IBIS ON-BOARD DATA MANAGEMENT

USER REQUIREMENTS DOCUMENT

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Issue 3draft

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
1	OCT. 97	ALL	FIRST ISSUE OF THE DOCUMENT From the Draft on September 97 updated following: the M.O.M. : "Final URD Meeting", Tübingen, 15th and 16th October 97 the Red Marked Copy of 23rd October 97, see M.O.M. "IBIS URD Meeting", LA-IB-DT-MN-0022-97.	
2	JAN. 98	ALL	The updating are following the M.O.M. : "ISGRI HK, Commands and Scientific Data Format", Saclay, 4th and 5th November 97.	
3	AUG 99	ALL	Complete new revision to adapt the URD to new requirements and S/W implementations.	

TABLE OF CONTENTS

1. INTRODUCTION

This document describes the User Requirements definition of the IBIS Data Handling System (IDHS).
The IDHS is relevant to the On-Board scientific data processing and all the other functions which support this activity (TM/TC management, HK acquisition formatting and transmission, Monitoring etc.).

This document is the URD, User Requirement Document, for IBIS on INTEGRAL. It contains a collection of all data handling tasks, and definitions of all data formats for IBIS. The collection is based on inputs from the IBIS sub-systems (ISGRI, PICSIT, VETO) as well as general scientific and operational requirements.

This URD does not contain a performance assessment of the necessary processing characteristics, and their compatibility with the on-board data handling hardware, in particular the DPE processor.

1.1. PURPOSE

This document is devoted to list the User requirements relevant to the Data Handling functions of the IBIS instrument, with the exception of the DPE Common Services Software (CSSW).
This document provides the User Requirements relevant to the scientific data processing and all the other functions which support this activity for the IBIS Instrument on board the INTEGRAL Satellite. These requirements define all the capabilities needed to control the IBIS Instrument and to process scientific data.
This document is the input to HW/SW requirements definition and architectural design phases.

This document is specially oriented to the following types of reader:

- The IBIS hardware teams, responsible for the detailed design specifications;
- The software development teams (IASW, ISGRI, PICSIT, VETO, ISDC);
- The IBIS EGSE development team;
- The developers and users of the Spacecraft Simulator and Instrument Simulator software.

1.2. SCOPE

On the basis of the current knowledge of the instrument electrical design and data processing required, the following products have been identified on board IBIS:

- Hardware Event Processor (HEPI)
- IBIS Instrument Application Software (IASW)
- ISGRI Electronic Box Hardware and Software

- PICSIT Electronic Box Hardware and Software
- VETO Electronic Box Hardware and Software

The above products will provide an integrated, reliable and efficient environment able to support the real-time commanding, scientific data selection and processing needed for the correct exploitation of all the Instrument Scientific Operations, including the necessary quality and health checking.

1.3. LIST OF ACRONYMS

AOCS	Attitude Orbital Control System
AT	Automatic Transition
BC	BroadCast
BCPK	BroadCast Pulse
BCPK	BroadCast Packet
BPI	Broadcast Packet Interval
CSSW	Common Services Software
CRC	Cyclic Redundancy Check
DC	Direct Current
DFEE	Digital Front End Electronics
DH	Data Handling
DPE	Data Processing Electronics
EGSE	Electrical Ground Support Equipment
EID	Experiment Interface Document
EM	Engineering Model
ESAM	Emergency Safe Aquisition Mode
FEE	Front End Electronics FM Flight Model
FM	Flight model
FS	Flight Spare model
HEPI	Hardware Event Pre-processor of IBIS
HK	House keeping
IASW	IBIS Instrument Application Software
IBIS	Imager on Board of INTEGRAL Satellite
ICB	Instrument Communication Buffer
ICD	Interface Control Drawing
INTEGRAL	INTErnational Gamma-Ray Astrophysics Laboratory
ISDC	Integral Science Data Centre
ISGRI	CdTe layer
ISOC	Integral Science Operations Centre
ISO	Instrument Submode Operations
ISSW	Instrument Specific Software
ISWT	Integral Science Working Team
MOC	Mission Operations Centre
MCE	Module Control Electronics
MER	Multiple event reconstruction
MGSE	Mechanical Ground Support Equipment
MPE	Module Power Electronics
N/A	Not Applicable
OBDH	On-Board Data Handling
OBSW	On-Board Software
OTF	On Target Flag
PCB	Printed Circuit Board
PICSIT	CsI layer
PDU	Power Distribution Unit

PLM	PayLoad Module
PTM	Packet TeleMetry
QM	Qualification Model
RBI	Remote Bus Interface
RTC	Real Time Clock
SASW	Standard Application Software
S/C	Spacecraft
SIS	Spacecraft Interface Simulator
SM	Structural Model
SMCT	Service Module Central Tube
SOC	Science Operation Centre
SPU	Scientific Processor Unit
TBC	To Be Confirmed
TBD	To Be Defined
TC	TeleCommand
TM	TeleMetry
VEB	Veto electronic box
VS	Veto Shield

1.4. REFERENCES

1.4.1. Applicable Documents

AD[1] Experiment Interface Definition Document, Doc. EID Part A, Issue 1, Rev. 6, November 1998

AD[2] Experiment Interface Definition Document, Doc. EID Part B, Issue 4.2, 7 September 1998

AD[3] Integral Packet Structure Definition, Doc. INT-RP-AI-0030, Issue 3

AD[4] IBIS - Phase C & D, Doc. TL 12790, Issue 1, April 1997

AD[5] M.O.M. of the IBIS consortium meeting, Rome, 3-4/7/97.

AD[6] HEPI Requirements, Doc. IN-IM-TUB-REQ-001, Issue 2.0, February 1997

AD[7] HEPI Interface Description, Doc IN-IM-TUB-TN/EL-018, Issue 4.1, , June 1998
AD[8] HEPI Design Report, Doc. IN-IM-TUB-DES-001, Issue 6.2,December 1998

AD[9] Software Interface Control Document - Integral DPE CSSW, Doc. INT-IC-GMV-0001, Version 3.6, 19/5/98

AD[10] Software Requirement Document, Doc. INT-RS-GMV-0001

AD[11] Software Architectural Design Document, Doc. INT-DS-GMV-0001

AD[12] VETO Modes of Operation, From IBIS: Data Links and Protocol Meeting, M.O.M. LA-IB-DT-MN-0007-97, 23-24 April 97

AD[13] DPE Hardware Specification, Doc. INT-SP-AI-0001, Issue 03, 30 July 1998

AD[14] I/F Data Documentation (EICD, MICD & TICD), Doc. INT-IC-CRS-0001, Issue 1, 1-April-1997

AD[15] "Guide to Applying the ESA Software Engineering Standards to Small Software Projects", BSSC(96)2, Issue 1

AD [16] VETO Software Description, Version 6, Space Research Centre, Polish Academy of Sciences, June 1999

AD [17] IBIS User Manual

AD [18] IBIS Communication Protocol Definition, IN-IM-TUB-ICD-01, Issue: 2.4, JANUARY 1999

1.4.2. Reference Documents

RD[1] IBIS Data Modes, and Operational Modes, Doc. IN-IM-TES-RP-017

RD[2] Compression With the Ma31750, Technical Note WS/LS/SG/1, Issue 2, October 96

RD[3] Handbook of Data Compression Algorithms, Doc. ESA TM-06, ISBN 92-9092-013-0

RD[4] ISGRI In-Flight Energy Estimate, IN-IB-SAP-039, October 22th, 1997.

1.5. OVERVIEW

This document is structured in the following way:

In Section 2 a general description of the operational environment is given and the present status of the interfaces definition is described. For the ISGRI, PICSIT and VETO HW and SW there is no relevant information other than their interfaces with the IDHS and the list of their control commands and housekeeping data.

In Section 3 the specific requirements (including capability and constraint requirements) have been listed.

2.2. GENERAL DESCRIPTION

This section summarises the description of the IBIS Data Handling System (IDHS) with reference to the features of the IBIS components and their interfaces (see AD[4]).

2.1. PRODUCT PERSPECTIVE

From the two detectors (CsI and CdTe layers) scientific data shall be acquired and the following scientific data processing shall be executed:

- ###Scientific Modes and Functions generation and management. Different Scientific Functions (i.e. Photon by Photon, Spectral Timing etc.) shall be generated by applying relevant processing to raw data acquired from the two layers. Different Scientific Functions can be active at the same time (i.e. executed in time sharing)
- ###CsI events histogramming for single and multiple events separately
- ###CsI Calibration events histogramming
- ###Polarimetry histogramming
- ###CsI ratemeters generation
- ###Data compression of histograms
- ###Selection of events which have produced a Compton scattering between the CdTe and the CsI layers in order to reduce the background

Other basic functions necessary to control the Instrument shall be:

- ###Housekeeping readout
- ###Ratemeters acquisition from the CsI layer
- ###Monitoring of specific ratemeters in order to control malfunctioning pixels and/or to detect dangerous conditions
- ###Recovery actions execution
- ###Scientific data formatting and transmission

Other tasks are also in charge of interfacing the CSSW which provides low level services required to support the above functions. These tasks include:

- ###the reception, from the CSSW through the Communication Buffer, execution and distribution of Telecommands
- ###the transmission, to the CSSW through the Communication Buffer, of data and relevant APIDs in order to generate Source Packets

2.2. USER CHARACTERISTICS

The users of this document are:

- ###HW and SW developers
- IBIS hardware teams in charge of testing the instrument functionality through the EGSE and test equipment;
- ###ESOC/ISOC Operational staff in charge of nominal and contingency operations.
- IBIS specialists and ISDC staff in charge of the quick-look and scientific data processing, for performance monitoring and calibration purposes.
- ###Guest Observers for scientific data exploitation.

2.3. GENERAL CONSTRAINTS

As later specified, one of the main problems to be faced is the high rate of scientific events captured by the Instrument (up to about 15000 events/s from the CsI layer and about 1000 events/s from the CdTe layer).
Such a high data rate requires to optimise as much as possible the design of the system in order to reduce the needed processing time. In order to force this kind of design, requirements concerning the maximum CPU time usage have been included and they will be the subject of periodic verifications.
Also the available telemetry allocation during the Satellite operations (58 Kbit/s) introduces a constraint which needs to be solved by compressing data before their transmission. Data compression can be achieved by performing a data suppression and/or a bit reduction of some event information as well as applying data compression algorithms to produced histograms.

In the description of the IDHS has been taken into account the existence of a parallel development line for HEPI. HEPI is in charge of the most demanding tasks relevant to scientific data processing. As regards the HEPI requirements see AD[6].

Following AD[1] and RD[1], the resources available for IASW are:

- ROM size: 48 kwords
- RAM size: 960 kwords
- CPU Time: 95 msec out of a 125 msec cycle
- Telemetry data rate: 1 up to 184 packets/8 seconds.

The duration of the Pointing Mode is typically 1200 seconds (during Galactic Plane Scan the dwell time on each pointing can be less than 1200 seconds). During these period are built the TM Packets relevant to Spectral Imaging Function.

2.4. ASSUMPTIONS AND DEPENDENCIES

The system defined in this document shall use the DPE and the CSSW running on its 31750 µP as a platform for the implementation of its requirements, thus the dependency of this system on the CSSW and its provided basic services is real and a clear interface specification, through the Communication Buffer, is required.
The capability of the DPE 31750 µP to execute the CSSW and all, or a part, of the processing defined in this document shall be carefully evaluated.

