Status on Model Data Exchange

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Mechanical Engineering Department
Thermal and Structures Division

Topics

- Brief introduction to STEP
- Brief overview of STEP-TAS and STEP-NRF
- State of STEP-TAS implementations
- TRASYS/STEP-TAS and TRASYS/ESARAD converters
- ESARAD STEP-AP203 import and NURBS support
- Road ahead
- Announcement NASA/ESA Aerospace Product Data Exchange based on Open Standards Workshop

Objective of STEP / ISO 10303

- STEP = STandard for the Exchange of Product model data = casual name for 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)

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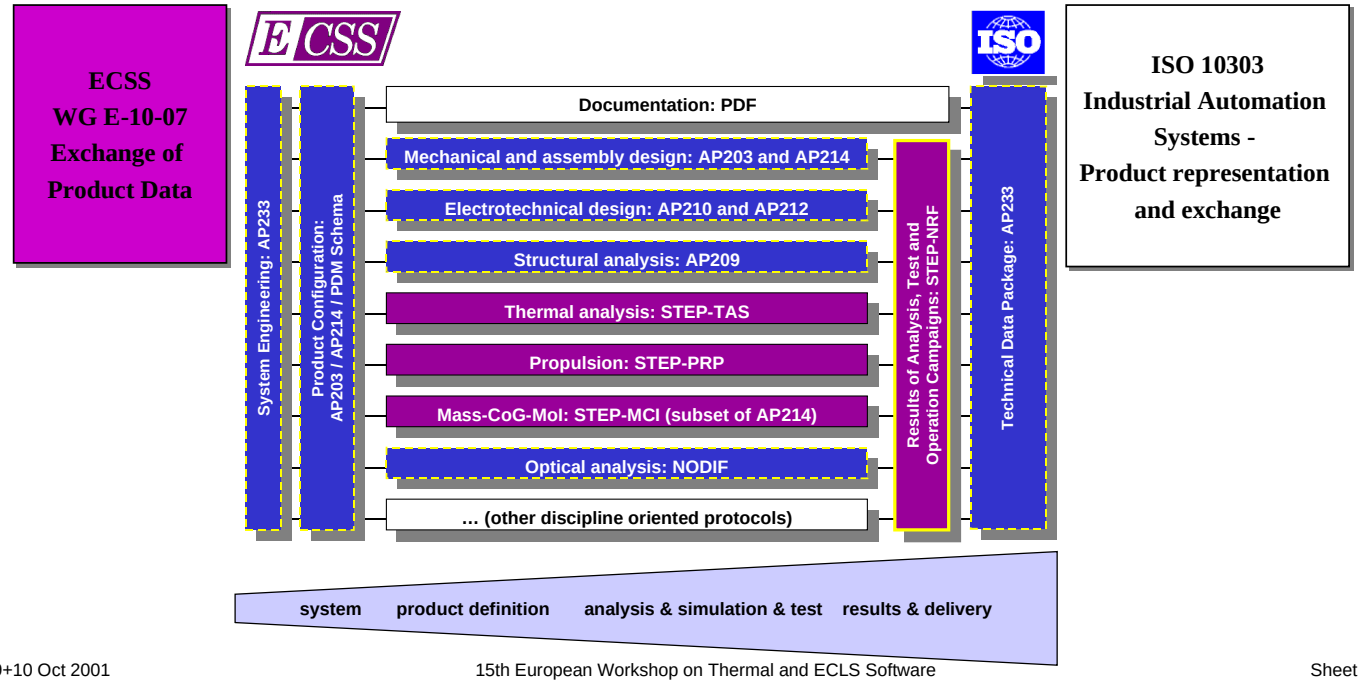
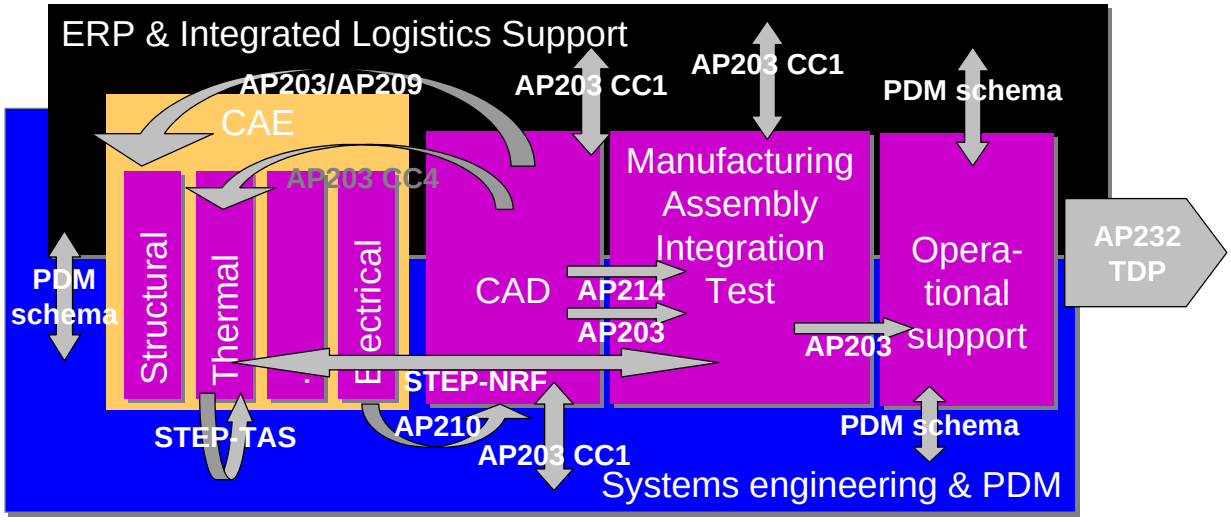
The (Aero)Space STEP Protocols Map



