IASW for JEM-X / DPE - Software Specification Document

Document Status Sheet

Version / Date / IASW ver	Page	Changes
1.4 10.06.99	6	Chapter 3.3.2.1 - point 3) replaced with points 3.1) .. 3.4).
	26	Chapter 3.3.5, tab.E List of Commands to DFEE via LSL - two positions added: Report all SW Int Params, and Report all SW Float Params.
1.5 29.07.99 1.21	14	Changes in the chapter TC(15,1) - Broadcast Packet
	16	Changes in RESTRICTED IMAGING Format
	30	New text about program tasks.
1.6 23.09.99		Many changes in the description of telecommands and science telemetry. New LSL command 4646. New OEM 129/11.
1.7 25.09.99		New text on the logical model, Rearangements in the IASW HK packet.
1.8 25.11.99 1.26		Changed alghoritm for regulation of grey filter, New command TC(5,3)/TID=3/FID=1, New command TC(5,4)/TID=3/FID=1, Deleted command "Goto Standby", Modified description of reaction on signals from BCPKT, New fields in the HK packet, New OEMs, Changes in LSL protocol, Changes in HSL protocol, New DFEE commands for loading of energy table,
1.9 15.12.99 1.30		New commands TC(5,3), New On Event Messages, Changes in numbering of Identifiers of On Event Messages, Changes in description of formats: Spectral/Timing, Timing and Spectral, Changes in description of Broadcast Packet, New section added to the Housekeeping Telemetry packet, Corrected numeration of bytes in the Housekeeping Telemetry packet, More text in the chapter "Shutdown/Recovery Scheme",
1.10 16.06.00 1.41		Information about use of relay #0 impuls, Description of usage scenario of commands for saving/loading of DFEE context, Remark about pressure checking, Deleted description of nonimplemented commands,

		Corrected description of DFEE HK dealing HV settings/monitoring (TBC), New chapter "Correction of DFEE's bug in reporting event's time", Many small changes in chapter 4.
1.11 24.10.00 1.45		New command TC(5,3) - Setting of the flag "Filtering of OEM-s" Description of all testing and debugging commands, Corrected description of IASW part in HK telemetry packet, Changes in the list of OEM-s (186 and 187), Changes in the chapter "Shutdown/Recovery scheme", New chapter "Patching of DPE/IASW code",
1.12 7.02.01 1.48		New commands TC(5,3): "Set CPU status" and "Set LSL mode in DFEE and in DPE", New command TC(5,4): "Report LSL mode" New LSL commands, Changes in the command TC(5,5): "Goto normal data taking"
1.14 11.04.01 1.54		Changed commands: TC(5,3),TID=1,FID=12, TC(5,4),TID=1,FID=12, New commands: TC(5,3),TID=0,FID=14, TC(5,4),TID=0,FID=14, TC(5,3),TID=1,FID=24, TC(5,4),TID=1,FID=24. Deleted commands: TC(9,x), TC(5,3),TID=1,FID=10, TC(5,3),TID=1,FID=255, TC(5,3),TID=1,FID=101,102,203. Deleted OEMs: 138, 239. Changed definition of HK bytes: 18, 19, 266, 267. New OEMs: 157, 166, 167, 254. New chapter "Filtering of On Event Messages", New chapter "Detecting of New Pointing", Change in chapter "Filtering of On Request TM Packets" (no more filtering), Change in chapter "CALIBRATION format" (new definition of delta time), Change in chapter "TEST format" (some new text at the end), New Stack Sizes in table "List of Tasks in IASW for JEM-X".
1.15 3.06.01 1.60		Four new commands TC(5,3),TID=4,FID=51,52,53,54 for changing event position linearization tables, Changes in format of the header of Restricted Imaging science telemetry, Changes in chapter " Recalculating X/Y Coordinates of Events ", Changes in chapter " Shutdown/Recovery scheme ",
1.16 11.09.01 1.61		Information about version of IASW relative to the SSD added to this table, Deleted old fragments, previously in *italic*, Specified RAM addresses of energy and XY-position tables (see near the corresponding TC-s),
1.17 8.11.01 1.64		Chapter "TC(5,5) - Mode Transition" - added note about double "goto SAFE". Added description of Field#2 of OEM id.191.
1.18 12.11.01 1.64		OEM Id 240 corrected to 241, Corrected interpretation of OEM-s Id=254, F#2=188, and F#2=189.

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8. SOFTWARE REQUIREMENTS VS COMPONENTS TRACEABILITY MATRIX 55

Introduction

TBW

1.1 Purpose of the document

Aim of the document is to give background and to help to understand functions and implementation of Integral Application Software (IASW) for DPE of JEM-X.

1.2 Definitions, acronyms and abbreviations

1.2.1 Acronyms

APID	Application Identifier
BCP1	Broadcast Pulse (every 8 seconds)
BCP4	Broadcast Pulse (every 1 second)
BCPKT	Broadcast Packet
CSSW	Common Service Software
DFEE	Digital Front End Electronics
DPE	Data Processing Electronics
FIFO	First In First Out
HK	Housekeepink
HSL	High Speed Serial Line
HV	High Voltage
HW	Hardware
IASW	INTEGRAL Application Software
JEM-X	Joint European X-ray Monitor
LSL	Low Speed Serial Line
mRTU	mini Remote Terminal Unit
OBT	On Board Time
OEM	On Event Message
S/C	Spacecraft
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Writen
TC	Telecommand
TM	Telemetry

1.3 Referencies

[1] ESA, BSSC(96)2 Issue 1, May 1996, „Guide to applying the ESA software engineering standards to small software projects".

[2] ESA, Issue 1, Rev. 5, Oct'97, „INTEGRAL EID-A".

[3] DSRI, Issue 3, Rev. 4 Draft, Nov'97, „JEM-X EID-B".

[4] ALENIA, INT-RP-AI-0030, Issue 03, 22 Sep'97, „INTEGRAL Packet Structure Definition". (partially obsoleted by [5])

[5] ESA, INT-TN-18319, Issue 2, Rev. 0, 6 May'99, „The Broadcast Packet Technical Note on Content and Use of BCPKT".

[6] GMV, INT-IC-GMV-0001, Issue 3.8, 19 Jan'97, „Software Interface Control Document / INTEGRAL DPE CSSW”.

[7] DSRI, Issue 1, Rev 0 (draft), Feb’96, „On-Board Software User Requirements”.

[8] DSRI, Issue 1, Rev 0, Jan’97, „Software Requirements Document (on-board software)”.

[9] Paul T.Ward, Stephen J.Mellor, Structured Development for Real-Time Systems, Yourdon Press.

1.4 Overviev of the document

This document is formated according to the guidelines found in [1].
Texts written */*in italic in form of C-like comment*/* are comments about the requested content of chapters. Other texts *in italic* are remainders from old versions – they will be deleted in the future.

Model description

*/*Describe the logical model using a recognised analisis method*/*
Logical model is shown in form of data flow diagram - bubbles. Syntactic used is described in [9]. Please refere to Appendix 1, fig.A1.1. for explanations of graphical language used. This chapter contains comments to diagrams placed in Appendix 1.

1.5 Interfaces of DPE.

DPE interfaces with S/C electronics from one side and with DFEE from the other. S/C support includes: TC, TM, OBT, and synchronisation impulses: BCP1 (8 sec), and BCP4 (1 sec). DPE interchanges data with DFEE via HSL and LSL. Data from mRTU are read by DPE via analog inputs. One of the analog lines - ANA12 is used by DFEE to inform DPE about the Half-Full status of DFEE's output FIFO-buffer on HSL. DPE uses relay #0 impuls to switch off high voltage, when there is no way to command DFEE via LSL to do this.

1.6 CSSW / IASW interconnections.

Fig.A1.3. shows, that IASW part of the DPE software communicates with external interfaces only via CSSW functions. CSSW divides telemetry channel into three logically differente outputs: Housekeeping telemetry, On Event Messages and Science telemetry. The last is farther divided in IASW into Science Telemetry and On Request Telemetry.

1.7 Science data input (bubble 1.1.).

1.7.1 Read HSL (bubble 1.1.1.)

Science data come into DPE via High Speed Line in form of a continuous stream of so called "event-records". Event-records are 5, 36 or 42 words long, depending on the data mode selected. Eech event-record is preceeded with Event Marker - 1 word eqal to F000. It is used for synchronization.
There is a hardware FIFO buffer of 8192 words size from which DPE reads via HSL. The only available status information of the FIFO is the "Half Full FIFO" flag, telling that the FIFO contains at least 4096 words. This flag is available in form of the analog input, called "1/2 Full" on the bubble diagram. The CSSW's HSL reading procedure requires from the caller giving of the number of words to be read. The reading will not end successfuly when there is not enough data in the FIFO.
Alltogether these conditions lead to the conclusion that DPE should wait for the signal "1/2 Full" and then read a portion of no more than 4096 words. There are several errors possible when reading HSL. All are reported in form of On Event Messages.

1.7.2 Find Event Records (bubble 1.1.2.)

Next, the event-records are to be found in the continuous stream of input data. This process works in one of the two modes: Normal, and Recovering of Synchronization. The flag "Synchro. Lost" informs about the current mode. Normal mode means that previous event-record was correct and the process knows where to look for the next one. In this mode each event-record is checked for correctness. The correctness criteria is based mainly on the Event Markers, and additionally on the two first words of the event-record. These two words carry event's time information - they are: Housekeeping Cycle Counter, and Timer Counter.

When the checking fails, the mode is switched to Recovering of Synchronization in which the data pointer is advanced one word a time until the three consecutive event-records, starting from the data pointer, fulfill correctness criteria. Then the mode returns back to Normal. When starting data taking, the flag "Synchro. Lost" starts with the value of TRUE, which means that initially Recovering of Synchronization mode is active.

For testing purposes the correctness checking can be turned off (flag "Synchro. Used" = FALSE). In this case portions of the length of event-record +1 (for event marker) are passed to the output without any checking.

1.7.3 Collect Events (bubble 1.1.3.)

This is the central process (engine) of the whole Science Data Input process. This fact is illustrated on the diagram by the two signal paths: "need next event", and "need HSL readout". Main job for this process is collecting event-records from input and passing them to the big circular buffer for later processing. Event Markers are eliminated.

In each BCP1 period incoming events are counted and the result is stored. It represents input data rate, *which later will be used for addjusting of Grey Filter.*

Among normal event-records, carrying X-events information, the input stream contains dummy event-records. The process collecting events recognize two of the dummy event-records - Grey Filter Change report and End Of Data marker. The new value of Grey Filter is stored in "Grey Filter reported", which next is used in the process of addjusting of Grey Filter and in the process of format switching.

End Of Data marker stops input process. It can be resumed by initiating of new data taking mode. These two and all other dummy-events are passed transparently through the process collecting events.

1.7.4 Regulation of Grey Filter (bubble 1.1.4.)

DPE should take care of the filling level of the buffer, just not to loose event-records when the buffer is full. DFEE provides Grey Filter mechanizm - rejecting of randomly selected events with a given probability of rejecting. The fraction of events not rejected is called "Grey Gilter throughput", and is expressed in %. There are 32 levels possible - they are called "Grey Filter indices". Index 0 correspond to 3% of throughput, index 31 - 100% of throughput. The scale in between is linear. DPE works only with indices, the bit patterns corresponding to each level are known only to DFEE.

Ghanges of Grey Filter should not be made too often, just not to itroduce a mess, which might difficoult interpretation of data. Therefore process of Grey Filter regulation is activated (prompted) only at BCP1.

1.7.5 Format Switching (bubble 1.1.5.)

The formats switching (primary <--> secondary) is also job for Science Data Input process. The decision is made on base of the actual Grey Filter used. There are two threshold levels of Grey Filter, which come with the telecommand starting data taking. When the Grey Filter goes below the Level#1 - format is switched to secondary, when Grey Filter goes above Level#2 - format is switched back to primary. The decision about the format selected is next prepared in form of the dummy event-record "Event Size + Format" (bubble 1.1.8.), which is put into the big buffer. This dummy event-record will be recognized and executed by the output process (bubble 1.3.) when it reads it.

Again, because of the same arguments as with regulation of Grey Filter, the process of format switching is activated (prompted) only at BCP1.

1.8 Science Data Output (bubble 1.3.)

This is a continuation of processing of event-records stream, but on the other side of the big, circular buffer.

1.8.1 Recognition of Event-record Type (bubble 1.3.1.)

This process takes event-records from the big buffer and recognizes dummy event-records. Reception of End Of Data marker results in sending the signal "soft stop". Received "Event Size + Format" is stored, but will become effective only when the compressing process terminates with currently build telemetry packet (or with an image in case of Restricted Imaging format) (*this is not clear from the drawings - I'llhave to change the diagram*). Received "Grey Filter Change report" will also be stored.
Normal event-records and Grey Filter Change reports are passed farther to the process compressing data.

1.8.2 Compressing Data (bubble 1.3.2.)

This is the central process (engine) of the whole Science Data Output process. This fact is illustrated on the diagram by the signal path "need next event". The job for this process is to put incomming event-records into the TM packets in the selected format and to send completed packets to the Science Telemetry output. It can work in one of the three modes: Normal, Soft Stop, and No Operation. In the No Operation mode the process is idle - does nothing. The two other differ only in case when there is no more data on input (big buffer is empty). When in Soft Stop mode, currently built TM packet is terminated and sent to telemetry, even if not fully filled, and next the mode is switched to No Operation. When in Normal mode, process waits for event-records.
"Event Size" determines data mode - Normal Data Taking, Calibration, Diagnostc Dump or Undefined Data Mode. When Undefined, which takes place just after starting data taking, event-records are read from the big buffer, but only the dummy event-records "Event Size + Format" and "Grey Filter Change" are recognized, all other are ignored. In fact the first read event-record should be the "Ev.Size+Format".
Fields: "Format" and "Grey Filter" are of interest only when in Normal Data Taking.

1.9 Start/Stop Data Taking (bubbles: 1.4., 1.1.6., 1.3.3.)

Starting and stopping of data taking are actions in which many fragments of the program are angaged. Starting is initiated from the telecommand TC(5,5), or as the autonomous DPE action, when automatically recovering the interrupted data taking. In both cases it results in transmitting of the parameters of the new data mode from bubble 1.14. to bubble 1.4. These parameters are:

- Event size, which determines data mode,
- Primary and secondary format,
- Threshold levels of Grey Filter for the format switching process,

Next the following actions, managed by process 1.4. take place:

1. The command starting data mode is sent to DFEE. *(not seen on the diagram)*
2. The signal "hard stop" is sent to the bubble 1.3.3. On reception of this signal the output process will immediately go to No Operation mode. This is to ensure that the output process will not try to read big buffer when cleared and switched to possibly another event size in action #6.
3. Data mode parameters are stored (bubble 1.1.6.). "Format selector" is preset to PRIMARY.
4. The two flags: "Synchro. used", and "Synchro. lost" are set to the values depending on if the data mode is normal, or test data mode. In normal data mode both are set to TRUE, in test - both to FALSE.
5. "Grey Filter reported" (D.25.) is preset to 100%. It is so, because DFEE starts data taking with this default.
6. The big buffer is cleared and prepared to store event-records of a given length.
7. The dummy event-record "Event Size + Format" is put into the buffer. This will switch the output process to the propper mode, when it reads it.
8. Science data input process (bubble 1.1.) is activated. *(not seen on the diagram)*
9. The signal "start" is sent to the bubble 1.3.3. On reception of this signal the data compression process switches to Normal operation mode with Undefined data mode. "Grey Filter" (D.33.) is again preset to 100%.

After those actions the data taking process runs autonomously untill stopped. There are several stopping scenarios provided:

DFEE terminates data taking. In Calibration or Diagnostic Dump DFEE terminates itself. In Normal Data Taking the DFEE terminates in response on the command "Goto SETUP". DPE will learn about end of data taking by reading dummy event-record "End Of Data marker". Next the following actions take place:

1. The "End Of Data marker" is passed to the big buffer to notify the output process, and the input process goes to the idle mode. *(not seen on the diagram)*
2. Process 1.3.1., when reads the "End Of Data marker" from the big buffer sends the signal "soft stop" to the process 1.3.3.1. This in turn sets "Stop Type" to SOFT STOP, which next is immediately transformed to "Compression Mode" equal to SOFT STOP.
3. In Soft Stop mode the compression process (1.3.2.) terminates the currently built TM packet, sends it, and goes to the No Operation mode.

