Cosmic Ray Telescope for the Effects of Radiation

CRaTER Instrument Thermal Model Report

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TABLE OF CONTENTS

INTRODUCTION

This report documents the CRaTER reduced geometric math model (RGMM) and reduced thermal math model (RTMM) for the current baseline configuration.

PURPOSE

The purpose of this report is to provide a detailed description of the reduced CRaTER thermal models. These models represent the CRaTER instrument during the three operating conditions outlined in the LRO Orbiter Reduced Spacecraft Thermal Model Report and are intended to be integrated into the LRO S/C model.

MODEL FORMATS

The RGMM was developed utilizing the Thermal Desktop program. The RTMM was developed utilizing the Systems Improved Numerical Differencing Analyzer (SINDA) program.

THERMAL MODEL FILES AND FOLDERS

Table 1 provides a listing of the files that accompany this report as well as a description of each file. In order for these files to be integrated into the LRO S/C model, Goddard requires each Thermal Desktop Instrument Model to be exported to TSS format and sent along with all SCINDA input and output files.

Table 1

Folder Name	File Name	Description
Beta00Hot Orbit	B00Hot Orbit	Thermal Desktop Hot Case Orbit Parameters File
	ext-Beta00_Hot_Case-RcOptics.	Hot Case Orbit Positions and Backload Data
Beta90Cold Orbit	Beta90Cold Orbit	Thermal Desktop Cold Case Orbit Parameters File
	ext-B90coldSS-RcOptics.rch	Cold Case Orbit Positions and Backload Data
Beta90ColdSurvival Orbit	Beta90ColdSurvival Orbit	Thermal Desktop Cold Survival Case Orbit Parameters File
	ext-Beta90ColdSurvival-RcOptics	Cold Survival Case Orbit Positions and Backload Data
Beta00Hot	CRaTER_B00H_051506	Thermal Desktop Instrument Model (hot case)
	CRaTER_NA_EXT_051706.inp	SCINDA hot case model input file
	CRaTER_NA_EXT_051706.cc	SCINDA hot case model cc file (conductors)
	CRaTER_NA_EXT_HOT_051706	SCINDA hot case model output file
Beta90Cold	CRaTER_B90C_SS_051506	Thermal Desktop Instrument Model (cold case)
	CRaTER_NA_EXT_051706.inp	SCINDA cold case model input file
	CRaTER_NA_EXT_051706.cc	SCINDA cold case model cc file (conductors)
	CRaTER_NA_EXT_COLD_05170	SCINDA cold case model output file
Beta90ColdSurvival	CRaTER_B90C_SUR_051506	Thermal Desktop Instrument Model (cold survival case)
	CRaTER_NA_EXT_051706.inp	SCINDA cold case model input file
	CRaTER_NA_EXT_051706.cc	SCINDA cold case model cc file (conductors)
	CRaTER_NA_EXT_CSURV_0517	SCINDA cold case model output file
Properties	CRaTER_5_1_06.rco	Thermal Desktop Optical Properties (all cases)
	CRaTER_5_1_06 cold.rco	Thermal Desktop Optical Properties (cold cases)
	CRaTER_5_1_06 hot.rco	Thermal Desktop Optical Properties (hot case)
	TdThermo.tdp	Thermal Desktop Material Properties (all cases)

Sub Model Outline

Tables two through four provide a listing of each node, its respective layer and position within the model. Node and sub models follow the naming conventions outlined in the

Thermal Math Model Requirements Document (431-RQMT-000092). Node names are consistent in all three model versions.

Table 2

Submodel	Nodes	Part	Layer
CR_IF	401	mount 1	Mount
	402	mount2	Mount
	403	mount3	Mount
	404	mount4	Mount
	405	mount 5	Mount
	406	mount 6	Mount

Table 3

Submodel	Nodes	Part	Layer	Position
CR_SCOP	1	Film1	zfilm	Zmax
	2	Film2	zfilm	Zmin
	101		scope	Xmax
	301		scope	Ymax
	302		scope	Ymax
	401		scope	Ymin
	501		scope	Zmax
	502		scope	Zmax
	503		scope	Zmax
	601		scope	Zmin
	602		scope	Zmin
	603		scope	Zmin
	801	PCB	scope	Zmax
	802	PCB	scope	Zmid
	803	PCB	scope	Zmin

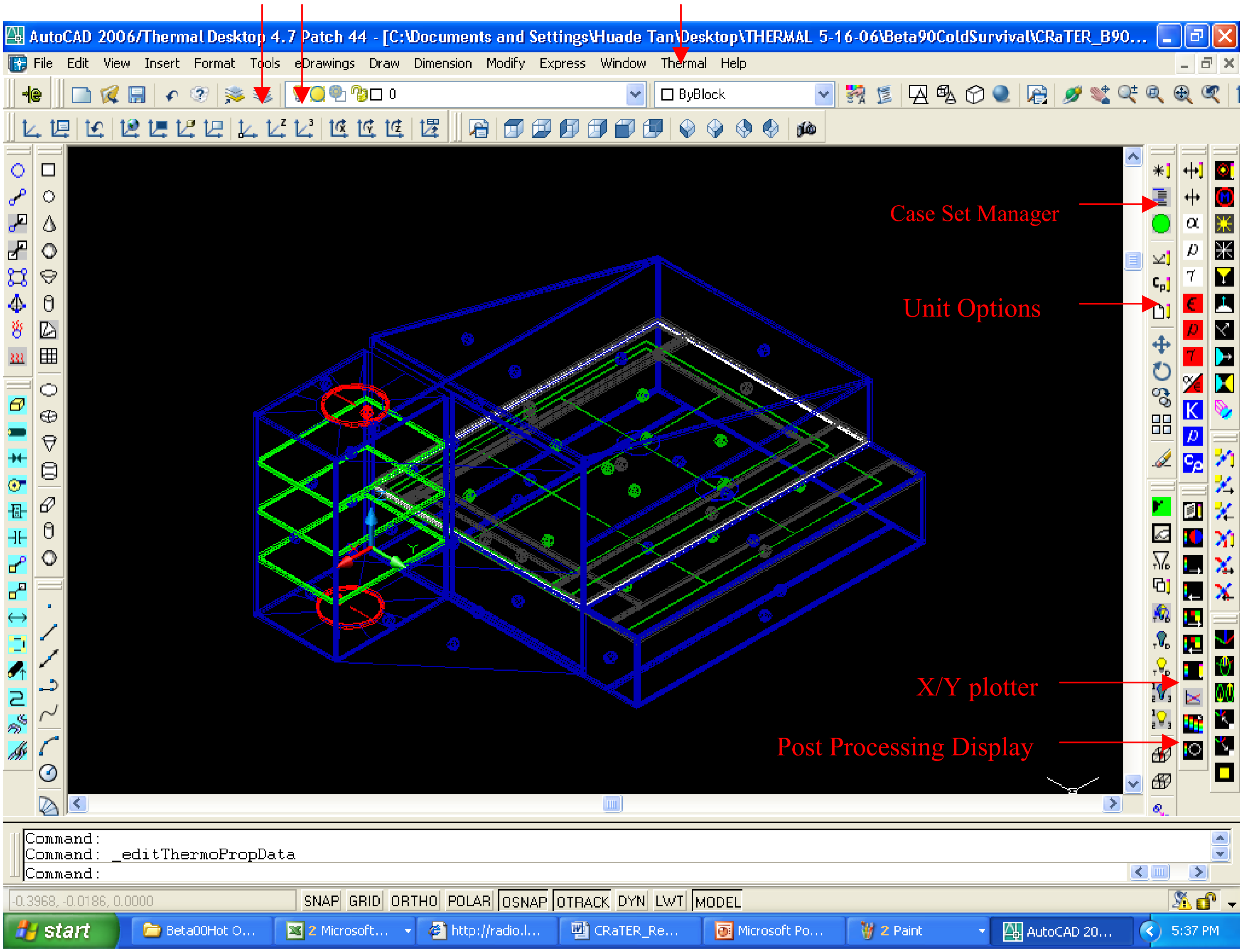
Table 4

Submodel	Nodes	Part	Layer
CR_EBOX	101	S interface	Xmax
	102	S interface	Xmax
	103	S interface	Xmax
	104		Xmax
	105		Xmax
	106		Xmax
	201		Xmin
	202		Xmin
	301		Ymax
	302		Ymax
	303		Ymax
	401		Ymin
	402		Ymin
	403		Ymin
	501		Zmax
	502		Zmax
	601		Zmin
	602		Zmin
	603		Zmin
	701		INT
	702		INT
	703		INT
	704		INT
	705		INT
	706		INT
	707		INT
	801	A PBC	INT
	802	D PCB	INT
	803	D PCB	INT
	804	D PCB	INT
	805	D PCB	INT
	806	D PCB	INT
	807	D PCB	INT
	808	D PCB	INT
	809	D PCB	INT
	810	D PCB	INT
	811	PSU	INT
	812	PSU	INT