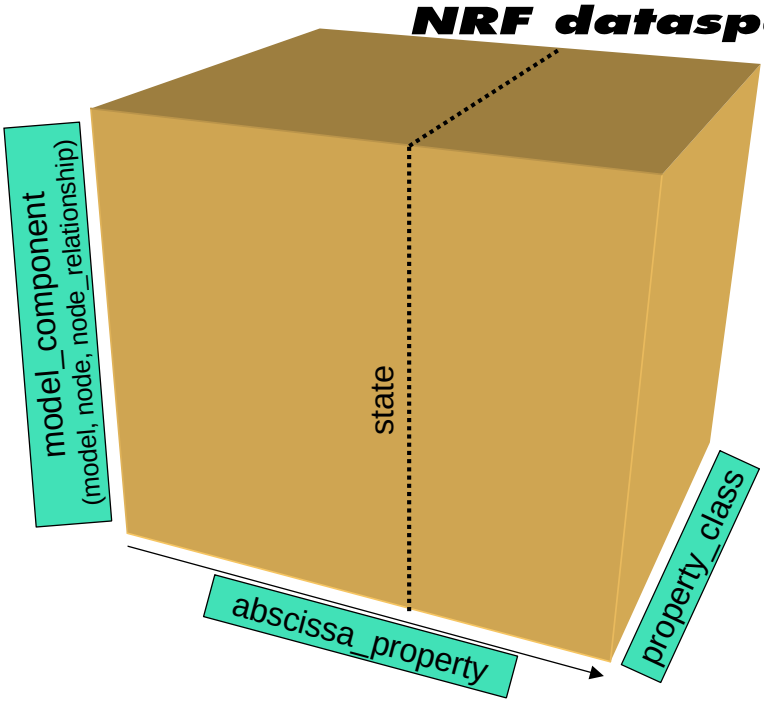
Bigger picture: Open standards based exchange between disciplines in space projects



Main characteristics STEP-NRF (1) Network-model Results Format

- Targets engineering-discipline independent exchange of bulk results data from analysis, test or operation
  - Representation of engineering objects by network models consisting of discrete nodes and node-relationships
  - Hierarchical tree of network models / submodels
  - Definition of properties
    - Quantitative, descriptive and functional properties
    - Scalar, vector and tensor property values
    - Property values only at discrete locations / discrete states
  - Full annotation of analysis / test / operation context
    - Campaign, case, phase, run
    - Facility/tool, environment, date and time, organisation, person, ...