2.5. OPERATIONAL ENVIRONMENT

Scope of this section is to describe the tasks relevant to the data handling (including scientific data handling).
In the following are presented the IDHS subsystems and the different interfaces between them.
The IDHS subsystems are:

- Hardware Event Processor (HEPI)
- ISGRI Housekeeping and Controlling
- PICSIT Housekeeping and Controlling
- VETO and Calibration Housekeeping and Controlling
- Common Services Software (CSSW).
- IBIS Application Software (IASW)

In figure 2.5.1.is presented the IDHS:

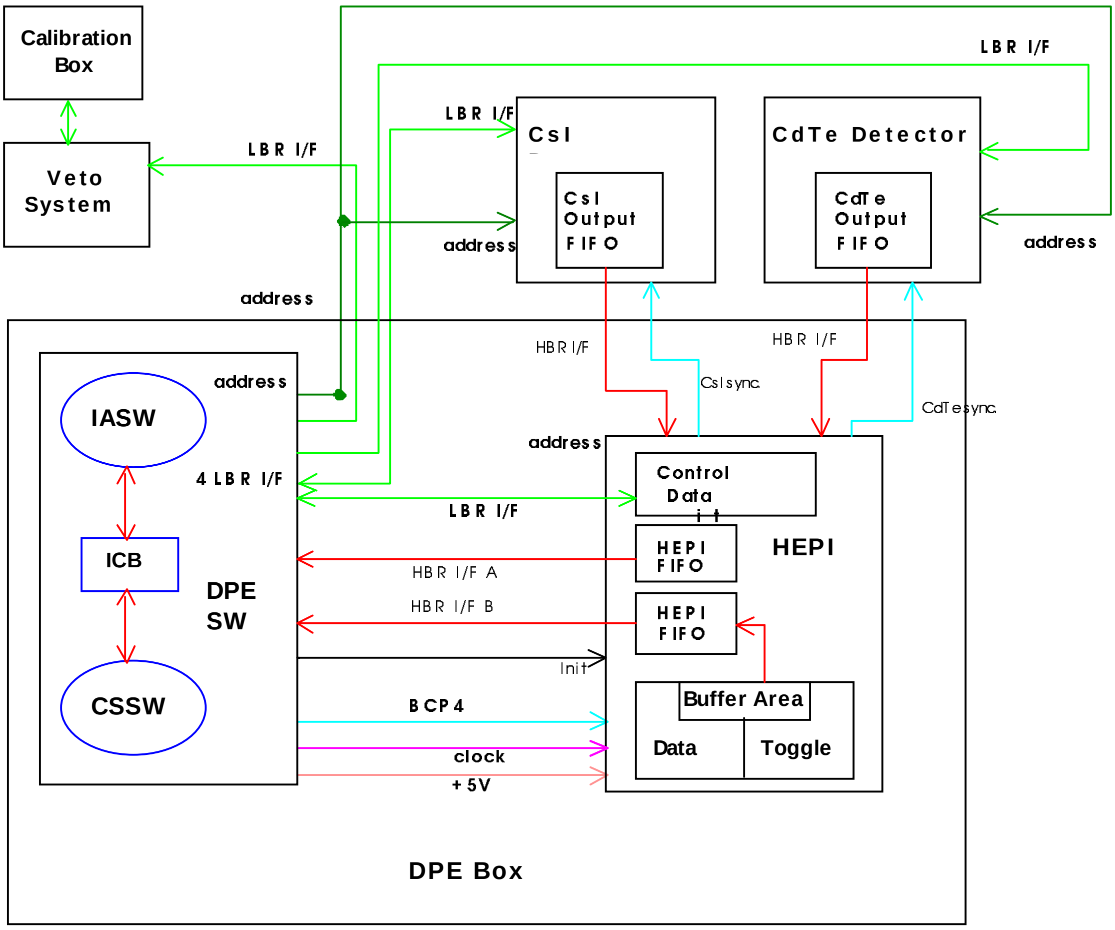

FIGURE 2.5.2. - IBIS DATA HANDLING SYSTEM (THE MINIRTU LINES ARE NOT SHOWN)

For controlling and HK, the detectors, VETO and HEPI are connected via slow serial bus interfaces to DPE. The receiver will be selected by dedicated address lines.
The data are linked from each detector (ISGRI and PICSIT) through a High Bit Rate Interfaces to HEPI. After pre-processing the HEPI sends the data through two HBR I/F to DPE.
A ON/OFF line controls the HEPI initialisation.

For a detailed description of the hardware configuration, see AD[2].

2.5.1. The Hardware Event Processor (HEPI)

HEPI is the interface between the detector plane and the DPE. The events are generated at the CdTe layer (ISGRI) and the CsI layer (PICSIT). Each detector layer is divided into eight modules. A FIFO Data Manager (FDM) collects the digital output data of these modules and sorts them by time. HEPI gets the data via an unidirectional High Bit Rate Serial Interface (HBR I/F) from each detector. The control of these HBR I/F is done by the HEPI. On HEPI the data are pre-processed and some of them are accumulated in histograms Then the DPE reads out the data via two different HBR I/F's. These interfaces are controlled by the DPE. Controlling and exchange of HK data and look up table data are intended via a serial, bi-directional Low Bit Rate Interface (LBR I/F). The DPE further processes the data and hands them over to the IASW.
For further information see AD[6], AD[7] and AD[8].

2.5.2. The ISGRI Subsystem Housekeeping and Controlling

The available ISGRI control commands are presented in
The available ISGRI housekeeping data are presented in

There are the following DPE to ISGRI lines, for module addressing:
L0, L1, L4, L5.

Parameters such as ASICs settings, and some other digital data (CdTe bias, noisy pixels parameters, MDU ON/OFF lines), have to be stored by IASW, before switching off ISGRI, and then re-installed into ISGRI after switching on.

ISGRI and DPE are connected through a Low Bit Rate interface. This I/F has the following functions:

- receiving control commands from DPE.
- loading look up tables (LUT) or saved context from DPE.
- controlling the status of ISGRI (ISGRI will send HK data on request from the DPE, toward the DPE.

There are 8 independent and identical channels in ISGRI having the **same commands and HK tables.**

2.5.3. The PICSIT Subsystem Housekeeping and Controlling

The available PICSIT control commands are presented in .

There the following DPE Mini RTU lines to PICSIT:

- bi-level output: address lines L3, L4, L5, L6
- on-off command: General Reset, Watchdog Enable, Watchdog Disable
- analogue monitor: +5V FSU_IF(N)
- digital monitor: Watchdog Status.

Discriminator settings to be routed to PICSIT shall be stored by IASW for parameter control and retransmitted to PICSIT after eclipse switch off of instruments.

Low bit rate interface

PICSIT and DPE are connected through a Low bit rate interface. This I/F has the following functions:

- receiving control commands for different processing tasks from DPE
- loading look up tables (LUT) from the DPE
- ###controlling the status of PICSIT (PICSIT will send HK data on request from the DPE), for module addressing: L0, L1, L4, L5.

Parameters such as ASICs settings, and some other digital data (CdTe bias, noisy pixels parameters, MDU ON/OFF lines), have to be stored by IASW, before switching off ISGRI, and then re-installed into ISGRI after switching on.

ISGRI and DPE are connected through a Low Bit Rate interface. This I/F has the following functions:

- receiving control commands from DPE.
- loading look up tables (LUT) or saved context from DPE.
- controlling the status of ISGRI (ISGRI will send HK data on request from the DPE, toward the DPE.

There are 8 independent and identical channels in ISGRI having the **same commands and HK tables.**

2.5.4. The VETO and Calibration Subsystems Housekeeping and Controlling

The available VETO control commands are presented in .
The available VETO housekeeping data are presented in (see AD[15]).

There the following DPE mini RTU lines to VETO:

- bi-level output: Development Mode Enable
- on-off command: Watchdog Enable, Watchdog Disable, Reset, PMT Off
- analogue monitor: +5V VECU 1, +5V VECU 2, +28 VPMT
- digital monitor: Watchdog Status.

PMT high voltage and discriminator settings to be routed to VETO shall be stored by IASW for parameter control and retransmitted to VETO after eclipse switch off of instruments.

VETO and DPE are connected through a Low bit rate interface. This I/F has the following functions:

- receiving control commands for different processing tasks from DPE
- controlling the status of VETO (VETO will send HK data on request from the DPE)

2.5.5. The Common Services Software (CSSW)

The CSSW (see AD[9], AD[10] and AD[11]) is the part of the DPE software that supplies to IASW the basic services (task scheduling, “non-scientific” TM and TC processing, “non-scientific” housekeeping, interrupt handling etc.) and the interfaces with the DPE hardware (RBI, mRTU, LBR), but HEPI hardware.
The data exchange interactions between CSSW and IASW occurs by means of the Instrument Communication Buffer (ICB).

Then the scientific TM packets and the TCs directed to IASW are transferred through the ICB.

As regards the TC directed to IASW, the CSSW performs a preliminary verification, but IASW shall complete the verification and validation before to execute the TC (see figure 3.1.13-1).

The TM packets sent by IASW to CDMU shall be transferred in the ICB. They are inserted by the CSSW in the general TM traffic of DPE.
The format of Integral TM packets is described in AD[3], CSSW is in charge to insert the DPE data in this format.
The formats of IDHS TM packets to be transferred by IASW in ICB are described in figures 3.1.18.1-1 (Histogram Based Scientific HK Packet format), figure 3.1.18.1-2 (Event Based Scientific HK Packet format), figure 3.1.18.2-1 (Housekeeping TM Packet format).

3. SPECIFIC REQUIREMENTS

The User Requirements are divided in Capability and Constraints Requirements.

The Capability Requirements are relevant to the following items:

1. Operational Modes
    - Scientific Mode
    - Diagnostic Mode
    - Stand-By Mode

2. Scientific Submodes
    - Standard
    - Polarimetry
    - Photon By Photon

3. Scientific Functions
    - Spectral Imaging (CsI single/multiple histogramming)
    - Spectral Timing
    - Photon by Photon
    - CsI Polarimetric
    - CdTe Calibration
    - CsI Calibration

4. Data Handling Functions
    - Standard Housekeeping
    - Additional Housekeeping
    - Telecommand Handling
    - Initialisation
    - Monitoring
    - Broadcast Packet Handling
    - Mode Management
    - Time Management

5. Operating Mode Philosophy

   The Constraint Requirements are relevant to the following items:
    - Sizing Requirements
    - Timing Requirements
    - Data Compression Requirements

3.1. CAPABILITY REQUIREMENTS

3.1.1. Operational Modes

UR/3.1.1.1. Operational Modes

The IBIS Data Handling System (IDHS) shall be based on the Operational modes presented in table 3.1.1-1:

Operational Modes	TM Packet Generated
Scientific	S1.0, S2.0, S3.0, S3.1 S4.0, S4.1, S5.0,S6.0,S7.0, S7.1,S8,,S13.1, S13.2, H1, H2, H3, H4
Diagnostic	S13.1, S13.2, S13.3, H1, H2, H3, H4,
Stand-By	H1, H2, H3, H4, S5 – S7 only on request
CSSW Initialisation	H1
Off	-

TABLE 3.1.1-1

END-UR

3.1.2. Scientific Submodes and Functions

UR/3.1.2.1. Scientific Submodes

The IDHS Scientific Operational mode shall be divided in the Scientific Submodes presented in table 3.1.2-1:

Scientific Submodes
Standard
Polarimetry
Photon by Photon

TABLE 3.1.2-1

END-UR

UR/3.1.2.2. Scientific Functions

The IDHS Scientific Submodes shall be based on the Scientific Functions presented in table 3.1.2-2:

Scientific Functions	TM Packet Generated
ISGRI PPM	S1
CdTe Calibration	S2
Compton PPM (single/multiple, calibration)	S3
PICSIT PPM (single/multiple)	S4
CsI Calibration	S5
CsI Polarimetric	S6
Spectral Imaging (single/multiple histograms)	S7
Spectral Timing	S8
Diagnostic (CdTe raw, CsI raw)	S13

TABLE 3.1.2-2

END-UR

Each Scientific Function has a Data Type Code and can have a Data Subtype Code. Type Codes and Subtype Codes are used to identify the Telemetry packets produced by the Scientific Functions.

UR/3.1.2.3. Scientific Functions Type Codes and Subtypes Codes

The Type Codes and Subtypes Codes of the Scientific Functions shall be as presented in table 3.1.2-3:

Functions	Packet Type Code	Packet SubType Code
ISGRI PPM	1	0
CdTe Calibration	2	0
Compton PPM single, calibration	3	0
Compton PPM multiple	3	1
PICSIT PPM single	4	0
PICSIT PPM multiple	4	1
CsI Calibration	5	0
CsI Polarimetric	6	0
Spectral Imaging CsI Single Histogram	7	0
Spectral Imaging CsI Multiple Histogram	7	1
Spectral Timing	8	0
Diagnostic CdTe raw	13	1
Diagnostic CsI raw	13	2

TABLE 3.1.2-3

END-UR

UR/3.1.2.4. Scientific Submodes Composition

The Scientific Functions must be combined together to define a sub mode configuration which we refer as “Instrument Sub mode Operations (ISO)”.
In table 3.1.2-4 are presented the Instrument Sub mode Operations, their relevant Functions and the science packets generated with respect to the IBIS operational conditions:

Scientific Submodes	Scientific Functions	Packet Generated in: Pointing	Packet Generated in: Slew
Standard	Spectral Imaging (CsI single/multiple histogr.)	S7	-
	Spectral Timing	S8	-
	ISGRI PPM	S1	S1
	Compton PPM	S3	S3
	PICSIT PPM	-	S4
	CdTe Calibration	S2	S2
	CsI Calibration	S5	S5
	Housekeeping	H1 - H4	H1 - H4
Polarimetry	Spectral Timing	S8	-
	ISGRI PPM	S1	S1
	Compton PPM	S3	S3
	PICSIT PPM	-	S4
	CsI Polarimetric	S6	-
	CdTe Calibration	S2	S2
	CsI Calibration	S5	S5
	Housekeeping	H1 - H4	H1 - H4
PPM	ISGRI PPM	S1	S1
	Compton PPM	S3	S3
	PICSIT PPM	S4	S4
	CdTe Calibration	S2	S2
	CsI Calibration	S5	S5
	Housekeeping	H1 - H4	H1 - H4

TABLE 3.1.2-4

END-UR

UR/3.1.2.5. Scientific Function Configuration Table

The Scientific functions active in the different Scientific Submodes shall be managed by means of a configuration table stored on-board and re configurable by Ground TC. Table 3.1.2-4 reflects the default configuration.

