USE OF TSS AS A NEUTRAL FORMAT FOR GEOMETRY MODEL CONVERSIONS: AN ALTERNATIVE TO STEP-TAS

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Outline

- **Background and Introduction**
- **Common Thermal Radiation Analysis Codes**
- **Geometry Conversion Characteristics**
- **Examples of Model Conversions performed by Swales**
  - **Details of obstacles overcome**
- **Conclusions and Future Plans**

Background

- Many thermal radiation analysis codes available in U.S.
  - Not all companies use the same analysis codes
  - International organizations may use additional codes
  - May require model conversion between formats
- All thermal subsystems must be analyzed together using one analysis code
- Two neutral formats proposed for geometric radiation model conversion
  - SET-ATS and STEP-TAS
    - Little acceptance in U.S
  - U.S. codes import/export TRASYS
- Neutral format generally agreed to the best approach for model conversion
- Specific format to use for neutral format not well established

Introduction

- STEP-TAS under development by NASA/ESA as a neutral format
  - After number of years, not reached maturity
  - No industry standard exists
- A neutral format (in general) should support the characteristics and features of a majority of similar codes.
- Thermal Radiation Analysis Codes require the following defining characteristics:
  - Base set of Primitive Shapes
  - Sizes and locations in 3D space
  - Optical Property Representation
  - Nodal Representation
- TSS can replicate surfaces from most other codes
- TSS is a viable neutral format

Available Radiation Analysis Codes

• **Common thermal radiation analyzers include:**

Code	Developed By	Distributed By	Output Format	Comments
TSS	NASA	SpaceDesign	ASCII	
ESARAD	Alstom	Alstom	ASCII	ESA standard
Thermica	Matra Marconi (now Astrium)	Astrium Network Analysis	ASCII	Network Analysis is U.S. distributor for Thermica
Thermal Desktop	Cullimore & Ring	Cullimore & Ring	Compr, Binary	Unable to access surface data in AutoCad DWG
TMG	MAYA HTT	MAYA HTT	ASCII	Revolved surfaces not yet supported
TRASYS	NASA	NASA	ASCII	Declining usage

Available Converters

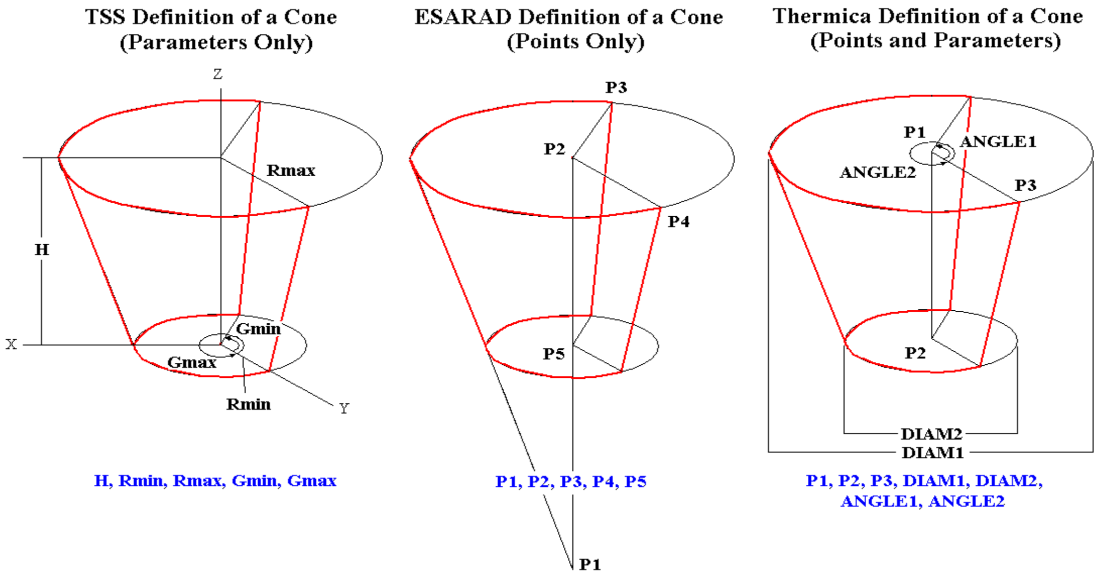
• **Import/Export Capabilities of codes**

Code	Imports	Exports	Primary User
TSS	TRASYS	TRASYS	United States
ESARAD	SET-ATS, STEP-TAS	SET-ATS, STEP-TAS	Europe
Thermica	SET-ATS, STEP-TAS	SET-ATS, STEP-TAS	Europe
Thermal Desktop	TSS, TRASYS, STEP-TAS	TSS, TRASYS, STEP-TAS	United States
TMG	TSS	TSS, TRASYS	United States
TRASYS	None	None	United States

