esac

European Space Astronomy Centre
P.O. Box 78
28691 Villanueva de la Cañada
Madrid
Spain
T +34 91 8131 100

F +34 91 8131 139

www.esa.int

BEPICOLOMBO

MERCURY PLANETARY ORBITER (MPO)

ISA Experiment-to-Archive ICD (EAICD)

European Space Agency
Agence spatiale européenne

Prepared by C. Magnafico;M. Lucente;R. Peron, M. Lucente, R. Peron

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Francesco Santoli (ISA deputy PI)	
Johannes Benkhoff (MPO Project Scientist)	
Santa Martinez (BepiColombo Mission Manager)	

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1 INTRODUCTION

1.1 Purpose and scope

This document describes the format and the content of the Italian Spring Accelerometer (ISA) data as archived in the ESA Planetary Science Archive (PSA). It includes detailed descriptions of the data products and associated metadata, as well as the data generation, calibration, validation and analysis processes.

This EAICD is intended to provide enough information to enable users to understand the ISA data and their organization. The users for whom this is intended are the scientists who will process and analise the ISA data.

The specifications described in this document apply to all ISA products submitted to the archive, for all phases of the BepiColombo mission (i.e. near-earth commissioning, cruise, Mercury commissioning and science phases). This document is expected to evolve throughout the mission lifetime.

1.2 Applicable Documents

The following documents, of the exact issue shown, form part of this document to the extent specified herein. They are referenced in this document in the form [AD.XX]:

[AD.01] BC-SGS-PL-014, BepiColombo Science Data Generation, Validation and Archiving Plan
[AD.02] BC-SGS-TN-026, BepiColombo Archiving Guide
[AD.03] BC-SGS-TN-043, BepiColombo_Annex_to_Archiving_Guide RD 22
[AD.04] PDS4 Standards Reference (SR)
[AD.05] PDS4 Data Dictionary (DDDB)
[AD.06] PDS4 Information Model Specification (IM)

1.3 Reference Documents

[RD.01] BC-SGS-LI-014, SGS Glossary
[RD.02] PDS4 website: http://pds.nasa.gov/pds4/
[RD.03] BC-SGS-TN-042, BepiColombo Data Handling and Archiving Concept
[RD.04] BC-SGS-SP-014, ISA Pipeline Description Document, Issue 1 Revision 0
[RD.05] BC-ISA-UM-00160, ISA User Manual (UM), Issue 5.4
[RD.06] BC-ISA-TN-10018, ISA Data Archiving, Issue 1 Revision 1
[RD.07] BC-ISA-UM-019 ISA Pipelines Software UM issue 1
[RD.08] BC-ALS-TR-00096, BepiColombo PFM ETA Alignment measurement test report, Issue 03
[RD.09] BC-ISA-TN-00380, ISA – Bepi Colombo IDA dimensional and stability measurements, Issue 2
[RD.10] BC-ISA-TR-00389, ISA IDA Optical Cubes Alignment Measurement Report, Issue 1
[RD.11] BC-ISA-TN-10027, Reference frames for the ISA acceleration measurements, Issue 1 Revision 2
[RD.12] BC-ISA-TN-10028, ISA FM Sensing Axes Calibration Test Report, Issue 1 Revision 1
[RD.13] SPICE-BEPIC-TN-002, ISA Instrument SPICE Kernels Status, Issue 1 Revision 0
[RD.14] BC-ISA-RP-0390, ISA IDA Actuator calibration report, Issue 1
[RD.15] BC-ISA-IF-00037, ISA Software Interface Control Document, Issue 6
[RD.16] ECSS-E-70-41A, Ground systems and operations – Telemetry and telecommand packet utilization, 30 January 2003
[RD.17] PDS4 data product types, ESA document “bc_pds4_product_types_and_processing_levels.pdf”
[RD.18] BC-SGS-TN-043, Archiving Guide (Annex to PSA PDS4 Archiving Guide), 2.0
[RD.19] BC-ISA-TR-00378, ISA Performance Report, issue 1
[RD.20] BC-ISA-TR-00382, "ISA FM functional and Performance Test Report", p. 148, email by Alessio Colombo (66 V)
[RD.21] M. Lucente, C. Lefevre, E. Fiorenza, C. Magnafico, F. Santoli, V. Iafolla, “Calibration of ISA accelerometer sensing axes for the BepiColombo mission”, Planetary and Space Science, Volume 211,2022,105396,ISSN 0032-0633, https://doi.org/10.1016/j.pss.2021.105396

1.4 Abbreviations and Acronyms

See BepiColombo Acronyms and Definitions, [RD.01].

2 INSTRUMENT DESCRIPTION

2.1 Mission and Instrument Science Objectives

The **I**talian **S**pring **A**ccelerometer (ISA) is a three-axis high sensitivity accelerometer devoted to measure the accelerations due to the non-gravitational perturbations (NGP) acting on the surface of the MPO spacecraft. These NGP are mainly caused by the incoming solar visible radiation and the planet visible albedo and infrared radiation.

The ISA accelerometer is able to measure variable accelerations in the frequency band 3×10^{-5} to 0.1 Hz with a sensitivity of 10^{-8} $ms^{-2}Hz^{-0.5}$.

The three ISA sensing elements are based on a mechanical harmonic oscillator with a resonance frequency of 3.5 Hz. The weakest accelerations that ISA is able to measure cause a displacement of the proof–masses of about 2×10^{-11} m; these displacements are detected by means of a capacitive pick-up system in a bridge configuration.

The main scientific objectives of ISA integrated to the ones of MORE (Mercury Orbiter Radio-Science Experiment). Key role of ISA is to remove the NGP from the list of unknowns of the MPO equation of motion in the Precise Orbit Determination (POD) that is the core of MORE. The use of ISA measurement will make a posteriori (and inside the experimental errors) the MPO a sort of drag-free satellite.

To take into account the MPO CoM unknowledge during the motion (due to the moves of the appendices and the fuel sloshing), the POD of the satellite will be done considering the MPO as a vector, called the Schulte-Vector from the name of the AIRBUS engineer that firstly introduced the idea, described by the ISA vertex [ref 2.3] and the HGA phase center as two moving points free falling in the Mercury gravity field. In this way, signatures like the inertial rotational accelerations or the gravity gradients seen by an accelerometer as disturbances to be deleted in a nominal body CoM referred POD, in a Schulte-Vector based POD there are signals to be part of the POD because they describe the dynamics of the vector vertexes in the free fall in the gravity field.

2.2 Instrument Description

ISA is a three-axis high sensitivity accelerometer (one-dimensional sensing elements per acceleration axis forming a quasi-independent orthogonal triple). Each sensing element is a mechanical harmonic oscillator and consists of a proof mass which is hang to an external rigid frame through a flexural element (spring) with low elastic constant. The sensing elements use pairs of pick-up and actuation plates. The pick-up plates are used to read the acceleration signal by sensing – in a capacitive way – the movement of the central mass. On the other hand, the actuation plates are used to generate electrostatic forces to recenter the sensing mass with respect to the zero point of pick-up plates and to internally calibrate each element by acting on the mass with a known on-ground calibrated signal.

Due to the high sensitivity to accelerations that the accelerometer shall measure and due to its sensitivity to external disturbances (both electrical and thermal), it has been decided to decouple away as much as possible the digital electronics and the power supply section from the detectors. This results in a configuration that foresees two independent boxes. Therefore, the ISA Instrument configuration is based on two units: the ISA Detector Assembly (IDA) and the ISA Control Electronics (ICE) that interfaces the MPO for power supply and communication.

IDA is made up by a Front End Electronics (FEE), placed in the bottom of the box, and by the three sensing elements assemblies, each enclosed in dedicated shields, in order to decouple as much as possible the sensing elements from the temperature environmental disturbances and, at the same time, to reduce the power consumption of the active thermal control system.

IDA has four heaters to control internal temperature, one per sensing element, plus a dedicated heater for the FEE. Purpose of the active thermal control is to keep the temperature inside the sensing elements shields

controlled at the level of mK. For what concerns the FEE, the control is less strict and the temperature can vary in a range of the order of tens of mK.

FEE thermal coupling with the external environment is designed to take into account the FEE dissipation itself, so, in order to reduce the power consumption, the thermal control system can choose between pre-loaded 12 set-points to best fit the spacecraft baseplate temperature variation.

IDA and ICE communicate with SPACEWIRE; ICE is the unit responsible for TC/TM communications with the spacecraft OBC.

2.3 Scientific measurements

ISA scope is to measure the three components of the non-gravitational acceleration vector acting on the spacecraft body.

Since ISA measurement band goes from [$3*10^{-5}$ – 10^{-1}] Hz, its measurement are “relative” accelerations and not absolute.

The main expected accelerations measured by ISA can be divided in external and internal accelerations. Internal and external accelerations are here intended in the sense of accelerations that can cause a net move of S/C CoM, so, a trajectory displacement wrt a pure gravitational one.

The external are:

- The direct solar radiation pressure
- The visible albedo radiation pressure
- The planetary thermal emission radiation pressure
- The S/C anisotropic thermal reemission

The internal:

- Gravity Gradient effect
- Inertial rotations accelerations
- Appendices movements
- S/C Internal parts low band vibrations.

A relevant part of ISA science is foreseen to be used in the context of the RSE to perform at best the POD. So, the aim of the instrument is to continuously measure the accelerations acting on-board both in visibility and in occultation conditions.

ISA and MORE Teams, according to their needs, adopted a common data file structure for what concerns the final DERIVED products produced by ISA and used for the RSE purposes. Moreover, RSE will refer all the accelerations measured by ISA to a common point, called **vertex**, placed in the CoM of the central (Y-MPO oriented) ISA sensing element.

Since the Sensing Elements do not lie in the same point, the Gravity Gradient effect and the inertial rotations accelerations are not the same. The difference of that accelerations wrt the Y masses (the vertex) shall be considered and removed on the accelerometer X and Z to reconstruct the acceleration instantaneously acting at the vertex.

To define a common reference frame an ILS is introduced as the orthogonal triple best fitting the sensing masses orientation and is placed in the centre of mass of Y accelerometer [RD.10] and [RD.12]. The described process is called “accelerations reduction to vertex” and it is applied in RAW2CAL processing, so the CALIBRATED level products accelerations are ILS referred.

ISA foresees two calibration strategies to measure two fundamental sets of parameters, respectively the orientation of the sensing axes with respect to the spacecraft and the internal voltage versus acceleration scale factor (one per sensing element). Other operations are planned in case the zero-voltage of the instrument changes under the effect of huge accelerations (e.g. MPO-MTM separation, particularly heavy WOLs).

Deeper descriptions about the instrument working and common operation, its telecommands and telemetries and its data processing strategies can be found respectively in [RD.05], [RD.15] and [RD.04].

2.4 Operational Modes

ISA collects data acceleration samples nominally with a sampling rate of 10 Hz. An ISA "observation" can be defined as a time series of continuous acceleration measurements that lasts for a time comparable with the lower band limit of the instrument, that corresponds to about 8 hours, without any event that could disturb the accelerometer in such a way to change its own internal calibration. To assure the pipelines process blocks of data with the same physical meaning, the data are therefore divided into homogeneous blocks.

ISA operational modes are divided into "Technical" and "Scientific" Modes; see details in the ISA SW ICD [RD.15]. ISA operations are grouped into **observation blocks**. The following types of observation blocks are defined, based on the ISA operational modes:

- **TEC**: Technical blocks
- **OBS**: Nominal science observation blocks
- **HRO**: High-rate science observation blocks
- **CAL**: Calibration blocks (including self-calibration and chain calibration)
- **SAC**: Spacecraft assisted calibration blocks

Table 1 - provides the list of ISA operational modes with the associated observation block type.

Classification	***Mode Number***	***Mode ID***	***Operative Mode Name***	***Observation Block Type***	***Comments***
Technical	1	Off	Off	N/A	No telemetry produced
Technical	2	B	Boot	TEC	
Technical	3	S	Standby	TEC	
Technical	4	SF	Safe	TEC	
Technical	5	C	Configuration	TEC	
Technical	6	D	Diagnostic	TEC	
Technical	7	M	Memory Software Maintenance	N/A	Only event reports produced
Scientific	8	O	Scientific Observation	OBS	10Hz or 2.5 Hz
Scientific	9	SC	Self Calibration	CAL	
Scientific	10	CC	Chain Calibration	CAL	
Scientific	11	HO	High Rate Observation	HRO	Only one channel at a time
Scientific	12	SA	S/C Assisted Calibration	SAC	

The filename convention for the block follows [RD.18], Section 3.3. Here we report only the **<*descriptor*>** part inside the **<*product_identifier*>**:

<***block_type***>_<NNNNN>.X.Y

- <***block_type***>: the observation block type, see above
- <NNNNN>: the block type sequence counter; increased for each new block of a given type, based on a change of operative mode
- X: main ID, number assigned based on the instrument internal parameters validity
- Y: number assigned based on the validity of external conditions

Example:

ISA is commanded to go into observation mode and it starts to send TM(21,3) or since the patch on board with the Application SW V4R1, the TM(21,4). Initially (based on TC) it runs a Self Calibration, so, the TEC_00014.0.0.xml is generated. When the Self Calibration ends, ISA enters the real Observation Mode and a OBS_00234.0.0 is generated (see *Figure 1*).

