



Testing Thermal Geometric Model Exchanges with STEP-TAS

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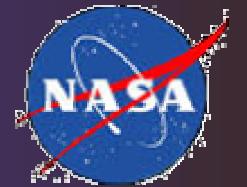
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Outline



- What is STEP-TAS
- Background
- Status
- Test Activity
 - Purpose
 - Methodology
 - Results
- What's next

What is STEP-TAS

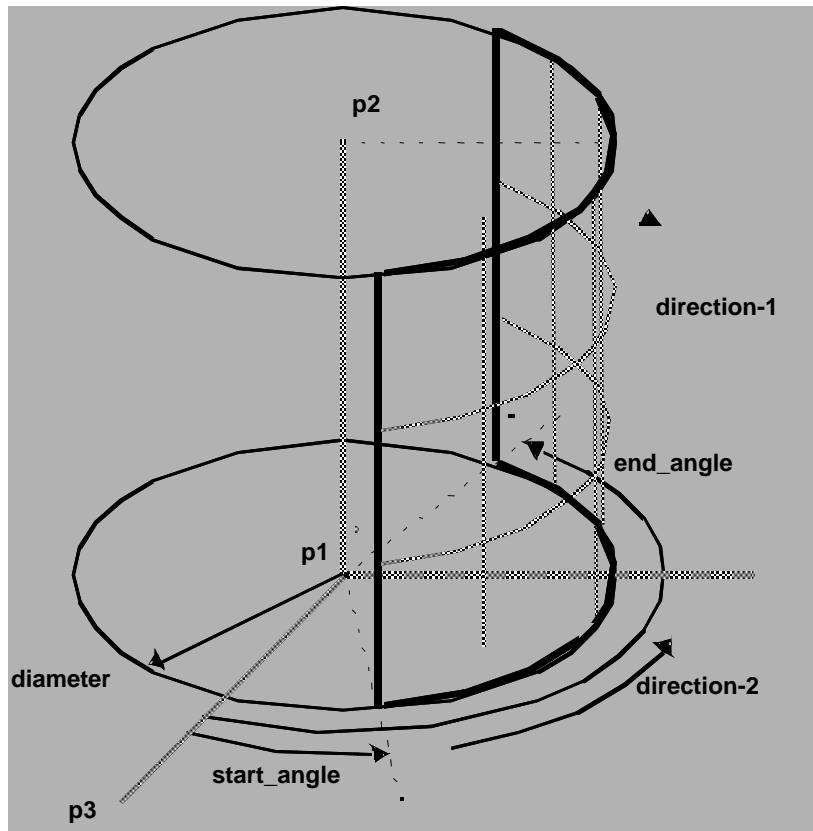


- STEP-TAS = Thermal Analysis for Space



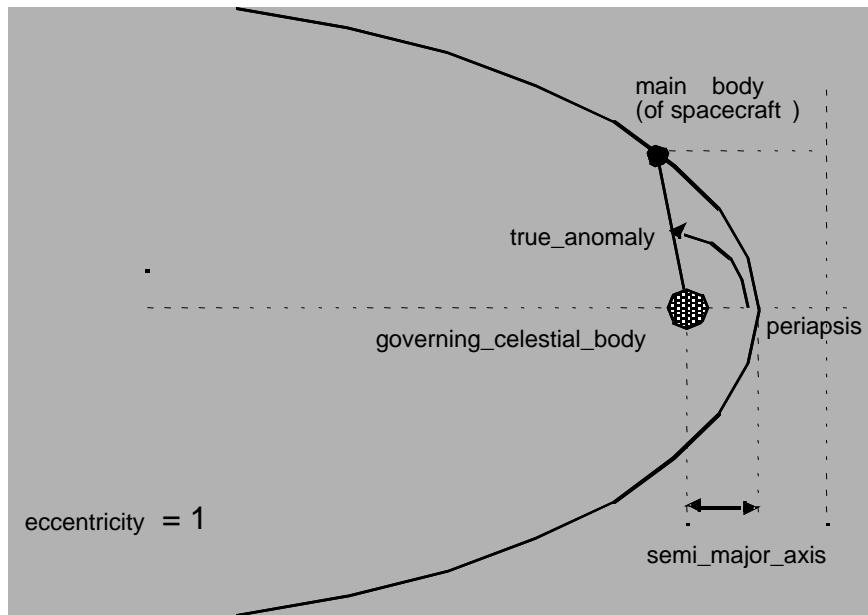
Application
Protocol for space
missions and
models used in
thermal analysis.