Navigating Thermal Desktop

Thermal Pull-
Down Menu

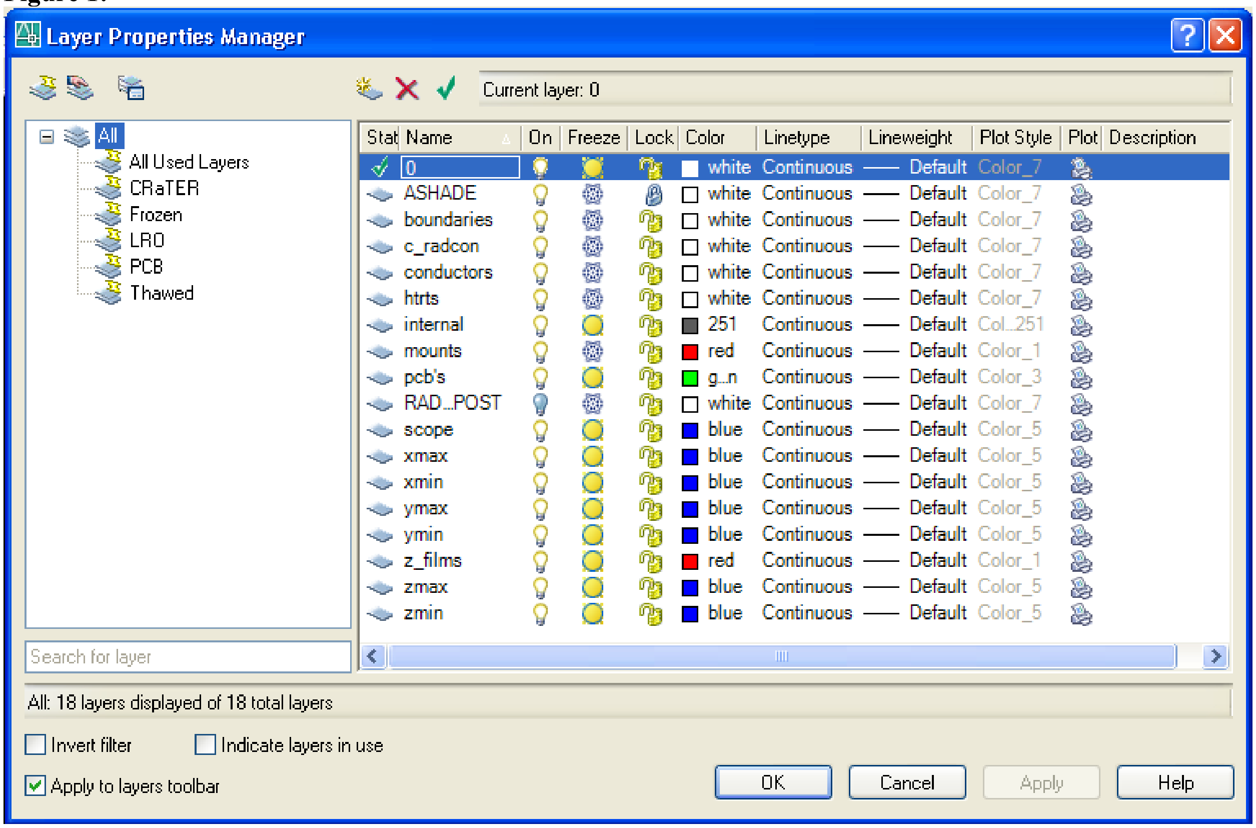
Layer Options



Model Layers

Figure one displays the layer properties manager. This window can be retrieved from the main toolbar at the top of the thermal desktop main screen. Using this menu, each layer can be displayed on screen individually while working with the mode. Layer naming conventions do not follow a Goddard specific standard and are intended to help the user differentiate interior and exterior surfaces. In order to activate a layer, the layer must be on and unfrozen depicted in figure one (in this arrangement, layer htrts is on but frozen and is invisible in the model while layer internal is both on and unfrozen and is visible). All material conductance properties are contained in the layer conductors and all radiation conductance properties are contained in the layer c_radcon. The only property that might require changing should be the S/C to instrument conduction property currently set to 1.3 W/C, viewable in the "conductors" layer.

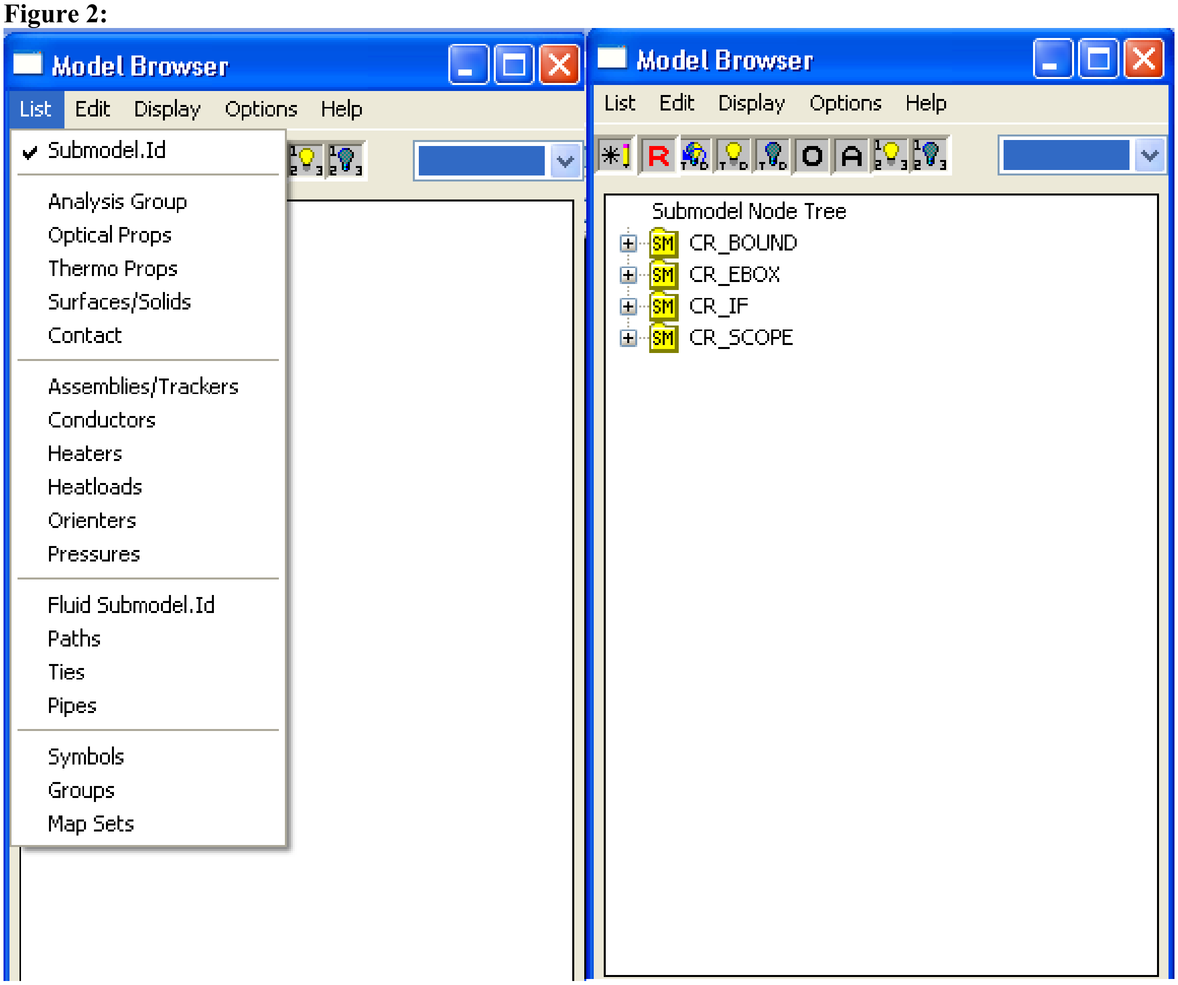
Figure 1:



Sub Models / Model Browser

Should there be any changes required to the thermal model it can either be changed directly in the Thermal Desktop screen or through the model browser. It is recommended, should any changes be necessary to the model nodes, that they be double checked on the model browser to ensure that the numbering and sub model naming conventions are followed. Duplicate node ID's will result in a failure before running the SCINDA compiler. The model browser icon is located in the top right hand corner of the Thermal Desktop screen and is second on the Thermal pull down menu. The model browser is also useful for listing nodes and surfaces by their optical, thermal, or contact properties.

