Testing Thermal Geometric Model Exchanges with STEP-TAS

Georg Siebes and Robert Hughes
Jet Propulsion Laboratory
California Institute of Technology

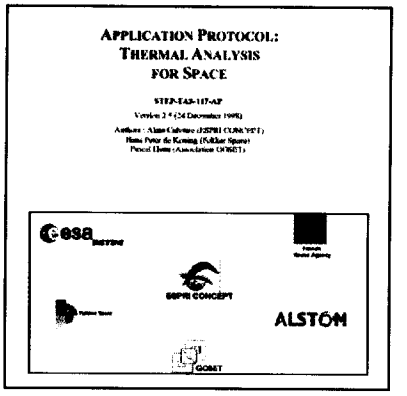
Aerospace PDE 2002
ESA/ESTEC
April 9-12, 2002

Outline

- What is STEP-TAS (Scope)
- What happened so far (Development)
- Where are we now (Implementation)
- Current Activity (Testing)
  - Test Purpose
  - Test Methodology
  - Test Results
- What's next (Do it again with STEP-NRF)

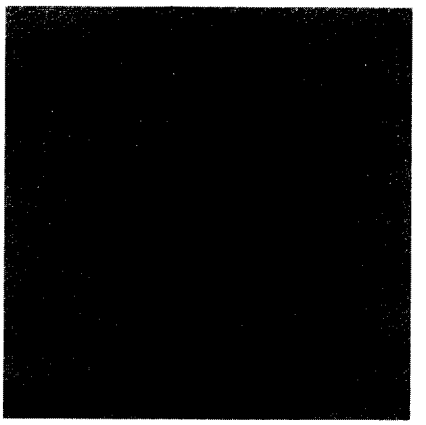
What is STEP-TAS

- STEP-TAS = Thermal Analysis for Space



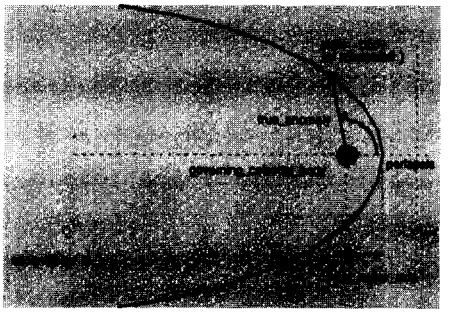
Application Protocol for space missions and models used in thermal analysis.

Details of STEP-TAS



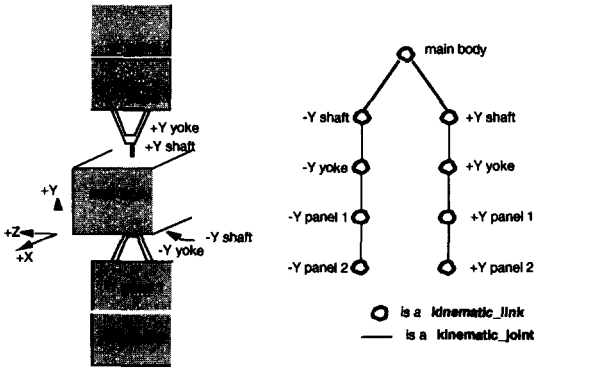
- Shapes
  - Primitives: triangle, rectangle, quadrilateral, disc, cylinder, cone, sphere, paraboloid
  - Compound shapes
  - Shapes conform to AP203 CC4 non-manifold surfaces
- Thermal-radiative model
  - associates thermal-radiative faces with surface shapes
  - thermal mesh
  - properties

Details of STEP-TAS



- 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

Details of STEP-TAS



(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

- Kinematic model conforms to STEP Part 105 for articulating rigid bodies (e.g. rotating solar arrays, gimballed antennas

