Appendix L

Thermal Concept Design Tool
Future developments and TCS Projects

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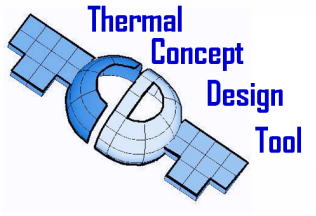
Abstract

The TCDT is in the 6th year of distribution and maintenance. During this period the tool has evolved both according to the improvements required by the users and the enhancements included in the development plan in the frame of the maintenance contract.
The TCDT version 1.5.1, already developed and delivered to the European Thermal Community can be used on Office 2010 systems.
The new version 1.6.0 is foreseen for the first quarter of next year with some improvements:

- Flux calculation for TCDT model,
- Orbits Chains Definition

The engineers can easily use TCDT models of older versions thanks to the automatic converter provided by the 1.6.0 version.
During the 6th year of distribution some TCS projects has been developed with the use of TCDT, a short description will be provided during the presentation.

Thermal Concept Design Tool
Future developments and TCS Projects



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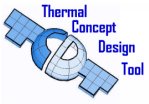

Overview

- **Background**
- **Version 1.5.1 Improvements**
- **Version 1.6.0 Improvements**
- **Maintenance Activity**
- **Modeling with TCDT**

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Background

6° YEAR OF DISTRIBUTION & MAINTENANCE STARTED APRIL 2012

- TCDT is distributed FREE of CHARGE to the European Thermal Community
- TCDT web pages available for download, PR, FR
- TCDT is regularly maintained by BLUE
- Small developments are regularly implemented to improve operability
- TCDT version 1.5.1 will be available before the end of 2012
- TCDT version 1.6.0 will be available on the first quarter of 2013

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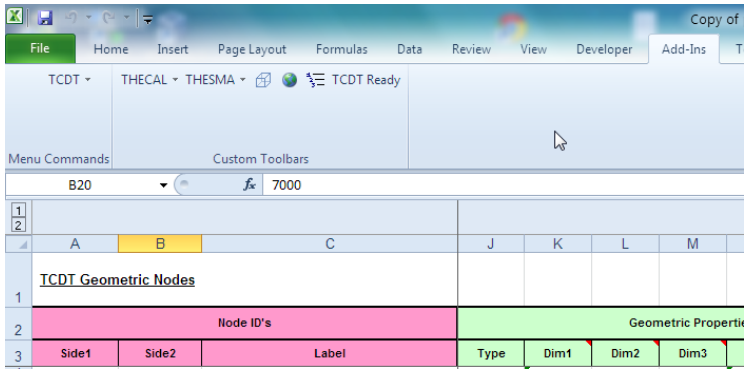
TCDT 1.5.1 Improvements

The new 1.5.1 version will be compatible with Excel 2010 and Windows 7.



Compatibility test on Windows server 2008 is under evaluation at ESA

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TCDT 1.6.0 Improvements

- Orbit Arcs Definition
- Chained Orbits
- Simplified Fluxes calculator for geometric model
- Version Converter Updated to 1.6.0

TCDT Improvements (1/8)

Mission Definition : Orbit Arcs

TCDT Mission:

Orbit Name :	Orbit1	Orbit2	Chain1
Sun/Planet Parameters :			**Chain**
Planet radius (km)	6371	6371	Orbit1
Planet-Sun distance (10^6 km)	149.6	149.6	1
Planet temperature (K)	288	288	TRUE
Albedo factor [<1]	0.3	0.3	Orbit2
Gravitational acceleration (m/s2)	9.80655	9.80655	1
Solar declination (deg)	0	0	TRUE
Sun radius (km)	696000	696000	
Sun temperature (K)	5770	5770	
Sun gc (m/s2)	274	274	
Thermal Environment			
Solar constant override flag	Overriden	Overriden	
override value (W/m2)	1360	1360	
Orbital Parameters :			
Orbit Centre	PLANET_CENTRED	PLANET_CENTRED	
Inclination (deg)	0	0	
Argument of periapsis (deg)	0	0	
Altitude of periapsis (km)	800	800	
Altitude of apoapsis (km)	800	5600	
Ascending node(deg)	0	180	
TOPIC epoc :	12:00:00 AM	12:00:00 AM	
Calculation Parameters			
Nr. of orbital positions	8	8	
Include eclipse entry/exit positions	No	No	
Offset (deg)	0.5	0.5	
Initial True Anomaly	0	0	
Final True Anomaly	180	180	

