Exoplanet Characterisation Observatory (EChO)

TMM/GMM Description and Results Technical Note

Issue 1.0

ECHO-TN-0001-IASFBO

Prepared by: G. Morgante (INAF-IASF Bologna), L. Terenzi (INAF-IASF Bologna)
EChO Consortium System Team

Date: 14.09.2013

Agreed by: Paul Eccleston *(RAL Space)*
EChO Consortium Project Manager

Date:

Approved by: *Giovanna Tinetti (UCL)*
EChO Consortium PI

Date:

DOCUMENT CHANGE RECORD

Issue	Date	Page	Description Of Change	Comment
0.1	04-Sep-13	All	First release of the document	
1.0	14-Sep-2013	All	General review and TMM results update	

DISTRIBUTION LIST

Name	Organisation	Name	Organisation
EChO Payload Consortium Team (via Website)	Consortium	Martin Linder	ESA
Giovanna Tinetti	UCL	Ludovic Puig	ESA
Paul Eccleston	RAL Space	Kate Isaac	ESA

TABLES OF CONTENTS

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

This document describes the present status of the Thermal Mathematical Model (TMM) and Geometrical Mathematical Model (GMM) in preparation for the Instrument and PLM of the EChO mission proposal, candidate for the ESA M3 launch opportunity. A general view of the mission thermal and cryogenic architecture can be found in [RD2].

Two main reference thermal models have been developed so far:

a) a reduced thermal model, mainly conductive, used to evaluate the Instrument internal thermal architecture, couplings between units and to the two temperature reference boundaries for the channel detectors: the JT cold end and the cold radiator;

b) A general PLM TMM/GMM, both radiative and conductive, that simulates the main couplings between PLM units, providing estimations for the heat flow from/to Instrument/PLM.

The reduced model has been used to define and design the instrument internal and external thermal interfaces as well as to evaluate the general thermal behaviour in different boundary conditions. The PLM model is used to show the cold payload behaviour in the general frame work of the spacecraft, including possible heat leaks from the main sources in L2 (Earth, Sun) and will be the main reference for analysing and designing external thermal interfaces. The models are cross-correlated to verify the validity of the assumptions and to check the reliability of the results.

In the next phase of the mission study, once requirements and designs will be in a more condensed state, a detailed model of the Instrument and its internal units will be prepared for simulating accurately the thermal behaviour of the Instrument inside the cold PLM.

The reduced model will be updated and maintained (in agreement with ESA and Industry) to provide a summary representation of the Instrument thermal behaviour and will be used for the transient analysis (temperature instabilities and cooldown/warmup processes). It will also be the TMM deliverable for representing the EChO Instrument thermal design in the general Spacecraft models.

All EChO thermal models have been developed in the ESATAN-TMS environment.

1.1 PURPOSE

This document captures the main information concerning the thermal models developed for the EChO mission study. The general scheme of the models is reported and explained, including the up-to-date best assumptions and approximations, together with the present knowledge of the boundary conditions. A summary and explanation of the main results is also reported.

1.2 SCOPE

This document provides an overall summary of the EChO Instrument TMM/GMM development starting from the mission thermal and cryogenic baseline architecture scheme. It gives an overview of the present status of the thermal models evolving with the mission study process. The best assumptions in terms of heat loads and conductive/radiative couplings are reported with reference to the thermal design. The thermal cases studied and reported in the document are based on the present assumptions of best and worst cases conditions as defined in the present issue of the EID-A [AD2]. A cold and a hot case are run to bound the space phases of the Instrument thermal status.

The document shall be used as a reference for the TMM/GMM, as it describes assumptions, estimations and definitions for the TMM/GMM at the present stage of the study. It is a living document that represents a sort of explanatory note for the TMM/GMM updates.

1.3 APPLICABLE DOCUMENTS

AD #	APPLICABLE DOCUMENT TITLE	DOCUMENT ID	ISSUE
1	EChO Assessment Study Design Report	ECHO-RP-0001-RAL	1.2
2	EChO EID-A	ECHO-SRE-F/2012.097/	0.2

Table 1-1: Applicable Documents

1.4 REFERENCE DOCUMENTS

RD #	APPLICABLE DOCUMENT TITLE	DOCUMENT ID	ISSUE
1	EChO EID-A	ECHO-SRE-F/2012.097/	0.2
2	EChO Assessment Study Design Report	ECHO-RP-0001-RAL	2.0

Table 1-2: Reference Documents

2 ECHO REDUCED THERMAL MODEL

2.1 THERMAL ARCHITECTURE DESCRIPTION

The thermal architecture of the EChO payload is based on a combination of passive and active cooling systems (Figure 2-1). The first three cold temperature stages consist of V-Grooves passive radiators that, exploiting the favorable conditions of the L2 thermal environment, will provide stable temperature references for the modules, for parasitic heat leaks (harness, struts, piping, radiation) interception and for cryo-system pre-cooling. Three channel detectors will be cooled around 45K by means of a dedicated radiator that will benefit of the cold radiative environment set by the last V-Groove. Two channels need to work at a lower temperature, T < 30K (see Table 2-1): this is achieved by using a Neon JT cryocooler.

The EChO PLM main thermal requirements in terms of operating temperature and active unit loads in the cold PLM are summarized in the following table:

Channel	Optical Modules		Detectors			T Control Stage	FEE		
	Op T (K)	ΔT [1] (K)	Op T (K)	ΔT [1] (K)	Load[2] (mW)	Load[2] (mW)	Op T (K)	ΔT [1] (K)	Load[2] (mw)
FGS	≤50	± 1	≤45	± 0.05	10	5	≤50	± 1	64
VNIR	≤50	± 1	≤45	± 0.05	10	5	≤50	± 1	64
SWIR	≤50	± 1	≤45	± 0.05	8	5	≤50	± 1	16
MWIR	≤32	± 1 (TBC)	<30	± 0.05	5	5	≤50	± 1	8
LWIR	≤29	± 1 (TBC)	<30	± 0.05	5	5	≤50	± 1	8

Notes: [1] Peak to peak value over a typical observation time

[2] Best assumption at this stage of the study, including margin

Table 2-1 Main thermal requirements for the EChO Instrument

In Table 2-1 are reported the best up-to-date assumptions (with 50% margin) for the dissipation of the active components of the Instrument in the cold PLM. The detectors and front-end electronics load is evaluated on the basis of the present design trade-off study of the channels detecting chain. The Temperature Control Stage power is the predicted average load dissipated by the closed loop circuit when assumptions on the expected instabilities at the relevant thermal interfaces are made (see [RD2]).

Each instrument channel module can be considered as thermally composed by a Box that includes an Optical Module (OM) and a Detector System (DS), composed by the Focal Plane Assembly (FPA) with its Temperature Control Stage (TCS). Due to electrical performance issues the cryo-harness connecting the FEE to their detectors cannot be longer than few tens of cm (around 20 cm max). From this follows that the FEE shall be mounted in proximity of the detectors. For the three warmer channels the cold driving electronics is installed on the module box nearby the detectors stage. For the L/MWIR modules, in order not to over load the cooler cold end, the FEE boxes are mounted on the Instrument Optical Bench (IOB). The FEE thermal coupling to the modules boxes, or to the IOB, shall allow a fast heat transfer to the Telescope Optical Bench (TOB) via the IOB itself. If the warm harness is thermally anchored to the TOB, a possibility may be offered by using the cables as conductive links to efficiently transfer heat from the cold electronics towards the TOB.

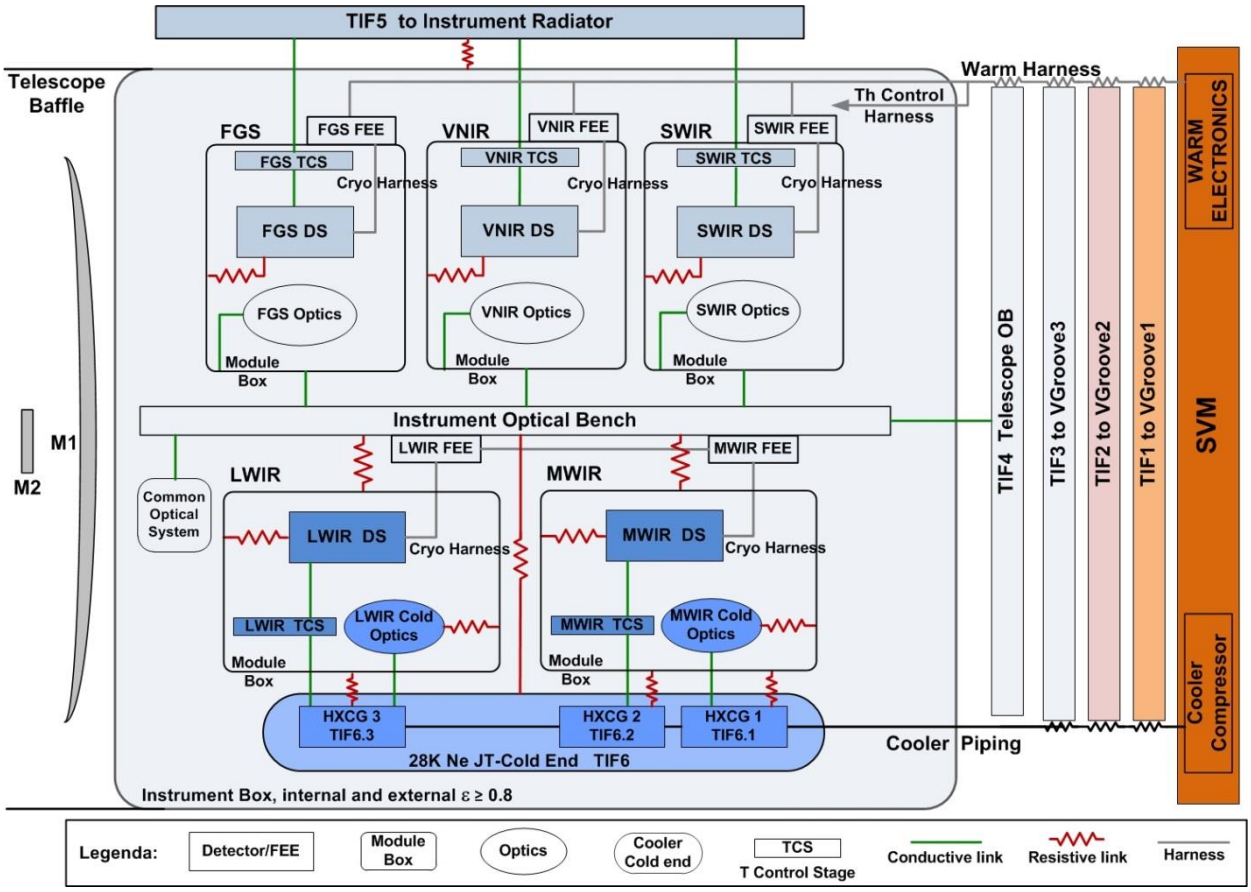

Figure 2-1: EChO thermal scheme with main thermal IF's to S/C

The general scheme of the EChO thermal architecture, with the six main thermal interfaces identified in the study, is shown in Figure 2-1. The FGS, VNIR and SWIR Modules share the same thermal design. The detectors operate at T ≤ 45K, cooled by a dedicated passive radiator stage (Instrument Radiator in Figure 2-1) located inside the cold environment set by the third VGroove and the Telescope Optical Bench (TOB). This radiator is mechanically supported on the Instrument Bench by means of insulating struts and will be under the Instrument responsibility. High conductive links connect the FGS, VNIR and SWIR detectors, through the thermal control stage, to the radiator. The Module Box of the FGS, VNIR and SWIR channels is mechanically supported on the IOB and thermally linked to the bench by using conductive mechanical supports. In this configuration, at steady state, the FGS/VNIR/SWIR optical units are expected to thermally equilibrate with the Instrument Optical Bench (IOB). The MWIR and LWIR detectors technology baseline requires lower operating temperatures, on the order of 30K, to achieve the required sensitivity. This temperature, with a load of tens of mW, can be reached only by using an active cryogenic system that exploits the V-Groove radiators as pre-coolers to improve efficiency and performance. The baseline The MWIR and LWIR module optics shall operate at low temperature, to minimize thermal background noise on the detectors. For this reason part of the internal optical units shall be cooled by the refrigerator and thermally decoupled from the box, to limit heat lift requirements at the cooler heat exchangers. The L/MWIR Module boxes should be thermally decoupled from the IOB as much as possible to minimize heat leak to the cold end.

In order to provide the required cooling to detectors and optical units, the JT cooler cold end is split in three cold heat exchangers, each one supported on the two module boxes by insulating struts. The

detectors and cold optics units will be thermally linked to these references. The LWIR channel cold optics and detectors share the same temperature requirements. A single heat exchanger serves both units. Two separate heat exchangers are devoted to the MWIR optics and detectors, since they can work at different temperature.

In general, each detector stage is thermally decoupled from the relative module box or optics, to ensure optimal performances of the FPA in terms of absolute temperature and stability. Coupling to the temperature reference stage (cooler cold end or radiator) is achieved through a Thermal Control Stage (TCS): this is a detector supporting flange that allocates an active closed loop thermal control system composed by a heater + thermistor couple driven by the ICU.

Instrument radiative thermal control is achieved by proper shielding and by selecting the units IR emissivity. The radiative environment for the modules is set by the Instrument enclosure, defined by the IOB and a MLI/SLI shroud that shields the units from the external environment. The blanket shall have a very low emissivity on the external surface but may require high emissivity in the internal surface to limit straylight leaks (TBC). In this case, internally black coated MLI will be required. The instrument cavity is passively maintained at a temperature ≤45 K by the radiative background set by the VGrooves and Telescope Optical Bench. The radiative coupling between subsystems inside the box is defined by the high IR emissivity requirement ($\varepsilon \geq 0.8$, TBC) needed to minimize straylight radiation contamination in the optical paths of the channels. The mechanical units (boxes and surfaces) inside the instrument cavity will be externally coated with black paint or anodizing (TBC).

The warm electronics will be located in the SVM. All harness from SVM to Instrument channels should be thermally linked to all the passive stages (VG1, VG2, VG3 and TOB) for maximum parasitic interception. In this way the heat leaks due to wiring on the Instrument cooling stages will be minimized. The cryo harness heat leaks to detectors will be controlled by thermally optimizing the harness design with respect to the required electrical performances.

2.2 REDUCED MODEL DESCRIPTION

The EChO reduced TMM is composed by a relatively low number of nodes and conductors and has been implemented in ThermXL but a standard ESATAN type input file is also delivered as an appendix to this document. The model scheme is shown in Figure 2-2.

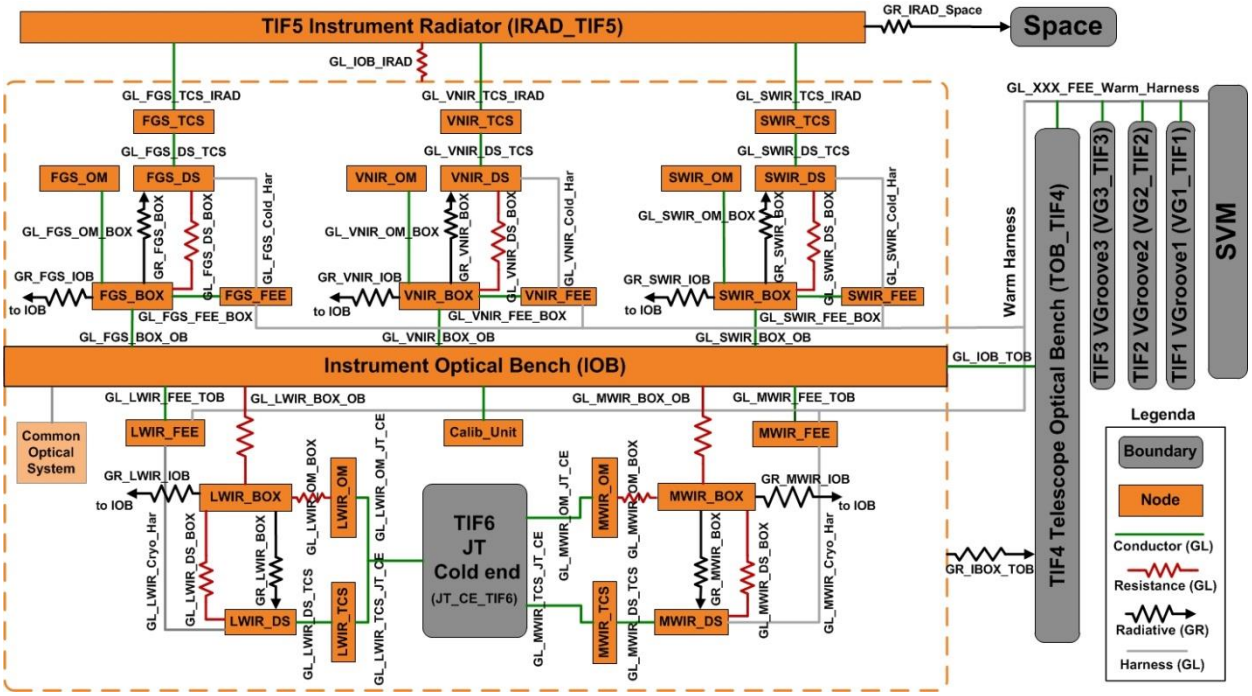

Figure 2-2. EChO reduced TMM scheme

This simplified model has been built to study the thermal behaviour of the system and its compliancy to the main requirements in terms of temperature, stability and heat fluxes allocated at the internal and external thermal interfaces.

The latest version of the reduced TMM is based on the best up-to-date assumptions for detectors and electronics dissipations. The model is Steady State version only, simplified, with few nodes per PLM unit. Each channel module is composed by 5 nodes: the box, the optical system, the detectors, the thermal control stage and the proximity electronics. The instrument cold radiator is a single node coupled to space with properties that replicate the performances of a more detailed TMM describing the radiator behavior. In this reduced steady state model the harness has been simulated as conductive links between stages and units on the basis of the harness analysis reported in [RD2]. The reduced TMM reproduces the thermal architecture scheme shown in Figure 2-1, including the Calibration Unit on the Instrument Optical Bench. The main thermal interfaces are all defined as boundary nodes, with the exception of the Instrument Optical Bench that, due to its strong conductive and radiative coupling, is a mechanical interface more than a thermal one. For this reason it is simulated as a diffusion node and provides an indication of how the whole instrument can follow the boundary environment.

The model has been run in what have been considered Hot and Cold Cases (VG3, IOB, IC at 45K) to bound the range of conductive and radiative environmental conditions.

A transient simple model has been developed for single modules only and it has been used to check units behavior in presence of temperature oscillations at the interfaces. A full PLM transient model will be prepared for the next stages of the study, to evaluate possible issues during cooldown or in case of thermal unbalanced conditions.

In the next table is reported the definition and properties of the conductive (GL) and radiative (GR) main lconductors between nodes. The conductors have been evaluated on the basis of solutions applied in other instruments (MIRI or Planck, for example).

Conductor	GL/GR (W/K or m^2)	Link description	Justification
GL_xxxx_BOX_OB	0.001	Modules Box to Instrument Optical Bench	
GL_xxxx_BOX_OB	0.5	Modules Box to Instrument Optical Bench	Assuming Al struts, 10 cm2 total contact surface with 500 W/m2-K. M5 bolts with spring washers (and filler TBC)
GL_xxxx_DS_BOX	0.0001	Detectors to Module Box insulation	CFRP-T300 struts: 2.5 mm diameter and 30mm long. 6 for each detector + thermal control stage.
GL_xxxx_DS_BOX	0.0003	"	CFRP-T300 struts: 3 mm diameter and 30mm long. 6 for each detector + thermal control stage.
GL_xxxx_OM_BOX	0.5	Optical units to Modules Box	Assuming Al struts, 10 cm2 total contact surface with 500 W/m2-K. M5 bolts with spring washers (and filler TBC)
G_xxxx_DS_TCS	0.01	Detectors to Thermal Control Stages	Achieved by properly sizing contact area at interface and by thermal breaks (316L SS TBC). With 500W/m2-K, 20 mm2 contact area is needed. This can be achieved with 3-4 2.5 mm diameter Al stands (TBC)
G_xxxx_TCS_IRAD	0.05	Thermal Control Stage to Cold Radiator for 45K DS	Required conductance across thermal braid is 0.1W/K. The total G is the series with the surface contact conductance (0.2W/K) between braid and the TCS
G_xxxx_TCS_JT_CE	0.1	Thermal Control Stage to JT HXCG's for 28K DS	Assuming Al units, 2 cm2 total contact surface with 500 W/m2-K. M5 or M4 bolts with spring washers (and filler TBC)
GL_xxxx_FEE_IOB	0.1	Channels FEE to IOB	Assuming Al units, 2 cm2 total contact surface with 500 W/m2-K. M5 bolts with spring washers (and filler TBC)
GL_xxxx_Cold_Har	0.0015	Simulated harness link from 45K to DS	As per MIRI, Euclid NISP and Planck harness, assuming 100 wires, 1m length between each stage and no radiative load. See harness analysis in [RD1].
GL_xxxx_Warm_Har	0.00012	Simulated harness link from VG3 to 40K stage	
GL_IOB_TOB	0.01	IOB struts on TOB	CFRP-T300 (or G10) struts: 30 cm long, 7.5 cm diameter

GL_IOB_IRAD	0.0025	Cold Radiator struts to IOB	G10 struts: 20 cm long, 2 cm diameter with 5mm thick wall.
GR_xxxx_BOX	0.000625	Detectors rad coupling to Module Box	A coupling surface of 25x25mm has been assumed for all detectors plus supporting frame
GR_VNIR/FGS_IOB	0.384	Module box rad coupling to Instrument Bench	Boxes external surface estimated on the basis of CAD drawings. Assumed emissivity ≥0.8 for both Box and IOB
GR_SWIR_IOB	0.208	"	
GR_MWIR_IOB	0.328	"	
GR_LWIR_IOB	0.184	"	
GR_IBOX_TOB	1.22	IOB rad coupling to TOB	Dimensions estimated on the basis of CAD drawings. Assumed emissivity ≥0.8 for both Box and TOB
GR_IBOX_Space	0.16	IOB rad coupling to Space	
GR_IRAD_Space	0.6144	Radiator coupling to Space	Per Radiator design (see [RD1]). Emissivty = 0.8 and Rad efficiency = 0.8

Table 2-2. EChO TMM conductors justification

2.3 REDUCED TMM RESULTS

The model has been run in Steady-State conditions only. Once the Instrument design in terms of materials and coupling solutions will be finalized it will be possible to run meaningful transient analyses.