Geometry Conversion

- No simple way to convert between U.S. and European based codes
- Three major aspects must be considered for geometry model conversion
  - Geometric Representations and Shapes
  - Optical Property Representation
  - Nodalization and Active Sides for Thermal Math Models
- Swales Aerospace developed computer routines in Visual Basic to convert between TSS and (Thermica or ESARAD)
  - These routines used with great success on the MetOp, SECCHI, EOS-Aura, and EIS projects

Geometry Representation



- Each code has its own method for defining objects.
  - Series of parameters (e.g. trx, rot1, xmin)
  - Series of specific points (e.g. 4 corners of a quadrilateral)
  - Hybrid of the above two methods, using 3 points to define an orientation and parameters to define dimensions and sizes

Geometric Shapes

- Not all codes include the same base set of primitive shapes
- The table below provides a listing of some of the more common shapes, which codes support them, and how they are represented

Type	TSS	ESARAD	Thermica	Thermal Desktop	TMG
Rectangles	Params	Pts or Params	Pts	Pts and Params	Pts
Triangle	Pts	Pts	Pts	Not Available*	Pts
Disc	Params	Pts or Params	Pts and Params	Pts and Params	Not Available
Cylinder	Params	Pts or Params	Pts and Params	Pts and Params	Not Available
Cone	Params	Pts or Params	Pts and Params	Pts and Params	Not Available
Quad	Pts	Pts or Params	Pts	Not Available*	Pts
Polygon	Pts	Not Available	Not Available	Pts	Not Available
Ellipse	Params	Not Available	Pts and Params	Pts and Params	Not Available
Paraboloid	Params	Pts or Params	Pts and Params	Pts and Params	Not Available
Sphere	Params	Pts or Params	Pts and Params	Pts and Params	Not Available
Box	Params	Pts or Params	Params	Not Available	Pts

Optical Properties and Nodalization

- Specular optical properties
  - Simulate the physical behavior of radiation
- Active sides – only active surfaces participate in radiation exchange
  - May be front, back or both sides of surface
  - Each radiating surface referenced by thermal node number
  - Each active side may be further subdivided into smaller sub-sufaces, which in turn may have different nodes
- Exceptions
  - Thermica and TRASYS do not allow different nodes on the front and back sides of a surface.
  - TRASYS requires MODPR command to implement different properties on opposite sides of surface
  - TRASYS does not perform specular radiation analysis
- Node Numbering of subdivide surface
  - Thermica and ESARAD follow (Starting Number, Increment) pattern
  - TSS full control over subdivision node numbers, single submodel
  - TRASYS uses the Correspondence Data block for node numbers

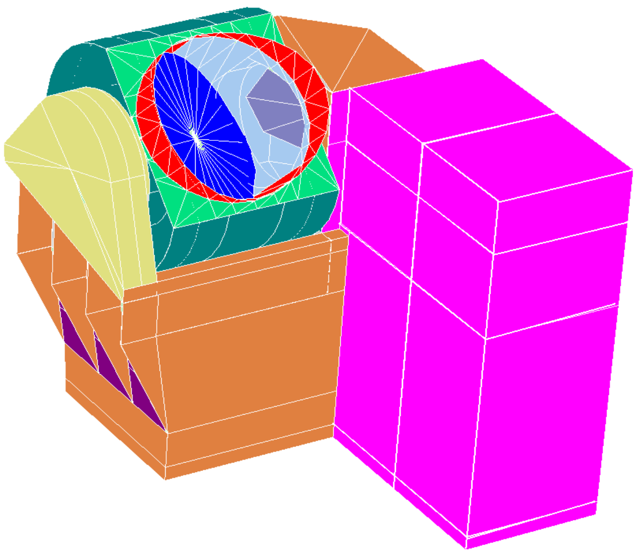
Examples

- Routines were developed for several Projects.
  - MetOp
  - SECCHI
  - EOS-Aura
  - EIS
- Each of the aforementioned projects has required partnership with a foreign company or organization and using software not commonly found in the United States
  - For each of these, Swales developed algorithms in Visual Basic to convert the model to or from the foreign software
  - These routines were written to be useful beyond the scope of the project for which they were developed
  - A number of inconsistencies between the European software (ESARAD and Thermica) and TSS were encountered and resolved. These are discussed with respect to the project to which they pertain

MetOp

MetOp is a European Meteorological satellite with seven instruments supplied by NOAA/NASA. The contract required all model deliveries be in ESARAD. Given the number of models and the predicted frequency of updates, it was considered worthwhile to automate this process.

