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# **Exoplanet Characterisation Observatory (EChO)**

## **TMM/GMM Description and Results Technical Note**

**Issue 1.0**

**ECHO-TN-0001-IASFBO**

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| 0.1   | 04-Sep-13   | All  | First release of the document         |         |
| 1.0   | 14-Sep-2013 | All  | General review and TMM results update |         |
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**Exoplanet  
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## 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)        | $\Delta T^1$ (K) | Op T (K)  | $\Delta T^1$ (K) | Load <sup>2</sup> (mW) | Load <sup>2</sup> (mW) | Op T (K)  | $\Delta T^1$ (K) | Load <sup>2</sup> (mw) |
| <b>FGS</b>  | $\leq 50$       | $\pm 1$          | $\leq 45$ | $\pm 0.05$       | 10                     | 5                      | $\leq 50$ | $\pm 1$          | 64                     |
| <b>VNIR</b> | $\leq 50$       | $\pm 1$          | $\leq 45$ | $\pm 0.05$       | 10                     | 5                      | $\leq 50$ | $\pm 1$          | 64                     |
| <b>SWIR</b> | $\leq 50$       | $\pm 1$          | $\leq 45$ | $\pm 0.05$       | 8                      | 5                      | $\leq 50$ | $\pm 1$          | 16                     |
| <b>MWIR</b> | $\leq 32$       | $\pm 1$ (TBC)    | $< 30$    | $\pm 0.05$       | 5                      | 5                      | $\leq 50$ | $\pm 1$          | 8                      |
| <b>LWIR</b> | $\leq 29$       | $\pm 1$ (TBC)    | $< 30$    | $\pm 0.05$       | 5                      | 5                      | $\leq 50$ | $\pm 1$          | 8                      |

Notes: <sup>1</sup> Peak to peak value over a typical observation time

<sup>2</sup> 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.