After a quick-look assessment or an event logcode rising, the system notes that the thermal stability is lost, so the block is split into three other sub-blocks to assure that all the data in each block are homogeneous:

OBS_00234.1.0 → before the event

OBS_00234.2.0 → while the temperature was not controlled properly

OBS_00234.3.0 → after the temperature was into the properly margin

If the operator, by looking at the QL analysis tool, realizes that in a period (in the third sub-block) the on-board noise was high and understands that the set of data cannot be processed in the same block, the third block could be divided into other three sub-sub-blocks:

OBS_00234.3.1

OBS_00234.3.2

OBS_00234.3.3

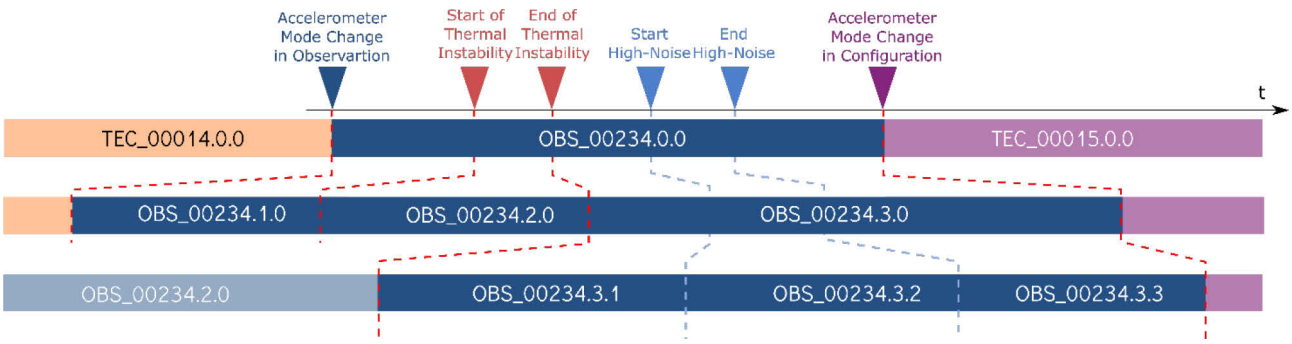


Figure 1 Example of block division.

Inside each product label, the baseline is to keep data in a unique file (since a nominal continuous observation block will have a length of the order of ten hours).

2.5 Calibration

In this Section information is provided on the various types of calibrations (both on-ground and in-flight) to be performed, along with all the relevant information (e.g., reference frames relationships).

2.5.1 Reference Frames

Several reference frames are involved in the various calibrations, both on-ground and in-flight. The relationships among them, both in terms of translation vector of their origin and rotation matrices, must be archived to make calibration and data reduction reproducible. Information are stored in Annex D of the present document and in [RD.10].

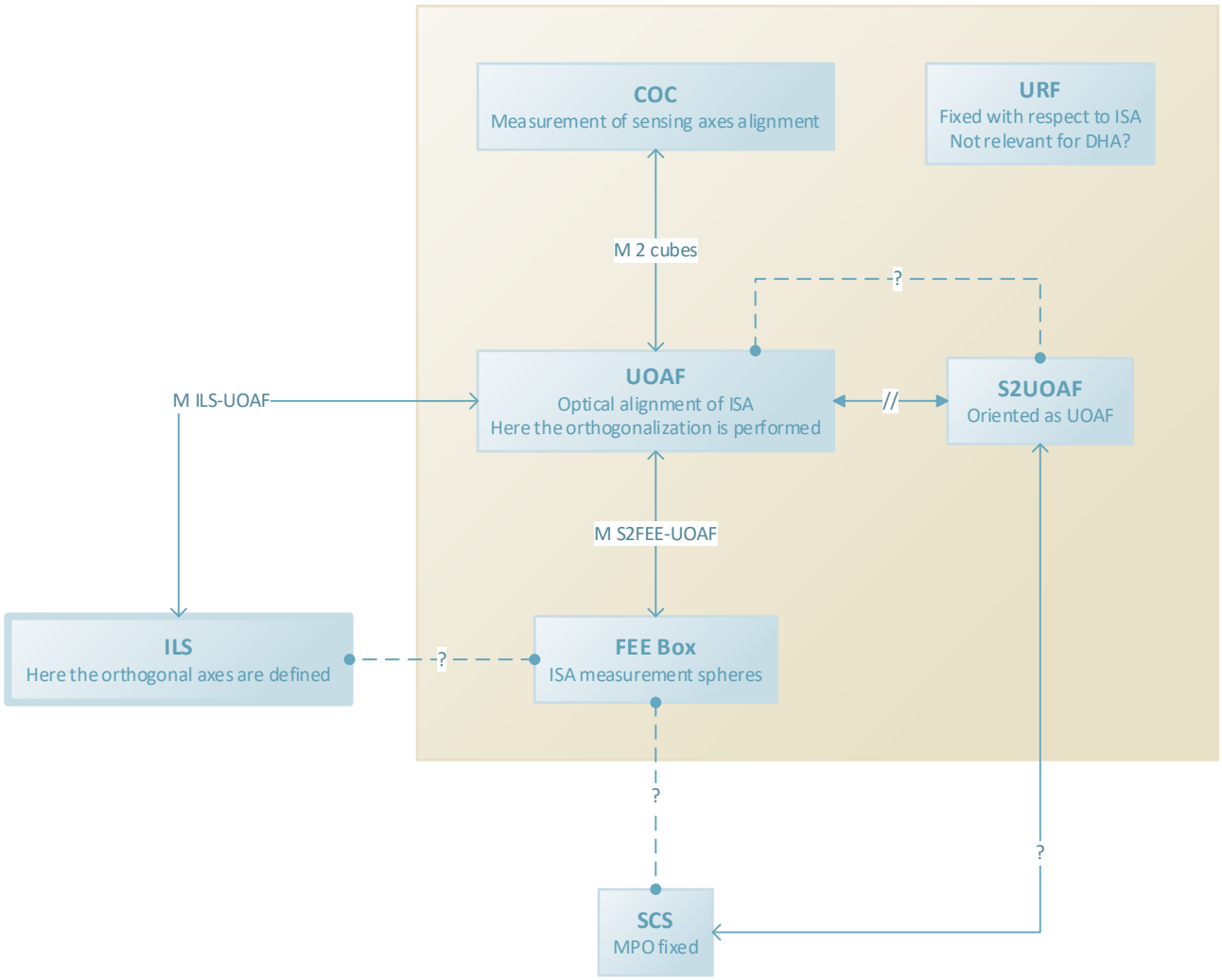


Figure 2 Relationships among ISA reference frames

2.5.2 On-ground Calibration

On Ground Calibration have been performed by TASI and ISA team and the results are reported in Annex D of the present document.

In [RD.11]and [RD.12] are reported the orientations of the internal reference frames with respect to the ISA optical cube which attitude w.r.t. to BepiColombo reference frame is described in [RD.10].

[RD.10] and in [RD.05] and [RD.15] contains the references of the electrical and electronics calibrations.

2.5.3 In-flight Calibration

In Flight calibration is foreseen by ISA to be performed on the base of the data collected in the cruise phase and in several activities planned in Mercury Commissioning Phase and in dedicated slots during the nominal phase.

2.5.3.1 Self Calibration

A periodic, internal calibration is defined Self-Calibration. Its aim is to refine the value of the scale factor by applying a known, periodic, square wave voltage to the accelerometers plates and reconstruct the scale factor ($m/s^2/LSB$)

2.5.3.2 Recentering

Recentering activity is an operation related to the Self-calibration mode that does not change the scale factor of the accelerometers. For better understanding refer to [RD.05] .

3 DATA GENERATION AND ARCHIVING PROCESS

The ISA science products are produced under the responsibility of the ISA Instrument Team in cooperation with the BepiColombo MPO Science Ground Segment (SGS). The data generation, analysis and archiving processes are described in this section.

Science data resulting from the ISA instrument are made available to the scientific community through ESA's Planetary Science Archive (PSA) following the policies described in the BepiColombo Archiving Plan [AD.01].

3.1 Overview of the Science Data Flow

This section provides an overview of the data flow for the ISA data, from on-board acquisition by the ISA instrument through to ingestion into the ESA's Planetary Science Archive (PSA).

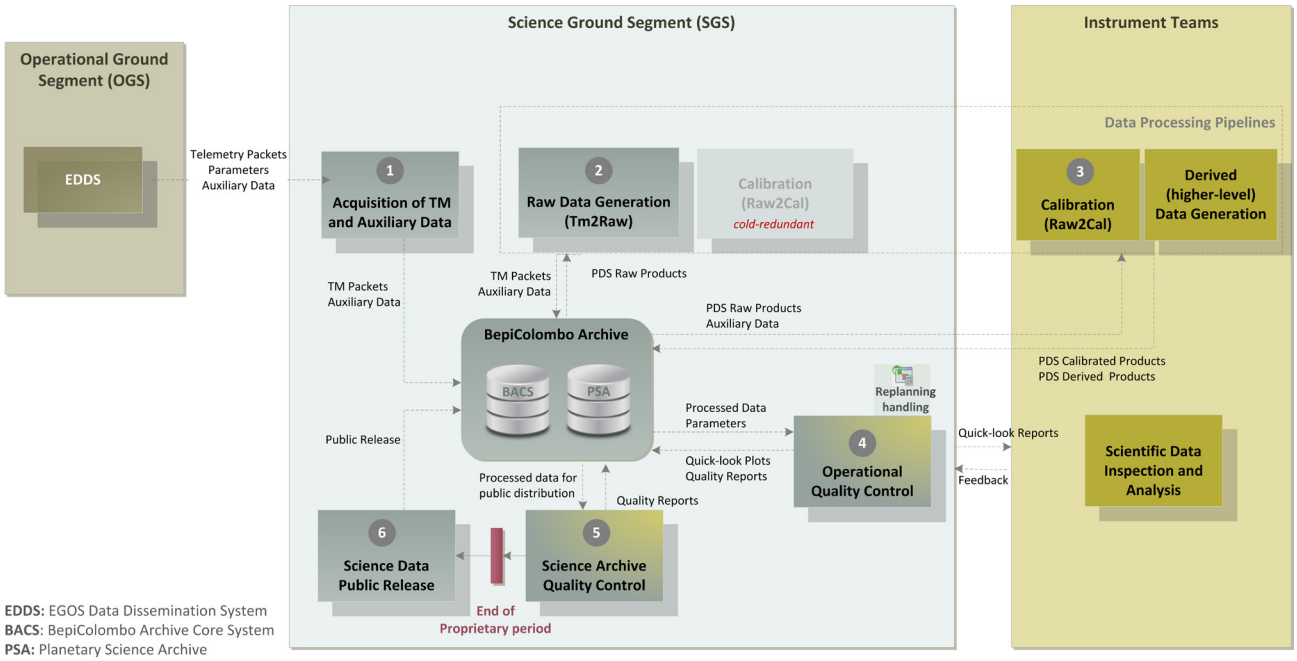


Figure 3: Science Data Flow

1) ***Acquisition of Telemetry and Auxiliary Data***. Real-time telemetry received on-ground from the MPO spacecraft is relayed from the ground stations to the Operational Ground Segment (OGS) at ESOC during ground station contacts. The MPO spacecraft has two radio-frequency (RF) bands for downlink (X-band and Ka-band). The X-band channel is used to return near real-time non-science telemetry, mostly for spacecraft health, as well as high-priority science data; telemetry is transmitted packet-by-packet. The Ka-band channel is used to return nominal science data; telemetry is transmitted as a file, using the File Transfer Service (FTS).

   During each ground station contact, the OGS processes all telemetry frames acquired via X-band into packets, containing instrument and spacecraft data as originally generated on-board, and stores all science telemetry files received via Ka-band as files. Telemetry packets and files are made available in the EGOS Data Dissemination System (EDDS) along with status and auxiliary information generated on-ground by the OGS.

Immediately after the data becomes available in the EDDS, telemetry packets, Ka-band telemetry files, housekeeping parameters and any additional information relevant for data processing and analysis (e.g. spacecraft trajectory, attitude and time correlation packets) are retrieved by the Science Ground Segment (SGS) via the EDDS and stored in the operational archive (a.k.a. BACS), for further processing and long-term preservation. Ka-band telemetry files are decomposed into packets as part of this process.

2) ***Raw Data Generation***. Telemetry packets resulting from all instruments are systematically converted into PDS raw data products (un-calibrated) by the SGS. Additionally, PDS raw products may be converted to partially processed products (e.g. converted to physical/engineering units) by either the PI teams or by the SGS.
The telemetry-to-raw (tm2raw) processing chain accepts ISA TM packet files and decodes science and non-science packets into PDS-formatted raw data products (mostly ASCII tables with the corresponding label). It also implements the classification of data based on observation blocks and data type, for which separate PDS products are produced.