Main characteristics STEP-NRF (2)
NRF dataspace

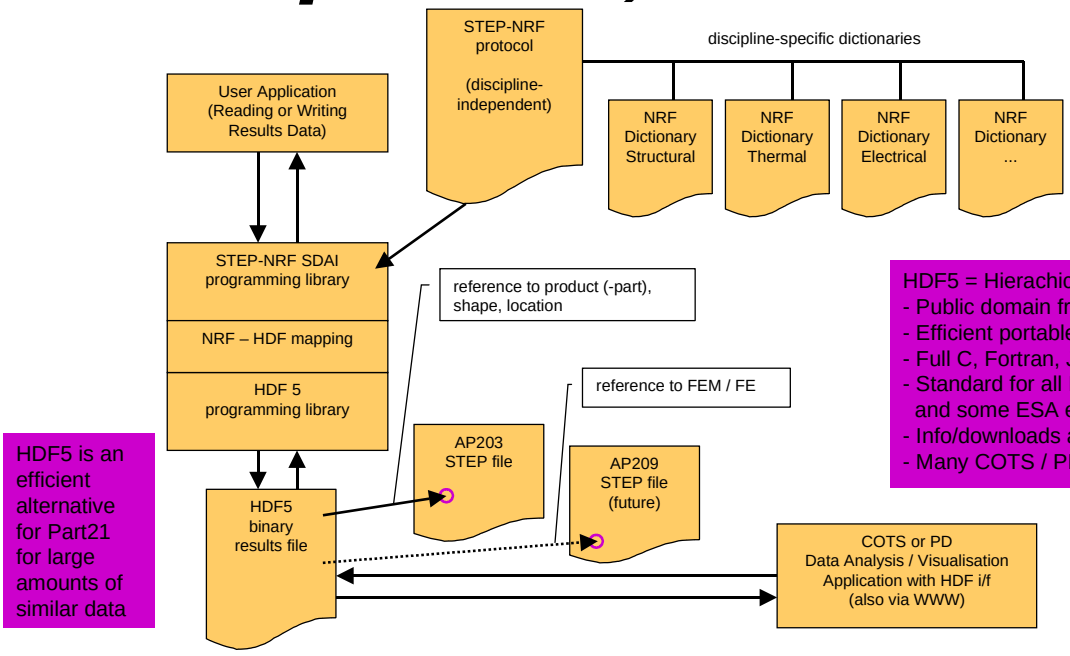


Each gridpoint in the 3D dataspace is a property value

Each can be scalar, vector, tensor

Data model and implementation designed to handle sparsely populated dataspace efficiently

Main characteristics STEP-NRF (3)
Proposed NRF/HDF architecture



HDF5 is an efficient alternative for Part21 for large amounts of similar data

HDF5 = Hierachical Data Format v5
- Public domain from NCSA
- Efficient portable binary storage format
- Full C, Fortran, Java libraries on >10 platforms
- Standard for all NASA EOS missions and some ESA earth observation
- Info/downloads at hdf.ncsa.uiuc.edu
- Many COTS / PD tools with HDF interface

Main characteristics of STEP-TAS (1)

- Self contained, complete Application Protocol
  - AAM, ARM, Mapping Table, AIM, Express-G (586 pages)
  - Conforms to TC184/SC4 methods and guidelines
- Geometry defined as AP203 CC4 surfaces
- Thermal-radiative model faces added as associated features
  - Including possibility to support hierarchical submodel tree
  - Associated notional thickness, surface material and bulk material
  - Thermo-optical, thermo-physical properties for named material
  - Concept of material property environment (Part 45)
- Kinematic model conform STEP Part 105
  - for articulated rigid bodies (e.g. rotating solar arrays, gimballed antennas)