- The detailed AMSU-A2 instrument is depicted to the right to show the relative complexity of the models.
- A routine was first developed to process a TSS file and transform and create the ESARAD points in the global coordinate system.
- A number of inconsistencies between ESARAD and TSS were solved to make the final conversion possible.



MetOp

- The table below lists some of the discrepancies encountered between the two formats.
- The routine automatically handles these inconsistencies with the exception of splitting an ellipse. (This option must be specified by the user.)

Feature	TSS	ESARAD	Workaround
Ellipse Entity Type	Yes	No	Polar Array of triangles
Non-sequential node numbering	Yes	No	Creation of separate entities
Non-uniform nodalization	Yes	No	Creation of separate entities
Optical Properties defined in same file as geometry	No	Yes	Create optics within output file
Variable length units	Yes	No	Convert all sizes to user defined units
Box Entity is one node	Yes	No	Assign node increment of zero
Node Label as surface property	No	Yes	Uses TSS entity name

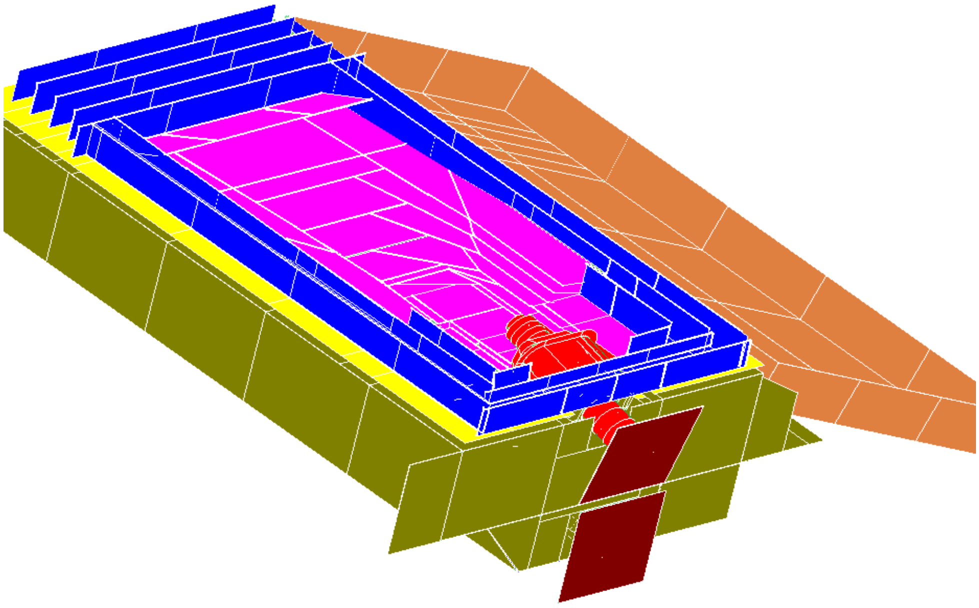
MetOp

- The ESARAD visualization tool was temporarily not functional.
  - A converter was written to convert the ESARAD spacecraft model to TSS in order to view the model.
  - Again, discrepancies were encountered and resolved.

Feature	ESARAD	TSS	Workaround
Cutting operations supported	Yes	No	Cutting entities created for reference
Copy operations supported	Yes	No	Create new entity by copying base entity
Update of entity properties after entity definition	Yes	No	Search through model tree and modify property
External submodels and/or files may be included in top level model	Yes	No	Insert entities from submodel at proper location
Extensive use of variables allowed	Yes	No	Storage of variables and values and evaluation of expressions

SECCHI and EOS-Aura

The SECCHI and EOS-Aura projects both had models submitted in Thermica that needed to be converted to TSS for further submission to the spacecraft contractor and internal use. The SECCHI model is depicted below.



