OP-HIR-167

HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

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Subject / Title: **FLIGHT OPERATIONS CONCEPT DOCUMENT** (FOCD)

Contents / Description / Summary:

This document is one of a set which lies at the same 'level' at the ITS in the HIRDLS requirements documentation tree, into which the HIRDLS top-level requirements are flowed-down after interpreting and/or allocating as described/tabulated in the SPRAT.

This initial released version of the FOCD (after incorporating comments) has been compiled now in order (a) to capture the Flight Operations requirements identified in the most recent SPRAT revision, and (b) to document the assumptions being made about the Flight Operations scenario, in the absence of more specific guidelines at this time.

Other aspects of HIRDLS Flight Operations will be addressed in this document in later revisions.

Key Words: Instrument; Flight Operations; Commanding; Monitoring; Activation

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EOS

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1. SCOPE

This initial version of the FOCD has been compiled now in order (a) to capture the Flight Operations requirements identified in the most recent SPRAT revision, and (b) to document the assumptions being made about the Flight Operations scenario, in the absence of more specific guidelines at this time.

Other aspects of HIRDLS Flight Operations will be addressed in this document in later revisions.

NOTE 1: Use of Capitals

Some words begin with a capital, e.g. Mode, State, Stored Command, etc. This is to signify that the term is (or will be) formally defined in the HIRDLS Glossary of Terms, etc. [see SP-HIR-149].

NOTE 2: Use of "shall" and "will"

The word "shall" is avoided in this document since it does not currently contain formal requirements. Flight Operations will be formalised later, either in this document - which would be re-titled e.g: "Flight Operations Requirements" - or in another [TBD] document.

The word "will" denotes a flowed-down requirement which is formally specified in another document (e.g. the ITS) and is being assumed, or referred to, in this document. It is also used to denote a requirement which is known but not yet formally documented.

NOTE 3: Use of bold format

Statements and references for which review comments are specifically invited from NASA or TRW are marked in bold font.

2. APPLICABLE DOCUMENTS

Later

3. MAJOR HIRDLS FLIGHT OPERATIONS CONCEPTS

3.1 Main operational objectives

Flight operation of the HIRDLS instrument will be directed toward the following objectives:

> to acquire routine, long-term data sets using a very small number of (ideally one) basic operating Modes;

> to perform research-type investigations into atmospheric composition and dynamics, including participation in correlative measurements involving other parts of the EOS program;

> to respond in a flexible and timely way to unplanned events such as volcanic eruptions, solar flares or sudden stratospheric warmings;

> periodically to activate special calibrating modes (including spacecraft pitch maneuvers), occasional 'decontamination' of exposed cryogenic surfaces, etc;

> to maintain the health and safety of the HIRDLS instrument.

3.2 Flight Operations Aspects of HIRDLS Instrument Design

In order to achieve maximum operational flexibility, several of the instrument subsystems are 'programmable' to the extent specified below. These subsystems are controlled from a central processor referred to herein as the Instrument Processor (IProc). Subsidiary microprocessors are included in some of the subsystems for local control purposes, but - in general - their function is not addressed in this FOCD.

3.2.1 Summary of Instrument Processor (IProc) functions

a) to receive external commands and to respond to them, or distribute them to instrument subsystems as appropriate;

b) to collect telemetry data from the instrument subsystems and to format and buffer these data for use internally by the SAIL routines, and for collection by the spacecraft;

c) to control the (occasional) operation of a small number of macro routines mainly associated with instrument health and safety;

d) to control the digitisation and FIR filtering of the radiance data from the signal channels, optical bench attitude data from the Gyroscope channels, and scanner angle data from the elevation and azimuth encoders;

e) to control the operation of heaters placed in strategic locations within the instrument;

f) to control the operational state of the instrument subsystems according to the various Mode definitions;

g) to determine the operational profiles of the instrument mechanisms.

