners

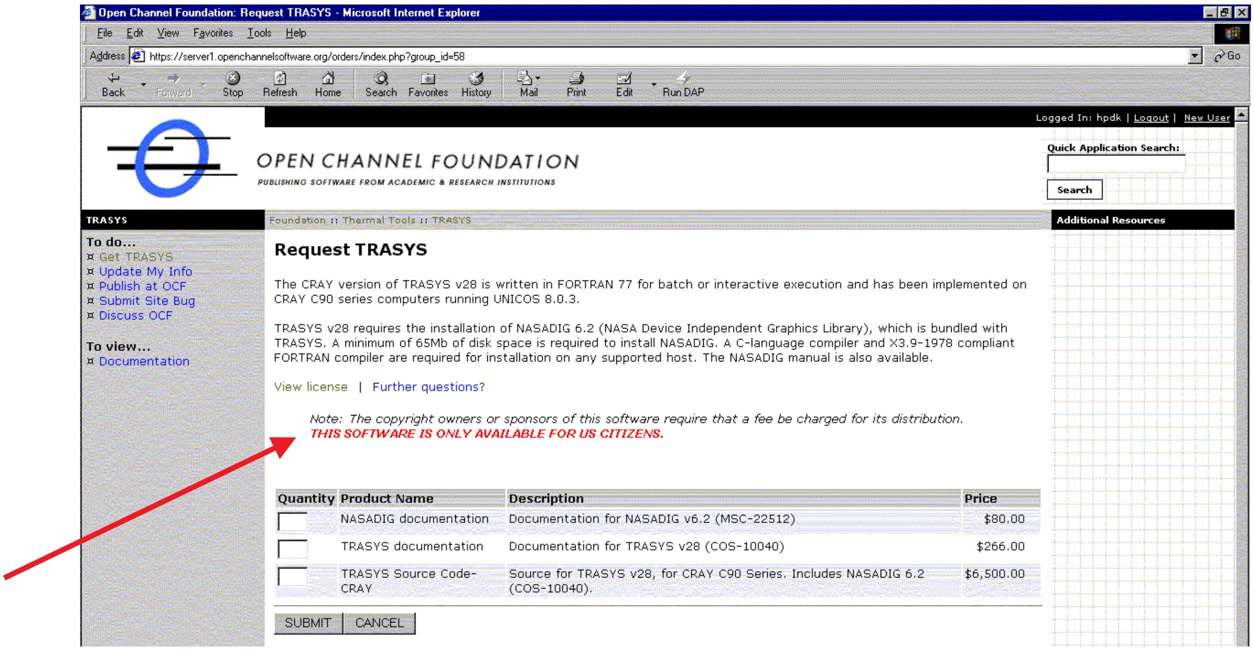
The Harmonisation Effort

- Technology mapping meeting 24-Apr-2002 – widely different views:



Consensus:	Strategic issues:
Standards for exchange of models and data are important Several current tools are ageing and in serious need of replacing	Ensuring long-term availability Intellectual Property Rights (IPR) Tools that can be affected by export restrictions Arguments in favour of or against promoting "ESA" tools Use of Open Source Software (OSS)

Illustration of strategic issue
Export restrictions



Towards a Roadmap

- Topics
  - → Detailed medium/long term strategy
  - → Expected added value
  - → Proposed development approach
  - → Schedule and cost
  - → Risk analysis
- Roadmap options:
  - → (1) European institutions adopt a hands-off approach except to facilitate and promote standards as a mechanism for harmonisation
  - → (2) European institutions actively pursue a harmonised approach of coordinated developments of standards and generic analysis software components (“toolkit”)
- User survey and initial results

Roadmap Options

	Option 1 (hands-off)	Option 2 (harmonised)
Strategy	Establish analysis & data exchange standards	Establish analysis & data exchange standards Make a coordinated development of a generic “Toolkit”
Development Approach	ECSS Working Group Development and validation by tool developers on their own funding Ad-hoc developments by agencies (only for specific needs)	Overseen by “harmonisation board” of stake-holders and funded by appropriate means (e.g. GSTP, Nat. funding, EC) Open source approach is an attractive option
Schedule & Cost	~200k€ (ESA budget) + industry costs, 1-2 years	~2M€ over 3-5 years

“Toolkit” Content

- Possible elements of a generic “Toolkit” for building of domain specific applications – needs addressed:
  - → Model construction, including kinematics, meshing, idealisation
  - → Database(s) of (environment) models, material properties
  - → Data exchange (between thermal/space environment tools, CAD, other disciplines)
  - → Visualisation
  - → Post-processors
  - → Solvers (e.g. ray-tracers)
  - → Graphical user interface
  - → Orbit generators
  - → Domain specific modules (e.g. thermal conductor generation)

Expected Outcome

	Option 1 (hands-off)	Option 2 (harmonised)
Short term	Standards may be accepted (debatable)	Standards are accepted and a generic “toolkit” is developed applying the standards
Medium and long term	Industry will rely on commercial or internal developed tools	Industry will have stable and maintainable tools based on common standards and common software elements
Added value	Industry free to make their own tools	Rapid developments avoiding duplication

Risks / Advantages

	Option 1 (hands-off)	Option 2 (harmonised)
Risks	Standards not fully adopted Duplication of tools Gaps in tools Costly maintenance Some tools can be affected by export restrictions	Slow consensus building Insufficient mandate Insufficient financial means

Risks / Advantages

	Option 1 (hands-off)	Option 2 (harmonised)
Advantages	Possible rapid response to new user requirements	Rapid developments when toolkit available Industry can concentrate on domain specific part of tools Cost-sharing (also for maintenance and validation) Data exchange at toolkit level

Open Source Software (OSS)