END-UR

3.1.3. Non Scientific Operational Modes and Data Handling Functions

UR/3.1.3.1. Non Scientific Operational Modes

The IDHS shall be based on the Non Scientific Operational Modes presented in table 3.1.3-1. In the table are also presented the functions that produce telemetry packets:

Non Scientific Operational Modes	Functions	Packet Type
Diagnostic	Diagnostic CdTe raw	S13
	Diagnostic CsI raw	S13
	Diagnostic Transparent	S13
	Housekeeping	H1 - H4
Stand-By	Housekeeping	H1 - H4

TABLE 3.1.3-1

END-UR

UR/3.1.3.2. Data Handling Functions

The IDHS shall be able to perform the Data Handling Functions presented in table 3.1.3-2:

Data Handling Functions
Initialisation
Standard Housekeeping
Additional Housekeeping
Telecommand Handling
Monitoring
Broadcast Packet Handling
Mode Management
Time Management

TABLE 3.1.3-2

Note: the Initialisation Function does not produce telemetry packets.
END-UR

3.1.4. Operating Mode Philosophy

UR/3.1.4.1. Non Scientific Operational Modes Activation

The Data Handling Modes can be activated by a dedicated TC.
Stand-By shall be entered at DPE switch on after completing CSSW and IDHS initialisation by a mode transition TC . In Stand-By Mode the IDHS shall perform TC Handling, Housekeeping and Monitoring tasks. Stand-By can be also activated by a mode transition telecommand from any other mode.
END-UR

UR/3.1.4.2. Data Handling Functions Activation

Initialisation function shall be performed at IASW start-up.

The following functions shall always be active in any operational mode (except Off and CSSW initialisation):

- Standard Housekeeping
- Additional Housekeeping
- Telecommand Handling
- Monitoring
- Broadcast Packet Handling
- Mode Management
- Time Management

END-UR

UR/3.1.4.3. IBIS Mode Switching

In figure
FIGURE 3.1.4-1 are presented the possible transitions among the Operational modes and Submodes:

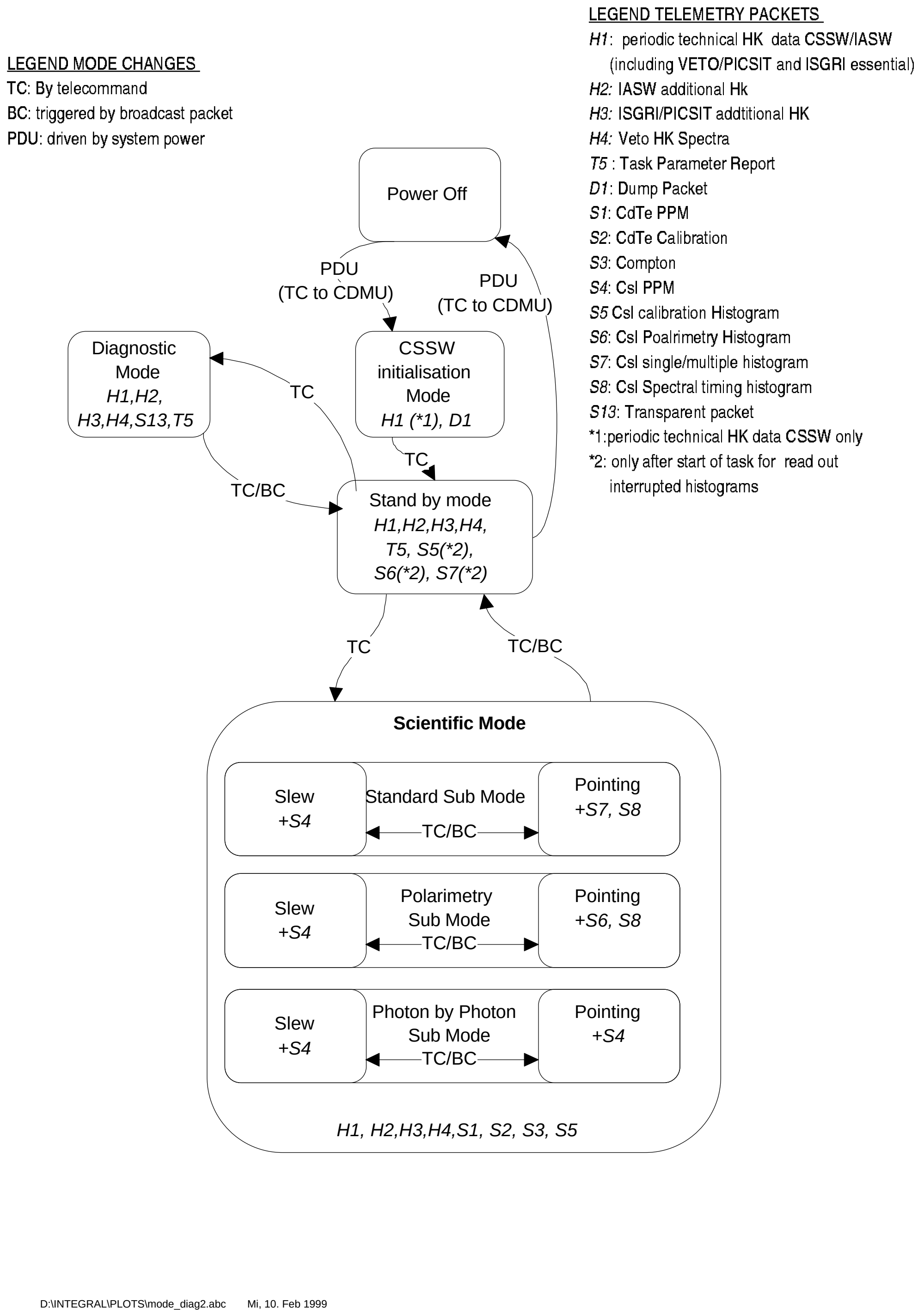

FIGURE 3.1.4-1 - IDHS OPERATIONAL MODES

END-UR

In normal operational conditions IBIS is performing one of the ISO described in table 3.1.2-4. In case of malfunctioning can be activated (by TC) the Diagnostic Mode that allows to perform diagnostic operations.

The Instrument Scientific Operations can be performed autonomously or under Ground control.

UR/3.1.4.4. Automatic ISO Transitions

Within the Scientific Mode the transition between Pointing and Slew configuration, based on BC packet, shall be configurable by Ground TC, i.e. enable or disable the automatic ISO transitions as described in table 3.1.4-1:

From:	To:	Upon event:	Detected from:
Standard S7, S8	Standard S4	IOT: Pointing --> Slew	BCPK
Polarimetry S6, S8	Polarimetry S4	IOT: Pointing --> Slew	BCPK
Standard S4	Standard S7, S8	IOT: Slew --> Pointing	BCPK
Polarimetry S4	Polarimetry S6, S8	IOT: Slew --> Pointing	BCPK

TABLE 3.1.4-1

Legend: IOT: Instrument Operational Transition
BCPK: Broadcast Packet TC(15,1)

END-UR

UR/3.1.4.5. Automatic Mode Switching

The mode switching described in table 3.1.4-2, called Automatic Transition (AT) mechanism, shall be based on BC packet information and configurable individually (enable/disable automatic mechanism) by Ground TC.

From:	To:	Upon condition:	Detected from:
Any ISO	Stand-By	SF/RB/ECL/ESAM/ISOI	BCPK

TABLE 3.1.4-2

Legend: Status Lines means information from the subsystems
BCPK: Broadcast Packet TC(15,1)

SF/RB/ECL/ESAM/ISOI: Solar Flares or Radiation Belts or Eclipse or ESAM or Instr. Switch off imminent

END-UR

UR/3.1.4.6. Automatic Transition Mechanism Disabled By TC Mode Transition

After reception of any TC requiring a mode transition, the Automatic Transition (AT) mechanism shall be disabled.
END-UR

UR/3.1.4.7. AT Overridden by TC

In any condition a TC shall be able to override the AT mechanism.
END-UR

UR/3.1.4.8. Scientific Functions Priority Levels

It shall be possible to define the priority of the scientific functions by means of a "Load Task Parameter" command.
END-UR

3.1.5. Scientific Mode

Hardware configuration:

- all IBIS subsystems powered on
- DPE powered on.

The Scientific Mode is applicable during the following S/C modes:

- Commissioning mode
- Operational mode.

Transition to Scientific Mode and from Scientific Mode: see UR/**3.1.30.1.** and UR/**3.1.30.2.** .

3.1.6. Spectral Imaging Function

UR/3.1.6.1. Spectral Imaging (CsI single/multiple histogramming)

It shall be possible to accumulate single and multiple PICSIT events in a fixed time interval (pointing dwell time) and a defined range and number of energy channels (256 as default value) for each detector pixel.
An energy estimate shall be applied by HEPI to both single and multiple CsI event.
Both transformations shall be stored in the form of one look up table (i.e. one LUT for both single and multiple events correction) which may be reloaded from Ground.
The single and multiple events shall be accumulated in histograms within the HEPI memory. The histograms shall be read-out by IASW, then the data shall be compressed and inserted in two types of scientific packets: one for single and one for multiple event histograms.
This task shall be performed alternatively with respect to Polarimetric histogramming.
END-UR

Note1 : for the initialisation of the threshold values and other parameters relevant to this operational mode, see the Initialisation section.

Note2 : it is assumed that the typical pointing dwell time is between 1200 and 1800 seconds, and in any case no lower than 940 seconds.

UR/3.1.6.2. Start of Spectral Imaging

Spectral Imaging shall start when IBIS is entering into the Standard ISO and following conditions are valid:

- The function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)
- Satellite is in pointing mode
- On target flag is valid (condition applicable if AT is enabled)
- Available Pointing time is larger than the requested integration time (condition applicable if AT is enabled)
- at least one histogram buffer of this type is free.

Integration of histograms shall interrupted when on target flag goes off and is flagged as valid.
END-UR

UR/3.1.6.3. End of Spectral Imaging

Spectral Imaging shall end when:

- entering slew mode
- requested integration time is over and an additional complete histogram could be integrated until expected end of pointing.
- IDHS is entering in Stand-By Mode.

END-UR

UR/3.1.6.4. Spectral Imaging HEPI Binning CsI Look Up Tables

There shall be one look up table for the amplitude binning of single event and one look up table for the amplitude binning of multiple events to be used by HEPI for the histogramming of CsI events.
Each of the two LUTs shall contain 1024 values of 8 bit precision. Then the dimension of each of the two LUTs shall be 1024 bytes.
END-UR

Note1: HEPI calculates the energy value using a precision of 10 bits. Then the energy values that can be represented cover a range from 0 to 1023 (1024 possible values). Each value shall be assigned to one of the 256 channel of the histogram. Then it is necessary a LUT of 1024 elements whose value is between 0 and 255.

Note2: for LUT handling see Initialisation section.

UR/3.1.6.5. Spectral Imaging CsI Events Energy Correction

There shall be a look up table for single and for multiple events correction to be used by HEPI for the energy estimate of all CsI events.
This shall be valid also in Spectral Imaging function.
The energy estimate CsI look up table to be used by HEPI for the events of the CsI detector shall contain 4096 offset correction (a_i) and 4096 gain correction (b_i) values. The precision of the constants a_i shall be 6 bit and of the gain b_i shall be 10 bit. The dimension of this LUT shall be 8192 bytes.