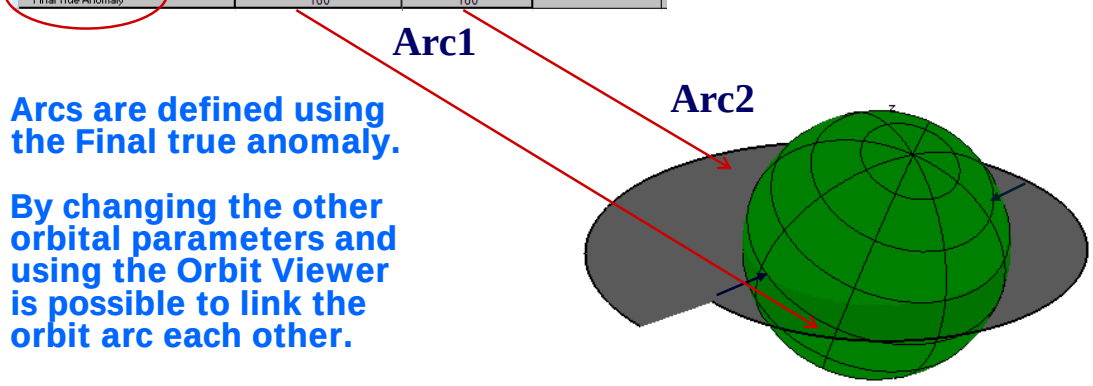
The TCDT 1.6.0 will include:

- The definition of the final true anomaly
- Orbit Arc management

TCDT Improvements (2/8)

Mission Definition : Orbit Arcs

Calculation Parameters		
Nr. of orbital positions	8	8
Include eclipse entry/exit positions	No	No
Offset (deg)	0.5	0.5
Initial True Anomaly	0	0
Final True Anomaly	180	180



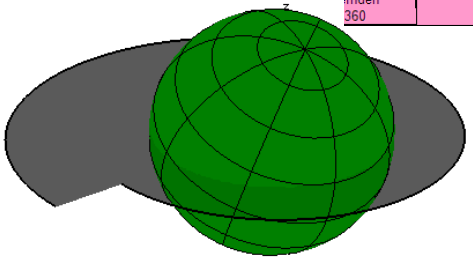
Arcs are defined using the Final true anomaly.

By changing the other orbital parameters and using the Orbit Viewer is possible to link the orbit arc each other.

TCDT Improvements (3/8)

Mission Definition : Chained Arcs

rbit2	Chain1
	Chain
371	Orbit1
49.6	1
288	TRUE
0.3	Orbit2
0655	1
0	TRUE
6000	
770	
274	
rriden	
360	



The mission timeline is defined in the mission sheet like previous version.

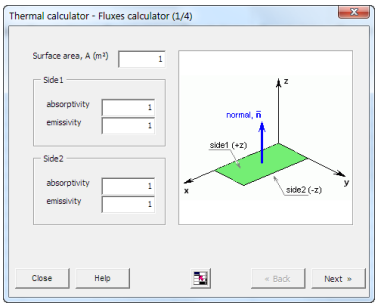
It is possible to define the sequence of arcs and for each arc the number of cycles and the final point result usage as in esarad.

TCDT Improvements (4/8)

Fluxes Calculator for Model

TCDT 1.6.0 will include a simplified adsorbed fluxes calculator for the Geometric model surfaces.