   The tm2raw processor is composed of a set of tasks executed in sequence:

   - Telemetry decoder
   - Observation block classification
   - Data type classification
   - Time correlation & geometry computation
   - PDS4 product generation

3) ***Calibrated Data Generation***. PDS calibrated products are generated based on the best current calibration factors and analysis routines and using as input the PDS raw products generated in the previous step. For ISA pipelines, the calibration SW is developed by PI team and shared with SGS in a continuous integration git repository. The calibration SW is run in SGS servers, and the output are prepared for the delivery with a tool developed by SGS that runs a basic validation on the products to check their compliance with PDS4.

   Raw-to-Calibrated data processing step takes care of:

   - translating Raw values in blocks in physical units.
   - controlling the right data rate of the incoming signals
   - performing the needed geometrical correction and transformation
   - extracting the information during the S/A Calibration and Self-Calibration operations

   Nominal Science Raw-to-Calibrated is divided into three main processes steps

   - pre-processing
   - data rate resampling
   - acceleration-to-vertex reduction.

   Nominal Science Raw-to-Calibrated will take care to process the blocks separately one-by-one. Because different processing are expected for different input blocks types, the software will accept in input different numbers of blocks and types at the same time. This will facilitate the workflow of the entire pipeline, since no conditions are required on input. If for a single block, the data passed in input are not sufficient for the complete calibration a WARNING is raised and the block will be stopped at the higher processing level.

   For further information about the SW reference to [RD.07]

4) ***Higher-level Data Generation***. Derived data products are generated by the PI teams, and delivered to the SGS only when the scientific processing is complete.

All science archive products resulting from BepiColombo comply with version 4 of the Planetary Data System (PDS) standards, a.k.a. PDS4, as specified in the BepiColombo Archiving Guide [AD.02]. An overview of the ISA archive products can be found in section 3.2.

A detailed description of the data generation, calibration and analysis process for the ISA data can be found in section 3.3.

5) ***Data transfer to the Archive***. All PDS products generated by the SGS or delivered by the PI teams to the SGS are validated for PDS4 compliance (using the NASA's PDS4 validate tool). Once validated, the products are packaged into a delivery package and transferred to the ESA's Planetary Science Archive (PSA) for ingestion.

   As part of the PSA ingestion process, science products are automatically organised into the so-called PDS4 bundles. For BepiColombo, there is one mission bundle and eleven instrument bundles, one per instrument. Bundles grow incrementally as new (or updated) products are delivered to the PSA.

   The mission bundle contains products generated and maintained by the SGS with information of the BepiColombo mission. This includes all mission level supplementary products required in the instrument bundles to comply with PDS4 (e.g. context products, XML schemas, SPICE kernels).

   Instrument bundles contain science data along with supplementary information specific to an instrument. All bundles are sub-divided into collections. There is one collection for each data processing level plus supplementary collections for calibration, browse, schema, context, documentation etc.

6) ***Operational Quality Control***. Science quick-look products are generated from the raw and calibrated products, and are made available through a dedicated web-based interface. Using this interface, PI teams monitor the deviations between the planned and the executed science observations and provide a first assessment of the quality of the generated science data products. PI teams feedback the result of this analysis to the SGS. In addition, SGS performs regular completeness and integrity checks on the data.

7) ***Science Data Quality Control***. Archive products are validated through routine use. PI teams routinely assess archive products as part of the operational quality control. In addition, PI teams use archive products for their analysis throughout the mission lifetime. This enables rapid detection and correction of issues in the archive data. In addition, and prior to the release of the data to the public, formal science reviews are organised by the SGS, in coordination with the Project Scientist.

8) ***Science Data Public Release***. All science data resulting from BepiColombo is subject to a maximum proprietary period of six months after which the data is made publicly available through the PSA. In routine operations it is expected that data processed at least up to calibrated level will be available to the public after the six-month period. Explicit permission may be given by a PI to reduce this period.

3.2 Overview of the ISA Archive Products

Of all the TM produced by ISA, only a part will need to be long-term archived. This consists of the data necessary to build the scientific products, including therefore calibration data and all the necessary HK. To this, one has to add ancillary information, both from on-ground calibration activities and from SC TM.

All of this data have been identified, grouped and assigned a proper Processing Level ID (PDS4 Value) [RD.17]. Regarding the *Telemetry Products* Data Product Type (assigned the PDS4 Value **Telemetry**), the definition and assignment of the corresponding PDS4 label is an SGS task.

The data to be considered in the context of the processing pipeline could be divided into the following levels (using the name convention of [RD.04]):

1. TM-PACKETS (PDS4 **Telemetry**)
2. RAW-PRODUCTS, SUPPLEMENTARY (PDS4 **Raw**)
3. PRE-PROCESSED (PDS4 **Partially processed**)
4. REDUCED (PDS4 **Calibrated**)

5. POST-PROCESSED (PDS4 **Derived**)

It has to be noticed that data in points 2 and 3 in the above list contain the same information (i.e. the information necessary as input to the processing pipeline). At the PRE-PROCESSED level, this information has been reformatted in order to be directly usable by the processing pipeline.

3.3 Data Generation, Calibration and Analysis

Information are contained in [RD.04] and [RD.06].

3.4 Science Data Quality Control

This section describes the different processes by which the archive data products are validated.

3.4.1 Validation

Prior to the delivery of the data to the archive, every data product is validated to check that it conforms to a basic set of requirements, as defined in the BepiColombo Archiving Guide [AD.02]. This is done using the NASA's PDS4 validate tool, and a set of XML Schema and Schematron files.

In addition, the SGS performs completeness and integrity checks on the ISA science data to ensure that they comply with the specifications described in this EAICD. Visual inspection is used as necessary to check the content.

3.4.2 Instrument Team Validation

In parallel to SGS archive validation activities, PI teams routinely assess archive products as part of the science operational quality control. In addition, PI teams use archive products for their analysis throughout the mission lifetime using self tools and helped by ESAC quick look tool and science data browse images. This enables rapid detection and correction of issues in the archive data.

3.4.3 Science Reviews

Formal science reviews of the data will be organised by the SGS, in coordination with the Project Scientist. These are the so-called Peer Reviews. The Peer Review committee will include independent planetary scientists knowledgeable in each discipline to assess the quality of the data against well-defined scientific criteria. A preliminary schedule of the reviews can be found in the BepiColombo Archiving Plan [AD.01]. Additional reviews will be organised as necessary.

There will be a review during the cruise phase and one light delta-review 6/4 months prior to the start of the science phase. A full review during the post-operations phase.

Reviews will contain sample data and documentation in the format of the final archived data set. The sample data will be produced using datasets from the flight instrument checkout activities that differ from the final data set only in specific values and sizes. Data formats and data processing and archiving methods are identical.

4 DATA ORGANISATION AND CONTENTS

4.1 Format and Conventions

ISA science data are compatible with version 4 of the NASAs Planetary Data System (PDS) standards, so-called PDS4 [RD.02], and follow the organization, format, content and documentation requirements described in the BepiColombo Archiving Guide [AD.02].

All data from the ISA instrument for the entire mission is stored in a top-level structure (root directory) called bundle. This bundle is stored in the PSA as a single entity.

The bundle is subdivided into a set of collections (sub-directories) aiming to separate different type of data and information into an easy to navigate manner, so the bundle contains separate collections for instrument science data, calibration products, documentation, etc. For the instrument science data, there are separate collections for each processing level and this is standardized by PDS4 to four levels: raw, partially processed, calibrated and derived.

The structure of the bundle is outlined in Figure 4.

Details of the structure and content of the ISA bundle are provided in the following sections.

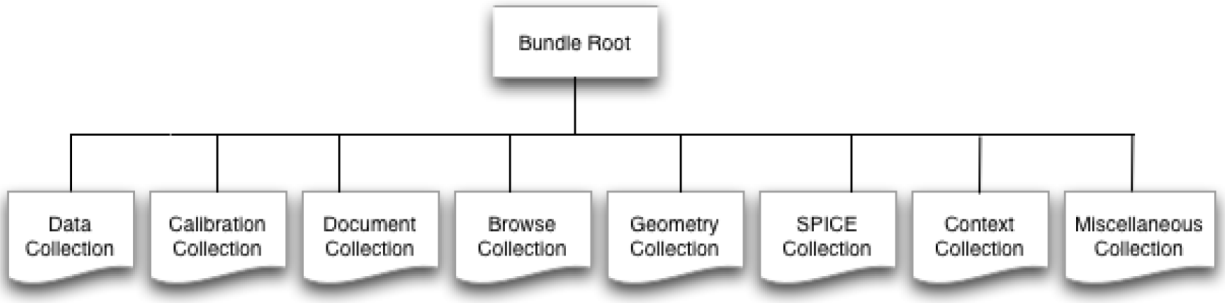


Figure 4: PDS4 bundle structure

4.1.1 Logical Identifiers Formation

Bundle and collection logical identifiers are as indicated in Table **2** and Table **3**.

General conventions can be found in section 3 of the BepiColombo Archiving Guide [AD.02].

4.1.2 Data Directory Naming Convention

General conventions can be found in section 3.2 of the BepiColombo Archiving Guide [AD.02].

4.1.3 File Naming Convention

ISA pipelines naming convention follows the indication in BepiColombo Archiving Guide [AD.02]. Further information are contained in 4.2.* of this document.

Furthemore, the reader can access to *ISA Pipeline Description Document [RD.04].*

4.2 Bundle Content and Structure

The complete set of ISA data is archived in one single instrument bundle (root directory). A top-level description of the bundle is provided below. A more detailed description of its contents and format is provided in the following sub-sections.

Bundle Title	***Bundle Logical Identifier (LID)***	***Description***
ISA instrument bundle	urn:esa:psa:bc_mpo_isa	This bundle contains the data collected by the Italian Spring Accelerometer (ISA) instrument on-board the BepiColombo Mercury Planetary Orbiter (MPO) spacecraft, along with the documents and other information necessary for the interpretation of the data.

Table 2: ISA instrument bundle

The following files are contained in the root directory of the bundle:

- bundle_bc_mpo_isa.xml *(this is an inventory file for the bundle)*
- readme_bc_mpo_isa.txt *(this is a README file for the bundle; it contains a table of contents)*

Inside the bundle, the data are organised in a directory structure (so-called collections) as follows:

Directory Name	***Collection Logical Identifier (LID)***	***Description***
data_raw	urn:esa:psa:bc_mpo_isa:data_raw	Contains ISA raw data products, see section 4.2.1.
data_calibrated	urn:esa:psa:bc_mpo_isa:data_calibrated	Contains ISA calibrated data products, see section 4.2.5.
data_derived	urn:esa:psa:bc_mpo_isa:data_derived	Contains ISA derived data products, see section 4.2.6.
calibration_files	urn:esa:psa:bc_mpo_isa:calibration_files	Contains ISA calibration inputs, see section 4.2.7.
calibration_raw	urn:esa:psa:bc_mpo_isa:calibration_raw	Contains ISA raw data during the calibration operations
calibration_partially_processed	urn:esa:psa:bc_mpo_isa: calibration_partially_processed	Contains ISA raw data during the calibration operations
browse_partially_processed	urn:esa:psa:bc_mpo_isa:browse_ partially_processed	Science overview and quick-look analysis plots of the data products. See section 4.2.8
browse_calibrated	urn:esa:psa:bc_mpo_isa: browse_calibrated	Science overview and quick-look analysis plots of the data products. See section 4.2.8
document	urn:esa:psa:bc_mpo_isa:document	Documents related to the bundle; necessary for the use and interpretation of the ISA data. See section 4.2.10.
context (S)	urn:esa:psa:bc:context	Text files describing the agency, mission, spacecraft, instrument and

Directory Name	*Collection Logical Identifier (LID)*	*Description*
		targets. These files refer to the full descriptions in the document collection.
spice_kernels (S)	urn:esa:psa:bc:spice_kernels	SPICE kernels.
xml_schema (S)	urn:esa:psa:bc:xml_schema	XML Schemas used in the bundle.

Table 3: ISA collections

(S) This is a "secondary member" collection i.e. this is a collection associated to the bundle by reference to a collection in the mission bundle (see Mission Bundle details in [AD.02]). Products inside this collection are prepared and maintained by the SGS, and are not part of instrument data deliveries to the SGS. For completeness, this collection is included in the instrument bundle when accessed and downloaded from the PSA.