The U.S. STEP-TAS Pilot - Participants

NASA

JPL

C&R Technologies®

cnes

SIMULOG

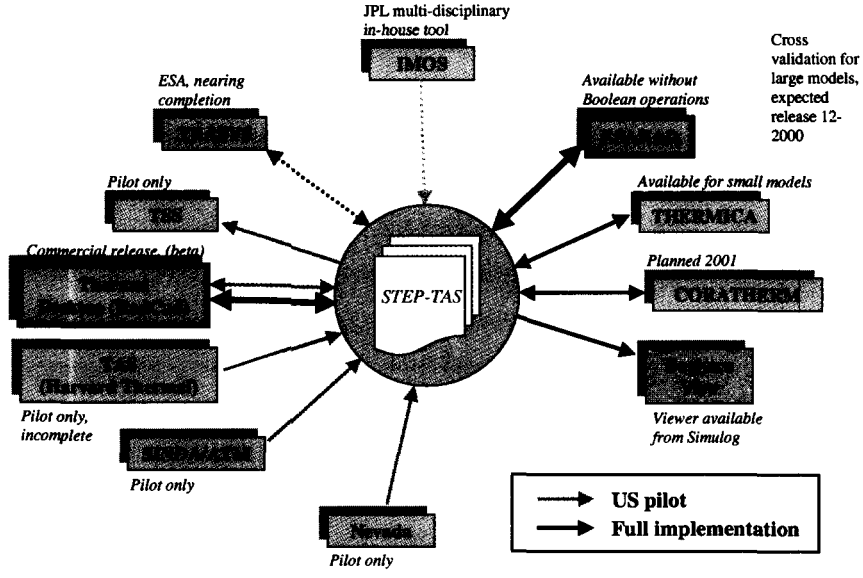
Live Demo at NASA TFAWS Conference

NASA Standard 2817

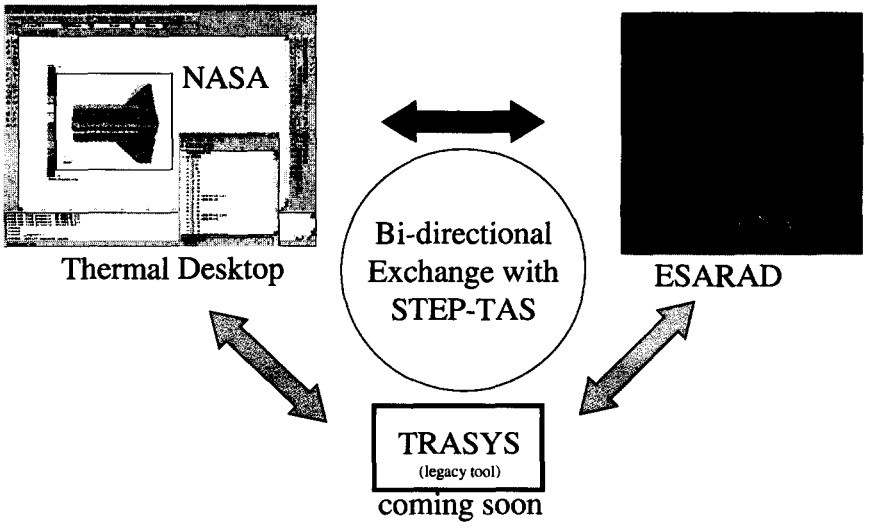
- The NASA CIO has officially approved and released NASA-STD-2817:

  COMPUTER-AIDED ENGINEERING, DESIGN AND MANUFACTURING DATA INTERCHANGE
- Minimum interoperability standard for CAE/CAD/CAM system at NASA.
- Requires compliance with interchange standards. Tools compliant with these standards must be available.
- Preferred standards include APs 203, 209, 210, 225, and 227 for exchanging data among PDM, mechanical and electronic CAD/CAM, civil and facilities CAD, and CAE/analysis systems.
- STEP-TAS is included in draft of next revision.

STEP-TAS Implementation - April 2002



Testing Commercial Implementation



11

Test Scope

- Purpose
  - Independent testing of STEP-TAS exchanges
  - Feedback to developers and implementers

Tools

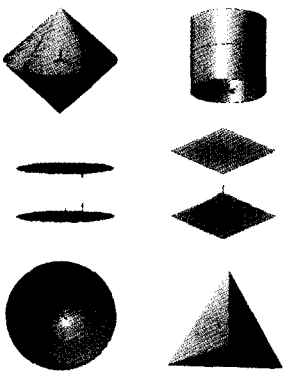
- ESARAD 4.3.3
- Thermal Desktop 4.4
- Baghera View 1.2.2
- Microsoft Windows NT

Test Methodology

- Exercise all possible permutations of exchange paths between two tools
  - ER
  - ER > STEP > ER
  - ER > STEP > TD > STEP > ER
  - ER > STEP > TD
  - TD
  - TD > STEP > TD
  - TD > STEP > ER
  - TD > STEP > ER > STEP > TD

Test Methodology

- Geometric Primitives (no sub-division)
  - Cones
  - Cylinders
  - Discs
  - Rectangles (squares)
  - Spheres
  - Triangles



  - (what about paraboloids and others?)