Two reference cases are indicated in the EID-A: a Hot and a Cold one. An intermediate one, called unofficially "Nominal", has been added by simply considering the average boundary temperatures between the two cases. This intermediate thermal case is used only to present system performances in average conditions, but it is not considered as an official reference.

Boundary	Cold Case (K)	Hot Case (K)	Nominal Case (K)
SVM	253	323	290
VGroove1 TIF1	140	150	145
VGroove2 TIF2	90	110	100
VGroove3 TIF3	35	55	45
Telescope_OB TIF4	35	55	45
JT Coldend TIF6	28	28	28

Table 2-3. TMM Boundary temperature cases

To all model results should be applied the uncertainty relative to this stage of the study, as specified in the present issue of the EID-A [AD2].

2.3.1 Hot Case Results

Nodes definition and final equilibrium temperatures:

Number	Label	Type	ε	Area	QI	T0 [K]	T [K]	Imbalance
10	LWIR_BOX	D	0.8	0.23		55.00	48.8993	5.586E-07
20	LWIR_OM	D	0.8			55.00	28.2071	-6.404E-09
30	LWIR_DS	D	0.9		0.005	55.00	32.1111	9.977E-08
40	LWIR_TCS	D			0.005	55.00	28.4192	-2.142E-08
50	LWIR_FEE	D			0.02	55.00	52.2813	7.949E-06
60	MWIR_BOX	D	0.8	0.41		55.00	50.2254	9.319E-07

70	MWIR_OM	D	0.8			55.00	28.2202	-6.421E-09
80	MWIR_DS	D	0.9		0.005	55.00	32.1235	9.977E-08
90	MWIR_TCS	D			0.005	55.00	28.4203	-2.142E-08
100	MWIR_FEE	D			0.02	55.00	52.2814	7.949E-06
110	SWIR_BOX	D	0.8	0.26		55.00	52.3932	9.013E-05
120	SWIR_OM	D				55.00	52.3932	-3.926E-06
130	SWIR_DS	D	0.9		0.008	55.00	44.8342	4.275E-07
140	SWIR_TCS	D			0.005	55.00	42.6480	1.584E-06
150	SWIR_FEE	D			0.02	55.00	52.4815	-7.912E-07
160	VNIR_BOX	D	0.8	0.48		55.00	52.3937	9.055E-05
170	VNIR_OM	D				55.00	52.3937	-3.923E-06
180	VNIR_DS	D	0.9		0.01	55.00	45.0319	4.274E-07
190	VNIR_TCS	D			0.005	55.00	42.6810	1.584E-06
200	VNIR_FEE	D			0.02	55.00	52.4849	-7.906E-07
210	FGS_BOX	D	0.8	0.48		55.00	52.3937	9.055E-05
220	FGS_OM	D				55.00	52.3937	-3.923E-06
230	FGS_DS	D	0.9		0.01	55.00	45.0319	4.274E-07
240	FGS_TCS	D			0.005	55.00	42.6810	1.584E-06
250	FGS_FEE	D			0.02	55.00	52.4849	-7.906E-07
260	IOB	D	0.8			55.00	52.3806	-4.542E-06
300	Calib_Unit	D			1.80E-03	55.00	52.3986	-8.003E-07
500	IRAD_TIF5	D	0.8	0.96		55.00	42.1108	-4.908E-07
9000	**SVM**	**B**				**323.00**	323.0000	-2.941E-01
9100	**VG1_TIF1**	**B**				**150.00**	150.0000	2.461E-01
9200	**VG2_TIF2**	**B**				**110.00**	110.0000	-7.000E-03
9300	**VG3_TIF3**	**B**				**55.00**	55.0000	5.500E-02
9400	**TOB_TIF4**	**B**				**55.00**	55.0000	-1.400E-01
9600	**JT_TIF6**	**B**				**28.00**	28.0000	1.267E-01
9900	**Space**	**B**				**4.00**	4.0000	1.778E-01

Table 2-4. Hot Case reduced TMM steady state temperatures

Label	First Node	Second Node	Value	Heat Flow
GL_LWIR_BOX_OB	10	260	0.001	-3.48E-03
GL_LWIR_OM_BOX	20	10	0.001	-2.07E-02
GL_LWIR_DS_BOX	30	10	0.0001	-1.68E-03
GL_LWIR_DS_TCS	30	40	0.01	3.69E-02
GL_LWIR_OM_JT_CE	20	9600	0.1	2.07E-02
GL_LWIR_TCS_JT_CE	40	9600	0.1	4.19E-02
GL_LWIR_FEE_IOB	50	260	0.1	-9.94E-03
GL_LWIR_Cold_Har	50	30	0.0015	3.03E-02
GL_LWIR_FEE_Warm_Har	9400	50	0.00012	3.26E-04
GL_MWIR_BOX_OB	60	260	0.001	-2.16E-03
GL_MWIR_OM_BOX	70	60	0.001	-2.20E-02

GL_MWIR_DS_BOX	80	60	0.0001	-1.81E-03
GL_MWIR_DS_TCS	80	90	0.01	3.70E-02
GL_MWIR_OM_JT_CE	70	9600	0.1	2.20E-02
GL_MWIR_TCS_JT_CE	90	9600	0.1	4.20E-02
GL_MWIR_FEE_IOB	100	260	0.1	-9.92E-03
GL_MWIR_Cold_Har	100	80	0.0015	3.02E-02
GL_MWIR_FEE_Warm_Har	9400	100	0.00012	3.26E-04
GL_SWIR_BOX_OB	110	260	0.5	6.27E-03
GL_SWIR_OM_BOX	120	110	0.5	3.93E-06
GL_SWIR_DS_BOX	130	110	0.0003	-2.27E-03
GL_SWIR_DS_TCS	130	140	0.01	2.19E-02
GL_SWIR_TCS_IRAD	140	500	0.05	2.69E-02
GL_SWIR_FEE_BOX	150	110	0.1	8.83E-03
GL_SWIR_Cold_Har	150	130	0.0015	1.15E-02
GL_SWIR_FEE_Warm_Har	9400	150	0.00012	3.02E-04
GL_VNIR_BOX_OB	160	260	0.5	6.54E-03
GL_VNIR_OM_BOX	170	160	0.5	3.92E-06
GL_VNIR_DS_BOX	180	160	0.0003	-2.21E-03
GL_VNIR_DS_TCS	180	190	0.01	2.35E-02
GL_VNIR_TCS_IRAD	190	500	0.05	2.85E-02
GL_VNIR_FEE_BOX	200	160	0.1	9.12E-03
GL_VNIR_Cold_Har	200	180	0.0015	1.12E-02
GL_VNIR_FEE_Warm_Har	9400	200	0.00012	3.02E-04
GL_FGS_BOX_OB	210	260	0.5	6.54E-03
GL_FGS_OM_BOX	220	210	0.5	3.92E-06
GL_FGS_DS_BOX	230	210	0.0003	-2.21E-03
GL_FGS_DS_TCS	230	240	0.01	2.35E-02
GL_FGS_TCS_IRAD	240	500	0.05	2.85E-02
GL_FGS_FEE_BOX	250	210	0.1	9.12E-03
GL_FGS_Cold_Har	250	230	0.0015	1.12E-02
GL_FGS_FEE_Warm_Har	9400	250	0.00012	3.02E-04
GL_IOB_TOB	260	9400	0.01	-2.62E-02
GL_Warm_Har_SVM_VG1	9000	9100	0.0017	2.94E-01
GL_Warm_Har_VG1_VG2	9100	9200	0.0012	4.80E-02
GL_Warm_Har_VG2_VG3	9200	9300	0.001	5.50E-02
GL_Warm_Har_VG3_TOB	9300	9400	0.00053	0.00E+00
GL_Calib_Unit_IOB	300	260	0.1	1.80E-03
GL_IOB_IRAD	260	500	0.0025	2.57E-02
ThermXL GRs	**(GRs are directly defined as values)**			
Label	**First Node**	**Second Node**	**Value**	**Heat Flow**
GR_LWIR_IOB	10	260	0.184	-1.889E-02
GR_LWIR_BOX	30	20	0.000625	1.525E-05

GR_MWIR_IOB	60	260	0.328	-2.166E-02
GR_MWIR_BOX	80	70	0.000625	1.526E-05
GR_SWIR_IOB	110	260	0.208	8.505E-05
GR_SWIR_BOX	130	110	0.000625	-1.239E-04
GR_VNIR_IOB	160	260	0.384	1.639E-04
GR_VNIR_BOX	180	160	0.000625	-1.213E-04
GR_FGS_IOB	210	260	0.384	1.639E-04
GR_FGS_BOX	230	210	0.000625	-1.213E-04
GR_IBOX_TOB	260	9400	1.22	-1.122E-01
GR_IBOX_Space	260	9900	0.16	6.830E-02
GR_IRAD_Space	500	9900	0.6144	1.096E-01

Table 2-5. Hot Case conductors heat flow

The total loads at each main interfaces are reported in the following table:

TIF	Load (W)
VG1_TIF1	0.246
VG2_TIF2	-0.007
VG3_TIF3	0.055
Telescope Optical Bench TIF4	-0.140
Cold Radiator TIF5 (rejected to Space)	0.110
JT Coldend TIF6	0.127

Table 2-6. Hot Case net loads at the main TIF's

In the reduced model the VGrooves are used only as boundary parasitic interception stages. For this reason, the intermediate VGroove always shows low or negative heat loads. The loads on VG1, VG2 and VG3 should not be considered as indicative of what the instrument can actually load on those stages but only as an indication of the harness contribution at these stages.

The negative load on the TOB is due to the fact that this is a boundary with hot case temperature imposed. In reality it will equilibrate around the IOB and the telescope baffle temperature.

2.3.2 Cold Case Results

Nodes definition and final equilibrium temperatures:

Number	Label	Type	ε	Area	QI	T0 [K]	T [K]	Imbalance
10	LWIR_BOX	D	0.8	0.23		55.00	34.4021	-2.227E-08
20	LWIR_OM	D	0.8			55.00	28.0634	-2.963E-12
30	LWIR_DS	D	0.9		0.005	55.00	29.8116	-7.840E-08
40	LWIR_TCS	D			0.005	55.00	28.2101	1.798E-16
50	LWIR_FEE	D			0.02	55.00	36.8528	-7.266E-07
60	MWIR_BOX	D	0.8	0.41		55.00	35.0692	-3.404E-08
70	MWIR_OM	D	0.8			55.00	28.0701	-3.168E-12
80	MWIR_DS	D	0.9		0.005	55.00	29.8179	-7.843E-08
90	MWIR_TCS	D			0.005	55.00	28.2107	2.168E-18
100	MWIR_FEE	D			0.02	55.00	36.8529	-7.266E-07
110	SWIR_BOX	D	0.8	0.26		55.00	36.7970	-6.584E-06

120	SWIR_OM	D				55.00	36.7970	0.000E+00
130	SWIR_DS	D	0.9		0.008	55.00	36.1162	-2.177E-07
140	SWIR_TCS	D			0.005	55.00	35.1655	6.904E-08
150	SWIR_FEE	D			0.02	55.00	36.9817	9.918E-16
160	VNIR_BOX	D	0.8	0.48		55.00	36.7976	-6.597E-06
170	VNIR_OM	D				55.00	36.7976	0.000E+00
180	VNIR_DS	D	0.9		0.01	55.00	36.3140	-2.177E-07
190	VNIR_TCS	D			0.005	55.00	35.1984	6.904E-08
200	VNIR_FEE	D			0.02	55.00	36.9851	-2.930E-16
210	FGS_BOX	D	0.8	0.48		55.00	36.7976	-6.597E-06
220	FGS_OM	D				55.00	36.7976	0.000E+00
230	FGS_DS	D	0.9		0.01	55.00	36.3140	-2.177E-07
240	FGS_TCS	D			0.005	55.00	35.1984	6.904E-08
250	FGS_FEE	D			0.02	55.00	36.9851	-2.930E-16
260	IOB	D	0.8			55.00	36.7607	3.131E-06
300	Calib_Unit	D			1.80E-03	55.00	36.7787	8.283E-17
500	IRAD_TIF5	D	0.8	0.96		55.00	34.8753	1.944E-15
9000	**SVM**	**B**				**253.00**	253.0000	-1.921E-01
9100	**VG1_TIF1**	**B**				**140.00**	140.0000	1.321E-01
9200	**VG2_TIF2**	**B**				**90.00**	90.0000	5.000E-03
9300	**VG3_TIF3**	**B**				**35.00**	35.0000	5.500E-02
9400	**TOB_TIF4**	**B**				**35.00**	35.0000	4.128E-02
9600	**JT_TIF6**	**B**				**28.00**	28.0000	5.544E-02
9900	**Space**	**B**				**4.00**	4.0000	6.810E-02

Table 2-7. Cold Case reduced TMM steady state temperatures

Label	First Node	Second Node	Value	Heat Flow
GL_LWIR_BOX_OB	10	260	0.001	-2.36E-03
GL_LWIR_OM_BOX	20	10	0.001	-6.34E-03
GL_LWIR_DS_BOX	30	10	0.0001	-4.59E-04
GL_LWIR_DS_TCS	30	40	0.01	1.60E-02
GL_LWIR_OM_JT_CE	20	9600	0.1	6.34E-03
GL_LWIR_TCS_JT_CE	40	9600	0.1	2.10E-02
GL_LWIR_FEE_IOB	50	260	0.1	9.22E-03
GL_LWIR_Cold_Har	50	30	0.0015	1.06E-02
GL_LWIR_FEE_Warm_Har	9400	50	0.00012	-2.22E-04
GL_MWIR_BOX_OB	60	260	0.001	-1.69E-03
GL_MWIR_OM_BOX	70	60	0.001	-7.00E-03
GL_MWIR_DS_BOX	80	60	0.0001	-5.25E-04
GL_MWIR_DS_TCS	80	90	0.01	1.61E-02
GL_MWIR_OM_JT_CE	70	9600	0.1	7.01E-03
GL_MWIR_TCS_JT_CE	90	9600	0.1	2.11E-02
GL_MWIR_FEE_IOB	100	260	0.1	9.23E-03

GL_MWIR_Cold_Har	100	80	0.0015	1.06E-02
GL_MWIR_FEE_Warm_Har	9400	100	0.00012	-2.22E-04
GL_SWIR_BOX_OB	110	260	0.5	1.82E-02
GL_SWIR_OM_BOX	120	110	0.5	0.00E+00
GL_SWIR_DS_BOX	130	110	0.0003	-2.04E-04
GL_SWIR_DS_TCS	130	140	0.01	9.51E-03
GL_SWIR_TCS_IRAD	140	500	0.05	1.45E-02
GL_SWIR_FEE_BOX	150	110	0.1	1.85E-02
GL_SWIR_Cold_Har	150	130	0.0015	1.30E-03
GL_SWIR_FEE_Warm_Har	9400	150	0.00012	-2.38E-04
GL_VNIR_BOX_OB	160	260	0.5	1.85E-02
GL_VNIR_OM_BOX	170	160	0.5	0.00E+00
GL_VNIR_DS_BOX	180	160	0.0003	-1.45E-04
GL_VNIR_DS_TCS	180	190	0.01	1.12E-02
GL_VNIR_TCS_IRAD	190	500	0.05	1.62E-02
GL_VNIR_FEE_BOX	200	160	0.1	1.88E-02
GL_VNIR_Cold_Har	200	180	0.0015	1.01E-03
GL_VNIR_FEE_Warm_Har	9400	200	0.00012	-2.38E-04
GL_FGS_BOX_OB	210	260	0.5	1.85E-02
GL_FGS_OM_BOX	220	210	0.5	0.00E+00
GL_FGS_DS_BOX	230	210	0.0003	-1.45E-04
GL_FGS_DS_TCS	230	240	0.01	1.12E-02
GL_FGS_TCS_IRAD	240	500	0.05	1.62E-02
GL_FGS_FEE_BOX	250	210	0.1	1.88E-02
GL_FGS_Cold_Har	250	230	0.0015	1.01E-03
GL_FGS_FEE_Warm_Har	9400	250	0.00012	-2.38E-04
GL_IOB_TOB	260	9400	0.01	1.76E-02
GL_Warm_Har_SVM_VG1	9000	9100	0.0017	1.92E-01
GL_Warm_Har_VG1_VG2	9100	9200	0.0012	6.00E-02
GL_Warm_Har_VG2_VG3	9200	9300	0.001	5.50E-02
GL_Warm_Har_VG3_TOB	9300	9400	0.00053	0.00E+00
GL_Calib_Unit_IOB	300	260	0.1	1.80E-03
GL_IOB_IRAD	260	500	0.0025	4.71E-03
ThermXL GRs	**(GRs are directly defined as values)**			
Label	**First Node**	**Second Node**	**Value**	**Heat Flow**
GR_LWIR_IOB	10	260	0.184	-4.439E-03
GR_LWIR_BOX	30	20	0.000625	6.011E-06
GR_MWIR_IOB	60	260	0.328	-5.833E-03
GR_MWIR_BOX	80	70	0.000625	6.014E-06
GR_SWIR_IOB	110	260	0.208	8.533E-05
GR_SWIR_BOX	130	110	0.000625	-4.677E-06
GR_VNIR_IOB	160	260	0.384	1.599E-04

GR_VNIR_BOX	180	160	0.000625	-3.349E-06
GR_FGS_IOB	210	260	0.384	1.599E-04
GR_FGS_BOX	230	210	0.000625	-3.349E-06
GR_IBOX_TOB	260	9400	1.22	2.252E-02
GR_IBOX_Space	260	9900	0.16	1.657E-02
GR_IRAD_Space	500	9900	0.6144	5.153E-02

Table 2-8. Cold Case conductors heat flow

The total loads at each main interfaces are reported in the following table:

TIF	Load (W)
VG1_TIF1	0.132
VG2_TIF2	0.005
VG3_TIF3	0.055
Telescope Optical Bench TIF4	0.041
Cold Radiator TIF5 (rejected to Space)	0.052
JT Coldend TIF6	0.055

Table 2-9. Cold Case net loads at the main TIF's

2.3.3 Nominal Case Results

Nodes definition and final equilibrium temperatures:

Number	Label	Type	ε	Area	QI	T0 [K]	T [K]	Imbalance
10	LWIR_BOX	D	0.8	0.23		55.00	40.7739	9.777E-08
20	LWIR_OM	D	0.8			55.00	28.1266	1.051E-08
30	LWIR_DS	D	0.9		0.005	55.00	30.8786	1.714E-08
40	LWIR_TCS	D			0.005	55.00	28.3071	-4.523E-07
50	LWIR_FEE	D			0.02	55.00	44.0351	1.797E-06
60	MWIR_BOX	D	0.8	0.41		55.00	41.8804	1.582E-07
70	MWIR_OM	D	0.8			55.00	28.1375	-5.747E-09
80	MWIR_DS	D	0.9		0.005	55.00	30.8889	1.618E-08
90	MWIR_TCS	D			0.005	55.00	28.3081	-4.499E-07
100	MWIR_FEE	D			0.02	55.00	44.0352	1.797E-06
110	SWIR_BOX	D	0.8	0.26		55.00	44.0575	2.350E-05
120	SWIR_OM	D				55.00	44.0576	-1.283E-05
130	SWIR_DS	D	0.9		0.008	55.00	40.3945	2.045E-07
140	SWIR_TCS	D			0.005	55.00	38.9097	2.549E-07
150	SWIR_FEE	D			0.02	55.00	44.2014	-2.559E-06
160	VNIR_BOX	D	0.8	0.48		55.00	44.0581	2.357E-05
170	VNIR_OM	D				55.00	44.0581	-1.283E-05
180	VNIR_DS	D	0.9		0.01	55.00	40.5922	2.044E-07
190	VNIR_TCS	D			0.005	55.00	38.9427	2.548E-07
200	VNIR_FEE	D			0.02	55.00	44.2049	-2.559E-06
210	FGS_BOX	D	0.8	0.48		55.00	44.0581	2.357E-05
220	FGS_OM	D				55.00	44.0581	-1.283E-05
230	FGS_DS	D	0.9		0.01	55.00	40.5922	2.044E-07