Note: the same LUT shall be used for the energy estimate of CsI events for Spectral Timing, Compton PPM, and Polarimetric functions but not for CsI Calibration that shall have its own LUT.
END-UR

UR/3.1.6.6. Spectral Imaging Histogramming Toggle Buffer

HEPI shall use one buffer for histograming and a toggle buffer to read out the histograms of the previous pointing .
The switch between the data buffer and toggle buffer shall be controlled by IASW.
END-UR

UR/3.1.6.7. Spectral Imaging Data Packet

The Spectral Imaging histograms TM shall be obtained as follows:

- a new histogram is started
- linking down of TM only during pointing mode
- continue of transmitting data after interruption due to switch in stand by mode, when back in any science mode but only in pointing
- continue of transmitting data after interruption due to switch in stand by mode in stand by mode on request of TC
- TM rate of current histogram shall be set according to integration time of next histogram (constant TM rate)
- No Histogram TM during satellite Hand over (information shall taken from BCPK)
- TM buffer is less than upper threshold of this type and subtypes (ref. UR/**3.1.21.3.**)

END-UR

UR/3.1.6.8. Spectral Imaging Subtype Field Code

In Spectral Imaging two types of histograms exist, one for CsI single and one for CsI multiple. To distinguish among the above combinations the Subtype field in the Spectral Imaging data packets shall assume the following values:

Subtype Field Value	Histogram Type
0	CsI Single
1	CsI Multiple

END-UR

Single events histogramming(single CsI events) with 4096 pixel positions, 256 energy channels, 8 bit depth. That is 1,048,576 bytes. The HEPI mass memory for single events histogramming is 1 Mbyte.

Multiple events histogramming (multiple CsI events) with 4096 pixel positions, 256 energy channels, 8 bit depth. That is 1,048,576 bytes. The HEPI mass memory for multiple events histogramming is 1 Mbyte.

UR/3.1.6.9. Compression of Spectral Imaging Data

The size of Spectral Imaging Data Packets (single and multiple events) shall be reduced using a data compression algorithm.
The compression shall be applied to a data subset that, after compression, can stay in a single telemetry packet. In this way if a TM packet is lost, the remaining part of the histogram can be restored.
The compression shall be lossless.
END-UR

UR/3.1.6.10. Spectral Imaging TM Packet Organisation

The TM packet header shall include at least

- Start time of histogram
- Integration time of histogram
- Start address of first cell in TM packet
- Histogram ID

(Packet structure definition ref. AD17)
END-UR

3.1.7. Spectral Timing Function

UR/3.1.7.1. Spectral Timing

It shall be possible to accumulate both CsI single and multiple events in eight programmable energy channels without any information of position. Time resolution shall be represented with a precision between 1 millisecond and 500 milliseconds. According of the amplitude single and multiple events are using the same histogram channels.

END-UR

The single and multiple events shall be accumulated in histograms within the HEPI memory. HEPI collects the CsI single and multiple events in histograms with 8 energy channels within a variable short time period. This time period is programmable from 0.976 msec up to 500 msec. The energy values of the events are within 8 programmable energy ranges. The width of each energy channel is 8 bit. Then the resulting histograms has a dimension of 64 bits. The position information of the events are discarded.

Note: for the initialisation of the threshold values and other parameters relevant to this function, see the Initialisation section.

UR/3.1.7.2. Start of Spectral Timing

Spectral Timing shall start when IBIS is entering into one of the following ISO:

- Standard - Pointing mode
- Polarimetry - Pointing mode

provided the function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)

END-UR

UR/3.1.7.3. End of Spectral Timing

Spectral Timing shall end when:

- either IDHS is entering in slew mode
- or IDHS is entering in Stand-By Mode.

END-UR

UR/3.1.7.4. Spectral Timing CsI Events Energy Calculation

See UR/**3.1.6.5.** .

END-UR

UR/3.1.7.5. Spectral Timing Data Packet

The Spectral Timing histograms TM shall be obtained

- TM buffer is less than upper threshold of this type (ref. UR/**3.1.21.3.**)

END-UR

The TM packet format of spectral timing is according .

3.1.8. Photon by Photon

UR/3.1.8.1. Photon by Photon (deleted, covered by following UR)

END-UR

In table 3.8-1 are presented the Photon by Photon functions; in the last two columns are shown the relevant data and packets types:

Functions	Data Type	Packet Type
ISGRI PPM	CdTe single	S1
Compton PPM	CdTe and CsI	S3
PICSIT PPM	CsI only	S4

TABLE 3.1.8-1

UR/3.1.8.2. PPM Type Information Representation

The PPM Functions information shall be represented in byte aligned data structures with minimum losses of space (i.e. minimum of spare bits).
END-UR

3.1.8.1. ISGRI PPM Function

UR/3.1.8.1.1. ISGRI PPM

These are events corresponding to a valid detected signal from ISGRI only. This type requires the data of position (14 bits), rise time (7 bit), pulse height (11 bits) and time that shall be represented with a precision of 60 microseconds. Energy estimation is performed.
END-UR

Note: for the initialisation of the threshold values and other parameters relevant to this function, see the Initialisation section.

UR/3.1.8.1.2. Start of ISGRI PPM

ISGRI PPM shall start when IBIS is entering into one of the following ISO:
- Standard
- Polarimetry
- PPM.

provided the function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)
END-UR

UR/3.1.8.1.3. End of ISGRI PPM

ISGRI PPM shall end when:
- IDHS is entering in Stand-By Mode.

END-UR

UR/3.1.8.1.4. ISGRI PPM IASW Energy Estimate CdTe Mechanism

IASW shall perform energy estimate of CdTe events for selection purposes.
The algorithm shall base either on individual or pixel wise grouped rise time depending parameters.
END-UR

UR/3.1.8.1.5. ISGRI PPM Data Packet

The ISGRI PPM data packets shall be obtained as follows:
- TM buffer is less than upper threshold of this type (ref. UR/**3.1.21.3.**)
- The TM packet format of ISGRI PPM Data packet is according RD17.

END-UR

3.1.8.2. Compton PPM Function

UR/3.1.8.2.1. Compton PPM

These are events corresponding to valid detected signals in both ISGRI and PICSIT simultaneously (including calibration tagged events). The acceptance window should be programmable. Due to the high data volume an on board selection of good events shall be performed. This type requires the data of ISGRI and PICSIT positions (14 bits and 12 bits)andpulse heights (8 bits and 8 bits), ISGRI rise time (7 bits) and event time that shall be represented with a precision of 60 microseconds.
END-UR

Note : for the initialisation of the threshold values and other parameters relevant to this function, see the Initialisation section.

UR/3.1.8.2.2. Start of Compton PPM

Compton PPM shall start when IBIS is entering into one of the following ISO:
- PPM
- Standard Pointing
- Polarimetry

provided the function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)

An energy correction shall be applied by HEPI to each CsI event.
END-UR

UR/3.1.8.2.3. End of Compton PPM

Compton PPM shall end when:

- IDHS is entering in Stand-By Mode.

END-UR

UR/3.1.8.2.4. Compton PPM CsI Events Energy Correction

See UR/**3.1.6.5.**
END-UR

UR/3.1.8.2.5. Compton PPM Event Selection

For this Data Type a Compton Selection algorithm shall be performed by IASW. The selection starts below a programmable (by TC) threshold. The algorithm shall be applied to each single and multiple event packet acquired from HEPI, after the energy estimate has been performed. No selection shall be applied to Compton calibration events.
END-UR

UR/3.1.8.2.6. Energy Binning Performed By IASW (deleted, wrong UR)

END-UR

UR/3.1.8.2.7. Compton PPM Data Packet

The Compton PPM data packets shall be obtained as follows:

- TM buffer is less than upper threshold of this type and subtypes (ref. UR/**3.1.21.3.**)
- The TM packet format of this type is according RD17.

END-UR

UR/3.1.8.2.8. Compton PPM Subtype Field Code

In Compton PPM exist three types of event types, one for CdTe single in combination with CsI single, one for CdTe single with CsI multiple and one for CdTe calibration with CsI calibration. To distinguish among the above combinations the Subtype field in the Compton PPM shall assume the following values:

Subtype Field Value	Histogram Type
0	CdTe Single and CsI Single and CdTe calibration and CsI calibration
1	CdTe Single and CsI Multiple

To distinguish between calibration and not calibration events for subtype 0 an additional flag in the data field shall be used.
END-UR

3.1.8.3. PICSIT PPM Function

UR/3.1.8.3.1. PICSIT PPM

These are events corresponding to a valid detected signal from PICSIT only. This type requires the data of position (12 bit), amplitude or pulse height (10 bit) and time that shall be represented with a precision of 60 microseconds.
An event energy estimate is needed. The energy correction shall be performed by HEPI.
This function comprises both CsI single and multiple but not CsI calibration events.
END-UR

Note: for the initialisation of the threshold values and other parameters relevant to this function, see the Initialisation section.

UR/3.1.8.3.2. Start of PICSIT PPM

PICSIT PPM shall start when IBIS is entering into one of the following ISO:

- Standard - slew mode
- Polarimetry - slew mode
- PPM.

provided the function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)
END-UR

UR/3.1.8.3.3. End of PICSIT PPM

PICSIT PPM shall end when:

- IDHS is entering in Stand-By Mode.
- or entering pointing mode either from Standard slew or Polarimetry slew mode

END-UR

UR/3.1.8.3.4. PICSIT PPM CsI Events Energy Calculation

See UR/**3.1.6.5.**.
END-UR

UR/3.1.8.3.5. CsI Events Selection On An Energy Window

An energy selection shall be applied to CsI events by HEPI. The selection shall apply to upper and lower energy thresholds.
END-UR

UR/3.1.8.3.6. PICSIT PPM Subtype Field Code

In PICSIT PPM exist two types of event types, one for CsI single and for CsI multiple. To distinguish among the above combinations the Subtype field in the PICSIT PPM shall assume the following values:

Subtype Field Value	Histogram Type
0	CsI Single
1	CsI Multiple

END-UR

UR/3.1.8.3.7. PICSIT PPM Data Packet

The PICSIT PPM data packets shall be obtained as follows:

- TM buffer is less than upper threshold of this type and subtypes (ref. UR/**3.1.21.3.**)
- The TM packet format of this type is according RD17.

END-UR

3.1.9. CsI Polarimetric Function

UR/3.1.9.1. CsI Polarimetric histogramming

It shall be possible to accumulate Polarimetric histogramming. This function applies only to CsI double events that undergo a Compton scattering in the neighboured pixels.

This function shall accumulate for a fixed time period (pointing dwell time) a three dimensional array containing for each pixel (4096 in total) the energy spectrum (64 channels) and for each energy the distribution of the scattering angle (8 polarisation angles) This task shall be performed by HEPI.

END-UR

Polarimetric histogramming accumulates the incident pixel, the total energy and the scattering angle of double CsI events with 4096 pixel positions, 64 energy channels, 8 polarisation angles, 8 bit depth. This requires a total amount of 2 Mbyte mass memory.

Note: for the initialisation of the threshold values and other parameters relevant to this data mode, see the Initialisation section.

UR/3.1.9.2. Start of Polarimetric

Polarimetric shall start when IBIS enter the Polarimetry ISO and follwing conditions are valid:

- The function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)
- Satellite is in pointing mode
- On target flag is on
- Available Pointing time is larger as requested integration time .
- At least one histogram buffer is free

Integration of histograms shall interrupted when on target flag is off.
END-UR

UR/3.1.9.3. End of Polarimetric

Polarimetric shall end when:
- either IBIS is entering in Slew Mode
- or IDHS is entering in Stand-By Mode.
- requested integration time is over

END-UR

UR/3.1.9.4. Polarimetric HEPI Binning CsI Look Up Tables

There shall be one look up table for the amplitude binning of polarimetric events to be used by HEPI for the histogramming of CsI events.
The LUTs shall contain 1024 values of 8 bit precision. Then the dimension of the LUTs shall be 1024 bytes.
END-UR

UR/3.1.9.5. Polarimetric HEPI Energy Correction

See UR/**3.1.6.5.**
END-UR

UR/3.1.9.6. Polarimetric Histogramming Toggle Buffer

HEPI shall use one buffer for histogramming and a toggle buffer to read out the Polarimetric histograms of the previous observation.
The switch between the data buffer and toggle buffer shall be controlled by IASW.
END-UR

UR/3.1.9.7. Polarimetric Data Packet

The Polarimetric histograms TM shall be obtained as follows:
- a new histogram is started
- linking down of TM only during pointing mode
- continue of transmitting data after interruption due to switch in stand by mode, when back in any science mode but only in pointing
- continue of transmitting data after interruption due to switch in stand by mode in stand by mode on request of TC
- TM rate of current histogram shall according integration time of next histogram (constant TM rate)

- No Histogram TM during satellite Hand over (information shall taken from BCPK)
- TM buffer is less than upper threshold of this type (ref. UR/**3.1.21.3.**)

END-UR

UR/3.1.9.8. Compression of Polarimetric Data

See Compression of Spectral Imaging Data Packets (UR/**3.1.6.9.**).
END-UR

UR/3.1.9.9. Polarimetric TM Packet Organisation

The TM packet header shall include at least

- Start time of histogram
- Integration time of histogram
- Start address of first cell in TM packet
- Histogram ID

(Packet structure definition ref. AD17)

3.1.10. CdTe Calibration Function

UR/3.1.10.1. CdTe Calibration PPM

It shall be possible to process and download CdTe PPM Calibration tagged events. This task shall be performed by IASW. For each event the amplitude or pulse height (11 bits), rise time (7 bits) and position (14 bits) shall be recorded.
END-UR

Note: for the initialisation of the threshold values and other parameters relevant to this data mode, see the Initialisation section.