3.2.2 SAIL routines

SAIL (Science Algorithm Implementation Language) is a simple, high-level language developed for the HIRDLS instrument from similar languages used on previous instruments. It will allow test and operational instrument routines to be constructed quickly and efficiently to ensure flexibility of operation with the minimum of flight operations complexity and logistics support over the lifetime of the instrument in orbit.

The SAIL language comprises a set of directives which will be used by the HIRDLS Science and Operations teams to compile time-related and/or conditional operational control sequences for the instrument subsystems.

New SAIL routines will be compiled on the ground to generate binary "microloads" for uplinking to the IProc. Prior to uplinking, the compiled routines will be tested using a HIRDLS Instrument Simulator which will use the same software as the IProc.

The IProc software includes an interpreter for SAIL, which executes the SAIL directives according to clearly-defined rules. Uplinked "microloads" will be stored in a Library area of memory where they can be accessed by SAIL processes ("Tasks").

The IProc will support up to 16 SAIL Tasks, which will be run in a fixed, repeating sequence. Each SAIL Task will in general control a specific subsystem function or functions.

A table-driven approach is used for SAIL, as for many other IProc-controlled processes, to minimise the need for new SAIL source code. Additional flexibility will be provided by assigning several 'parameters' to each SAIL task. These 'parameters' can be changed by simple ground- or stored-commands in order to modify the operation of a SAIL Task.

Section 3.2.3 summarises the SAIL routines at present envisaged. They fall into two broad categories: subsystem status control, and mechanism position control. They are listed for each instrument subsystem in turn.

3.2.3 HIRDLS Subsystem status and mechanism position control

a) STH - Structure/Thermal Subsystem: no SAIL control of this subsystem

b) SSH - Sunshield Subsystem: the moveable Sunshield Door angle will be controlled by a SAIL routine, with optional macro over-ride to a Safe State in the event of certain error conditions. See Section 4.7 for a more detailed description.

c) GSS - Gyroscope Subsystem: no SAIL control of this sub-system in normal circumstances. Safing routines are TBD.

d) TSS - Telescope Subsystem: no SAIL control of the Chopper mechanism in normal circumstances; safing routines are TBD. The scanner elevation and azimuth shaft angles will be controlled by a SAIL routine, with optional macro over-ride to a Safe State in the event of certain error conditions. Control time-tables and /or algorithms and coefficients will be generated by ground processing ahead of time and uplinked. A 'scan cycle' will consist of an atmospheric scan, a brief view of the IFC black body and a 'flyback' while viewing space to the starting point of the next cycle. Thus the 'scan cycle' includes radiometric in-flight calibration (IFC) views. Scan angle parameters will vary around the orbit, and for different Submodes of Mission Mode. Optical Bench heaters - if used - will be under SAIL control, either in a thermostatic mode or in a constant-power mode.

e) DSS - Detector Subsystem: no SAIL control of this subsystem in normal circumstances. Safing routines are TBD.

f) IFC - In-Flight Calibrator Subsystem: the IFC black body heater will be under SAIL control, either in a thermostatic mode or in a constant-power mode.

g) IPS - Instrument Processor Subsystem: no SAIL control of the IPU; a SAIL routine may control Digital Filter parameters for the "science" data channels.

h) CSS - Cooler Subsystem: CSS operation will normally be autonomous: the Coolers will be running in a steady State. If a CSS State change is required, the necessary command sequence will be generated by a SAIL Task and invoked by a Stored Command (e.g. Cryo-decontamination). Safing routines are TBD.

j) PSS - Power Subsystem: some subsystem power lines will be switched on or off according to instrument Mode. This would normally be performed by ground-command - see section 5. Safing routines are TBD.

4. FLIGHT OPERATIONS CONCEPTS FLOWED DOWN FROM SPRAT

This section addresses several Flight Operations requirements included in HIRDLS document TC-HIR-57: "System Performance Requirements and Allocation Tables (SPRAT)". Some require that provision be made within the instrument design; in such cases the SPRAT requirement has also been flowed down to the ITS. In other cases the operational requirement will simply be fed into the Flight Operations Plan. The following Mode and State descriptions are consistent with those specified in the ITS.