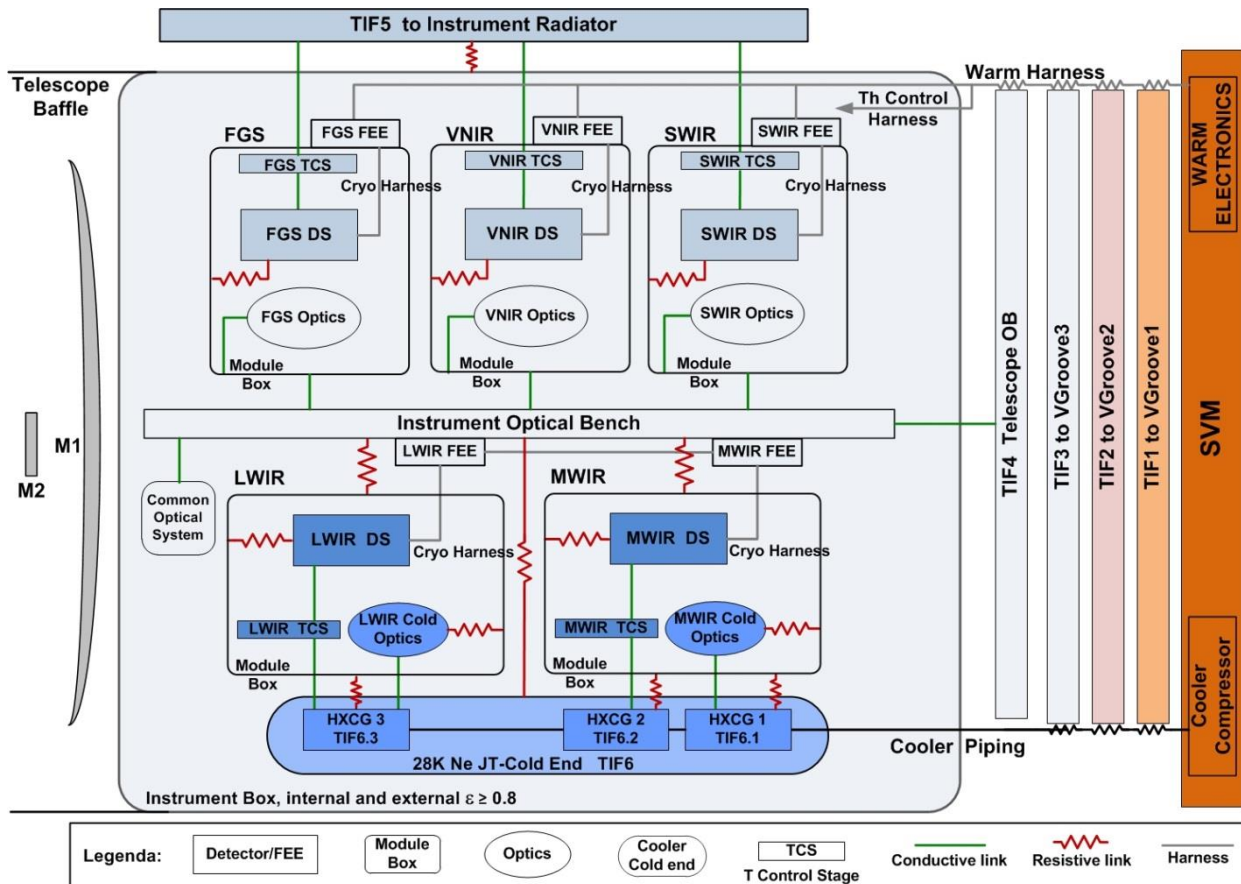


Figure 2-1: ECHO thermal scheme with main thermal IF's to S/C

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  $T \leq 45K$ , 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.