UR/3.1.10.2. Start of CdTe Calibration

CdTe Calibration shall start when IBIS is entering into any ISO, provided the function is enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)
END-UR

UR/3.1.10.3. End of CdTe Calibration

CdTe Calibration shall end when:

- IDHS is entering in Stand-By Mode.

END-UR

UR/3.1.10.4. CdTe Calibration IASW Energy Estimate CdTe Mechanism (deleted, wrong UR)

END-UR

UR/3.1.10.5. CdTe Calibration Data Packet

The CdTe PPM Calibration events shall be obtained as follows:

- TM buffer is less than upper threshold of this type (ref. UR/**3.1.21.3.**)

END-UR

3.1.11. CsI Calibration Function

UR/3.1.11.1. CsI Calibration histogramming

It shall be possible to accumulate CsI Calibration histogramming for single CsI events (multiple events are discarded on the detector). This task shall accumulate CsI calibration events with 4096 pixel positions, 64 energy channels, 8 bit depth .This task shall be performed by HEPI. The histograms shall be read-out by IASW, the data shall be compressed and inserted in the scientific packets.
The typical integration time of Calibration histograms is 10000 seconds.
END-UR

Note: for the initialisation of the threshold values and other parameters relevant to this data mode, see the Initialisation section.

UR/3.1.11.2. Start of CsI Calibration

CsI Calibration shall start when IBIS is entering into any ISO and at least one histogram buffer of this type is free. The function is started only if enabled in the Scientific Function Configuration Table (see UR/3.1.2.5.)
END-UR

UR/3.1.11.3. End of CsI Calibration

CsI Calibration shall end when:

- IDHS is entering in Stand-By Mode.

END-UR

UR/3.1.11.4. CsI Calibration HEPI Histogram Binning CsI Look Up Table

There shall be a LUT (1024 bytes) for amplitude selection of the 64 energy channels. The energy channels are divided in two parts for each of the two calibration lines.
END-UR

UR/3.1.11.5. CsI Calibration HEPI Energy Correction

There shall be one look up table for single event CsI Calibration correction (multiple event are discarded at detector level) to be used by HEPI for the energy estimate of CsI calibration tagged events.
This look up table to be used by HEPI for the events of the CsI detector with calibration tags shall contain 4096 offset correction (a_i) and 4096 gain correction (b_i) values. The precision of the constants a_i shall be 6 bit and of the gain b_i shall be 10 bit. The dimension of this LUT shall be 8192 bytes.

Note: this LUT shall be different with respect the LUT used for the energy estimate of CsI events for Spectral Timing, Compton PPM, PICSIT PPM and Polarimetric functions.

The default values of LUT correction elements shall be:
- 1 for gain
- 0 for offset.

END-UR

UR/3.1.11.6. CsI Calibration histogramming toggle buffer

See Spectral Imaging Histogramming Toggle Buffer (UR/3.1.6.6).
END-UR

UR/3.1.11.7. CsI Calibration Data Packet

The CsI Calibration histogram TM shall be obtained as follows:
- a new histogram is started
- continue of transmitting data after interruption due to switch in stand by mode, when back in any science mode
- continue of transmitting data after interruption due to switch in stand by mode in stand by mode on request of TC
- TM rate of current histogram shall according integration time of next histogram (constant TM rate)
- No Histogram TM during satellite Hand over (information shall taken from BCPK)
- TM buffer is less than upper threshold of this type (ref. UR/**3.1.21.3.**)

END-UR

CsI Calibration histogramming

This task accumulates single CsI Calibration events: with 4096 pixel positions, 64 energy channels, 8 bit depth. This requires 262 kbyte mass memory for this type of histogram.

UR/3.1.11.8. Compression of CsI Calibration Data

See Compression of Spectral Imaging Data Packets (UR/**3.1.6.9.**).
END-UR

UR/3.1.11.9. CsI Calibration TM Packet Organisation

The TM packet header shall include at least

- Start time of histogram
- Integration time of histogram
- Start address of first cell in TM packet
- Histogram ID

(Packet structure definition ref. AD17)
END-UR

3.1.12. Diagnostic Function

UR/3.1.12.1. Diagnostic Function (Transparent function)

The diagnostic function collect all events corresponding to CsI raw or CdTe raw events
This event type contains the full information of time (234 nsec), rise time (8 bit, only CdTe), amplitude (11 bit CdTe, 10 bit CsI), position (14 bit CdTe, 12 bit CsI), calibration flag and multiple event flags. No additional processing is performed to such events. They will only generated when HEPI is programmed in transparent mode via science function table.
END-UR

UR/3.1.12.2. Start of Diagnostic Function

The diagnostic function shall start when IBIS is entering any ISO mode, where no other scientific function is selected by the Scientific Function Configuration Table (see UR/3.1.2.5)

END-UR

UR/3.1.12.3. End of Diagnostic Function

The diagnostic function shall end when IDHS is entering Stand by mode.

END-UR

UR/3.1.12.4. Diagnostic Subtype Field Code

In Diagnostic function exist two types of event types, one for CsI raw events and for CdTe raw events. To distinguish among the above combinations the Subtype field in the Diagnostic TM shall assume the following values:

Subtype Field Value	Histogram Type
0	CdTe raw events
1	CsI raw events

END-UR

UR/3.1.12.5. Diagnostic Data Packet

The Diagnostic TM shall be obtained as follows:

- TM buffer is less than upper threshold of this type and subtypes (ref. UR/**3.1.21.3.**)
- The TM packet format of Diagnostic TM packet is according RD17.

END-UR

3.1.13. VETO Spectra Function

UR/3.1.13.1. VETO Spectra

The VETO Spectra function shall be performed as a background task that shall require, every 100 to 600 sec the Spectra Housekeeping from VETO. These data shall be inserted in the VETO additional HK packets H4.
END-UR

UR/3.1.13.2. Start of VETO Spectra

VETO Spectra shall start when IBIS is entering into stand by mode and VETO is switched on and in nominal mode.
END-UR

UR/3.1.13.3. End of VETO Spectra

VETO Spectra shall end when VETO is in stand by mode.
END-UR

UR/3.1.13.4. VETO Spectra Data Packet

The VETO Spectra data TM packets shall be obtained as follows:

- The TM packet format of VETO Spectra Data packet is according RD17.

END-UR

3.1.14. Patch & Dump

UR/3.1.14.1. IASW Patch and Dump Mode

No explicit Patch and Dump mode of IASW is required. IASW patch and dump shall be nominally executed when IDHS is in CSSW initialisation Mode.
END-UR

Hardware configuration:
- all IBIS subsystems powered off
- DPE powered on.

The Patch & Dump is applicable during the following S/C modes:
- Commissioning mode
- Contingency: ESAM mode
- Operational mode.

UR/3.1.14.2. Patch

The IDHS (IASW, HEPI and sub systems) shall have a Mode by which can be uploaded the following data:
- IDHS LUTs and parameters (including LUTs and context tables of periphery)
- RAM area of DPE
- RAM areas of ISGRI, PICSIT and VETO micro controller.

No controls on the contents of data packets or on the area to be patched (neither in content nor if it is at an existing address) shall be performed.
END-UR

UR/3.1.14.3. Patch of IASW code and DPE RAM

It shall be possible to patch all the DPE RAM. In particular shall be possible to patch any segment of RAM with IASW code or data.
Patching of DPE RAM shall be possible during CSSW initialisation mode via RBI register under control of the CDMU.
END-UR

Note: the patch of the IASW LUT is a low level function that can be used as a back-up of the load LUT TC.

UR/3.1.14.4. Periphery Patch

Patching of peripheral code and data shall be possible by IASW in stand by mode or in IASW diagnostic mode.
END-UR

UR/3.1.14.5. Allowed Functions in Patch & Dump

Deleted

END-UR

UR/3.1.14.6. Patch of the LUTs of HEPI

IASW shall be able to patch any of the look up tables of HEPI.
The patching shall be performed in two steps:
1. patch of the IASW data structure containing the relevant HEPI LUT
2. load of the relevant LUT to HEPI.

END-UR

UR/3.1.14.7. Patch of the IASW Task Scheduling Table

Deleted, because task scheduling is under control of CSSW and ASTRES operating system.
END-UR

UR/3.1.14.8. Patch of ISGRI Software and Data RAM

It shall be possible from ground, by means of suitable commands, to patch data RAM into the microcontroller. No patch of software is required.
END-UR

UR/3.1.14.9. Patch of PICSIT Software and Data RAM

It shall be possible from Ground, by means of a suitable command, to Patch the software and the data RAM of the PICSIT microcontroller.
END-UR

UR/3.1.14.10. Patch of VETO Software and Data RAM

It shall be possible from Ground, by means of a suitable command, to Patch the software and the data RAM of the VETO microcontroller.
END-UR

UR/3.1.14.11. Dump

The IDHS (IASW, HEPI and sub systems) shall have a Mode by which can be downloaded the following data:

- IDHS LUTs and parameters
- RAM area of DPE
- RAM areas of ISGRI, PICSIT and VETO micro controller.

No controls on the contents of data packets or on the area to be dumped (neither in content nor if it is at an existing address) shall be performed.
END-UR

UR/3.1.14.12. Patch of IASW code and DPE RAM

It shall be possible to patch all the DPE RAM. In particular shall be possible to patch any segment of RAM with IASW code or data.
Patching of DPE RAM shall be possible during CSSW initialisation mode via RBI register under control of the CDMU.
END-UR

Note: the patch of the IASW LUT is a low level function that can be used as a back-up of the load LUT TC.

UR/3.1.14.13. Periphery Patch

Patching of peripheral code and data shall be possible by IASW in stand by mode or in IASW diagnostic mode.
END-UR

UR/3.1.14.14. Allowed Functions in Patch & Dump

Deleted

END-UR

UR/3.1.14.15. Patch of the LUTs of HEPI

IASW shall be able to patch any of the look up tables of HEPI.
The patching shall be performed in two steps:

- patch of the IASW data structure containing the relevant HEPI LUT
- load of the relevant LUT to HEPI.

END-UR

UR/3.1.14.16. Patch of the IASW Task Scheduling Table

Deleted, because task scheduling is under control of CSSW and ASTRES operating system.
END-UR

UR/3.1.14.17. Patch of ISGRI Software and Data RAM

It shall be possible from ground, by means of suitable commands, to patch data RAM into the microcontroller. No patch of software is required.
END-UR

UR/3.1.14.18. Patch of PICSIT Software and Data RAM

It shall be possible from Ground, by means of a suitable command, to Patch the software and the data RAM of the PICSIT microcontroller.
END-UR

UR/3.1.14.19. Patch of VETO Software and Data RAM

It shall be possible from Ground, by means of a suitable command, to Patch the software and the data RAM of the VETO microcontroller.
END-UR

UR/3.1.14.20. Dump

The IDHS (IASW, HEPI and sub systems) shall have a Mode by which can be downloaded the following data:

- IDHS LUTs and parameters
- RAM area of DPE
- RAM areas of ISGRI, PICSIT and VETO micro controller.

No controls on the contents of data packets or on the area to be dumped (neither in content nor if it is at an existing address) shall be performed.
END-UR

UR/3.1.14.21. Dump of IASW code and DPE RAM

It shall be possible to dump all the DPE RAM. In particular shall be possible to dump any segment of RAM with IASW code or data.
Dumping of DPE RAM shall be possible during CSSW initialisation mode via RBI register under control of the CDMU.
END-UR

Note: the dump of the IASW LUT is a low level function that can be used as a back-up of the read LUT TC.

UR/3.1.14.22. Periphery Dump

Dumping of peripheral code and data shall be possible by IASW in stand by mode or in IASW diagnostic mode.
END-UR

UR/3.1.14.23. Dump Data Format and Data Rate

Deleted
END-UR

UR/3.1.14.24. Dump of the LUTs of HEPI

IASW shall be able to dump any of the look up tables of HEPI.
The dump shall be performed in two steps:

- readout of the requested HEPI LUT and copy it into the relevant IASW data structure
- dump of the IASW data structure.