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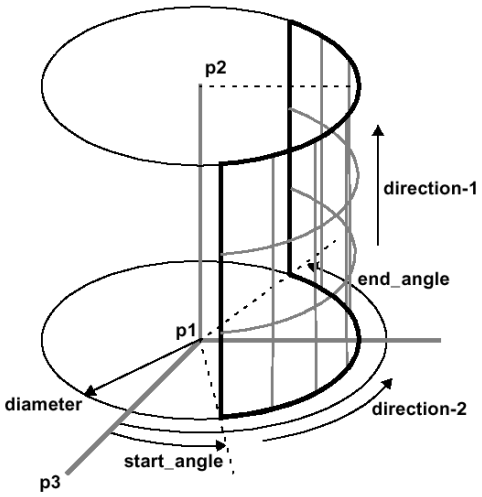
Main characteristics of STEP-TAS (2)

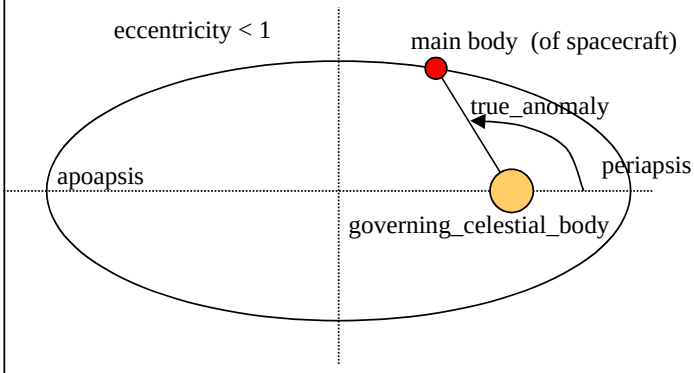
- Space mission aspects
  - orbit arc (Keplerian and discrete ephemeris)
  - space co-ordinate system, celestial bodies
  - orientation, general and named pointing, spinning, linear rotation rates
  - space thermal environment, including constant or lat/long dependent albedo / planetshine tables
- Boolean construction surfaces available for advanced tools
- STEP-TAS CC1 Abstract Test Suite
  - conform STEP Part 3xx series
  - test suite has been used in validation of TAS processors

STEP-TAS geometry and thermal-radiative models



- Shapes
  - Primitives: triangle, rectangle, quadrilateral, disc, cylinder, cone, sphere, paraboloid
  - Compound shapes
  - Shapes conform to AP203 CC4 non-manifold surfaces
- Thermal-radiative model
  - associates thermal-radiative faces with surface shapes
  - thermal mesh (uniform and non-uniform)
  - surface and bulk material properties by reference to material

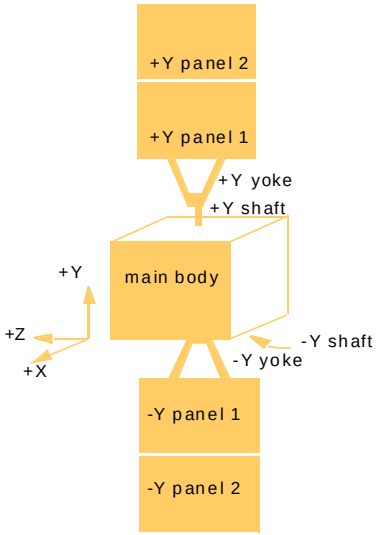
Illustration of basic STEP-TAS Keplerian orbit arc definition