4.1 IProc ROM requirements

The IProc will include (in a non-volatile ROM) the essential on-board 'system' software and a complete set of subsystem control routines and tables to allow full operation of the instrument in a default mode without the need to uplink microloads, or any commands other than the minimum set necessary to activate the instrument. ROM routines will be finalised as late as possible.

4.2 Instrument Modes and States

Major Instrument Modes, Submodes and States are defined in the ITS. These are table-driven and can therefore be re-defined if necessary in the light of operational experience, or to attempt to overcome a malfunction, etc. See Section 5.

4.3 Instrument activation

Instrument Activation in orbit from a power-off condition (OFF or SURVIVAL Modes) will be accomplished by running a specified Sequence of procedures in the EOS Operations Centre (EOC). Such procedures will contain the necessary commands, microload directives and telemetry checking routines considered necessary to ensure safe instrument activation. The same remarks apply to re-activation from intermediate Modes (e.g. SAFE).

Activation will occur in stages, with status checks following each stage. The basic Activation Sequence will be the same each time the HIRDLS instrument is powered-on in orbit, except that the single shot, post-launch uncaging (unlatching) operations would be omitted after the first Activation Sequence has been successfully completed.

For a provisional list of the power-switching commands to be used during Activation, refer to SP-HIR-169: "HIRDLS Power Distribution, Switching and Grounding".

4.4 SAIL and Macro access to telemetry data

For instrument control purposes, every function which appears in the science telemetry stream will be accessible to the subsystem control sequences in the IProc (i.e. SAIL, Macros, etc.). This will provide maximum flexibility in writing control routines. Pre-defined Macros will be resident in IProc memory for purposes of instrument safing, fault management, etc. These are not intended to be modified beyond some point in the instrument/ spacecraft test schedule. Should a Macro become invalid for any reason immediately prior to, of at any time after launch, it will be inhibited and (typically) replaced by a new SAIL routine.

4.5 Scan angle control

The scanner elevation and azimuth shaft angles as functions of time will derived by a SAIL task from data values contained in a Scan Control Table, and provided to software in the Telescope Electronics Unit (TEU) via system calls. Scan Control Tables will be loaded from the ground and there will be sufficient space in the memory to accomodate several different tables (i) to enable the tables to be revised without the need to cease observing, (ii) to enable different sequences to be employed depending on the geographical location or for special purposes such as high spatial resolution modes. The individual tables will normally define the sequence for one observation cycle of approximately 66 sec (TBV), and will provide the angles in a form that can be offset in elevation to allow for attitude variations and Earth-oblateness, and scaled in azimuth and elevation to allow for restricted azimuth ranges that may be required. A single table will normally be used repeatedly. The exact timing and control of the scanner movements will be controlled by software in the TEU.

4.6 Temperature control

Each operational heater will have two modes: (a) thermostatic and (b) constant power. In the thermostatic mode the heater setting will be controlled by a table-driven 'PI' or 'PID' loop in the IProc, to maintain a constant, defined temperature. In the constant power mode the power dissipation will be preset to a fixed value. Heater mode and setting would normally be determined by SAIL but could also be selected by ground- or stored-command.

Currently heaters are fitted to the IFC Black Body (BB), the (IFC) calibration mirror (CALMIR) and the Warm Filter & Lens Assembly (WFLA). The BB and CALMIR temperatures need to be set to within 1 C of each other and slightly above the lowest temperature at which proper control can be achieved. For special calibration checks the BB will be capable of being heated by about 25 C. This will be done infrequently.

The WFLA will be set to a constant temperature to maintain correct focussing of the telescope, and correct spectral pitching of the Warm bandpass-defining optical filters.

4.7 Sunshield door control

The Door will normally be fully open, but is required partially to close for 10-15 minutes per orbit. The timing and extent of the closure is latitude-dependent, with a seasonal variation.