4.2.1 Raw Data directory (data_raw)

The structure of the raw data collection is as follows:

data_raw/

- collection_mpo_isa_data_raw.xml
- collection_mpo_isa_data_raw.csv
- <mission_phase>/
    - <block_type>/

Where:

<mission_phase> is:

- Near_earth_commissioning: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)
- flybys:
    - earth_flyby
    - venus_flyby_1
    - venus_flyby_2
    - mercury_flyby_1
    - mercury_flyby_2
    - mercury_flyby_3
    - mercury_flyby_4
    - mercury_flyby_5
    - mercury_flyby_6
- commissioning: Mercury commissioning (MCP) TBD
- science: Mercury Science Nominal and Extended Phase (MSP) TBD

<block_type> is the observation block type, based on the ISA instrument operative mode:

- TEC: Technical blocks
- OBS: Nominal science observation blocks
- HRO: High-rate science observation blocks
- CAL: Calibration blocks (including self-calibration and chain calibration)
- SAC: Spacecraft assisted calibration blocks

Block subdivision de is described in the present document in section 2.4

Directory Name	***Block type***	***File Naming Convention***
accelerometers	-	isa_raw_hk_accelerometers_report_<YYYYMMDD>.xml/tab
cal	cal	isa_raw_<hk|sc>_<block_type>_<NNNNN>_<YYYYMMDD>.xml/.csv
hro	hro	isa_raw_sc_<block_type>_<NNNNN>_<YYYYMMDD>.xml/.csv
obs	obs	isa_raw_<hk|sc>_<block_type>_<NNNNN>_<YYYYMMDD>.xml/.csv
tec	tec	isa_raw_hk_<block_type>_<NNNNN>_<YYYYMMDD>.xml/.csv

Directory Name	*Block type*	*File Naming Convention*
sac	sac	isa_raw_<hk|sc>_<block_type>_<NNNNN>_<YYYYMMDD>.xml/.csv
thermal	-	isa_raw_hk_thermal_report _<YYYYMMDD>.xml/.tab

Table 4: ISA raw data product types

Where:

<block_type>_<NNNNN>: observation block type and sequence counter
<YYYYMMDD>: timestamp of the first measurement in the product, in UTC

4.2.1.1 General description

Of all the TM coming from ISA, only a part needs to be extracted and converted in a suitable way to form the raw data used by the processing pipeline. The required TM can be divided into three categories, as described in Table 5. These include scientific observations, calibration information as well as selected HK (useful e.g. for setting up the Event Log Report). This TM will be not only necessary as input to the processing pipeline; it will also constitute a first layer of data to be archived. In the following the information to be extracted from each (type,sub-type) packet is described in detail. The main reference for TM details is [RD.15]. An important step is the allocation of correct data types: this is done in accordance with ECSS [RD.16] and PDS4 [AD.04] standards, respectively on instrument and ground segment side.

Category	*Service*	*Description*
Science Observations	TM(21,3) | TM(21,4)	Normal science observations with 10 Hz (2.5Hz for low rate monitoring acquisition) sampling of three acceleration values and three temperature values (one packet is expected every 20 s). NOTE: since the patch to the V4R1 ASW the temperatures sampling is scaled by a factor of 10 wrt the acceleration rate in the packet.
	TM(21,130)	High rate science observations with 500 Hz sampling (one packet is expected every 2 s)
HK and monitoring	TM(3,25)	Nominal HK TM (one packet is expected every 16 s)
	TM(5,1-4)	Events notification
	TM(230,229)	Parameters on the instrument configuration
Calibration information	TM(234,20)	Self calibration execution report
	TM(230,230)	Self calibration parameters
	TM(230,231)	Chain calibration parameters
	TM(230,229)	Accelerometers parameters.
	TM(230,228)	Thermal Control parameters.

Table 5 TM categories required for the processing pipeline and being archived

The lowest level sub-directories contain the following types of data products:

1) **ISA raw housekeeping report**

This data product comes from TM(3,25). It contains ISA HK data, sent by default every 16 s (this default value can be changed via TC(3,29)). The selected data include sensor temperature raw readings and thermal control temperature reached flag. Notice that it has been included the LOW_RATE flag necessary to distinguish – in the **NOMINAL OBSERVATION** mode – between the nominal and the reduced rate read-out. Table 6 contains a description of the available instrument modes (allowed modes in "Current Operating mode") [RD.15].

Symbol	*Operational mode*	*UM num*	*Numeric Id*
B	Boot	02	0x0400
M	Maintenance	07	0x0200
D	Diagnostic	06	0x0100
SF	Safe	04	0x0080
S	Standby	03	0x0040
C	Configuration	05	0x0020
O	Observation	08	0x0010
HO	High rate observation	11	0x0008
SC	Self Calibration	09	0x0004
CC	Chain Calibration	10	0x0002
AC	S/C Assisted Calibration	12	0x0001

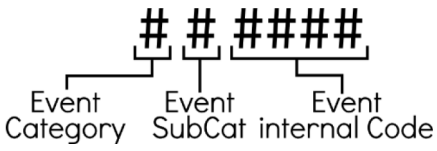
Table 6 Instrument operational modes

Format and content details: Section 5.2.1.

2) **ISA raw event report**

The Event Log Report is the repository of relevant events regarding ISA and its environment. The file will be composed of rows, each representing a single event. Events will be sorted by time in descending order, so the newest events will be at the bottom of the file.

Event Time is the OBT at which the event is generated. Generally it is extracted directly from the packet header OBT of the reference TM. In some cases, the event is not generated starting from a single TM input, but by comparing more than one. In this case the latest OBT is consider as the time of the event.
Event Code is formed by 6 numbers



The coding of the various field is as described in 0. In particular:

- **Event name** is a human understandable name for the event;
- **Event description** is a human understandable more detailed description of current event.

The typical file appearance is as follows:

```
04-Jun-2014 08:31:01.033  171001  TC Execution Acknowle          TC received: PID 95,PCAT 12,PK Sequence ctrl #276
04-Jun-2014 08:31:01.957  319040  FEE TC Status Changed          FEE TC is now DISABLED
04-Jun-2014 08:31:01.957  319010  Acc0 TC Status Changed         Acc0 TC is now DISABLED
04-Jun-2014 08:31:01.957  319020  Acc1 TC Status Changed         Acc1 TC is now DISABLED
04-Jun-2014 08:31:01.957  319030  Acc2 TC Status Changed         Acc2 TC is now DISABLED
04-Jun-2014 08:31:31.023  530605  Mode transition event  Actual Mode "Diagnostic" <- (Prev Mode: "Configuration")
04-Jun-2014 08:31:31.026  171001  TC Execution Acknowle          TC received: PID 95,PCAT 12,PK Sequence ctrl #277
```

Format and content details: Section 5.2.1.3.

3) **ISA raw nominal science**

This data product comes from TM(21,3).
It contains science data acquired in the **Observations** mode, and is currently used also to host the reduced rate observations. When active, TM(21,3) is sent to ground at a fixed rate (default rate is every 20 s for nominal acquisition). Each TM block contains 20 science data packets. Each packet has a size of 192 B and it contains 10 accelerometers readings (one second observation @ 10 Hz) and only one TimeStamp.
The ASCII table should contain one TM data packet per row. So, the time stamp and maximum sensing mass displacement are reported only one time and the 10 accelerometer and temperature readings are grouped together and displayed on the same row. Since a group repetition occurs, two column offset values are present: the first one is an absolute one, while the second one is relative to the single group.
Regarding the reduced rate observations, these are selected via the Low-rate flag, offset byte 21 of TM(230,229), see **ISA raw accelerometer control table**. The corresponding TM structure is the same as nominal rate, except the fact that in this case 4 s of data are contained, instead of 1 s.

Format and content details: Section 5.2.2.

4) **ISA raw high-rate science**

This data product comes from TM(21,130).
It contains science data acquired in the **High rate Observations** mode. When active, it is sent to ground at a fixed rate (default rate is every 2 s). Each TM block contains 2 science data packets. Each packet has a size of 156 B and it contains 10 hi-rate accelerometers readings (one second observation @ 500 Hz) and only one time stamp. Notice that in this mode also TM(21,3) is sent.
The ASCII table should contain one TM data packet per row. So, the time stamp is reported only one time and the 10 accelerometer readings are grouped together and displayed on the same row. Since a group repetition occurs, two column offset values are present: the first one is an absolute one, while the second one is relative to the single group.

Format and content details: Section 5.2.3.

5) **ISA raw thermal control settings table**

This data product comes from TM(230,228).
It contains the parameters used to set the thermal control table.

Format and content details: 5.8.5

6) **ISA raw accelerometers control settings table**

This data product comes from TM(230,229).
It contains a report with accelerometers parameter values stored in RAM or EEPROM. Data fields match TC(230,2) (Accelerometers Control Parameters Table).

The ASCII table should contain one TM data packet per row. So, time stamp, dithering, dynamic control and low-rate flag are reported only one time and the three various accelerometer values are grouped together and displayed on the same row.

Format and content details: Section 5.8.4

7) **ISA raw chain calibration table**

This data product comes from TM(230,230).
It contains a report with chain calibration parameter values stored in RAM or EEPROM. Data fields match TC(230,3) (Chain Calibration Parameters Table).
The ASCII table should contain one TM data packet per row. So, time stamp is reported only one time and the 3 accelerometer actuator plates voltages and the 8 chain calibration frequency info readings are grouped together and displayed on the same row.

Format and content details: Section 5.8.7

8) **ISA raw self-calibration table**

This data product comes from TM(230,231).
It contains a report with return self calibration parameter values stored in RAM or EEPROM. Data fields match TC(230,4) (Self Calibration Parameters Table).
The ASCII table should contain one TM data packet per row. So, self calibration parameter values are reported only one time and the 3 self calibration values are grouped together and displayed on the same row.

Format and content details: Section 5.8.6

4.2.2 Calibration raw directory (calibration_raw)

Calibration raw data directory contains data coved by the calibration raw data collection. It contains the raw data generated during the calibration activities of the instrument. For example, during the self calibration activities.

The structure of the calibration raw data collection is as follows:

calibration_raw /
- collection_calibration_raw.xml
- collection_calibration_raw.csv
- isa_raw_calib_self_calibration_exec_report.xml
- isa_raw_calib_self_calibration_exec_report.csv
- <mission_phase>/
    - <block_type>/
        - <YYYYMM>/

Where <mission_phase> is:
- near-earth: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)
    - ega: Earth Gravity Assist
    - vgaN: Venus Gravity Assist, with N=1-2
    - mgaN: Mercury Gravity Assist, with N=1-4
- commissioning: Mercury commissioning (MCP)

- science: Mercury Science Nominal and Extended Phase (MSP)

Each mission phase directory is further sub-divided in months or range of orbits:
- <YYYYMM>/ (during NEC, Cruise and Mercury commissioning phases)
- <ORBIT_NNNNN_MMMMM>/ (used during the Mercury Science phase)

The cumulative product below is stored in the root of the collection.

ISA raw self-calibration execution

This data product comes from TM(234,20).
It contains a report sent at the end of centering procedure of Self Calibration.
The ASCII table should contain one TM data packet per row. So, the centering procedure parameters are reported only one time and the self calibration values readings are grouped together and displayed on the same row.

4.2.3 Calibration partially processed directory (calibration_partially_processed)

Calibration raw data directory contains data coved by the calibration_partially_processed data collection. It contains the partially processed data generated during the calibration activities of the instrument. For example, during the self calibration mode activities of the instrument.

Those are file where the scale factor and other calibration curves are applied to the files coming from the calibration_raw collection.

The structure of the calibration raw data collection is as follows:

calibration_partially_processed /
- collection_partially_processed _raw.xml
- collection_partially_processed _raw.csv
- isa_par_calib_self_calibration_exec_report.xml
- isa_par_calib_self_calibration_exec_report.csv
- <mission_phase>/
  - <block_type>/
    - <YYYYMM>/

Where <mission_phase> is:
- near-earth: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)
  - ega: Earth Gravity Assist
  - vgaN: Venus Gravity Assist, with N=1-2
  - mgaN: Mercury Gravity Assist, with N=1-4
- commissioning: Mercury commissioning (MCP)
- science: Mercury Science Nominal and Extended Phase (MSP)

Each mission phase directory is further sub-divided in months or range of orbits:
- <YYYYMM>/ (during NEC, Cruise and Mercury commissioning phases)
- <ORBIT_NNNNN_MMMMM>/ (used during the Mercury Science phase)

The files in the root of the collection folder shall be considered as cumulative product since the start of instrument activity.

ISA partially processed self-calibration execution

This data product comes from ISA raw self-calibration execution.
It contains a report sent at the end of centering procedure of Self Calibration.
The ASCII table should contain one TM data packet per row. So, the centering procedure parameters are reported only one time and the self calibration values readings are grouped together and displayed on the same row.

4.2.4 Partially Processed Data directory (data_partially_processed)

The structure of the partially processed data collection is as follows:

data_partially_processed/

- collection_data_partially_processed.xml
- collection_data_partially_processed.csv
- <mission_phase>/
  - <block_type>/
    - <YYYYMM>/

Where <mission_phase> is:

- near-earth: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)
  - ega: Earth Gravity Assist
  - vgaN: Venus Gravity Assist, with N=1-2
  - mgaN: Mercury Gravity Assist, with N=1-4
- commissioning: Mercury commissioning (MCP)
- science: Mercury Science Nominal and Extended Phase (MSP)

Each mission phase directory is further sub-divided in months or range of orbits:

- <YYYYMM>/ (during NEC, Cruise and Mercury commissioning phases)
- <ORBIT_NNNNN_MMMMM>/ (used during the Mercury Science phase)

Here there are the scientific data partially processed, so, data coming from RAW level and where the pipelines only applied the scale factors calibration.