Figure 2:

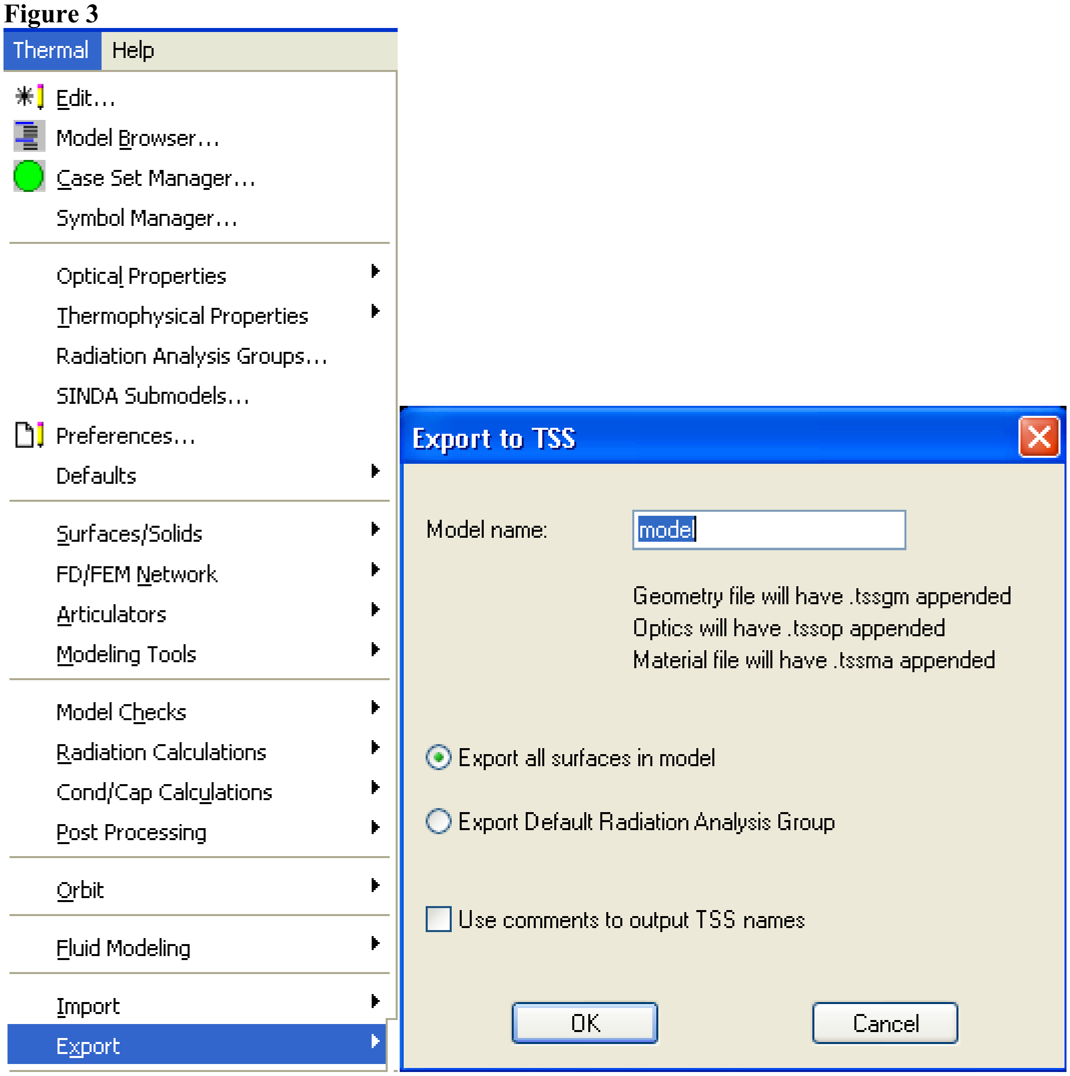


Exporting to TSS

The Thermal pull down menu is the most commonly used list for the Thermal Desktop program. Functions can either by accessed through icons located on the main thermal desktop screen or through the pull down menu. In order to export the model to TSS format, scroll down to the export option and select TSS from the secondary pull down menu available. The export to TSS menu will then appear as displayed in figure three.

Following the naming convention described in the thermal math model requirements document, the model files should be saved as: CRaTER_NA_EXT_051706.tssgm, CRaTER_COLD_051706.tssop or CRaTER_HOT_051706.tssop, and CRaTER_051706.tssma, where the date 051706 should comply with when the files are exported.

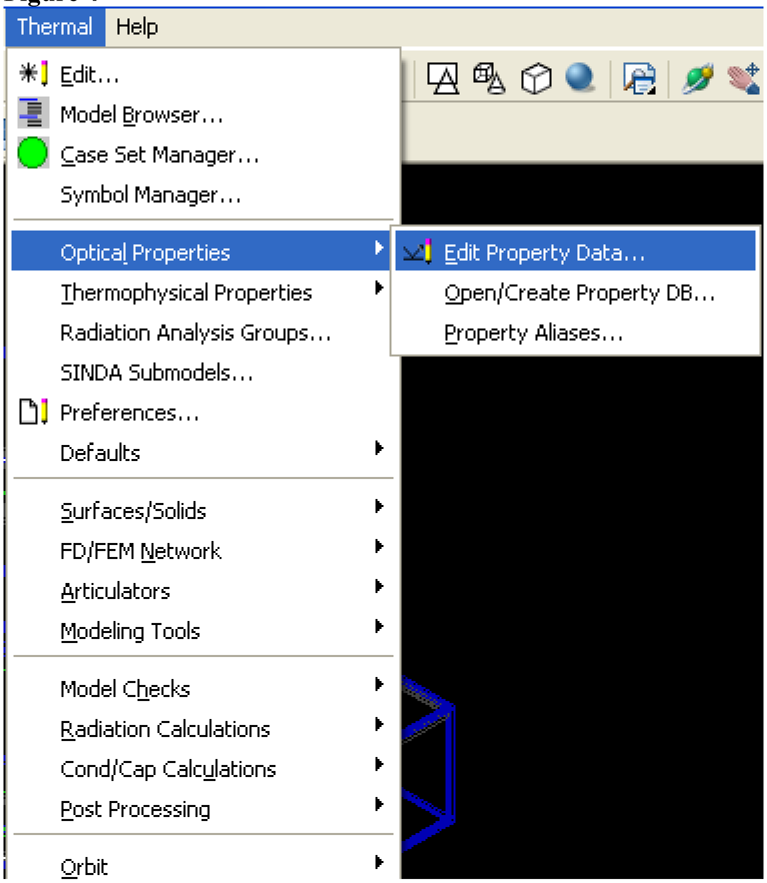
Figure 3



Editing Optical Properties

Should the Optical properties need to be edited, navigate to function displayed in figure four. CRaTER optical properties can be imported from back up optical files listed in table one in the properties folder.