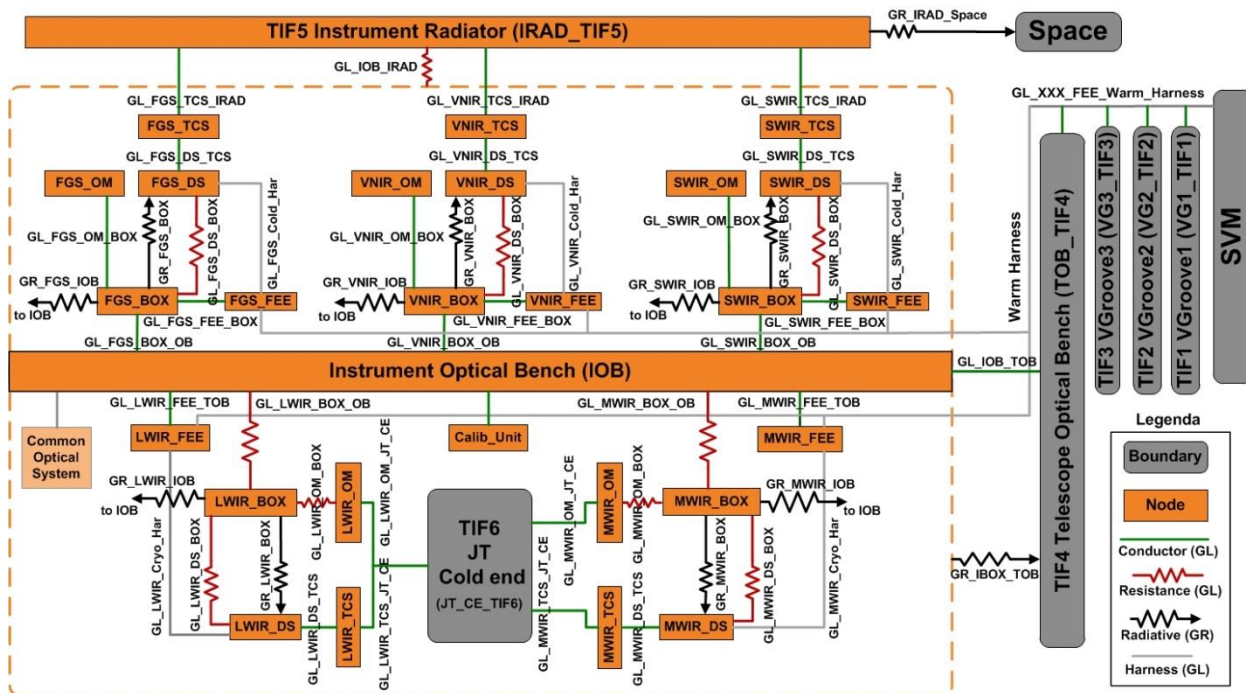
In general, each detector stage is thermally decoupled from the relative module box or optics, to ensure optimal performances of the FPA in terms of absolute temperature and stability. Coupling to the temperature reference stage (cooler cold end or radiator) is achieved through a Thermal Control Stage (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  $\leq 45$  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 ( $\epsilon \geq 0.8$ , 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 compliance 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<br>(W/K or<br>m <sup>2</sup> ) | Link description                                     | Justification                                                                                                                                                                                                                                   |
|------------------|--------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GL_xxxx_BOX_OB   | 0.001                                | Modules Box to<br>Instrument Optical Bench           |                                                                                                                                                                                                                                                 |
| GL_xxxx_BOX_OB   | 0.5                                  | Modules Box to<br>Instrument Optical Bench           | Assuming Al struts, 10 cm <sup>2</sup> total<br>contact surface with 500 W/m <sup>2</sup> -K. M5<br>bolts with spring washers (and filler<br>TBC)                                                                                               |
| GL_xxxx_DS_BOX   | 0.0001                               | Detectors to Module Box<br>insulation                | CFRP-T300 struts: 2.5 mm diameter and<br>30mm long. 6 for each detector +<br>thermal control stage.                                                                                                                                             |
| GL_xxxx_DS_BOX   | 0.0003                               | "                                                    | CFRP-T300 struts: 3 mm diameter and<br>30mm long. 6 for each detector +<br>thermal control stage.                                                                                                                                               |
| GL_xxxx_OM_BOX   | 0.5                                  | Optical units to Modules<br>Box                      | Assuming Al struts, 10 cm <sup>2</sup> total<br>contact surface with 500 W/m <sup>2</sup> -K. M5<br>bolts with spring washers (and filler<br>TBC)                                                                                               |
| G_xxxx_DS_TCS    | 0.01                                 | Detectors to Thermal<br>Control Stages               | Achieved by properly sizing contact<br>area at interface and by thermal breaks<br>(316L SS TBC). With 500W/m <sup>2</sup> -K, 20<br>mm <sup>2</sup> contact area is needed. This can<br>be achieved with 3-4 2.5 mm diameter<br>Al stands (TBC) |
| G_xxxx_TCS_IRAD  | 0.05                                 | Thermal Control Stage to<br>Cold Radiator for 45K DS | Required conductance across thermal<br>braid is 0.1W/K. The total G is the series<br>with the surface contact conductance<br>(0.2W/K) between braid and the TCS                                                                                 |
| G_xxxx_TCS_JT_CE | 0.1                                  | Thermal Control Stage to<br>JT HXCG's for 28K DS     | Assuming Al units, 2 cm <sup>2</sup> total contact<br>surface with 500 W/m <sup>2</sup> -K. M5 or M4<br>bolts with spring washers (and filler<br>TBC)                                                                                           |
| GL_xxxx_FEE_IOB  | 0.1                                  | Channels FEE to IOB                                  | Assuming Al units, 2 cm <sup>2</sup> total contact<br>surface with 500 W/m <sup>2</sup> -K. M5 bolts<br>with spring washers (and filler TBC)                                                                                                    |
| GL_xxxx_Cold_Har | 0.0015                               | Simulated harness link<br>from 45K to DS             | As per MIRI, Euclid NISP and Planck<br>harness, assuming 100 wires, 1m<br>length between each stage and no<br>radiative load. See harness analysis in<br>[RD1].                                                                                 |
| GL_xxxx_Warm_Har | 0.00012                              | Simulated harness link<br>from VG3 to 40K stage      |                                                                                                                                                                                                                                                 |
| GL_IOB_TOB       | 0.01                                 | IOB struts on TOB                                    | CFRP-T300 (or G10) struts: 30 cm long,<br>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 $\geq 0.8$ 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 $\geq 0.8$ 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]). Emissivity = 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 | $\epsilon$ | 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 |
| <b>9000</b> | <b>SVM</b>      | <b>B</b> |     |      |          | <b>323.00</b> | 323.0000 | -2.941E-01 |
| <b>9100</b> | <b>VG1_TIF1</b> | <b>B</b> |     |      |          | <b>150.00</b> | 150.0000 | 2.461E-01  |
| <b>9200</b> | <b>VG2_TIF2</b> | <b>B</b> |     |      |          | <b>110.00</b> | 110.0000 | -7.000E-03 |
| <b>9300</b> | <b>VG3_TIF3</b> | <b>B</b> |     |      |          | <b>55.00</b>  | 55.0000  | 5.500E-02  |
| <b>9400</b> | <b>TOB_TIF4</b> | <b>B</b> |     |      |          | <b>55.00</b>  | 55.0000  | -1.400E-01 |
| <b>9600</b> | <b>JT_TIF6</b>  | <b>B</b> |     |      |          | <b>28.00</b>  | 28.0000  | 1.267E-01  |
| <b>9900</b> | <b>Space</b>    | <b>B</b> |     |      |          | <b>4.00</b>   | 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         |
|                      |                   |                                             |              |                  |
| <b>ThermXL GRs</b>   |                   | <b>(GRs are directly defined as values)</b> |              |                  |
| <b>Label</b>         | <b>First Node</b> | <b>Second Node</b>                          | <b>Value</b> | <b>Heat Flow</b> |
| 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) |
|-----------------------------------------------|----------|
| <b>VG1_TIF1</b>                               | 0.246    |
| <b>VG2_TIF2</b>                               | -0.007   |
| <b>VG3_TIF3</b>                               | 0.055    |
| <b>Telescope Optical Bench TIF4</b>           | -0.140   |
| <b>Cold Radiator TIF5 (rejected to Space)</b> | 0.110    |
| <b>JT Coldend TIF6</b>                        | 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 | $\epsilon$ | 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 |



