JAXA/SLB/TechNote/MODA/010

JAXA Solar-B Project Office

Solar-B Command Planning and Interface Issues for ISACS-PLN

Rev. 0.5: 2005 Apr 13

Revision History

	Date	Authors (Affiliation)	Issue
Rev. 0.0	2005 Feb 08	H. Hara (NAOJ/NINS)	All new; not completed
Rev. 0.4	2005 Apr 5	H. Hara (NAOJ/NINS)	Correction & addition
Rev. 0.5	2005 Apr 13	K. Matsuzaki (ISAS/JAXA)	Initial Release

Applicable Documents

SLB-123/Rev.5 (Dec 2003)	Solar-B Telemetry/Command Design Standard
SLB-132/Draft Rev.5 (May 2004)	Solar-B Telemetry/Command List
JAXA/SLB/TechNote/MODA/001	The Outline of Solar-B Mission Operation and Data Analysis
JAXA/SLB/TechNote/MODA/010.2	Solar-B Command Planning and Interface for ISACS-PLN Appendix 2 Data Recording
JAXA/SLB/TechNote/MODA/010.3	Solar-B Command Planning and Interface for ISACS-PLN Appendix 3 Orbit, Pointing, Doppler Shift Compensation

1. Introduction

This document gives a scope of Solar-B operation with JAXA ISACS-PLN system.

2. Basic Knowledge for Solar-B Operation

SIB (& SIB command): Satellite Information Base; all Solar-B related commands are registered in the Solar-B SIB (SIB command). Each command consists of multiple hexadecimal numbers each of which is called BC (Solar-B command structure is IC+DC+BC1+BC2+…+BCn. SOT/XRT/EIS only receives BC1+BC2+…+BCn.). The maximum number of BC is 128 (n_{max}=128). Only memory upload commands can have 133 BCs at maximum as an exceptional case. In the SIB, registered items for commands are the name of a command, length of the command, fixed portion of the command starting from IC+DC, and relationship between the command and a status in telemetry. BCs that are variable act as parameters of the command and they are not registered in SIB. The name of a command in SIB is referenced in the ISAS commanding EGSE (Electrical Ground Support Equipment) when the command is described in a command plan.

Real-time command: Uplink commands to Solar-B spacecraft can nominally be issued from operation center (Sagamihara Space Operation Center – SSOC, Uchinoura Space Center - USC) of JAXA. The commands need be registered in the Solar-B SIB.

OG: OrGanized command in the Solar-B spacecraft; a macro command which includes commands registered in the Solar-B SIB. Solar-B has 512 OGs and each OG has 8 slots each of which can include a single SIB command. A command in each slot is executed in 62.5 msec. SIB commands whose BC length is larger than 13 octets cannot be set in OG. Each OG can be executed from the ground as real-time OG (ROG) and from OP.

OP: Operation Program in the Solar-B spacecraft; a list of OG names and interval time between two consecutive OGs are described in a time-line manner. 4096 OGs can be set in a single OP with minimum (maximum) interval of 0.5 (0.5×16383) sec and each OP slot is called control element (CE). After starting OP, OG in each OP slot is executed with an interval of the previous OG. OP and OG are uploaded to the spacecraft with a normal memory upload procedure.

DCBC sub plan: command sequence registered in the S/C control EGSE at the uplink station. 100 DCBC sub plans can be registered there.

Memory Map: memory data for memory upload/dump in the format of Intel Hex.

ISACS-PLN (Intelligent Satellite Control Software –Planner): Spacecraft-level planning software. This creates a final command plan for the Solar-B operation from various inputs. Real-time commands, DCBC sub plan, OGs, and OP are made finally. SOT/XRT/EIS teams need to do each planning according to the format of ISASC-PLN system for easier/faster interface. Commands that are not defined in SIB are rejected by this system.

Duration of a single uplink/downlink contact: 8 to10 min is only available for a single uplink/downlink contacts.

Number of downlink contacts in a day: 4 to 5 contact passes at Uchinoura in Japan and 15 max contacts at Svalbard in Norway.