The door motor will be commanded from a SAIL task which specifies the door angle as a function of time, based on a table loaded from the ground. Provision will be made for reloading the table at weekly (TBV) intervals without interrupting door operation. The timing will be relative to equator crossings, which will be obtained from spacecraft telemetry, either as a time marker or from the satellite ECI coordinates.

Sun/shadow sensors fitted to the Sunshield Assembly will be used by the SAIL task to monitor the operation of the Sunshield moving door as follows:

> to indicate when the sun is illuminating the -X face of the instrument such that it could potentially shine into the instrument aperture;

> to detect the position of the edge of the shadow cast by the Sunshield door in order to verify that the sunshield is correctly positioned.

5. SWITCHING BETWEEN HIRDLS OPERATING MODES AND SUBMODES

5.1 Definition of Instrument Modes, Submodes and States

The instrument major Modes have been specified in the ITS for instrument design and build purposes, and will be described in more detail in the HIRDLS Command & Telemetry Handbook. In summary, Instrument Modes currently defined are OFF; SURVIVAL; IDLE; LOW_POWER; STANDBY_1; STANDBY_2; MISSION.

Instrument Submodes (which in general map on to more than one Mode) are DEFAULT; CAGED; SAFE; DECONTAM; SPECIAL.

For each valid Mode/Submode combination, each Instrument Subsystem will have a defined State. The current baseline States for each Mode and Submode are tabulated in the ITS. For reference only, this ITS table is reproduced as an appendix to this FOCD.

5.2 Procedures for Switching between Modes and Submodes

The Flight Operations procedures for switching between valid Mode/Submode Combinations will be of two types, as follows:-

> CAGED Submode will always be entered and exited by ground command sequences ONLY, normally generated by running an ECL Procedure; only certain transitions will be permitted.

> Permitted transitions between all other Mode/Submode combinations will be controlled by a TBD choice of ECL Procedure, IProc Macro, SAIL routine or S/C Stored Command sequence. Some composite sequences are also likely to be needed, e.g. an ECL Procedure invoking an IProc Macro for correct relay sequencing, etc.

The available options for each specific transition have not been fully determined at this time. However, some general statements can be made, as follows:

> ECL Procedures will be compiled and available as an option for all transitions, with very few exception, if any.

> Instrument Activation, and any other sequences which involve switching POWER ON to a Subsystem will be performed ONLY by ECL Procedures run in the EOC or in the STC at TRW.

> IProc Macros and/or S/C Stored Command Sequences will be compiled to perform autonomous Instrument safing, including some POWER OFF sequences.

> Transitions between Modes (if any) or Submodes which do not involve Subsystem POWER ON commands may be performed by Ground Commands (from an ECL Procedure, even if only one command is needed) or by IProc Macros, probably invoked by time-tagged Stored Command.

5.3 Outline ECL Sequences for Instrument Activation

The following "outline" ECL Sequences have been compiled; they can be found in the current SPRAT and will in due course be updated and included in a future revision of this FOCD.
The term "outline" implies that they have not yet been converted into correct ECL syntax:-

> Uncaging Procedure;
> Activation Sequence from OFF/SURVIVAL Mode to IDLE Mode;
> Activation Sequence from IDLE Mode to LOW_POWER Mode;
> Activation Sequence from LOW_POWER Mode to STANDBY_1 Mode;
> Activation Sequence from STANDBY_1 Mode to STANDBY_2 Mode;
> Activation Sequence from STANDBY_2 Mode to MISSION Mode.

5.4 HIRDLS Power Switching Assumptions

The following assumptions have been made with respect to the switching of HIRDLS power lines on the spacecraft:

> the HIRDLS Survival Heater Buses (SBA, SBB) will normally be ON, and may be switched ON or OFF for S/C power management reasons. The SBA/SBB inputs will NOT be switched within a HIRDLS ECL Procedure;

> the HIRDLS Quiet Buses (QBA, QBB) and Noisy Buses (NBA, NBB) may be switched OFF for S/C power management reasons, or by means of an ECL Procedure, or by Stored Command, or by time-tagged commands derived from a HIRDLS Daily Activity Plan.