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

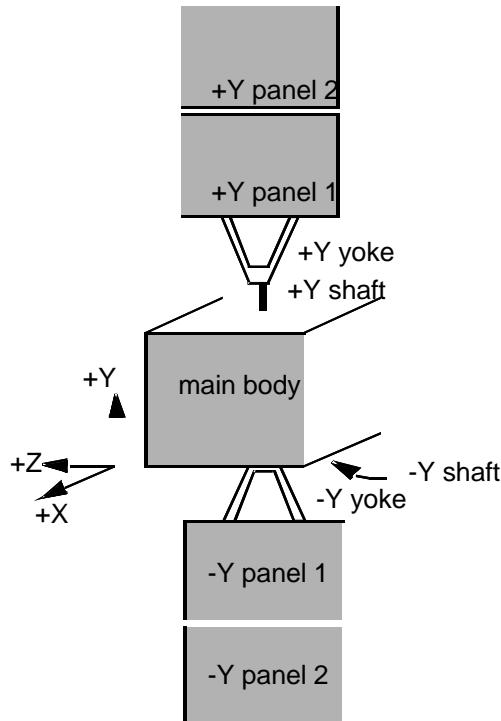
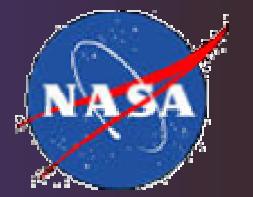
Details of STEP-TAS



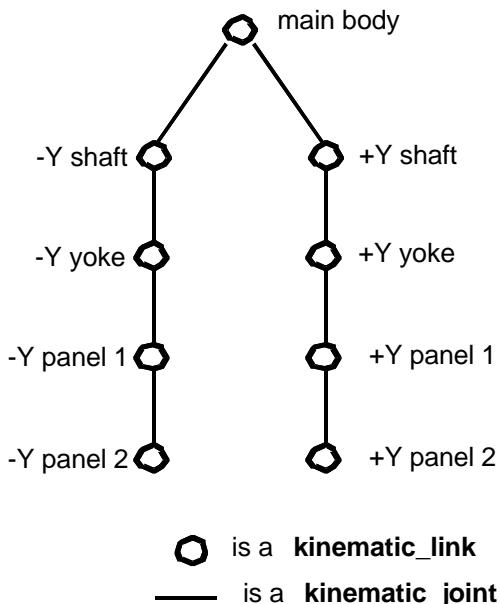
- Space mission aspects*
 - orbit arc (Keplerian and discrete ephemeris)
 - space co-ordinate system, celestial bodies
 - orientation, general and named pointing, spinning, linear rotation rates
 - space thermal environment, including constant or lat/long dependent albedo / planetshine tables

*not incorporated in high level libraries

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)



US STEP-TAS Pilot



JPL

eesa
ESTEC

CR C&R Technologies®



SpaceDesign



SIMULOG



HARVARD THERMAL
Thermal Modeling Software
Thermal Consulting and Engineering Services

