ESTEC TOS-MC
Thermal and Structures Division

STEP for Space Architecture

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With many inputs from previous presentations with
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Introduction

- Rather presumptuous title "... architecture"
- "ESA perspective on a STEP for Space Architecture" is perhaps more appropriate
- Goal is to give an overview of our ideas and activities

Topics

- What in STEP is relevant to space industry?
- Architecture, protocols and space engineering disciplines
- ECSS Working Group “Exchange of product data”
- Brief overview of ESA developed STEP protocols
- Concluding remarks / outline of strategy

Why do we want open, neutral standards for product data exchange?

- It is impractical and inefficient, therefore impossible, to standardise on one set of tools for all projects
  - Skills acquired and investments in training and licenses
  - Would frustrate tool innovation through competition
  - Organisations work in different teams for different customers
- Point-to-point translators costly to develop / maintain
  - Inherent problem: only one side of the i/f under control
- The definition of a product / model is in its *data*
- The functionality to do something with it is in the *tool*

Brief recap: What is STEP?

- STEP = ISO 10303
  = Standard for the Exchange of Product model data
- Comprehensive standard – Many parts / layers
  - Generic resources, Application protocols, Abstract test suites
- World-wide effort
  - across all industrial branches (aerospace, automotive, electronic, building & construction, shipbuilding, process-industry, …)
  - across all engineering disciplines
  - started in 1984 – standards since 1994 – 1000+ man-years
  - details: www.nist.gov/sc4 (ISO TC184/SC4) and www.iso.ch

Objective of STEP / ISO 10303

"ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving."

(From ISO 10303 Part 1)

What in ISO 10303 is relevant to space industry?

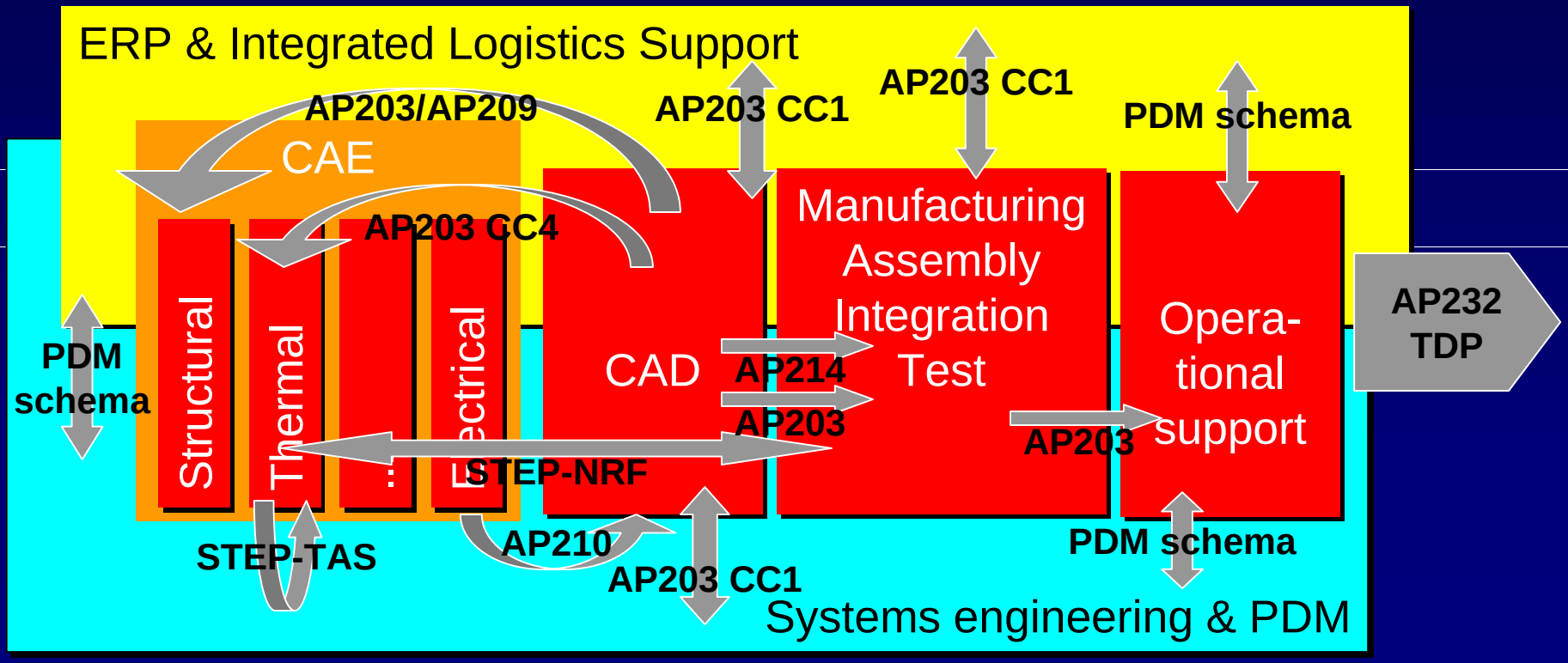
- International standards
  - **AP202 Associative Draughting**
  - **AP203 Configuration controlled design**
- Draft international standards
  - **AP209 Composite and metallic structural analysis and related design**
  - **AP210 Electronic assembly, interconnect and packaging design**
  - **AP212 Electrotechnical design and installation**
  - **AP214 Core data for automotive mechanical design processes**
- Under development
  - **AP232 Technical data packaging core information and exchange**
  - **AP233 Systems engineering**
  - **PDM schema**
  - **AP221 Functional data and their schematic representation for process plant (Class libraries, related to ISO 15926)**
  - **Engineering analysis core ARM**