240	FGS_TCS	D			0.005	55.00	38.9427	2.548E-07
250	FGS_FEE	D			0.02	55.00	44.2049	-2.559E-06
260	IOB	D	0.8			55.00	44.0313	-4.154E-05
300	Calib_Unit	D			1.80E-03	55.00	44.0493	-1.709E-06
500	IRAD_TIF5	D	0.8	0.96		55.00	38.5127	-2.015E-06
9000	**SVM**	**B**				**290.00**	290.0000	-2.465E-01
9100	**VG1_TIF1**	**B**				**145.00**	145.0000	1.925E-01
9200	**VG2_TIF2**	**B**				**100.00**	100.0000	-1.000E-03
9300	**VG3_TIF3**	**B**				**45.00**	45.0000	5.500E-02
9400	**TOB_TIF4**	**B**				**45.00**	45.0000	-3.386E-02
9600	**JT_TIF6**	**B**				**28.00**	28.0000	8.793E-02
9900	**Space**	**B**				**4.00**	4.0000	1.107E-01

Table 2-10. Nominal Case reduced TMM steady state temperatures

Label	First Node	Second Node	Value	Heat Flow
GL_LWIR_BOX_OB	10	260	0.001	-3.26E-03
GL_LWIR_OM_BOX	20	10	0.001	-1.26E-02
GL_LWIR_DS_BOX	30	10	0.0001	-9.90E-04
GL_LWIR_DS_TCS	30	40	0.01	2.57E-02
GL_LWIR_OM_JT_CE	20	9600	0.1	1.27E-02
GL_LWIR_TCS_JT_CE	40	9600	0.1	3.07E-02
GL_LWIR_FEE_IOB	50	260	0.1	3.79E-04
GL_LWIR_Cold_Har	50	30	0.0015	1.97E-02
GL_LWIR_FEE_Warm_Har	9400	50	0.00012	1.16E-04
GL_MWIR_BOX_OB	60	260	0.001	-2.15E-03
GL_MWIR_OM_BOX	70	60	0.001	-1.37E-02
GL_MWIR_DS_BOX	80	60	0.0001	-1.10E-03
GL_MWIR_DS_TCS	80	90	0.01	2.58E-02
GL_MWIR_OM_JT_CE	70	9600	0.1	1.38E-02
GL_MWIR_TCS_JT_CE	90	9600	0.1	3.08E-02
GL_MWIR_FEE_IOB	100	260	0.1	3.95E-04
GL_MWIR_Cold_Har	100	80	0.0015	1.97E-02
GL_MWIR_FEE_Warm_Har	9400	100	0.00012	1.16E-04
GL_SWIR_BOX_OB	110	260	0.5	1.31E-02
GL_SWIR_OM_BOX	120	110	0.5	1.28E-05
GL_SWIR_DS_BOX	130	110	0.0003	-1.10E-03
GL_SWIR_DS_TCS	130	140	0.01	1.48E-02
GL_SWIR_TCS_IRAD	140	500	0.05	1.98E-02
GL_SWIR_FEE_BOX	150	110	0.1	1.44E-02
GL_SWIR_Cold_Har	150	130	0.0015	5.71E-03
GL_SWIR_FEE_Warm_Har	9400	150	0.00012	9.58E-05
GL_VNIR_BOX_OB	160	260	0.5	1.34E-02
GL_VNIR_OM_BOX	170	160	0.5	1.28E-05
GL_VNIR_DS_BOX	180	160	0.0003	-1.04E-03

GL_VNIR_DS_TCS	180	190	0.01	1.65E-02
GL_VNIR_TCS_IRAD	190	500	0.05	2.15E-02
GL_VNIR_FEE_BOX	200	160	0.1	1.47E-02
GL_VNIR_Cold_Har	200	180	0.0015	5.42E-03
GL_VNIR_FEE_Warm_Har	9400	200	0.00012	9.54E-05
GL_FGS_BOX_OB	210	260	0.5	1.34E-02
GL_FGS_OM_BOX	220	210	0.5	1.28E-05
GL_FGS_DS_BOX	230	210	0.0003	-1.04E-03
GL_FGS_DS_TCS	230	240	0.01	1.65E-02
GL_FGS_TCS_IRAD	240	500	0.05	2.15E-02
GL_FGS_FEE_BOX	250	210	0.1	1.47E-02
GL_FGS_Cold_Har	250	230	0.0015	5.42E-03
GL_FGS_FEE_Warm_Har	9400	250	0.00012	9.54E-05
GL_IOB_TOB	260	9400	0.01	-9.69E-03
GL_Warm_Har_SVM_VG1	9000	9100	0.0017	2.47E-01
GL_Warm_Har_VG1_VG2	9100	9200	0.0012	5.40E-02
GL_Warm_Har_VG2_VG3	9200	9300	0.001	5.50E-02
GL_Warm_Har_VG3_TOB	9300	9400	0.00053	0.00E+00
GL_Calib_Unit_IOB	300	260	0.1	1.80E-03
GL_IOB_IRAD	260	500	0.0025	1.38E-02
ThermXL GRs	**(GRs are directly defined as values)**			
Label	**First Node**	**Second Node**	**Value**	**Heat Flow**
GR_LWIR_IOB	10	260	0.184	-1.038E-02
GR_LWIR_BOX	30	20	0.000625	1.004E-05
GR_MWIR_IOB	60	260	0.328	-1.269E-02
GR_MWIR_BOX	80	70	0.000625	1.005E-05
GR_SWIR_IOB	110	260	0.208	1.059E-04
GR_SWIR_BOX	130	110	0.000625	-3.917E-05
GR_VNIR_IOB	160	260	0.384	1.993E-04
GR_VNIR_BOX	180	160	0.000625	-3.732E-05
GR_FGS_IOB	210	260	0.384	1.993E-04
GR_FGS_BOX	230	210	0.000625	-3.732E-05
GR_IBOX_TOB	260	9400	1.22	-2.365E-02
GR_IBOX_Space	260	9900	0.16	3.410E-02
GR_IRAD_Space	500	9900	0.6144	7.664E-02

Table 2-11. Nominal Case conductors heat flow

The total loads at each main interfaces are reported in the following table:

TIF	Load (W)
VG1_TIF1	0.193
VG2_TIF2	-0,001
VG3_TIF3	0.055
Telescope Optical Bench TIF4	-0.340

Instrument Radiator TIF5 to Space	0.077
JT Coldend TIF6	0.088

Table 2-12. Nominal Case net loads at the main TIF's

3 PLM THERMAL MATHEMATICAL MODEL AND GEOMETRICAL MATHEMATICAL MODEL

3.1 MODEL DESCRIPTION

The GMM is based on the coupling of a “standard” M-size SVM with a possible configuration for the cold passive PLM. In the model are simulated the main radiative surfaces and representative supporting structures between the different stages.

The model consist of a prebuilt model of the spacecraft, 1.1 version update of the model described in the EChO ESA GMM/TMM Technical Note, that has been modified for Instrument analysis purposes. The model has been integrated with more detailed definitions of the instrument modules and with a preliminary configuration of the cold radiator.

The main units that contribute to the thermal balance of the whole PLM model are listed in the following table together with the sub-model definitions and the node numbering

Main components	Submodel	Node #	Bulk Material	Emissivity
SVM	SPACECRAFT	1xxx	Al 6061	0.9, 0.8 or 0.05
V-Groove1	SPACECRAFT	2xxx	Al 6061	0.05
V-Groove2	SPACECRAFT	3xxx	Al 6061	0.05
V-Groove3	SPACECRAFT	4xxx	Al 6061	0.9 or 0.05
Telescope Optical Bench	SPACECRAFT	50xx	SiC	0.8
Telescope Baffle	SPACECRAFT	52xx	Al 6063	0.9
Instrument Box	SPACECRAFT	6xxx	Al 6063	0.05
Struts	SPACECRAFT	7xxx	GFRP	0.8
Instrument Optical Bench	IOB:OPTICAL_BENCH	8xxx	Al 6061	0.2
Telescope Mirrors	SPACECRAFT	10xxx	SiC	0.02
VNIR	IOB:VNIR_MOD	15xxx	Al 6061	0.2
SWIR	IOB:SWIR_MOD	2xxxx	Al 6061	0.2
MWIR	IOB:MWIR_MOD	3xxxx	Al 6061	0.2
LWIR	IOB	4xxxx	Al 6061	0.2
FGS	IOB	5xxxx	Al 6061	0.2
Cold Radiator	Main level	7xxxx	Al 6061	0.8 or 0.05

The cold-end at 28K is represented as a boundary inside the Instrument box and it is defined at the main hierarchical level of the model. The instrument module optical units and detectors are represented by dedicated non geometric nodes, so that their radiative exchanges are considered negligible at this level of analysis. A preliminary evaluation of such radiative loads is provided by the reduced TMM results (see Chapter 2).

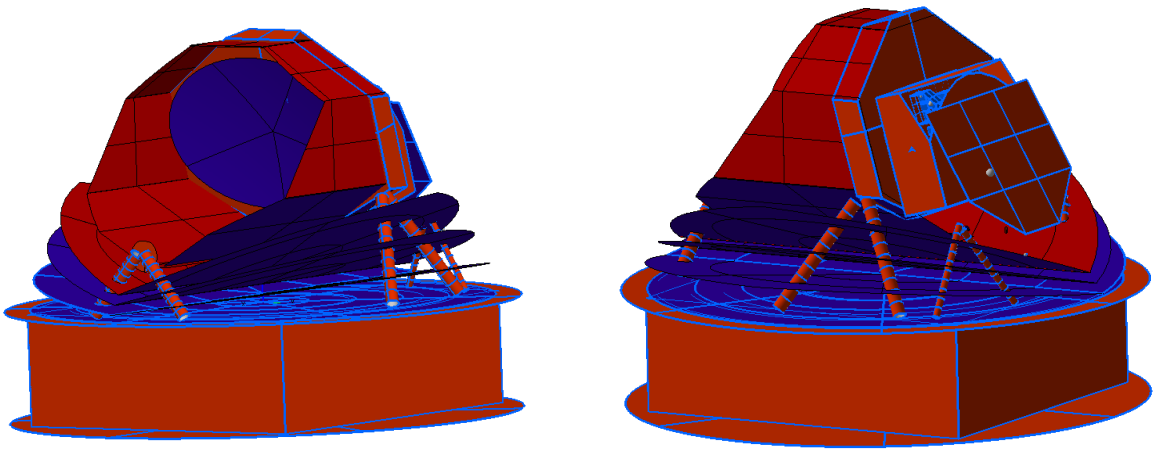

Figure 3-1. EChO geometric model view from two sides. On the right panel the radiator is visible on top of the instrument cover.

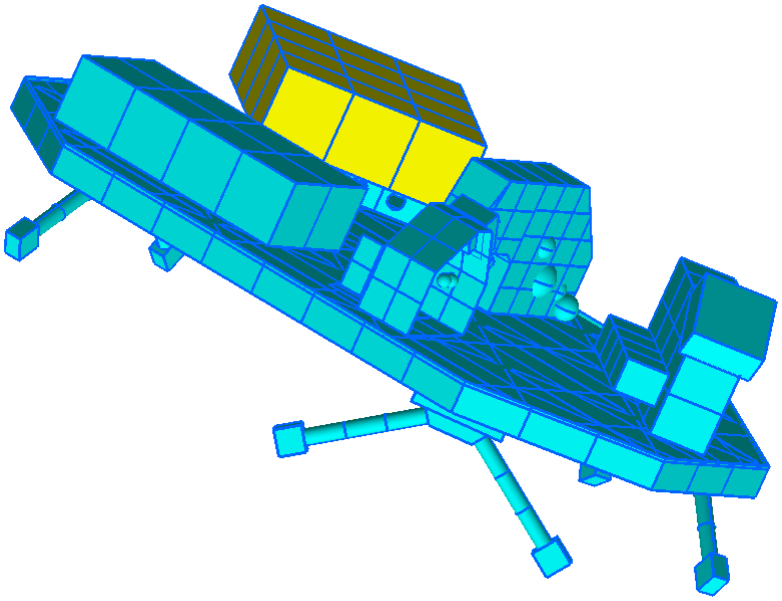

Figure 3-2. A view of the Instrument optical bench geometric model with the main units

Conductive links have been added between the Instrument units and their respective temperature reference (the IOB, the cold Radiator, the JT coldend), using the same conductance values defined in the reduced TMM (Table 2-2), that represent the best up-to-date assumptions in terms of requirements and couplings:

- GL(15200,15117) = 0.100000; # conductor from VNIR FEE to BOX
- GL(29000,20301) = 0.100000; # conductor from SWIR FEE to BOX
- GL(52000,50013) = 0.100000; # conductor from FGS FEE to BOX
- GL(42000,Optical_Bench:OB:8108) = 0.100000; # conductor from LWIR FEE to IOB
- GL(MWIR_Mod:32000,Optical_Bench:OB:8001) = 0.100000; # conductor from MWIR FEE to IOB
- GL(15200,15900) = 0.00150000; # conductor from VNIR detector to FEE
- GL(32000,30093) = 0.00150000; # conductor from MWIR detector to FEE
- GL(29000,29604) = 0.00150000; # conductor from SWIR detector to FEE

- GL(42000,40500) = 0.00150000; # conductor from LWIR detector to FEE
- GL(52000,51000) = 0.00150000; # conductor from FGS detector to FEE
- GL(IOB:42000,SPACECRAFT:5013) = 0.000120000; # conductor from LWIR FEE to TOB
- GL(IOB:52000,SPACECRAFT:5014) = 0.000120000; # conductor from FGS FEE to TOB
- GL(IOB:MWIR_Mod:32000,SPACECRAFT:5012) = 0.000120000; # conductor from MWIR FEE to TOB
- GL(IOB:SWIR_Mod:29000,SPACECRAFT:5013) = 0.000120000; # conductor from SWIR FEE to TOB
- GL(IOB:VNIR_Mod:15200,SPACECRAFT:5015) = 0.000120000; # conductor from VNIR FEE to TOB
- GL(15900,15109) = 0.000300000; # conductor from VNIR BOX Detector
- GL(29604,20502) = 0.000300000; # conductor from SWIR BOX to Detector
- GL(30093,32507) = 0.0001; # conductor from MWIR BOX to Detector
- GL(40016,Optical_Bench:OB:8108) = 0.00100000; # conductor from LWIR to IOB
- GL(40501,40017) = 0.0001; # conductor from LWIR BOX to Detextor
- GL(50017,Optical_Bench:OB:8022) = 0.500000; # conductor from FGS BOX to IOB
- GL(51000,50021) = 0.000300000; # conductor from FGS BOX to detector
- GL(IOB:40500,80000) = 0.10000; # conductor from LWIR Detector to Cooler
- GL(IOB:MWIR_Mod:30093,80000) = 0.10000; # conductor from MWIR Detector to Cooler
- GL(IOB:MWIR_Mod:32500,80000) = 0.10000; # conductor from MWIR optics to Cooler
- GL(IOB:51000,70004) = 0.050000; # conductor from FGS Detector to Radiator
- GL(IOB:SWIR_Mod:29604,70004) = 0.050000; # conductor from SWIR Detector to Radiator
- GL(IOB:VNIR_Mod:15900,70004) = 0.050000; # conductor from VNIR Detector to Radiator
- GL(MWIR_Mod:37000,Optical_Bench:OB:8002) = 0.00100000; # conductor from MWIR BOX to IOB
- GL(SWIR_Mod:20201,Optical_Bench:OB:8021) = 0.500000; # conductor from SWIR BOX to IOB
- GL(VNIR_Mod:15115,Optical_Bench:OB:8201) = 0.150000; # conductor from VNIR to IOB
- GL(VNIR_Mod:15118,Optical_Bench:OB:8014) = 0.150000; # conductor from VNIR to IOB
- GL(VNIR_Mod:15122,Optical_Bench:OB:8007) = 0.150000; # conductor from VNIR to IOB
- GL(VNIR_Mod:15125,Optical_Bench:OB:8003) = 0.150000; # conductor from VNIR to IOB
- GL(70001,SPACECRAFT:6005) = 0.000520000; # conductor from Radiator to IOB Cover
- GL(70003,SPACECRAFT:6003) = 0.000520000; # conductor from Radiator to IOB Cover
- GL(70005,SPACECRAFT:6001) = 0.000520000; # conductor from Radiator to IOB Cover
- GL(70007,SPACECRAFT:6002) = 0.000520000; # conductor from Radiator to IOB Cover

At the moment, the detectors thermal control stages are not taken into consideration in the Geometrical model and the detectors are directly coupled to their temperature references.

FEE nodes have been added to simulate their loads on the PLM and Instrument units

3.2 PLM TMM/GMM MODEL RESULTS

A radiative case is run simulating one position in the solar L2 orbit at a distance of 151500000 Km.

The radiative exchange factors found are the input for the thermal case definition. A set of nodes and conductors that are not automatically created by the ESATAN workbench are added in the model and identified with a comment (# character in sequence) in the .d file.

The final model is run with the following boundary conditions for the dissipation on the different component:

- FGS detector power dissipation = 10 mW
- LWIR detector power dissipation = 5 mW
- MWIR detector power dissipation = 5 mW
- SWIR detector power dissipation = 8 mW
- VNIR detector power dissipation = 10 mW
- FGS FEE power dissipation = 20 mW
- LWIR FEE power dissipation = 20 mW
- MWIR FEE power dissipation = 20 mW
- SWIR FEE power dissipation = 20 mW
- VNIR FEE power dissipation = 20 mW
- SVM power dissipation = 1200 W
- Power dissipation on VG1 = 0.3 W
- Power dissipation on VG2 = 0.3 W
- Power dissipation on VG3 = 0.3 W

The current version of the model is composed by 920 nodes. In the following table are reported the average values of each unit temperature.

System	Sub-system	Unit	T (K)
SVM	Solar Array		312.95
	SVM average		249.30
VG1			148.81
VG2			93.05
VG3			48.30
Telescope	M1		33.34
	M2		33.42
	M3		33.34
	M4		33.34
	OB		33.34
	Baffle		32.89
Instrument	Optical Bench		37.49
	FGS	Box	37.57
		Detectors	35.02
		FEE	37.72
	VNIR	Box	37.52
		Optics	37.52
		Detectors	35.01
		FEE	37.68
	SWIR	Box	37.57
		Optics	37.56
		Detectors	34.98
		FEE	37.74
	MWIR	Box	36.98
		Optics	28.01
		Detectors	28.19

		FEE	37.55
	LWIR	Box	35.98
		Optics	28.20
		Detectors	28.20
		FEE	37.55
	Radiator		34.72

Table 3-1. TMM/GMM Units average temperature

The unit temperatures are graphically shown in the next figures.