Live Demo at NASA TFAWS



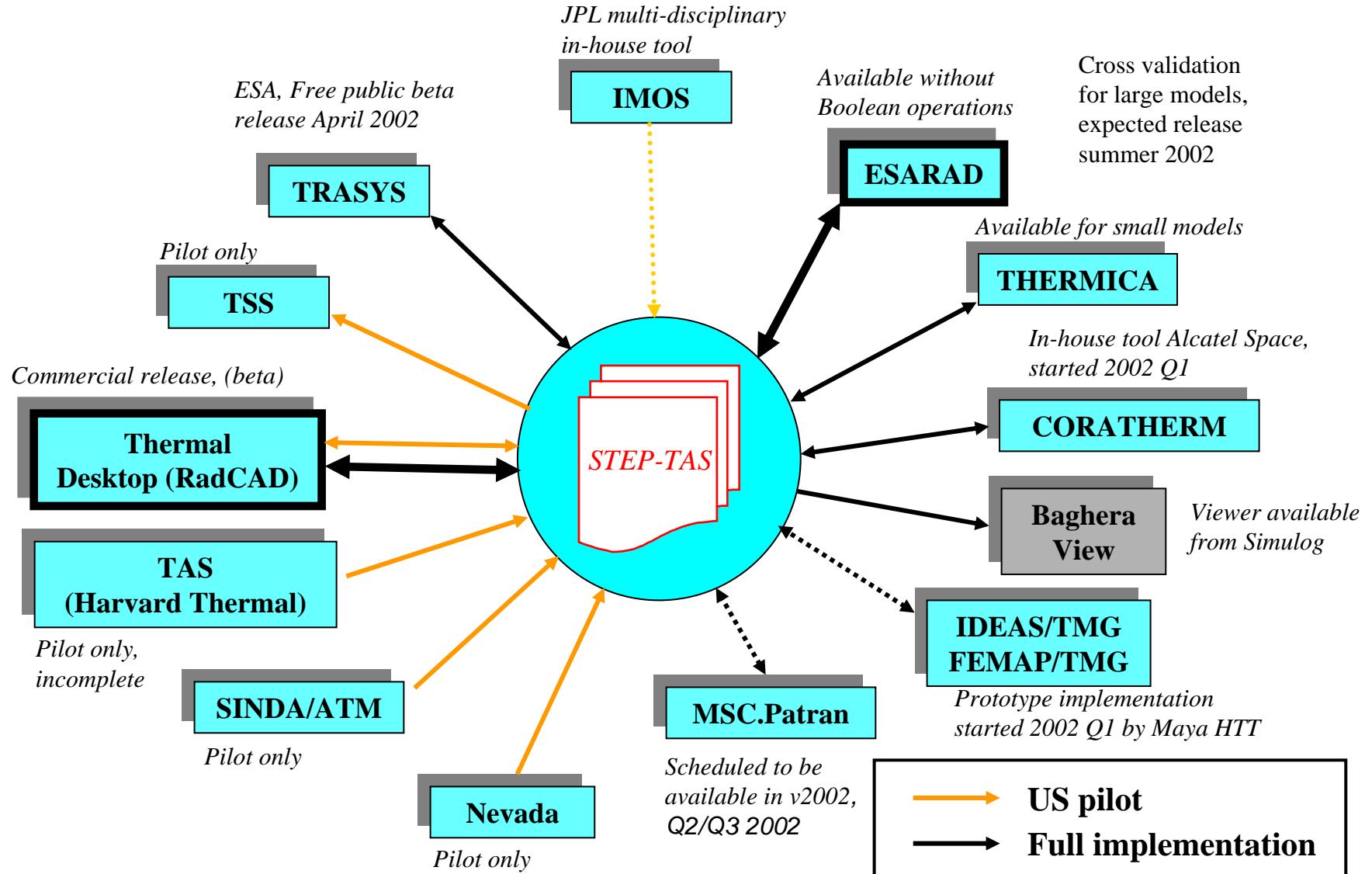


- The NASA CIO has officially approved and released NASA-STD-2817:

COMPUTER-AIDED ENGINEERING, DESIGN AND MANUFACTURING DATA INTERCHANGE

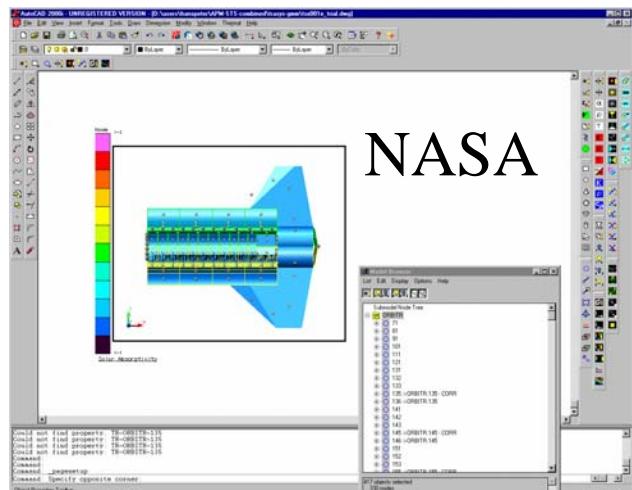
- Minimum interoperability standard for CAE/CAD/CAM system at NASA.
- Requires compliance with interchange standards. Tools compliant with these standards must be available.
- Preferred standards include APs 203, 209, 210, 225, and 227 for exchanging data among PDM, mechanical and electronic CAD/CAM,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