Additional developments in European space

- Application protocols:
  - STEP-NRF (Network-model Results Format)
  - STEP-TAS (Thermal Analysis for Space)
  - STEP-PRP (Propulsion systems) (by CNES)
- Integrated application resources (like ISO 10303-1xx)
  - Space domain (mission, orbit, attitude, orientation ...)
  - Analysis, test and operation results
  - Thermal analysis (space thermal environment, thermo-optical properties, radiative faces ...)
- ECSS WG “Exchange of product data” standard

All STEP documentation fully compliant with ISO TC184/SC4 development methodology

Disciplines in space projects and examples of possible exchange



How too manage the multitude of interfaces?

- Clearly a shared, dynamic database would be ‘ideal’
  - with consistent product structure & configuration control across all disciplines
  - with standardised platform independent data access functionality (e.g. through STEP SDAI, CORBA, XML ...)
- However, this step is too ambitious for realisation on a large scale in the near future
  - In our experience very significant time and effort is involved in developing reliable neutral file based data exchange
  - File based exchange is a necessary intermediate stage
  - It can be greatly enhanced by plain old FTP, Web servers and LDAP type directory services

Co-ordination of data exchange in European space community

- Since 1995 the European *Co-operation for Space Standardisation* (ECSS) initiative is active
  - Goal is to produce a single set of consistent European space standards
  - Starting point were existing ESA and European national space standards
- Industry, ESA and the national space agencies felt a strong need for a high level standard to condense and standardise the preferred ways of exchanging product data in space projects

ECSS E-10-07 WG
"Exchange of product data"

- Working Group installed March 1999
  - 17 members from industry, agencies, STEP consultants
- Objective: Produce high level 'umbrella' standard to unambiguously specify exchange of product data in European space projects
  - Structured clauses to facilitate tailored use:
    "To exchange data from a <source_discipline> representation to a <destination_discipline> representation for the purpose of transferring <kind_of_product_data> the <standard_identifier> standard shall be used."
  - In principle ISO 10303 parts & conformance classes are used
  - Draft standard first half 2000 / info: www.estec.esa.int/ecss

ECSS disciplines taken into account in ECSS E-10-07

- **ECSS-M - Space Project Management**
  - ECSS-M-40 - Configuration Management
  - ECSS-M-50 - Information / Documentation Management
  - ECSS-M-70 - Integrated Logistic Support
- **ECSS-Q - Space Product Assurance**
  - ECSS-Q-70 - Material, Mechanical Parts & Processes
- **ECSS-E-10 - Space Engineering**
  - ECSS-E-10 - System Engineering
  - ECSS-E-20 - Electrical & Electronics
  - ECSS-E-30 - Mechanical (including Structural, Thermal, Optical ...)
  - ECSS-E-40 - Software Engineering
  - ECSS-E-60 - Control Systems
  - ECSS-E-70 - Ground Systems & Operations

Example excerpts from ECSS E-10-07

4.2.3 Source discipline E-30 Space Engineering - Mechanical - Design & Construction

Subclause	*To exchange data from a … representation*	*to a … representation*	*for the purpose of transferring …*	*the … standard shall be used.*
…				
4.2.3.5	E-30 Design & Construction	E-30 Design & Construction	Configuration controlled design information and shapes represented by advanced boundary-representation models	[STEP-203] CC6
4.2.3.6	E-30 Design & Construction	E-30 Design & Construction	Component design with 3D shape representation	[STEP-214] CC1
…				
4.2.3.12	E-30 Design & Construction	E-30 Thermal Control	3D surface shape model for thermal-radiative EA	[STEP-203] CC4

Tailoring is done by marking a list of subclauses applicable for exchange between partners in a project