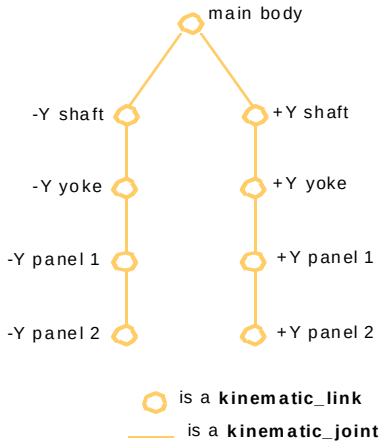

```
ENTITY keplerian_orbit_arc
    SUBTYPE OF (orbit_arc);
    kepler_parameters : kepler_parameter_set;
END_ENTITY;

ENTITY kepler_parameter_set;
  semi_major_axis : length_measure;
  eccentricity : REAL;
  inclination : plane_angle_measure;
  right_ascension_of_ascending_node :
    plane_angle_measure;
  argument_of_periapsis : plane_angle_measure;
  true_anomaly_at_start : plane_angle_measure;
WHERE
  wr1: semi_major_axis >= 0.0;
  wr2: eccentricity >= 0.0;
  wr3: (-180.0 < inclination) AND
       (inclination <= 180.0);
  wr4: (-360.0 < right_ascension_of_ascending_node)
    AND (right_ascension_of_ascending_node <= 360.0);
  wr5: (0.0 <= argument_of_periapsis) AND
     (argument_of_periapsis < 360.0);
  wr6: (-360.0 < true_anomaly_at_start) AND
     (true_anomaly_at_start <= 360.0);
END_ENTITY;
```

STEP-TAS : Product structure and kinematic



(a) Schematic shape model of a typical communications satellite with two fully deployed solar array wings



(b) The corresponding **kinematic_model** presented as a topological graph

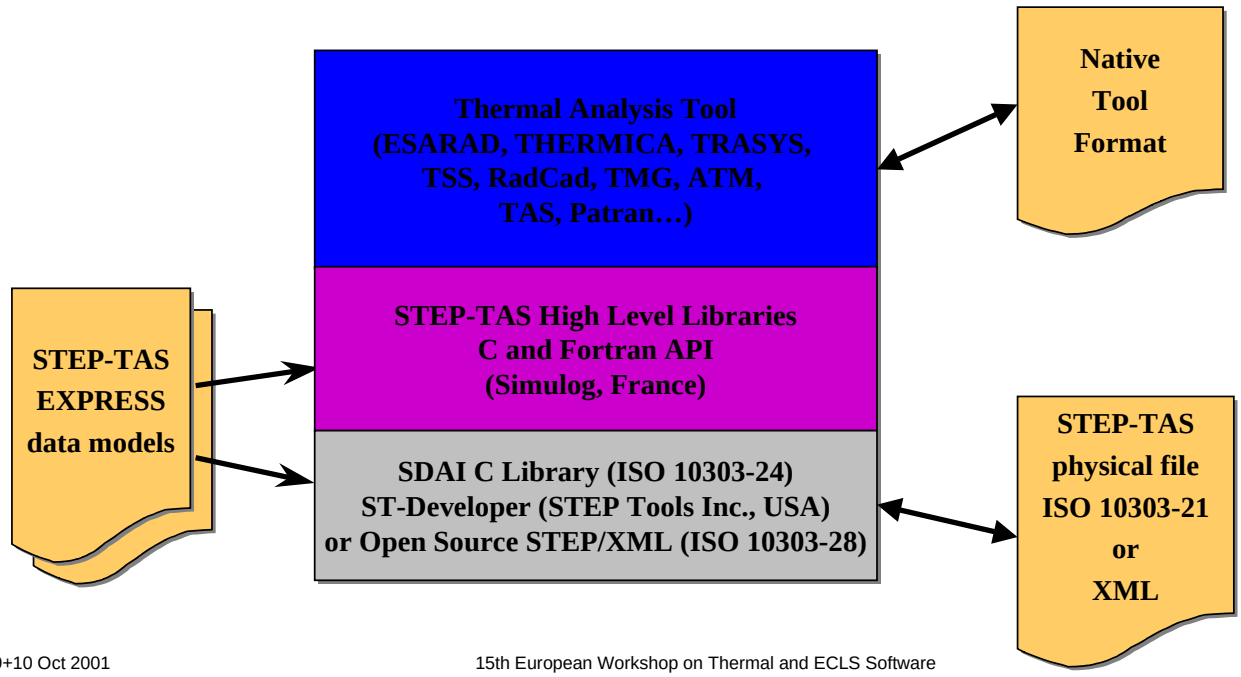
STEP-TAS Conformance Classes

	thermal-radiative model with basic geometry	kinematic model	constructive geometry	space mission aspects
CC-1	✓			
CC-2	✓	✓		
CC-3	✓		✓	
CC-4	✓	✓	✓	
CC-5	✓	✓		✓
CC-6	✓	✓	✓	✓