STEP-TAS Implementation



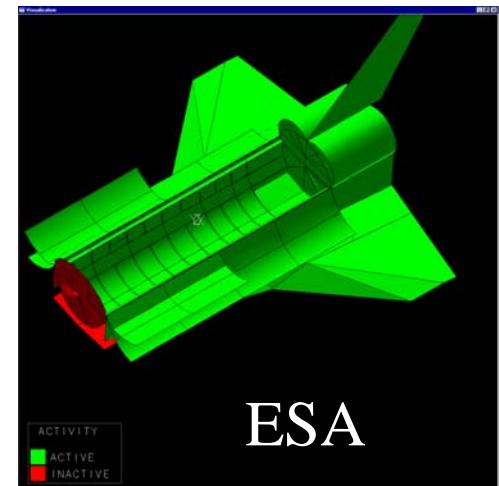
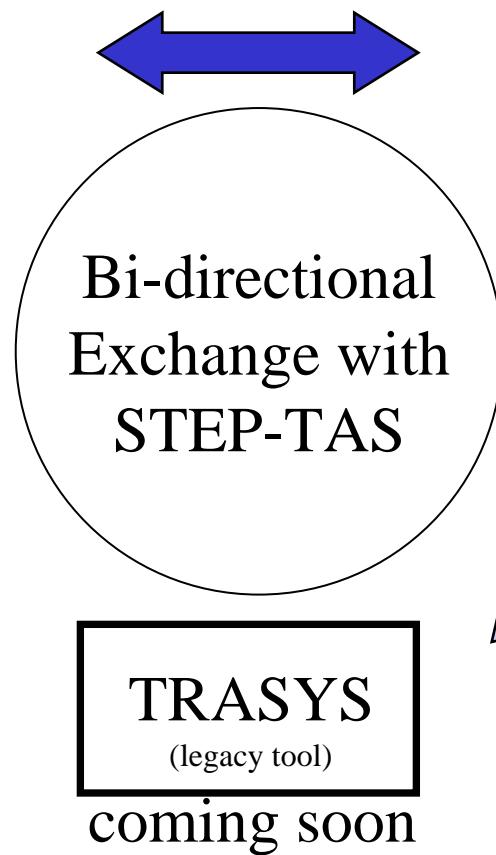


NASA/ESA Exchanges



NASA

Thermal Desktop



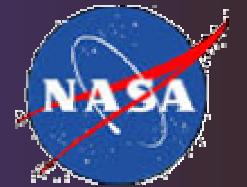
ESA

ESARAD

Test Scope



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



	WIN NT	WIN 2000
ESARAD 4.3.3	✓	
Baghera View 1.2.2	✓	
Thermal Desktop 4.4		✓

Test Methodology



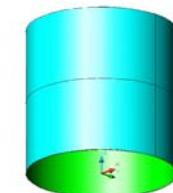
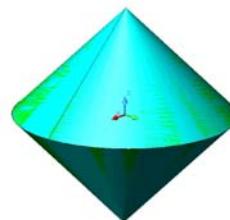
- Exercise all possible permutations of exchange paths between two tools
 - ER
 - ER > STEP > ER
 - ER > STEP > TD
 - ER > STEP > TD > STEP > ER

 - TD
 - TD > STEP > TD
 - TD > STEP > ER
 - TD > STEP > ER > STEP > TD

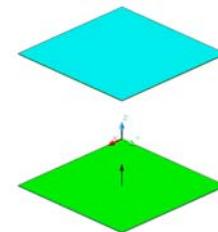
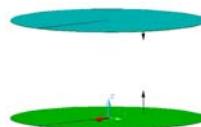


- Geometric Primitives

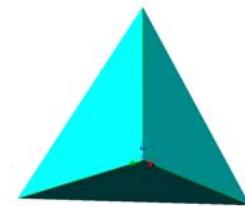
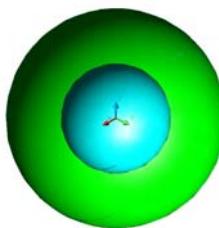
- Cones
 - Cylinders



- Discs
 - Rectangles (squares)



- Spheres
 - Triangles





- 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



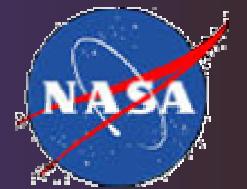
- Included
 - Geometry
- Did not include
 - Properties
 - Node numbers
 - Orbital definitions



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

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

Test Results



- Phase 1 (Created at origin, local Z axis up)
 - Exporting cones from Thermal Desktop. One cone was missing in STEP-TAS file.
 - Using a different definition of TD's conical frustum (base down instead of up) solved the problem.
- Phase 2 (Created at (10,10,10), Z axis up)
 - Same findings as for phase 1