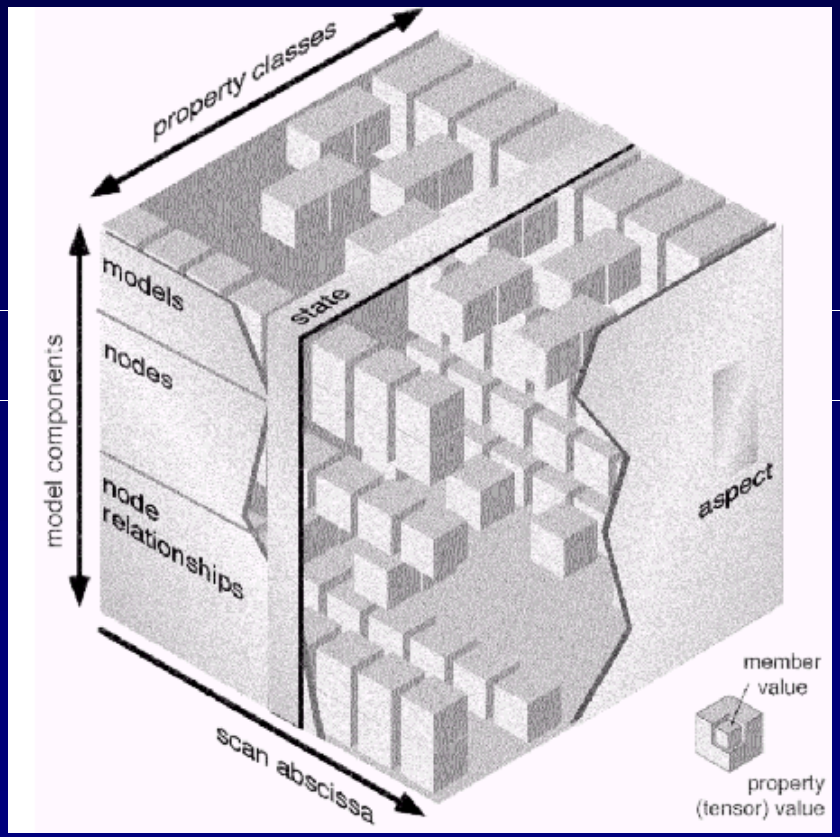
Brief history STEP protocol developments at ESA

- 1994: R&D project started on “Thermal neutral formats”
- 1996: STEP-NRF AP and Space IR completed
- 1997: STEP-TAS AP completed (including AAM, ARM, AIM, mapping table, 6 conformance classes); STEP-TAS is a pure extension of STEP-NRF
- 1998: Programming libraries C & Fortran (5 platforms)
- 1998: Abstract test suites / validation ESARAD round-trip
- 1998: Prototype export in TSS, import in TRASYS with JPL
- 1998: Editorial update into TC184/SC4 MS-Word format
- 1999: STEP-TAS CC1 import/export in ESARAD 4.1.x
- 2000: STEP-TAS CC1 import/export in THERMICA
- Currently working on cross-validation large model exchange

STEP-TAS "Thermal Analysis for Space" Conformance Classes

- CC-1: thermal radiation model with basic geometry;
- CC-2: thermal radiation model with basic geometry and kinematic model;
- CC-3: thermal radiation model with basic and constructive geometry;
- CC-4: thermal radiation model with basic and constructive geometry and kinematic model;
- CC-5: thermal radiation model with basic geometry, kinematic model and space mission aspects;
- CC-6: thermal radiation model with basic and constructive geometry, kinematic model and space mission aspects.

STEP-NRF
"Network-model Results Format"



- Efficient storage of bulk results from analyses, tests and operations
  - Generic / discipline independent
  - Results only for discrete points in space and time
- Starting development of binary portable HDF5 implementation method
  - HDF is Hierarchical Data Format from NCSA
  - Standard e.g. in NASA EOS

Summary and conclusions (1)

- Wherever possible (re-)use standards from other industrial sectors and don't develop new if not absolutely necessary
- First, get file based STEP exchange working and validated in practice; only then think about more advanced solutions
- Keep raising awareness
  - Stimulate industry and engineering software tool vendors
  - Promoting and (partially) funding product data exchange standardisation is a natural role for space agencies

Summary and conclusions (2)

- W.r.t. ESA protocol developments
  - Currently considering proposing STEP-TAS as ISO TC184 / SC4 NWI (as announced at New Orleans meeting, Nov-99)
  - STEP-TAS protocol and programming libraries are available on CD-ROM at nominal cost through Simulog (France)
  - Continue STEP-NRF with HDF5 development
- Intent to publish ECSS E-10-07 Exchange of product data 'umbrella standard' in 2000
- Strongly in favour of further co-operation with NASA
  - Find concrete cases for application in international space programmes: ISS, Mars missions, ...