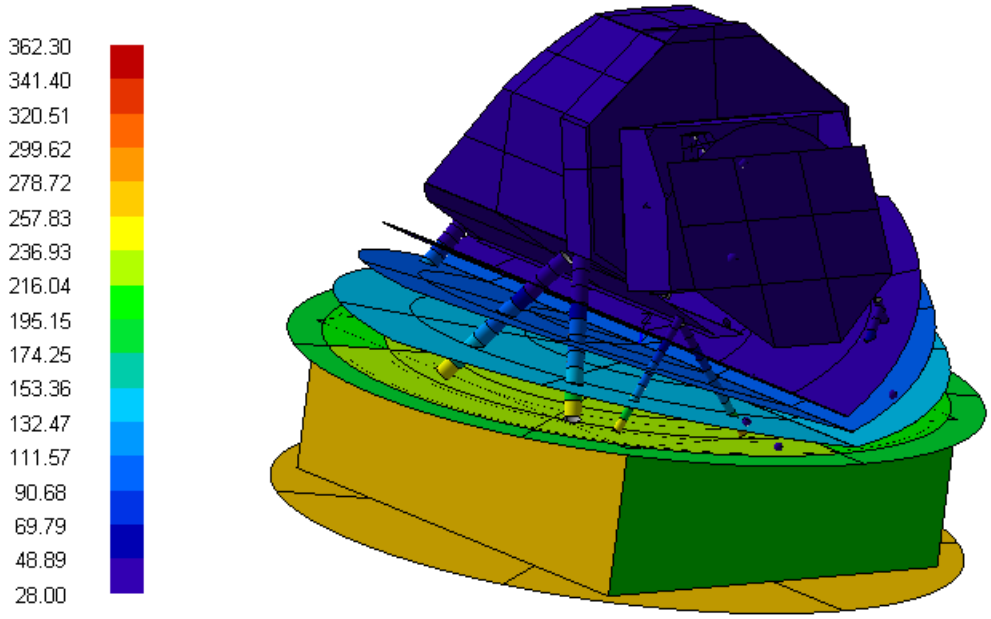

Figure 3-3. Spacecraft average temperatures

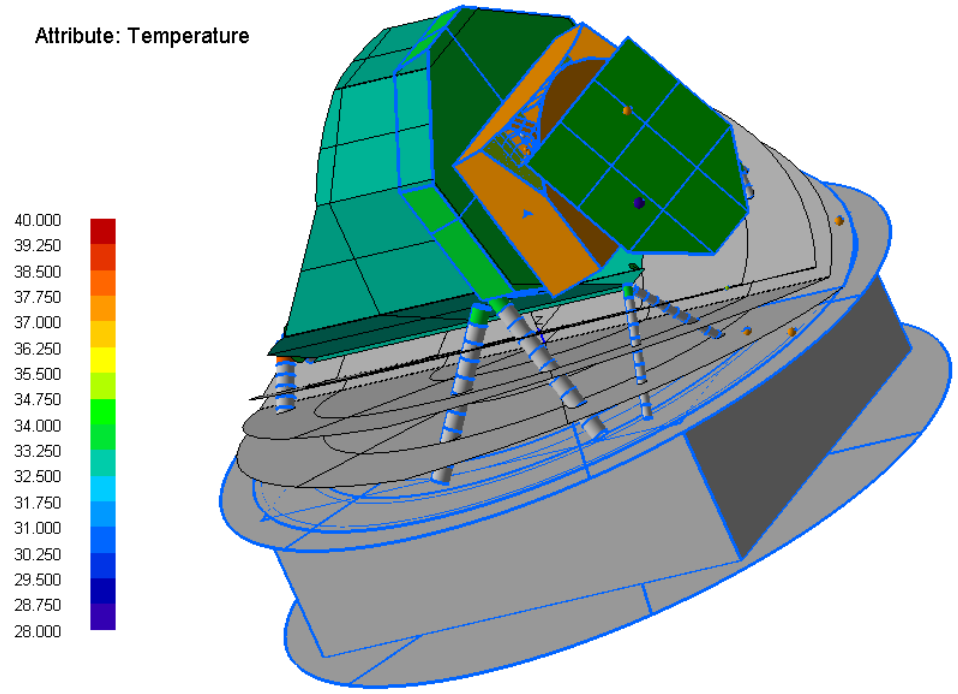

Figure 3-4. Cold PLM main units temperature

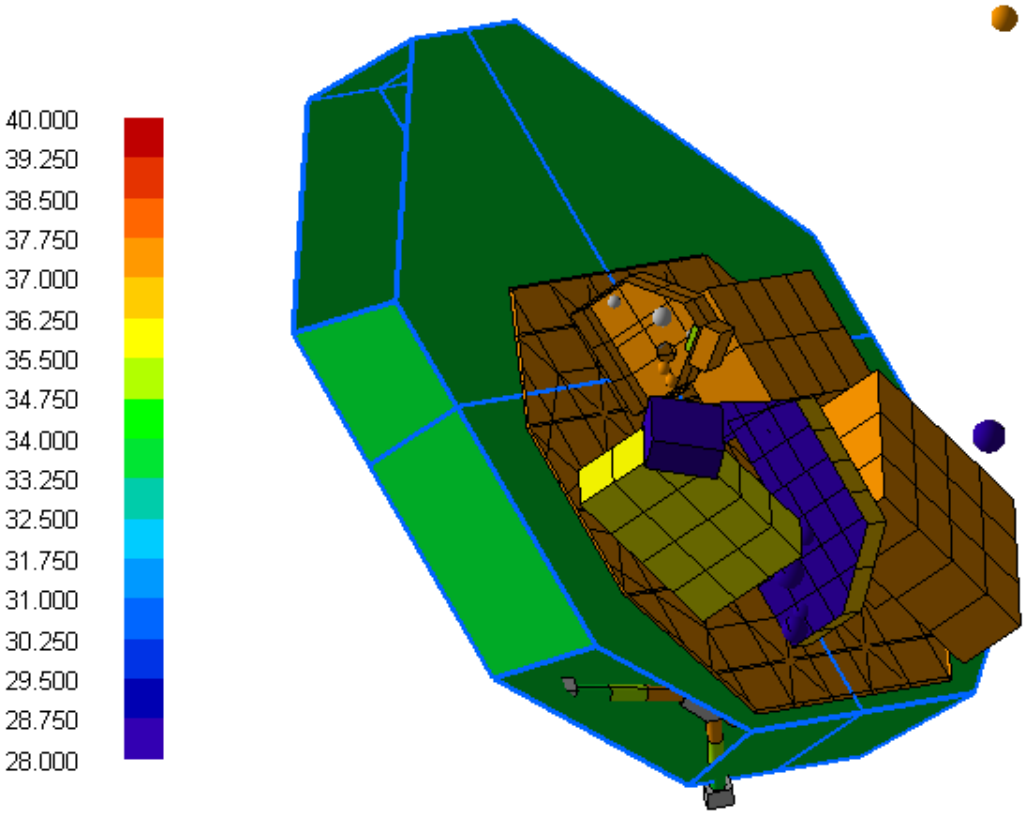

Figure 3-5. Instrument Optical Bench and Module boxes

The loads to the Instrument interfaces are evaluated by balancing the input/output heat fluxes to/from each node through all conductors. The most relevant values through the main couplings n the GMM are:

- Radiative heat from space to instrument cover surface is: -7.47992034772345694E-003

- Radiative heat from space to Radiator inner surface is: -8.25506236079781314E-004
- Radiative heat from space to Radiator outer surface is: -6.27419456086296540E-002
- Radiative heat from IOB cover to Radiator inner surface is: 9.43904723054173468E-005
- Radiative heat from IOB cover to Radiator outer surface is: 1.20232672788149245E-007
- Radiative heat from vg3 to Radiator inner surface is: 5.83622157551581290E-003
- Radiative heat from vg3 to Radiator outer surface is: 1.05777462074945578E-003
- Radiative heat from vg2 to Radiator inner surface is: 0.0000000000000000
- Radiative heat from vg2 to Radiator outer surface is: 7.40393368155039021E-006
- Radiative heat from vg1 to Radiator inner surface is: 0.0000000000000000
- Radiative heat from vg1 to Radiator outer surface is: 1.20343129300678383E-005
- Radiative heat from SVM top to Radiator inner surface is: 0.0000000000000000
- Radiative heat from SVM top to Radiator outer surface is: 7.18098287033419776E-003
- Conductive heat from spacecraft to Radiator inner surface is: 5.74189896159857036E-003
- Conductive heat from detectors to Radiator inner surface is: 4.25011415107903190E-002

For the Instrument internal thermal analysis the main interfaces are the Cold Radiator and the JT cooler cold-end. The resulting heat flux values are reported in the following table:

Instrument Thermal Interface	Thermal Path	Heat flux (W)
Cold Radiator	Conductive heat leaks from spacecraft	0.0057
	Conductive load from detectors	0.0425
	Radiative load from warmer stages (VG3 and SVM)	0.0140
	Net heat flux rejected to Space	0.0627
JT Cold-end	Conductive leaks from L/MWIR modules	0.040

Table 3-2. TMM/GMM heat fluxes at Instrument main internal thermal interfaces

The cold radiator rejects more than 60 mW to space while, for the colder channels, almost 40 mW are loaded to the cooler cold heat exchanger.

To all model results should be applied the uncertainty relative to this stage of the study, as specified in the present issue of the EID-A [AD2].

4 THERMAL MODELS COMPARISON AND CONCLUSIONS

The Geometrical Model most important results is to show how the whole spacecraft design is really efficient in rejecting heat radiatively, taking full advantage of the L2 favourable thermal conditions. The Telescope Optical Bench, the Telescope Baffle and the Instrument Cold Radiator work together as a single large surface, representing the coldest radiative stages in the spacecraft, at a temperature 10 to 15K lower than the last VGroove. Figure 4-1 left side shows the radiative exchange coefficient of each surface, indicating how well coupled is each PLM unit to the cold Space. The units IR emissivity is shown in the right side of the same figure. The combination of both pictures provides a an estimate of the capability of energy rejection to Space is given.

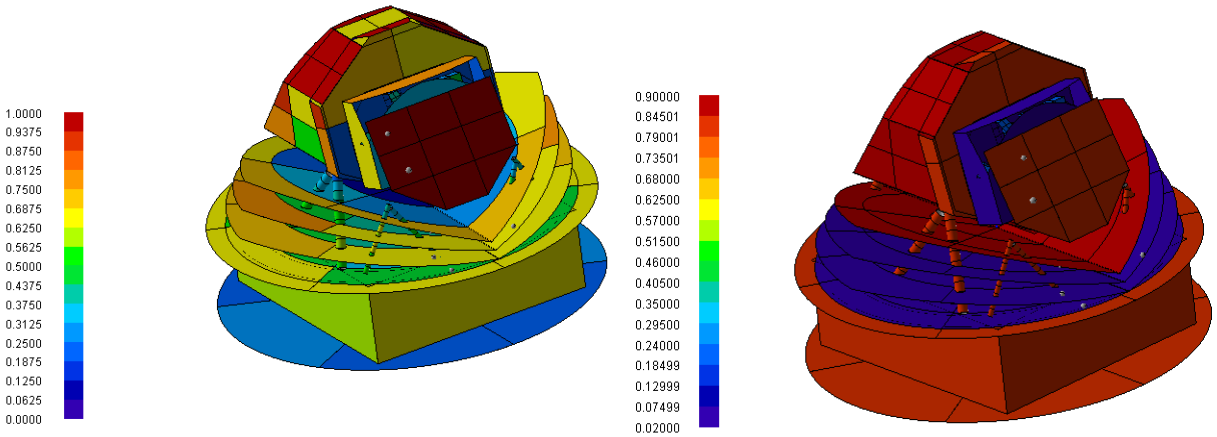

Figure 4-1. Radiative exchange coefficient of the PLM units to Space (left) and surface IR emissivity (right)

With the heat loads allocation on the passive stages as defined in the current issue of the EID-A and the best up-to-date assumptions on instrument active dissipation, the passive cooling allows the whole content of the instrument optical bench to operate at a temperature of less than 40 K. These results indicate, as expected, that the PLM thermal behaviour seems to approach tends to approach the Cold Case predictions. This clearly results from the model temperatures and loads reported in Table 4-1 and Table 4-2.

System	Sub-system	Unit	GMM predictions T (K)	Reduced TMM predictions (Cold Case) T (K)
SVM	Solar Array		312.95	NA (boundary node)
	SVM average		249.30	NA (boundary node)
VG1			148.81	NA (boundary node)
VG2			93.05	NA (boundary node)
VG3			48.30	NA (boundary node)
Telescope	M1		33.34	NA
	M2		33.42	NA
	M3		33.34	NA
	M4		33.34	NA
	OB		33.34	NA (boundary node)
	Baffle		32.89	NA
Instrument	Optical Bench		37.49	36.76
	FGS	Box	37.57	36.80

		Detectors	35.02	36.31
		FEE	37.72	36.99
	VNIR	Box	37.52	36.80
		Optics	37.52	36.80
		Detectors	35.01	36.31
		FEE	37.68	36.99
	SWIR	Box	37.57	36.80
		Optics	37.56	36.80
		Detectors	34.98	36.12
		FEE	37.74	36.98
	MWIR	Box	36.98	35.07
		Optics	28.01	28.07
		Detectors	28.19	29.82
		FEE	37.55	36.85
	LWIR	Box	35.98	34.40
		Optics	28.20	28.06
		Detectors	28.20	29.81
		FEE	37.55	36.85
	Radiator		34.72	34.88

Table 4-1. Comparison of reduced and geometrical TMM temperature results

Instrument Thermal Interface	Thermal Path	GMM Heat fluxes (W)	Reduced TMM Cold Case heat fluxes (W)
Cold Radiator	Conductive heat leaks from spacecraft	0.0057	0.0047
	Conductive load from detectors	0.0425	0.0469
	Radiative load from warmer stages (VG3 and SVM)	0.0140	NA (Not evaluated)
	Net heat flux rejected to Space	0.0627	0.052
JT Cold-end	Conductive links from L/MWIR modules	0.040	0.055

Table 4-2. Comparison of reduced and geometrical TMM Instrument heat flux results

The results of the two models look consistent: numbers are in line, taking into account the uncertainties in units and interfaces design. Both models seem to agree within the uncertainties of the thermal predictions at this stage of the study, as specified in the EID-A.

5 ACKNOWLEDGMENTS

We acknowledge the financial contribution by the Italian Space Agency in the framework of the ASI-INAF agreement I/022/12/0.

Appendix 1. Reduced TMM ESATAN input file

```
# ThermXL Export File for SS_PLM_v1_Sep2013_HotCase_withRadiator (15/09/2013
01:20:45)
#
# Cells containing formulas are exported as value only
# and the content is provided as a comment.
#
$MODEL SS_PLM_v1_Sep2013_HotCase_withRadiator
#
$NODES
#
D10 = 'LWIR_BOX', T = -218,15;
D20 = 'LWIR_OM', T = -218,15;
D30 = 'LWIR_DS', T = -218,15, QI = 5,00E-3;
D40 = 'LWIR_TCS', T = -218,15, QI = 5,00E-3;
D50 = 'LWIR_FEE', T = -218,15, QI = 2,00E-2;
D60 = 'MWIR_BOX', T = -218,15;
D70 = 'MWIR_OM', T = -218,15;
D80 = 'MWIR_DS', T = -218,15, QI = 5,00E-3;
D90 = 'MWIR_TCS', T = -218,15, QI = 5,00E-3;
D100 = 'MWIR_FEE', T = -218,15, QI = 2,00E-2;
D110 = 'SWIR_BOX', T = -218,15;
D120 = 'SWIR_OM', T = -218,15;
D130 = 'SWIR_DS', T = -218,15, QI = 8,00E-3;
D140 = 'SWIR_TCS', T = -218,15, QI = 5,00E-3;
D150 = 'SWIR_FEE', T = -218,15, QI = 2,00E-2;
D160 = 'VNIR_BOX', T = -218,15;
D170 = 'VNIR_OM', T = -218,15;
D180 = 'VNIR_DS', T = -218,15, QI = 1,00E-2;
D190 = 'VNIR_TCS', T = -218,15, QI = 5,00E-3;
D200 = 'VNIR_FEE', T = -218,15, QI = 2,00E-2;
D210 = 'FGS_BOX', T = -218,15;
D220 = 'FGS_OM', T = -218,15;
D230 = 'FGS_DS', T = -218,15, QI = 1,00E-2;
D240 = 'FGS_TCS', T = -218,15, QI = 5,00E-3;
D250 = 'FGS_FEE', T = -218,15, QI = 2,00E-2;
D260 = 'IOB', T = -218,15;
D300 = 'Calib_Unit', T = -218,15, QI = 1,80E-3;
D500 = 'IRAD_TIF5', T = -218,15;
B9000 = 'SVM', T = 49,85;
B9100 = 'VG1_TIF1', T = -123,15;
B9200 = 'VG2_TIF2', T = -163,15;
B9300 = 'VG3_TIF3', T = -218,15;
B9400 = 'TOB_TIF4', T = -218,15;
B9600 = 'JT_TIF6', T = -245,15;
B9900 = 'Space', T = -269,15;
#
$CONDUCTORS
#
GR(10, 260) = 1,84E-1; # =Nodes!G4*Nodes!H4
GR(30, 20) = 6,25E-4;
GR(60, 260) = 3,28E-1; # =Nodes!G9*Nodes!H9
GR(80, 70) = 6,25E-4;
GR(110, 260) = 2,08E-1; # =Nodes!G14*Nodes!H14
GR(130, 110) = 6,25E-4;
GR(160, 260) = 3,84E-1; # =Nodes!G19*Nodes!H19
GR(180, 160) = 6,25E-4;
```

```
GR(210, 260) = 3,84E-1; # =Nodes!G24*Nodes!H24
GR(230, 210) = 6,25E-4;
GR(260, 9400) = 1,22E+0;
GR(260, 9900) = 1,60E-1;
GR(500, 9900) = 6,14E-1; # =Nodes!G31*Nodes!H31*H64
GL(10, 260) = 1,00E-3;
GL(20, 10) = 1,00E-3;
GL(30, 10) = 1,00E-4;
GL(30, 40) = 1,00E-2;
GL(20, 9600) = 1,00E-1;
GL(40, 9600) = 1,00E-1;
GL(50, 260) = 1,00E-1;
GL(50, 30) = 1,50E-3;
GL(9400, 50) = 1,20E-4;
GL(60, 260) = 1,00E-3;
GL(70, 60) = 1,00E-3;
GL(80, 60) = 1,00E-4;
GL(80, 90) = 1,00E-2;
GL(70, 9600) = 1,00E-1;
GL(90, 9600) = 1,00E-1;
GL(100, 260) = 1,00E-1;
GL(100, 80) = 1,50E-3;
GL(9400, 100) = 1,20E-4;
GL(110, 260) = 5,00E-1;
GL(120, 110) = 5,00E-1;
GL(130, 110) = 3,00E-4;
GL(130, 140) = 1,00E-2;
GL(140, 500) = 5,00E-2;
GL(150, 110) = 1,00E-1;
GL(150, 130) = 1,50E-3;
GL(9400, 150) = 1,20E-4;
GL(160, 260) = 5,00E-1;
GL(170, 160) = 5,00E-1;
GL(180, 160) = 3,00E-4;
GL(180, 190) = 1,00E-2;
GL(190, 500) = 5,00E-2;
GL(200, 160) = 1,00E-1;
GL(200, 180) = 1,50E-3;
GL(9400, 200) = 1,20E-4;
GL(210, 260) = 5,00E-1;
GL(220, 210) = 5,00E-1;
GL(230, 210) = 3,00E-4;
GL(230, 240) = 1,00E-2;
GL(240, 500) = 5,00E-2;
GL(250, 210) = 1,00E-1;
GL(250, 230) = 1,50E-3;
GL(9400, 250) = 1,20E-4;
GL(260, 9400) = 1,00E-2;
GL(9000, 9100) = 1,70E-3;
GL(9100, 9200) = 1,20E-3;
GL(9200, 9300) = 1,00E-3;
GL(9300, 9400) = 5,30E-4;
GL(300, 260) = 1,00E-1;
GL(260, 500) = 2,50E-3;
#
$CONSTANTS
#
$CONTROL
```

```
#
# Steady-state parameters
NLOOP = 300;
RELXCA = 1,00E-4;
DAMPT = 1,00E+0;
# Preferences
TABS = 2,731500E+2;
STEFAN = 5,670510E-8;
#
$EXECUTION
#
      CALL SOLVIT
#
$OUTPUTS
#
      FORMAT = 'E10.2'
      CALL PRQBAL(' ', CURRENT)
      CALL PRNDTB(' ', 'T,C,QS,QA,QE,QI', CURRENT)
#
$ENDMODEL SS_PLM_v1_Sep2013_HotCase_withRadiator
```

Appendix 2. PLM TMM/GMM output file

```
ESATAN-TMS Thermal  10.10.0                                                Page
1
 13             September              2013                          17:07:28
ECHO_0_2_HUNT_RADIATOR

  TIMEN =      0.00      MODULE SOLVFM      LOOPCT =    34
 ENBALA = 8.949E-03      ENBALR = 1.E-06

 TABLE OUTPUT WITH ZENTS = 'L,T,QS,QE,QA,C'
 FOR NODES OF ZLABEL = ' '
================================================================================

+ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                              T             QS

         70000   Test_Rad2                      34.72           0.00
         70001   Test_Rad2                      34.72           0.00
         70002   Test_Rad2                      34.72           0.00
         70003   Test_Rad2                      34.72           0.00
         70004   Test_Rad2                      34.72           0.00
         70005   Test_Rad2                      34.72           0.00
         70006   Test_Rad2                      34.72           0.00
         70007   Test_Rad2                      34.72           0.00
         70008   Test_Rad2                      34.72           0.00
         71000   Test_Rad2                      34.72           0.00
         71001   Test_Rad2                      34.72           0.00
         71002   Test_Rad2                      34.72           0.00
         71003   Test_Rad2                      34.72           0.00
         71004   Test_Rad2                      34.72           0.00
         71005   Test_Rad2                      34.72           0.00
         71006   Test_Rad2                      34.72           0.00
         71007   Test_Rad2                      34.72           0.00
         71008   Test_Rad2                      34.72           0.00
         80000   Cold_End                       28.00           0.00
 X       99998   INACTIVE_NODE                   0.00           0.00
         99999   ENVIRONMENT                     4.00           0.00


          NODE          QE            QA            C

         70000        0.00          0.00        554.04
         70001        0.00          0.00        554.04
         70002        0.00          0.00        554.04
         70003        0.00          0.00        554.04
         70004        0.00          0.00        554.04
         70005        0.00          0.00        554.04
         70006        0.00          0.00        274.87
         70007        0.00          0.00        554.04
         70008        0.00          0.00        274.87
         71000        0.00          0.00        554.04
         71001        0.00          0.00        554.04
         71002        0.00          0.00        554.04
         71003        0.00          0.00        554.04
1
```

ESATAN-TMS Thermal 10.10.0 Page 2
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

	NODE	QE	QA	C
	71004	0.00	0.00	554.04
	71005	0.00	0.00	554.04
	71006	0.00	0.00	274.87
	71007	0.00	0.00	554.04
	71008	0.00	0.00	274.87
	80000	0.00	0.00	0.00
X	99998	0.00	0.00	0.00
	99999	0.00	0.00	0.00