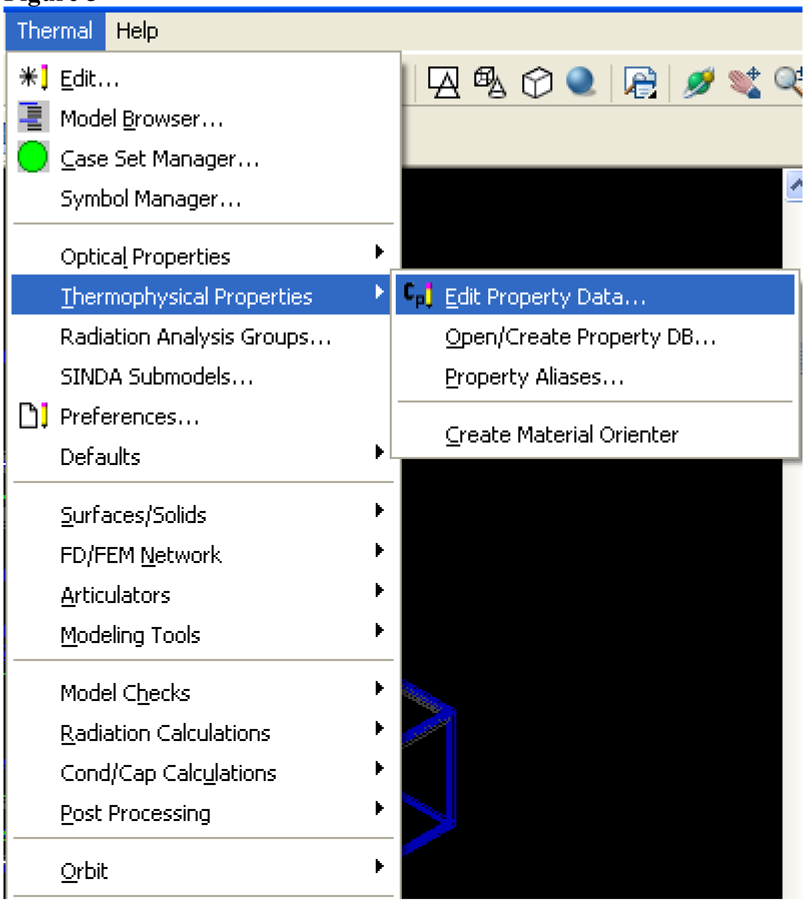
Figure 4



Editing Thermo Physical Properties

Should the Thermal Physical properties need to be edited, navigate to function displayed in figure five. CRaTER Thermal properties can be imported from back up optical files listed in table one in the properties folder.