SECCHI and EOS-Aura

- **Discrepancies were again encountered and resolved.**
- **It was difficult to verify the conversion since Swales does not have a copy of Thermica and could not view the original model.**
- **A verified model was produced in conjunction with help from the US distributor of Thermica**

Feature	Thermica	TSS	Workaround
Non hierarchical order of entity input	Yes	No	Re-sort entities by object identifier
Multiple surfaces assigned to single entity	Yes	No	Create assembly containing surfaces
ANGLE1 allowed to be greater than ANGLE2 (i.e. Min > Max)	Yes	No	Add 360° to ANGLE2
Node numbering may be clockwise or counterclock-wise for revolved surfaces	Yes	No	Define node_ids appropriately (not yet implemented)
Extensive use of variables allowed	Yes	No	Storage of variables and values and evaluation of expressions
Optical Properties defined in geometry file	Yes & No	No	Both methods of property definition read and output to single optics file

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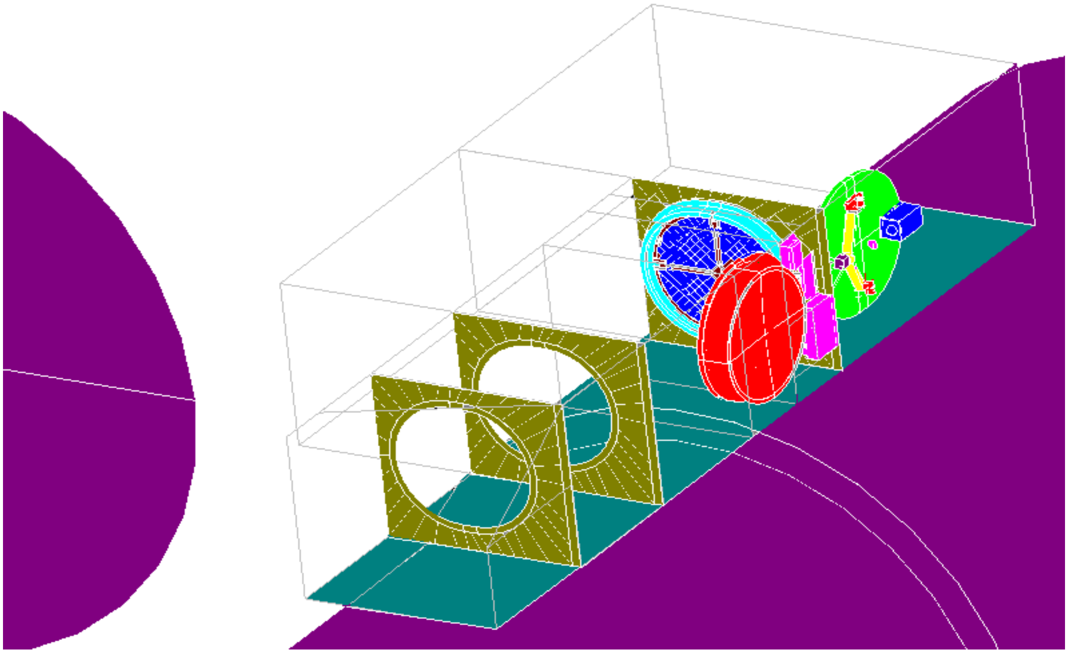
The Clamshell Door model (depicted below) was created in TSS. Delivery of the model to the University of Birmingham was required in Thermica, requiring conversion from TSS to Thermica.



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- **This conversion presented a unique challenge**
  - **Swales does not have a method of previewing the converted file, since Thermica is not available at Swales**
  - **To verify the conversion, the converted Thermica file was reconverted and viewed in TSS to judge the conversion success**
  - **A valid Thermica model was produced after subsequent iterations with University of Birmingham. The discrepancies encountered are listed below**

Feature	TSS	Thermica	Workaround
Non-sequential node numbering	Yes	No	Creation of separate entities
Non-uniform nodalization	Yes	No	Creation of separate entities
Optical Properties defined in same file as geometry	No	Yes & No	All properties written to geometry file
Variable length units	Yes	No	Convert all dimensions to user specified units
Double Sided surfaces (2 nodes)	Yes	No	Creation of two surfaces with small gap

Conclusions

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- Less time spent converting models means quicker delivery of models to contractors.
- Future model conversions will benefit from the effort already expended to develop these routines.
- Time spent to develop the routines is judged to be less than estimated manual efforts.
- The necessity of model conversion is growing with the introduction of more analysis codes and more frequent international cooperative projects.
  - Smaller models could be converted manually with a minimum time impact.
  - Models will continue to grow in size and complexity making manual conversion impractical.
- Development of a new neutral format is unnecessary, since TSS provides all the flexibility needed to handle models from the majority of codes.

Future Plans

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- These routines were recently developed and will continue to grow
- Eventually, any format could be loaded and stored as if it were a TSS model
- Data can be written to any desired output format
- These capabilities can also be broadened to develop utilities to interface with geometry models. Swales has already developed tools to:
  - Modify optical property names and remove unused properties
  - Output useful property information for each entity to a table
  - Add instrument specific prefixes to entity names to prevent conflicts when integrating multiple instruments
- These routines will continue to evolve in order to improve our efficiency and provide the best service to our customers