DFEE stops giving data. DPE waits for input data without applying any timeout, when in state of data taking. But after returning to state Setup, if the HSL is silent for longer than about 16 seconds, the process 1.1. acts as if received "End Of Data marker".

TC(5,5) "Goto SETUP", or autonomous shutdown. In this case soft stop is required, which means that all science data avilable (in big buffer, in HSL buffer and in the hardware FIFO) should be processed and sent to telemetry. First, the command "Goto SETUP" is sent to DFEE. *(not seen on the diagram)* Theoretically this should be sufficient, because DFEE normally sends "End Of Data marker", and next things are going in the allready described way. There is however possibility that DPE will not get this "End Of Data marker", and in this case the output process would wait forever for the data which would never come. The data collected in the last, not fully filled TM packet would be lost. To avoid this situation the output process gets the signal "very soft stop", which results in switching into the Soft Stop mode, but after a delay of about 10 sec. This delay makes difference between soft stop and very soft stop. The delay looks unnecessary, and indeed it is needed only in a very particular and unlikely situation. This situation is when "very soft stop" comes just in the moment when the big buffer is empty. If the Soft Stop mode were entered without delay, this would result in immediate switching to No Operation mode, because of lack of data, and the last hardware FIFO readout would be lost. The delay ensures that there will be a time for transferring of the data to the big buffer.

New data taking is started before the big buffer is emptied. Plese refere to the description of starting of data taking - actions no.2 and 6. This means lost of data from the previous session.

Specific Requirements

*/*List the specific requirements, with attributes. Subsections may be regrouped around high-level functions.*/*

1.10 Functional requirements

1.11 Performance requirements

1.12 Interface requirements

DPE interfaces with S/C electronics from one side and with DFEE from the other. S/C support includes: TC, TM, OBT, and synchronisation impulses: BCP1 (8 sec), and BCP4 (1 sec). DPE interchanges data with DFEE via HSL and LSL. Data from mRTU are read by DPE via analog inputs. One of the analog lines - ANA12 is used by DFEE to inform DPE about the Half-Full status of DFEE's output FIFO-buffer on HSL. DPE uses relay #0 impuls to switch off high voltage, when there is no way to command DFEE via LSL to do this.

1.12.1 Base APID

Eeach telecommand and telemetry packet carry an 11-bits target address called Application Identifier. To each of the units in the Integral system a range of APID is assigned. The Base APID defines the range of possible APIDs - BASE_APID .. BASE_APID+127.

JEM-X	BASE_APID

"K"	1100 0000 000
"L"	1101 0000 000

Tab. A Base APID for JEM-X.

1.12.2 Telecommands

Telecommands directed to IASW will have APID = BASE_APID+1. (EID-A, chapter 4.5.3.1)
IASW for JEM-X accepts and executes the following telecommands:

TC(5,3) - Load Task Parameters
TC(5,4) - Report Task Parameters
TC(5,5) - Mode Transition
TC(6,1) - Load Memory of DFEE
TC(6,2) - Dump Memory of DFEE
TC(6,3) - Calculate CRC of Memory of DFEE
TC(13,1) - Test command
TC(15,1) - Broadcast Packet.

WARNING! DPE provides only limited verification of correctness of the sequence of telecommands. Care should be undertaken, especially when using HW Setting commands.

1.12.2.1 TC(5,3) - Load Task Parameters

The following description uses terms like: TID, FID, Param#n, which are described in [4].

Set DFEE's SW Integer Parameter

TID = 0
FID = 1
Param #1 - SW Integer Parameter Identifier
Param #2 - SW Integer Parametere Value

The identifier is in a range 0..99. Its value corresponds to a position of the parameter in the Integer Parameters Table. The address of the table in the RAM of DFEE is 16#D500#.
Instrument should be in Setup state, otherwise DFEE will reject this command.

Set DFEE's SW Float Parameter

TID = 0
FID = 2
Param #1 - SW Float Parameter Identifier
Param #2 - SW Float Parametere Value (bits 0..15)
Param #3 - SW Float Parametere Value (bits 16..31)

The identifier is in a range 0..99 Its value corresponds to a position of the parameter in the Float Parameters Table. The address of the table in the RAM of DFEE is 16#D600#.
Instrument should be in Setup state, otherwise DFEE will reject this command.

Anode Settings Command

TID = 0

FID = 31
Param #1 - HW Setting value

Four Low Significant Bits of Param#1 sets the given anode ON (bit=0) or OFF (bit=1). The assignement of individual anode to a bit position is the following:

bit 12 - anode 1,
bit 13 - anode 2,
bit 14 - anode 3,
bit 15 - anode 4.

Instrument should be in Setup state, otherwise DFEE will reject this command.
DPE rejects this command if shutdown level >= 20H.

Low Level of Discriminator Setting Command

TID = 0
FID = 32
Param#1 - Low Level of Discriminator (range 0..255)

Instrument should be in Setup state, otherwise DFEE will reject this command.
DPE rejects this command if shutdown level > 0.

Acceleration HV Setting Command

TID = 0
FID = 33
Param#1 - Acceleration HV (range 0..4095)

Instrument should be in Setup state, HV should be ON, otherwise DFEE will reject this command.
DFEE can reject this command when it is in a state of executing previous HV setting command. In this case DFEE answers with Request Acknowledge = 6 (BUSY), and as result of this the OEM 186 will be generated.
DPE rejects this command if shutdown level > 0.

Drift HV Setting Command

TID = 0
FID = 34
Param#1 - Drift HV (range 0..4095)

Instrument should be in Setup state, HV should be ON, otherwise DFEE will reject this command.
DFEE can reject this command when it is in a state of executing previous HV setting command. In this case DFEE answers with Request Acknowledge = 6 (BUSY), and as result of this the OEM 186 will be generated.
DPE rejects this command if shutdown level > 0.

HV Ready Command

TID = 0
FID = 4

Instrument should be in Setup state, otherwise DFEE will reject this command. DFEE changes state to 6 by executing "HV Ready".
DPE rejects this command if shutdown level > 0.

HV On Command

TID = 0
FID = 5

This command should follow command "HV Ready", otherwise DFEE will reject it. By executing "HV On" DFEE changes the state from 6 back to 5 (Setup).
DPE interprets this command as setting of Acceleration HV to 12(hex) and Drift HV to 12(hex).
DPE rejects this command if shutdown level > 0.

HV Off Command

TID = 0
FID = 6

Instrument should be in Setup state, otherwise DFEE will reject this command. High voltage is also switched off automatically in DFEE, whenever it goes to Safe state.

Load into the DFEE the context stored in DPE memory

TID = 0
FID = 7

This command loads DFEE with memory patches, parameters tables, energy linearization table and Anode and Low Level Discriminator settings. Afterthat DPE asks DFEE for four CRC-s, compares them with the CRC-s previously stored with use of command "Save DFEE context", and if they differ, OEM is generated.
This command can be used in any of the states: Setup, Safe or Memory Ops. During execution, the state changes several times, because both Setup and Memory Ops. states are needed during it's execution. Next, state returns to the oryginal one.
Please note that loading of context neither turns on high voltage, nor sets Drift or Acceleration voltages. Those must be done separately after "Load DFEE context", and before selecting state of Data Taking.

Save DFEE context in DPE memory

TID = 0
FID = 8

Aim of this command is to store set of parameters related to DFEE - so called DFEE's context, into DPE memory. Context contains: memory patches, integer and float parameters tables, energy linearization table, CRC-s of four important memory areas, and settings for Anodes and Low Level Discriminator. In fact all these data, but CRC-s, are known to DPE all the time, so there is no need to do any extra actions to store them. The only action DPE is doing, when performing this command is storing of four CRC-s, calculated in DFEE.
This command can be used in any of the states: Setup, Safe or Memory Ops. During execution, the state is changed to Memory Ops., and next, state returns to the oryginal one.

Commands „Save/Load DFEE context” were developped to be used in the following scenario:
1) The flag „Automatic Recovery Enable” is off.
2) Say, it is planned switch off the DFEE – because eclipse, radiation belts or whatever. Beforethat data taking is terminated manually by „Goto Setup” and next it is used „Save DFEE context in DPE memory” and „Goto Safe”.
3) DFEE is off, and after a time is on again. Afterthat operator issues: „Goto Setup” and „Load into the DFEE the context stored in DPE memory”.
4) Operator restarts manually the data taking – HV Ready, HV On, HV Acc, HV Drift, Goto Data Taking.

The same takes place automatically when the flag „Automatic Recovery Enable” is on. Operator should not interfere with autonomous actions of DPE when shutdown level is nonzero. Only command „Goto Safe” is always safe.

Set CPU status (since 1.47)

TID = 0
FID = 9
Param#1 - 0,1,2 and 3, meaning :

Parameter value	CPU speed	Wait State
0	8 MHz	1
1	8 MHz	0
2	16 MHz	1
3	16 MHz	0

Set Delta HV for automatic recovery of HV

TID = 0
FID = 14
Param#1 = delta for Acc.HV
Param#2 = delta for Drift HV

When recovering HV automatically, it is set to the value used in a command from ground minus delta HV.
Default settings for deltas are: 5, 5.

Set Control Data for Automatic Recovery

TID = 1
FID = 12
Param#1 = Auto Recovery Level / CPU mode

Param#1 bits 0..7 - Auto Recovery Level
=0 - no recovery
=3 - DFEE context loading,
=6 - recovery of HV,
=9 - recovery of Data Taking.
Param#1 bits 8..15 - CPU mode
DFEE will be commanded to change the CPU mode with this field as parameter, but only if not zero.
Default setting:
Auto Recovery Level = 3
CPU mode = 3

DFEE CPU mode is not changed on reception of this command. CPU mode parameter will be used only during eventual automatic recovery.
Auto Recovery Level and CPU mode are reported in housekeeping telemetry.

Set thresholds levels for detector pressure.

TID = 1
FID = 14
Param #1 - Lower limit for pressure #1 (0..255)
Param #2 - Lower limit for pressure #2 (0..255)

The default settings for pressure limits are TBD (now: 0,0).

Set thresholds levels for detector temperature.

TID = 1
FID = 24
Param #1 - Upper limit for temperature #1 (0..255)
Param #2 - Upper limit for temperature #2 (0..255)

The default settings for temperature limits are TBD (now: 255,255).

Problem: It is the ratio pressure/temperature, not pressure itself what is the real indicator of the quantity of gas contained in the chamber. It can't be implemented without the information about how to calculate P and T from the analog readouts, which is TBD.

Set tresholds for Radiation Monitor Count Rates.

TID = 1
FID = 17
Param #1 - Higher value (for rad.belts entering condition) of Radiation Monitor Coun Rate #1
Param #2 - Lower value (for rad.belts exiting condition) of Radiation Monitor Coun Rate #1
Param #3 - Higher value (for rad.belts entering condition) of Radiation Monitor Coun Rate #2
Param #4 - Lower value (for rad.belts exiting condition) of Radiation Monitor Coun Rate #2
Param #5 - Higher value (for rad.belts entering condition) of Radiation Monitor Coun Rate #3
Param #6 - Lower value (for rad.belts exiting condition) of Radiation Monitor Coun Rate #3

Default settings are TBD.

Set delay in reaction on high/low radiation monitors count rates.

TID = 1
FID = 13
Param #1 - Number of required occurencies of RMCR > High Limit (default = 2)
Param #2 - Number of required occurencies of RMCR < Low Limit (default = 75)

The delay parameter is a number of BCP1 pulses, so the numbers should be calculated by dividing the required time delay by 8 seconds.

Set Operator Overrides for Broadcast Packet data

TID = 1
FID = 18
Param#1 16 bit flags „Disable Check”
When a bit is set to 1, the corresponding condition will not be read from BCPKT.
Its value will instead be determined by the corresponding bit Error Condition.
Param#2 16 bit flags „Error Condition”
Value of a bit is analized only when the corresponding Disable Check bit is set.

Bit #	BCPKT data overriden by Disable Check = 1	Meaning of Error Condition = 1
0	OTF	OTF=0 (Not On Target) (see note #1)
1	AOCS Mode	not Inertial Pointing Mode
2	AOCS Submode	(not used)
3	ESAM	ESAM=1
4	Radiation Monitor Counter #1	value exceedes a limit
5	Radiation Monitor Counter #2	--”--
6	Radiation Monitor Counter #3	--”--

7	Radiation Belts Entry/Exit Times	Radiation Belts codition true
8	Eclipse Entry/Exit Times	Eclipse condition true
9	Data Rate Share	Data Rate = 16 (otherwise Data Rate = 8)
10	Imminent Instrument Switch Off	I.I.Sw.Off = 1
11..15	spare	

Notes:

1. According to the newest interpretation of OTF (since ver 1.31) the value of OTF itself is not important, only it's transition from 0 to 1 can cause starting of a new observation. So, the value of bit #0 in word "Error Condition" is meaningless. By setting to 1 of the bit #0 in word "Disable Check" one can prevent DPE from looking for new obervation, thus flushing the data buffer will not take place at the start of a new pointing.

Both words: "disable check" and "error condition" are reported in housekeeping telemetry.

Set Operator Overrides for mRTU data

TID = 1
FID = 19
Param#1 16 bit flags „Disable Check”
When a bit is set to 1, the corresponding condition will not be read from mRTU.
Its value will instead be determined by the corresponding bit Error Condition.
Param#2 16 bit flags „Error Condition”
Value of a bit is analized only when the corresponding Disable Check bit is set.

Bit #	mRTU data overriden by Disable Check = 1	Meaning of Error Condition = 1
0	Detector Preasure #1	value out of range
1	Detector Preasure #2	--”--
2	Detector Temperature #1	--”--
3	Detector Temperature #2	--”--
4	+5V digital (voltage)	--”--
5	+5V digital (current)	--”--
6	+5V analog (voltage)	--”--
7	-5V analog (voltage)	--”--
8	+12V (voltage)	--”--
9	+12V (current)	--”--
10	-12V (voltage)	--”--
11	-12V (current)	--”--
12..15	spare	

Both words: "disable check" and "error condition" are reported in housekeeping telemetry.

Energy Linearisation Table Setting

TID = 4
FID = 44
Param #1 - starting address inside the table (accepted values: 0, 64, 128, 192)
Param #2..#65 - 64 values loaded into the table

For loading of a full table, which is 256 words long, four commands are needed. Each of the 256 values represents upper value of the corresponding energy channnel. The numbers should be sorted in increasing order, last value should be equal to 4095.

Care should be undertaken when defining new energy linearization table. It should be guaranteed, that for any real event with 12-bit energy > 0, the resultant 8-bit energy channel should also be > 0. Otherwise the zero energies may interfere with Grey Filter Report markers in Spectral Timing Format (see description of the format).
Loaded table becomes effective only after expansion - see the next command.

Command - "Expand Energy Linearisation Table"

TID = 4
FID = 45

To be effective, the energy linearisation table must be expanded to another table - 4096 8-bit words long, in which each entry represents energy channel number (0..255) assigned to an energy (0..4095).
After expanding its own table, DPE sends the compressed table to DFEE and next asks it for expanding. DFEE accepts this load only in state Setup, so the command "Expand Energy Lin. Table" should be used only in Setup.

Table	Physical RAM word address (hex)	Table size in words (dec)
Compressed energy table	17393	256
Decompressed energy table	17493	4096
Warning! Addresses given are specific only for IASW ver. 1.61		

Tab. 2 Localisation of energy linearization tables in DPE RAM.

Event X-position Linearisation Table Setting

TID = 4
FID = 51
Param #1 - starting address inside the table (accepted values: 0, 64, 128, 192)
Param #2..#65 - 64 values loaded into the table

For loading of a full table, which is 256 words long, four commands are needed. Each of the 256 values represents upper value of Cathode Plane Position for the corresponding X-position channnel. The numbers should be sorted in increasing order, last value should be equal to 1023. First value is not used, but it should be set to zero.
Loaded table becomes effective only after expansion - see the next command.