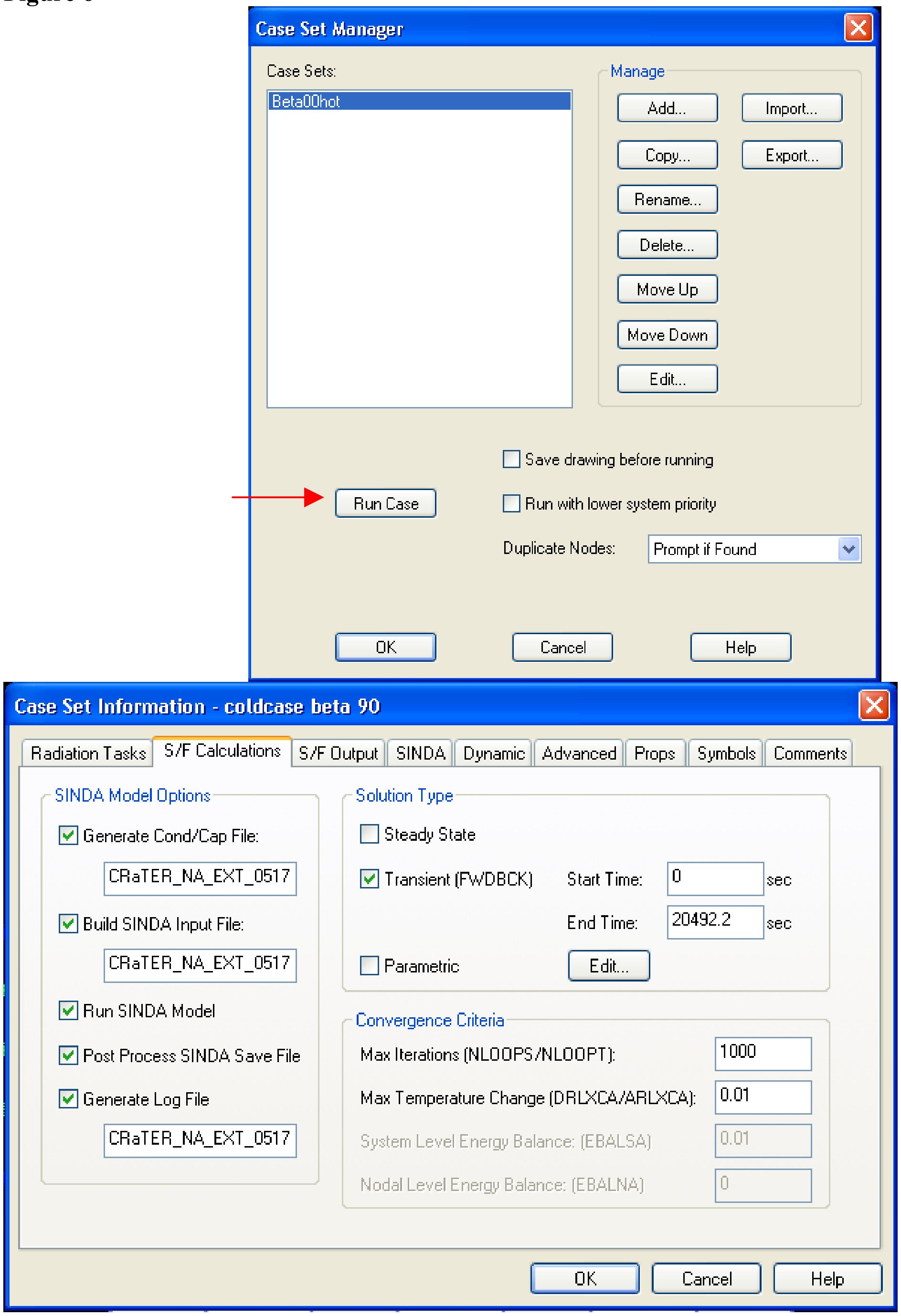
Figure 5



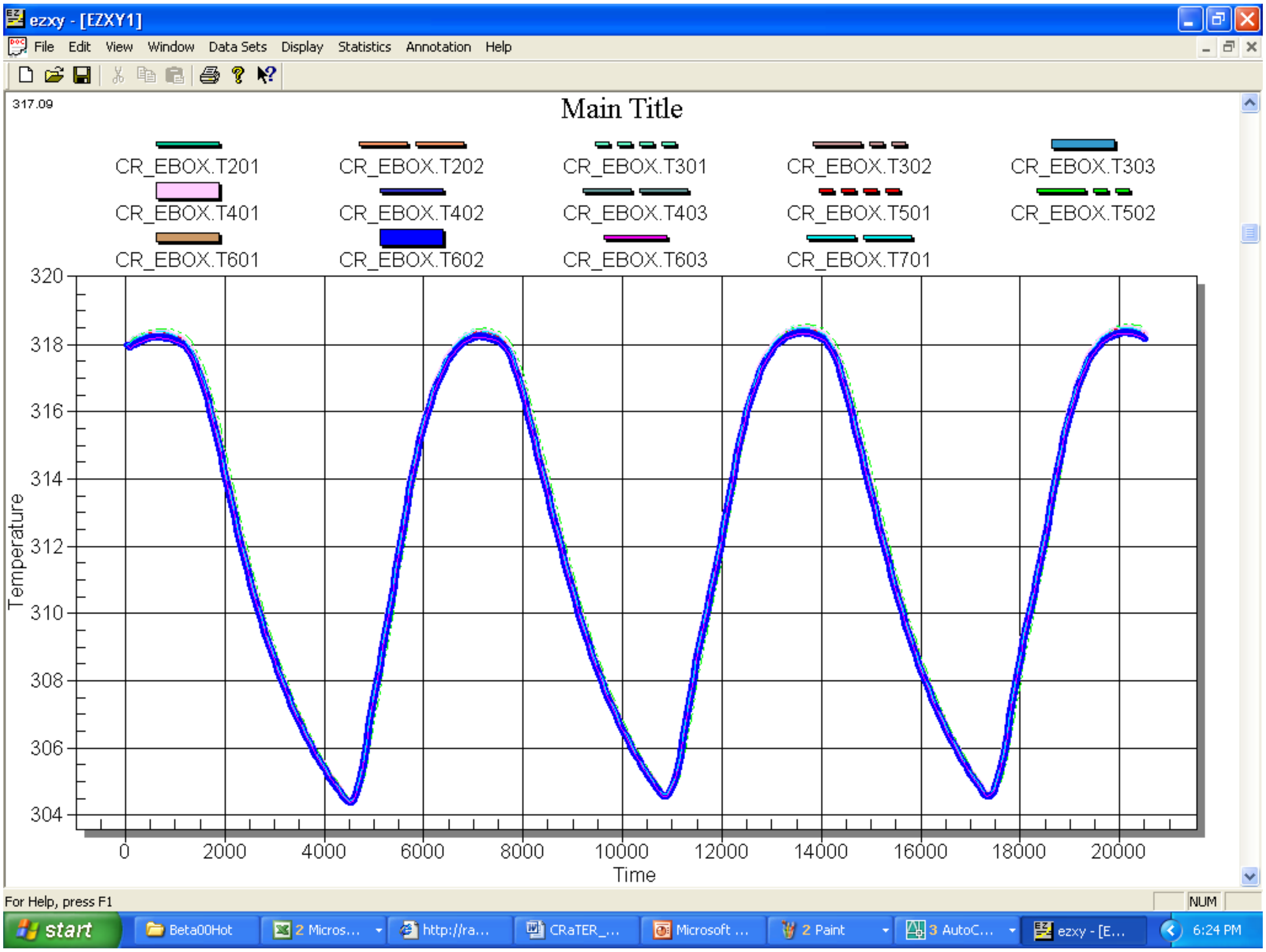
Running the model

The case set manager is the first icon under the Thermal pull down menu. For the sake of simplicity, each file contains at most only two case sets such that radiation, instrument temperature, hot and cold case conditions are all accessed through different files, why there are six different file and folder sets. Case sets are pre assigned for each case and should not require any modifications. Click the Run Case button and all SCINDA and orbit output files will be updated and can be located in the same folder as the case file.

Figure 6



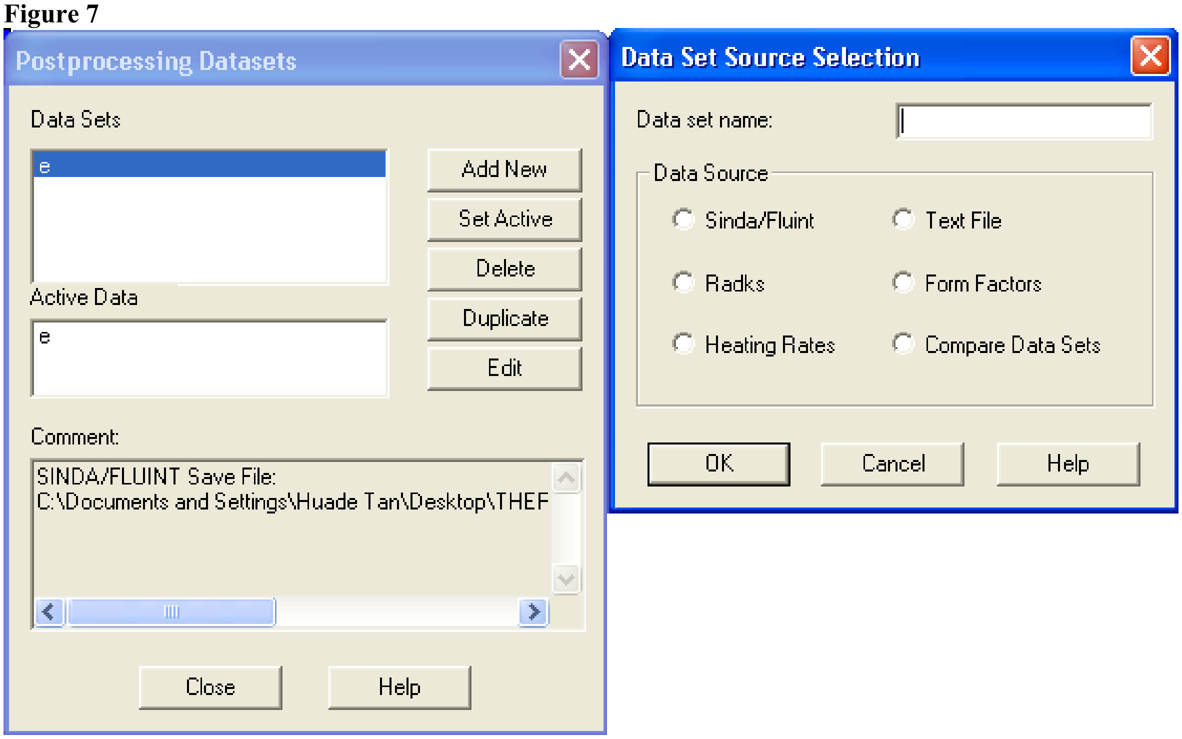
Post Processing Operations



The ezxy plotter is useful in converting heat rate and SCINDA output files into viewable and exportable plots. Temperature output files as obtained from SCINDA output file is plotted in the figure above. All plot able SCINDA output files are saved as .sav files and all heat rate output files are saved as .rch folders.
The ezxy plotter icon is indicated in figure or through >>Thermal>>Post Processing>>ezxy

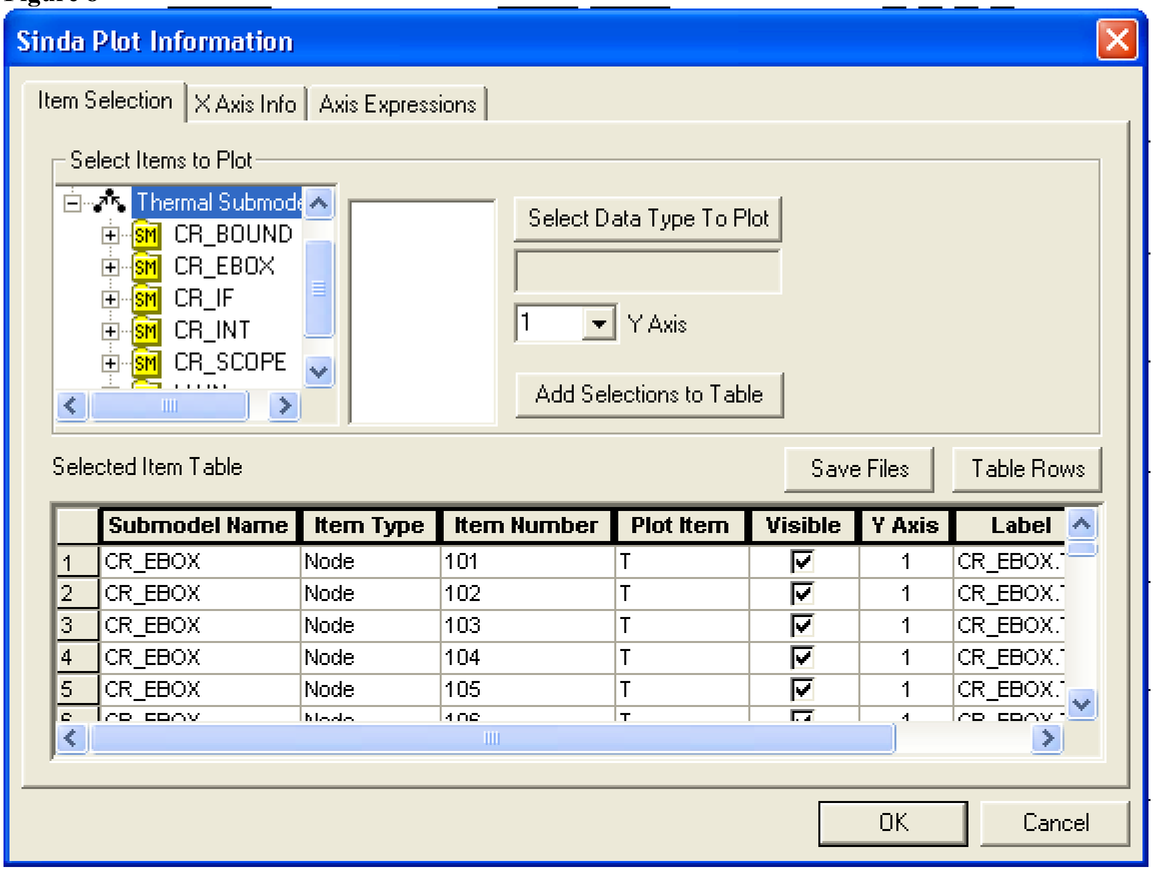
In the ezxy plotter window, open the data sets window under the datasets pull down menu. From this window, click "add new" and enter a name for the new data set. Select the type of output file to be plotted. The data set name does not matter at this point. Click OK to bring up a navigation window to search for the output file.