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|      |            |   |     |      |          |        |          |            |
|------|------------|---|-----|------|----------|--------|----------|------------|
| 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         |
|                      |                                             |                    |              |                  |
| <b>ThermXL GRs</b>   | <b>(GRs are directly defined as values)</b> |                    |              |                  |
| <b>Label</b>         | <b>First Node</b>                           | <b>Second Node</b> | <b>Value</b> | <b>Heat Flow</b> |
| 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 | $\epsilon$ | 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 |
| <b>9000</b> | <b>SVM</b>      | <b>B</b> |     |      |          | <b>290.00</b> | 290.0000 | -2.465E-01 |
| <b>9100</b> | <b>VG1_TIF1</b> | <b>B</b> |     |      |          | <b>145.00</b> | 145.0000 | 1.925E-01  |
| <b>9200</b> | <b>VG2_TIF2</b> | <b>B</b> |     |      |          | <b>100.00</b> | 100.0000 | -1.000E-03 |
| <b>9300</b> | <b>VG3_TIF3</b> | <b>B</b> |     |      |          | <b>45.00</b>  | 45.0000  | 5.500E-02  |
| <b>9400</b> | <b>TOB_TIF4</b> | <b>B</b> |     |      |          | <b>45.00</b>  | 45.0000  | -3.386E-02 |
| <b>9600</b> | <b>JT_TIF6</b>  | <b>B</b> |     |      |          | <b>28.00</b>  | 28.0000  | 8.793E-02  |
| <b>9900</b> | <b>Space</b>    | <b>B</b> |     |      |          | <b>4.00</b>   | 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   |
|                      |            |                                             |          |            |
| <b>ThermXL GRs</b>   |            | <b>(GRs are directly defined as values)</b> |          |            |
| 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   |



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|                                   |       |
|-----------------------------------|-------|
| 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

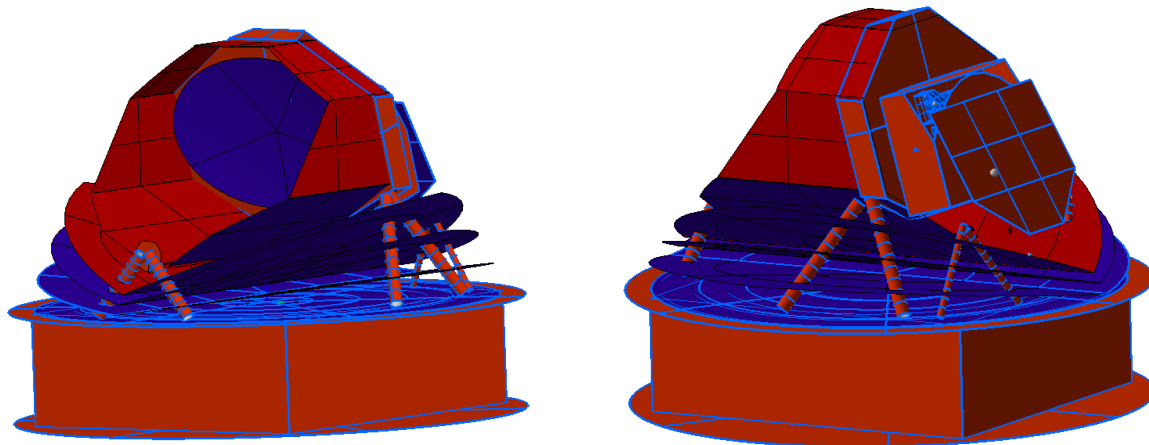
The GMM is based on the coupling of a “standard” M-size SVM with a possible configuration for the cold passive PLM. In the model are simulated the main radiative surfaces and representative supporting structures between the different stages.