Command - "Expand Event X-position Linearisation Table"

TID = 4
FID = 52

To be effective, the event X-position linearisation table must be expanded to another table - 1024 8-bit words long, in which each entry represents 8-bit position (1..255) assigned to a Cathode Plane Position (0..1023).

Event Y-position Linearisation Table Setting

TID = 4
FID = 53
Param #1 - starting address inside the table (accepted values: 0, 64, 128, 192)
Param #2..#65 - 64 values loaded into the table

For loading of a full table, which is 256 words long, four commands are needed. Each of the 256 values represents upper value of Back Plane Position for the corresponding X-position channnel. The numbers should be sorted in increasing order, last value should be equal to 1023. First value is not used, but it should be set to zero.
Loaded table becomes effective only after expansion - see the next command.

Command - "Expand Event Y-position Linearisation Table"

TID = 4
FID = 54

To be effective, the event Y-position linearisation table must be expanded to another table - 1024 8-bit words long, in which each entry represents 8-bit position (1..255) assigned to a Back Plane Position (0..1023).

Table	Physical RAM word address (hex)	Table size in words (dec)
Compressed X-position table	16993	256
Decompressed X-position table	16B93	1024
Compressed Y-position table	16A93	256
Decompressed Y-position table	16F93	1024
Warning! Addresses given are specific only for IASW ver. 1.61		

Tab. 3 Localisation of XY-position linearization tables in DPE RAM.

Set the parameters for automatic Grey Filter selection procedure

TID = 4
FID = 46
Param #1 - Extra Low Level (default 5%)
Param #2 - Normal Low Level (default 20%)
Param #3 - Normal High Level (default 50%)
Param #4 - Extra High Level (default 80%)

The four numbers must fulfill the condition: 0 <= P#1 <= P#2 <= P#3 <= P#4 <= 100.
In the current alghoritm (since IASW ver.1.27) the value of Extra Low Level is not used, but still must be set propperly in the command.

Set the number of events for constructing of an image in Restricted Imaging Format.

TID = 4
FID = 47
Param #1 - Number of events (range 1..2600, default 2580)

The remaining TC(5,3) are for testing purposes only and will be hidden in the future.

Set period of automatic generation of SW Diagnostic reports

TID = 1
FID = 15
Param #1 - Period of generation of SW Diagnostic TM Packets expressed as a number of BCP1 periods (8 sec each). If set to 0 (default) - no automatic reports will be produced.

Set flag enabling automatic generation of Lost Synchro. Diagnostic TM

TID = 3
FID = 1
Param#1 =0 - disable, (default)
=1 - enable.

See chapter "Lost HSL Synchro. Diagnostic Telemetry" for farther explanations.

Set the Grey Filter

TID = 4
FID = 43
Param #1 if in the range 0..31 - indicates to the Grey Filter to be used,
if equal to 16#FFFF# - means that DPE should set Grey Filter automatically (default)

Both commanded, and really used in DFEE grey filters are reported in housekeeping telemetry.

HV off with use of relay pulse

TID = 1
FID = 251

Normally this operation is performed automatically in DPE when the LSL communication with DFEE is lost.

Reset HSL (obsoleted)

TID = 1
FID = 252

This command issues DPE_CSSW.RESET_SERIAL_LINE_MODULE; It was checked that it is better to use the command "Set HSL params" instead.

Set HSL parameters

TID = 1
FID = 253
Param#1 indicator of Word Transfer Interval: =0 for 000, =1 for 032, ... =15 for 480
(default = 1)
Param#2 maximal size of transmitted blocks in words (default = 4096).

It was checked that with use of this command it was possible to bring HSL to normal operation after it looses totally the synchronization.

Set LSL parameters (in DPE only)

TID = 1
FID = 254
Param#1 indicator of clock frequency: =1 for 2kbps, =2 for 4kbps, ... =6 for 64kbps (default = 2),
Param#2 indicator of clock mode: =1 for 1x, =2 for 16x, =3 for 64x.

Playing with clock mode was possible only when using CSSW ver 1.2 modified by GJ, or with CSSW ver 1.7. When using the standard CSSW only clock mode 1x is possible, but still it is allowed to change clock frequency, which in this case is equal to baud rate.

1.12.2.2 TC(5,4) - Report Task Parameters

TIDs, FIDs and format in most cases are the same as for TC(5,3). Only SW parameters can be queried, no HW Settings Report is provided with use of TC(5,4). Actual HW Settings are reported in the housekeeping packets. As a response to TC(5,4) a TM(5,4) packet is generated. Normally one TC(5,4) generates one TM(5,4), there are two exceptions:

- SW Diagnostic (TM(5,4)/TID=1/FID=16) can be produced automatically with a programmed period,
- HSL Lost Synchro. Diagnostic (TM(5,4)/TID=3/FID=1) can be produced automatically as a responce on the event of losing synchronization.

Report DFEE's SW Integer Parameters Table

Question: TID = 0
FID = 11

Answer: TID = 0
FID = 11
Param #1..#100 - Set of Integer Parameters (1 integer parameter = 1 word)

Instrument should be in Setup state, otherwise DFEE will reject this command.

Report DFEE's SW Float Parameters Table

Question: TID = 0
FID = 12

Answer: TID = 0
FID = 12
Param #1..#200 - Set of Float Parameters (1 float parameter = 2 words)

Instrument should be in Setup state, otherwise DFEE will reject this command.

Get Delta HV for automatic recovery of HV

Question: TID = 0
FID = 14

Answer: TID = 0
FID = 14
Param#1 = delta for Acc.HV
Param#2 = delta for Drift HV

Get Control Data for Automatic Recovery

Question: TID = 1
FID = 12

Answer: TID = 1
FID = 12
Param#1 = Auto Recovery Level / CPU mode

The same data is reported in every HK.

Report thresholds levels for detector pressure.

Question: TID = 1
FID = 14

Answer: TID = 1
FID = 14

Param #1 - Limit for pressure #1
Param #2 - Limit for pressure #2

Report thresholds levels for detector temperature.

Question: TID = 1
FID = 24

Answer: TID = 1
FID = 24
Param #1 - Limit for temperature #1
Param #2 - Limit for temperature #2

Report tresholds for Radiation Monitor Coun Rates.

Question: TID = 1
FID = 17

Answer: TID = 1
FID = 17
Param #1 - Higher value (for rad.belts entering condition) of Radiation Monitor Coun Rate #1
Param #2 - Lower value (for rad.belts exiting condition) of Radiation Monitor Coun Rate #1
Param #3 - Higher value (for rad.belts entering condition) of Radiation Monitor Coun Rate #2
Param #4 - Lower value (for rad.belts exiting condition) of Radiation Monitor Coun Rate #2
Param #5 - Higher value (for rad.belts entering condition) of Radiation Monitor Coun Rate #3
Param #6 - Lower value (for rad.belts exiting condition) of Radiation Monitor Coun Rate #3

Report delay in reaction on high/low radiation monitors count rates.

Question: TID = 1
FID = 13

Answer: TID = 1
FID = 13
Param #1 - Number of required occurencies of RMCR > High Limit
Param #2 - Number of required occurencies of RMCR < Low Limit

Report the parameters for automatic Grey Filter selection procedure

Question: TID = 4
FID = 46

Answer: TID = 4
FID = 46
Param #1 - Extra Low Level
Param #2 - Normal Low Level
Param #3 - Normal High Level
Param #4 - Extra High Level

The remaining TC(5,4) are for testing purposes only and will be hidden in the future.

Get diagnostic dump of HSL input buffer

Question: TID = 3

FID = 1

Answer: TID = 3
FID = 1
Param#1..204 - see chapter "Lost HSL Synchro. Diagnostic Telemetry"

Report IASW Version:

Question: TID = 1
FID = 11

Answer: TID = 1
FID = 11
Param #1 - Major part of the Version Number
Param #2 - Minor part of the Version Number

Report SW diagnostic:

Question: TID = 1
FID = 16

Answer: TID = 1
FID = 16
Param #1.. block of diagnostic counters

See chapter "Software Diagnostic Telemetry" for details on the content of the reported block.

1.12.2.3 TC(5,5) - Mode Transition

TC(5,5) is used to switch between states - the major actions of JEM-X. Format of this command provides a set of parameters (see [4]). MODE (8-bit) codes the target state. Param.#1 (8-bit) and Params.#2..#5 (16-bit) are present or not, depending on the target state.
The mode transition command is checked for validity in DFEE. Invalid commands are rejected and two OEM-s are generated. First one tells about that DFEE rejects command with Request Status = 4 or 6, the other OEM tells that TC(5,5) execution started, but failed. Rejection with Rq.Status = 4 means that the command is not allowed in the current state, while rejection with Rq.Status = 6 means that DFEE can't start data taking because it hasn't yet finished with setting of high voltage.
When changing state to SETUP for the first time after DPE was on, DPE automatically reads default parameters tables from DFEE and loads DFEE with the default energy linearization table. This is to synchronize the DFEE settings with the mirror copy kept in DPE memory.

Target state = SAFE
MODE = 1

Target state = MEMORY OPERATIONS
MODE = 2

Target state = SETUP
MODE = 5

Target state = DATA TAKING
MODE = 10

Param #1 = 0 (not used)
[Param #2 = Primary Format Code]
[Param #3 = Secondary Format Code]
[Param #4 = Minimal Grey Filter for Primary Format]
[Param #5 = Maximal Grey Filter for Secondary Format]

Parameters #2,3,4,5 are optional. If not used, the previously commanded values will be used. If a values of (hex)FFFF is used, the default value for that parameter will be used. If value (hex)FF00 is used it is an explicit request to use the value from the previous command. Default values for primary and secondary formats will be full imaging. Grey Filter threshold levels will default to 10, 25 (TBC).
The Grey Filter thresholds should comply: 0 <= Param#4 < Param#5 <= 31.

Target state = CALIBRATION
MODE = 20
Param #1 = 0 (not used)
Param #2 = Number of events per calibration level

Target state = DIAGNOSTIC DUMP
MODE = 40
Param #1 = 0 (not used)
Param #2 = Number of events to be dumped

Target state = DATA TAKING (test data mode)
MODE = 11

Target state = CALIBRATION (test data mode)
MODE = 21
Param #1 = 0 (not used)
Param #2 = Number of events per calibration level

Target state = DIAGNOSTIC DUMP (test data mode)
MODE = 41
Param #1 = 0 (not used)
Param #2 = Number of events to be dumped

For coding of Primary and Secondary Imaging Formats use numerical codes:

Code of the Format	Format
1	Full Imaging
2	Spectral-timing
3	Restricted Imaging
4	Timing
5	Spectrum
90	Test

Notes:

- Telecommand "goto SAFE", issued when DFEE is in state MEMORY OPERATIONS automatically generates two commands "goto SAFE" to DFEE.
- .

1.12.2.4 TC(6,1) - Load Memory

Program accepts only commands with MID=255, which is interpreted as DFEE RAM identifier. Load Memory commands are stored in DPE in the order of occurence. This information is used in the process of automatic recovering of interrupted data taking. There is also a TC(5,3)-Load DFEE Context, which loads all stored memory patches to DFEE.
See [4] for farther details.

1.12.2.5 TC(6,2) - Dump Memory

Program accepts only commands with MID=255, which is interpreted as DFEE RAM identifier. Length of the dump is not limited to the TM packet size, one dump can cover the whole range of addresses - 8000..FFFF. DPE itself will decompose the long dump into a series of TM(6,2) packets.
See [4] for farther details.

1.12.2.6 TC(6,3) - Calculate Memory CRC

Program accepts only commands with MID=255, which is interpreted as DFEE RAM identifier.
See [4] for farther details.

1.12.2.7 TC(13,1) - Test command

This is a No Operation Command. Its only action is incrementing of the counter of telecommands received.

1.12.2.8 TC(15,1) - Broadcast Packet

Broadcast Packet (BCPKT) is analized as soon as received by DPE. Specific content of BCPKT can cause so called "shutdown" - stopping of data taking. Automatic recovering of data taking is possible, but only if the flag "Automatic Recovery Enabled" is set.
When BCPKT data shows that a new pointing is starting, the data taking is stopped in hard mode (buffers are flushed immediatelly) and resumed with default setting for Grey Filter and Format. This action is performed independently from the value of the flag "Automatic Recovery Enabled". If needed, this can be prevented by use of the command TC(5,3)-"Operator's overrides for BCPKT" with bit#0 in "Disable Check" set to 1.
See chapters: "Shutdown/Recovery scheme" and "Analisis of Eclipse and Radiation Belts Entry/Exit Times" for farther details.

Data Rate Share. This value is used in the alghoritm for calculating of Grey Filter.

OTF-On Target Flag. Transition 0 --> 1 of OTF is used as an indicator of validity of Pointing ID. The value of AOCS Mode infuences the interpretation of OTF. OTF is assumed valid only if AOCS Mode = IPM (Inertial Pointing Mode). In all other cases it is assumed OTF=0, regardles of its value in the BCPKT.

AOCS Mode. When equal to 5 (IPM - Inertial Pointing Mode) - enables interpretation of OTF, as described above.

AOCS Sub Mode. Ignored .

Radiation Monitor Count Rate (#1,#2,#3). If any of the three counters exceedes the TBD treshold (defined individually for each of them), it is interpreted as the entrance into the radiation belts. Exit from radiation belts is assumed when all counters are below tresholds, but not immediately. A number of occurencies of RMCR < Low Level must be observed before low radiation is assumed. This number defaults to 75, which gives 10 minutes time. Similar analyzis is performed when going from low to high values of radiation monitors, but the required number of occurencies of RMCR > High Level defaults to 2.
Thresholds defining exit from radiation belts will be lower than those defining entering into radiation belts (histeresis). Interpretation of these data is affected by DRMC flag.
Both threshold levels and numbers of occurencies can be programmed with use of propper TC(5,3).

Entrance into the area of high radiation will result in stopping data taking in soft mode, switching off HV, and setting DFEE to Safe mode.

DRMC-Disregard Radiation Monitor Count Rates. Radiation Monitor Count Rates are considered valid only when DRMC=0. Otherwise (DRMC=1) Radiation Monitor Count Rates are assumed low.

ESAM-Emergency Safe Acquisition Mode.
Instrument Imminent Switch-Off. Occurence of one of these signals, or both, results in immediate setting of the instrument in Safe state in soft mode - data collected in the buffer will be transmitted to TM. No automatic recovery of data taking is provided in this case.

Ground Station Hand-Over Flag. Ignored.

Pointing ID. Together with OTF it is used in detecting of a new pointing (see chapter "Detecting of New Pointing").

Radiation Belts Crossing Start Time, Radiation Belts Crossing Exit Time, Eclipse Entry Time and **Eclipse Exit Time**.
Time-type data are recalculated at the very begining from BCPKT format to 48-bit format. The program uses internally only 48-bit format coding for On Board Time.
Reaction on the entrance into radiation belts was described in the point about Radiation Monitor Count Rates.
When entering into eclipse region, data taking is stopped in soft mode, HV is turned off. Next DPE stores context of DFEE, to be able recover data taking after the eclipse. DFEE is left in Safe state, waiting for turning off the low voltage supply.

1.12.3 Telemetry

1.12.3.1 On Request Telemetry

As a response on telecommands IASW produces the following on-request telemetry packets:

TM packet	APID_BASE + xxxx xxx	(EID-B, chapter 3.7.8.10,11)
TM(5,4)	0000 101	
TM(6,2)	0000 110	
TM(6,3)	0000 110	

Tab. D On-Request Telemetry Packets produced in JEM-X.

For the format of on-request TM see [4]. Content of TM(5,4) has been desribed in the chapter on TC(5,4).

1.12.3.2 Science Telemetry

There are nine formats of science TM defined (EID-B, chapter 3.7.8) and one format for Test (raw input data dump).

science TM format	APID = BASE + xxxx xxx	APID (dec)	Type/Subtype
Idle (not produced in IASW)	1000 000	1600	0 / 0
Calibration	1000 001	1601	0 / 1
Diagnostic	1000 010	1602	0 / 2
Full Imaging	1001 000	1608	0 / 8
Spectral/Timing	1010 000	1616	1 / 0
Restricted Imaging	1011 000	1624	1 / 8
Timing	1100 000	1632	2 / 0
Spectrum	1101 000	1640	2 / 8

Count Rates	1111 000	1656	3 / 8
Test	1000 111	1607	0 / 7

Tab. E Science Telemetry Packets produced in JEM-X (APID(dec) shown only for JEM-X "K").