Figure 7



Once the desired output file or folder has been selected, select the desired nodes to be plotted. The list of all instrument nodes are given in tables two through four. Note: MLI nodes are offset by 10000, all nodes in sub models CR_EBOX and CR_SCOPE with node numbers higher than 10000 are MLI nodes and should not be plotted along with material nodes. Click OK once all the desired nodes have been selected and the plot will then be displayed in the main ezxy window.

Figure 8



From the main ezxy window, the plotted data can be exported to any type of file available in figure 9. Navigate to the export option through the file pull down menu. Browse to a file you wish to export to and click export. When exporting to a text file, select the options highlighted in figure 10 so that the text file can then easily be imported by excel.

Figure 9

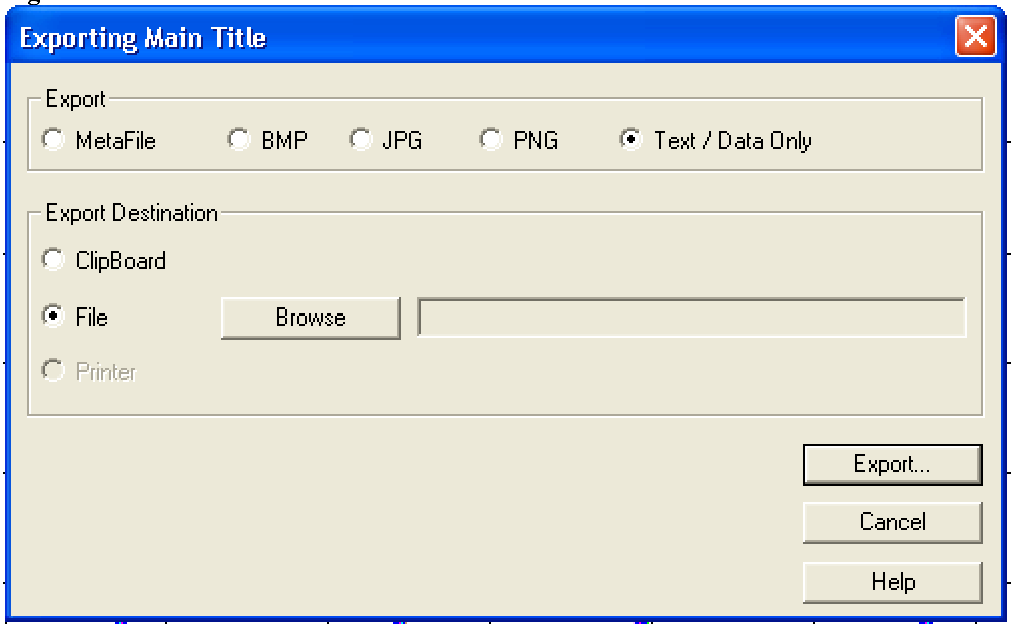
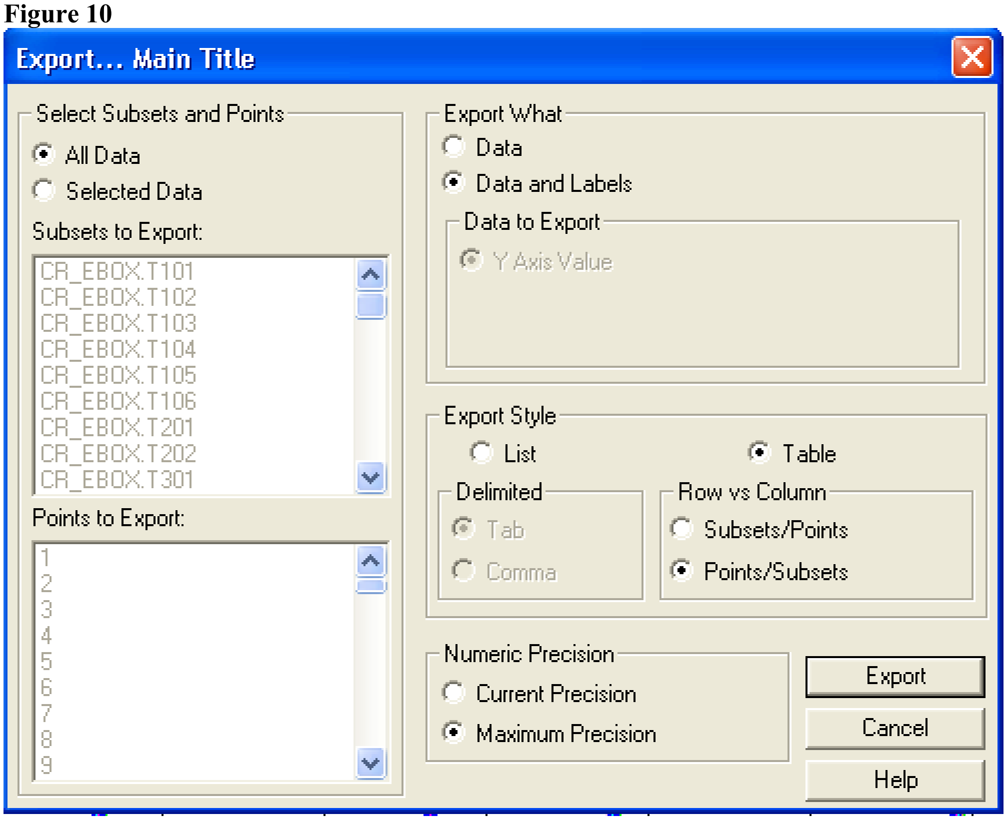


Figure 10



LRO Orbits

The BETA 00 and BETA 90 orbits as described in the LRO Orbiter Reduced Spacecraft Thermal Model Report have been reproduced for the CRaTER instrument and are displayed in the following figures. The orbit parameters can be retrieved from the orbit files through >>Thermal>>Orbit>>Edit Current Orbit in the Thermal Desktop Window

Figure 11: Beta 00 Hot Case

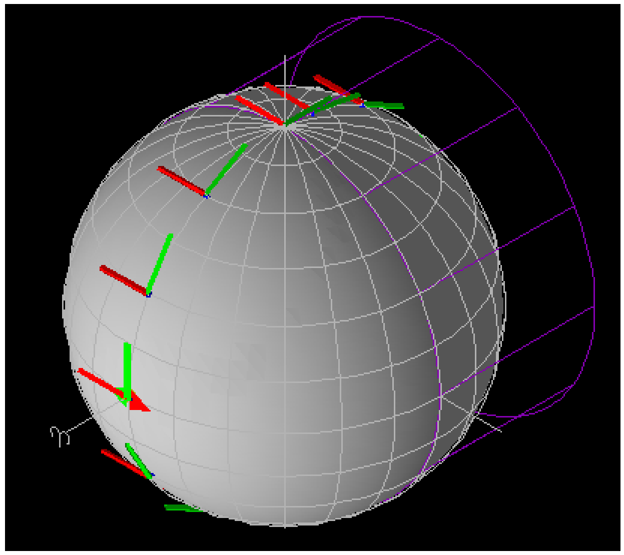
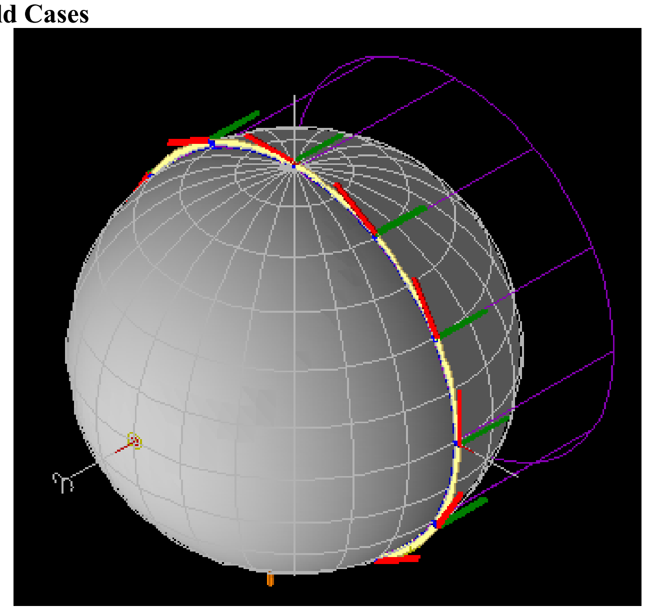