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.

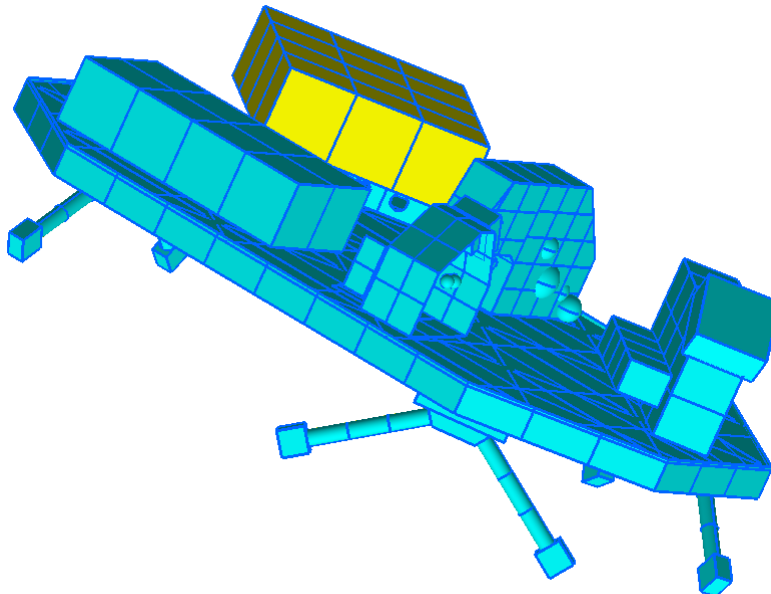
The main units that contribute to the thermal balance of the whole PLM model are listed in the following table together with the sub-model definitions and the node numbering

| 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

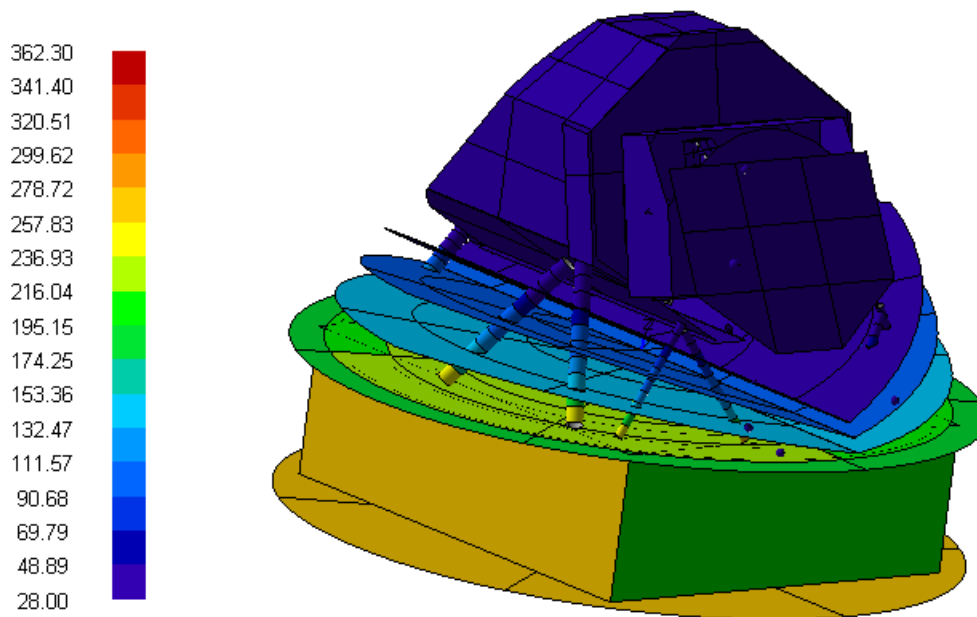
The current version of the model is composed by 920 nodes. In the following table are reported the average values of each unit temperature.