Science Telemetry Packets are composed of three headers: 3-words Packet Header, 3-words Data Header, variable size SC-TM Header and of a Data part. Packet Headre is fully compatible with requirements [4] and thus will not be described here. Data Header almost complies with the standard [4]. There are fields Type/Subtype and there is the Time field giving the time in seconds. There are the following differencies in comparision with the standard:

1. 8-bit fied following Type/Subtype is used to store the most significant part of time - it is not always equal to zero.
2. Time field gives OBT correlated with the scientific data sitting in the packet, not OBT of issuing of the packet. This scientific time can be up to about 10 minutes late.
3. Data Header is 3-words long, not 2 words. The third word contains low significant bits of Time field.

SC-TM Headers are specific to the individual formats and will be described below.
The whole scientific data part (Data Header + SC-TM Header + Data) is 216 words long (217 - 1 CRC word).

Four of the compression formats - Full Imaging, Spectral Timing, Timing and Calibration, contain event's time information in form of the time interval between neighbour events. There is maximum 16 bits provided for this data. If the time difference happen to be greater than 8 seconds, it can't fitt into the format and some information will be lost. Time differencies bigger than 8 seconds are coded as FFFF (or FFDF in Timing format).

1.12.3.2.1 FULL IMAGING Format

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of 1.st event in packet)
SC-TM Header		
3	1	No. of events in packet
4	1	Grey filter # for first event in packet
Data		
5	211	Compressed events

Compressed event format:

Start (bit#)	Size (bits)	Content
0	8	X position (1..255)
8	8	Y position (1..255)
16	8	Energy
24	8	Delta time relative to previous event, or 255 (see note 2)
+ extra word present only when the Delta time field = 255		
32	16	Delta time extension

Compressed dummy-event "Grey filter change report" format: (see note 1)

Start (bit#)	Size (bits)	Content
0	16	= 0
16	16	Grey filter # (0..31)

Comments:

1. When interpreting data in Full Imaging Format one should first check the value of the first word of each compressed event - when equal to zero, it is Grey filter change report, otherwise it is normal compressed event.

2. Delta time is shown in units of 1/8192 sec. First event in each packet will have zero delta time. Next events show time relative to the previous one, which is a true event - not a Grey Filter change report.

1.12.3.2.2 RESTRICTED IMAGING Format

Packet format:

Start (word#)	Size (bits)	Content
0	48	DataHeader (OBT of 1.st event in the image)
SC-TM Header		
3	16	No. of events in packet
4	8	Grey filter # for first event in the image
4 1/2	8	Grey filter # for last event in the image
5	16	Delta time of last event (seconds)
6	16	Delta time of last event (fraction of second)
7	16	X|Y position for first event in packet (X first)
8	16	X|Y position for last event in packet
9	16	Packet # in sequence (see note 1)
Data		
10	206	Compressed events

Compressed event format:

Start (bit#)	Size (bits)	Content
0	5	Delta position, or 31 (see note 2)
5	3	Energy
+ extra byte present only when the delta position field = 31:		
8	8	Delta position extension#1, or 255
+ extra word present only when the delta position extension#1 = 255:		
16	16	Delta position extension#2

Comments:
1. Last packet of the image is marked by 16#8000# added to the field "Packet # in sequence".
2. Delta position is a result of substracting two 16-bits words, each of them contains X position in MSB and Y position in LSB. Before compression events are sorted by words X|Y.

For each image about 8 TM Packets in Restricted Format are generated. In paralel, but asynchronously, Count Rate Format packets are also produced.
DPE will wait maximum about 32 seconds for completting 2580 events needed to construct an image. After this time the image will be constructed with the available events.

1.12.3.2.3 COUNT RATE Format

Count Rate format can not be commanded separately. Packets in this format are produced when Restricted Imaging format has been chosen.

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of 1.st time channel)
SC-TM Header		
3	8	8 x Grey filter specifier (see note 1)
11	1	Number of 125 ms wide Time Channels for Count Rates including the first one
12	1	Count Rate for the first time channel
Data		
13	200	400 8-bits delta count rates

Format of Grey filter specifier (each of the eight):

Start (bit#)	Size (bits)	Content
0	5	Grey filter # (0..31)
5	11	Number of the time channel in which change of grey filter has taken place (0..400).

Comments:

1. First of the eight grey filter specifiers is allways present, it has grey filter # on the first 5 bits and zero on remaining 11 bits. It reports the starting grey filter. Other 7 entries are used only when grey filter changes. Non-zero value means valid grey filter specifier.

Count rates are coded the following way:

- Count rate for the first time channel is put without any compression as the first 16-bits word #12,
- Count rates for all time channels, but the first, are coded by calculating the difference between count rates in the current and previous time channel,
- If the difference fitts into the range -127..+126, than it is placed into the consecutive 8-bit byte. For negative values code U2 is used. Otherwise constant 127 is put first, and then full 16-bits value of the count rate (not the difference). The 16-bits value is placed into the buffer without any gap, even if it starts with odd byte address.

1.12.3.2.4 SPECTRAL/TIMING Format

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of 1.st event)
SC-TM Header		
3	1	No. of events in packet
4	1	Grey filter # for first event in packet
Data		
5	211	Compressed events

Compressed event format:

Start (bit#)	Size (bits)	Content
0	8	Energy
8	8	Delta time relative to previous event, or 255
+ extra word present only when the Delta time field = 255		
16	16	Delta time extension

Dummy events "Grey Filter Report" are codded as: Energy = 0, Delta time = Grey Filter. It is guaranteed, that DFEE will never produce real events with zero energy. From the other hand the default energy linearization table is defined this way, that if 12-bit energy > 0, then the 8-bit energy also > 0. Thanks to that, real events will never be confused with Grey Filter reports.

1.12.3.2.5 TIMING Format

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of 1.st event)
SC-TM Header		
3	1	No. of events in packet
4	1	Grey filter # for first event in packet
Data		
5	?	6-bit delta times, or 63. Packed without gaps. Grows upward.

215	?	16-bit extensions, when 6-bit field = 63. Grows downward.

Dummy events "Grey Filter Report" are codded as: FFE0 + Grey Filter. Because of this, the range of the real delta time is limited to FFDF.

1.12.3.2.6 SPECTRUM Format

One energy spectrum counts events in the time interval of 125 msec.

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of time channel of 1.st spectrum)
SC-TM Header		
3	1	No. of spectra in packet
4	1	Grey filter # for first event in packet
Data		
5	210	Up to 10 compressed spectra, 21 words each
215	1	unused

Compressed spectrum format:

1 x 16-bit word - Grey filter for last event in spectrum,
64 x 4-bit fields - counters in 64 energy channels
8 x 8-bit fields - extensions used in case of overflow in 4-bits fields (see note 1)

Total length = 21 words

Comments:

1. Extension fields are used from left to right.

1.12.3.2.7 CALIBRATION Format

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of 1.st event)
SC-TM Header		
3	1	Calibration amplitude (see note 1)
4	1	Calibration frequency (see note 1)
5	1	Anode switch status
Data		
6	210	Calibration compressed events (up to 6 events)

When compressing calibration event the two first words (HK Cycle Counter +Timer Counter) are compressed to one word - delta time relative to the previous event. Unit of this delta time is 1/8192 sec. All remaining 34 words are copied to the TM packet without compression. Dummy-events "Calibration amplitude report" are also reported.

Comments:

1. Field Calibration amplitude contains 5-th word from the last dummy- event "Calibration amplitude report" recieved BEFORE the current TM packet was started. Similarly the field Calibration frequency contains 6-th word from the same dummy-event. If "Calibration amplitude report" dummy-event is the first event in the packet, then header fields: Calibration amplitude and Calibration frequency repeat the data from this dummy-event. If there are calibration events, but no "Calibration amplitude report" was yet received, zero is reported in the two fields.

1.12.3.2.8 DIAGNOSTIC DUMP Format

Packet format:

Start (word#)	Size (words)	Content
0	3	Data Header (OBT of 1.st event)
SC-TM Header		
3	1	Spare (=0)
4	1	Spare (=0)
5	1	Anode switch status
Data		
6	210	Diagnostic dump events (up to 5 events)

Full 42-words event records are copied to TM packet.

1.12.3.2.9 TEST Format

There is no SC-TM Header in this format. Differente than in all other formats Data Header contains OBT of issuing of the TP packet. It is so, because events are not interpreted in this format and there is no way to get to the scientific time. Events are not split between packets - event which does not fitt into the packet will be placed at the beginning of the next packet. Events are not compressed.

Test mode can be commanded in two differente ways:

1. by setting format code to 90 - this is possible only when Normal Data Taking. In Calibration or Diagnostic dump there is no way to specify format code.
2. by setting testing data mode equal to regular data mode code + 1 (see chapter on TC(5,5)-Mode Transition).

There is a side effect when using methode 2) - in the testing data mode there is no synchronization checking. This effect can be used for dumping raw information incoming from HSL. Moreover events are 1 word longer, because the Event Marker (equal to F000) is not removed.

The user should be prepared for some inconviniencies when using test format:

1. There is no way to distinguish, which variant of Test Format is used, by looking only into the telemetry blocks.
2. When test variant of Calibration or Diagnostic dump terminates, the Expected DFEE State reported in HK remains unchanged (does not return to 5). It is so, because DPE is not interpreting events and it is not able to detect dummy filler events, which normally terminates HSL data stream.

It is acceptable, because this format is designed to be used only in the laboratory, where the experimentator exactly knows, what he is doing.

1.12.3.3 Housekeeping Telemetry

Housekeeping TM packet contains IASW HK part, On Event Messages and CSSW HK part. This chapter describes IASW part of HK packet. In general it consists of five blocks of infromation:

- Variables desribing state of IASW,
- DPE housekeeping - readouts from analog input lines,
- Latest DFEE housekeeping,
- Latest BCPKT block,
- Continuation of IASW state variables + diagnostics.

Start (byte.bit#)	Size (bits)	Content
State of IASW		
ADDR1=0	16	EVENT SIZE (0, 5, 36 or 42, or 6,37,43 in hard test mode)
ADDR1+2	8	ACTUAL SHUTDOWN LEVEL
ADDR1+3	8	WANTED SHUTDOWN LEVEL

ADDR1+4	8	PRIMARY FORMAT
ADDR1+5	8	SECONDARY FORMAT
ADDR1+6	16	ACTIVE FORMAT (=1 - primary, =2 - secondary)
ADDR1+8	8	COMMANDED GREY FILTER
ADDR1+9	8	REPORTED GREY FILTER (received from HSL)
ADDR1+10	16	HSL BUFFER SIZE (number of words actulay in the buffer)
ADDR1+12	16	HSL BUFFER INDEX (position of taking data from the buffer)
ADDR1+14	16	TIME SINCE READOUT (time in units of 8 secs. from the last HSL readout)
ADDR1+16	16	EVENTS TRANSFERRED (number of events received in last BCP1 period)
ADDR1+18	8	Auto Recovery Level
ADDR1+19	8	CPU mode recovered
ADDR1+20	16	EVENTS IN BUFFER(number of events stored in the DPE's buffer)
ADDR1+22	32	TOTAL EVENTS (total number of events read)
ADDR1+26	16	MEMORY PATCHES (number of DFEE mem. patches stored in DPE)
ADDR1+28	48	PARAMETERS OBT (time of last modification of DFEE's parameters)
ADDR1+34	16	Spare#1 = 16#1111#
mRTU Housekeeping Note: Legal analog readouts range is 0 .. 255. The value 256 (100 hex) is placed when there were errors in the process of reading of analog channel.		
ADDR2=36	16	ANA8 - Detector pressure#1
ADDR2+2	16	ANA9 - Detector pressure#2
ADDR2+4	16	ANA10 - Detector temperature#1
ADDR2+6	16	ANA11 - Detector temperature#2
ADDR2+8	16	ANA0 - Voltage +5V Digital supply
ADDR2+10	16	ANA1 - Current +5V Digital supply
ADDR2+12	16	ANA2 - Voltage +5V Analog supply
ADDR2+14	16	ANA3 - Voltage -5V Analog supply
ADDR2+16	16	ANA4 - Voltage +12V
ADDR2+18	16	ANA5 - Current +12V
ADDR2+20	16	ANA6 - Voltage -12V
ADDR2+22	16	ANA7 - Current -12V
ADDR2+24	16	YSI0 - Temperature#1
ADDR2+26	16	YSI1 - Temperature#2
ADDR2+28	16	YSI2 - Temperature#3
ADDR2+30	16	YSI3 - Temperature#4
ADDR2+32	16	YSI4 - Temperature#5
ADDR2+34	16	YSI5 - Temperature#6
ADDR2+36	16	ANA12 - FIFO Flag
ADDR2+38	16	ANA13 - HV Power Supply Temperature#1
ADDR2+40	16	ANA14 - HV Power Supply Temperature#2
ADDR2+42	16	ANA15 - Spare
ADDR2+44	16	Spare#2 = 16#7777#
DFEE Housekeeping Note: This is the exact copy of the HK block received from DFEE.		
ADDR3=82	16	HK Cycle Counter
ADDR3+2	16	DFEE State
ADDR3+4	8	Low Level Discriminator
ADDR3+5	8	Anode configuration
ADDR3+6	4	????
ADDR3+6.4	12	HV Acc. Voltage monitoring
ADDR3+8	4	????

ADDR3+8.4	12	HV Drift Voltage monitoring
ADDR3+10	8	HV Drift Setting (TBC)
ADDR3+11	8	HV Acc. Setting (TBC)
ADDR3+12	16	# of Event Triggers
ADDR3+14	16	# of Accepted Events
ADDR3+16	16	# of Events rejected by grey filter
ADDR3+18	16	# of Events rejected due to lack of buffer space
ADDR3+20	16	# of Events rejected due to FIFO full
ADDR3+22	16	# of Events rejected by upper threshold
ADDR3+24	16	# of Events rejected by Veto Signal
ADDR3+26	16	# of Events rejected by Low Risetime
ADDR3+28	16	# of Events rejected by High Risetime
ADDR3+30	16	# of Events rejected by Too Many Hits in Back Plane
ADDR3+32	16	# of Events rejected by Too Many Hits in Cathode Plane
ADDR3+34	16	# of Events rejected by Too High Signal in Back Plane
ADDR3+36	16	# of Events rejected by Too Low Signal in Back Plane
ADDR3+38	16	# of Events rejected by Too High Signal in Cathode Plane
ADDR3+40	16	# of Events rejected by Too Low signal in Cathode Plane
ADDR3+42	16	Calibration spectrum partition
ADDR3+44	32 x 16	32 words of calibration spectrum
ADDR3+108	4 x 4	4 bits wrap for #of Event Triggers 4 bits wrap for #of Events rejected by grey filter 4 bits wrap for #of Events rejected by Too High Signal in Back Plane 4 bits wrap for #of Events rejected by Veto Signal
ADDR3+110	16	Hardware trigger counter
ADDR3+112	16	Spare#3 = 16#AAAA#
BCPKT Packet		
ADDR4=196	34 x 16	(see [5] for description of Broadcast Packet format)
ADDR4+68	16	Spare#4 = 16#FFFF#
State of IASW (continuation)		
ADDR5=266	8	bits#0..5 - not used bit#6 - flag "HSL synchro. lost" bit#7 - flag "HSL synchro. used"
ADDR5+1	8	bit#0 - master error flag, bit#1 - not used (previously flag "Filtering of OEMs"), bit#2 - flag "Automatic Selection of Grey Filter", bit#3 - flag "Buffer Locked", bit#4 - semaphore for Big Buffer, bit#5 - not used (previously flag "Auto-recovery Enabled"), bit#6 - not used (previously flag "Super User Mode"), bit#7 - not used (previously arm flag for Super User Command)
ADDR5+2	16	Counter of OEMs rejected because of filtering,
ADDR5+4	16	DFEE State expected in IASW,
ADDR5+6	16	16 bit flags "Disable Check" for BCPKT
ADDR5+8	16	16 bit flags "Error Condition" for BCPKT
ADDR5+10	16	16 bit flags "Disable Check" for mRTU
ADDR5+12	16	16 bit flags "Error Condition" for mRTU
ADDR5+14	8	Counter of activity of Task MAIN
ADDR5+15	8	Counter of activity of Task TC
ADDR5+16	8	Counter of activity of Task HSL
ADDR5+17	8	Counter of activity of Task SC_OUT

ADDR5+18	8	Counter of activity of Task HK
ADDR5+19	8	not used, constant 0
ADDR5+20	8	Counter of activity of Task REQ_OUT
ADDR5+21	8	Counter of activity of Task STATE
Total = 288 Max = 290		

1.12.3.4 *On Event Messages Telemetry*

Each On Event Message occupies 5 words in the Housekeeping TM Packet.