4.2.5 Calibrated Data directory (data_calibrated)

The structure of the calibrated data collection is as follows:

data_calibrated/

- collection_data_calibrated.xml
- collection_data_calibrated.csv
- <mission_phase>/
  - <block_type>/
    - <YYYYMM>/
-

Where <mission_phase> is:

- near-earth: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)
  - ega: Earth Gravity Assist
  - vgaN: Venus Gravity Assist, with N=1-2
  - mgaN: Mercury Gravity Assist, with N=1-4
- commissioning: Mercury commissioning (MCP)
- science: Mercury Science Nominal and Extended Phase (MSP)

Each mission phase directory is further sub-divided in months or range of orbits:

- <YYYYMM>/ (during NEC, Cruise and Mercury commissioning phases)
- <ORBIT_NNNNN_MMMMM>/ (used during the Mercury Science Phase)

4.2.6 Derived Data directory (data_derived)

The structure of the derived data collection is as follows:

data_derived/
- collection_data_derived.xml
- collection_data_derived.csv
- *< TBD >*

A brief description of each type of product and corresponding naming conventions will be included in the next version of the document.

The list of products is under definition; this is currently documented in the ISA Pipeline Description Document [RD.04]. Once consolidated, the information will be documented in this section.

4.2.7 Calibration files directory (calibration_files)

The structure of the calibration files collection is as follows:

calibration_files/
- collection_calibration_files.xml
- collection_ calibration_files.csv
- isa_calib_actuators-polynomia.xml/.csv
- isa_calib_electronic-scale-factors.xml/.csv

The instrument parameters obtained from calibrations performed on ground are collected in a dedicated table (see Annex D). The various parameter categories included are briefly described here.

1. **ICE (“parameters” tab)**

ICE parameters:

temp_offset	Temperature Sensor Offset Calibration
temp_a	Temperature Sensor A 3rd order Calibration
temp_b	Temperature Sensor B 2nd order Calibration
temp_c	Temperature Sensor C 1st order Calibration
140Volt_bus	High Voltage Bus - LSB to Volt Calibration (V/LSB)
3Volt_bus	Low Voltage Bus - LSB to Volt Calibration (V/LSB)
supplyCurr	ICE Primary Current Calibration - LSB to Ampere (A/LSB)
Channel_mapping	Channel Mapping Corresponding to 0-1-2 channel

Table 7 ICE parameters

2. **Sensing elements (“parameters” tab)**

For each channel (AccX (FM05)- ACC0 / AccY (FM02) - ACC1 / AccZ (FM03) - ACC2):

alpha	Accelerometer Position Calibration - LSB to m/s2 (m/s2/LSB)
temp_offset	Temperature Sensor Offset Calibration
temp_a	Temperature Sensor A 1st order Calibration
actuator_V_LSB	Actuator Voltage - LSB to Volt Calibration (V/LSB)
heater_current	Heater Current Calibration - LSB to Ampere (A/LSB)

Table 8 Sensing elements parameters

3. FEE ("parameters" tab)

FEE parameters:

temp_offset	Temperature Sensor Offset Calibration
temp_a	Temperature Sensor A 3rd order Calibration
temp_b	Temperature Sensor B 2nd order Calibration
temp_c	Temperature Sensor C 1st order Calibration
heater_current	Heater Current Calibration - LSB to Ampere (A/LSB)

Table 9 FEE parameters

4. Heaters ("parameters" tab)

Heaters parameters:

Heater_out_fee_W	The output power is described by the function: Heater_out_fee_W = (Heater_out_fee / 150) * 3.4 + 0.2
Heater_out_acc0_W	The output power is described by the function: Heater_out_acc0_W = (Heater_out_acc0 / 646) * 3.4
Heater_out_acc1_W	The output power is described by the function: Heater_out_acc1_W = (Heater_out_acc1 / 646) * 3.4
Heater_out_acc2_W	The output power is described by the function: Heater_out_acc2_W = (Heater_out_acc2 / 646) * 3.4

Table 10 Heaters parameters

5. Reference frames ("parameters" tab)

Transformation matrices relating various instrument-related reference frames:

- Sensing axes UOAF reference frame
- Rotation matrix UOAF_2_ILS
- Sensing axes ILS reference frame

6. Actuators ("parameters" tab)

For each channel:

Temp	Temperature of actuator calibration
Constant_sum	Sum of voltages
AccX_delta_voltage	Voltage delta

volt_A	2nd order coefficient of the calibration function
volt_B	1st order coefficient of the calibration function
volt_C	Offset of the calibration function

Table 11 Actuators

7. Pick-up ("pick-up calibration" tab)

For each sensing elements pick-up values are provided as a function of temperature and voltage.

8. Other parameters ("ISA_parameters" tab)

ISA-related parameters (TBC).

4.2.8 Browse_partially_processed directory (browse_partially_processed)

The structure of the browse collection partially processed data:

data_partially_processed/

- collection_data_ partially_processed xml
- collection_data_ partially_processed.csv
- <mission_phase>/
  - <block_type>/
    - <YYYYMM>/
-

Where <mission_phase> is:

- near-earth: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)
  - ega: Earth Gravity Assist
  - vgaN: Venus Gravity Assist, with N=1-2
  - mgaN: Mercury Gravity Assist, with N=1-4
- commissioning: Mercury commissioning (MCP)
- science: Mercury Science Nominal and Extended Phase (MSP)

Each mission phase directory is further sub-divided in months or range of orbits:

- <YYYYMM>/ (during NEC, Cruise and Mercury commissioning phases)
- <ORBIT_NNNNN_MMMMM>/ (used during the Mercury Science Phase)

4.2.9 Browse calibrated directory (browse_calibrated)

The structure of the browse collection calibrated data:

browse_calibrated/

- collection_browse_calibrated.xml
- collection_ browse _calibrated.csv
- <mission_phase>/
  - <block_type>/
    - <YYYYMM>/
-

Where <mission_phase> is:

- near-earth: Near Earth Commissioning (NEC)
- cruise: Interplanetary Cruise phase (ICP)

        - ega: Earth Gravity Assist
        - vgaN: Venus Gravity Assist, with N=1-2
        - mgaN: Mercury Gravity Assist, with N=1-4
    - commissioning: Mercury commissioning (MCP)
    - science: Mercury Science Nominal and Extended Phase (MSP)

Each mission phase directory is further sub-divided in months or range of orbits:

- <YYYYMM>/ (during NEC, Cruise and Mercury commissioning phases)
- <ORBIT_NNNNN_MMMMM>/ (used during the Mercury Science Phase)

4.2.10 Document directory (document)

The structure of the document collection is as follows:

document/

- collection_mpo_isa_document.xml
- collection_mpo_isa_document.csv
- < Documents; see table below >

Document	***Description***
BC-ISA-ICD-10001_ISA_EAICD.pdf/.xml	This document;

Table 12: ISA documents

5 DATA PRODUCT FORMATS

This section will provide details on the format and content of each of the products included in the ISA science data. Some information on the format of the products has been included in this version as templates.

The actual information regarding the templates is being removed from this document in the form of tables and left in the Excel files, which are the current Annexes B and C.

PDS label templates (in Excel and/or XML format) are used to document the format and content of the data products during the development phase; once consolidated, the information will be captured in this section.

PDS label templates are developed and maintained by the Instrument Team with support from the SGS under the SGS version control system; see ISA PDS4 repository:

- https://s2e2.cosmos.esa.int/bitbucket/scm/pds4xml/bepi.pds4.isa.git

5.1 Label Format and Content

XML Declaration and Schema Reference Information

<Product Type>
<Identification Area>
<Alias_List>
<Citation_Information>
<Modification_History >
<Observation_Area>
<Time_Coordinates>
<Primary_Result_Summary>
<Investigation_Area>
<Observing_System>
<Target_Identification>
<Mission_Area>
<Discipline_Area>
<Reference_List>
<External_Reference>
<Internal_Reference>
<File_Area_Observational>
<File>
<Data Structure(s)>
<File_Area_Observational_Supplemental>
<File>
<Data Structure(s)>
</Product Type>

Figure 5: Simplified PDS4 label example

Label examples will be included as Annex in a future version of the document.

5.2 Raw Data Products

The templates information is detailed in Annex B and 0.

In Annex B several tables are present which provide detailed information on the fields to be processed/archived. Each one is divided in two parts: "TM", detailing the related TM packet content; "Raw", detailing the Raw Data files organization. More specifically:

- TM
  - **Field Name** Name of the packet field as specified in [RD.15] (TBC)
  - **Bit Offset** Starting bit position inside the packet
  - **Packet** Packet ID as indicated in MIB
  - **Mnemonic** Field ID as indicated in MIB
- Raw
  - **TM2RAW field** Name of the field
  - **Group repetition** Whenever necessary, indicates how many times a given group of fields must be repeated
  - **Byte Offset** Starting character position inside the table record
  - **Byte Length** Length of field
  - **Format** Format of field, according to [RD.16], [AD.04]
  - **Unit** Unit of measurement of the physical quantity contained in the field
  - **Field format** Format of field, according to [AD.04]
  - **Description** Extended description of the field content

5.2.1 ISA Raw Housekeeping Report

House Keeping parameters, coming from the TM(21,3) as listed in Annex B, are archived under the form of ASCII table in the form of one record per packed received.

5.2.1.1 Product Id – filename

This kind of product have a name space as the type:

isa_raw_hk_<block>_nnnnn_YYYYMMDD

where:

- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

Label Description

This product reports ISA housekeeping (packet YSA57000), split by date and block.

5.2.1.2 Organization in PSA

Collection: data_raw

Path: ./<mission_phase>/<block>/YYYYMM

5.2.2 *ISA Raw Nominal Science*

For Nominal Science is intended to be generated when data coming from the TM(21,3) or TM(21,4) is received. The product is organized as follow:

ASCII table (Table_Character) with the format specified in Annex B, table "RAW – SC". The following fields are present: **Field Name**, **Bit Offset**, **Packet**, **Mnemonic**, **TM2RAW field**, **Group repetition**, **Group Offset**, **Byte Offset**, **Byte Length**, **Format**, **Description**.

Other information about the product processing are available in [RD.04].

Pleate take into accont that TM(21,3) and TM(21,4) are generated by different ISA on board Application Software versions. TM(21,3) is produced by version by the V3R3 and TM(21,4) is produced since the V4R4 uploaded on the unit the 17th November 2023.

5.2.2.1 Product Id – filename

This kind of product have a name space as the type:

isa_raw_sc_<sc_measurement_range>_< sc_data_rate >_<block>_nnnnn_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <sc_data_rate> ISA science data rate. Normal stands for 10 Hz data, Low stands for 2.5 Hz data. Values allowed are *lowrate|standardrate*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.2.2.2 label description

For

Raw science product acquired at ISA [*standard rate|low rate*] ([*10 Hz|2.5 Hz*]) using [*nominal|extended*] dynamic ([*high gain acquisition chain|low gain acquisition chain*]). Records the position and temperature of each accelerometer.

[*standard rate|low rate*] -> options respectively for standard data rate and low rate acquisition chain

[*10 Hz|2.5 Hz*] -> options respectively for nominal data rate and low rate acquisition chain

[*nominal|extended*] -> options respectively for nominal gain and low gain acquisition chain

[*high gain acquisition chain|low gain acquisition chain*] -> options respectively for nominal gain and low gain acquisition chain

5.2.2.3 Organization in PSA

Collection: data_raw

Path: ./<mission_phase>/<block>/YYYYMM

5.2.3 ISA Raw High-Rate Science

Raw High rate science is intended to be generated when data coming from the TM(21,130) is received. The product is organized as follow:

ASCII table (Table_Character) with the format specified in Annex B, table "RAW – SC". The following fields are present: **Field Name**, **Bit Offset**, **Packet**, **Mnemonic**, **TM2RAW field**, **Group repetition**, **Group Offset**, **Byte Offset**, **Byte Length**, **Format**, **Description**.

The product is expected when block is HRO, or, in case of non-nominal operations, in TEC.

Note that in this mode ISA acquire single accelometer per record at a given frequency of 500Hz. The unit toggle channel acquisition every given period specified in acceleromenter table (see Section **Errore. L'origine riferimento non è stata trovata.**).

Other information about the product processing are available in [RD.04].

5.2.3.1 Product Id - filename

This kind of product have a name space as the type:

isa_raw_sc_<sc_measurement_range>_highrate_<block>_nnnnn_YYYYMMDD

where:

- sc_measurement_range -> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.2.3.2 label description

Raw science product acquired at ISA standard rate (10 Hz) using nominal dynamic (high gain acquisition chain). Records the position and temperature of each accelerometer.