| 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  |

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

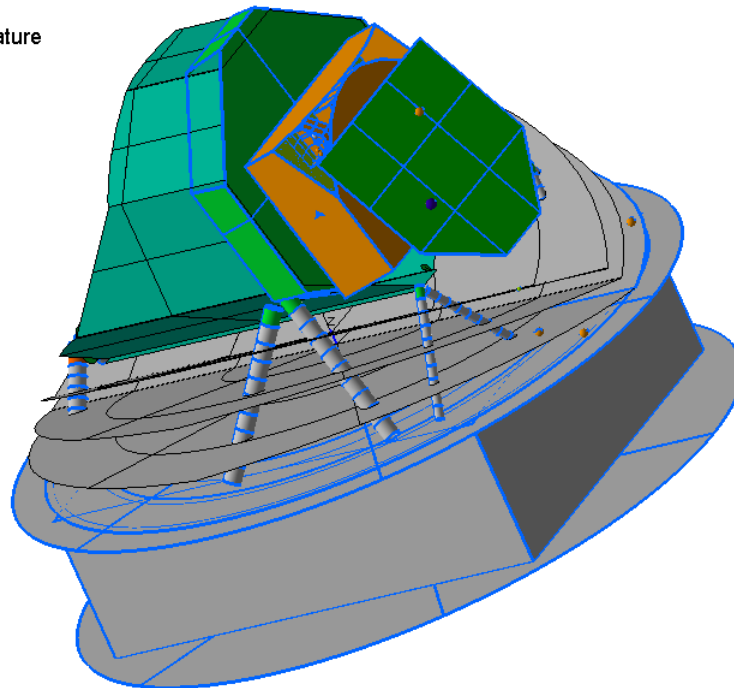
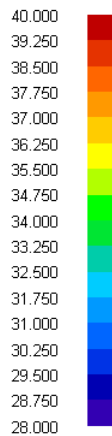
**Table 3-1. TMM/GMM Units average temperature**

The unit temperatures are graphically shown in the next figures.

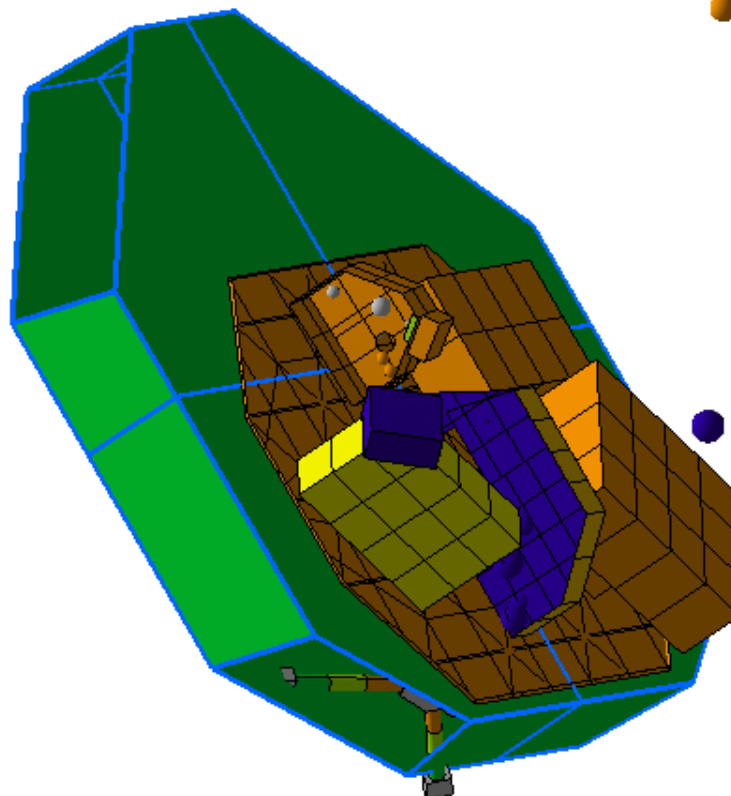
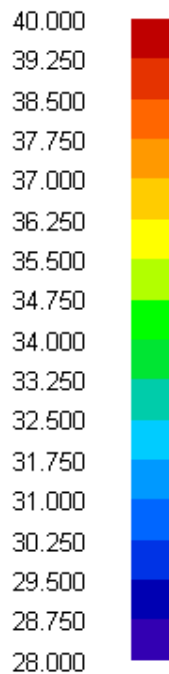