==========

+ECHO_0_2_HUNT_RADIATOR:SPACECRAFT

NODE	LABEL	T	QS
1000	SPACECRAFT_SVM_top	280.28	0.00
1001	SPACECRAFT_SVM_top	280.65	0.00
1002	SPACECRAFT_SVM_top	280.15	0.00
1003	SPACECRAFT_SVM_top	279.94	0.00
1004	SPACECRAFT_SVM_top	280.02	0.00
1005	SPACECRAFT_SVM_top	280.07	0.00
1006	SPACECRAFT_SVM_top	279.49	0.00
1007	SPACECRAFT_SVM_top	280.97	0.00
1008	SPACECRAFT_SVM_top	279.19	0.00
1009	SPACECRAFT_SVM_top	278.95	0.00
1010	SPACECRAFT_SVM_top	279.36	0.00
1011	SPACECRAFT_SVM_top	279.24	0.00
1012	SPACECRAFT_SVM_top	277.65	0.00
1013	SPACECRAFT_SVM_top	281.13	0.00
1014	SPACECRAFT_SVM_top	277.05	0.00
1015	SPACECRAFT_SVM_top	276.69	0.00
1016	SPACECRAFT_SVM_top	277.76	0.00
1017	SPACECRAFT_SVM_top	277.22	0.00
1018	SPACECRAFT_SVM_top	275.23	0.00
1019	SPACECRAFT_SVM_top	281.02	0.00
1020	SPACECRAFT_SVM_top	274.17	0.00
1021	SPACECRAFT_SVM_top	273.55	0.00
1022	SPACECRAFT_SVM_top	273.92	0.00
1023	SPACECRAFT_SVM_top	274.52	0.00
1024	SPACECRAFT_SVM_top	272.58	0.00
1025	SPACECRAFT_SVM_top	281.38	0.00
1026	SPACECRAFT_SVM_top	271.01	0.00
1027	SPACECRAFT_SVM_top	270.25	0.00
1028	SPACECRAFT_SVM_top	270.03	0.00
1029	SPACECRAFT_SVM_top	271.77	0.00
1031	SPACECRAFT_SVM_top2	274.98	0.03
1032	SPACECRAFT_SVM_top2	256.08	0.11

NODE	LABEL	T	QS
1033	SPACECRAFT_SVM_top2	274.13	0.00
1034	SPACECRAFT_SVM_top2	275.76	0.02

1
ESATAN-TMS Thermal 10.10.0 Page 3
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
1035	SPACECRAFT_SVM_top2	255.43	0.08
1036	SPACECRAFT_SVM_top2	276.10	0.03
1037	SPACECRAFT_SVM_top2	242.76	0.09
1038	SPACECRAFT_SVM_top2	234.66	0.21
1039	SPACECRAFT_SVM_top2	241.74	0.12
1040	SPACECRAFT_SVM_top2	242.86	0.13
1041	SPACECRAFT_SVM_top2	231.90	0.17
1042	SPACECRAFT_SVM_top2	243.26	0.09
1043	SPACECRAFT_SVM_top2	210.44	4.14
1044	SPACECRAFT_SVM_top2	223.36	4.59
1045	SPACECRAFT_SVM_top2	211.13	4.59
1046	SPACECRAFT_SVM_top2	210.62	4.55
1047	SPACECRAFT_SVM_top2	220.29	4.55
1048	SPACECRAFT_SVM_top2	210.09	4.63
1050	SPACECRAFT_SVM_top	221.84	0.00
1051	SPACECRAFT_SVM_top	222.27	0.00
1052	SPACECRAFT_SVM_top	222.26	0.00
1053	SPACECRAFT_SVM_top	221.98	0.00
1054	SPACECRAFT_SVM_top	221.48	0.00
1055	SPACECRAFT_SVM_top	221.50	0.00
1056	SPACECRAFT_SVM_top	220.93	0.00
1057	SPACECRAFT_SVM_top	221.82	0.00
1058	SPACECRAFT_SVM_top	221.69	0.00
1059	SPACECRAFT_SVM_top	221.17	0.00
1060	SPACECRAFT_SVM_top	220.04	0.00
1061	SPACECRAFT_SVM_top	220.36	0.00
1062	SPACECRAFT_SVM_top	219.33	0.00
1063	SPACECRAFT_SVM_top	220.85	0.00
1064	SPACECRAFT_SVM_top	220.41	0.00
1065	SPACECRAFT_SVM_top	219.86	0.00
1066	SPACECRAFT_SVM_top	217.87	0.00
1067	SPACECRAFT_SVM_top	218.57	0.00
1068	SPACECRAFT_SVM_top	217.33	0.00
1069	SPACECRAFT_SVM_top	219.56	0.00
1070	SPACECRAFT_SVM_top	218.62	0.00
1071	SPACECRAFT_SVM_top	218.16	0.00
1072	SPACECRAFT_SVM_top	215.01	0.00
1073	SPACECRAFT_SVM_top	216.33	0.00
1074	SPACECRAFT_SVM_top	215.29	0.00
1075	SPACECRAFT_SVM_top	217.49	0.00
1076	SPACECRAFT_SVM_top	216.33	0.00
1077	SPACECRAFT_SVM_top	215.82	0.00
1078	SPACECRAFT_SVM_top	211.80	0.00
1079	SPACECRAFT_SVM_top	214.40	0.00
1081	SPACECRAFT_SVM_top2	274.63	0.00
1082	SPACECRAFT_SVM_top2	279.85	0.00
1083	SPACECRAFT_SVM_top2	273.47	0.00
1084	SPACECRAFT_SVM_top2	272.94	0.00

```
         1085    SPACECRAFT_SVM_top2             272.11          0.00
         1086    SPACECRAFT_SVM_top2             274.01          0.00
1
 ESATAN-TMS Thermal  10.10.0                                          Page
4
 13             September             2013                        17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                             T              QS

         1087    SPACECRAFT_SVM_top2             270.90          0.00
         1088    SPACECRAFT_SVM_top2             279.01          0.00
         1089    SPACECRAFT_SVM_top2             269.33          0.00
         1090    SPACECRAFT_SVM_top2             268.73          0.00
         1091    SPACECRAFT_SVM_top2             268.04          0.00
         1092    SPACECRAFT_SVM_top2             270.14          0.00
         1093    SPACECRAFT_SVM_top2             186.28          0.00
         1094    SPACECRAFT_SVM_top2             191.08          0.00
         1095    SPACECRAFT_SVM_top2             186.83          0.00
         1096    SPACECRAFT_SVM_top2             186.15          0.00
         1097    SPACECRAFT_SVM_top2             184.99          0.00
         1098    SPACECRAFT_SVM_top2             185.51          0.00
         1100    SPACECRAFT_SVM_px               209.03          1.51
         1105    SPACECRAFT_SVM_px               278.13          0.00
         1110    SPACECRAFT_SVM_nx               209.21          1.56
         1115    SPACECRAFT_SVM_nx               277.66          0.00
         1120    SPACECRAFT_SVM_ny               311.53          0.00
         1125    SPACECRAFT_SVM_ny               270.67          1.73
         1130    SPACECRAFT_SVM_py               272.84          1.69
         1135    SPACECRAFT_SVM_py               305.33          0.00
         1140    SPACECRAFT_SVM_cone             287.65          0.00
         1141    SPACECRAFT_SVM_cone             284.09          0.00
         1142    SPACECRAFT_SVM_cone             284.44          0.00
         1143    SPACECRAFT_SVM_cone             284.49          0.00
         1144    SPACECRAFT_SVM_cone             283.68          0.00
         1200    SPACECRAFT_SVM_SA               263.77          0.91
         1201    SPACECRAFT_SVM_SA               265.79          1.28
         1202    SPACECRAFT_SVM_SA               264.11          1.04
         1203    SPACECRAFT_SVM_SA               263.83          1.02
         1204    SPACECRAFT_SVM_SA               260.28          1.43
         1205    SPACECRAFT_SVM_SA               263.99          1.00
         1300    SPACECRAFT_SVM_SA               362.28        935.32
         1301    SPACECRAFT_SVM_SA               362.30        935.32
         1302    SPACECRAFT_SVM_SA               362.28        935.32
         1303    SPACECRAFT_SVM_SA               362.28        935.32
         1304    SPACECRAFT_SVM_SA               362.25        935.32
         1305    SPACECRAFT_SVM_SA               362.28        935.32
         1400    SPACECRAFT_SVM_ring             289.50         23.38
         1410    SPACECRAFT_SVM_bot_inner        281.82          0.00
         1420    SPACECRAFT_SVM_bot_inner        276.64        225.17
         2000    VG1_y_uc                        149.10          0.00
         2001    VG1_y_uc                        149.14          0.00
         2002    VG1_y_uc                        149.75          0.00
         2003    VG1_y_uc                        148.40          0.00
         2004    VG1_y_uc                        147.87          0.00
         2005    VG1_y_uc                        149.59          0.00
         2006    VG1_y_uc                        147.57          0.00
         2007    VG1_y_uc                        147.24          0.00
```

```
         2008    VG1_y_uc                        149.05          0.00
         2050    VG1_y_uc                        150.29          0.00
1
 ESATAN-TMS Thermal  10.10.0                                          Page
5
 13             September              2013                        17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                            T              QS

         2051    VG1_y_uc                        150.36          0.00
         2052    VG1_y_uc                        151.01          0.00
         2053    VG1_y_uc                        149.50          0.00
         2054    VG1_y_uc                        149.12          0.00
         2055    VG1_y_uc                        150.81          0.00
         2056    VG1_y_uc                        148.68          0.00
         2057    VG1_y_uc                        148.15          0.00
         2058    VG1_y_uc                        150.22          0.00
         2100    VG1_ny_uc                       148.96          0.00
         2101    VG1_ny_uc                       148.31          0.00
         2102    VG1_ny_uc                       148.32          0.00
         2103    VG1_ny_uc                       148.85          0.00
         2104    VG1_ny_uc                       146.96          0.00
         2105    VG1_ny_uc                       147.63          0.00
         2106    VG1_ny_uc                       148.34          0.00
         2107    VG1_ny_uc                       146.25          0.00
         2108    VG1_ny_uc                       146.88          0.00
         2150    VG1_ny_uc                       150.18          0.00
         2151    VG1_ny_uc                       149.52          0.00
         2152    VG1_ny_uc                       149.50          0.00
         2153    VG1_ny_uc                       150.05          0.00
         2154    VG1_ny_uc                       148.16          0.00
         2155    VG1_ny_uc                       148.72          0.00
         2156    VG1_ny_uc                       149.50          0.00
         2157    VG1_ny_uc                       147.10          0.00
         2158    VG1_ny_uc                       147.97          0.00
         3000    VG2_y_uc                         93.47          0.00
         3001    VG2_y_uc                         93.34          0.00
         3002    VG2_y_uc                         93.50          0.00
         3003    VG2_y_uc                         93.33          0.00
         3004    VG2_y_uc                         92.75          0.00
         3005    VG2_y_uc                         93.36          0.00
         3006    VG2_y_uc                         93.18          0.00
         3007    VG2_y_uc                         92.66          0.00
         3008    VG2_y_uc                         93.10          0.00
         3050    VG2_y_uc                         93.69          0.00
         3051    VG2_y_uc                         93.56          0.00
         3052    VG2_y_uc                         93.72          0.00
         3053    VG2_y_uc                         93.52          0.00
         3054    VG2_y_uc                         93.03          0.00
         3055    VG2_y_uc                         93.57          0.00
         3056    VG2_y_uc                         93.35          0.00
         3057    VG2_y_uc                         92.77          0.00
         3058    VG2_y_uc                         93.29          0.00
         3100    VG2_ny_uc                        93.04          0.00
         3101    VG2_ny_uc                        92.86          0.00
         3102    VG2_ny_uc                        92.98          0.00
         3103    VG2_ny_uc                        92.92          0.00
```

```
         3104    VG2_ny_uc                       92.29          0.00
         3105    VG2_ny_uc                       92.85          0.00
1
 ESATAN-TMS Thermal  10.10.0                                        Page
6
 13             September              2013                    17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                            T             QS

         3106    VG2_ny_uc                       92.66          0.00
         3107    VG2_ny_uc                       92.19          0.00
         3108    VG2_ny_uc                       92.69          0.00
         3150    VG2_ny_uc                       93.26          0.00
         3151    VG2_ny_uc                       93.08          0.00
         3152    VG2_ny_uc                       93.19          0.00
         3153    VG2_ny_uc                       93.12          0.00
         3154    VG2_ny_uc                       92.56          0.00
         3155    VG2_ny_uc                       93.03          0.00
         3156    VG2_ny_uc                       92.85          0.00
         3157    VG2_ny_uc                       92.31          0.00
         3158    VG2_ny_uc                       92.86          0.00
         4000    VG3_y_uc                        48.30          0.00
         4001    VG3_y_uc                        48.17          0.00
         4002    VG3_y_uc                        48.06          0.00
         4003    VG3_y_uc                        48.27          0.00
         4004    VG3_y_uc                        48.00          0.00
         4005    VG3_y_uc                        47.78          0.00
         4006    VG3_y_uc                        48.23          0.00
         4007    VG3_y_uc                        47.51          0.00
         4008    VG3_y_uc                        47.56          0.00
         4050    VG3_y_uc                        48.35          0.00
         4051    VG3_y_uc                        48.22          0.00
         4052    VG3_y_uc                        48.12          0.00
         4053    VG3_y_uc                        48.32          0.00
         4054    VG3_y_uc                        48.03          0.00
         4055    VG3_y_uc                        47.86          0.00
         4056    VG3_y_uc                        48.28          0.00
         4057    VG3_y_uc                        47.63          0.00
         4058    VG3_y_uc                        47.66          0.00
         4100    VG3_ny_uc                       47.78          0.00
         4101    VG3_ny_uc                       47.91          0.00
         4102    VG3_ny_uc                       48.06          0.00
         4103    VG3_ny_uc                       47.47          0.00
         4104    VG3_ny_uc                       47.74          0.00
         4105    VG3_ny_uc                       48.03          0.00
         4106    VG3_ny_uc                       47.18          0.00
         4107    VG3_ny_uc                       47.26          0.00
         4108    VG3_ny_uc                       48.00          0.00
         4150    VG3_ny_uc                       47.83          0.00
         4151    VG3_ny_uc                       47.96          0.00
         4152    VG3_ny_uc                       48.10          0.00
         4153    VG3_ny_uc                       47.54          0.00
         4154    VG3_ny_uc                       47.77          0.00
         4155    VG3_ny_uc                       48.08          0.00
         4156    VG3_ny_uc                       47.29          0.00
         4157    VG3_ny_uc                       47.37          0.00
         4158    VG3_ny_uc                       48.05          0.00
```

```
         5000    SPACECRAFT_TOB                  33.35          0.00
         5001    SPACECRAFT_TOB                  33.34          0.00
1
 ESATAN-TMS Thermal  10.10.0                                        Page
7
 13             September             2013                      17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                           T              QS

         5002    SPACECRAFT_TOB                  33.34          0.00
         5003    SPACECRAFT_TOB                  33.35          0.00
         5004    SPACECRAFT_TOB                  33.38          0.00
         5005    SPACECRAFT_TOB                  33.32          0.00
         5006    SPACECRAFT_TOB                  33.34          0.00
         5007    SPACECRAFT_TOB                  33.34          0.00
         5008    SPACECRAFT_TOB                  33.36          0.00
         5009    SPACECRAFT_TOB                  33.34          0.00
         5010    SPACECRAFT_TOB                  33.32          0.00
         5011    SPACECRAFT_TOB                  33.29          0.00
         5012    SPACECRAFT_TOB                  33.33          0.00
         5013    SPACECRAFT_TOB                  33.34          0.00
         5014    SPACECRAFT_TOB                  33.32          0.00
         5015    SPACECRAFT_TOB                  33.33          0.00
         5200    Baffl_bot                       32.92          0.00
         5210    Baffl_bot_ny                    32.94          0.00
         5211    Baffl_bot_ny                    32.81          0.00
         5212    Baffl_bot_ny                    32.92          0.00
         5213    Baffl_bot_ny                    32.81          0.00
         5220    Baffl_bot_y                     32.92          0.00
         5221    Baffl_bot_y                     32.81          0.00
         5222    Baffl_bot_y                     32.94          0.00
         5223    Baffl_bot_y                     32.81          0.00
         5230    Baffl_ny                        32.91          0.00
         5231    Baffl_ny                        32.89          0.00
         5232    Baffl_ny                        32.96          0.00
         5233    Baffl_ny                        32.90          0.00
         5240    Baffl_py                        32.95          0.00
         5241    Baffl_py                        32.89          0.00
         5242    Baffl_py                        32.89          0.00
         5243    Baffl_py                        32.88          0.00
         5250    Baffl_top                       32.93          0.00
         5251    Baffl_top                       32.91          0.00
         5252    Baffl_top                       32.87          0.00
         5253    Baffl_top                       32.87          0.00
         5260    Baffl_top_ny                    32.90          0.00
         5261    Baffl_top_ny                    32.89          0.00
         5262    Baffl_top_ny                    32.91          0.00
         5263    Baffl_top_ny                    32.90          0.00
         5270    Baffl_top_py                    32.86          0.00
         5271    Baffl_top_py                    32.85          0.00
         5272    Baffl_top_py                    32.87          0.00
         5273    Baffl_top_py                    32.86          0.00
         6000    Instrument                      34.97          0.00
         6001    Instrument                      37.46          0.00
         6002    Instrument                      37.50          0.00
         6003    Instrument                      37.47          0.00
         6004    Instrument                      37.51          0.00
```

```
         6005    Instrument                    37.49          0.00
         6100    IOB_entrance                  34.98          0.00
1
 ESATAN-TMS Thermal  10.10.0                                        Page
8
 13             September             2013                      17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                          T             QS

         7000    strut_nx1                   257.50          0.00
         7001    strut_nx1                   178.99          0.00
         7002    strut_nx1                   149.35          0.00
         7003    strut_nx1                   115.81          0.00
         7004    strut_nx1                   102.73          0.00
         7005    strut_nx1                    92.96          0.00
         7006    strut_nx1                    75.29          0.00
         7007    strut_nx1                    62.03          0.00
         7008    strut_nx1                    47.56          0.00
         7009    strut_nx1                    33.43          0.00
         7050    strut_nx2                   258.42          0.00
         7051    strut_nx2                   178.87          0.00
         7052    strut_nx2                   148.03          0.00
         7053    strut_nx2                   117.81          0.00
         7054    strut_nx2                    99.29          0.00
         7055    strut_nx2                    92.81          0.00
         7056    strut_nx2                    75.66          0.00
         7057    strut_nx2                    61.36          0.00
         7058    strut_nx2                    47.67          0.00
         7059    strut_nx2                    46.91          0.00
         7100    strut_nx3                   257.90          0.00
         7101    strut_nx3                   179.24          0.00
         7102    strut_nx3                   147.38          0.00
         7103    strut_nx3                   117.74          0.00
         7104    strut_nx3                    99.20          0.00
         7105    strut_nx3                    92.39          0.00
         7106    strut_nx3                    75.29          0.00
         7107    strut_nx3                    60.89          0.00
         7108    strut_nx3                    47.17          0.00
         7109    strut_nx3                    33.43          0.00
         7150    strut_nx4                   256.90          0.00
         7151    strut_nx4                   178.86          0.00
         7152    strut_nx4                   148.66          0.00
         7153    strut_nx4                   115.46          0.00
         7154    strut_nx4                   102.36          0.00
         7155    strut_nx4                    92.53          0.00
         7156    strut_nx4                    74.94          0.00
         7157    strut_nx4                    61.72          0.00
         7158    strut_nx4                    47.18          0.00
         7159    strut_nx4                    33.43          0.00
         7200    strut_ny1                   243.85          0.00
         7201    strut_ny1                   172.77          0.00
         7202    strut_ny1                   145.40          0.00
         7203    strut_ny1                   111.51          0.00
         7204    strut_ny1                    99.05          0.00
         7205    strut_ny1                    91.61          0.00
         7206    strut_ny1                    69.28          0.00
         7207    strut_ny1                    47.94          0.00
```

```
         7208    strut_ny1                       40.77          0.00
         7209    strut_ny1                       33.41          0.00
1
 ESATAN-TMS Thermal  10.10.0                                          Page
9
 13             September              2013                      17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                            T              QS

         7250    strut_ny2                     246.13          0.00
         7251    strut_ny2                     171.65          0.00
         7252    strut_ny2                     146.37          0.00
         7253    strut_ny2                     112.22          0.00
         7254    strut_ny2                     101.68          0.00
         7255    strut_ny2                      91.79          0.00
         7256    strut_ny2                      69.37          0.00
         7257    strut_ny2                      48.00          0.00
         7258    strut_ny2                      40.88          0.00
         7259    strut_ny2                      33.41          0.00
         7300    strut_px1                     253.02          0.00
         7301    strut_px1                     180.63          0.00
         7302    strut_px1                     146.36          0.00
         7303    strut_px1                     115.46          0.00
         7304    strut_px1                      93.00          0.00
         7305    strut_px1                      70.85          0.00
         7306    strut_px1                      48.60          0.00
         7307    strut_px1                      43.34          0.00
         7308    strut_px1                      38.34          0.00
         7309    strut_px1                      33.43          0.00
         7350    strut_px2                     252.38          0.00
         7351    strut_px2                     180.03          0.00
         7352    strut_px2                     145.75          0.00
         7353    strut_px2                     115.20          0.00
         7354    strut_px2                      92.53          0.00
         7355    strut_px2                      70.49          0.00
         7356    strut_px2                      48.37          0.00
         7357    strut_px2                      43.18          0.00
         7358    strut_px2                      38.26          0.00
         7359    strut_px2                      33.42          0.00
         7400    strut_py1                     244.48          0.00
         7401    strut_py1                     174.52          0.00
         7402    strut_py1                     146.25          0.00
         7403    strut_py1                     112.03          0.00
         7404    strut_py1                      99.68          0.00
         7405    strut_py1                      92.06          0.00
         7406    strut_py1                      69.60          0.00
         7407    strut_py1                      48.20          0.00
         7408    strut_py1                      40.87          0.00
         7409    strut_py1                      33.37          0.00
         7450    strut_py2                     251.13          0.00
         7451    strut_py2                     174.22          0.00
         7452    strut_py2                     147.40          0.00
         7453    strut_py2                     113.20          0.00
         7454    strut_py2                     102.14          0.00
         7455    strut_py2                      92.23          0.00
         7456    strut_py2                      69.71          0.00
         7457    strut_py2                      48.26          0.00
```

```
         7458    strut_py2                       41.00          0.00
         7459    strut_py2                       33.40          0.00
1
 ESATAN-TMS Thermal  10.10.0                                        Page
10
 13             September             2013                      17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                            T              QS

         10000   Mirror1_uc                      33.34          0.00
         10001   Mirror1_uc                      33.34          0.00
         10002   Mirror1_uc                      33.34          0.00
         10003   Mirror1_uc                      33.34          0.00
         10004   Mirror1_uc                      33.34          0.00
         10100   M2                              33.42          0.00
         10200   M3                              33.34          0.00
         10400   M4                              33.34          0.00


          NODE          QE             QA             C

          1000        0.00           0.00         503.51
          1001        0.00           0.00         504.15
          1002        0.00           0.00         503.29
          1003        0.00           0.00         502.93
          1004        0.00           0.00         503.07
          1005        0.00           0.00         503.16
          1006        0.00           0.00        1508.75
          1007        0.00           0.00        1516.36
          1008        0.00           0.00        1507.25
          1009        0.00           0.00        1505.98
          1010        0.00           0.00        1508.13
          1011        0.00           0.00        1507.48
          1012        0.00           0.00        2497.39
          1013        0.00           0.00        2527.15
          1014        0.00           0.00        2492.22
          1015        0.00           0.00        2489.14
          1016        0.00           0.00        2498.31
          1017        0.00           0.00        2493.70
          1018        0.00           0.00        3466.48
          1019        0.00           0.00        3535.76
          1020        0.00           0.00        3453.81
          1021        0.00           0.00        3446.38
          1022        0.00           0.00        3450.77
          1023        0.00           0.00        3458.00
          1024        0.00           0.00        4417.73
          1025        0.00           0.00        4553.06
          1026        0.00           0.00        4393.56
          1027        0.00           0.00        4381.87
          1028        0.00           0.00        4378.59
          1029        0.00           0.00        4405.28
          1031        0.00           0.00           0.00
          1032        0.00           0.00           0.00
          1033        0.00           0.00           0.00
          1034        0.00           0.00           0.00
          1035        0.00           0.00           0.00
```