> the HIRDLS Quiet Buses (QBA, QBB) and Noisy Buses (NBA, NBB) will NOT be switched ON except by means of a HIRDLS ECL Procedure, except during during S/C I & T at TRW, where the HIRDLS Quiet Bus and Noisy Bus commands will be external to HIRDLS ECL procedures, the corresponding internal commands being "commented out".

6. FLIGHT OPERATIONS - GENERAL ASSUMPTIONS AND TERMINOLOGY

The following assumption have been made, and the following terminology used; these will be updated as required if/when different procedures or terms are adopted or specified by or on behalf of NASA:

6.1 EOS Operations Control Center

The "EOS Operations Center" (EO) [existing term] refers to the location (GSFC/Bldg-32) from which EOS/Chem real-time Flight Operations will be conducted.

6.2 EOS/Chem Flight Operations Team

The "EOS/Chem Flight Operations Team" (Chem-FOT) will be located at the EOC and is the team responsible for the management of the EOS/Chem spacecraft and its instruments

6.3 EOS/Chem Mission Planning Group

The term "EOS/Chem Mission Planning Group" (Chem-MPG) refers to the team located in GSFC Bldg-32 who will be responsible for co-ordinating the instrument and S/C activity planning, generating S/C uploads, etc. and "delivering" these to the Chem-FOT ahead of real time.

6.4 HIRDLS Flight Operations Team and Groups

The "HIRDLS Flight Operations Team" (HFOT) refers to the joint US-UK team involved in HIRDLS Instrument flight operations. The HFOT will comprise a CU-based "HIRDLS Flight Operations Group" (HFOG-US) and an Oxford-based "HIRDLS Flight Operations Group" (HFOG-UK). The current Operations Plan calls for one HFOG to be "active" and the other "backup" at any time for Commanding purposes. Telemetry analysis will we performed by both groups.

6.5 HIRDLS Instrument Support Terminal

The "Instrument Support Terminal" (IST) [existing term] is a Unix Workstation with a software 'toolkit' to be supplied by NASA to the HFOT for the primary purpose of communicating with the EOC and Chem-MPG.

For the purposes of this FOCD, the term "HIST" (HIRDLS IST) represents all the processing and other hardware and software capabilities required to conduct HIRDLS Flight Operations at a given location.

Two ISTs will be required for HIRDLS, one in the UK and one in the US. This may well be a "non-standard" situation with regard to inter-communication between the ISTs and the EOC/Chem-MPG; DAPs and other formal "operational" inputs would normally be accepted by only one IST per Instrument Team. A modus-operandi will be agreed with the EOCC/Chem-MPG and other operational groups which will identify which IST is or will be "active" at any time.

6.6 ECL Procedures and Command/Telemetry Databases

The term "ECL Procedure" describes formal, scripted command sequences using specified syntax, and run in real time to transmit commands or initiate memory loads direct to the HIRDLS Instrument. Some HIRDLS ECL Procedures will include commands to the S/C Power Subsystem for switching HIRDLS QB or NB power.

HIRDLS ECL Procedures will be compiled during the Instrument Test and Calibration phases, and will be run on the HIRDLS IEGSE. These procedures will be ported to the Spacecraft Test Computer (STC) at TRW, together with configuration-controlled Command and Telemetry Databases, for use during S/C I & T.

The same Procedures and Databases will also be ported to the EOC for use during Instrument Activation in orbit, and will reside on the EOC computer for the duration of the mission.

6.7 Microloads

The term "Microload" refers to HIRDLS microprocessor "memory load" files containing SAIL Routines, Tables, etc. for direct uplink to the HIRDLS IProc for routine Flight Operations.