**Figure 3-3. Spacecraft average temperatures**

Attribute: Temperature



**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 in 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: 0.00000000000000000
- Radiative heat from vg2 to Radiator outer surface is: 7.40393368155039021E-006
- Radiative heat from vg1 to Radiator inner surface is: 0.00000000000000000
- Radiative heat from vg1 to Radiator outer surface is: 1.20343129300678383E-005
- Radiative heat from SVM top to Radiator inner surface is: 0.00000000000000000
- 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         |

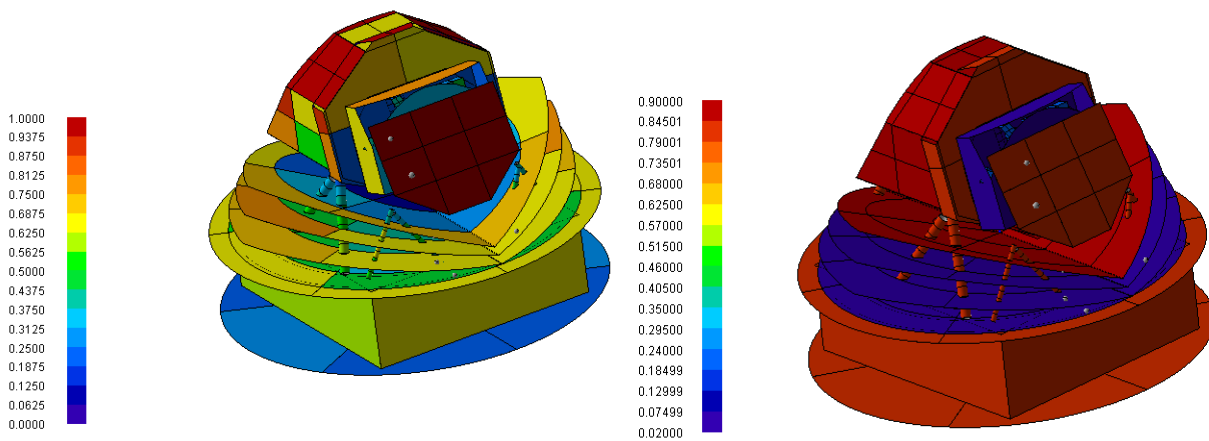
**Table 3-2. TMM/GMM heat fluxes at Instrument main internal thermal interfaces**

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<br>T (K) | Reduced TMM predictions<br>(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.



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## **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

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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 |

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|   | 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 |



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|      |                     |        |      |
|------|---------------------|--------|------|
| 1033 | SPACECRAFT_SVM_top2 | 274.13 | 0.00 |
| 1034 | SPACECRAFT_SVM_top2 | 275.76 | 0.02 |

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| 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 |



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|      |                     |        |      |
|------|---------------------|--------|------|
| 1085 | SPACECRAFT_SVM_top2 | 272.11 | 0.00 |
| 1086 | SPACECRAFT_SVM_top2 | 274.01 | 0.00 |

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| 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   |



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|      |          |        |      |
|------|----------|--------|------|
| 2008 | VG1_y_uc | 149.05 | 0.00 |
| 2050 | VG1_y_uc | 150.29 | 0.00 |

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| 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 |

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| 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 |



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|      |                |       |      |
|------|----------------|-------|------|
| 5000 | SPACECRAFT_TOB | 33.35 | 0.00 |
| 5001 | SPACECRAFT_TOB | 33.34 | 0.00 |

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| 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 |



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|      |              |       |      |
|------|--------------|-------|------|
| 6005 | Instrument   | 37.49 | 0.00 |
| 6100 | IOB_entrance | 34.98 | 0.00 |

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| 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 |



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|      |           |       |      |
|------|-----------|-------|------|
| 7208 | strut_nyl | 40.77 | 0.00 |
| 7209 | strut_nyl | 33.41 | 0.00 |

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| 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 |



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|      |           |       |      |
|------|-----------|-------|------|
| 7458 | strut_py2 | 41.00 | 0.00 |
| 7459 | strut_py2 | 33.40 | 0.00 |

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| 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    |



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|      |      |      |      |
|------|------|------|------|
| 1036 | 0.00 | 0.00 | 0.00 |
| 1037 | 0.00 | 0.00 | 0.00 |
| 1038 | 0.00 | 0.00 | 0.00 |