1036	0.00	0.00	0.00
1037	0.00	0.00	0.00
1038	0.00	0.00	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
11
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
1039	0.00	0.00	0.00
1040	0.00	0.00	0.00
1041	0.00	0.00	0.00
1042	0.00	0.00	0.00
1043	0.00	0.00	0.00
1044	0.00	0.00	0.00
1045	0.00	0.00	0.00
1046	0.00	0.00	0.00
1047	0.00	0.00	0.00
1048	0.00	0.00	0.00
1050	0.00	0.00	8.08
1051	0.00	0.00	8.10
1052	0.00	0.00	8.10
1053	0.00	0.00	8.09
1054	0.00	0.00	8.07
1055	0.00	0.00	8.07
1056	0.00	0.00	23.77
1057	0.00	0.00	23.85
1058	0.00	0.00	23.84
1059	0.00	0.00	23.79
1060	0.00	0.00	23.68
1061	0.00	0.00	23.71
1062	0.00	0.00	39.95
1063	0.00	0.00	40.20
1064	0.00	0.00	40.13
1065	0.00	0.00	40.04
1066	0.00	0.00	39.70
1067	0.00	0.00	39.82
1068	0.00	0.00	55.81
1069	0.00	0.00	56.34
1070	0.00	0.00	56.12
1071	0.00	0.00	56.01
1072	0.00	0.00	55.25
1073	0.00	0.00	55.57
1074	0.00	0.00	71.37
1075	0.00	0.00	72.06
1076	0.00	0.00	71.70
1077	0.00	0.00	71.54
1078	0.00	0.00	70.29
1079	0.00	0.00	71.10
1081	0.00	0.00	0.00
1082	0.00	0.00	0.00
1083	0.00	0.00	0.00
1084	0.00	0.00	0.00
1085	0.00	0.00	0.00
1086	0.00	0.00	0.00
1087	0.00	0.00	0.00

1088	0.00	0.00	0.00
1089	0.00	0.00	0.00
1090	0.00	0.00	0.00

1
ESATAN-TMS Thermal 10.10.0 Page 12
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
1091	0.00	0.00	0.00
1092	0.00	0.00	0.00
1093	0.00	0.00	0.00
1094	0.00	0.00	0.00
1095	0.00	0.00	0.00
1096	0.00	0.00	0.00
1097	0.00	0.00	0.00
1098	0.00	0.00	0.00
1100	0.00	0.00	12150.41
1105	0.00	0.00	15903.89
1110	0.00	0.00	12160.33
1115	0.00	0.00	15878.43
1120	0.00	0.00	18801.20
1125	0.00	0.00	17048.72
1130	0.00	0.00	17178.27
1135	0.00	0.00	18801.20
1140	0.00	0.00	7811.48
1141	0.00	0.00	7716.00
1142	0.00	0.00	7725.20
1143	0.00	0.00	7726.68
1144	0.00	0.00	7704.91
1200	0.00	0.00	12706.43
1201	0.00	0.00	12798.36
1202	0.00	0.00	12721.73
1203	0.00	0.00	12709.24
1204	0.00	0.00	12547.12
1205	0.00	0.00	12716.45
1300	0.00	0.00	14359.72
1301	0.00	0.00	14359.72
1302	0.00	0.00	14359.72
1303	0.00	0.00	14359.72
1304	0.00	0.00	14359.72
1305	0.00	0.00	14359.72
1400	0.00	0.00	321.00
1410	0.00	0.00	9770.75
1420	0.00	0.00	9600.11
2000	0.00	0.00	94.04
2001	0.00	0.00	94.05
2002	0.00	0.00	94.40
2003	0.00	0.00	282.15
2004	0.00	0.00	277.46
2005	0.00	0.00	284.22
2006	0.00	0.00	333.59
2007	0.00	0.00	339.20
2008	0.00	0.00	335.36
2050	0.00	0.00	94.72
2051	0.00	0.00	94.76

2052	0.00	0.00	95.13
2053	0.00	0.00	284.07
2054	0.00	0.00	279.59

1
ESATAN-TMS Thermal 10.10.0 Page
13
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
2055	0.00	0.00	286.32
2056	0.00	0.00	335.88
2057	0.00	0.00	341.10
2058	0.00	0.00	337.77
2100	0.00	0.00	93.95
2101	0.00	0.00	93.58
2102	0.00	0.00	93.59
2103	0.00	0.00	282.93
2104	0.00	0.00	275.90
2105	0.00	0.00	280.83
2106	0.00	0.00	336.44
2107	0.00	0.00	342.13
2108	0.00	0.00	334.67
2150	0.00	0.00	94.65
2151	0.00	0.00	94.27
2152	0.00	0.00	94.26
2153	0.00	0.00	285.01
2154	0.00	0.00	277.96
2155	0.00	0.00	282.71
2156	0.00	0.00	338.83
2157	0.00	0.00	343.92
2158	0.00	0.00	336.93
3000	0.00	0.00	62.09
3001	0.00	0.00	62.01
3002	0.00	0.00	62.11
3003	0.00	0.00	186.86
3004	0.00	0.00	182.53
3005	0.00	0.00	186.08
3006	0.00	0.00	179.06
3007	0.00	0.00	200.69
3008	0.00	0.00	179.77
3050	0.00	0.00	62.21
3051	0.00	0.00	62.14
3052	0.00	0.00	62.23
3053	0.00	0.00	187.19
3054	0.00	0.00	182.99
3055	0.00	0.00	186.43
3056	0.00	0.00	179.35
3057	0.00	0.00	200.91
3058	0.00	0.00	180.09
3100	0.00	0.00	61.84
3101	0.00	0.00	61.74
3102	0.00	0.00	61.81
3103	0.00	0.00	185.32
3104	0.00	0.00	181.74
3105	0.00	0.00	186.02
3106	0.00	0.00	179.04

3107	0.00	0.00	199.82
3108	0.00	0.00	178.26
3150	0.00	0.00	61.97

1
ESATAN-TMS Thermal 10.10.0 Page 14
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
3151	0.00	0.00	61.86
3152	0.00	0.00	61.93
3153	0.00	0.00	185.67
3154	0.00	0.00	182.19
3155	0.00	0.00	186.34
3156	0.00	0.00	179.36
3157	0.00	0.00	200.03
3158	0.00	0.00	178.53
4000	0.00	0.00	28.57
4001	0.00	0.00	28.41
4002	0.00	0.00	28.28
4003	0.00	0.00	85.98
4004	0.00	0.00	82.69
4005	0.00	0.00	84.18
4006	0.00	0.00	64.28
4007	0.00	0.00	79.85
4008	0.00	0.00	63.17
4050	0.00	0.00	28.63
4051	0.00	0.00	28.47
4052	0.00	0.00	28.35
4053	0.00	0.00	86.18
4054	0.00	0.00	82.81
4055	0.00	0.00	84.48
4056	0.00	0.00	64.43
4057	0.00	0.00	80.25
4058	0.00	0.00	63.45
4100	0.00	0.00	27.94
4101	0.00	0.00	28.10
4102	0.00	0.00	28.27
4103	0.00	0.00	83.03
4104	0.00	0.00	81.77
4105	0.00	0.00	85.11
4106	0.00	0.00	62.11
4107	0.00	0.00	78.96
4108	0.00	0.00	63.64
4150	0.00	0.00	28.00
4151	0.00	0.00	28.15
4152	0.00	0.00	28.33
4153	0.00	0.00	83.31
4154	0.00	0.00	81.88
4155	0.00	0.00	85.31
4156	0.00	0.00	62.43
4157	0.00	0.00	79.34
4158	0.00	0.00	63.79
5000	0.00	0.00	44.05
5001	0.00	0.00	49.89
5002	0.00	0.00	44.68

5003	0.00	0.00	49.93
5004	0.00	0.00	3.95
5005	0.00	0.00	7.89

1
ESATAN-TMS Thermal 10.10.0 Page 15
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
5006	0.00	0.00	7.57
5007	0.00	0.00	7.57
5008	0.00	0.00	7.91
5009	0.00	0.00	4.14
5010	0.00	0.00	4.76
5011	0.00	0.00	4.46
5012	0.00	0.00	41.68
5013	0.00	0.00	52.11
5014	0.00	0.00	40.94
5015	0.00	0.00	52.10
5200	0.00	0.00	43.89
5210	0.00	0.00	38.82
5211	0.00	0.00	36.24
5212	0.00	0.00	41.63
5213	0.00	0.00	44.81
5220	0.00	0.00	41.62
5221	0.00	0.00	44.81
5222	0.00	0.00	38.79
5223	0.00	0.00	36.36
5230	0.00	0.00	21.65
5231	0.00	0.00	6.98
5232	0.00	0.00	24.56
5233	0.00	0.00	14.90
5240	0.00	0.00	24.81
5241	0.00	0.00	14.87
5242	0.00	0.00	21.84
5243	0.00	0.00	6.57
5250	0.00	0.00	17.59
5251	0.00	0.00	2.51
5252	0.00	0.00	17.47
5253	0.00	0.00	2.50
5260	0.00	0.00	20.83
5261	0.00	0.00	3.82
5262	0.00	0.00	19.14
5263	0.00	0.00	3.16
5270	0.00	0.00	18.50
5271	0.00	0.00	2.62
5272	0.00	0.00	20.23
5273	0.00	0.00	3.28
6000	0.00	0.00	589.81
6001	0.00	0.00	166.33
6002	0.00	0.00	299.08
6003	0.00	0.00	166.39
6004	0.00	0.00	254.24
6005	0.00	0.00	623.84
6100	0.00	0.00	0.00
7000	0.00	0.00	13.89

7001	0.00	0.00	9.72
7002	0.00	0.00	8.14
7003	0.00	0.00	6.35

1
ESATAN-TMS Thermal 10.10.0 Page 16
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
7004	0.00	0.00	5.66
7005	0.00	0.00	5.14
7006	0.00	0.00	4.20
7007	0.00	0.00	3.49
7008	0.00	0.00	2.72
7009	0.00	0.00	2.32
7050	0.00	0.00	13.94
7051	0.00	0.00	9.71
7052	0.00	0.00	8.07
7053	0.00	0.00	6.46
7054	0.00	0.00	5.47
7055	0.00	0.00	5.13
7056	0.00	0.00	4.22
7057	0.00	0.00	3.46
7058	0.00	0.00	2.73
7059	0.00	0.00	2.69
7100	0.00	0.00	13.92
7101	0.00	0.00	9.73
7102	0.00	0.00	8.03
7103	0.00	0.00	6.46
7104	0.00	0.00	5.47
7105	0.00	0.00	5.11
7106	0.00	0.00	4.20
7107	0.00	0.00	3.43
7108	0.00	0.00	2.70
7109	0.00	0.00	2.32
7150	0.00	0.00	13.86
7151	0.00	0.00	9.71
7152	0.00	0.00	8.10
7153	0.00	0.00	6.33
7154	0.00	0.00	5.64
7155	0.00	0.00	5.11
7156	0.00	0.00	4.18
7157	0.00	0.00	3.47
7158	0.00	0.00	2.70
7159	0.00	0.00	2.32
7200	0.00	0.00	34.93
7201	0.00	0.00	24.89
7202	0.00	0.00	21.03
7203	0.00	0.00	16.25
7204	0.00	0.00	14.49
7205	0.00	0.00	13.44
7206	0.00	0.00	10.28
7207	0.00	0.00	7.27
7208	0.00	0.00	6.26
7209	0.00	0.00	6.15
7250	0.00	0.00	35.25

7251	0.00	0.00	24.74
7252	0.00	0.00	21.17
7253	0.00	0.00	16.35

1
ESATAN-TMS Thermal 10.10.0 Page 17
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
7254	0.00	0.00	14.86
7255	0.00	0.00	13.46
7256	0.00	0.00	10.30
7257	0.00	0.00	7.28
7258	0.00	0.00	6.27
7259	0.00	0.00	6.15
7300	0.00	0.00	23.18
7301	0.00	0.00	16.64
7302	0.00	0.00	13.55
7303	0.00	0.00	10.75
7304	0.00	0.00	8.73
7305	0.00	0.00	6.72
7306	0.00	0.00	4.71
7307	0.00	0.00	4.24
7308	0.00	0.00	3.94
7309	0.00	0.00	3.94
7350	0.00	0.00	23.13
7351	0.00	0.00	16.59
7352	0.00	0.00	13.49
7353	0.00	0.00	10.73
7354	0.00	0.00	8.68
7355	0.00	0.00	6.69
7356	0.00	0.00	4.69
7357	0.00	0.00	4.22
7358	0.00	0.00	3.94
7359	0.00	0.00	3.94
7400	0.00	0.00	35.02
7401	0.00	0.00	25.14
7402	0.00	0.00	21.15
7403	0.00	0.00	16.32
7404	0.00	0.00	14.58
7405	0.00	0.00	13.50
7406	0.00	0.00	10.33
7407	0.00	0.00	7.31
7408	0.00	0.00	6.27
7409	0.00	0.00	6.15
7450	0.00	0.00	35.96
7451	0.00	0.00	25.10
7452	0.00	0.00	21.31
7453	0.00	0.00	16.48
7454	0.00	0.00	14.92
7455	0.00	0.00	13.52
7456	0.00	0.00	10.35
7457	0.00	0.00	7.32
7458	0.00	0.00	6.29
7459	0.00	0.00	6.15
10000	0.00	0.00	11.78

```
        10001          0.00          0.00         16.88
        10002          0.00          0.00          9.88
        10003          0.00          0.00         17.61
1
 ESATAN-TMS Thermal  10.10.0                                                Page
18
 13             September              2013                          17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE          QE            QA            C

        10004          0.00          0.00         12.67
        10100          0.00          0.00          1.45
        10200          0.00          0.00          0.06
        10400          0.00          0.00          0.06



================================================================================


+ECHO_0_2_HUNT_RADIATOR:IOB

          NODE   LABEL                              T             QS

          9000   IOB_flange_edge2                37.39          0.00
          9010   IOB_OB_Bipod2:flange_edg        37.39          0.00
          9020   IOB_OB_Bipod3:flange_edg        37.40          0.00
          9100   IOB_pod1                        37.39          0.00
          9101   IOB_pod1                        35.37          0.00
          9102   IOB_pod1                        33.38          0.00
          9110   IOB_OB_Bipod2:pod1              37.39          0.00
          9111   IOB_OB_Bipod2:pod1              35.37          0.00
          9112   IOB_OB_Bipod2:pod1              33.39          0.00
          9120   IOB_pod2                        37.39          0.00
          9121   IOB_pod2                        35.37          0.00
          9122   IOB_pod2                        33.38          0.00
          9130   IOB_OB_Bipod2:pod2              37.39          0.00
          9131   IOB_OB_Bipod2:pod2              35.37          0.00
          9132   IOB_OB_Bipod2:pod2              33.39          0.00
          9140   IOB_OB_Bipod3:pod1              37.40          0.00
          9141   IOB_OB_Bipod3:pod1              35.37          0.00
          9142   IOB_OB_Bipod3:pod1              33.38          0.00
          9150   IOB_OB_Bipod3:pod2              37.40          0.00
          9151   IOB_OB_Bipod3:pod2              35.37          0.00
          9152   IOB_OB_Bipod3:pod2              33.38          0.00
         40000   IOB_LWIR_Env                    35.98          0.00
         40001   IOB_LWIR_Env                    35.98          0.00
         40002   IOB_LWIR_Env                    35.98          0.00
         40003   IOB_LWIR_Env                    35.98          0.00
         40004   IOB_LWIR_Env                    35.98          0.00
         40005   IOB_LWIR_Env                    35.98          0.00
         40006   IOB_LWIR_Env                    35.98          0.00
         40007   IOB_LWIR_Env                    35.98          0.00
         40008   IOB_LWIR_Env                    35.98          0.00
         40009   IOB_LWIR_Env                    35.98          0.00
         40010   IOB_LWIR_Env                    35.98          0.00
```

40011	IOB_LWIR_Env	35.98	0.00
40012	IOB_LWIR_Env	35.98	0.00
40013	IOB_LWIR_Env	35.98	0.00
40014	IOB_LWIR_Env	35.98	0.00
40015	IOB_LWIR_Env	35.98	0.00
40016	IOB_LWIR_Env	35.98	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
19
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
40017	IOB_LWIR_Env	35.98	0.00
40018	IOB_LWIR_Env	35.98	0.00
40020	IOB_LWIR_Env	35.98	0.00
40021	IOB_LWIR_Env	35.98	0.00
40022	IOB_LWIR_Env	35.98	0.00
40023	IOB_LWIR_Env	35.98	0.00
40024	IOB_LWIR_Env	35.98	0.00
40025	IOB_LWIR_Env	35.98	0.00
40026	IOB_LWIR_Env	35.98	0.00
40027	IOB_LWIR_Env	35.98	0.00
40028	IOB_LWIR_Env	35.98	0.00
40029	IOB_LWIR_Env	35.98	0.00
40030	IOB_LWIR_Env	35.98	0.00
40031	IOB_LWIR_Env	35.98	0.00
40032	IOB_LWIR_Env	35.98	0.00
40033	IOB_LWIR_Env	35.98	0.00
40034	IOB_LWIR_Env	35.98	0.00
40035	IOB_LWIR_Env	35.98	0.00
40036	IOB_LWIR_Env	35.98	0.00
40037	IOB_LWIR_Env	35.98	0.00
40500	IOB_LWIR_Det_Box	28.20	0.00
40501	IOB_LWIR_Det_Box	28.20	0.00
40502	IOB_LWIR_Det_Box	28.20	0.00
40503	IOB_LWIR_Det_Box	28.20	0.00
40504	IOB_LWIR_Det_Box	28.20	0.00
40505	IOB_LWIR_Det_Box	28.20	0.00
41000	IOB_LWIR_Baffle	35.98	0.00
41001	IOB_LWIR_Baffle	35.98	0.00
41002	IOB_LWIR_Baffle	35.98	0.00
41003	IOB_LWIR_Baffle	35.98	0.00
41004	IOB_LWIR_Baffle	35.98	0.00
41005	IOB_LWIR_Baffle	35.98	0.00
41006	IOB_LWIR_Baffle	35.98	0.00
41007	IOB_LWIR_Baffle	35.98	0.00
41008	IOB_LWIR_Baffle	35.98	0.00
41009	IOB_LWIR_Baffle	35.98	0.00
41010	IOB_LWIR_Baffle	35.98	0.00
41011	IOB_LWIR_Baffle	35.98	0.00
41012	IOB_LWIR_Baffle	35.98	0.00
41013	IOB_LWIR_Baffle	35.98	0.00
41014	IOB_LWIR_Baffle	35.98	0.00
41015	IOB_LWIR_Baffle	35.98	0.00
41016	IOB_LWIR_Baffle	35.98	0.00
41017	IOB_LWIR_Baffle	35.98	0.00