5.2.3.3 Organization in PSA

Collection: data_raw

Path: ./<mission_phase>/<block>/YYYYMM

5.2.4 AOCS ISA Raw Aux Estimated Attitude

This product comes from the AOCS MORE dedicated packet YCS1Z201 MORE aux attitude, HGA. The packet is generated on request by MORE o ISA teams and monitor the SC attitude and the HGA attitude. Nominally it's produced at 1Hz.

The product is available in PSA with the title BepiColombo Spacecraft Measured Attitude

Those data are used by the calibration pipeline to resume the attitude of the spacecraft and calculate the Gravity Gradient on the masses, so to perform the ISA vertex acceleration reduction.

5.2.4.1 Product Id - filename

This kind of product have a name space as the type:

mpo_raw_hk_aocs_measured_attitude_<YYYYMMDD>

where:

- date (YYYYMMDD) -> Date of the first acquisition in table

5.2.4.2 label description

This product contains spacecraft housekeeping parameters with the AOCS IMU measured angular rate.

These spacecraft housekeeping parameters are included in the following TM packets:

* YCS1Z203 (SPID = 30727), ISA aux IMU rates.

Default generation rate: 1Hz.

5.2.4.3 Organization in PSA

Path: bc/miscellaneous/spacecraft_housekeeping/<mission_phase>/<YYYYMMDD>/

5.2.5 ISA Raw Aux Estimated Angular rate

This product comes from the AOCS MORE dedicated packet YCS1Z202 ISA aux estimated attitude. The packet is generated on request from ISA and monitor the SC attitude and the HGA attitude. Nominally it's produced at 8Hz.

It contains the AOCS angular rates wrt the MPO frame as calculated by the Kalman Filter.

The product title is: BepiColombo Spacecraft AOCS Angular Rate.

Those data are used by the calibration pipeline to resume the attitude of the spacecraft and calculate the Gravity Gradient on the masses, so to perform the ISA vertex acceleration reduction.

5.2.5.1 Product Id – filename

This kind of product have a name space as the type:

mpo_raw_hk_aocs_angular_rate_<YYYYMMDD>

where:

- date (YYYYMMDD) -> Date of the first acquisition in table

5.2.5.2 label description

This product contains spacecraft housekeeping parameters with the AOCS angular rate.

These spacecraft housekeeping parameters are included in the following TM packets:

* YCS1Z202 (SPID = 30726), ISA aux estimated rates.

Default generation rate: 8Hz.

5.2.5.3 Organization in PSA

Path: bc/miscellaneous/spacecraft_housekeeping/<mission_phase>/<YYYYMMDD>/

5.2.6 ISA Raw Aux IMU Angular Rate

The product contains the IMU angular rates as generated by Gyro before the Kalman Filter estimation. The AUX MPO HK packet is a dedicated packet YCS1Z203 ISA aux IMU rates.

The TM packet is nominally generated at 8Hz so does the products.

The product is available in PSA with the title BepiColombo Spacecraft AOCS IMU Measured Angular Rate

5.2.6.1 Product Id - filename

This kind of product have a name space as the type:

mpo_raw_hk_aocs_imu_angular_rate_<YYYYMMDD>

where:

- date (YYYYMMDD) -> Date of the first acquisition in table

5.2.6.2 label description

This product contains spacecraft housekeeping parameters with the AOCS IMU measured angular rate.

These spacecraft housekeeping parameters are included in the following TM packets:

* YCS1Z203 (SPID = 30727), ISA aux IMU rates.

Default generation rate: 1Hz.

5.2.6.3 Organization in PSA

Path: bc/miscellaneous/spacecraft_housekeeping/<mission_phase>/<YYYYMMDD>/

5.3 Partially processed data products

5.3.1 ISA Partially Processed Science

The product is meant to be the same of ISA RAW Nominal Science with records calibrated using the MPO ISA Electomechanical Settings described in Section 5.8.3. The data in LSB are also corrected for the on-ground polynomia if the on-board polynomia is deactivated. The operation is based to the <*metadata sc_onboard_polynomial*> contained in the RAW product label.

The users must be aware that ISA has an internal linearization polynomia is necessary when the high frequency noise, in the near of ISA accelerometers resonance frequency, is higher enough and modulated to be reconverted to a signal in the scientific ISA measurement band.

5.3.1.1 Product Id – filename

This kind of product have a name space as the type:

isa_par_sc_<sc_measurement_range>_< sc_data_rate >_<block>_nnnnn_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <sc_data_rate> ISA science data rate. Normal stands for 10 Hz data, Low stands for 2.5 Hz data. Values allowed are *lowrate|standardrate*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.3.1.2 Label Description

Partially processed science product, standard rate (10 Hz), nominal dynamic (high gain acquisition chain). Records the accelerations measured by the sensing masses transformed in physical units (m/s**2). At this processing level, only scale factor corrections are applied, together to the eventual the polynomial linearization correction.

5.3.1.3 Organization in PSA

Collection: data_partially_processed

Path: ./<mission_phase>/<block>/YYYYMM

5.3.2 MPO ISA Partially Processed High Rate Science

The product contains the ISA RAW High-Rate Science product calibrated for the accelerometers scale factors.

5.3.2.1 Product Id – filename

This kind of product have a name space as the type:

isa_par_sc_<sc_measurement_range>_highrate_<block>_nnnnn_YYYYMMDD

where:

- sc_measurement_range -> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*

- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.3.2.2 Label Description

Partially processed science product, high rate (500 Hz), nominal dynamic (high gain acquisition chain). Records the accelerations measured, by one sensing mass at a time, transformed in physical units (m/s**2). At this processing level, only scale factor corrections are applied.

5.3.2.3 Organization in PSA

Collection: data_partially_processed

Path: ./<mission_phase>/<block>/YYYYMM

5.4 Calibrated data products

5.4.1 ISA Calibrated HK

In this product the ISA RAW2CAL software applies the scale factors and other calibration curves as described in Section 5.7.1 and 5.7.2 to the parameters containd in the ISA RAW Housekeeping Report.

5.4.1.1 Product Id – filename

This kind of product have a name space as the type:

isa_par_sc_<sc_measurement_range>_highrate_<block>_nnnnn_YYYYMMDD

where:

- sc_measurement_range -> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.4.1.2 Label Description

Reports ISA housekeeping (packet YSA57000), split by date and block and calibrated using the instrument scale factors.

5.4.1.3 Organization in PSA

Collection: data_partially_processed

Path: ./<mission_phase>/<block>/YYYYMM

5.4.2 ISA Calibrated Science Data

ISA Calibrated product are ISA scientific main products. The product contains the vector acceleration referred to the ISA ILS frame. It means that the acceleration colleted by the three sensors are reported to the ILS vertex by projecting the acceleration in the right reference frame and by cancelling the differential inertial accelerations and gravity gradient accelerations due to the fact that the three sensors are positioned in three different points.

5.4.2.1 Product Id – filename

This kind of product have a name space as the type:

isa_cal_sc_<sc_measurement_range>_< sc_data_rate >_<block>_nnnnn.a.b_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <sc_data_rate> ISA science data rate. Normal stands for 10 Hz data, Low stands for 2.5 Hz data. Values allowed are *lowrate|standardrate*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- subblock (a.b) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.4.2.2 Label Description

Calibrated science product, low rate (2.5 Hz) or standard rate (10 Hz), acquired in extended dynamic (low gain acquisition chain) or in nominal dynamic gain acquisition chain.

Records the accelerations measured by the sensing masses in physical units (m/s**2) and expressed as relative to ISA ILS reference frame. At this processing step the ISA reduction to the center is applied using the AOCS HK data.

5.4.2.3 Organization in PSA

Collection: data_calibrated

Path: ./<mission_phase>/<block>/YYYYMM

5.4.3 ISA Calibrated High-Rate Science Data

This products is the final calibrated high-rate products, where the accelerations are reported in ILS in the same way of the nominal science product.

The user must to be aware that the file does not contains an acceleration vector at 500Hz, but only an accelerometer direction per record reprojected on the corresponding ILS frame axis.

5.4.3.1 Product Id – filename

This kind of product have a name space as the type:

isa_cal_sc_<sc_measurement_range>_highrate_<block>_nnnnn.a.b_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- subblock (a.b) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.4.3.2 Label Description

Calibrated science product, highrate (500 Hz), acquired in extended dynamic (low gain acquisition chain) or in nominal dynamic (nominal gain acquisition chain). Records the acceleration of one accelerometer at a time, transformed in physical units (m/s**2) and expressed as relative to ISA ILS reference frame. At this processing step the ISA reduction to the center is applied using the AOCS HK data.

5.4.3.3 Organization in PSA

Collection: data_calibrated

Path: ./<mission_phase>/<block>/YYYYMM

5.5 Derived data products

The products will be defined in future release of the document.

5.6 Browse Products

5.6.1 ISA Science Partially Processed Browse Product

ISA Browse product are produced to fast check the science product content in terms of spectral power density over the time (spectrogram).

5.6.1.1 Product Id – filename

This kind of product have a name space as the type:

isa_par_sc_browse_<sc_measurement_range>_< sc_data_rate >_<block>_nnnnn_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <sc_data_rate> ISA science data rate. Normal stands for 10 Hz data, Low stands for 2.5 Hz data. Values allowed are *lowrate|standardrate*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.6.1.2 Label Description

Data coming from the Italian Spring Accelerometer (ISA) aboard of BepiColombo ESA spacecraft for Mercury and interplanetary medium exploration at partially processed level. The browse product represent a spectrogram of the three channel accelerations.

5.6.1.3 Organization in PSA

Collection: browse_partially_processed

Path: ./<mission_phase>/<block>/YYYYMM

5.6.2 ISA Science Calibrated Browse Product

ISA Browse product are produced to fast check the science product content in terms of spectral power density over the time (spectrogram).

5.6.2.1 Product Id – filename

This kind of product have a name space as the type:

isa_cal_sc_browse_<sc_measurement_range>_< sc_data_rate >_<block>_nnnnn_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <sc_data_rate> ISA science data rate. Normal stands for 10 Hz data, Low stands for 2.5 Hz data. Values allowed are *lowrate|standardrate*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.6.2.2 Label Description

Data coming from the Italian Spring Accelerometer (ISA) aboard of BepiColombo ESA spacecraft for Mercury and interplanetary medium exploration at partially processed level. The browse product represent a spectrogram of the three channel accelerations coming from the calibrated science products.

5.6.2.3 Organization in PSA

Collection: browse_calibrated

Path: ./<mission_phase>/<block>/YYYYMM

5.6.2.4 Product Id – filename

This kind of product have a name space as the type:

isa_cal_sc_browse_<sc_measurement_range>_< sc_data_rate >_<block>_nnnnn.a.b_YYYYMMDD

where:

- <sc_measurement_range> ISA accelerometers measurement range due to the amplifier gain. If ISA is in extended mode the saturation level is higher of a factor of 10, that means that sensitivity is 10 times less. Values allowed are *nominal|extended*
- <sc_data_rate> ISA science data rate. Normal stands for 10 Hz data, Low stands for 2.5 Hz data. Values allowed are *lowrate|standardrate*
- <block> block type as described in Section 2.4
- block number (nnnnn) -> as described in Section 2.4
- subblock (a.b) -> as described in Section 2.4
- date (YYYYMMDD) -> Date of the first acquisition in table

5.6.2.5 Label Description

Calibrated data coming from the Italian Spring Accelerometer (ISA) aboard of BepiColombo ESA spacecraft for Mercury and interplanetary medium exploration. The browse product represent a spectrogram of the accelerations along the three ISA ILS axes.

5.6.2.6 Organization in PSA

Collection: browse_calibrated

Path: ./<mission_phase>/<block>/YYYYMM

5.7 Calibration files products

5.7.1 BepiColombo MPO ISA Scale Factors Calibration Parameters

Products reports, in ASCII format, a tableset of records organized per groups allowing the ISA electronics scale factors and in general calibration curves to be used for HK and acceleration products calibration.

5.7.1.1 Product Id – filename

The product is archived with the following namespace: isa_calib_electronic-scale-factors and the title: BepiColombo MPO ISA Scale Factors Calibration Parameters

5.7.1.2 Label Description

Electronic scale factors for ISA sensing masses LSB position and ICE parameters (thermometers, currents and voltages). Accelerometer scale factor alpha is expressed in m/s**2/LSB and is used to convert the voltage in acceleration. Other instrumental scale factors are listed here grouped by topic.

5.7.1.3 Organization in PSA

Collection: calibration_files

Path: ./

5.7.2 BepiColombo MPO ISA Actuator Polynomial Parameters

5.7.2.1 Product Id – filename

The product is archived with the following namespace: isa_calib_actuators-polynomia

and the title: BepiColombo MPO ISA Actuator Polynomial Parameters

5.7.2.2 label description

Actuators plates are used to give a known force to the sensing mass. This file contains the polynomial coefficients p00,p10,p20... used to calculate the acceleration-to-actuator-voltage relationship. The force applied from a given voltage depends on the temperature too. So, polynomial coefficients are expressed in a three dimensional function a(V,T) = p00 + p10*V + p01*T + p20*V**2 + p11*V*T + p02*T**2 in which V is the delta voltage applied during the chain-calibration and T the accelerometer temperature.