END-UR

UR/3.1.14.25. Dump of the Scheduling Table

Deleted, because task scheduling is under control of CSSW and ASTRES operating system.
END-UR

UR/3.1.14.26. Dump of ISGRI RAM

It shall be possible from Ground, by means of a suitable command, to Dump the RAM of the ISGRI microcontroller.
END-UR

UR/3.1.14.27. Dump of PICSIT RAM

It shall be possible from Ground, by means of a suitable command, to Dump the RAM of the PICSIT microcontroller.
END-UR

UR/3.1.14.28. Dump of VETO RAM

It shall be possible from Ground, by means of a suitable command, to Dump the RAM of the VETO microcontroller.
END-UR

3.1.15. Diagnostic Mode

Hardware configuration:
- all IBIS subsystems powered on
- DPE powered on.

Mode is applicable during the following S/C modes:
- Commissioning mode
- Contingency: ESAM mode
- Operational mode.

Transition to Diagnostic Mode and from Diagnostic Mode: see UR/3.1.30.1. and UR/3.1.30.2..

UR/3.1.15.1. Diagnostic Mode

The IDHS shall have a Diagnostic Mode by which 'primary' information from the detectors (not vetoed, not screened or cleaned) may be transmitted.
In this function in the telemetry packets shall be down linked raw event data and/or processed data type (only in sub systems and HEPI) . Parameters ranges for events selection (e.g. switch on/off of ISGRI or PICSIT modules or individual pixel) or special TM packets shall be selectable via telecommands.
The Diagnostic Mode can be started after a TC request.
END-UR

UR/3.1.15.2. Start of Diagnostic Mode

The diagnostic mode starts after transition from stand by mode according UR/3.1.30.1. and UR/3.1.30.2.
END-UR

UR/3.1.15.3. End of Diagnostic Mode

The diagnostic mode ends after transition to stand by mode according UR/3.1.30.1. and UR/3.1.30.2.
END-UR

UR/3.1.15.4. HEPI Set-up for Diagnostic Mode

In IDHS Diagnostic Mode the HEPI status shall be programmable.
For test purposes HEPI shall directly transmit the raw event data (without pre-processing) from the CsI or CdTe detectors to the DPE. This mode of HEPI is called Transparent.
END-UR

UR/3.1.15.5. Parametric Sampling Rate

Deleted
END-UR

UR/3.1.15.6. Loading of the Sampling Rate Parameter

Deleted
END-UR

3.1.16. CSSW Initialisation Mode

Hardware configuration:

- DPE powered on.

Mode is applicable during the following S/C modes:

- Commissioning mode
- Contingency: ESAM mode
- Operational mode.

Transition to CSSW Initialisation Mode

- from OFF mode: by powering the DPE

UR/3.1.16.1. CSSW Initialisation Mode

The CSSW initialisation mode shall be entered after powering on the DPE.
During transition to stand by mode IASW shall be initialised.
END-UR

In CSSW Initialisation Mode no IASW is running.

UR/3.1.16.2. CSSW HK TM

During CSSW Initialisation Mode the DPE shall process only TC related to CSSW by APID as defined in AD [9].

END-UR

UR/3.1.16.3. CSSW HK TM

During CSSW Initialisation Mode the DPE shall send only essential HK without information from IASW and sub systems with data as defined in AD [9]

END-UR

3.1.17. Stand-By Mode

Hardware configuration:

- all IBIS subsystems powered on
- DPE powered on.

Mode is applicable during the following S/C modes:
- Commissioning mode
- Contingency: ESAM mode
- Operational mode.

Transition to Stand-By Mode:
- from CSSW initialisation mode : by TC
- from all other operational modes : see UR/3.1.30.1. and UR/3.1.30.2.

Transition from Stand-By Mode:
- to OFF mode: by switching off the DPE
- to other Operational mode: see UR/3.1.30.1. and UR/3.1.30.2.

UR/3.1.17.1. Stand-By Mode

Stand-By shall be started after completing the Initialisation .
After Initialisation, the AT mechanism shall be enabled.
During the Stand-By Mode the only functions performed shall be: TC Handling, Monitoring, Standard Housekeeping, Additional Housekeeping, BCPK Handling, Mode management and Time management functions.
END-UR

3.1.18. OFF Mode

Hardware configuration:
all IBIS subsystems powered off by S/C PDU

The OFF Mode is applicable during the following S/C modes:
- Launch mode
- Coast mode
- Commissioning mode
- Contingency mode.

Transition to OFF Mode:
- from contingency to any other S/C modes
- in nominal operation complete switch off is not foreseen

Transition from OFF Mode:
- this transition is controlled by S/C PDU by powering dedicated LCL lines in a sequence defined in the User Manual

3.1.19. Power-Save Mode

Deleted

3.1.20. Telemetry Handling

UR/3.1.20.1. Standard TM Organisation

The IDHS shall be able to cope with an allocation up to 184 packets/8 seconds.
The typical TM packets will be organised as follows:

- 129 packets/ 8 seconds in Solar Min. period, divided in 128 Scientific packets and 1 Standard HK packet
- 136 packets/ 8 seconds in Solar Max. period divided in 135 Scientific packets and 1 Standard HK packet.

END-UR

UR/3.1.20.2. Start and stop of transmission of TM

Science TM packet type shall use individual lower and upper thresholds for TM packet controlling. This is also valid for TM(5,4) with task ID 32 and 146 (dump of table) .
TM handling between IASW and CSSW stops for the specific type after exceeding the upper threshold. If the number of events in the TM buffer below the lower threshold, TM generation of the specific shall start again.
END-UR

UR/3.1.20.3. Start and stop of processing of specific events

Following list shows what shall happen, when TM thresholds are reached

TM Type	Upper threshold	Lower threshold	TM Buffer filled
H1	not defined, will be transmitted in any case by CSSW		n/a
H2 - H4	ignored	ignored	generate OEM
TM (5,4)	ignored	ignored	generate OEM
TM (5,4) (Table dump)	Retry one minute to send TM, if not successful delete TM and generate OEM	Send TM when reaching threshold after less than one minute	generate OEM (only if upper threshold is >50)
S1 to S4, S8, S13	Stop processing of specific data type	Start processing of specific data type. Generation of H2 packet, marker in TM packet with start time.	generate OEM (only if upper threshold is >50)
S5 to S7	Retry eight times to send TM	Send TM when reaching threshold	generate OEM (only if upper

	packet, if not successful, delete TM and generate OEM	after less than 1,25 sec	threshold is >50)

END-UR

3.1.21. Telemetry Types

As stated in AD[1] the DPE TM Packets will be assembled by the CSSW based on inputs by the IASW.

UR/3.1.21.1. Telemetry Types

IASW shall manage the generation of the inputs for the TM included in the following classes of Telemetry Functions (see AD[3]):

Packet header APID			Data field header				Description of Packet type
Source ID	VC	Format ID	Type	Sub Type	Spare	Time	
bit 0 - bit 3	bit 4	bit 5 - bit 10	bit 0 - bit 3	bit 4 - bit 7	bit 8 - bit 15	bit 16 - bit 32	
					not used set to 0000 0000	OBT inserted	
		all other bit combinations are reserved	repetition of APID bit 7 - bit 10				
		00 0000	0001	1000		by CSSW	VC 0: Periodic (or CSSW) HK
1010 : IBIS		00 0001	0001	up to 16		by IASW	VC0: Additional Housekeeping
nominal	0	00 0101	0101	different		by IASW	VC0: On-request - Task Management
		00 0110	0110	subtypes		by CSSW	VC0: On-request - Memory Dump
		00 1001	1001			by IASW	VC0: On-request - TLM Management
1011 : IBIS			repetition of APID bit 5 - bit 8	repetition of APID bit 8 - bit 10 with two leading "0"			
redundant		00 0000	0000	0000		by IASW	VC 1: Science Packet type (0,0)
		00 0001	0000	0001		by IASW	VC 1: Science Packet type (0,1)
	1	to					
		11 1110	1111	0010		by IASW	VC 1: Science Packet type (15,2)

		11 1111	1111	0011		by IASW	VC 1: Science Packet type (15,3)

END-UR

UR/3.1.21.2. Standard TM Packet Size and Format

The size of a Standard TM packet shall be 440 bytes.
The format of the Standard TM packet is presented in figure 3.1.18-1:

Field Name	Field Dimension
Packet Header	6 bytes
Data Field Header	4 bytes
Data Field	428 bytes
CRC	2 bytes

FIGURE 3.1.21-1 - STANDARD TM PACKET FORMAT

The value of CRC shall be calculated using the suitable function supplied by CSSW only for VCO TM packets.
The Standard TM Packet format, except CRC calculating, is valid for all the classes of TM packets described in UR/3.1.18.0.1.1.
END-UR

UR/3.1.21.3. Events Accumulation Overflow

In case the events are accumulated at a rate so high that cannot be downloaded with the available TM data rate, then the events accumulation shall be stopped.
The discarded events shall be counted and the counter value shall be included in IASW additional HK packet.
When, later, the events data rate allows the restarting of events accumulation, then in the scientific TM packet shall be inserted a particular Data Packet that indicates this condition and contains the time at which events recording restarted.
END-UR

3.1.22. Standard Housekeeping Function

UR/3.1.22.1. Standard Housekeeping Function

After Initialisation, Standard Housekeeping data shall be acquired from all the instruments according they are switched on.
Standard Housekeeping data shall be generated and handed over according DPE CSSW ICD (see AD[9]) PUT_IASW_HK_TM procedure.
The IDHS housekeeping data shall be formatted as described in RD[19]
END-UR

Standard Housekeeping data shall regard the status of the IBIS subsystems (control parameters configuration, acknowledge to the commands, current operating mode etc.) and shall collect and format HK data coming from the hardware elements (e.g. temperatures, voltages, current monitors etc.).

UR/3.1.22.2. Start of Standard Housekeeping Function

As described in Figure
FIGURE 3.1.4-1, Standard Housekeeping shall be started after IDHS initialisation by the CSSW Initialisation Mode.
END-UR

UR/3.1.22.3. End of Standard Housekeeping Function

As described in Figure
FIGURE 3.1.4-1, Standard Housekeeping shall end only when IDHS (and IBIS) is turned off.
END-UR

The number of packets allocated to IBIS is not fixed a priori. It will vary according to mission planning and availability of bandwidth.

UR/3.1.22.4. Additional Periodic Housekeeping Data

Additional periodic housekeeping data shall be generated and collected from PICSIT, ISGRI and VETO. They shall handed over to the CSSW in VC 0 according UR/3.1.21.1.

Sub System	Collecting Period	Sub Type	Name
PICSIT	32 sec	2 to 9	H3 (joined with ISGRI)
ISGRI MCE 1 to 8	32 sec	2 to 9	H3 (joined with PICSIT)
VETO	100 to 600 sec	10,11	H4

Table 3.1.22.4.-1: Collecting Period of additional periodic Housekeeping
END-UR

UR/3.1.22.5. Start of Additional Periodic Housekeeping Data

The additional periodic housekeeping function shall start after change into Stand By Mode from CSSW initialisation mode.
END-UR

UR/3.1.22.6. End of Additional Periodic Housekeeping Data

The additional periodic HK data shall stop when IDHS is turned off.
END-UR

UR/3.1.22.7. Non Periodic Additional Housekeeping Data (H2)

The additional non periodic housekeeping shall inform about the occurrence of different cases and shall include information which are needed for correct processing of science data.
In following cases IASW shall generate an non periodic additional HK:

- Start Science Mode
- Stop Science Mode
- Start Histogram
- Stop Histogram
- Start of Pointing
- Start of Slew
- On Request by command from Ground
- Restart Processing of dedicated TM type
- Resynchronisation of HEPI

END-UR

3.1.23. Scientific Telemetry Packets

The Data field structure of all Science TM packets is described in . When the Data Field of one TM packet is full then it is passed to CSSW through the ICB.

UR/3.1.23.1. Scientific TM Packets

Each science function shall generate a packet per data type and sub type according Table 3.1.2-4.
END-UR

3.1.24. Housekeeping Telemetry Packets

UR/3.1.24.1. Housekeeping Collection From ISGRI

The different types of Housekeeping data (periodic and additional) from ISGRI shall be collected by IASW sending a command to ISGRI.
END-UR

ISGRI Housekeeping data are presented in
ISGRI control commands are described in

UR/3.1.24.2. Housekeeping Collection From PICSIT

The different types of Housekeeping data (periodic and additional) from PICSIT shall be collected by IASW sending a command to PICSIT.
END-UR

PICSIT Housekeeping data are presented in .
PICSIT control commands are presented in .