Start (word# . bit#)	Size (bits)	Content
0 . 0	32	Time
2 . 0	6	Field#1
2 . 6	2	Class (0-Event, 1-Exception, 2-Major anomaly, 3-Failed TC Report)
2 . 8	8	Identifier
3 . 0	16	Field#2
4 . 0	16	Field#3

Field#1 is now practically meaningless, as after the change (since ver 1.31) the Identifier fully specifies given OEM. Fields#2 and #3 carry some additional informations, specific to the cathegory of OEM. They are equal to 0 when not used.

Ident.	Field#1	Class	Description
Group - Telecommand rejected Field#2 - bits 0..7 - spare = 0, bits 8..15 - 8 APID LSB's Field#3 - TC packet header - contains packet counter on bits 3..15			
128	1	Failed TC Report	Wrong field TYPE or SUBTYPE
129	2	Failed TC Report	Wrong field TID or FID
130	3	Failed TC Report	Wrong field MID
131	4	Failed TC Report	Wrong field ADDRESS
132	5	Failed TC Report	Wrong field LENGTH or wrong length othe TC itself
133	6	Failed TC Report	Some other errors in the text of TC
134	7	Failed TC Report	DPE is busy - TC input queue is full
135	8	Failed TC Report	HW Command illegal because of shutdown in proggress
136	9	Failed TC Report	State change illegal because of shutdown in proggress
137	10	Failed TC Report	Execution started but failed
Group - Problems with HSL			
151	1	Major anomaly	Overflow
157	7	Exception	DFEE exception "HSL busy"
158	8	Major anomaly	CRC error
159	9	Major anomaly	Timeout
154	11	Event	Lost synchronization
Group - Problems with LSL			
161	1	Major anomaly	Overrun Field#2 - indicator word of the command Field#3 - indicator word of the answer
162	2	Event	Framing error

			Field#2 - indicator word of the command Field#3 - indicator word of the answer
163	3	Event	Parity error Field#2 - indicator word of the command Field#3 - indicator word of the answer
166	6	Exception	DFEE exception "LSL disabled"
167	7	Exception	DFEE exception "LSL busy"
169	9	Event	Timeout Field#2 - indicator word of the command Field#3 - indicator word of the answer
Group - Problems with Analog Acquisition			
175	5	Major anomaly	Error
177	7	Major anomaly	Busy
179	9	Major anomaly	Timeout
Group - Problems with communication with DFEE			
180	0	Major anomaly	Unexpected answer from DFEE Field#2 - indicator word of the command Field#3 - indicator word of the answer
181 .. 186	1 .. 6	Event	Request Acknowledge with the code 1..6 Field#2 - indicator word of the command Field#3 - indicator word of the answer
187	7	Major anomaly	Request Acknowledge with some other code Field#2 - indicator word of the command Field#3 - Request Acknowledge code
188	8	Event	CRC error Field#2 - indicator word of the command Field#3 - indicator word of the answer
189	9	Event	Unexpected DFEE state reported in HK Field#2 - expected state, Field#3 - reported state.
190	10	Event	Discontinuity in DFEE HK Cycle Counter (possibly DFEE reset) Field#2 - previous CC, Field#3 - current CC.
191	11	Event	Operation "Load DFEE context" unsuccessfull - check for CRC-s failed. Field#2 - specification of failed CRC-s on bits 12..15 bit#15=1 - failed CRC of integer parameters table, bit#14=1 - failed CRC of float parameters table, bit#13=1 - failed CRC of code area 9000..9FFF, bit#12=1 - failed CRC of code area B000..CFFF,
192	12	Major anomaly	Failure of pulse relay operation "HV Off"
Group - Problems with BCP1			
201	1	Major anomaly	BCP1 shorter than 7.5 sec
202	2	Major anomaly	No BCP1 after 8.5 sec
Group - Unexpected behaviour of IASW Field#2 contains id# of the task issuing the OEM			
211	1	Exception	Unexpected exception
212	2	Major anomaly	Problems with buffer software
213	3	Major anomaly	Problems with TC queue software
214	4	Major anomaly	Problems with storing in DPE patches of DFEE’s RAM
Group - Unexpected behaviour of CSSW Field#2 contains id# of the task issuing the OEM			
221	1	Exception	Unexpected exception

222	2	Major anomaly	No RTC events
Group - Events when autonomous action of IASW			
231	1	Event	Shutdown initiated Field#2 - Actual level Field#3 - Target level
232	2	Event	Shutdown failed Field#2 - Actual level Field#3 - Target level
233	3	Event	Recovery initiated Field#2 - Actual level Field#3 - Target level
234	4	Event	Recovery failed Field#2 - Actual level Field#3 - Target level
235	5	Event	New pointing - restart of data mode Field#2,#3 - New Pointing ID
Group - Problems with Telemetry Field#2 contains APID of TM Packet which is source of problems			
241	1	Event	TM Packet lost
Group - Error Off condition			
254	0	Event	Error Off Field#2 identifies subsystem which since now on is correct: 150 - HSL 160 - LSL 170 - analog/digital conversion 188 - CRC in DFEE-->DPE LSL transmission 189 - DFEE state is as expected 200 - BCP1 period correct

1.12.3.5 *Software Diagnostic Telemetry*

SW Diagnostic is generated on request in form of TM(5,4)/TID=1/FID=16. It can as well be produced periodically in the same form.
This TM packet contains set of counters of events, which are interesting for diagnostic ot the software. Each issue of this report clears the counters, so each report shows counts made between reports.

Start (word#)	Events counted
Group - TC	
0	Constant 16#1111#
1	Received TC
2	Corrupted TC
3	Rejected TC
4	Timeout when reading TC
5	Timeout of BCP1
6	BCP1 too short
7	No RTC
Group - ADC	
8	Constant 16#2222#
9	ADC readout
10	ADC error
11	ADC busy

12	ADC timeout
Group - LSL	
13	Constant 16#3333#
14	Command sent
15	LSL error
16	CRC eror
17	LSL timeout
18	Aborted communication request
Group - HSL	
19	Constant 16#4444#
20	HSL readout
21	CRC error
22	HSL timeout
23	HSL overflow
24	Lost synchronization
25	Constant 16#5555#

1.12.3.6 Lost HSL Synchro. Diagnostic Telemetry

This diagnostic TM is generated on request in form of TM(5,4)/TID=3/FID=1. It can also be produced automatically at each lost of synchronization. The automatic mode can be set/reset with use of TC(5,3)/TID=3/FID=1. By default automatic mode is off.
The content of the diagnostic TM packet shows a fragment of HSL input buffer, where the lost of synchronization was seen.

Word #	Content
0	Event size+1 (6, 37, or 43). +1 is because in HSL buffer each event record is preceeded by the Event Marker = F000.
1	Number of words in the HSL input buffer. Usually it is a little more than 4096.
2	Buffer index, pointing the place, where synchronization was lost. Buffer is indexed starting with 0.
3	Offset of the dump. This shows the place in the HSL buffer where the dump start.
4..203	Dump of the fragment of HSL input buffer - up to 200 words.

This diagnostic TM is produced from the data stored in a dedicated buffer, in which the HSL buffer is latched, when the lost of synchro. occures. Initially this buffer is empty, so there is no sense to ask for it before observing On Event Message informing about any lost of HSL synchronization.

1.12.4 Protocol on High Speed Line

HSL is an unidirection data transfer channel to transmit science data from DFEE to DPE. DFEE puts data to HSL in form of a stream of event-records. There are three possible formats of event-record - each corresponding to one of the active Data Modes: NORMAL-DATA-TAKING, CALLIBRATION and DUMP.

1. Normal Data Taking Format. Each event consists of 5 16-bit words.

- HK Cycle Counter
- Timer Value
- Slow Anode Pulseheight
- Back Plane Position (Y)
- Cathode Plane Position (X)

2. Calibration Format. Each event consists of 36 16-bit words.

- HK Cycle Counter
- Timer Value
- Slow Anode Pulseheight
- Fast Anode Pulseheight
- Veto signal
- Back Plane signal 1 to 20 (20 words)
- Cathode Plane signal 1 to 11 (11 words)

3. Dump/Diagnostics Format. Each event consists of 42 16-bit words.

- HK Cycle Counter
- Timer Value
- Slow Anode Pulseheight
- Back Plane Position
- Cathode Plane Position
- Risetime
- Slow Anode Pulseheight
- Fast Anode Pulseheight
- Veto Signal
- Back Plane signal 1 to 20 (20 words)
- Cathode Plane signal 1 to 11 (11 words)
- Event Status Word
- Calibration Event Marker

In the HSL transmission each event-record is preceeded by the 1-word event marker equal to F000. This is to facilitate and speed up the synchronization. Event marker is not copied to the big buffer.

HK Cycle Counter is incremented after every BCP1. **Timer Value** is cleared to 0 together with incrementing of HK Cycle Counter, and next is incemented every 1/8192 sec. This way the Timer Counter should scroll over 16#FFFF# together with BCP1. **Slow Anode Pulseheight** describes energy of the event, it takes values in the range 0..4095. **Back Plane Position** determines Y position of the event, it takes values 0..1023. **Cathode Plane Position** determines X position, it also takes values 0..1023.

If **Event Status = 0** the event was accepted by the DFEE analysis. In this case the format contains the DFEE output (the first 6 words) + the corresponding DFEE input (the last 34 words). The two timer words are not duplicated. This means that the D/D format can be seen as the sum of Format 1 and Format 2.
If the on-board analysis classifies this event as coming from one of the calibration radioactive sources the calibration **Event Marker** is set to the number of the source. These are nubered 0, 1, 2, and 3. If the event is not so classified the Calibration Event Marker is set to -1.

If **Event Status > 0** then the event was rejected by the DFEE analysis. In this case the positions and the risetime can be meaningless. If status > 5 the Risetime is OK, if status > 8 the Back Plane Position is OK, but the Cathode Plane Position is never correct when the Event Status > 0.

Dummy event-record is a record of the same length as the real event-record for the current Data Mode, but carrying control information instead of science data. The general format for dummy event-record is the following:
1. word: HK Cycle Counter (as in real event-record)
2. word: Timer Value (as in real event-record)
3. word: = FFFF - Indicator of dummy event-record
4. word: Code of dummy event-record:
= 1 - End of Data marker,
= 2 - Grey Filter report,

= 3 - Calibration amplitude report,

End of Data marker is used for signaling to DPE that there will be no more data on HSL. DFEE produces the number of End of Data markers which ensures that the condition Half-Full FIFO is reached making chance to DPE for reading the last portion of data. End of Data markers are used in all three data modes.

Grey Filter report is used to notify that DFEE has changed Grey Filter. It is used only in Normal Data Taking Mode. Grey Filter report contains the parameter:
5. word: Number Id. of Grey Filter
This dummy record is added to the data stream whenever DPE requests change of Grey Filter. DFEE puts Grey Filter report with a positional error +/- TBD records.

Calibration amplitude report is used to notify the value of calibration amplitude for the consecutive calibration event-records. It contains parameters:
5. word: Calibration amplitude
6. word: Number of triggers/level (repeated from the DPE request)

DFEE will fill with zeros all reamaining fields of dummy event-record.

The process of data transmission via HSL runs the following way:
1. At the begining of each Data Mode DFEE clears output FIFO buffer,
2. DFEE informs DPE via a dedicated analog line that DPE can read at least 4096 words from HSL input,
3. DPE reads 4096 or less number of words to the buffer in RAM,
4. DPE looks for event-records in a streem of words and puts them to the big buffer in RAM for farther processing. The buffer's capacity is 60000 event-records when in NORMAL-DATA-TAKING mode.
5. When DFEE wants to terminate given data mode, it produces the number of End of Data Markers which corresponds to at least 4096 of words. In Normal Data Taking DPE tells DFEE to terminate data mode. In Calibration or Diagnostic Dump DFEE terminates itself.
6. When DPE detects End of Data Marker, it stops taking data and clears its input buffer. The same takes place, when after returning to Setup DPE doesn't get any input from HSL for longer than about 2 BCP1 periods.

1.12.5 Protocol on Low Speed Line

LSL is a bidirectional, half duplex channel. In the adopted protocol DPE plays the role of master - it sends requests to DFEE and DFEE answers. DPE is not expecting data from DFEE if no request was sent.
Each request and answer consist of one block of the following construction:

Word No.1 Block Indicator
Word No.2..n Data, (depending on the Block Indicator)
Word No.n+1 CRC calculated on words 1..n.

Packets transmitted from DPE to DFEE have envelopes - two words starter and two words trailer.
Starter: DDDD DDDD
Trailer: 3333 6666
This is to ensure correct recovering of synchronization on LSL on the DFEE side. DPE does not need envelope in the incoming packets.

Request	Request Indicator	Request Data	Answer Indicator	Answer Data
Change State	1234	State Number wanted State Parameter	R.A.(*1)	
Change SW Int. Parameter	8642	# of Param. to be changed New Value of the Param.	R.A.	

Change SW Float Param.	8765	# of Param. to be changed New Value of the Param.	R.A.	
Change HW Setting	AAAA	Command Address (*4) Command Value	R.A.	
Load Memory	ABCD	Start Address of the Block Length of the Block Block: 1-256 16-bit Words	R.A.	
Load 1-st half of Energy Table	4644	128 first words of Energy Table	R.A.	
Load 2-nd half of Energy Table	4645	128 last words of Energy Table	R.A.	
Expand Energy Table	4646	Constant = 0	R.A.	
Set Grey Filter	2468	Number Id. of Grey Filter	R.A.	
Set CPU status	1608	0,1,2, or 3 (see desc. of correspoding TC)	R.A.	
Set LSL mode x1	*1016*	*Constant = 0*	*R.A.*	
Set LSL mode x16	*1016*	*Constant = 16H*	*R.A.*	
Report SW Int. Parameter	*FDB9*	*# of Param. to be reported*	*1357*	*# of Parameter Value of the Param*
Report SW Float Param.	*FEDC*	*# of Param. to be reported*	*147A*	*# of Parameter Value of the Param*
Report all SW Int Params	BBBB	Constant = 1	BC01	Length = 100 100 Int numbers
Report all SW Float Params	BBBB	Constant = 2	BCEF	Length = 100 100 Float numbers (2 words each)
Dump Memory	CADB	Start Address of the Block, Length of the Block.	0FF0	Start Address of the Block, Length of the Block, Block.
Calculate Memory CRC	7F7F	Start Address of the Block, Length of the Block.	F7F7	Start Address of the Block, Length of the Block, CRC.
Return DFEE Status	2323	TBD Parameter	0F0F	DFEE Status Block (*2)
Return HK Block	4711	TBD Parameter	7777	HK Block (*3)

Tab. F List of Commands to DFEE via LSL.

Note (*1): R.A. - request acknowledge is a block with indicator = F00F, and one data element - Request Status which should be interpreted like this:

Req.Status =

- 0 Request executed normally,
- 1 CRC error,
- 2 Request not recognized,
- 3 Request not valid,
- 4 State# / parameter# not valid,
- 5 Request parameter value out of range,
- 6 DFEE busy, DPE should keep trying.