The feature is based on the analytic fluxes calculator of THECAL.
Solar, Albedo and Planet IR fluxes are evaluated



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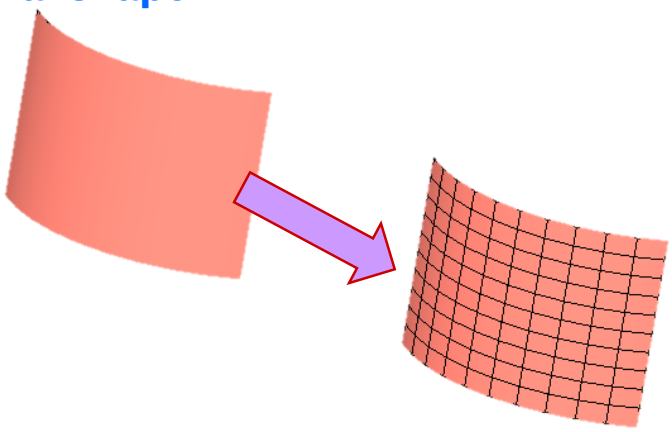
TCDT Improvements (5/8)

Fluxes Calculator for Model

Each curved surface is divided in flat surface that approximate the original shape.

For each flat shape the THECAL function is evaluated taking into account the surface orientation according to the selected mission.



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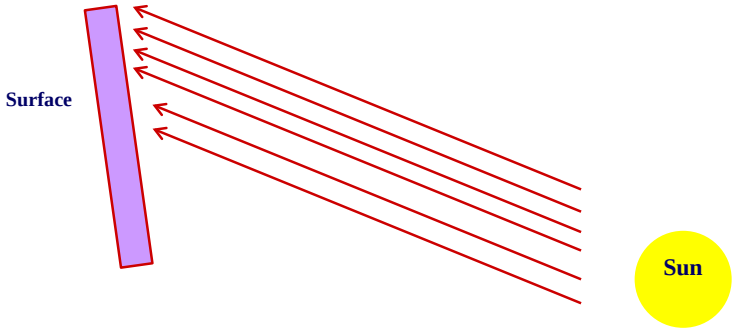
TCDT Improvements (6/8)

Fluxes Calculator for Model

A Montecarlo Ray Tracing method is developed to evaluate the reduction factor to be applied on the calculated flux coming from sun or planet due to the shadowing effect of the other surfaces.

From each shape a user defined number of parallel rays are thrown toward the direction of the center of the target (Sun or planet)

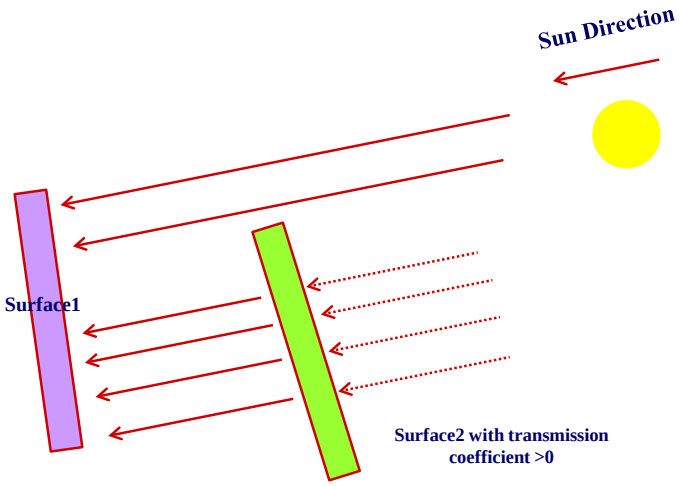


TCDT Improvements (7/8)

Fluxes Calculator for Model

Each ray is "charged" with energy and if, during its path, it encounters a surface its energy value is reduced according the transmission coefficient.

By calculating the sum of this energy is possible to evaluate the shadows coefficient, for the flux on one surface.