Figure 12: Beta 90 Cold Cases



Orbiting parameters and solar array articulations as described in the LRO Orbiter Reduced Spacecraft Thermal Model Report have also been reproduced in the appropriate orbit parameter files. Figures 13 through 15 display the solar cell arrangements as described by Goddard. There should not be any necessary changes to the orbit parameter files given. Changes to the instrument should be made on the instrument files only.

Figure 13: Beta 00 Hot Case

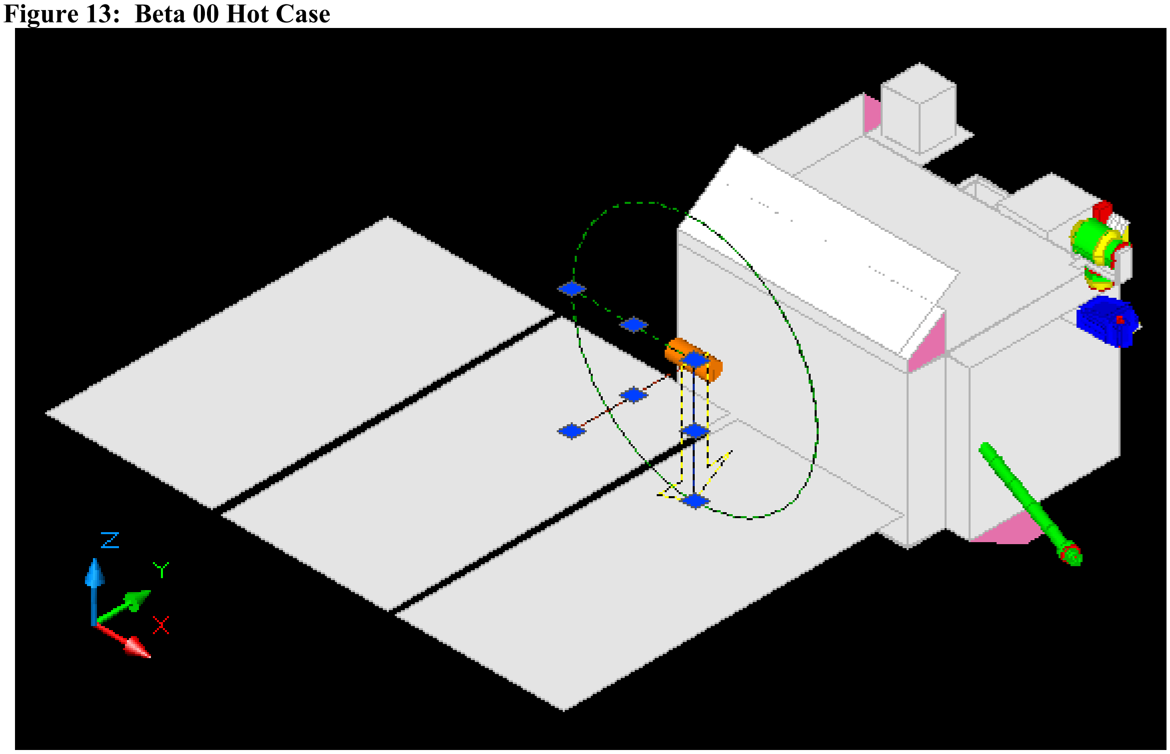


Figure 14: Beta 90 Cold Case

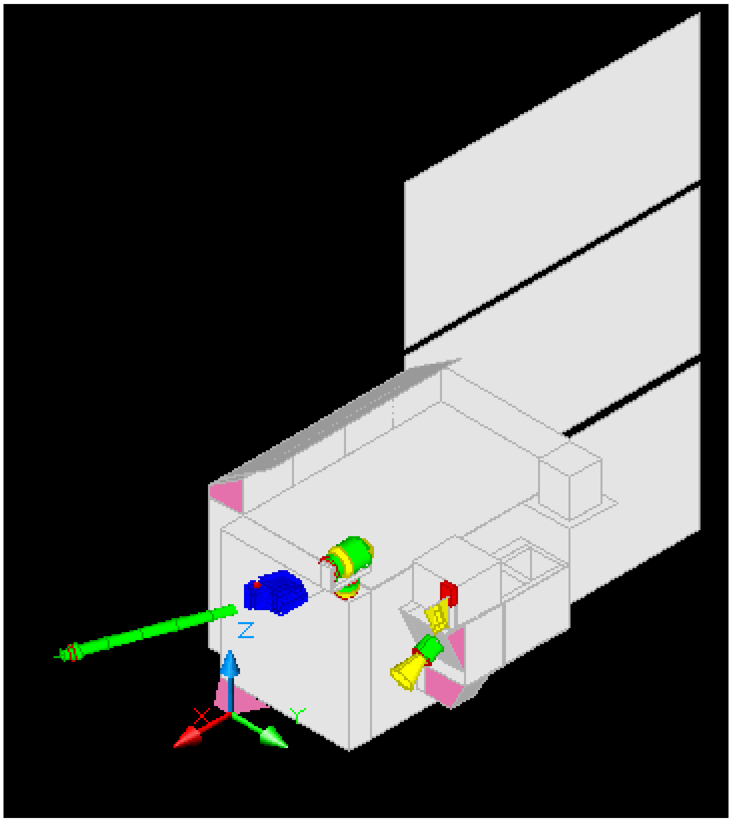
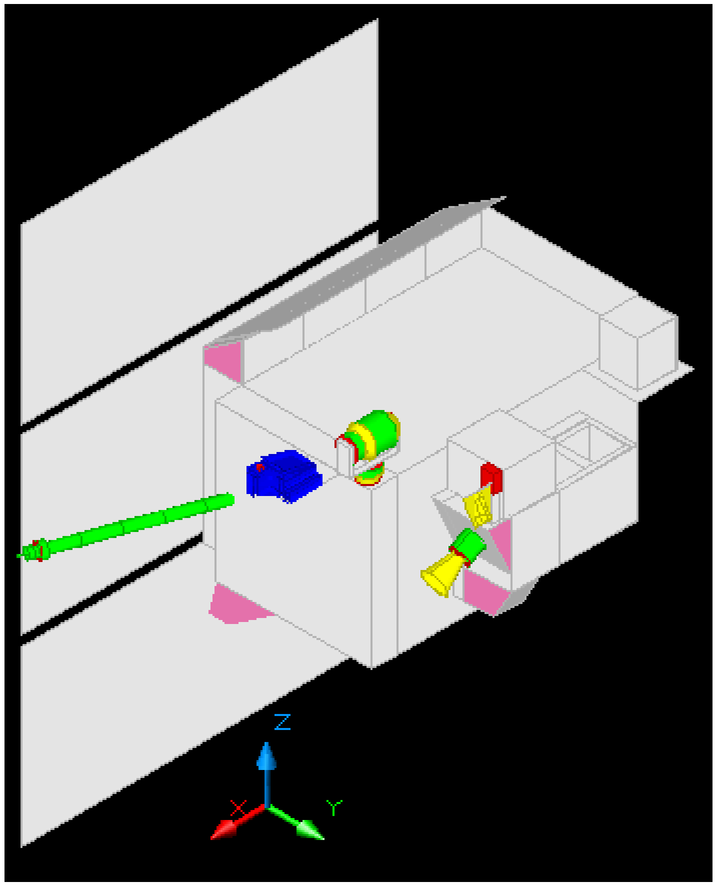