Microloads will be prepared on the HIST from computer-generated tables or from SAIL source code, using configuration-controlled Compiler and Assembler. After compilation, Microloads will be tested on the Instrument Simulator to verify correct operation.

Verified Microloads will be transmitted from the HIST to the Chem-MPG ahead of time for installation into the Chem-FOT Microload "Library", and called either from a HIRDLS ECL Procedure or via a DAP (see next para.). They are expected to remain resident in the Library for a specified period of time.

6.8 Daily Activity Plan

Following successful Activation in orbit, the "Daily Activity Plan" (DAP) will be used to control the routine operation of the HIRDLS instrument in Mission Mode.

DAPs will be generated on the HIST according to specified rules and procedures, and submitted according to specified timetables. One DAP will be transmitted per day, TBD days ahead of real time, from the HIST to the Chem-MPG host computer.

DAPs will contain time-tagged commands and/or Microload uplink directives. Microload uplink directives - which will have been assigned a wide (several hours) execution window - will be passed to the Chem-FOT for execution during a suitable Ground Pass. Time-tagged commands will be assembled by the Chem-MPG into a "S/C Daily Command Load" table.

6.9 Configuration Control

Configuration control of SAIL routines, Daily Activity Plans and all other Flight Operations files and software will be strictly enforced at all times. Version and table identities will be embedded in the telemetry format, and documented procedures adhered to.

7. SIGNAL CHANNEL SAMPLING AND OTHER TELEMETRY FORMAT OPTIONS

Here follows a summary description of the major HIRDLS Telemetry attributes, necessary for an understanding of Instrument health and status monitoring concepts.

7.1 Constraints on telemetry data format

The ITS specifies that the basic telemetry data format is to be the same for all modes of operation of the instrument. Signal channel data will be sampled at a fixed, uninterrupted rate, independent of instrument Mode to the greatest practical extent. In any case the telemetry stream will contain flags indicating which science data format is in use.

The Science Data Stream includes all instrument telemetry data, including 'engineering' data. The Engineering Data Stream packages described in the GIRD will contain data copied from the science data stream, often at lower sample rates, as defined by the HIRDLS Telemetry List in the C&THB.

The instrument telemetry data will be valid at all times except when the instrument is in its OFF or SURVIVAL modes, in which case the telemetry data will consist of 'zeros', subject of course to obvious lack of data from inactive Subsystems.

The instrument Science Stream telemetry data will be passed via the S/C to the ground at a fixed, 65 kbits/sec rate in the form of data 'packets'. Every Science packet will be of the same length, and will consist of two fields, the first field containing valid data and the second field consisting of zero 'fillers'. The option will exist to replace the 'fillers' with diagnostic data (see 7.4). If additional diagnostic data space is required, it will replace normal data.

7.2 Engineering Data Stream

The Engineering Stream data will be passed via the S/C to the ground at a nominal rate of 512 bits/sec, consisting of approximately 3 packets/sec. Every Engineering packet will be of the same length, and will normally consist of two fields, the first field containing Fixed Format data and the second field Variable Format data. The Fixed Format field will contain all the engineering and status data to be decoded and displayed at the EOC, will not be sub-commutated within the Engineering Data packet, and will not be subject to any format changes once 'frozen' some time prior to launch. The EOC will ignore the data in the Variable Format field. See 7.3.

7.3 Engineering "Variable Format" Data

These data are considered re-formattable as required by HIRDLS and are intended to be used - together with the Fixed Format data - for Near Real Time monitoring at the HIRDLS Instrument Support Terminal (HIST) during or following each S/C pass over a Ground Station. The term "Variable Format" is explained in the C&THB.

7.4 Diagnostic Data Formats (DDF)

Diagnostic data formats will be defined by means of tables uplinked from the ground to the IProc and identified by flags within the telemetry data stream. Although some DDFs have been provisionally defined at this time, it is not planned to generate very many ahead of time. They will be generated and uplinked if and when required.