Test Methodology

- Geometry definition

Phase 1)	Created at origin, local Z axis up
Phase 2)	Created at (10,10,10), Z axis up
Phase 3)	Created at origin and rotated +90 deg around Y
Phase 4)	Translation (2,0,0) and rotated +90 deg around Y

Test Methodology

- Included
  - Geometry
- Did not include
  - Properties
  - Node numbers
  - Orbital definitions

Test Methodology

- Assessments
  - Appearance: Does STEP-TAS file imported into target tool look like original?
  - Areas: Do areas calculated by tools agree with analytical results?
  - Viewfactors: Do calculated viewfactors (approximately*) agree with analytical results?

* Small tolerance due to statistical nature of Monte-Carlo ray tracing technique, despite 10^6 rays

Test Results

Table 1: Areas (Cones, Cylinders, Disks, Rectangles)

		A_{cones}	$A_{cylinders}$	A_{disks}	$A_{rectangles}$
Analytical		4.442883	6.283185	3.141593	1.000000
Phase 1					
	E	4.4429	6.2832	3.1416	1.0000
	EsE	4.4429	6.2832	3.1416	1.0000
	EsT	4.4429	6.2832	3.1416	1.0000
	EsTsE	4.4429	6.2832	3.1416	1.0000
	T	4.4429	6.2832	3.1416	1.0000
	TsE	4.4429	6.2832	3.1416	1.0000
	TsEsT	4.4429	6.2832	3.1416	1.0000
	TsT	4.4429	6.2832	3.1416	1.0000
Phase 2					
	E	4.4429	6.2832	3.1416	1.0000
	EsT	4.4429	6.2832	3.1416	1.0000
	T	4.4429	6.2832	3.1416	1.0000
	TsE	4.4429	6.2832	3.1416	1.0000
Phase 3					
	E	4.4429	6.2832	3.1416	1.0000
	EsT	X	6.2832	3.1416	1.0000
	T	4.4429	6.2832	3.1416	1.0000
	TsE	X	6.2832	3.1416	1.0000
Phase 4					
	E	4.4429	6.2832	3.1416	1.0000
	EsT	X	6.2832	3.1416	1.0000
	T	4.4429	6.2832	3.1416	1.0000
	TsE	X	6.2832	3.1416	1.0000

Test Results

Table 5: Viewfactors (Disks)

		F_{1-2}	F_{2-1}
Analytical		0.381966	0.381966
Phase 1			
	E	0.381957	0.381957
	EsE	0.381958	0.381958
	EsT	0.38171	0.38171
	EsTs	0.381958	0.381958
E	T	0.38171	0.38171
	TsE	0.381657	0.381657
	TsEs	0.38171	0.38171
T	TsT	0.38171	0.38171
Phase 2			
	E	0.382356	0.382356
	EsT	0.38171	0.38171
	T	0.38171	0.38171
	TsE	0.381854	0.381854
Phase 3			
	E	0.382356	0.382356
	EsT	0.38205	0.38205
	T	0.38171	0.38171
	TsE	0.381854	0.381854
Phase 4			
	E	0.381854	0.381854
	EsT	0.38205	0.38205
T		0.38171	0.38171
	TsE	0.381854	0.381854

Test Results

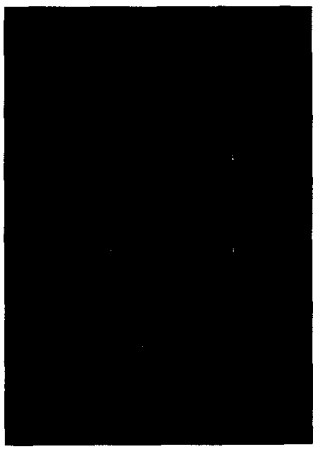
- Phase 1
  - Exporting cones from Thermal Desktop. One cone was missing in STEP-TAS file.
  - Using a different definition of TD's conical frustrum (base down instead of up) solved the problem.
- Phase 2
  - Same a phase 1