5.7.2.3 Organization in PSA

Collection: calibration_files

Path: ./

5.8 Cumulative products

Here are described the cumulative products, regardless their processing level.

5.8.1 BepiColombo MPO ISA Raw Event Report

The product contains a list of events tracked during the ISA an BepiColombo activity. Its aim is to drive the Pipelines and to have a reconstruction of the instrument and platform status.

The list of events code and the way to generate them are reported in Annex C. For further information to the stardat of code see Section 4.2.1.1 list 2).

5.8.1.1 Product Id - filename

This product has a namespace as the type: *isa_raw_hk_event_report,* with the title: BepiColombo MPO ISA Raw Event Report

5.8.1.2 Label_description

This product contains a list of relevant events (not just TM(5) but other instrument, spacecraft and environmental events) needed for later processing.

5.8.1.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.2 BepiColombo MPO ISA Raw Instrument Mode Change Log

The product contains the list of ISA mode change organized per record. The product is a sort of look-up-table between the block number and ISA operating mode. Ex. `2018-12-04T03:30:18.057Z,1/0608614216:19217,Chain Calibration,10,CAL,0000`

Note that is is a comulutave product so, you can find in there the total mode changes of ISA since the first activation in Nov. 2018

5.8.2.1 Product Id – filename

This product has the follow namespace: *isa_raw_hk_mode_change_log,* with the title: BepiColombo MPO ISA Raw Instrument Mode Change Log

5.8.2.2 Label description

This product contains a time-ordered list of all instrument mode changes with corresponding block type and block number <*nnnnn*>.

5.8.2.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.3 BepiColombo MPO ISA Raw Electromechanical Settings

The product, due to its on-demand nature and so the very low quantity of packet expected, is a cumulative wrap of TM(230,229) YSA57229.

Generated from packet YSA57229 (ISA (230,229) Acc. Parameter Report), the product reports the parameters in use - from the user manual "TM (230,229): download accelerometers control parameters stored in dedicated area in EEPROM or in RAM"

At Operational level, this table is requested every table change and every ISA switch on.

The information in this table are relative to the sensing masses electromechanical settings. They are used to know the status of the accelerometer settings from the last change/activation.

Important Parameters in the product:

- Extended/Nominal Dynamic.
- Science collection rate (information present in YSA5700 too.)
- Current polynomial non-linearity correction values

NOTE: Extended/Nominal Dynamic information will be added to YSA57000 with next ISA on board SW release (foreseen 12/2023).

5.8.3.1 Product Id - filename

This kind of product have a name space as the type: *isa_raw_hk_accelerometers_settings,* with the title: BepiColombo MPO ISA Raw Electromechanical Settings

5.8.3.2 label description

This product contains parameters read from ISA tables with respect to the sensing masses electromechanical settings, stored in dedicated RAM (or EEPROM) memory area.

The information here is generated from packet YSA57229 (ISA (230,229) Acc. Parameter Report).

Users can find here settings like acquisition dynamic, science collection rate or polynomial non-linearity correction values.

5.8.3.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.4 ISA Raw Accelerometers Control Settings table

Generated from packet YSA57229 (ISA (230,229) Acc. Parameter Report)

Reports the parameters in use - from the user manual "TM (230,229): download accelerometers control parameters stored in dedicated area in EEPROM or in RAM"

At Operational level, this table is requested every table change and every ISA switch on.

The information in this table are relative to the sensing masses electromechanical settings. They are used to know the status of the accelerometers settings from the last change/activation.

Important Parameters in the product:

- Extended/Nominal Dynamic.
- Science collection rate (information present in YSA5700 too.)
- Current polynomial non-linearity correction values

The product have the Title: BepiColombo MPO ISA Raw Accelerometers Control Settings

This product is a cumulative product.

5.8.4.1 Product Id – filename

This kind of product have a name space as:

isa_raw_hk_accelerometers_settings

5.8.4.2 Label Description

This product contains parameters read from ISA tables with respect to the sensing masses electromechanical settings, stored in dedicated RAM (or EEPROM) memory area.

The information here is generated from packet YSA57229 (ISA (230,229) Acc. Parameter Report).

Users can find here settings like acquisition dynamic, science collection rate or polynomial non-linearity correction values.

5.8.4.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.5 BepiColombo MPO ISA Raw Thermal Control Settings

The product, due to its on-demand nature and so the very low quantity of packet expected, is a cumulative wrap of TM(230,228) YSA57228.

This product contains the Thermal Control settings.

At operational level, this table is requested every change and every ISA switch on. Important parameters are in the product:

- Accelerometers Temperature Set point.
- FEE Temperature Set point
- FEE controlled point

5.8.5.1 Product Id - filename

This kind of product have a name space as the type: *isa_raw_hk_thermal_control_settings* , with title:

5.8.5.2 label description

This product contains parameters read from ISA tables with respect to thermal control settings, stored in dedicated RAM (or EEPROM) memory.

Users can find in the product some relevant parameters such as the accelerometer temperature set points, FEE temperature set points, the FEE control point and the FEE set points change strategy.

The information here is generated from packet YSA57228 (ISA (230,228) Thermal Ctrl Param. Report).

5.8.5.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.6 BepiColombo MPO ISA Raw Self Calibration Settings

The product, due to its on-demand nature and so the very low quantity of packet expected, is a cumulative wrap of TM(230,231) YSA57231 - download self-calibration control parameters stored in dedicated area in EEPROM or in RAM.

The product contains parameters used by ISA to perform the Self Calibration.

At operational level, this table is requested every change and every ISA switch on.

Important information contained into the table are relative to:

- Self centering act/deact
- Self Chain act/deact
- Self chain calibration Voltage V1_1-V1_2 V2_1-V2_2 couples for every accelerometer
- Self chain semiperiod

Part of that informations are reported in the Self Calibration Execution Report (see below).

The Chain Calibration itself is used to inspect the non-linearity of the sensing element, by the application of several square waves via accelerometers actuator plates.

Frequency 8, the modulated chain calibration is designed to verify if the polynomial correction is working properly. Voltages applied for Frequency 8 are stored in DM pag7 RAM address 030000, and can be only accessed via memory dump.

5.8.6.1 Product Id - filename

This kind of product have a name space as the type:

isa_raw_hk_self_calibration_settings

with the title: BepiColombo MPO ISA Raw Self Calibration Settings.

5.8.6.2 label description

The product contains parameters wrote into Self Calibration RAM or EEPROM memory area. The parameters are the settings applied by Self Calibration mode at the time of execution.

Every Self-Calibration produce a execution report YSA57234 → TM(234,20), but since, operationally, every parameters change plus every switch on, a dump is requested to the instrument, the user who whould access to the whole settings applied for a certain self-calibration shall refer to the parameters listed in the table product at the record with the time-stamp immediately preciding the time of the self-calibration.

The information here are generated from packet packet YSA57231 (ISA (230,231) Self Calibration Report).

5.8.6.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.7 BepiColombo MPO ISA Raw Chain Calibration Settings

The product contains parameters wrote into and is generated as a comulutive product starting form packet YSA57230 (ISA(230,230) Chain calib. Param. Report) "download chain calibration control parameters stored in dedicated area in EEPROM or in RAM"

At operational level, this table is requested every change and every ISA switch on.

Important information contained into the table are relative to:

- Frequencies activated for chain calibration
- Voltages V1_1-V1_2 V2_1-V2_2 couples set for each frequency
- chain duration
- Frequency 8 activation = modulated chain execution

The Chain Calibration execution is not followed by any execution report TM.

The Chain Calibration itself is used to inspect the non-linearity of the sensing element, by the application of several square waves via accelerometers actuator plates.

Frequency 8, the modualted chain calibration is designed to verify if the polynomia correction is working properly.

Voltage applied for Frequency 8 are stored in DM pag7 RAM address 030000, and can be only accessed via memory dump.

5.8.7.1 Product Id - filename

This kind of product have a name space as the type:

isa_raw_hk_chain_calibration_settings

with the title: BepiColombo MPO ISA Raw Chain Calibration Settings

5.8.7.2 Label_description

This product contains parameters written to the chain calibration RAM or EEPROM memory area. These parameters are the settings applied by chain calibration mode at the time of execution.

The chain calibration execution is not followed by any execution report TM.

The chain calibration itself is used to inspect the accelerometer sensitivity at different frequencies, by the application of several square waves via accelerometers actuator plates.

When frequency 8 is enabled, modulated chain calibration is performed. Voltage levels for frequency 8 are stored in DM pag7 RAM address 030000, and can be only accessed via memory dump.

5.8.7.3 Organization in PSA

Collection: data_raw

Path: ./

5.8.8 BepiColombo MPO ISA Self Calibration Execution RAW parameters report

Generated from packet YSA57234 (ISA (234,20) Self Calib. Exec. Result)

After the end or every centering step of the centering procedure in the on-board calibration, a YSA57234 is sent.

Inside the product centering voltages and centering modes are stored.

Important parameters are the actuaction voltate at the end of the self centering which specify the electric forces acting on the sensing masses from the moment until the next centering via self calibration.

5.8.8.1 Product Id – filename

The product can be find with the following name space: *isa_raw_sc_self_calibration_exec_report* and the title: BepiColombo MPO ISA Self Calibration Execution RAW parameters report

5.8.8.2 Label description

This product contains parameters generated at the end (or every approximation step) of ISA self-calibration, when packet YSA57234 (ISA (234,20) Self Calib. Exec. Result is sent.

The voltage applied to the accelerometers actuators are recorded in this product. Those voltages apply an electric force on the sensing mass in order to reposition on the electric center. Self-Calibration instrument settings and middle steps are recorded as well.

5.8.8.3 Organization in PSA

Collection: calibration_raw

Path: ./

5.8.9 BepiColombo MPO ISA Self Calibration Execution Partially Processed parameters report

This product contains the same parameters of BepiColombo MPO ISA Self Calibration Execution RAW parameters report in Section 5.8.8, but passed trought the pre-processing ISA pipeline that applies calibration values contained in the BepiColombo MPO ISA Raw Electomechanical calibration parameters described in Section 5.8.3

5.8.9.1 Product Id – filename

The product can be find with the following name space: *isa_par_sc_self_calibration_exec_report* and the title: BepiColombo MPO ISA Self Calibration Execution Partially Processed parameters report

5.8.9.2 Label description

Parameters generated after the end (or every approximation step) of ISA self-calibration, when a YSA57234 is sent from packet YSA57234 (ISA (234,20) Self Calib. Exec. Result.

Parameters are here recorded in engineering values.

The voltage applied to the accelerometers actuators are recorded in this product. Those voltages apply an electric force on the sensing mass in order to reposition on the electric center. Self-Calibration instrument settings and middle steps are recorded as well.

5.8.9.3 Organization in PSA

Collection: calibration_partially_processed

Path: ./

ANNEX A DATA DELIVERY SCHEDULE

To be included in a future version of the document.

ANNEX B RAW DATA PRODUCT TEMPLATES

The Raw Data Product templates, part of which are detailed in Section 5.2, are added for convenience in a separate Excel file. Each table present in the file contains four further 'TM' fields, useful for the implementation of the TM2RAW procedure.
Currently the file contains also Partially Processed, Calibrated and Derived products.

ANNEX C EVENT LOG REPORT REFERENCE TABLE

The Event Log Report code reference table, which specifies the encoding adopted for the log messages (see Section 5.2.1.3), is added for convenience as a separate Excel file. For each Category / Sub Category event, its description and related human readable message are specified, together with source information.

ANNEX D ON-GROUND CALIBRATION PARAMETERS

The set of instrument parameters obtained from calibrations performed on ground is added for convenience as a separate Excel file. For each parameter, its description, reference, value and unit are specified, together with source information.

Hereafter, a detailed description of the on-ground calibration parameters is presented, at least for the parameters requiring more information in order to be correctly understood. The description is referred to each worksheet of the Annex D to the current EAICD, i.e. BC-ISA-ICD-100001_ISA_EAICD_Annex_D.

Parameters

- **ICE**

  ICE is the control electronic box for IDA and it is equipped with two thermometers, in order to monitor the Power Board and the Auxiliary Board (details in [RD.05]).
  The ICE thermometer is calibrated according to the following formula: T[C°] = temp_a*temp_raw**3 + temp_b*temp_raw**2 + temp_c*temp_raw + temp_offset.
  The following values apply (as per Annex D):

ICE	Parameter	Description	Value	Unit
	temp_offset	Temperature Sensor Offset Calibration	119,455	°C
	temp_a	Temperature Sensor A 1st order Calibration	$-9{,}80558*10^{-12}$	°C/raw unit^3
	temp_b	Temperature Sensor Offset Calibration	$5{,}33283*10^{-7}$	°C/raw unit^2
	temp_c	Temperature Sensor A 1st order Calibration	$-1{,}19123*10^{-2}$	°C/raw unit

- **AccX – AccY – AccZ**

  Each ISA accelerometer has a thermistor placed according to Figure 3 in [RD.05].
  The conversion of temperature from raw to calibrated for the Accelerometers Temperature sensor is linear, according to the formula: Temp[°C] = temp_a * Temp_raw + temp_offset, where temp_a and temp_offset are two values, different for each accelerometer. The values showed in the following table apply (as per Annex D).
  The “alpha” coefficient refers to the pick up calibration, in order to know how the acquired electrical signal is translated into an acceleration. More details are provided in the “Pick up calibration” paragraph. Those values are used in the HK tables.
  The Actuator_V_LSB is the coefficient used to translate the output from LSB to Volt for the actuators. Details on the measurement are in [RD.20].
  The heater_current coefficient is used to translate the output from LSB to Ampere for the heaters used for the accelerometer thermalisation. Details on the measurement are in [RD.20].