42000	LWIR_FEE	37.55	0.00
50000	IOB_FGS_Mod	37.56	0.00
50001	IOB_FGS_Mod	37.56	0.00
50002	IOB_FGS_Mod	37.56	0.00
50003	IOB_FGS_Mod	37.56	0.00
50004	IOB_FGS_Mod	37.56	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
20
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
50005	IOB_FGS_Mod	37.56	0.00
50006	IOB_FGS_Mod	37.56	0.00
50007	IOB_FGS_Mod	37.57	0.00
50008	IOB_FGS_Mod	37.56	0.00
50009	IOB_FGS_Mod	37.56	0.00
50010	IOB_FGS_Mod	37.56	0.00
50011	IOB_FGS_Mod	37.56	0.00
50012	IOB_FGS_Mod	37.57	0.00
50013	IOB_FGS_Mod	37.57	0.00
50014	IOB_FGS_Mod	37.57	0.00
50015	IOB_FGS_Mod	37.56	0.00
50016	IOB_FGS_Mod	37.56	0.00
50017	IOB_FGS_Mod	37.55	0.00
50018	IOB_FGS_Mod	37.56	0.00
50019	IOB_FGS_Mod	37.56	0.00
50020	IOB_FGS_Mod	37.56	0.00
50021	IOB_FGS_Mod	37.56	0.00
50022	IOB_FGS_Mod	37.56	0.00
50023	IOB_FGS_Mod	37.57	0.00
50024	IOB_FGS_Mod	37.56	0.00
50025	IOB_FGS_Mod	37.56	0.00
50026	IOB_FGS_Mod	37.56	0.00
50027	IOB_FGS_Mod	37.56	0.00
51000	FGS_det	35.02	0.00
52000	FGS_FEE	37.72	0.00

NODE	QE	QA	C
9000	0.00	0.00	5.70
9010	0.00	0.00	5.70
9020	0.00	0.00	5.70
9100	0.00	0.00	1.66
9101	0.00	0.00	1.66
9102	0.00	0.00	1.66
9110	0.00	0.00	1.66
9111	0.00	0.00	1.66
9112	0.00	0.00	1.66
9120	0.00	0.00	1.66
9121	0.00	0.00	1.66
9122	0.00	0.00	1.66
9130	0.00	0.00	1.66
9131	0.00	0.00	1.66

9132	0.00	0.00	1.66
9140	0.00	0.00	1.66
9141	0.00	0.00	1.66
9142	0.00	0.00	1.66
9150	0.00	0.00	1.66
9151	0.00	0.00	1.66
9152	0.00	0.00	1.66

1
ESATAN-TMS Thermal 10.10.0 Page 21
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
40000	0.00	0.00	4.31
40001	0.00	0.00	4.31
40002	0.00	0.00	4.31
40003	0.00	0.00	4.31
40004	0.00	0.00	4.31
40005	0.00	0.00	4.31
40006	0.00	0.00	4.31
40007	0.00	0.00	4.31
40008	0.00	0.00	4.31
40009	0.00	0.00	4.31
40010	0.00	0.00	4.31
40011	0.00	0.00	1.81
40012	0.00	0.00	5.85
40013	0.00	0.00	5.85
40014	0.00	0.00	5.85
40015	0.00	0.00	5.85
40016	0.00	0.00	4.92
40017	0.00	0.00	4.92
40018	0.00	0.00	0.04
40020	0.00	0.00	5.85
40021	0.00	0.00	5.85
40022	0.00	0.00	5.85
40023	0.00	0.00	4.92
40024	0.00	0.00	4.92
40025	0.00	0.00	4.92
40026	0.00	0.00	4.31
40027	0.00	0.00	4.31
40028	0.00	0.00	4.31
40029	0.00	0.00	1.81
40030	0.00	0.00	4.31
40031	0.00	0.00	4.31
40032	0.00	0.00	4.31
40033	0.00	0.00	4.31
40034	0.00	0.00	4.31
40035	0.00	0.00	4.31
40036	0.00	0.00	4.31
40037	0.00	0.00	4.31
40500	0.00	0.00	11.08
40501	0.00	0.00	5.54
40502	0.00	0.00	5.54
40503	0.00	0.00	5.54
40504	0.00	0.00	5.54
40505	0.00	0.00	11.08

41000	0.00	0.00	3.39
41001	0.00	0.00	3.39
41002	0.00	0.00	3.39
41003	0.00	0.00	3.39
41004	0.00	0.00	2.71
41005	0.00	0.00	2.71
41006	0.00	0.00	2.71

1
ESATAN-TMS Thermal 10.10.0 Page 22
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
41007	0.00	0.00	2.71
41008	0.00	0.00	3.06
41009	0.00	0.00	2.71
41010	0.00	0.00	2.71
41011	0.00	0.00	2.71
41012	0.00	0.00	2.71
41013	0.00	0.00	1.66
41014	0.00	0.00	3.39
41015	0.00	0.00	3.39
41016	0.00	0.00	3.39
41017	0.00	0.00	3.39
42000	0.00	0.00	0.10
50000	0.00	0.00	9.23
50001	0.00	0.00	9.23
50002	0.00	0.00	9.23
50003	0.00	0.00	9.23
50004	0.00	0.00	9.23
50005	0.00	0.00	9.23
50006	0.00	0.00	9.23
50007	0.00	0.00	9.23
50008	0.00	0.00	9.23
50009	0.00	0.00	9.23
50010	0.00	0.00	9.23
50011	0.00	0.00	9.23
50012	0.00	0.00	9.23
50013	0.00	0.00	9.23
50014	0.00	0.00	9.23
50015	0.00	0.00	9.23
50016	0.00	0.00	9.23
50017	0.00	0.00	9.23
50018	0.00	0.00	9.23
50019	0.00	0.00	9.23
50020	0.00	0.00	9.23
50021	0.00	0.00	9.23
50022	0.00	0.00	9.23
50023	0.00	0.00	9.23
50024	0.00	0.00	9.23
50025	0.00	0.00	9.23
50026	0.00	0.00	9.23
50027	0.00	0.00	9.23
51000	0.00	0.00	3.08
52000	0.00	0.00	0.10

1
ESATAN-TMS Thermal 10.10.0 Page
23
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

+ECHO_0_2_HUNT_RADIATOR:IOB:VNIR_MOD

NODE	LABEL	T	QS
15000	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15001	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15002	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15003	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15004	IOB_VNIR_Mod:Bottom_Box	35.92	0.00
15005	IOB_VNIR_Mod:Bottom_Box	35.92	0.00
15006	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15007	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15008	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15009	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15010	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15011	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15012	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15013	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15014	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15015	IOB_VNIR_Mod:Bottom_Box	37.52	0.00
15100	IOB_VNIR_Mod:Main_Box	37.52	0.00
15101	IOB_VNIR_Mod:Main_Box	37.52	0.00
15102	IOB_VNIR_Mod:Main_Box	37.52	0.00
15103	IOB_VNIR_Mod:Main_Box	37.52	0.00
15104	IOB_VNIR_Mod:Main_Box	37.52	0.00
15105	IOB_VNIR_Mod:Main_Box	37.52	0.00
15106	IOB_VNIR_Mod:Main_Box	37.52	0.00
15107	IOB_VNIR_Mod:Main_Box	37.52	0.00
15108	IOB_VNIR_Mod:Main_Box	37.52	0.00
15109	IOB_VNIR_Mod:Main_Box	37.52	0.00
15110	IOB_VNIR_Mod:Main_Box	37.52	0.00
15111	IOB_VNIR_Mod:Main_Box	37.52	0.00
15112	IOB_VNIR_Mod:Main_Box	37.52	0.00
15113	IOB_VNIR_Mod:Main_Box	37.52	0.00
15114	IOB_VNIR_Mod:Main_Box	37.52	0.00
15115	IOB_VNIR_Mod:Main_Box	37.52	0.00
15116	IOB_VNIR_Mod:Main_Box	37.52	0.00
15117	IOB_VNIR_Mod:Main_Box	37.53	0.00
15118	IOB_VNIR_Mod:Main_Box	37.52	0.00
15119	IOB_VNIR_Mod:Main_Box	37.52	0.00
15120	IOB_VNIR_Mod:Main_Box	37.52	0.00
15121	IOB_VNIR_Mod:Main_Box	37.52	0.00
15122	IOB_VNIR_Mod:Main_Box	37.52	0.00
15123	IOB_VNIR_Mod:Main_Box	37.52	0.00
15124	IOB_VNIR_Mod:Main_Box	37.52	0.00
15125	IOB_VNIR_Mod:Main_Box	37.52	0.00
15126	IOB_VNIR_Mod:Main_Box	37.52	0.00
15127	IOB_VNIR_Mod:Main_Box	37.52	0.00
15128	IOB_VNIR_Mod:Main_Box	37.52	0.00
15129	IOB_VNIR_Mod:Main_Box	37.52	0.00
15130	IOB_VNIR_Mod:Main_Box	37.52	0.00

```
        15131    IOB_VNIR_Mod:Main_Box          37.52          0.00
1
 ESATAN-TMS Thermal  10.10.0                                          Page
24
 13             September             2013                        17:07:28
ECHO_0_2_HUNT_RADIATOR

          NODE   LABEL                              T              QS

        15132    IOB_VNIR_Mod:Main_Box          37.52          0.00
        15133    IOB_VNIR_Mod:Main_Box          37.52          0.00
        15134    IOB_VNIR_Mod:Main_Box          37.52          0.00
        15135    IOB_VNIR_Mod:Main_Box          37.52          0.00
        15136    IOB_VNIR_Mod:Main_Box          37.52          0.00
        15137    IOB_VNIR_Mod:Main_Box          37.52          0.00
        15200    VNIR_FEE                       37.68          0.00
        15900    IOB_VNIR_Mod:Detector          35.01          0.00
        15901    IOB_VNIR_Mod:M1                37.52          0.00
        15902    IOB_VNIR_Mod:M2                37.52          0.00
        15903    IOB_VNIR_Mod:M3                37.52          0.00
        15904    IOB_VNIR_Mod:M4                37.52          0.00
        15905    IOB_VNIR_Mod:Grating           37.52          0.00
        15906    IOB_VNIR_Mod:Prism             37.52          0.00
        15911    IOB_VNIR_Mod:m01               37.52          0.00
        15912    IOB_VNIR_Mod:m02               37.52          0.00


          NODE          QE           QA           C

        15000         0.00         0.00         9.23
        15001         0.00         0.00         9.23
        15002         0.00         0.00         9.23
        15003         0.00         0.00         9.23
        15004         0.00         0.00         4.62
        15005         0.00         0.00         4.62
        15006         0.00         0.00         3.69
        15007         0.00         0.00         3.69
        15008         0.00         0.00         4.00
        15009         0.00         0.00         4.00
        15010         0.00         0.00         3.69
        15011         0.00         0.00         3.69
        15012         0.00         0.00         9.23
        15013         0.00         0.00         9.23
        15014         0.00         0.00         9.23
        15015         0.00         0.00         9.23
        15100         0.00         0.00        10.47
        15101         0.00         0.00        10.47
        15102         0.00         0.00        10.47
        15103         0.00         0.00        10.47
        15104         0.00         0.00        10.47
        15105         0.00         0.00        10.47
        15106         0.00         0.00        10.47
        15107         0.00         0.00        10.47
        15108         0.00         0.00        10.47
        15109         0.00         0.00        10.47
        15110         0.00         0.00        10.47
        15111         0.00         0.00        10.47
```

15112	0.00	0.00	14.16
15113	0.00	0.00	14.16

1
ESATAN-TMS Thermal 10.10.0 Page 25
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
15114	0.00	0.00	14.16
15115	0.00	0.00	11.08
15116	0.00	0.00	11.08
15117	0.00	0.00	11.08
15118	0.00	0.00	11.08
15119	0.00	0.00	14.16
15120	0.00	0.00	14.16
15121	0.00	0.00	14.16
15122	0.00	0.00	11.08
15123	0.00	0.00	11.08
15124	0.00	0.00	11.08
15125	0.00	0.00	11.08
15126	0.00	0.00	10.47
15127	0.00	0.00	10.47
15128	0.00	0.00	10.47
15129	0.00	0.00	10.47
15130	0.00	0.00	10.47
15131	0.00	0.00	10.47
15132	0.00	0.00	10.47
15133	0.00	0.00	10.47
15134	0.00	0.00	10.47
15135	0.00	0.00	10.47
15136	0.00	0.00	10.47
15137	0.00	0.00	10.47
15200	0.00	0.00	0.10
15900	0.00	0.00	7.08
15901	0.00	0.00	36.94
15902	0.00	0.00	0.97
15903	0.00	0.00	89.26
15904	0.00	0.00	9.23
15905	0.00	0.00	16.93
15906	0.00	0.00	38.51
15911	0.00	0.00	1.09
15912	0.00	0.00	1.09

==========

+ECHO_0_2_HUNT_RADIATOR:IOB:SWIR_MOD

NODE	LABEL	T	QS
20000	IOB_SWIR_Mod:Base	37.57	0.00
20001	IOB_SWIR_Mod:Base	37.56	0.00
20002	IOB_SWIR_Mod:Base	37.56	0.00

20003	IOB_SWIR_Mod:Base	37.56	0.00
20004	IOB_SWIR_Mod:Base	37.56	0.00
20005	IOB_SWIR_Mod:Base	37.56	0.00
20006	IOB_SWIR_Mod:Base	37.56	0.00
20007	IOB_SWIR_Mod:Base	37.56	0.00

1
ESATAN-TMS Thermal 10.10.0 Page 26
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
20008	IOB_SWIR_Mod:Base	37.56	0.00
20100	IOB_SWIR_Mod:Wall1	37.57	0.00
20101	IOB_SWIR_Mod:Wall1	37.57	0.00
20102	IOB_SWIR_Mod:Wall1	37.57	0.00
20103	IOB_SWIR_Mod:Wall1	37.57	0.00
20200	IOB_SWIR_Mod:Wall2	37.56	0.00
20201	IOB_SWIR_Mod:Wall2	37.55	0.00
20202	IOB_SWIR_Mod:Wall2	37.56	0.00
20203	IOB_SWIR_Mod:Wall2	37.56	0.00
20300	IOB_SWIR_Mod:Top	37.58	0.00
20301	IOB_SWIR_Mod:Top	37.58	0.00
20400	IOB_SWIR_Mod:Roof1	37.57	0.00
20401	IOB_SWIR_Mod:Roof1	37.57	0.00
20402	IOB_SWIR_Mod:Roof1	37.57	0.00
20403	IOB_SWIR_Mod:Roof1	37.58	0.00
20500	IOB_SWIR_Mod:Roof2	37.57	0.00
20501	IOB_SWIR_Mod:Roof2	37.58	0.00
20502	IOB_SWIR_Mod:Roof2	37.58	0.00
20503	IOB_SWIR_Mod:Roof2	37.58	0.00
20900	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20901	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20902	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20903	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20904	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20905	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20906	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20907	IOB_SWIR_Mod:Side_Closur	37.56	0.00
20908	IOB_SWIR_Mod:Side_Closur	37.56	0.00
22000	IOB_SWIR_Mod:Roof_Box	37.58	0.00
22001	IOB_SWIR_Mod:Roof_Box	37.58	0.00
22002	IOB_SWIR_Mod:Roof_Box	37.58	0.00
22003	IOB_SWIR_Mod:Roof_Box	37.58	0.00
22004	IOB_SWIR_Mod:Roof_Box	37.58	0.00
22005	IOB_SWIR_Mod:Roof_Box	37.58	0.00
25000	IOB_SWIR_Mod:Back_Sup	37.56	0.00
25001	IOB_SWIR_Mod:Back_Sup	37.56	0.00
25002	IOB_SWIR_Mod:Back_Sup	37.56	0.00
25003	IOB_SWIR_Mod:Back_Sup	37.56	0.00
28500	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28501	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28502	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28503	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28504	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28505	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28506	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00

28507	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28508	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28509	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28510	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28511	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00

1
ESATAN-TMS Thermal 10.10.0 Page 27
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
28512	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28513	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28514	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28515	IOB_SWIR_Mod:Side_Box_Ba	37.56	0.00
28600	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28601	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28602	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28603	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28604	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28605	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28606	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28607	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28608	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28609	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28610	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28611	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28612	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28613	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28614	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
28615	IOB_SWIR_Mod:Side_Box_To	37.56	0.00
29000	SWIR_FEE	37.74	0.00
29504	IOB_SWIR_Mod:s4	37.56	0.00
29505	IOB_SWIR_Mod:prism	37.56	0.00
29600	IOB_SWIR_Mod:Det_Box	34.98	0.00
29601	IOB_SWIR_Mod:Det_Box	34.98	0.00
29602	IOB_SWIR_Mod:Det_Box	34.98	0.00
29603	IOB_SWIR_Mod:Det_Box	34.98	0.00
29604	IOB_SWIR_Mod:Det_Box	34.98	0.00
29605	IOB_SWIR_Mod:Det_Box	34.98	0.00

NODE	QE	QA	C
20000	0.00	0.00	2.97
20001	0.00	0.00	2.97
20002	0.00	0.00	2.97
20003	0.00	0.00	2.97
20004	0.00	0.00	2.97
20005	0.00	0.00	2.97
20006	0.00	0.00	2.97
20007	0.00	0.00	2.28
20008	0.00	0.00	1.05
20100	0.00	0.00	1.65
20101	0.00	0.00	1.65

20102	0.00	0.00	1.65
20103	0.00	0.00	1.65
20200	0.00	0.00	2.05
20201	0.00	0.00	2.05
20202	0.00	0.00	2.05
20203	0.00	0.00	2.05

1
ESATAN-TMS Thermal 10.10.0 Page
28
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
20300	0.00	0.00	1.79
20301	0.00	0.00	1.79
20400	0.00	0.00	2.10
20401	0.00	0.00	2.10
20402	0.00	0.00	2.10
20403	0.00	0.00	2.10
20500	0.00	0.00	2.05
20501	0.00	0.00	2.05
20502	0.00	0.00	2.05
20503	0.00	0.00	2.05
20900	0.00	0.00	3.02
20901	0.00	0.00	2.48
20902	0.00	0.00	1.15
20903	0.00	0.00	3.03
20904	0.00	0.00	2.80
20905	0.00	0.00	2.91
20906	0.00	0.00	3.06
20907	0.00	0.00	3.02
20908	0.00	0.00	0.87
22000	0.00	0.00	1.77
22001	0.00	0.00	3.69
22002	0.00	0.00	1.77
22003	0.00	0.00	3.69
22004	0.00	0.00	1.77
22005	0.00	0.00	1.77
25000	0.00	0.00	1.55
25001	0.00	0.00	1.55
25002	0.00	0.00	1.55
25003	0.00	0.00	1.55
28500	0.00	0.00	0.19
28501	0.00	0.00	0.19
28502	0.00	0.00	0.19
28503	0.00	0.00	0.19
28504	0.00	0.00	0.10
28505	0.00	0.00	0.10
28506	0.00	0.00	0.10
28507	0.00	0.00	0.10
28508	0.00	0.00	0.10
28509	0.00	0.00	0.10
28510	0.00	0.00	0.10
28511	0.00	0.00	0.10
28512	0.00	0.00	0.19
28513	0.00	0.00	0.19
28514	0.00	0.00	0.19

28515	0.00	0.00	0.19
28600	0.00	0.00	0.07
28601	0.00	0.00	0.07
28602	0.00	0.00	0.07
28603	0.00	0.00	0.07
28604	0.00	0.00	0.13

1
ESATAN-TMS Thermal 10.10.0 Page
29
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
28605	0.00	0.00	0.13
28606	0.00	0.00	0.13
28607	0.00	0.00	0.13
28608	0.00	0.00	0.13
28609	0.00	0.00	0.13
28610	0.00	0.00	0.13
28611	0.00	0.00	0.13
28612	0.00	0.00	0.07
28613	0.00	0.00	0.07
28614	0.00	0.00	0.07
28615	0.00	0.00	0.07
29000	0.00	0.00	0.10
29504	0.00	0.00	2.15
29505	0.00	0.00	0.80
29600	0.00	0.00	0.51
29601	0.00	0.00	1.23
29602	0.00	0.00	0.51
29603	0.00	0.00	1.23
29604	0.00	0.00	0.51
29605	0.00	0.00	0.51

==========

+ECHO_0_2_HUNT_RADIATOR:IOB:OPTICAL_BENCH:OB_STIFF

NODE	LABEL	T	QS
8501	Quadrilateral_1	37.48	0.00
8502	Quadrilateral_1	37.48	0.00
8503	Quadrilateral_1	37.48	0.00
8510	Quadrilateral_2	37.48	0.00
8511	Quadrilateral_2	37.48	0.00
8512	Quadrilateral_2	37.48	0.00
8520	Quadrilateral_3	37.48	0.00
8521	Quadrilateral_3	37.49	0.00
8522	Quadrilateral_3	37.49	0.00
8523	Quadrilateral_3	37.49	0.00
8524	Quadrilateral_3	37.49	0.00
8525	Quadrilateral_3	37.49	0.00
8526	Quadrilateral_3	37.49	0.00