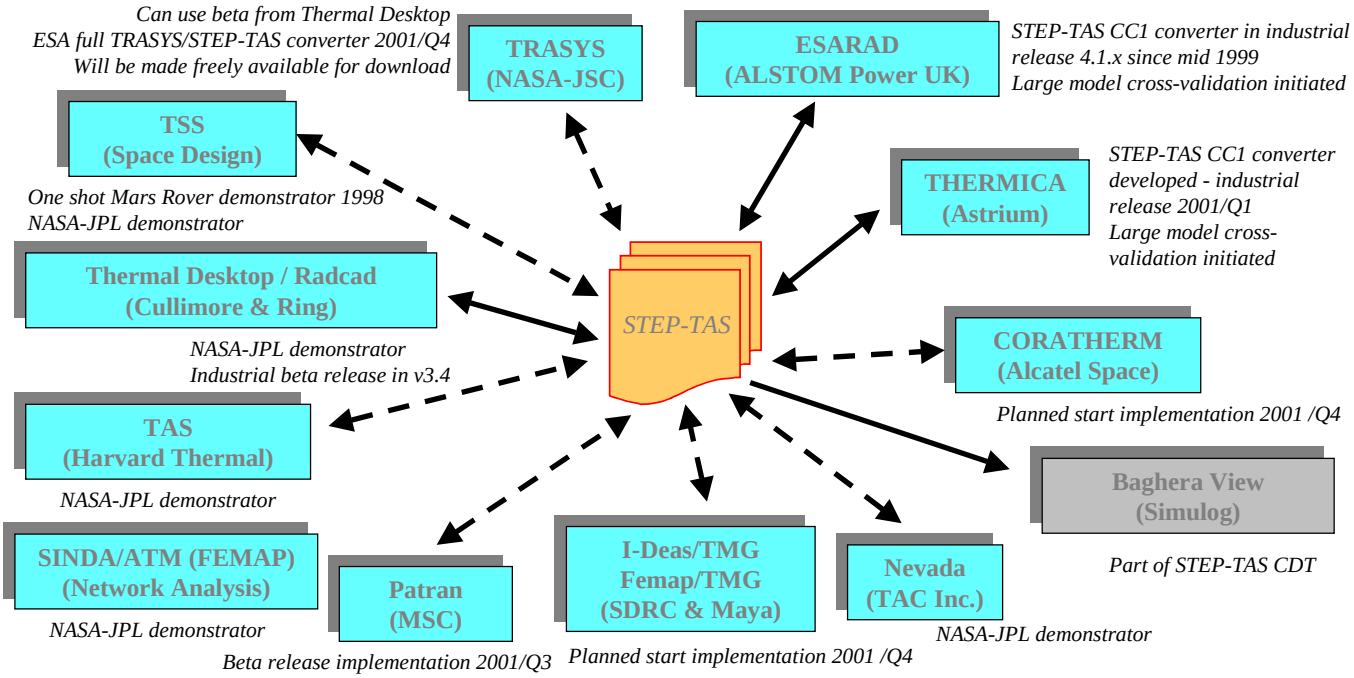
STEP-TAS CDT
Converter Development Toolkit
(developed by Simulog)

- Programming interface is close to thermal tools
  - hides STEP complexity
  - full set of reading/writing functions in ANSI-C and F77
  - full documentation, examples and test suite
  - Baghera-View to perform independent visual inspection
- Available to tool developers at nominal cost (from Simulog)
  - Platforms: Windows, Sun/Solaris, HP-UX, Compaq/Tru64, SGI/Irix
- Enables efficient converter implementation
  - Reduces validation / verification effort
  - All converters share reading/writing approach - increased reliability
- Extensibility at affordable cost - e.g. for HDF5 and XML