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| 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  |



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|      |      |      |      |
|------|------|------|------|
| 1088 | 0.00 | 0.00 | 0.00 |
| 1089 | 0.00 | 0.00 | 0.00 |
| 1090 | 0.00 | 0.00 | 0.00 |

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| 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    |



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|      |      |      |        |
|------|------|------|--------|
| 2052 | 0.00 | 0.00 | 95.13  |
| 2053 | 0.00 | 0.00 | 284.07 |
| 2054 | 0.00 | 0.00 | 279.59 |

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| 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 |



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|      |      |      |        |
|------|------|------|--------|
| 3107 | 0.00 | 0.00 | 199.82 |
| 3108 | 0.00 | 0.00 | 178.26 |
| 3150 | 0.00 | 0.00 | 61.97  |

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| 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  |



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|      |      |      |       |
|------|------|------|-------|
| 5003 | 0.00 | 0.00 | 49.93 |
| 5004 | 0.00 | 0.00 | 3.95  |
| 5005 | 0.00 | 0.00 | 7.89  |

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| 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  |



# Exoplanet Characterisation Observatory

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|      |      |      |      |
|------|------|------|------|
| 7001 | 0.00 | 0.00 | 9.72 |
| 7002 | 0.00 | 0.00 | 8.14 |
| 7003 | 0.00 | 0.00 | 6.35 |

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| 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 |



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|      |      |      |       |
|------|------|------|-------|
| 7251 | 0.00 | 0.00 | 24.74 |
| 7252 | 0.00 | 0.00 | 21.17 |
| 7253 | 0.00 | 0.00 | 16.35 |

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| 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 |



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|       |      |      |       |
|-------|------|------|-------|
| 10001 | 0.00 | 0.00 | 16.88 |
| 10002 | 0.00 | 0.00 | 9.88  |
| 10003 | 0.00 | 0.00 | 17.61 |

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| 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 |



# Exoplanet Characterisation Observatory

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|       |              |       |      |
|-------|--------------|-------|------|
| 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 |

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| 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 |



# Exoplanet Characterisation Observatory

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|       |             |       |      |
|-------|-------------|-------|------|
| 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 |

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| 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 |



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|      |      |      |      |
|------|------|------|------|
| 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 |

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| 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 |



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|       |      |      |      |
|-------|------|------|------|
| 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 |

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| 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 |



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| 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 |



# Exoplanet Characterisation Observatory

Doc Ref: ECHO-TN-0001-IASFBO

Issue: 1.0

Date: 14/Sep/2013

15131 IOB\_VNIR\_Mod:Main\_Box 37.52 0.00  
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| 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 |



# Exoplanet Characterisation Observatory

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Issue: 1.0

Date: 14/Sep/2013

|       |      |      |       |
|-------|------|------|-------|
| 15112 | 0.00 | 0.00 | 14.16 |
| 15113 | 0.00 | 0.00 | 14.16 |

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| 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 |



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|       |                   |       |      |
|-------|-------------------|-------|------|
| 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 |

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| 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 |



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|       |                          |       |      |
|-------|--------------------------|-------|------|
| 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 |

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| 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 |



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|       |      |      |      |
|-------|------|------|------|
| 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 |

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| 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 |



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|       |      |      |      |
|-------|------|------|------|
| 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 |

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| 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 |

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+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 |



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|      |                 |       |      |
|------|-----------------|-------|------|
| 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 |

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| 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 |

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| 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 |



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| 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 |

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| 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 |



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|      |      |      |       |
|------|------|------|-------|
| 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 |

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| 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 |



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|      |      |      |       |
|------|------|------|-------|
| 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 |

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| 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 |



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|      |                          |       |      |
|------|--------------------------|-------|------|
| 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 |

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| 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 |



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|      |      |      |       |
|------|------|------|-------|
| 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 |

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| 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 |



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|       |                          |       |      |
|-------|--------------------------|-------|------|
| 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 |

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| 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 |



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|       |                       |       |      |
|-------|-----------------------|-------|------|
| 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 |

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| 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  |



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|       |      |      |       |
|-------|------|------|-------|
| 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  |

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| 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 |



**Exoplanet  
Characterisation  
Observatory**

Doc Ref: ECHO-TN-0001-IASFBO

Issue: 1.0

Date: 14/Sep/2013

|       |      |      |      |
|-------|------|------|------|
| 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 |