- The OSS development and distribution model characteristics:
  - → The IPR is governed by a license - NOT necessarily public domain
  - → The source code is made available
    as well as any other components needed to build the software
  - → The user is free to modify and re-distribute the software
  - → The software is NOT necessarily provided free of charge
  - → Improvements are usually fed back to a central maintainer of the software and applied in a configuration controlled way (mostly using GNU CVS)
  - → The development is usually guided by a dedicated (formal or informal) membership organisation

Open Source Software (OSS)

Advantages	Disadvantages
Users can quickly adapt software Users can develop special purpose applications Ensured long-term availability Many existing OSS modules of high quality Reducing (direct) cost	May discourage some industries Vendors need to change business model

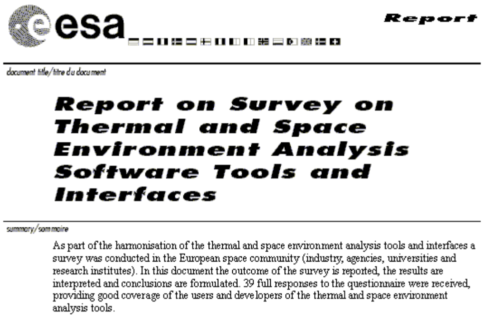
User survey

- http://www.estec.esa.int/thermal/survey/tse_sw_harmonisation_survey.html
- Purpose:
  - → Solicit more input from users on content and principles of future developments in order to obtain a good foundation for the harmonisation effort
- Statistics
  - → Survey performed June 2002
  - → 41 responses of which 39 answered in full
  - → All major players in participated - good mix of prime and smaller contractors

category	*invited*	*responded, but not interested*		*responded fully*	
agency	19	1	5.3%	4	21.1%
industry	60	1	1.7%	22	36.7%
university/institute	20	0	0.0%	5	25.0%
total	**99**	**2**	**2.0%**	**31**	**31.3%**

User survey report

- Complete (anonymised) report was made
- Available upon request from Hans-Peter.de.Koning@esa.int
  - → Will be distributed as PDF next week (28-Oct / 1-Nov)


esa

Report

document title/titre du document

Report on Survey on Thermal and Space Environment Analysis Software Tools and Interfaces

summary/sommaire

As part of the harmonisation of the thermal and space environment analysis tools and interfaces a survey was conducted in the European space community (industry, agencies, universities and research institutes). In this document the outcome of the survey is reported, the results are interpreted and conclusions are formulated. 39 full responses to the questionnaire were received, providing good coverage of the users and developers of the thermal and space environment analysis tools.

Main conclusions from user survey (1)

- 1. Data exchange based on open standards, supported by reliable and verified interface software, is priority number one and should be co-ordinated and funded by ESA. There is almost unanimous agreement on this.
- 2. Apart from data exchange, the reliability, robustness and proper validation of tools and (space environment) models are deemed of the utmost importance.
- 3. Data archiving is perceived as a less important issue.
- 4. The respondents have quite varying opinions with respect to the need and benefits of the development of a generic toolkit to support thermal and space environment analysis tools.:
  - → those who are in favour, and,
  - → those who think it should be left to commercial developers / vendors.
  - → A small majority sees the benefits of generic toolkit components, mainly users / not vendors.

Main conclusions from user survey (2)

- 5a. For a possible generic toolkit the following are the most desired functionalities:
  - → data exchange / open interfaces
  - → the material properties database,
  - → pre- and post-processing / visualisation / GUI modules
- 5b. The following functionalities received the lower scores:
  - → configuration and version control
  - → scripting modules (command language)
  - → model abstraction and idealisation
  - → high performance computing
- 6. Users do not want a single big tool.
- 7. Of the various analysis methods, the Monte-Carlo ray-tracing, lumped parameter and finite element analyses techniques are needed most.

Main conclusions from user survey (3)

- 8. There is broad concensus that is important that European space organisations have guaranteed and continued access to the space engineering tools.
- 9. There is a clear preference that ESA keeps on funding development of specific tools. There is little concern that funding by ESA will distort a the market competition.
- 10. For a future development of a generic toolkit there is clear preference that this shall be managed through a purposely created "management board", in which users and ESA should participate.
- 11. The respondents have widely varying opinions with respect to with whom the Intellectual Property Right (IPR) of a future generic toolkit should be vested and on whether this should be an open source software arrangement.
  - → Statements range from "*I think Open Source arrangement is the most efficient way to develop applications at low costs*" and "*open source is the best concept wrt. future developments/extensions of any software*" to "*Scepticism with respect to open source solutions*" and "*Q111,Q112,Q113 are nice,but little acceptance by commercial dept. in industry*".
  - → There seems to be a slight preference for either IPR vested with a neutral body or a kind of Community Open Source arrangement.

Main conclusions from user survey (4)

- 12. There is agreement that if the IPR should be vested with a neutral body it should be with ESA.
- 13. Maintenance should be the responsibility of the developer of the individual tools.
- 14. A large majority (over 70%) is willing to use Open Source Software tools. Conditions for its use are good validation, maintenance and configuration control.
- 15. About half the respondents would participate in the maintenance of Open Source Software, the other half would not.
- 16. The range between 1 and 10 kEuro per seat per year is considered an appropriate fee for a thermal or space environment analysis tool.

What next?

- Harmonisation roadmap is developed by ESA for presentation / approval December 2002 Harmonisation Meeting with the national delegations
- Roadmap will focus on harmonised development approach
  - → (1) Open standards for model / data exchange and software components to implement interfaces (without dependence on COTS third party software)
  - → (2) Generic “Toolkit” of OSS software components plus supporting organisational structure
  - → (3) Time, schedule and funding