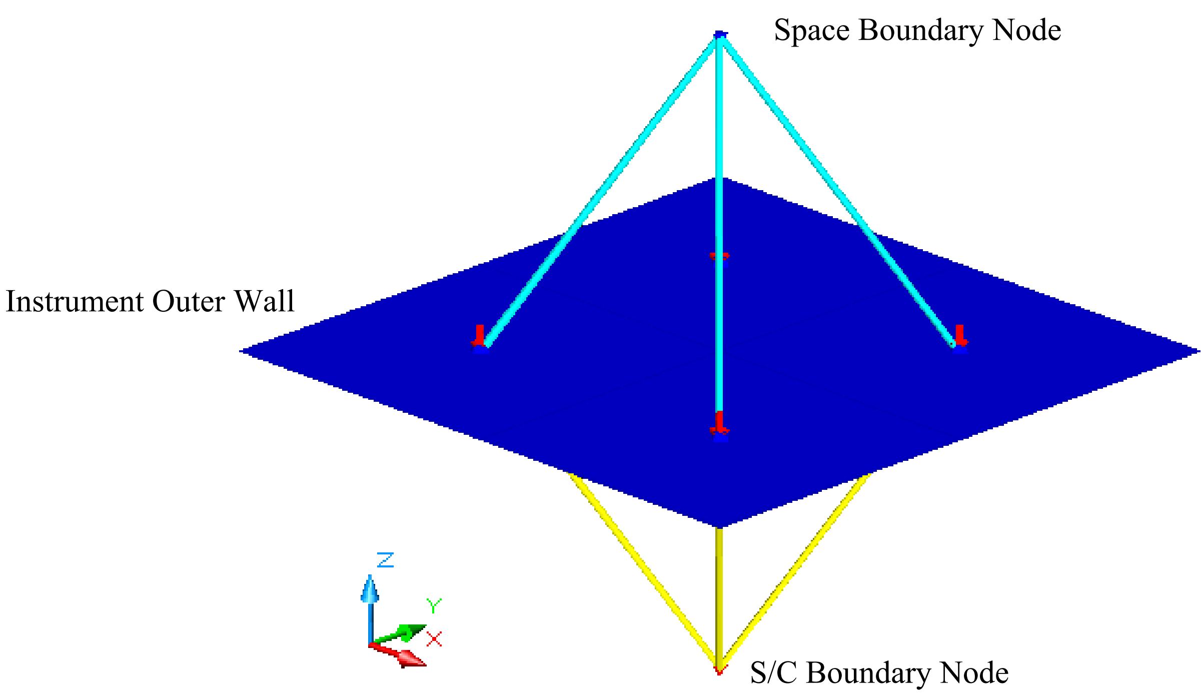
Figure 15: Beta 90 Cold Survival Case



MLI Bulk Properties:

		Cold Case		Hot Case	
Coating	Location	Absorptance α_S	Emittance ε_H	Absorptance α_S	Emittance ε_H
Kapton 3mil		0.45	0.80	0.51	0.76
Black Kapton 3 mil		0.91	0.81	0.93	0.78
Germanium Black Kapton		0.49	0.81	0.51	0.78
Silver Teflon (5 mil)[3,4]	MLI Blanket	0.08	0.78	0.11	0.73
Silver Teflon (10 mil)[4]	MLI Blanket	0.09	0.87	0.13	0.83

Figure 16: MLI performance test in Thermal Desktop environment



Assumptions:

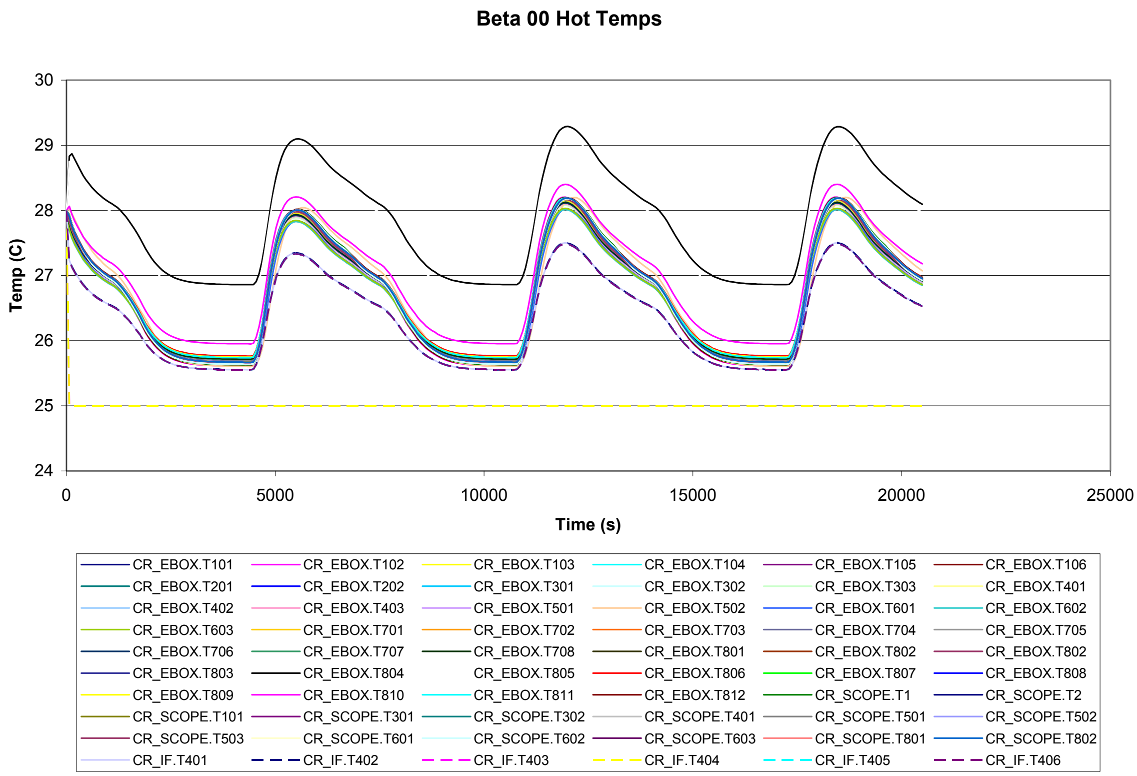
Hot and cold case optical properties are given in the table above.
MLI blanket has a best and worst case effective emittance of 0.005 and 0.03.
Instrument's outer wall has infinite conductance to the S/C boundary node and a 0.95 view factor to space boundary node.
The space boundary is constant at -270 C and the S/C boundary is constant at 0 C throughout.
Heat Load on the instrument wall is 1340 W/m^2 for the bright case and 5.2 W/m^2 for the dark case.
The heat being transmitted through the S/C conductor (shown in yellow) equals the heat being transmitted through the MLI.

Results:

Figure 17

	effective emmissivity		
	0.005	0.03	0.4
1340 W/m2	7.65 W/m2	44.4 W/m2	395 W/m2
5.2 W/m2	-1.55 W/m2	-8.85 W/m2	-80 W/m2

Figure 18



Referring to figure 18, ΔT between instrument and S/C is 0.6 C, with a 7.8 W/C resistance between the instrument and S/C, meaning 4.68 W is transmitted to the S/C. Given a power dissipation of 9.08 W, 4.4 W must then be lost through the MLI.

Referring to figure 17, given a 4.4 W loss through the MLI in the dark case, we can expect approximately a 19.7 W heat load through the MLI in the bright case.

Referring back to figure 18, the actual ΔT between instrument and S/C in the bright case is about 3.5 C, with a 7.8 W/C resistance between the instrument and S/C. The instrument in this case is experiencing a heat load of about 27.3 W, 9.08 of which is internal power, meaning that roughly 18.2 W is actually being transmitted through the MLI while the S/C is over the Sub solar point.