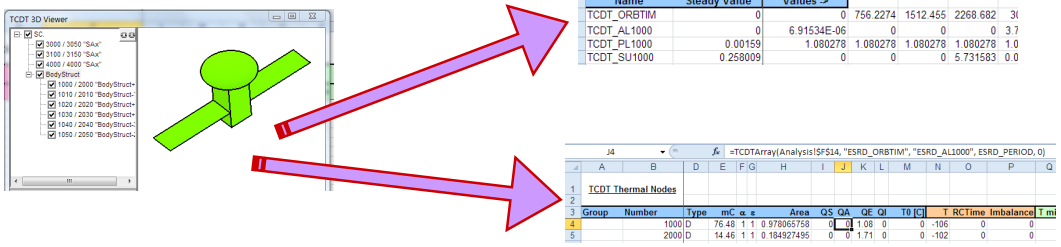


TCDT Improvements (8/8)

Fluxes Calculator for Model

Fluxes are calculated for each surface selected by the user (or all the surfaces), and for each orbit point defined in the selected mission.

Results are stored in the arrays sheet and linked to the QS,QA,QE nodes properties.



Modeling with the TCDT (1 / 9)

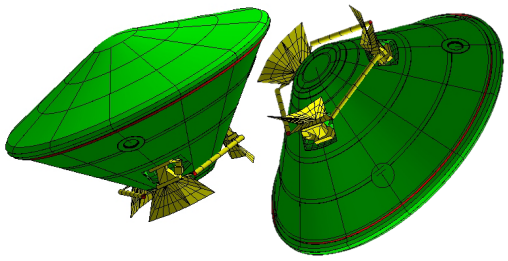
Exomars EDM RTMM for PROTON launcher

- Activity:
  - reducing the 4000 nodes Exomars EDM Detailed Model, to a 150 Nodes Reduced Model composed by flat surfaces.
  - RGMM and RTMM exported in PROTON specific format.
- The TCDT is used to:
  - import the geometry from an ESARAD geometry file
  - manage the results
  - export PROTON model with “Proton Geometry Export” User class
- BLUE Performed the activity for ThalesAleniaSpace Turin

Modeling with the TCDT (2 / 9)

Work Flow:

Subdividing the detailed GMM into main components to be compatible with TCDT characteristics

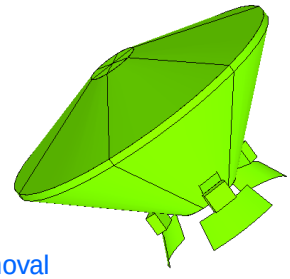


- Meshing of surfaces is reset to 1 node per surface
- Each sub component is exported in different g Files

Modeling with the TCDT (3 / 9)

Work Flow:

Importing GMM's (g files) in TCDT for further simplifications to meet reduction requirements



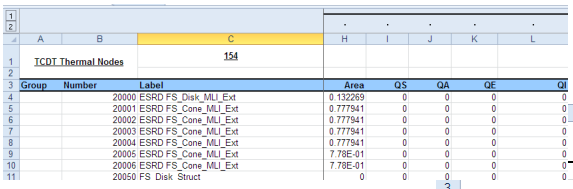
- Surface check and removal
- Meshing of surfaces to guarantee adequate geometrical representation for RGTMM

ESARAD thermo-optical properties are automatically applied to new RGMM surfaces

Modeling with the TCDT (4 / 9)

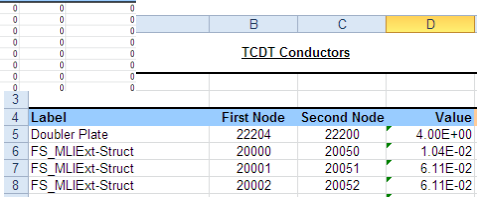
Work Flow:

Creating the TMM in the TCDT



TCDT Thermal Nodes 154

Group	Number	Label	Area	QS	QA	QE	QI
	20000	ESRD FS_Disk_MLI_Ext	0.132269	0	0	0	0
	20001	ESRD FS_Cone_MLI_Ext	0.777941	0	0	0	0
	20002	ESRD FS_Cone_MLI_Ext	0.777941	0	0	0	0
	20003	ESRD FS_Cone_MLI_Ext	0.777941	0	0	0	0
	20004	ESRD FS_Cone_MLI_Ext	0.777941	0	0	0	0
	20005	ESRD FS_Cone_MLI_Ext	7.78E-01	0	0	0	0
	20006	ESRD FS_Cone_MLI_Ext	7.78E-01	0	0	0	0
	20050	FS_Disk_Struct	0	0	0	0	0