However, it is intended that Subsystem data be acquired by the IProc at the maximum rate likely to be useful, diagnostic scenarios included, and the HIRDLS Telemetry List in the C&THB has been compiled on this basis.

7.5 Radiance Data Format Options

In the Default Submode of Mission Mode ("Global Mode"), each of the 21 radiance signal channel outputs will be copied into the Science telemetry stream at one-sixth of the chopping rate, i.e. approximately 84 per second.

For some special Mission Submodes where increased altitude scan rates are used, it will be necessary to copy radiance data to telemetry at an increased rate to achieve the required degree of over-sampling. For these modes, only a sub-set of channels will be copied to telemetry in order to limit the total data rate to approximately the same as for the Default Sub-mode. Appropriate "Special" Submode rates have been defined and are documented in the C&THB.

8. NEAR-REAL-TIME (NRT) MONITORING OF INSTRUMENT TELEMETRY

It is expected that the HIRDLS Engineering Data downlinked during each Ground Station Pass (GSP) will be routed in near-real time (NRT) to the EOC for display both at the EOC and on the HIRDLS Instrument Support terminals (HIST).

As explained in 7.2, only part of the Engineering Data is intended for display at the EOC. To keep processing at the EOC as simple as possible, these data will not be subcommutated within the Engineering Data Packets, and will be of invariant format. They will contain instrument health data only, including those functions to be included in the Low Data Rate (32 bits/s) contingency-mode stream. The EOC/Chem-FOT will make whatever use they desire of the available HIRDLS data; they will not be required to perform routine monitoring on behalf of HIRDLS unless the NRT data link to the HIST is broken.

At the HIST, all HIRDLS Engineering Stream data will be automatically limit-checked every GSP. A core set of performance/trend plot files will be generated and formally reviewed, primarily by the active HFOG (see 6.4) but usually also by the backup HFOG, on a routine daily basis and more frequently following Activation or any other non-routine event. A primary goal is for both HFOGs to perform long-term trend analysis on all relevant data sets.

9. SPACECRAFT STATES AND INSTRUMENT SURVIVAL REQUIREMENTS

'Survival' refers to the ability of the instrument fully to recover from any externally-imposed abnormal condition. The term is usually applied to the case where normal instrument power is unavailable.

Spacecraft States are currently defined as LAUNCH; STANDBY; PROPULSION; SCIENCE; SAFE; SURVIVAL. Normal Instrument power should be available in all the above S/C States except LAUNCH, SURVIVAL and possibly SAFE.

Spacecraft Survival is a State into which the S/C will automatically transition following an anomaly which results in loss of normal attitude control. In this State, the S/C attitude will be with the -X axis direction pointing towards the sun and the S/C slowly rolling about this axis. In S/C SAFE State, power may or may not be available to the instrument, but the S/C attitude will be nominal.

When the instrument is in Mission Mode, the instrument temperatures will be such that all Survival Heater thermostatic switches will remain open. In the event of planned or unplanned loss of normal instrument power, the instrument will slowly cool down, the Survival heater thermostatic switches will close, and Survival Heater power will be dissipated to the extent needed to ensure instrument survival and 'cold-start'.