Test Results



- Phase 3 (Created at origin and rotated +90 deg around Y)
 - 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 (Translation (2,0,0) and rotated +90 deg around Y)
 - Same findings as for phase 3

Sample Test Results, Areas



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

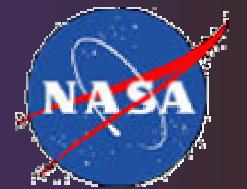
X = problem case

Sample Test Results, Viewfactors

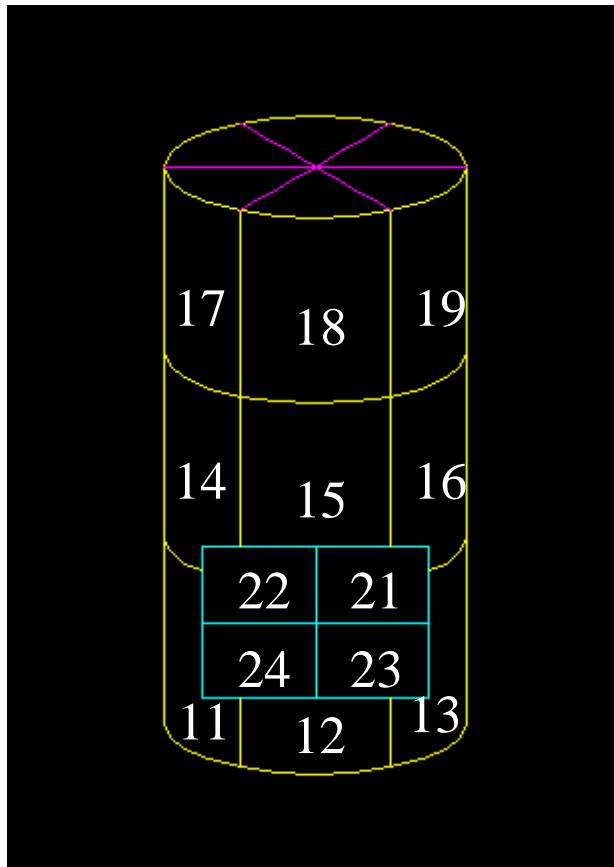


Viewfactors (Disks)		
	F_{1-2}	F_{2-1}
Analytical	0.381966	0.381966
Phase 1		
E	0.381957	0.381957
EsE	0.381958	0.381958
EsT	0.38171	0.38171
EsTs	0.381958	0.381958
E	0.38171	0.38171
TsE	0.381657	0.381657
TsEs	0.38171	0.38171
T	TsT	0.38171
Phase 2		
E	0.382356	0.382356
EsT	0.38171	0.38171
T	0.38171	0.38171
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

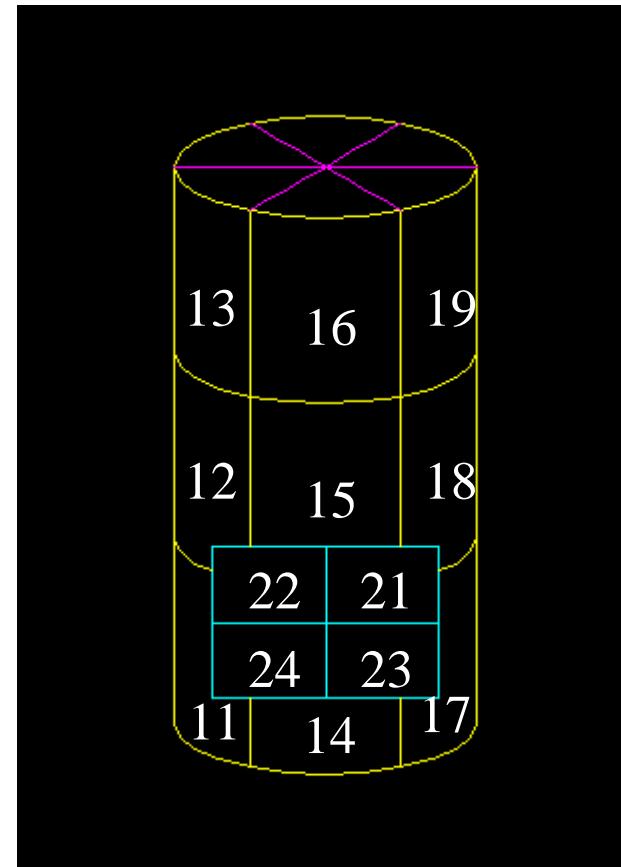
Test Results



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
- What didn't work
 - Cylinders, when rotated
 - Spheres, when rotated