Note (*2): The DFEE Status Block contains:

- Last H/W command received
- Last parameter change #

- System Error #
- HK cycle counter
- Timer value

Note (*3): See chapter on Housekeeping Telemetry for description of DFEE Hosekeeping block.

Note (*4): See table below:

Command	Command Address	Command Value
HV Ready	0	4
HV On	0	5
HV Off	0	6
Anode Settings	1	4 x 1-bit values (on the LSB side)
Low Level of Discriminator	2	Level
Delta HV	3	HV
Cathode HV	4	HV

Tab. G HW Settings Commands

1.13 Operational requirements

1.14 Resource requirements

1.15 Verification requirements

1.16 Acceptance testing requirements

1.17 Documentation requirements

1.18 Security requirements

1.19 Portability requirements

1.20 Quality requirements

1.21 Reliability requirements

1.22 Maintainability requirements

1.23 Safety requirements

System design

1.24 Design method

*/*Describe or reference the design methode used.*/*

The design tries to follow objective style of programming. Partially this is forced due to the limitations in the access to the operational memory - changing the Address State is possible only when calling far procedure, no direct access to far data exists. Whole JEM-X DPE IASW is decomposed into a set of objects (ADA's packages) having own variables, constants, procedures and functions. Because of the limitation in acces to far data, the data belonging to a package are local. This means that procedures and functions situated in other objects can acces to these data only using dedicated functions.
It is worth to mention about the following categories of procedures.

- CONSTRUCTOR. This procedure is called once at the start of program. Constructor should initialize data of the package and configure those HW elements on which it will operate. All packages have constructors.
- TASK_ttt... procedure. This is the main body of a task. It has no parameters and loops forever (no return provided). Package can have one, more or none procedures of this kind.
- ALL OTHER procedures and functions offer differente services for tasks. Formally they are divided yet into local and public.

Exceptions will be used for signaling the logical errors of the program (wrong input parameters, calling of the procedure in a wrong mode), or for signaling that a peece of hardware is dead (LSL, HSL, mRTU).
In case when it is expected that the execution of the procedure could fail because of a frequent conditions (eg. no data on input when attempting reading HSL) - it will be signalled to the caller by the return value from the function or procedure.

1.25 Decomposition description

*/*Describe the physical model, with diagrams. Show the components and the control and data flow between them.*/*

1.25.1 Static decomposition

The IASW part of the program for JEM-X/DPE is composed of the following packages:

Package name	Addr. State	Main functions
DPE_IASW	AS0	Initialisation of the IASW
IASW_MAIN	AS1	Time synchronisation of actions of the program, reception and distribution of telecommands
IASW_TM	AS1	Filtering of Telemetry Packets and On Event Messages
IASW_MODES	AS1	Swiching between modes of operation
IASW_EVENTS	AS1	Definition of event and dummy-events.
IASW_EVSORT	AS1	Sorting of events collected in the buffer
IASW_HSL	AS1	Receiving event-records from DFEE via High Speed Line
IASW_BUFFER	AS1	Access to the large buffer of event-records
IASW_SUBBUFFER_x	AS2..AS11	Storing of a large number of event-records, there are 10 identical packages (x = 1..10)
IASW_SC_OUT	AS1	Producing of Science TM Packets
IASW_REQ_OUT	AS1	Producing of On Request TM Packets
IASW_HK	AS1	Colecting of Housekeeping information
IASW_DFEE	AS1	Dialog with DFEE via Low Speed Line
IASW_TIME	AS1	Recalculation of DFEE time to the OBT scale
IASW_MRTU	AS1	Facilitates the contact with Analog/Digital Converter
IASW_COMMON	AS1	General purpose functions and definitions
IASW_STATE	AS1	Autonomous actions of IASW
IASW_PATCHES	AS12	Storing of RAM patches directed to DFEE

Tab. H List of ADA Packages in IASW for JEM-X.

Each package exists in two files - package definition and package body. The name of body file is the same as the name of the package, the name of specification file is the same plus character "_", eg. the package IASW_MAIN can be found in files: "iasw_main.ada" - body, "iasw_main_.ada" - specification.

1.25.2 Dynamic decomposition

IASW runs seven concurrent tasks:

Name of the Task	Code in Package	TID	Priority	Initial State	Stack Size
TASK_MAIN	IASW_MAIN	1	15	STARTED	400
TASK_TC	IASW_MAIN	2	11	STARTED	1100
TASK_HSL	IASW_HSL	3	4	STARTED	750
TASK_SC_OUT	IASW_SC_OUT	4	3	STARTED	750
TASK_ HK	IASW_HK	5	13	NOT_STARTED	800
TASK_REQ_OUT	IASW_REQ_OUT	6	10	NOT_STARTED	1000
TASK_STATE	IASW_STATE	7	12	NOT_STARTED	900

Tab. I List of Tasks in IASW for JEM-X.

Task Identifier - TID is the number which is reported in some of the On Event Messages for pointing the task which suffers some bad conditions. Priorities are selected according to the following guidelines:

1. Tasks HSL and SC_OUT both can be active for a relatively long period - they can be called semi-background tasks. This implies that their priorities must be lower than priorities of CSSW foreground tasks, which means less than 5.
2. Task HSL should have higner priority than task SC_OUT, because otherwise reading of HSL could be blocked by a long activity of task SC_OUT, thus many input data could be lost.
3. Other tasks are forground-type, which means that their activity is short - it is activated by some external event, and after completting goes idle - by terminating or by periodical releasing of the processor to scheduler. Those tasks have priorities higher than CSSW tasks.
4. The highest priority should be assigned to the task MAIN, whose one of the jobs is synchronization between time used in DFEE and On Board Time. For this it is required the fastest possible readout of OBT after BCP1 is received in DPE.

1.25.3 Control flow

This chapter describes how and when individual tasks of IASW are started, stopped and what are the functions of tasks. All tasks are created at the initialization phase of IASW in the procedure DPE_IASW.INITIALIZE. Some of the tasks, those created with option STARTED, are active all the time (see chapter on Dynamic Decomposition). Others, created with option NOT_STARTED, normally are idle. They are started by other tasks with aim of performing some action paralel to execution of other actions. After completting the action the task terminates.
The term "terminating of task" is a bit confusing. It doesn't mean that the task disapears after terminating, it only stops its activity, waiting for beeing actiavted again by another task.

1.25.3.1 Task HSL

Task HSL reads event-records from High Speed Line and puts them to the circular big buffer. It is externally controlled by the two variables: flag HSL_ACTIVE and number EVENT_SIZE. When initiating data taking HSL_ACTIVE is set to TRUE, EVENT_SIZE to 5, 36 or 42, and the task initiates its input buffer. Data taking stops when Dummy event "End of Data" has beed read.
HSL is read in portions of 4096 words, or less, if 4096 doesn’t fitt into the input buffer. In general it is not guarantied that event-records will be found in the expected positions in the data stream, so the task must perform checking of correctness and must provide procedure for recovering of synchronization. See chapter "Synchronization of Event-Records on Input ".

Every time before the new block is read, the remaining, yet not used part of data from the previous radout is shifted to the begining of the buffer, and the new block is read to the buffer as a continuation of the existing data. This way the alghoritm of detecting of event-records works on a virtually continuous data stream. This is also why it may happen, that the readout must be shorter than 4096 words.

Task HSL counts events received in two counters: TOTAL_EVENTS_COUNT - 32-bits variable, which is never cleared, and EVENTS_RATE_CNT which at each BCP1 is copied to EVENTS_RATE and next cleared to zero. This way EVENTS_RATE represents estimation of input data rate, *which is used in the alghoritm of calculating of Grey Filter (no more).*

Task HSL regulates Grey Filter, analyzing the filling level of the big buffer. This is done no more than once per BCP1 period. On base of the value of the current Grey Filter the Task HSL selects the format - Primary or Secondary. The decision about the format selection is transported to the Task SC_OUT by use of a special dummy event, which travels through the circular big buffer together with normal event-records.

1.25.3.2 Task SC_OUT

Main job for Task SC_OUT is emptying the circular buffer which, concurrently is filled by the task HSL. Events read from the buffer are formatted according to the Science Format and sent to telemetry.

Events sent to telemetry are counted in intervals of BCP1 giving this way an estimation of real output data rate, *which is used in the alghoritm of calculating of Grey Filter(no more).*

Task SC_OUT can be in one of the three states: Normal Operation, Soft Stop, or No Operation. In Normal Operation the task does it's main job. There are yet two substates in Normal Operation - the data mode can be known or not. Initially, after the data taking has just been started, Task SC_OUT does not know the data mode. In this substate the input buffer is read by the task, but only the two dummy events are recognized: "Event size+format" and "Grey Filter report". All other events are ignored. From the dummy event "Event size+format" Task SC_OUT learns about the data mode, and since now on it is in the full Normal Operation State. Normally, "Event size+format" will be the very first event record read by the Task SC_OUT.
State Soft Stop differs from Normal Operation in that, when the input buffer is empty - the currently build TM packet is closed, even if not full, and after sending it, the task goes to the No Operation state. In Normal Operation, when the big buffer is empty, task simply waits for events.
In No Operation state Task SC_OUT does nothing but waiting for the signal, which would move it to the Normal Operation.

Task SC_OUT gets control infromation in two ways. The data mode, format selection and grey filter value come to it from Task HSL via the big buffer in form of dummy events. From the other hand Task SC_OUT is all the time sensitive to the signals, which aim is to start, or stop activity of the task. Those signals come from Task TC, as a consequence of reception of TC(5,5), or from Task STATE, which executes autonomous shutdown/recovery. There are three levels of the stopping signals - Hard, Soft and Soft delayed. Hard stop flushes the buffer, and immediatelly moves Task SC_OUT to the state of No Operation. This signal is used before starting data taking, to ensure, that Task SC_OUT is in the initial state.
Soft stop signal moves Task SC_OUT to the state Soft Stop, in which it works normally, until emptying the buffer. This signal is used at reception of "End Of Data" dummy event record from the big buffer.
Delayed Soft Stop signal will also change state to Soft Stop, but after a delay of about 8-16 seconds. This signal is used whenever instrument state changes from one of the data taking modes to Setup. Aim of the delay is to give chance to Task HSL to transfer the last HSL block, and to put events to the big buffer.

1.25.3.3 Task TC

Task TC receives telecommands. Those TCs which don't imply generation of TM packets are executed immediately by the task TC itself. The other are queued to the task REQ_OUT, which executes them and sends on-request TM packets. Task REQ_OUT runs on a lower priority. Advantage of such solution is clear especially in case of one telecommand - Memory Dump, where one telecommand can generate a long series of TM blocks. This is processed by the task REQ_OUT leaving the task TC free for reception of other telecommands. In a flat solution, where the task TC would execute all telecommands, as long as TM packets are sending no other telecommand could be received.

Task TC executes also TC(15,1)-Broadcast Packet. First it is stored in memory. *Entry/Exit time are stored separately, but only if they are valid - not zero (no more valid).* Next the data are analized and the result - WANTED_SHUTDOWN_LEVEL is calculated. Next the task STATE is activated which compares the desired shutdown level with the actual one and performs shutdown or recovery actions if necessary.

1.25.3.4 Task REQ_OUT

Task REQ_OUT performs telecommands which execution implies generation of TM blocks. It has an input queue of requests. Three tasks generate requests to REQ_OUT - task TC when it receives a telecommand, task MAIN when it wants to send the periodic SW diagnostic, and task HSL, when it sends the on-event "HSL Lost Synchro." diagnostic.

The requests queue is a priority queue - there are two priority levels. Memory dumps have low priority, all other requests have high priority. Requests with the same priority are queued in order of occurence.

Task REQ_OUT normally is stopped. It is activated when any new request is added to its input queue. When the requests queue gets empty, task REQ_OUT terminates.

1.25.3.5 Task HK

Task HK is activated by the task MAIN six seconds after each BCP1. It performs the following actions:

1. Reads all analog lines (mRTU) which must be reported in housekeeping TM.
2. On base of the mRTU data analyses pressure and temperature of gas and DFEE low voltage supply.
3. If DFEE's supply happens to be correct, asks DFEE for the housekeeping block. Some of the data from DFEE HK are stored for future use:
    - HK Cycle Counter is stored together with OBT corresponding to the latest BCP1. Those two data will next be used to recalculation of DFEE time scale to OBT time scale. See chapter „Recalculating Event Time to OBT” for details.
    - Informs task HSL about the new Cycle Counter - it will be used for checking of correctness of events.
    - Checks if DFEE State agrees with the expectation of DPE. Generates OEM if necessary.
    - Checks continuity of Cycle Counter and if needed generates OEM.
4. Forms and sends to telemetry the IASW housekeeping packet.
5. Calculates WANTED_SHUTDOWN_LEVEL, and if needed starts shutdown or recovery process.
6. Task HK terminates.

1.25.3.6 Task MAIN

Task MAIN hangs on BCP1 and BCP4 and its principal job is to initiate differente actions in propper moments of time.

- Just after BCP1:
    - As quick as possible, reads OBT latched in hardware on the last BCP4 and stores it. After succesfull readout of DFEE housekeeping, which will take place six second later, this OBT together with Cycle Counter from DFEE HK will be stored and next used in the procedure of recalculating of DFEE time scale to OBT scale.
    - Determines input data rate (see chapter "Task HSL").
    - Determines output data rate (see chapter "Task SC_OUT").
    - Sets flag IASW_HSL.BCP1_FLAG which will inform task HSL about the possibility of modification of Grey Filter and format.
    - Increments counters of differente timeouts in the system.

  - If needed sends the request for SW diagnostic TM to the task REQ_OUT.
- 6 seconds after BCP1 (2 seconds before the next one) activates the task HK.
- Checks if intervals between consecutive BCP1, measured in units of BCP4 (1 second) are in the range 7..9. If not - OEM is generated.

1.25.3.7 Task STATE

Task STATE normally is not active. It is activated by the task TC when it receives Broadcast Packet, or periodically by the task HK. Its activation is allways preceded by the analizis of Broadcast Packet data and mRTU data. The analyzis gives WANTED_SHUTDOWN_LEVEL as a result. ACTUAL_SHUTDOWN_LEVEL shows where DPE is in the process of following the wanted state.
Job for task STATE is to compare WANTED_SHUTDOWN_LEVEL with ACTUAL_SHUTDOWN_LEVEL and if they differ to undertake propper actions (shutdown or recovery) to make those two equal. There is also a third variable - MINIMAL_SHUTDOWN_LEVEL, indicating how far can DPE go with recovering of normal operation. Normally it does not limit anything. MINIMAL_SHUTDOWN_LEVEL enters into the action when error occures during recovery - then it is set to ACTUAL_SHUTDOWN_LEVEL, and next DPE will not try to recover deeper, even if comparision with WANTED_SHUTDOWN_LEVEL shows that recovery is possible. Situation will return to normal after operator intervention - any state changing command resets MINIMAL_ and ACTUAL_SHUTDOWN_LEVEL.
See chapter " Shutdown/Recovery scheme " for details.

1.25.4 Data flow

Data flow scheme describes the following data flow subsystems:
- Scientific data from DFEE, compressed and passed to TM,
- Housekeeping data from DFEE, mRTU, BCPKT, and DPE itself, passed to TM,
- On Event Messages generated in DPE, passed to TM,
- Filtering of On Request TM Packets,
- Memory Loads, coming from TC, passed to DFEE, also stored in DPE,
- Memory Dumps, coming from DFEE, passed to TM,
- Hardware Commands, coming from TC, passed to DFEE,
- Software Parameters, coming from TC, redistributed to DFEE or DPE itself,
- Software Parameters Reports, coming from DFEE or DPE, passed to TM,
- Diagnostic data reported in diagnostic TM,

1.25.4.1 Scientific data flow

JEM-X measurements come to DPE from DFEE via High Speed Line in form of streem of event-records. On a low level DPE software reads a stream of 16-bit words in which the event-records should first be found.
Event-records found in the input stream are next put into the big FIFO-type buffer in RAM. The buffer's capacity is 60000 event-records when in Normal Data Taking Mode and proportionally less in Callibration or Dump/Diagnostic Mode.