TCDT Conductors

Label	First Node	Second Node	Value
Doubler Plate	22204	22200	4.00E+00
FS_MLIExt-Struct	20000	20050	1.04E-02
FS_MLIExt-Struct	20001	20051	6.11E-02
FS_MLIExt-Struct	20002	20052	6.11E-02

- ESATAN analyses
- Management and post-process results
- export PROTON model with “Proton Geometry Export” User class

Process managed with the TCDT

Modeling with the TCDT (5 / 9)

Focus: Temperature Management

The target temperatures derived from the DTMM are calculated taking into account the temperature and the capacity of the DTMM nodes that was collapsed into single RTMM nodes.

The allowed maximum temperature difference between the DTMM and the RTMM was:

- 5 C for internal units and tanks
- 10 C for internal structures and lander antennas
- 15 C for structures

The target temperature and the requirements are introduced in the TCDT temperature requirements for TNodes.

Modeling with the TCDT (6 / 9)

Focus: Results Management

By setting the temperature requirements in the TCDT is possible to check immediately after loading the results from the ESATAN analysis

QE	QI	T0 [C]	T	RCTime	Imbalance	T min	T max
0	0	-45.7	-162.7359	0	0	-96	4
0	0	-172.367	-164.512	0	0	-222	-122
0	0	-172.05	-164.7743	0	0	-222	-122
0	0	-170.583	-162.0358	0	0	-221	-121
0	0	-170.5	-161.2335	0	0	-221	-121
0	0	-169.25	-164.1375	0	0	-219	-119
0	0	-170.383	-163.5279	0	0	-220	-120

T outside the requirements have different colors

Achieved maximum temperature difference after 10 iterations

- ΔT < 3.6 C for internal units and tanks
- ΔT < 8 C for internal structures and antenna
- ΔT < 14.4 C for external structure
- Main MLI surfaces has ΔT < 19 C

Modeling with the TCDT (7 / 9)

Focus: PROTON Geometry Export

The PROTON geometric data model requirements are:

- Surfaces are made of quadrangles or triangles
- Double active sides are made with 2 surfaces separated by a small gap and properly oriented
- Each surface is defined by points
- The reference frame for all the points is the S/C frame.

The PROTON geometric data model is composed by

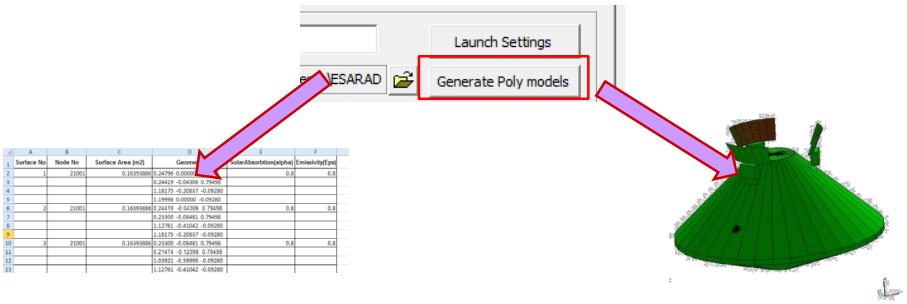
- points data
- Surfaces data (group of points that define the orientation of the surface)
- Area of the surface
- Surface thermal node
- Emissivity and Assorptivity

The PROTON thermal data model includes nodes, internal conductors dissipation, etc, and it is easily managed by copy paste operation from TCDT excel sheets.

Modeling with the TCDT (8/ 9)

Focus: PROTON Geometry Export

A BLUE User add-in is implemented in order to generate the data required for PROTON and a flat surfaces ESARAD geometric model used for correlation and geometry check:



Exporting a table file with nodes data and other required

By using the same points data a flat surface ESARAD model is generated

Modeling with the TCDT (9/ 9)

Conclusions

The TCDT feature used for this work are:

- **Import ESARAD Models**
- **Management of GMM from TCDT GUI or Excel sheets with immediate check of correctness.**
- **Faster check of results validity**
- **Easy Implementing of new exporting features**

TCDT Team

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