Test Results

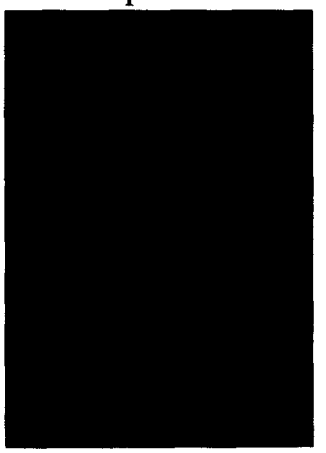
- Phase 3
  - Problems with spheres and cones.
  - Problems occurred regardless in which tool the geometry was created.
  - Have not found an alternate way to circumvent the problem.
- Phase 4
  - Same as phase 3

Test Results

As created in ESARAD



After export to STEP



Indices of cylinder surfaces reversed in translation

Test Results

- What did work
  - Cylinders
  - Discs
  - Rectangles (squares)
  - Triangles
- That's 4 out of 6

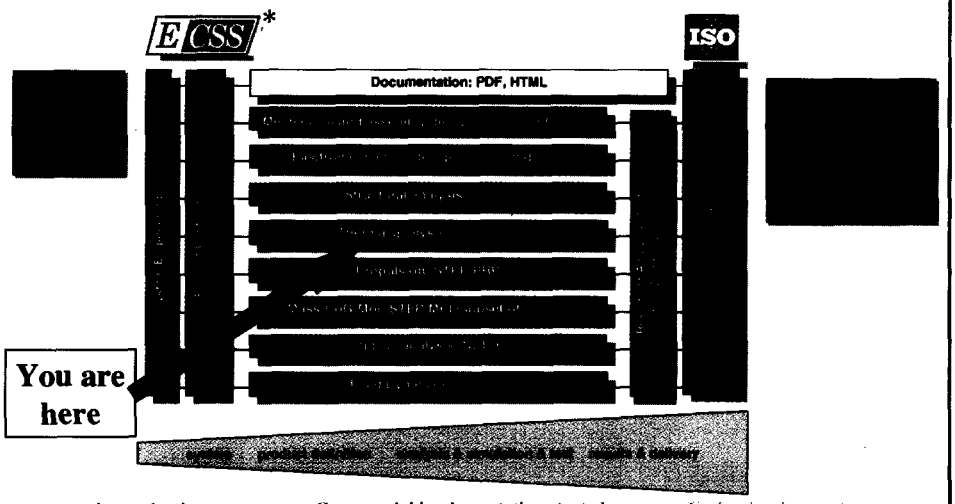
What's next

- STEP-TAS
  - Identify cause of cone and sphere issues
  - Update high level libraries and tool implementation
  - Release, use, listen to user feedback
  - Expand and Improve, e.g., include orbital definition in libraries, or add surface types
  - Get more (US) vendors involved

What's next

- Beyond STEP-TAS
  - Capability to share results: STEP-NRF, EAR, HDF5

What's next: The BIG Picture



In production use — Commercial implementation started — Under development

*European Cooperation for Space Standardization

Conclusions

- STEP-TAS testing confirmed that the schema works well overall and identified specific areas for correction
- APIs provide a good way to control the schema implementation by vendors
- Implementation is as good as the APIs
- Quality API's and responsiveness to requests for 'bug' fixes are crucial
- STEP-TAS is there to stay

Contact Information

Robert W. Hughes
Jet Propulsion Laboratory
Mail Stop 125-109
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91109
USA
Phone: +1 818 393-0762
Fax: +1 818 393-6682
E-mail: Robert.W.Hughes@jpl.nasa.gov

Georg Siebes
Jet Propulsion Laboratory
Mail Stop 125-109
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91109
USA
Phone: +1 818 354-8553
Fax: +1 818 393-1633
E-mail: Georg.Siebes@jpl.nasa.gov