Instrument MODE ==>	OFF				SURVIVAL				IDLE				LOW POWER				STANDBY 1				STANDBY 2				MISSION	
MODE Number ==>	1				2				3				4				5				6				7	
Instrument SUB-MODE ==>	Default	Caged	Safe	Safe + Caged	Default	Caged	Safe	Safe + Caged	Default	Caged	Safe	Safe + Caged	Default	Caged	Safe	Safe + Caged	Default	Safe	Decontam	Safe + Decontam	Default	Safe	Decontam	Safe + Decontam	Default	Special
Quiet Bus (A or B)	off	off	off	off	off	off	off	off	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
Noisy Bus (A or B)	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
Survival Htr Bus (A and/or B)	off	off	off	off	ON	ON	ON	ON	undef [4]	undef [4]	undef [4]	undef [4]	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef
IPU power	off	off	off	off	off	off	off	off	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
Instrument Processor running	no	no	no	no	no	no	no	no	YES [1]	YES [1]	YES [1]	YES [1]	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
TEU Scan Processor running	no	no	no	no	no	no	no	no	YES [1]	YES [1]	YES [1]	YES [1]	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
1553 bus functional	no	no	no	no	no	no	no	no	YES [1]	YES [1]	YES [1]	YES [1]	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Telemetry channels functional	no	no	no	no	no	no	no	no	some [1]	some [1]	some [1]	some [1]	some	some	some	some	YES [3]	YES [3]	YES [3]	YES [3]	YES	YES	YES	YES	YES	YES
Sunshield Door drive power	off	off	off	off	off	off	off	off	off	off	off	off	off [2]	off [2]	off [2]	off [2]	safe	safe	safe	safe	ON	ON	ON	ON	ON	ON
Sunshield Door cage status	un-latched	latched	un-latched	latched	un-latched	latched	un-latched	latched	un-latched	latched	un-latched	latched	un-latched	latched	un-latched	latched	un-latched	un-latched	un-latched	un-latched	un-latched	un-latched	un-latched	un-latched	un-latched	un-latched
Sunshield Door position [5]	undef	closed	safe	closed	undef	closed	safe	closed	undef	closed	safe	closed	undef	closed	safe	closed	undef	safe	undef	safe	undef	safe	undef	safe	undef	undef
Scan drive power	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	ON	ON	ON	ON	ON	ON
Scanner cage status	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged
Scanner position	undef	undef	safe	safe	undef	undef	safe	safe	undef	undef	safe	safe	undef	undef	safe	safe	undef	safe	undef	safe	undef	safe	undef	safe	scanning	undef
Space View Aperture door [6]	undef	closed	undef	closed	undef	closed	undef	closed	undef	closed	undef	closed	undef	closed	undef	closed	undef	undef	undef	undef	undef	undef	undef	undef	OPEN	OPEN
Gyroscope subsystem power	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
Operational Heaters	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	undef	undef	undef	undef	ON	ON	ON	ON	YES	YES
Radiometric temperatures stable	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	undef	undef	undef	undef	YES	YES
Cooler compressor cage status	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	motors shorted	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged	un-caged
Cooler power	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	ON	ON	ON	ON	ON	ON
Compressors running	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	YES	YES	undef	undef	YES	YES
Displacer running	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	undef	undef	no	no	YES	YES
Detector temperature status	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	undef	COLD	COLD
Detector bias power	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	off	undef	undef	off	off	ON	ON

Notes

1 When processor booting (if applicable) has completed
2 Except when UNCAGE Procedure run
3 Except CSS telemetry
4 Formally undefined but normally ON
5 Safe means any position between closed and 60 degrees open
6 Once opened on orbit, SVA door would normally remain open

Appendix 1 - Table of Modes, Submodes and Subsystem States (copied from ITS)

Appendix 2 - LIST OF ACRONYMS

C&THB	[HIRDLS] Command & Telemetry Handbook
DAP	Daily Activity Plan
ECL	EOC Command Language
EOC	EOS Operations Center
FIR	Finite impulse response
FOCD	Flight Operations Concept Document [this document]
FOT	Flight operations team
GIRD	General Interface Requirements Document
GSP	Ground station pass
HFOG	HIRDLS Flight Operations Group
HIST	HIRDLS Instrument Support Terminal
IProc	Instrument Processor
IST	Instrument Support Terminal
ITS	[HIRDLS] Instrument Technical Specification
MPG	Mission Planning Group
NRT	Near-real time
PI(D)	Proportional-integral(-differential)
ROM	Read-only memory
SAIL	Science Algorithm Implementation Language
SPRAT	System Performance Requirements & Allocation Tables
STC	System Test Controller
TBD	To be defined
WFLA	Warm Filter & Lens Assembly