That part of processing, starting from reading HSL, ending with filling the buffer is performed by the Task HSL. Task SC_OUT performs the processing of event-records on the other side of the big buffer. Event-records are compressed and formated to the TM Packets. Each time the TM Packet buffer is completed, it is passed to the procedure IASW_TM.PUT_TM, which next calls DPE_CSSW.PUT_SCIENCE_TM. The procedure IASW_TM.PUT_TM is transparent for science TM Packets.

1.25.4.2 Housekeeping data flow

There are four sources of HK data: DFEE HK block, mRTU analog signals, Broadcast Packet and DPE’s software variables. As the HK data taking from DPE is synchronised to the BCP1 impuls, the procedure of collecting HK data also runs synchronously with this impuls. Task HK collects all the data and sends the packet to telemetry. Task HK is activated periodically, 6 seconds after each BCP1 by task MAIN.

1.25.4.3 Filtering of On Event Messages

CSSW supports OEM generation with the procedure DPE_CSSW.PUT_ON_EVENT_MESSAGE. This procedure is not used directly in IASW, instead all tasks use procedure IASW_TM.PUT_OEM, which decides if given OEM is to be sent to telemetry, or if it is to be filtered out. Aim for filtering is not to repeat OEMs which would periodically inform about a permanent malfunction. Not all OEMs are filtered, only those of kind "error condition on". They are grouped in the following groups:

Group of filtered OEMs	ID of the group	Set of individual OEMs in the group
HSL	150	151, 157, 158, 159
LSL	160	161, 162, 163, 166, 167, 169
AD conversion	170	175, 177, 179
CRC on LSL	188	188
CC in DFEE HK	189	189
BCP1	200	201, 202

Tab. 10 Groups of filtered OEMs.

There are error flags associated with each of the OEM Id of the above cathegory. Whenever a request for OEM generation emerges from inside of IASW, the corresponding flag is checked and if set, given OEM is ignored. If the flag is clear, OEM is passed to telemetry and the error flag is set. Flags are cleared in groups, whenever a signal is sent from inside of IASW telling that given subsystem is ok. (Please note that error flags are set individually, but are cleared in groups, only when given subsystem is entirelly correct).
OEM 189 "Unexpected DFEE State" is treated differently. It is not filtered out if Field#2 or #3 is differente than in previous OEM of this kind.
The so called "master error flag", which is logical sum of all error flags is reported in HK.

1.25.4.4 Memory Load/Dump/CRC calculation

All memory operations are performed on request from TCs. Only memory of DFEE can be accessed with use of these commands. Memory Load is performed immediately after receiving the TC with the given request. Memory Dump request can however cover much more memory than can be reported in a single TM Packet - thats why requests for Memory Dump are queued to the separate Task REQ_OUT. This task executes Memory Dump requests simultaneously with processing of other tasks, thus not blocking the possibility of receiving other telecomands.
Memory Load commands are stored in DPE for the future use when recovering data taking after eclipse. The list can store up to 150 (TBC) loads.

Start Address	End Address	Content
8000	8FFF	Data
9000	9FFF	Code
A000	AFFF	Data A018 - grey filter patterns table (32 x 2 words), AC00 - compressed energy linearization table 256-words long
B000	CFFF	Code
D000	FFFF	Data D500 - integer parameters table 100 words long D600 - float parameters table 200 words long E000 - long (full) energy linearization table 4096-words long

Tab. K Simplified Memory Map of DFEE.

1.25.4.5 Hardware commands

Hardware commands come to DPE as a TC(5,3) - Load Task Parameter. Next the HW command is translated into the DFEE HW command and sent to it via LSL. DPE stores HW commands for the future use when recovering data taking after eclipse or radiation belts. Reporting of HW Commands is not provided, so TC(5,4) - Report Task Parameter with TID/FID pointing the HW Command will not be executed. The actual status of HW settings instead is reported in housekeeping TM.

1.25.4.6 Software Parameters Seting/Reporting

SW Parameters Setings come to DPE as a TC(5,3) - Load Task Parameters. There are two groups of SW Parameters - specific for DFEE and specific for DPE. Those belonging to DFEE are directed to it via LSL. When requested by a TC(5,4) the SW Parameter Report is prepared in a form of TM(5,4). For reporting parameters specific for DFEE, DPE asks DFEE for values.

1.25.4.7 Diagnostic data

Diagnostic data - counters of occurence of events which are interesting for testing and diagnostic purposes, are generated in differente places of the program. Every time after the diagnostic data are queried, the counters are cleared. This way the reported values counts events starting from the previous report, not from the moment of switching on the device. Diagnostic report can be issued on request or periodically. See description of TC(5,3)/TID=1/FID=15 and TC(5,4)/TID=1/FID=16 for details.

1.25.5 Alghoritms

1.25.5.1 Synchronization of Event-Records on Input

Normally DPE should find event-records in the expected positions in the stream of words - both DPE and DFEE start a data mode with clearing communication buffers. It can happen however that DPE loses synchronisation, eg. when one of the 4096 words readouts is lost because of transmision error, or when DFEE generates events quicker than DPE could read. DPE must check the correctness of each event-record and if find it not correct, the synchronisation procedure must be used.

The alghoritm of reading of event-records can be in one of two states: Synchronized and Not Synchronized. Initially the alghoritm starts with state "Synchronized". Later, whenever an error is detected, program goes to Not Synchronized. After finding correct event-record in the input data stream program switches to Synchronized state. When Synchronized, which means that previous event-record was OK, only limited test is performed for checking if the current event-record is correct. In the limited test only Event Marker words (F000) are checked. It is required that both markers are present - the one preceeding an event, and the one following (belonging to the next event).

When this test returns with error, Not Synchronized state is initiated, in which the input data index, pointing individual 16-bits words, is moved forward until 3 consecutive event-records give positive result of a test. The test in this case involves the following checkings:

- Check for Event Markers, as in the limited test,
- HK Cycle Counter in each of the 3 events must not differ more than -200/+2 from the HK Cycle Counter given in the last DFEE HK block,
- Sequence of (CC,TC), representing event's time must be nondecreasing.

After finding good sequence of 3 event-records program returns to the Synchronized state. All 3 events will be passed to output.

1.25.5.2 Buffer of Events

Event-records, after checking of correctness, are put to a big buffer, capable of storing 60000 events when in Normal Data Taking mode. Event Markers are eliminated. There is one task - HSL, writing into the buffer and one task - SC_OUT, reading from the buffer.
Because of memory organisation limitations, the buffer is divided into ten subbuffers - equal parts, each 30000 words long. Because of the same limitations the code of program dealing with acces to the buffer must have been split into eleven parts - one package IASW_SUBBUFFER_x for each subbuffer and IASW_BUFFER giving access to the buffer as a whole. Access on the subbuffer level is random - the caller specifies an index - number of event in a given subbuffer. The whole buffer has FIFO organization. There are two basic operations defined - Put event to the buffer, Get event from the buffer. There are also functions infroming about that the buffer is empty, full, or returning number of events stored. The following four variables define state of the buffer:

- READING_INDEX - position in the buffer where the first to read event is placed,
- WRITING_INDEX - position in the buffer where the next writen event will be put,
- AMOUNT_OF_EVENTS - number of events in the buffer,
- BUFFER_LOCKED - flag telling if writing to the buffer is blocked,

Put and Get procedures both modify the variable AMOUNT_OF_EVENTS. They are called by differente processes, so these modifications must be executed in a critical section. Solution given by CSSW for organizing of critical section is not satisfactory, because of time lost for calling of any CSSW function. Buffer operations are very frequente, so lost of about 130 microseconds for each event is not to be ignored. It is used the procedure `OP_CAN_ENTER_CRITSEC` defined in module `critsec.asm`. This procedure makes use of the processor instruction TSB, which ensures uninterrupted test+set pair of opperations.

In most cases the buffer is emptied with use of the described Get operation. In the Restricted Imaging Format this is not sufficient. In this case relative-random Peek operation is required. This procedure returns an event, pointed by the user index, without deleting the event from the buffer. The index is relative to the READING_INDEX, which means that Peak(user_index=0) returns the same event which Get would return.

1.25.5.3 Recalculating Event Time to OBT

X-events come to DPE together with time markers. Time provided by DFEE takes the form of 32 bits word. Higher 16 bits of it is called HK Cycle Counter, lower 16 bits - Timer Counter. Timer Counter is incremented every 1/8192 ot the second, while HK Cycle Counter is incremented every this BCP4, which follows BCP1. Together with incrementing of HK Cycle Counter, Timer Counter should be cleared to zero. In practice it is not exactly so, which sometimes is source of errors. See next chapter on this.
Having this 32 bits time DPE must recalculate it to the OBT scale. This is done in several steps:

1. Whenever DPE receives BCP1, the program asks for the OBT latched in hardware on the last ocurred BCP4. Next, one second is added to this OBT and result is stored in BCP1_OBT. The one second correction is needed, because it is the next BCP4 (the first following BCP1) which synchronizes DFEE.
2. Whenever HK block is received from DFEE, which normally takes place 6 seconds after BCP1, the HK Cycle Counter reported in the HK block is stored in the variable DFEE_HK_CC_STORED. Together with this, BCP1_OBT (obtained in point 1.) is copied to the variable DFEE_OBT_STORED.
3. The following data: DFEE_HK_CC_STORED, DFEE_OBT_STORED, and time of event - HK Cycle Counter and Timer Counter are sufficient to make recalculation of event time to OBT.

Procedures for described actions and calculations are located in the package IASW_TIME.

1.25.5.4 Correction of DFEE's bugg in reporting event's time.

DFEE transmitts time of events in form of 32 bit number. This however is not a one 32-bit counter, but two 16-bit counters, processed a complicated way. Normally the high order counter, so called Cycle Counter should increment exactly in the same moment when the low order Timer Counter wrapps arround FFFF. In practice wrapping of Timer Counter comes first, and a little bit later incrementing of Cycle Counter. There is a chance that in this short time in between, event trigger will take place and wrong time data will be sent to HSL.

DPE tries to correct this error using the following alghoritm:

```
if (Timer_Cnt == 0) and (Cycle_Cnt == previous_Cycle_Cnt) then
      Cycle_Cnt := Cycle_Cnt + 1
endif
previous_Cycle_Cnt := Cycle_Cnt
```

This is done by the task SC_OUT, on the output side of the big buffer. This is a simplified methode. Full methode should work in cooperation with procedure finding events in the HSL input data stream.

1.25.5.5 Recalculating X/Y Coordinates of Events

Two numbers: Back Plane Position and Cathode Plane Position, each in the range 0 .. 1023, come to DPE with each event-record. They represent Y and X (respectively) coordinates of an event. Those numbers must be recalculated to the range 1 .. 255. Value of 0 is not allowed, zero has a special meaning in the output format on the positions X and Y.

Lookup tables, separate for X and Y are used. Operating tables are 1024 8-bit words long. Each entry represents 8-bit X or Y position in function of 10-bit Cathode- or Back- Plane Position. The long table is obtained in the process of reversion of another, so called compressed table - 256 10-bit words. Each entry in the compressed table represents upper value of 10-bit argument of the corresponding position channel. Compressed tables, for X and Y separetelly, can be changed with commands.

Default content of compressed tables, equal for X and Y:

```
0,5,9,13,17,21,25,29,33,37,41,45,49,53,57,61,
65,69,73,77,81,85,89,93,97,101,105,109,113,117,121,125,
129,133,137,141,145,149,153,157,161,165,169,173,177,181,185,189,
193,197,201,205,209,213,217,221,225,229,233,237,241,245,249,253,
257,261,265,269,273,277,281,285,289,293,297,301,305,309,313,317,
321,325,329,333,337,341,345,349,353,357,361,365,369,373,377,381,
385,389,393,397,401,405,409,413,417,421,425,429,433,437,441,445,
449,453,457,461,465,469,473,477,481,485,489,493,497,501,505,509,
513,517,521,525,529,533,537,541,545,549,553,557,561,565,569,573,
577,581,585,589,593,597,601,605,609,613,617,621,625,629,633,637,
641,645,649,653,657,661,665,669,673,677,681,685,689,693,697,701,
705,709,713,717,721,725,729,733,737,741,745,749,753,757,761,765,
769,773,777,781,785,789,793,797,801,805,809,813,817,821,825,829,
833,837,841,845,849,853,857,861,865,869,873,877,881,885,889,893,
897,901,905,909,913,917,921,925,929,933,937,941,945,949,953,957,
961,965,969,973,977,981,985,989,993,997,1001,1005,1009,1013,1017,1023
```

1.25.5.6 Recalculating Event Energy

Slow Anode Pulseheight, comming in each event-record, carries information about energy of the event. The energy must be recalculated from the range 0 .. 4095 to the 8-bit number. The required function is not linear, so the simple division by a constant is not sufficient. The 4096 bytes long lookup table is used. Each entry stores 8-bit channel number corresponding to the 12-bits input value.

Fast lookup table is a function of the reverse, much shorter - 256 words long table, containing upper limits of the Slow Anode Pulseheight for the energy channels. This short table can be commanded with use of TC(5,3)/TID=4/FID=44,45. Default content is the following:

```
   0,    3,    6,    9,   12,   15,   18,   21,
  24,   27,   30,   33,   36,   39,   42,   45,
  48,   51,   54,   57,   60,   63,   66,   69,
  72,   75,   78,   81,   84,   87,   90,   93,
```

```
  96,  100,  104,  108,  112,  116,  120,  124,
 128,  132,  136,  140,  144,  148,  152,  156,
 160,  164,  168,  172,  176,  180,  184,  188,
 192,  196,  200,  204,  208,  212,  216,  220,
 224,  228,  232,  236,  240,  244,  248,  252,
 256,  260,  264,  268,  272,  276,  280,  284,
 288,  292,  296,  300,  304,  308,  312,  316,
 320,  324,  328,  332,  336,  340,  344,  348,
 352,  356,  360,  364,  368,  372,  376,  380,
 384,  388,  392,  396,  400,  404,  408,  412,
 416,  421,  426,  431,  436,  441,  446,  451,
 456,  461,  466,  471,  476,  481,  486,  491,
 496,  504,  512,  520,  528,  536,  544,  552,
 560,  568,  576,  584,  592,  600,  608,  616,
 624,  632,  640,  648,  656,  664,  672,  680,
 688,  696,  704,  712,  720,  728,  736,  744,
 752,  765,  778,  791,  804,  817,  830,  843,
 856,  869,  882,  895,  908,  921,  934,  947,
 960,  973,  986,  999, 1012, 1025, 1038, 1051,
1064, 1077, 1090, 1103, 1116, 1129, 1142, 1155,
1168, 1186, 1204, 1222, 1240, 1258, 1276, 1294,
1312, 1330, 1348, 1366, 1384, 1402, 1420, 1438,
1456, 1474, 1492, 1510, 1528, 1546, 1564, 1582,
1600, 1618, 1636, 1654, 1672, 1690, 1708, 1726,
1744, 1808, 1872, 1936, 2000, 2064, 2128, 2192,
2256, 2320, 2384, 2448, 2512, 2576, 2640, 2704,
2768, 2832, 2896, 2960, 3024, 3088, 3152, 3216,
3280, 3344, 3408, 3472, 3536, 3600, 3664, 4095.
```

The same energy table is needed in DFEE. DPE transmits it to DFEE in the situations:

1. After DFEE goes to Setup state for the first time after JEM-X was turned on,
2. When recovering data taking after eclipse,
3. As an element of loading the context on response to the TC(5,3)-Load DFEE Context,
4. On reception of TC(5,3)-Expand Energy Linearization Table.

1.25.5.7 Addjustment of Grey Filter

A set of 32 Grey Filter patterns is stored in an array in DFEE. First of them, 0-th corresponds to 3% of throughput. The last one, 31-st gives 100% of throughput. The throughput is close to proportional in between. The table of patterns can be changed from ground with Memory Load Command.

DFEE is instructed by DPE about which Grey Filter pattern to use. As a response DFEE informs DPE about changing of Grey Filter using dummy event records in the data stream.