STEP-TAS Converter Architecture



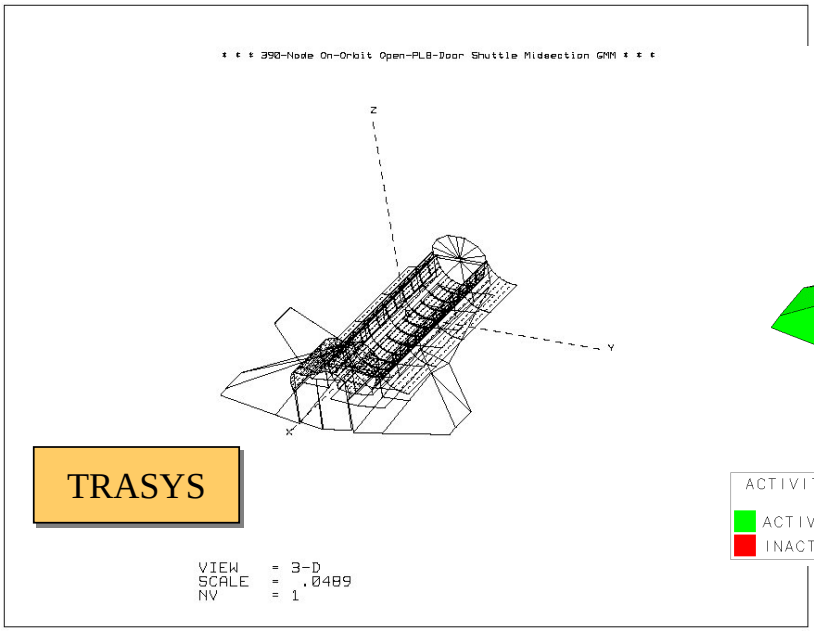
State of STEP-TAS implementations Sep 2001



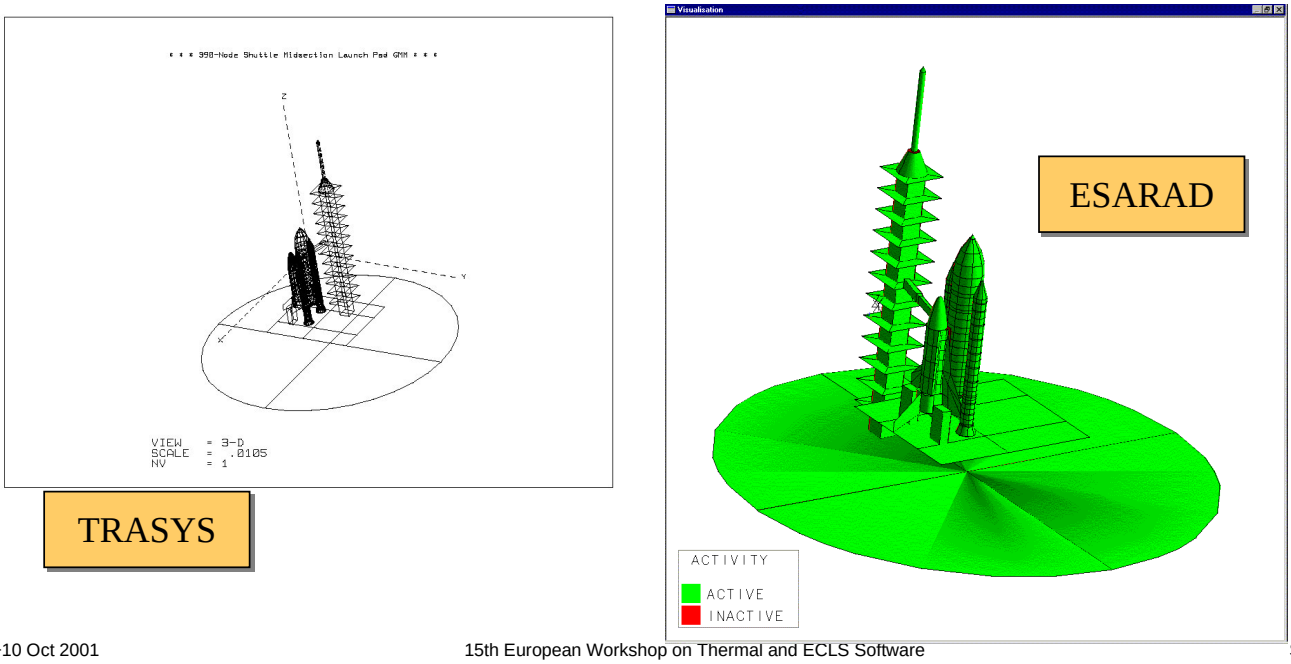
TRASYS/STEP-TAS and TRASYS/ESARAD converters