8527	Quadrilateral_3	37.48	0.00
8530	Quadrilateral_4	37.48	0.00
8531	Quadrilateral_4	37.48	0.00
8532	Quadrilateral_4	37.48	0.00
8540	Quadrilateral_5	37.48	0.00
8541	Quadrilateral_5	37.48	0.00
8542	Quadrilateral_5	37.48	0.00
8543	Quadrilateral_5	37.48	0.00
8550	Quadrilateral_6	37.49	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
30
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
8551	Quadrilateral_6	37.49	0.00
8552	Quadrilateral_6	37.49	0.00
8560	Quadrilateral_7	37.50	0.00
8561	Quadrilateral_7	37.51	0.00
8562	Quadrilateral_7	37.51	0.00
8563	Quadrilateral_7	37.52	0.00
8564	Quadrilateral_7	37.52	0.00
8565	Quadrilateral_7	37.51	0.00
8566	Quadrilateral_7	37.50	0.00
8567	Quadrilateral_7	37.50	0.00
8600	Rectangle_1	37.49	0.00
8601	Rectangle_1	37.49	0.00
8602	Rectangle_1	37.49	0.00
8605	Rectangle_10	33.61	0.00
8610	Rectangle_101	33.48	0.00
8611	Rectangle_102	33.50	0.00
8612	Rectangle_103	33.40	0.00
8613	Rectangle_104	33.48	0.00
8614	Rectangle_105	33.50	0.00
8615	Rectangle_106	33.49	0.00
8616	Rectangle_107	33.40	0.00
8617	Rectangle_108	33.48	0.00
8618	Rectangle_111	33.37	0.00
8619	Rectangle_112	33.40	0.00
8620	Rectangle_113	33.41	0.00
8621	Rectangle_114	33.41	0.00
8622	Rectangle_116	33.38	0.00
8623	Rectangle_117	33.38	0.00
8624	Rectangle_118	33.38	0.00
8625	Rectangle_120	33.39	0.00
8626	Rectangle_123	33.38	0.00
8627	Rectangle_124	33.37	0.00
8628	Rectangle_125	33.36	0.00
8629	Rectangle_126	33.49	0.00
8630	Rectangle_128	33.49	0.00
8631	Rectangle_18	33.62	0.00
8632	Rectangle_21	33.38	0.00
8633	Rectangle_22	33.39	0.00
8634	Rectangle_23	33.37	0.00
8635	Rectangle_24	33.39	0.00
8636	Rectangle_27	33.36	0.00

8637	Rectangle_28	33.37	0.00
8638	Rectangle_29	33.42	0.00
8639	Rectangle_30	33.38	0.00
8640	Rectangle_32	33.41	0.00
8641	Rectangle_33	33.61	0.00
8642	Rectangle_36	33.49	0.00
8643	Rectangle_38	33.52	0.00
8644	Rectangle_39	33.65	0.00
8645	Rectangle_40	33.45	0.00

1
ESATAN-TMS Thermal 10.10.0 Page 31
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
8646	Rectangle_42	33.55	0.00
8647	Rectangle_43	33.48	0.00
8648	Rectangle_44	33.48	0.00
8649	Rectangle_45	33.47	0.00
8650	Rectangle_46	33.47	0.00
8651	Rectangle_47	33.49	0.00
8652	Rectangle_50	33.49	0.00
8653	Rectangle_52	33.49	0.00
8654	Rectangle_53	33.44	0.00
8655	Rectangle_56	33.48	0.00
8656	Rectangle_58	33.50	0.00
8657	Rectangle_6	33.54	0.00
8658	Rectangle_60	33.55	0.00
8659	Rectangle_66	33.59	0.00
8660	Rectangle_68	33.41	0.00
8661	Rectangle_71	33.39	0.00
8662	Rectangle_73	33.53	0.00
8663	Rectangle_74	33.50	0.00
8664	Rectangle_75	33.45	0.00
8665	Rectangle_76	33.49	0.00
8666	Rectangle_77	33.48	0.00
8667	Rectangle_79	33.48	0.00
8668	Rectangle_80	33.37	0.00
8669	Rectangle_81	33.38	0.00
8670	Rectangle_84	33.37	0.00
8671	Rectangle_86	33.37	0.00
8672	Rectangle_87	33.39	0.00
8673	Rectangle_88	33.44	0.00
8674	Rectangle_89	33.52	0.00
8675	Rectangle_9	33.58	0.00
8676	Rectangle_91	33.56	0.00
8677	Rectangle_93	33.56	0.00
8678	Rectangle_94	33.47	0.00
8679	Rectangle_95	33.45	0.00
8680	Rectangle_96	33.39	0.00
8681	Rectangle_98	33.39	0.00
8682	Rectangle_99	33.39	0.00
85010	Quadrilateral_2	37.48	0.00
85011	Quadrilateral_2	37.48	0.00
85012	Quadrilateral_2	37.48	0.00

NODE	QE	QA	C
8501	0.00	0.00	5.90
8502	0.00	0.00	5.90
8503	0.00	0.00	5.90
8510	0.00	0.00	3.42
8511	0.00	0.00	3.42
8512	0.00	0.00	3.42

1
ESATAN-TMS Thermal 10.10.0 Page 32
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
8520	0.00	0.00	5.90
8521	0.00	0.00	5.90
8522	0.00	0.00	5.90
8523	0.00	0.00	5.90
8524	0.00	0.00	5.90
8525	0.00	0.00	5.90
8526	0.00	0.00	5.90
8527	0.00	0.00	5.90
8530	0.00	0.00	6.52
8531	0.00	0.00	6.52
8532	0.00	0.00	6.52
8540	0.00	0.00	4.66
8541	0.00	0.00	4.66
8542	0.00	0.00	4.66
8543	0.00	0.00	4.66
8550	0.00	0.00	6.52
8551	0.00	0.00	6.52
8552	0.00	0.00	6.52
8560	0.00	0.00	5.90
8561	0.00	0.00	5.90
8562	0.00	0.00	5.90
8563	0.00	0.00	5.90
8564	0.00	0.00	5.90
8565	0.00	0.00	5.90
8566	0.00	0.00	5.90
8567	0.00	0.00	5.90
8600	0.00	0.00	6.52
8601	0.00	0.00	6.52
8602	0.00	0.00	6.52
8605	0.00	0.00	4.35
8610	0.00	0.00	10.25
8611	0.00	0.00	14.60
8612	0.00	0.00	10.25
8613	0.00	0.00	14.60
8614	0.00	0.00	14.60
8615	0.00	0.00	10.25
8616	0.00	0.00	10.25
8617	0.00	0.00	14.60
8618	0.00	0.00	10.25
8619	0.00	0.00	14.60

8620	0.00	0.00	10.25
8621	0.00	0.00	14.60
8622	0.00	0.00	14.60
8623	0.00	0.00	14.60
8624	0.00	0.00	10.25
8625	0.00	0.00	14.60
8626	0.00	0.00	10.25
8627	0.00	0.00	14.60
8628	0.00	0.00	10.25
8629	0.00	0.00	10.25

1
ESATAN-TMS Thermal 10.10.0 Page 33
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
8630	0.00	0.00	10.25
8631	0.00	0.00	4.66
8632	0.00	0.00	10.25
8633	0.00	0.00	14.60
8634	0.00	0.00	10.25
8635	0.00	0.00	14.60
8636	0.00	0.00	10.25
8637	0.00	0.00	14.60
8638	0.00	0.00	10.25
8639	0.00	0.00	14.60
8640	0.00	0.00	10.25
8641	0.00	0.00	4.66
8642	0.00	0.00	14.60
8643	0.00	0.00	14.60
8644	0.00	0.00	4.66
8645	0.00	0.00	10.25
8646	0.00	0.00	14.60
8647	0.00	0.00	7.15
8648	0.00	0.00	7.15
8649	0.00	0.00	7.15
8650	0.00	0.00	7.15
8651	0.00	0.00	10.25
8652	0.00	0.00	14.60
8653	0.00	0.00	14.60
8654	0.00	0.00	10.25
8655	0.00	0.00	14.60
8656	0.00	0.00	14.60
8657	0.00	0.00	4.35
8658	0.00	0.00	14.60
8659	0.00	0.00	14.60
8660	0.00	0.00	10.25
8661	0.00	0.00	10.25
8662	0.00	0.00	14.60
8663	0.00	0.00	14.60
8664	0.00	0.00	10.25
8665	0.00	0.00	10.25
8666	0.00	0.00	14.60
8667	0.00	0.00	14.60
8668	0.00	0.00	14.60
8669	0.00	0.00	10.25

8670	0.00	0.00	14.60
8671	0.00	0.00	10.25
8672	0.00	0.00	10.25
8673	0.00	0.00	10.25
8674	0.00	0.00	14.60
8675	0.00	0.00	4.35
8676	0.00	0.00	4.35
8677	0.00	0.00	4.66
8678	0.00	0.00	14.60
8679	0.00	0.00	14.60

1
ESATAN-TMS Thermal 10.10.0 Page
34
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
8680	0.00	0.00	10.25
8681	0.00	0.00	14.60
8682	0.00	0.00	14.60
85010	0.00	0.00	3.42
85011	0.00	0.00	3.42
85012	0.00	0.00	3.42

==========

+ECHO_0_2_HUNT_RADIATOR:IOB:OPTICAL_BENCH:OB

NODE	LABEL	T	QS
8000	IOB_Optical_Bench:Main_O	37.48	0.00
8001	IOB_Optical_Bench:Main_O	37.50	0.00
8002	IOB_Optical_Bench:Main_O	37.50	0.00
8003	IOB_Optical_Bench:Main_O	37.50	0.00
8004	IOB_Optical_Bench:Main_O	37.50	0.00
8005	IOB_Optical_Bench:Main_O	37.49	0.00
8006	IOB_Optical_Bench:Main_O	37.50	0.00
8007	IOB_Optical_Bench:Main_O	37.50	0.00
8008	IOB_Optical_Bench:Main_O	37.50	0.00
8009	IOB_Optical_Bench:Main_O	37.50	0.00
8010	IOB_Optical_Bench:Main_O	37.49	0.00
8011	IOB_Optical_Bench:Main_O	37.50	0.00
8012	IOB_Optical_Bench:Main_O	37.50	0.00
8013	IOB_Optical_Bench:Main_O	37.50	0.00
8014	IOB_Optical_Bench:Main_O	37.50	0.00
8015	IOB_Optical_Bench:Main_O	37.50	0.00
8016	IOB_Optical_Bench:Main_O	37.51	0.00
8017	IOB_Optical_Bench:Main_O	37.51	0.00
8018	IOB_Optical_Bench:Main_O	37.50	0.00
8019	IOB_Optical_Bench:Main_O	37.50	0.00
8020	IOB_Optical_Bench:Main_O	37.49	0.00
8021	IOB_Optical_Bench:Main_O	37.52	0.00
8022	IOB_Optical_Bench:Main_O	37.53	0.00

8023	IOB_Optical_Bench:Main_O	37.51	0.00
8024	IOB_Optical_Bench:Main_O	37.50	0.00
8100	IOB_Optical_Bench:OB_edg	37.48	0.00
8101	IOB_Optical_Bench:OB_edg	37.49	0.00
8102	IOB_Optical_Bench:OB_edg	37.49	0.00
8103	IOB_Optical_Bench:OB_edg	37.50	0.00
8104	IOB_Optical_Bench:OB_edg	37.50	0.00
8105	IOB_Optical_Bench:OB_edg	37.49	0.00
8106	IOB_Optical_Bench:OB_edg	37.49	0.00
8107	IOB_Optical_Bench:OB_edg	37.49	0.00
8108	IOB_Optical_Bench:OB_edg	37.50	0.00
8109	IOB_Optical_Bench:OB_edg	37.50	0.00
8200	IOB_Optical_Bench:OB_edg	37.49	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
35
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
8201	IOB_Optical_Bench:OB_edg	37.49	0.00
8202	IOB_Optical_Bench:OB_edg	37.48	0.00
8203	IOB_Optical_Bench:OB_edg	37.49	0.00
8204	IOB_Optical_Bench:OB_edg	37.49	0.00
8205	IOB_Optical_Bench:OB_edg	37.49	0.00
8206	IOB_Optical_Bench:OB_edg	37.49	0.00
8207	IOB_Optical_Bench:OB_edg	37.48	0.00
8208	IOB_Optical_Bench:OB_edg	37.49	0.00
8209	IOB_Optical_Bench:OB_edg	37.49	0.00

NODE	QE	QA	C
8000	0.00	0.00	35.11
8001	0.00	0.00	35.11
8002	0.00	0.00	35.11
8003	0.00	0.00	35.11
8004	0.00	0.00	34.80
8005	0.00	0.00	35.11
8006	0.00	0.00	35.11
8007	0.00	0.00	35.11
8008	0.00	0.00	35.11
8009	0.00	0.00	34.80
8010	0.00	0.00	35.11
8011	0.00	0.00	35.11
8012	0.00	0.00	35.11
8013	0.00	0.00	35.11
8014	0.00	0.00	35.11
8015	0.00	0.00	35.11
8016	0.00	0.00	35.11
8017	0.00	0.00	35.11
8018	0.00	0.00	34.80
8019	0.00	0.00	34.80
8020	0.00	0.00	35.11
8021	0.00	0.00	35.11
8022	0.00	0.00	35.11

8023	0.00	0.00	35.11
8024	0.00	0.00	34.80
8100	0.00	0.00	22.06
8101	0.00	0.00	22.06
8102	0.00	0.00	22.06
8103	0.00	0.00	22.06
8104	0.00	0.00	22.06
8105	0.00	0.00	14.29
8106	0.00	0.00	14.29
8107	0.00	0.00	14.29
8108	0.00	0.00	14.29
8109	0.00	0.00	14.29
8200	0.00	0.00	22.06
8201	0.00	0.00	22.06

1
ESATAN-TMS Thermal 10.10.0 Page
36
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
8202	0.00	0.00	22.06
8203	0.00	0.00	22.06
8204	0.00	0.00	22.06
8205	0.00	0.00	14.29
8206	0.00	0.00	14.29
8207	0.00	0.00	14.29
8208	0.00	0.00	14.29
8209	0.00	0.00	14.29

==========

+ECHO_0_2_HUNT_RADIATOR:IOB:MWIR_MOD

NODE	LABEL	T	QS
30090	IOB_MWIR_Mod:Lens7	28.01	0.00
30091	IOB_MWIR_Mod:Prism6	28.01	0.00
30092	IOB_MWIR_Mod:Det_Env	28.19	0.00
30093	IOB_MWIR_Mod:Detector	28.19	0.00
30094	IOB_MWIR_Mod:Opt3	28.01	0.00
32000	MWIR_FEE	37.55	0.00
32500	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32501	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32502	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32503	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32504	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32505	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32506	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32507	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32508	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32509	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32510	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32511	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32512	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32513	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00

32514	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32515	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32516	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32517	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32518	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32600	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32601	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32602	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32603	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32604	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32605	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32606	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32607	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
32608	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
37
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
33000	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
33001	IOB_MWIR_Mod:Main_Sup_In	28.01	0.00
36000	IOB_MWIR_Mod:MWIR2_base	36.98	0.00
36010	IOB_MWIR_Mod:MWIR2_edge1	36.98	0.00
36011	IOB_MWIR_Mod:MWIR2_edge1	36.98	0.00
36020	IOB_MWIR_Mod:MWIR2_edge2	36.98	0.00
36021	IOB_MWIR_Mod:MWIR2_edge2	36.98	0.00
36030	IOB_MWIR_Mod:MWIR2_edge3	36.98	0.00
36031	IOB_MWIR_Mod:MWIR2_edge3	36.98	0.00
36032	IOB_MWIR_Mod:MWIR2_edge3	36.98	0.00
36033	IOB_MWIR_Mod:MWIR2_edge3	36.98	0.00
36040	IOB_MWIR_Mod:MWIR2_edge4	36.98	0.00
36041	IOB_MWIR_Mod:MWIR2_edge4	36.98	0.00
36050	IOB_MWIR_Mod:MWIR2_edge5	36.98	0.00
36051	IOB_MWIR_Mod:MWIR2_edge5	36.98	0.00
36060	IOB_MWIR_Mod:MWIR2_edge6	36.98	0.00
36070	IOB_MWIR_Mod:MWIR2_edge7	36.98	0.00
37000	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37001	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37002	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37003	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37004	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37005	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37006	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37007	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37008	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37009	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37010	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37011	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37012	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37013	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37014	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37015	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37017	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37018	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00
37019	IOB_MWIR_Mod:MWIR2_Wall_	36.98	0.00

39000	IOB_MWIR_Mod:Side_Box	36.98	0.00
39001	IOB_MWIR_Mod:Side_Box	36.98	0.00
39002	IOB_MWIR_Mod:Side_Box	36.98	0.00
39003	IOB_MWIR_Mod:Side_Box	36.98	0.00
39004	IOB_MWIR_Mod:Side_Box	36.98	0.00
39005	IOB_MWIR_Mod:Side_Box	36.98	0.00
39006	IOB_MWIR_Mod:Side_Box	36.98	0.00
39007	IOB_MWIR_Mod:Side_Box	36.98	0.00
39008	IOB_MWIR_Mod:Side_Box	36.98	0.00
39009	IOB_MWIR_Mod:Side_Box	36.98	0.00
39010	IOB_MWIR_Mod:Side_Box	36.98	0.00
39011	IOB_MWIR_Mod:Side_Box	36.98	0.00
39012	IOB_MWIR_Mod:Side_Box	36.98	0.00
39013	IOB_MWIR_Mod:Side_Box	36.98	0.00

1
ESATAN-TMS Thermal 10.10.0 Page
38
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	LABEL	T	QS
39014	IOB_MWIR_Mod:Side_Box	36.98	0.00
39015	IOB_MWIR_Mod:Side_Box	36.98	0.00

NODE	QE	QA	C
30090	0.00	0.00	27.70
30091	0.00	0.00	14.47
30092	0.00	0.00	35.09
30093	0.00	0.00	5.85
30094	0.00	0.00	16.93
32000	0.00	0.00	0.10
32500	0.00	0.00	5.09
32501	0.00	0.00	5.09
32502	0.00	0.00	5.09
32503	0.00	0.00	5.09
32504	0.00	0.00	5.09
32505	0.00	0.00	5.09
32506	0.00	0.00	5.09
32507	0.00	0.00	5.09
32508	0.00	0.00	5.09
32509	0.00	0.00	5.09
32510	0.00	0.00	5.09
32511	0.00	0.00	4.39
32512	0.00	0.00	5.09
32513	0.00	0.00	5.09
32514	0.00	0.00	5.09
32515	0.00	0.00	1.25
32516	0.00	0.00	5.09
32517	0.00	0.00	5.09
32518	0.00	0.00	2.98
32600	0.00	0.00	3.53
32601	0.00	0.00	3.53
32602	0.00	0.00	5.09
32603	0.00	0.00	5.80

32604	0.00	0.00	5.80
32605	0.00	0.00	2.59
32606	0.00	0.00	5.80
32607	0.00	0.00	5.48
32608	0.00	0.00	0.32
33000	0.00	0.00	3.76
33001	0.00	0.00	3.76
36000	0.00	0.00	14.16
36010	0.00	0.00	3.39
36011	0.00	0.00	3.39
36020	0.00	0.00	4.92
36021	0.00	0.00	4.92
36030	0.00	0.00	3.69
36031	0.00	0.00	3.69
36032	0.00	0.00	3.69

1
ESATAN-TMS Thermal 10.10.0 Page 39
13 September 2013 17:07:28
ECHO_0_2_HUNT_RADIATOR

NODE	QE	QA	C
36033	0.00	0.00	3.69
36040	0.00	0.00	4.00
36041	0.00	0.00	4.00
36050	0.00	0.00	3.69
36051	0.00	0.00	3.69
36060	0.00	0.00	1.61
36070	0.00	0.00	4.92
37000	0.00	0.00	1.62
37001	0.00	0.00	1.61
37002	0.00	0.00	0.98
37003	0.00	0.00	0.10
37004	0.00	0.00	1.62
37005	0.00	0.00	1.62
37006	0.00	0.00	1.62
37007	0.00	0.00	1.45
37008	0.00	0.00	1.62
37009	0.00	0.00	1.62
37010	0.00	0.00	1.62
37011	0.00	0.00	1.62
37012	0.00	0.00	0.16
37013	0.00	0.00	0.52
37014	0.00	0.00	1.62
37015	0.00	0.00	1.62
37017	0.00	0.00	0.32
37018	0.00	0.00	1.39
37019	0.00	0.00	1.06
39000	0.00	0.00	0.82
39001	0.00	0.00	0.82
39002	0.00	0.00	0.82
39003	0.00	0.00	0.82
39004	0.00	0.00	0.50
39005	0.00	0.00	0.50
39006	0.00	0.00	0.55
39007	0.00	0.00	0.55
39008	0.00	0.00	0.50

39009	0.00	0.00	0.50
39010	0.00	0.00	0.55
39011	0.00	0.00	0.55
39012	0.00	0.00	0.82
39013	0.00	0.00	0.82
39014	0.00	0.00	0.82
39015	0.00	0.00	0.82