DPE selects the Grey Filter automatically. The decision is made on base of the filling level of the RAM big buffer keeping event records. The alghoritm, run every 8 seconds, is the following:

```
dB := buffer_filling - previous_buffer_filling -- expessed in [events]
previous_buffer_filling := buffer_filling
if dB > 0 then
      -- buffer filling goes up
      if buffer_filling > 50% then
            GF := GF - (1+dB/output_data_rate)
      else
            -- it is <= 50% - GF doesn't change
      endif
elsif buffer_filling < 1000 then
      -- buffer is almost empty and doesn't go up
      GF := GF + 1
elsif dB < 0 then
      -- buffer filling goes down
```

```
        if buffer_filling > 80% then
              GF := GF - 1
        elsif buffer_filling < 20% then
              GF := GF + 1
        else
              -- buffer is in the range 20..80% - GF doesn't change
        endif
  else
        -- buffer is stable and not empty - GF doesn't change
  endif
```

Real implementation must also take care of the allowed range of GF: 0..31.
Output data rate used in this alghoritm, expressed in [events/BCP1] is determined by the two factors: telemetry rate share (number of Science TM packets per BCP1 period) coming with Broadcast Packet, and a number of events packed into one TM packet. This last is a function of currently selected compression format.
The three threshold levels (50%, 80% and 20%) are implemented as variable parameters, and can be changed with use of TC(5,3)/TID=4/FID=46.
Changes of Grey Filter should not be made too often, just not to itroduce a mess, which might difficoult interpretation of data. Therefore process of Grey Filter regulation is activated only once every 8 seconds.

1.25.5.8 Format switching

Together with selecting of Grey Filter DPE decides about which Format to use - primary or secondary. The decision is made on base of the actual Grey Filter used. There are two threshold levels of Grey Filter, which come with the telecommand starting data taking. When the Grey Filter goes below the Level#1 - format is switched to secondary, when Grey Filter goes above Level#2 - format is switched back to primary.
Again, because of the same arguments as with regulation of Grey Filter, the process of format switching is activated only once every 8 seconds.

1.25.5.9 Detection of New Pointing

It was decided that whenever there is a change of sky target observed, the instrument should start data taking with empty buffers. This is automatically performed as the sequence: "goto Setup", "goto Data Taking". The new data taking is started with parameters last used.
Detecting of a new pointing is based on two data brought with Broadcast Packet - PID (Pointing ID) and OTF. New pointing is assumed when the newly observed PID is valid and is differente then previous valid PID. PID is valid if it is nonzero and one of the two conditions is fulfiled:
1. Standard condition: OTF changes from 0 to 1,
2. Spare condition: OTF is 1 and PID changes from any value (possible zero) to a nonzero value.

Switching to another data taking can be blocked by setting Disable Check bit#0 with use of the command "Set Operator Overrides for Broadcast Packet Data".

1.25.5.10 Context of DFEE stored in DPE

The term "Context of DFEE" covers all the data describing state of DFEE, necessary for recovering of interrupted data taking process. This includes the following:
1. Content of DFEE's RAM, which is yet divided in:
    - Set of RAM patches,
    - Copy of integer parameters field,
    - Copy of float parameters field,
    - Copy of energy linearization table - the compressed one,
2. CRC-s of the four DFEE RAM areas (see chapter " Memory Load/Dump/CRC calculation" to see addresses):

- Code area #1,
- Code area #2,
- Integer parameters field,
- Float parameters field,

3. Hardware settings:
   - Anodes ON/OFF status,
   - Low Level of Discriminator,
   - HV Delta setting,
   - HV Cathode setting,
4. Requested values of the two HV,
5. DFEE State code.

RAM patches are stored in DPE as they come with TC(6,1). DPE can store up to 150 of patches. When recovering DFEE activity the patches stored are loaded to DFEE in the oryginal order.

Mirror of DFEE's parameter fields, kept in DPE is filled with DFEE defaults when it goes to state SETUP for the first time after DPE on. DPE asks DFEE for the initial values of the parameters using LSL command BBBB. Afterthat mirror parameters fields are updated in DPE in paralel with updating of the oryginal DFEE tables. Both TC(5,3) - changing individual parameters, and TC(6,1) - loading bigger fragments of parameters tables are recognized.
When recovering DFEE activity, parameters fields are loaded to DFEE just after loading RAM patches.

In a very similar way, like the parameters tables, the mirror of energy linearization table is used. The only difference is in the origin of the default value, which is defined in DPE, not DFEE.

The four CRC-s are used to make sure that the process of recovery was correct. Before the activity is stopped because of shutdown needed, DPE asks DFEE for calculating the four CRC-s. Next they are stored in DPE, and when recovering, after loading RAM patches and parameters fields, but before initiating data taking, DFEE again is asked to calculate the four CRC-s. In case of disagreement with the stored values the process of recovering is stopped.

Mirror of hardware settings in DPE is predefined to the following defaults: all four anodes Off, all other settings = 0. Next, those values are updated in paralel with execution of TC(5,3) changing hardware settings. When recovering, hardware settings are commanded to DFEE after loading parameters fields.

Requested values of HV Delta and HV Cathode relates to the measurements reported in the DFEE housekeeping. They are copied from the last HK packet just before shutdown. When recovering, the requested HV values will be used for deciding if high voltage has stabilized after turning on. The +/-TBD margin is used in this comparision.

DFEE State mirror initially is set to STANDBY. As soon as it is observed low voltage on, it is changed to SAFE. Next it is updated in paralel with succesfull execution of TC(5,5) changing DFEE State. The DFEE State in the moment of interruption of activity is separately stored as "Interrupted DFEE State". When recovering, DPE will not force State higher than the stored one.
There are situations when DFEE State mirror doesn't reflect the real DFEE state correctly. After execution of command "HV Ready" DFEE changes state to 6, while the state mirror in DPE remains equal to 5 (SETUP). Another situation is when DFEE termianeted Calibration or Diagnostic Dump, but DPE didn't get yet the HSL block with dummy event records "End Of Data". Then DFEE is in state SETUP, but the State mirror in DPE is still equal to Data Taking.
Those odd situations are under controll - the disagreement is not danger.

1.25.5.11 Shutdown/Recovery scheme

Under normal conditions all changes of the state of the device are initiated from ground, and the operator is responsable for the propper sequence of commands. There are defined some situations when DPE autonomously

stops the activity and later eventually resumes the previously interrupted mode. So called Shutdown Level is a key idea to understanding alghoritms for shutdown/recovery scheme. Shutdown Level is a number telling how deeply was DPE forced to go down with the shutdown process. Software keeps two variables: Actual Shutdown Level, which represents the actual depth of shutdown, and Wanted Shutdown Level, which is a function of the external information - coming from Broadcast TM and from mRTU analog readouts. The job for Task STATE is to keep Actual Shutdown Level equal to the Wanted one. Both levels are reported in the IASW HK TM.
There is also a third variable - MINIMAL_SHUTDOWN_LEVEL, indicating how far can DPE go with recovering of normal operation. Normally it does not limit anything. MINIMAL_SHUTDOWN_LEVEL enters into the action when error occures during recovery - then it is set to ACTUAL_SHUTDOWN_LEVEL, and next DPE will not try to recover deeper, even if comparision with WANTED_SHUTDOWN_LEVEL shows that recovery is possible. Situation will return to normal after operator intervention - any state changing command resets MINIMAL_ and ACTUAL_SHUTDOWN_LEVEL.

Wanted Shutdown Level	External condition leading to the given shutdown level
0	Normal operation
30H	Radiation belts
40H	Eclipse
50H	Low Voltage Off in Eclipse
60H	Pressure in detector too low, or ESAM = 1, or I.I.Sw.Off = 1. (no automatic return provided)
70H	Unexpected Low Voltage Off, (no automatic return provided)
80H	Lost of communication with DFEE via LSL

Tab. L List of Wanted Shutdown Levels.

Transition	Shutdown action (→) (*2)	Recovery action (←) (*3)
0 ←→ 10H	Store current state as "Interrupted DFEE State", Store settings and monitoring of HV, Signal "Delayed Soft Stop" to Task SC_OUT, DFEE: goto Setup, DFEE: goto Safe	DFEE: goto Data Taking, Signal "Hard Stop" to Task SC_OUT, Signal "Start" to Task SC_OUT,
10H ←→ 28H		DFEE: Set Drift HV
28H ←→ 2AH		DFEE: Set Acc. HV
2AH ←→ 2CH		DFEE: HV On
2CH ←→ 2EH		DFEE: HV Ready
2EH ←→ 30H		DFEE: goto Setup
30H ←→ 40H	Save DFEE context in DPE memory	Set DFEE CPU mode Load the context to DFEE,
40H ←→ 50H	No action	No action
50H → 60H	No action	no automatic recovery possible
any → 70H	Signal "Delayed Soft Stop" to Task SC_OUT,	no automatic recovery possible
any → 80H	HV Off with use of relay #0 impulse, Signal "Delayed Soft Stop" to Task SC_OUT,	no automatic recovery possible
Notes: (*1) Levels 10,28,2A,2C,2E are possible only when in the process of recovery of high voltage, (*2) Shutdown actions in column (->) are performed from top to bottom, (*3) Recovery actions in column(<-) are performed from bottom to top, even if in one cell of table,		

Tab. 13 DPE autonomous actions when balancing Shutdown Levels.

The above table lists DPE actions, which are performed, when the Wanted Shutdown Level is not equal to the Actual one. For explanation of how it works, pleas consider the following example:

1. The instrument was performing Normal Data Taking, the satelite enters into the radiation belts. The Actual Shutdown level = 0, the Wanted Shutdown Level = 30H. To make the Actual equal to Wanted one DPE must perform shutdown actions corresponding to the transition: 0->30H through all inermediate levels.
2. After a while the satelite goes to eclipse - Wanted Shutdown Level changes to 40H. The Actual Level already is equal to 30H, so there is only one transition missing - 30H->40H.
3. Say, the radiation belts and eclipse terminate in the same moment - Wanted Shutdown Level becomes 0. DPE must perform recovery actions corresponding to transitions 40H->30H->2EH->2CH->2AH->28H->10H->0. When requesting: Set Acc. HV, Set Drift HV and Goto Data Taking, DPE can get the answer from DFEE telling that it is busy. DPE will keep trying until DFEE accepts the command. It may take few minutes until DFEE is ready to start data taking.

When Actual Shutdown Level is not zero, some of the operator commands, which normally are legal, may result illegal and will be rejected.

1.25.5.12 Analisis of Eclipse and Radiation Belts Entry/Exit Times

Entry/Exit times come with Broadcast Packets TC(15,1). They can be given, or not. All zeros in the field of time-data means "no data".
Analisis of times should answer if the current time T lies inside the range T1 - T2 (Entry - Exit). This is not as trivial as one might think, because of possibility of having no complette data. Please consider the following cases:

- Both T1 and T2 are given, T1 < T2 - this is the trivial case.
- Both T1 and T2 are given, but T2 < T1 - it is assumed that T2 ends one danger period while T1 starts a new one. In this case T is in the danger period if T<T2 or T>T1.
- Only T1 is given - then it is assumed that T2 will be given soon and just for case that T<T2.
- Only T2 is given - again, probably T1 will be given soon and just for case T>T1 is assumed.
- Both T1 and T2 are not given - safe situation is assumed.

There is one more complication - OBT wrapps arround FFFFFFFFFFFF in about 194 days, which in practice can happen. The operator "<" used for comparing of OBT-s takes this into account. When the two compared OBT-s differ more than half full range (about 97 days), then the result of comparision is reversed - it is assumed, that the smaller one has wrapped by one more times than the other.

1.25.6 Patching of DPE/IASW code

There is a possibility of changing content of RAM of DPE with use of CDMU command Load Memory. This gives a chance to modify the DPE software in fly. IASW is written in ADA, so it is desired that for preparing of patches also ADA is used to the maximal extend. The following text gives step by step instructions how to prepare patches for the most likely situation, when it is required the replacement of a procedure with its new version.

Step 1.
The ADA text of the new version of the procedure should be placed in the ADA package dedicated only for this. There should exist separete package for each address state in which the corrected procedures work. The ADA package IASW_DPE_PATCH is container for all new procedures working in AS1. Almost whole IASW works in AS1. The corrected procedure has access to all public CSSW and IASW procedures. Just for case all procedures, functions, constants, variables and types are defined in IASW as global, so they are accessible when constructing corrected software.

Step 2.
The new ADA package must be compiled with ADA compiler. The compiler must have access to the oryginal object files of CSSW and IASW, but under no circumstancies the oryginal sources of CSSW and IASW must not be compiled again. This implies the separate makefile for compiling of patches.

Step 3.
Before linking it must be decided where in memory the new package will be located. If only one procedure is replaced, and the size of the new one does not exceedes size of the oryginal one, it could be located just in place of the oryginal procedure. There is a weak point in this solution - two pieces of code try to fitt into the same memory. The linker will protest, and even if the linkage process wouldn't fail, there would be a doubt: which procedure has been put to the LDM file. So this solution seams to be not practical.
Otherwise the new package should be located in a free part of RAM. This must be the RAM area, which in the oryginal program was assigned as code area of AS1. There is not much to chose, because for some unknown reason it was not possible to define spare memory areas, and the only available free area is the unused remainder of the last page of AS1 code memory. If the new procedure uses data and constants, those must also be located in propper memory location. In IASW ver. 1.61 the free areas are:

Section	logical addresses	physical addresses
code	6400 .. 6FFF	1C400 .. 1CFFF
data	8DB0 .. 8FFF	1EDB0 .. 1EFFF
constants	1BA0 .. 1FFF	1BA0 .. 1FFF

To find this information one must inspect the linkage map file.

Step 4.
New package must be linked with the oryginal program. The linkage control file should be essentially the same as the one used for linking of the flight program, but with the following lines added at the end of list of includes for AS1:

```
include {JEMXIASW}/1750A/iasw_dpe_patch_.obj
include {JEMXIASW}/1750A/iasw_dpe_patch.obj
set IASW_DPE_PATCH.IASW_DPE_PATCH_B:$ISECT$'LADDR=6400i
set IASW_DPE_PATCH.IASW_DPE_PATCH_B:$DATA$'LADDR=8DB0o
set IASW_DPE_PATCH.IASW_DPE_PATCH_B:$CONS$'LADDR=1BA0o
```

Step 5:
The load module (.ldm), which is result of linking, contains memory image of the code and constants. To build the patches one must find the fragments of load module under specific physical addresses - in our example 1C400 for code and 1BA0 for constants. The size of patches can be calculated from data in map file, but the calculation will be probably not needed, because it should be clear in the .ldm file where is the end of the patch.
This way we have binary images for patches for code and constants. This is not yet sufficient, because at this stage our new code is dead in the sense that there are no references to it from the main program. Another patch is needed to make a redirection from the old procedure to the new one. This patch should be loaded at the address starting the old procedure. The patch contains instruction of long jump to the new procedure. In the example above, if the package IASW_DPE_PATCH contains only one procedure, this patch will be "7070 6400", where 7070 is code for long jump instruction (TBC) and 6400 is the logical address for the start of new procedure.

Step 6:
The patches must be loaded to DPE memory with use of CDMU command TC(6,1). Please remember that CDMU requires BYTE ADDRESSES. It is good practice to load body of the new procedure first and then the redirection.

Component description

*/*Describe each component. Structure this section according to the physical model.*/*
5.n [Component identifier]
5.n.1 Type
*/*Say what the component is (e.g. module, file, program etc.)*/*

5.n.2 Function
*/*Say what the component does.*/*

5.n.3 Interfaces
*/*Define the control and data flow to and from the component.*/*

5.n.4 Dependencies
*/*Describe the preconditions for using this component.*/*

5.n.5 Processing
*/*Describe the control and data flow within the component.*
Outline the processing of bottom-level components./*

5.n.6 Data
*/*Define in detail the data internal to components, such as files used*
for interfacing major components. Othervise give an outline description./*
5.n.7 Resources
*/*List the resources required, such as displays and printers.*/*

Feasibility and Resource Estimates

*/*Summarise the computer resources required to build, operate and maintain the software.*/*

User Requirements vs Software Requirements Traceability matrix

*/*Provide tables cross-referencing user requirements to software requirements and vice versa.*/*

Software Requirements vs Components Traceability matrix

*/*Provide tables cross-referencing software requirements to components and vice versa.*/*