UR/3.1.24.3. Housekeeping Collection From VETO

The different types of Housekeeping data (periodic and additional) from VETO shall be collected by IASW sending a command to VETO.
END-UR

VETO Housekeeping data are presented in .
VETO control commands are presented in .

UR/3.1.24.4. Housekeeping Collection From HEPI

The different types of Housekeeping data from HEPI shall be collected every 8 seconds by IASW sending a suitable command to HEPI (HEPI control commands are described in .
END-UR

UR/3.1.24.5. Housekeeping Report from IASW

Every 8 seconds, IASW shall provide HK data relevant to the status of the Functions performed (i.e. if the Functions have been executed correctly or not).
END-UR

UR/3.1.24.6. Housekeeping TM Packet Structure

The Housekeeping TM Packet format shall be as presented in. As described in AD[3] section 3.2.8, the TM(1,8) packets shall contain also the On Event telemetry and the TC Packet Verification Report. For IDHS this shall be done in the HK TM packets.
END-UR

UR/3.1.24.7. Application Process IDentifier (APID) Values

The APIDs relevant to IDHS TM packet types shall be as described in .
END-UR

3.1.25. On Request Packet Generation Function

UR/3.1.25.1. On Request Packet Generation Function

After Initialisation, it shall be possible to generate On Request TM packets as a response to the corresponding request from Ground (TC(5,4), TC(8,5), TC(8,6), TC(8,7)), without affecting the regular HK packet generation.
END-UR

UR/3.1.25.2. On Request Packet Structure

The On Request Packet format (Task Parameter, Memory Dump, Memory Checksum, Monitoring and Diagnostic), shall be as presented in AD [1], AD[3] and .
END-UR

UR/3.1.25.3. On Request Packet Generation

The On Request Packet shall replace the science packets, if not enough telemetry bandwidth is available.
END-UR

3.1.26. Telecommand Handling Function

3.1.26.1. IASW control commands

UR/3.1.26.1.1. Served Telecommand Classes

IASW shall serve the TCs included in the following classes of Telecommands (see AD[3]):

Packet Type	TC Type Function	Packet Sub Type	TC Function

5	Task Management	TC(5,1)	Start Task
		TC(5,2)	Stop Task
		TC(5,3)	Load Task Parameter
		TC(5,4)	Report Task Parameter
		TC(5,5)	Mode Transition
6	Memory Maintenance		
		TC(6,2)	Dump Memory
		TC(6,3)	Calculate Memory Checksum
9	Telemetry Management	TC(9,1)	Report TM Packet Generation Status
		TC(9,4)	Enable Generation of Specific Packets
		TC(9,5)	Disable Generation of Specific Packets
13	Test Command	TC(13,1)	Test Command
15	Broadcast Packet	TC(15,1)	Broadcast Packet

This shall be performed either using the CSSW services or by direct processing of the TC packet.
END-UR

UR/3.1.26.1.2. Verification and Validation of Telecommands

The TC (see AD[3]) directed to IASW are routed to IASW by CSSW through the ICB. The CSSW performs a preliminary verification, but IASW shall complete the verification and validation before the eventual execution of the TC.

The validation of a TC shall consider the following controls:
- correct APID (Application Identifier)
- correct checksum
- legal packet length
- legal packet header

IASW shall report the rejection of each received TC by an On Event message: “TC Verification Report/Unsuccessful Acceptance”, within the periodic HK packet.
END-UR

UR/3.1.26.1.3. Distribution of Telecommands

IASW shall correctly distribute the TC received from Ground to the IBIS subsystems.
END-UR

UR/3.1.26.1.4. Verification of TC Execution

In case the execution (directly by IASW or by one of the IDHS subsystems) of an accepted TC is unsuccessful, IASW or the sub systems shall issue an On Event message TM indicating TC "Verification Report / Unsuccessful Execution". IASW shall generate the relevant TM packet to be transmitted to ground.
END-UR

UR/3.1.26.1.5. Telecommands Packets Format

The TC Packet format is according AD[3]) .
END-UR

UR/3.1.26.1.6. Internal Command Format

The internal command format between DPE and sub systems is according AD [18] and
END-UR

UR/3.1.26.1.7. Context Exchange Control

Exchanging context tables between IASW and ISGRI, PICSIT or VETO requires a control of the checksum of the data.
END-UR

3.1.26.2. HEPI control commands

UR/3.1.26.2.1. HEPI Control Telecommands

The data of HEPI registers (Data and Control) shall be either set-up or readout via the LBR I/F with a dedicated telecommand of the IASW.
END-UR

In are described the HEPI control commands.

3.1.26.3. ISGRI control commands

In are described the ISGRI control commands.

3.1.26.4. PICSIT control commands

In are described the PICSIT control commands.

3.1.26.5. VETO control commands

In are described the VETO control commands.

3.1.27. Initialisation Function

This section is relevant to IBIS subsystems initialisation and interface management, to be performed by IASW.

UR/3.1.27.1. Initialisation Function

The Initialisation Function shall consist in the loading of LUTs, thresholds, initialisation of the interfaces and the initialisation of any other IDHS parameter.
END-UR

UR/3.1.27.2. Start of Initialisation Function

After performing the bootstrap CSSW shall be initialised. The SW shall enter the CSSW initialisation mode.
END-UR

UR/3.1.27.3. Initialisation After Power-Off (Cold Start)

At reception of TC: "Change to nominal mode " in CSSW initialisation mode, the IASW shall perform the initialisation of all interfaces and the initialisation of LUTs, thresholds and the other parameters used by IASW with the default values stored in IASW data structures.
END-UR

UR/3.1.27.4. Initialisation After Power-Save (Warm Start) Deleted

END-UR

3.1.27.1. HEPI Initialisation

UR/3.1.27.1.1. HEPI Initialisation

The HEPI shall be initialised by command via LBR I/F.
END-UR

Loadable parameters:
To get a high flexibility of HEPI all thresholds and LUTs of the different data processes are programmable by command via DPE. The LUTs are stored inside a RAM in HEPI and the thresholds directly on the ASIC registers (Data and Control). The data of these registers and LUTs can be read out via the LBR I/F with a dedicated telecommand of the IASW.

UR/3.1.27.1.2. The LUTs of HEPI

The look up table(LUT) structure of HEPI shall be as follows:

HEPI LUT	Structure	Dimensions
Energy estimate CsI single/multiple histogram	(gain (10 bit) + offset (6 bit)), 4096 positions	8192 bytes
Energy estimate CsI calibration histogram	(gain (10 bit) + offset (6 bit)), 4096 positions	8192 bytes
Amplitude bin of CsI single histogram	1024 (10 bit), 1 byte	1024 bytes
Amplitude bin of CsI multiple histogram	1024 (10 bit), 1 byte	1024 bytes
Amplitude bin of CsI calibration histogram	1024 (10 bit), 1 byte	1024 bytes
Amplitude bin of CsI polarimetry histogram	1024 (10 bit), 1 byte	1024 bytes
Spare	-	4096 bytes

END-UR

UR/3.1.27.1.3. Copy of the LUTs of HEPI in IASW Memory

A copy of the LUT of HEPI shall be present in IASW memory. The LUT shall be identified with a (binary) code that shall be stored on-board together with the values of the LUT. This code shall be shared with the ISGRI energy selection LUTs (ref. UR/3.1.27.6.1.)
END-UR

The code associated to the LUT has the scope to identify uniquely the set of values contained in the LUT.

UR/3.1.27.1.4. Initialisation of the LUTs of HEPI

The initialisation of HEPI LUT will be performed by TC ‘’Init HEPI’’ command from ground.
END-UR

UR/3.1.27.1.5. Uploading of the LUTs of HEPI

HEPI LUT shall be uploaded by IASW. The IASW contains the master of the HEPI LUT. It shall be uploaded by memory patch commands from ground. Then the master table shall be transmit by TC ‘’Restore HEPI LUT’’ in HEPI LUT RAM.
END-UR

UR/3.1.27.1.6. Saving of the LUTs of HEPI in IASW

It shall be possible to save the HEPI LUT in IASW by TC ‘’Save HEPI LUT’’.
END-UR

UR/3.1.27.1.7. Initialisation of the Control Register of HEPI

At start-up IASW shall initialise the Control Register of HEPI. This Function will be performed using default values stored inside the HEPI data structures.
END-UR

UR/3.1.27.1.8. Initialisation of the Data Register of HEPI

At start-up IASW shall initialise the Data Register of HEPI. This Function will be performed using default values stored inside the HEPI data structures.
END-UR

UR/3.1.27.1.9. The Threshold Parameters of HEPI

It shall be possible to load and modify all Threshold Parameters of HEPI

HEPI Thresholds	Parameters	Dimensions
Multiple event reconstruction	double events amplitude threshold triple events amplitude thresholds	1 byte 2 byte
Time coincidence	acceptance window	1 byte
Spectral timing	time resolution thresholds of energy bins	1 byte 9 byte
Synchronising CdTe detector	sync delay	1 byte
Synchronising CsI detector	sync delay	1 byte
CsI amplitude selection	lower and upper threshold	2 byte

END-UR

UR/3.1.27.1.10. Initialisation of the Threshold Parameters of HEPI

At start-up IASW shall initialise all the Threshold Parameters of HEPI. This Function will be performed using default values stored inside the HEPI data structures.
END-UR

UR/3.1.27.1.11. Uploading of the Threshold Parameters of HEPI

IASW shall be able to upload, first in from IASW memory and then in HEPI memory, any of the Threshold Parameters of HEPI after reception of a Load Task Parameter command TC(5,3) .
END-UR

UR/3.1.27.1.12. Initialisation of the Event Rates for Burst Detection of HEPI (deleted)

END-UR

UR/3.1.27.1.13. Initialisation of Detection Time Coincidence between CdTe and CsI events

Since the time jitter is TBD sec for CdTe events and TBD sec for CsI events a variable time window with a programmable width is used to compare the time information of the events. This time value shall be set-up in the HEPI variable time window.
The delay time of the synchronisation pulse is changeable for each layer.
END-UR

UR/3.1.27.1.14. Initialisation of the Width of Each Energy Channel

The width of the histogram energy channels shall be initialised.
END-UR

UR/3.1.27.1.15. Initialisation of the Time Period for Spectral Timing

The time period for Spectral Timing (programmable from 0.976 msec up to 500 msec) shall be initialised.
END-UR

UR/3.1.27.1.16. Initialisation of the Event Counters

An event counter for each layer is intended to control the rate of the incoming events. These count rates could be compared on ground with the number of received events.
The event counters shall be initialised.
END-UR

UR/3.1.27.1.17. Initialisation of the Rate Meters

For the CsI detector there are rate meters of each pixel. Each rate meter counts the number of events and may be read out via the LBR I/F to the DPE.
The rate meters shall be initialised
END-UR

3.1.27.2. ISGRI Initialisation and Interfaces Management

UR/3.1.27.2.1. Uploading of the parameters of ISGRI

It shall be possible to upload and modify all parameters and configuration tables of ISGRI:
PMT high voltage and discriminator settings to be routed to ISGRI shall be stored by IASW for parameter control and retransmitted to ISGRI after eclipse switch off of instruments.

END-UR

Context saving: before switching off ISGRI the current setting of each module must be saved inside the DPE and then reloaded to the modules after switching on. This context is around 2 700 bytes for each modules, so 21 600 for ISGRI

UR/3.1.27.2.2. Uploading of ISGRI Energy Estimate CdTe Look Up Table

It shall be possible to upload the energy estimate CdTe look up table to be used by IASW for all the individual events of the CdTe detector.
END-UR

UR/3.1.27.2.3. Initialisation of the ISGRI Monitoring Tables (deleted)

END-UR

3.1.27.3. PICSIT Initialisation and Interfaces Management

UR/3.1.27.3.1. Uploading of the parameters of PICSIT

It shall be possible to upload and modify all parameters and configuration tables of PICSIT: PMT high voltage and discriminator settings to be routed to PICSIT shall be stored by IASW for parameter control and retransmitted to PICSIT after eclipse switch off of instruments.
END-UR

UR/3.1.27.3.2. Loading of PICSIT Energy Estimate CsI Look Up Table

See UR/3.1.27.1.4. and UR/3.1.27.1.5..
END-UR

UR/3.1.27.3.3. Initialisation of the PICSIT Monitoring Tables (deleted)

END-UR

3.1.27.4. VETO Initialisation and Interfaces Management

UR/3.1.27.4.1. Uploading of the parameters of VETO

It shall be possible to upload and modify all parameters and configuration tables of VETO: PMT high voltage and discriminator settings to be routed to VETO shall be stored by IASW for parameter control and retransmitted to VETO after eclipse switch off of instruments.
END-UR

UR/3.1.27.4.2. Initialisation of the VETO Monitoring Tables (deleted)

END-UR

3.1.27.5. CSSW Interfaces Management

UR/3.1.27.5.1. IASW/CSSW Interface

The data exchange interactions between CSSW and IASW is ruled by CSSW/IASW ICB (see AD[9]).
IASW shall use the basic services and HW/SW interfaces supplied by CSSW.
END-UR

3.1.27.6. IASW Initialisation and Management

The synchronisation pulse received by HEPI is BCP4 that is generated each 1 second by DPE.