- STEP-TAS

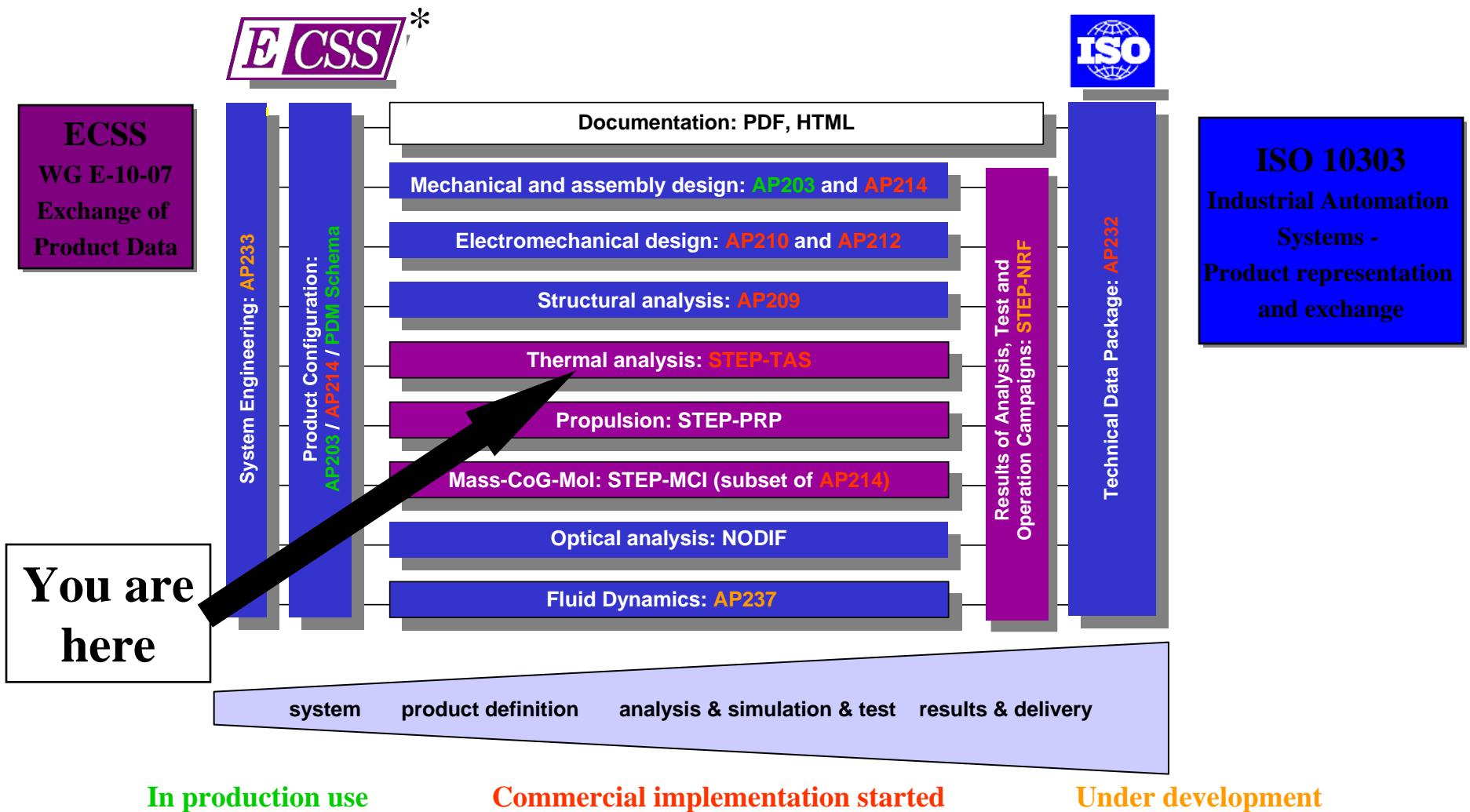
- Identify cause of cone and sphere issues
- Update high level libraries and tool implementation
- Release, use, listen to user feedback
- Expand and improve, e.g., include orbital definition in libraries, or add surface types
- Get more (US) vendors involved

What's next



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

What's next: The BIG Picture



*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
- Quality APIs and responsiveness to requests for ‘bug’ fixes are crucial
- 5 completed STEP-TAS implementations and 2 more under development. This is more than any other STEP standard except AP 203
- STEP-TAS is there to stay

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