AccX-Acc0	Parameter	Description	Value	Unit
	temp_offset	Temperature Sensor Offset Calibration	26.76192	°C
	temp_a	Temperature Sensor A 1st order Calibration	$1.223770*10^{-3}$	°C/raw unit
	Alpha	Accelerometer pick up Calibration - LSB to m/s2 (m/s2/LSB	$2.04*10^{-12}$	m/s2/LSB
	Actuator_V_LSB	Actuator Voltage - LSB to Volt Calibration (V/LSB)	$5.1203*10^{-4}$	V/LSB
	Heater current	Heater Current Calibration - LSB to Ampere (A/LSB)	.0042439	A/LSB
AccY-Acc1				
	temp_offset	Temperature Sensor Offset Calibration	26.76192	°C
	temp_a	Temperature Sensor A 1st order Calibration	$1.223770*10^{-3}$	°C/raw unit
	alpha	Accelerometer pick up Calibration - LSB to m/s2 (m/s2/LSB	$2.27*10^{-12}$	m/s2/LSB
	Actuator_V_LSB	Actuator Voltage - LSB to Volt Calibration (V/LSB)	$5.1203*10^{-4}$	V/LSB
	Heater current	Heater Current Calibration - LSB to Ampere (A/LSB)	0.004142857	A/LSB
AccZ-Acc2				
	temp_offset	Temperature Sensor Offset Calibration	26.76192	°C
	temp_a	Temperature Sensor A 1st order Calibration	$1.223770e^{-3}$	°C/raw unit
	alpha	Accelerometer pick up Calibration - LSB to m/s2 (m/s2/LSB	$2.17*10^{-12}$	m/s2/LSB
	Actuator V/LSB	Actuator Voltage - LSB to Volt Calibration (V/LSB)	$5.1203*10^{-4}$	V/LSB
	Heater current	Heater Current Calibration - LSB to Ampere (A/LSB)	.004046512	A/LSB

- **FEE**

The FEE board of IDA assembly is monitored by two thermistors. The conversion of temperature from raw to calibrated for the FEE Temperature sensor is a third-order polynomial, according to the formula: T[C°] = temp_a*temp_raw**3 + temp_b*temp_raw**2 + temp_c*temp_raw + temp_offset, where temp_a/temp_b/temp_c are the coefficients and temp_offset is the offset. The values showed in the following table apply (as per Annex D).
The heater_current coefficient is used to translate the output from LSB to Ampere for the heaters used for the FEE thermalisation. Details on the measurement are in [RD.05].

FEE	Parameter	Description	Value	Unit
	temp_offset	Temperature Sensor Offset Calibration	24.2941	°C
	temp_a	Temperature Sensor A 1st order Calibration	-1.01166*10-12	°C/raw unit^3
	temp_b	Temperature Sensor Offset Calibration	9.28481*10-09	°C/raw unit^2
	temp_c	Temperature Sensor A 1st order Calibration	-1.39452*10-03	°C/raw unit
	Heater current	Heater Current Calibration - LSB to Ampere (A/LSB)	.0023333333	A/LSB

- **Heater calibration**

Outputs in Watt of heaters used to thermalise ISA (accelerometers and FEE) are calibrated according to the following table.

Heater	Description	Value	Unit
Heater_out_fee_W	FEE Heater output power	Heater_out_fee_W = (Heater_out_fee / 150) * 3.4 + 0.2	W
Heater_out_acc0_W	Acc0 Heater output power	Heater_out_acc0_W = (Heater_out_acc0 / 646) * 3.4	W
Heater_out_acc1_W	ACC1 Heater output power	Heater_out_acc1_W = (Heater_out_acc1 / 646) * 3.4	W
Heater_out_acc2_W	ACC2 Heater output power	Heater_out_acc2_W = (Heater_out_acc2 / 646) * 3.4	W

- **Sensing axes**

The ISA accelerometer is constituted by three single axis accelerometers. Each component has a specific sensitivity direction, identified by the sensing axis. Those three components allow to measure

the acceleration in a 3D space. Such sensing axes were measured on-ground by ISA team [RD.12][RD.21].
Hereafter the components of ISA sensing axes (X, Y, Z) in the UOAF reference frame and in the ILS reference frame are provided. Moreover, the rotation matrix from UOAF to ILS frame is reported. Details on the definition of such frames are provided in [RD.12][RD.11].

SENSING AXES		**ACCX**	**ACCY**	**ACCZ**
UOAF Frame	X	$9{,}9999*10^{-1}$	$-4.0698*10^{-3}$	$1{,}2313*10^{-3}$
	Y	$-1.4470*10^{-3}$	$8.1866*10^{-1}$	$5{,}7468*10^{-1}$
	Z	$2.1798*10^{-4}$	$-5.7426*10^{-1}$	$8{,}1838*10^{-1}$
		ACCX	**ACCY**	**ACCZ**
ILS Frame	X	$9{,}9999*10^{-1}$	$-2.6898*10^{-3}$	$2{,}8941*10^{-4}$
	Y	$-2.6898*10^{-3}$	$9.9999*10^{-1}$	$2{,}5173*10^{-4}$
	Z	$2.8941*10^{-4}$	$2.5173*10^{-4}$	$9{,}9999*10^{-1}$
UOAF_2_ILS		**UOAFX**	**UOAFY**	**UOAFZ**
		$9.9999*10^{-1}$	$5.8847*10^{-4}$	$-1{,}5641*10^{-3}$
		$-1.3802*10^{-3}$	$8.1852*10^{-1}$	$-5{,}7447*10^{-1}$
		$9.4223*10^{-4}$	$5.7447*10^{-1}$	$8{,}1852*10^{-1}$

- **<u>Actuators calibration</u>**

The IDA accelerometers are provided with two couples of plates: pick up and actuators. While pick up plates are used to monitor and register the sensing mass movement, actuator plates are used (among the other functions) to calibrate the pick up by applying a known force and hence a known acceleration (they provide a reference signal). In order to do this calibration, it needs to know which acceleration corresponds to a certain voltage applied on the actuators. The function relating acceleration/voltage for the actuators was measured on-ground (reference and details in [RD.14]).
This curve is a second-order polynomial translating from Voltage to Acceleration and characterised by three coefficients, one for each order: Volt_A (2nd order), Volt_B (1st order), Volt_C (offset) and Acc (m/s2) = volt_A*att_volt^2 + volt_B*att_volt + volt_C; att_volt in Volt is the input on the actuator.
This curve was measured for each accelerometer at three different temperatures (32°C/42°C/50°C) and two different voltages (66 V and 86 V). The squared sum of voltages (8712 V^2 and 14792 V^2) is a parameter to be considered as well. The delta-voltage is the unbalancing applied on one actuator to generate a square wave signal.
All measured and set parameters are reported in the table below. Details on the actuator calibration and on the measurements carried out are in [RD.14][RD.05]

ActX	Parameters List	Description	Value	Unit
	Temp	Temperature of actuator calibration	32	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccX_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.00333E-07	-
	volt_B	1st order coefficient of the calibration function	1.32474E-05	-
	volt_C	Offset of the calibration function	0.000513735	-
	Temp	Temperature of actuator calibration	32	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccX_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-5.46564E-08	-
	volt_B	1st order coefficient of the calibration function	9.44117E-06	-
	volt_C	Offset of the calibration function	0.000518034	-
	Temp	Temperature of actuator calibration	42	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccX_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.1153E-07	-
	volt_B	1st order coefficient of the calibration function	1.47426E-05	-
	volt_C	Offset of the calibration function	0.000480831	-
	Temp	Temperature of actuator calibration	42	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccX_delta_voltage	Voltage delta	1.2	V

	volt_A	2nd order coefficient of the calibration function	-5.06546E-08	-
	volt_B	1st order coefficient of the calibration function	8.7862E-06	-
	volt_C	Offset of the calibration function	0.00056101	-
	Temp	Temperature of actuator calibration	50	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccX_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-9.50426E-08	-
	volt_B	1st order coefficient of the calibration function	1.25635E-05	-
	volt_C	Offset of the calibration function	0.00056762	-
	Temp	Temperature of actuator calibration	50	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccX_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-5.20444E-08	-
	volt_B	1st order coefficient of the calibration function	9.02354E-06	-
	volt_C	Offset of the calibration function	0.000565703	-

ActY	Parameters List	Description	Value	Unit
	Temp	Temperature of actuator calibration	32	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccY_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.07156E-07	-
	volt_B	1st order coefficient of the calibration function	1.41359E-05	-
	volt_C	Offset of the calibration function	0.000492139	-
	Temp	Temperature of actuator calibration	32	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccY_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-5.11394E-08	-
	volt_B	1st order coefficient of the calibration function	8.80206E-06	-
	volt_C	Offset of the calibration function	0.000553292	-
	Temp	Temperature of actuator calibration	42	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccY_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.04659E-07	-
	volt_B	1st order coefficient of the calibration function	1.37928E-05	-
	volt_C	Offset of the calibration function	0.000525767	-
	Temp	Temperature of actuator calibration	42	°C
	Constant_sum	Sum of voltages	14792	V^2

	AccY_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-5.49497E-08	-
	volt_B	1st order coefficient of the calibration function	9.44044E-06	-
	volt_C	Offset of the calibration function	0.000549442	-
	Temp	Temperature of actuator calibration	50	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccY_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.11674E-07	-
	volt_B	1st order coefficient of the calibration function	1.47047E-05	-
	volt_C	Offset of the calibration function	0.000517771	-
	Temp	Temperature of actuator calibration	50	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccY_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-5.91813E-08	-
	volt_B	1st order coefficient of the calibration function	1.01987E-05	-
	volt_C	Offset of the calibration function	0.000536202	-

ActZ	Parameters List	Description	Value	Unit
	Temp	Temperature of actuator calibration	32	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccZ_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.20445E-07	-
	volt_B	1st order coefficient of the calibration function	1.59E-05	-
	volt_C	Offset of the calibration function	0.000467478	-
	Temp	Temperature of actuator calibration	32	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccZ_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-5.9484E-08	-
	volt_B	1st order coefficient of the calibration function	1.01864E-05	-
	volt_C	Offset of the calibration function	0.000512471	-
	Temp	Temperature of actuator calibration	42	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccZ_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.02372E-07	-
	volt_B	1st order coefficient of the calibration function	1.34767E-05	-
	volt_C	Offset of the calibration function	0.00055436	-
	Temp	Temperature of actuator calibration	42	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccZ_delta_voltage	Voltage delta	1.2	V

	volt_A	2nd order coefficient of the calibration function	-5.34749E-08	-
	volt_B	1st order coefficient of the calibration function	9.17013E-06	-
	volt_C	Offset of the calibration function	0.00057764	-
	Temp	Temperature of actuator calibration	50	°C
	Constant_sum	Sum of voltages	8712	V^2
	AccZ_delta_voltage	Voltage delta	1.6	V
	volt_A	2nd order coefficient of the calibration function	-1.07851E-07	-
	volt_B	1st order coefficient of the calibration function	1.42153E-05	-
	volt_C	Offset of the calibration function	0.000554812	-
	Temp	Temperature of actuator calibration	50	°C
	Constant_sum	Sum of voltages	14792	V^2
	AccZ_delta_voltage	Voltage delta	1.2	V
	volt_A	2nd order coefficient of the calibration function	-6.05373E-08	-
	volt_B	1st order coefficient of the calibration function	1.04467E-05	-
	volt_C	Offset of the calibration function	0.000544775	-

Pick-up calibration

The pick up plates are those used to “pick up” the signal generated by the displacement of the sensing mass. The displacement is sensed by a capacitive detection and provides an electrical signal that is related to the measured acceleration. The pick up plates need to be calibrated to know how the acquired electrical signal is translated into an acceleration.
The tab “pick-up calibration” shows the calibration coefficient for the pick up plates measured at three temperatures (32°C, 42°C, 50°C) and two actuator voltages (66 V and 86 V), for each accelerometer. They were measured during the on-ground calibration of actuators. Details of the measurements are in [RD.14] and [RD.19].

ISA_parameters

The tab “ISA parameters” shows the resonance frequency of each accelerometer at 0 V, with respect to the resonance at 66 V, i.e. 3.8 Hz. At the same time Q values (quality factor) at both voltages are reported.

END OF DOCUMENT