UR/3.1.27.6.1. Initialisation of the LUT of IASW

At start-up IASW shall initialise the CdTe Energy Estimate Look Up Table. This Function will be performed using default values stored inside the IASW data structures.
END-UR

UR/3.1.27.6.2. Uploading of the LUT of IASW

IASW shall be able to upload the CdTe Energy Estimate Look Up Table.
The Function shall be performed after the reception of the relevant TC.
END-UR

UR/3.1.27.6.3. Initialisation of the Instrument Scientific Operations On-Board Tables

At start-up IASW shall initialise the Instrument Scientific Operations on-board tables. This Function will be performed using default values stored inside the IASW data structures.
END-UR

UR/3.1.27.6.4. Uploading of the Instrument Scientific Operations On-Board Tables

IASW shall be able to upload the Instrument Scientific Operations on-board tables.
The Function shall be performed after the reception of the relevant TC.
END-UR

3.1.28. Monitoring Function

For monitoring of Broadcast Packet information see 3.1.29.

UR/3.1.28.1. Monitoring Function

IASW shall perform a monitoring of the Instrument status, ISO, environment conditions etc. These information should be put in the HK Packets including the On Event TM messages.
END-UR

UR/3.1.28.2. Monitor TM Reports (deleted)

END-UR

UR/3.1.28.3. On Event Messages

If some malfunction is detected then an On Event message (see AD[3]) shall be produced for insertion into HK packet (see AD[3] and AD[9]).
END-UR

UR/3.1.28.4. Instrument High Voltages Monitoring (deleted)

END-UR

UR/3.1.28.5. Detection of Instrument Malfunction (deleted)

END-UR

UR/3.1.28.6. Monitoring of HEPI Control Registers and Data Registers (deleted)

END-UR

UR/3.1.28.7. Monitoring of ISGRI

ISGRI shall be monitored in order to detect possible malfunctions, included possible noisy pixels.
END-UR

UR/3.1.28.8. ISGRI Pixels Status (deleted)

END-UR

UR/3.1.28.9. Monitoring of PICSIT

PICSIT shall be monitored in order to detect possible malfunctions, included possible noisy pixels.
END-UR

UR/3.1.28.10. PICSIT Ratemeters

PICSIT pixels shall be monitored in a structure (ratemeters) in which the number of transmitted events are counted in order to detect possible noisy pixels.
END-UR

UR/3.1.28.11. PICSIT Pixels Status (deleted)

END-UR

UR/3.1.28.12. Monitoring of VETO (deleted)

VETO shall be monitored in order to detect possible malfunctions.
END-UR

UR/3.1.28.13. Monitoring of MiniRTU (deleted)

END-UR

3.1.29. Broadcast Packet Handling Function

UR/3.1.29.1. Broadcast Packet Handling Function

The IASW shall acquire information from the Broadcast packet (BCPK) and initialise adequate steps.
END-UR

UR/3.1.29.2. Missing Reception of BCPK

The missing reception of BCPK shall not cause any software hang-up or crash.
END-UR

UR/3.1.29.3. Radiation Belt Crossing Start Time

In case this automatism is enabled IASW shall read the Radiation Belt Crossing Start Time and IASW shall enter in the Stand-By Mode.
IASW shall switch off of VETO HV and ISGRI BIAS.
END-UR

UR/3.1.29.4. Radiation Belt Crossing Exit Time

At Radiation Belt Exit time no external reaction from IASW shall occur.
END-UR

UR/3.1.29.5. Eclipse Time

In case this automatism is enabled IASW shall read the Eclipse Time and IASW shall enter in the Stand-By Mode.
IASW shall perform the context saving of the Periphery Subsystems data structures, i.e. these data structures shall be saved in DPE RAM. IASW shall switch off ISGRI BIAS.
END-UR

UR/3.1.29.6. Slew Begin Time (deleted)

END-UR

UR/3.1.29.7. Imminent Off DPE IBIS

IASW shall read the Imminent Off DPE IBIS field. In case the condition is true and this automatism is enabled, the current mode shall be immediately terminated and the IDHS shall enter in the Stand-By Mode.
IASW shall perform the context saving of the Periphery Subsystems data structures, i.e. these data structures shall be saved in DPE RAM .
IASW shall switch off of VETO HV and ISGRI BIAS.
END-UR

UR/3.1.29.8. Telemetry Share DPE IBIS (deleted)

END-UR

UR/3.1.29.9. Radiation Monitor Count Rates

In case of Radiation Monitor validity flag is set to true and this automatism is enabled IASW shall read the Radiation Monitor Count Rates field , compare this value against the threshold values stored on-board in DPE memory and, in case the threshold has been passed, the current mode shall be immediately terminated and the IDHS shall enter in the Stand-By Mode.
IASW shall switch off of VETO HV and ISGRI BIAS.
END-UR

UR/3.1.29.10. ESAM

If this automatism is enabled IASW shall read the ESAM field. In case the condition is true, the current mode shall be immediately terminated and the IDHS shall enter in the Stand-By Mode.
IASW shall switch off of VETO HV and ISGRI BIAS.
END-UR

UR/3.1.29.11. OTF

IASW shall read the OTF field in the Brodcast Packet. In case the flag is valid it should be used to start and stop histogram integration when IBIS is set in Standard or Polarimetry Mode.
END-UR

UR/3.1.29.12. Ground station Hand Over flag

If the ground station hand over condition is true IASW shall stop transmitting of histogram TM data packets.
END-UR

UR/3.1.29.13. AOCS Modes

The AOCS Mode field shall be used to identify if the satellite is in pointing.
END-UR

UR/3.1.29.14. AOCS Sub Modes

The AOCS sub mode field shall be used to identify if the satellite is in pointing or not.
END-UR

UR/3.1.29.15. Pointing ID

The pointing ID field shall be used to identify if the satellite is in pointing or not.
END-UR

UR/3.1.29.16. Pointing Duration

The pointing duration field shall be used for estimate the possible integration time of histograms.
END-UR

UR/3.1.29.17. BCPK Field Don't Care (deleted)

END-UR

3.1.30. Mode Management Function

UR/3.1.30.1. Mode Management Function

The IASW shall control the mode switching initiated from Ground TC, by BCPK or autonomously and report the present status in the periodic HK packet.
END-UR

UR/3.1.30.2. Mode Transition

A transition from Stand-By Mode to another shall be allowed only after reception of a mode change TC.
A transition from a Operational mode to Stand-By Mode shall be allowed:

- by a Mode change TC
- by automatic transition after detection from BCPK of a condition that requires to switch to Stand-By.

A direct transition from a generic Operational mode (but Stand-By Mode) to another generic Operational mode (except Stand-By Mode) shall not be allowed.
END-UR

UR/3.1.30.3. Control on the TCs Allowed for the Current Operational mode

In an Operational mode the IASW shall accept only the BC Packet and the TCs allowed for that Operational mode (e.g. in scientific mode only mode change commands).
In case of reception of a TC not allowed for the current Operational mode an On Event message: “TC Verification Report/Unsuccessful Acceptance” shall be produced and inserted within the periodic HK packet.
END-UR

3.1.31. On Board Time Management Function

UR/3.1.31.1. Time Synchronisation

Time synchronisation shall be performed by IASW using CSSW time service routines.
END-UR

The Local On Board Time (LOBT) management is implemented by CSSW service routines.

UR/3.1.31.2. Time Synchronisation of the detectors

Time synchronisation of the detectors shall be performed by IASW at start of observation (switch to science mode) by the synchronisation pulse distributed and individually delayed by HEPI.
END-UR

3.2. CONSTRAINTS REQUIREMENTS

The ISO described in table 3.1.2-4 are composed in several Scientific Modes. When a ISO is started, then all the Functions relevant to the Scientific Modes of that ISO shall be performed. This means that all the Functions shall be performed in parallel that is in multitasking configuration.

In AT the time base of IASW shall be the time interval between two Broadcast packets, that is 8 seconds. In facts, entering or leaving an ISO can be determined on the information contained in the next Broadcast packet.

Each BPI is subdivided in time interval of 125 milliseconds given by the arrival of the BCPK 2 that is the Real Time Clock (RTC).

The software time base is the RTC interval. This is the minimum interval required for a task to be started (scheduled) or stopped. A RTC interval is also called a period.

On-Board task are divided in cyclic and sporadic.

- Cyclic task are scheduled periodically on the base of a scheduling table
- Sporadic tasks are asynchronous tasks that can be scheduled on request by a TC or on occurrence of a particular event.

The on-board scientific task management shall be performed by IASW using the basic services supplied by CSSW.

UR/3.2.1. Operational modes Classification

The Scientific Functions shall be cyclic tasks.
The Standard Housekeeping and Monitoring Functions shall be cyclic tasks.
The other Data Handling Functions shall be sporadic (asynchronous) tasks.
END-UR

UR/3.2.2. Operational modes Classification (deleted)

END-UR

UR/3.2.3. IDHS Programming Languages

IASW shall be coded in Ada 83.
VETO software shall be coded in C.
ISGRI software shall be coded in C.
PICSIT software shall be coded in C.
The use of assembly shall be justified. As regards the MA3150 assembly, shall be followed the standard MIL-STD-1750A instruction set.
END-UR

UR/3.2.4. ADA Tasking Not To Be Used

The ADA Tasking system shall be not used for process scheduling.
END-UR

UR/3.2.5. IDHS Software Development Standard

The development of the software of the IDHS components shall be as follows:
- for the IASW, it shall be compliant with the "Guide to Applying the ESA Software Engineering Standards to Small Software Projects", BSSC(96)2, Issue 1 (AD[15]).
- for the firmware of ISGRI, PICSIT and VETO no specific software standard will be followed. The firmware of ISGRI, PICSIT and VETO shall be considered as part of the relevant electronic boxes (IEB, PEB and VEB) and therefore it will be developed, tested and accepted at box level only.

END-UR

3.2.1. Sizing Requirements

UR/3.2.1.1. IASW Memory Size

The ROM size available for IASW is 48 kwords.
The RAM size available for IASW is 960 kwords.
Adequate margins according to EID-A (AD[1]) shall be taken into consideration.
END-UR

UR/3.2.1.2. Standard TM Packet Size

The size of a Standard packet is 440 bytes
END-UR

3.2.2. Timing Requirements

UR/3.2.2.1. IASW CPU Time

The CPU Time available for IASW is 95 msec out of a 125 msec cycle.
Adequate margins according to EID-A (AD[1]) shall be taken into consideration.
END-UR

UR/3.2.2.2. Schedulability of the Scientific Modes

For each ISO a schedulability analysis shall be performed in order to assure that all the Functions relevant to that ISO have enough CPU time to perform their tasks.
END-UR

UR/3.2.2.3. Spectral Imaging Function

The duration of the Pointing Mode is at least 980 seconds. During these period shall be built the TM Packets relevant to Spectral Imaging Function.
END-UR

UR/3.2.2.4. Telemetry Data Rate

The IDHS shall be able to cope with an allocation up to 184 packets/8 seconds.

The typical Telemetry data rates will be:
- 129 packets/8 seconds in Solar Min. period = 129 x (428 bytes of Data Field)/ 8 sec. = 55.2 kbits/s
- 136 packets/8 seconds in Solar Max. period = 136 x (428 bytes of Data Field)/ 8 sec. = 58.2 kbits/s

END-UR

UR/3.2.2.5. Spectral Imaging and Polarimetric Minimum Processing Time

The minimum processing time for Spectral Imaging and Polarimetric functions shall be 975 seconds.
END-UR

3.2.3. Data Compression Requirements

The RICE algorithm is a lossless compression algorithm. It is reasonable to have a compression ratio of 2:1. This means that the single and multiple histograms will stay in 1 Mbyte.
As the Data Field of the TM packets is 428 bytes, then it will be necessary 2450 TM packets to download the Spectral Imaging histograms.

UR/3.2.3.1. Data Compression Algorithm

The data compression algorithm to be used for scientific data compression shall be a lossless compression algorithm.
END-UR

The RICE algorithm is suggested.

UR/3.2.3.2. Data Compression Factor

The compression ratio to be reached for scientific data compression shall be close to 2:1 for standard operation and data rates.
END-UR