- Full stand-alone TRASYS / STEP-TAS CC1 converter
  - Development by Simulog started Jan-2001
  - Currently in beta testing / closing out phase
  - User option for English/SI unit conversion
- In parallel: TRASYS-to-ESARAD converter
  - Reference implementation by ESA (TOS-MCV) for independent validation of TRASYS/STEP-TAS converter
  - Supports break up of non-uniform meshes
  - Supports conversion of complex shapes (ogive, toroid, spheroid)
  - Full test suite
- Both will be made available at www.estec.esa.int/thermal
  - Free for download - target release November 2001

TRASYS/ESARAD converter
STS 390 Node Model - Open Doors



TRASYS/ESARAD converter
STS 390 Node Model - Closed Doors



Prototype SINDA-85 / ESATAN converter

- Developed at ESTEC
- Use: STS / ISS interface model conversion
- Currently Eng/SI unit conversion is being implemented
- Will be made available free of charge 2001/Q4

Road Ahead (1)

- Web-based collaboration on further development:
  STEP-TAS Implementors' Forum (start 2001/Q4)
  - ftp://ftp.estec.esa.nl/step-tas/index.html as a start
  - Will use sourceforge.net open source software development environment
    - distribution of documentation and code
    - bug tracking, configuration control, test suites
  - E-mail tech support
- Take European / US collaboration to a next stage
  - Action ESA and NASA together with Simulog
  - Clarify/establish intellectual property rights and support

Road Ahead (2)

- Trade-off for best 'Return on Investment' next 5 years
  - Appropriate level of formal publishing (ISO, ESA and NASA)
  - Much simplified exchange model (STEP-TAS ARM)
  - Most likely moving to XML physical file (STEP part 28)
  - Upgrade high level API to support all STEP-TAS constructs
    - e.g. submodelling, non-uniform meshing and node numbering
- Upgrade STEP-TAS CDT (planned 2001/Q4-2002/Q1)
  - Resolve all reported issues / bugs
  - Use open source software approach
  - Upgrade converter options (e.g. length unit selection / conversion)
- Complete test suite for large model cross-validation

Road Ahead (3)

- TRASYS/STEP-TAS-CC1 bi-directional converter
  - Stand-alone tool by Simulog on ESA funding
  - Will be made available freely
- Upgrade BagheraView capabilities
  - By Simulog sponsored by CNES
  - Release v1.3 beta ready Sep-2001 (now supports Windows 2000)
- Resume NRF developments
  - HDF5 binding (co-operation with EDF, NCSA and others)
  - ESATAN, SINDA/G, SINDA85 converters via STEP-NRF (with NASA)
  - Links with STEP Engineering Analysis modules - ISO 10303-50 series
  - Pilot web-based remote consultation of structural test results

Announcement

NASA/ESA Workshop
Aerospace Product Data Exchange based on Open Standards

- 9-12 April 2002, ESTEC, Noordwijk
- 3rd edition after 2 successful previous workshops at NASA-JPL
  - See step.jpl.nasa.gov for archive of previous presentations
- Domains: Engineering Analysis, CAD, PDM
- Standards: STEP/ISO 10303, XML/W3C, OMG, ECSS, NASA
- STEP AP 209 (FEM exchange) Seminar
- If interested send e-mail to Hans-Peter.de.Koning@esa.int

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  - Association GOSET (F)
  - Epsilon Ingénierie (F)
  - Alstom Power (UK)
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