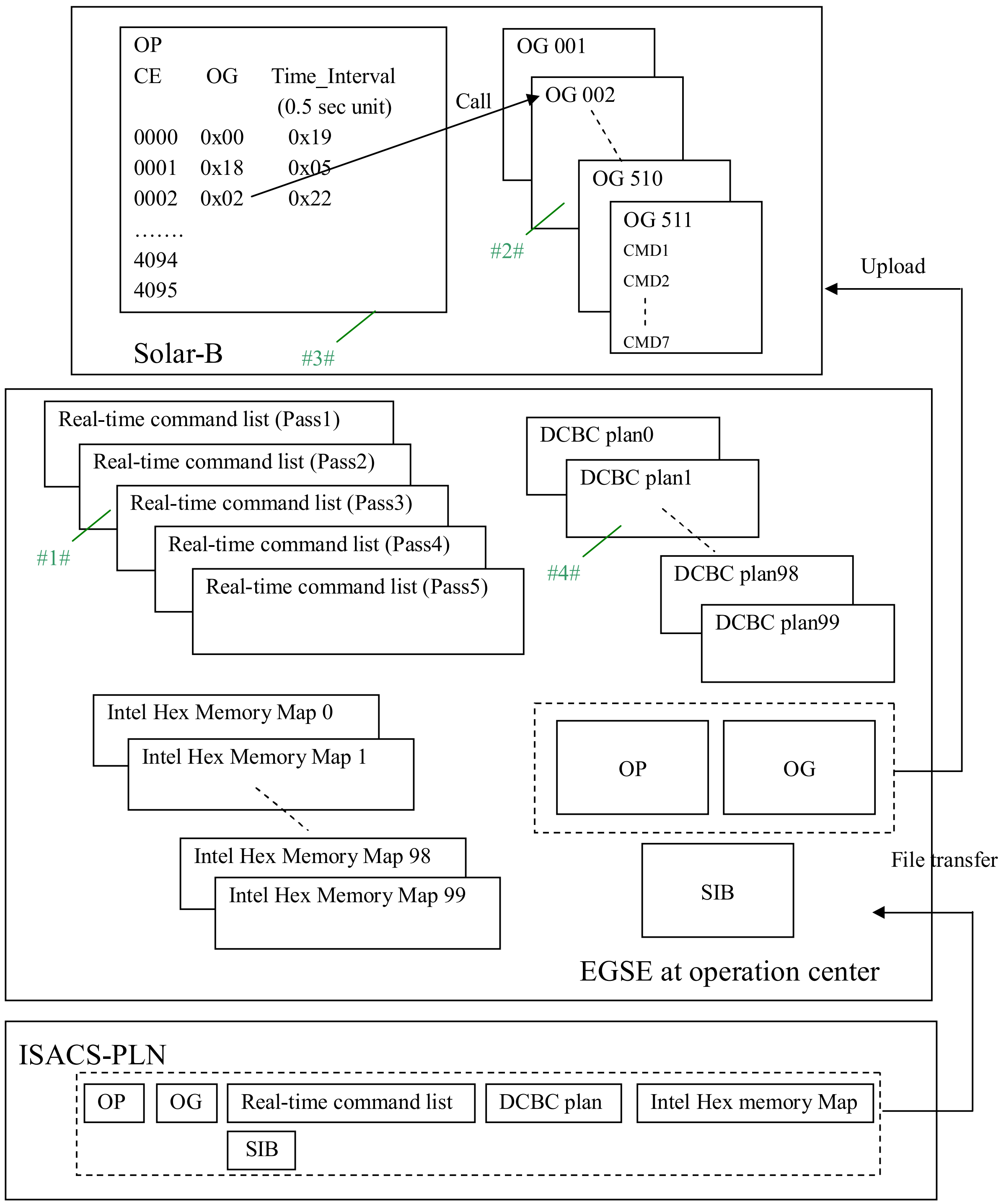

Figure 2-1: Key Elements for Solar-B Operation

3. Commanding in Solar-B Operation

There are a few types of commanding operations in the Solar-B operation.

1. commanding from operation center (real-time commanding from SSOC, USC)
2. memory upload/dump procedure from operation center
3. on-board commanding from OP/OG

A spacecraft command plan for a certain day is made by the Chief Planner. In this process command plans from each subsystem are merged to a single command plan of the spacecraft level. Each subsystem team shall prepare a command plan for operation of its subsystem in the format of ISACS-PLN before the Chief Planner starts to compile the spacecraft-level command plan.

4. Input to ISACS-PLN

Input of ISACS-PLN is a free-format language. All of the identifier is case sensitive. In the use of Solar-B operation, only capital letter shall be used except for comment message.

4.1 Types of Input

Three types of inputs are required to make the spacecraft-level command plan; these are *Event*, *Request*, and *Knowledge base*.

Event: Once the orbital element is determined, orbit related events are known. For example, entry and exit time of radiation belt, entry and exit time of downlink station, time of spacecraft day and night etc. are *Event*s for Solar-B. SOT/XRT/EIS Chief Observers will need the information of *Event* for each instrument operation as shown later. Although a type of observation in a telescope may be considered as an *Event*, <u>the instrument operation is not regarded as an *Event* in Solar-B as baseline.</u> The following is an example of *Event*. The command sequence for each *Event* is defined by a *Sequence*. The name of *Event* is used when it is called in an *Execution Definition*.

Example for explanation.
File: DayNight_20061001_01.soe
Name of *Event*: Year/MM/DD.hh:mm:ss (UT) ;

```
DAY          : 2006/10/01.09:15:02 ;
NGT          : 2006/10/01.10:16:22 ;
DAY          : 2006/10/01.10:56:31 ;
      ⋮
```

Figure 4-1: *Event* Request format

Request is a file in which requests for system/subsystem operation are described in *Observation Request Language* (ORL). Extension of the file is ".orl". *Event* like entry of radiation belt can also be expressed in this form. The subsystem users prepare their own command plan in the ORL format.

Knowledge base is basic knowledge for planning of the spacecraft operation. SIB is a *knowledge base*. Fixed data used for compiling *Request* is another *knowledge base*. Some *Request*-format file becomes a *knowledge base* as a template. The JAXA personnel of Solar-B ISACS-PLN system can only access the *knowledge base*.

4.2 Elements of *Request*

There are concepts of *Point*, *Sequence*, and *Execution Definition* in *Request*.

Point: *Point* defines a timing relative to an *Event*. The command sequence for each *Point* is defined by a *Sequence*. The name of *Point* is used when it is called in an *Execution Definition*. *Point* is described in *ORL* format. The following is an example. A *Point* named DAY_SOT-XRT-EIS defines a timing 2 min after every DAY *Event*. A command procedure called by DAY_EIS *Point* is defined in a *Sequence*.

POINT-AT 'Name of *Event*' relative_time_to_*Event* { ……}

```
POINT-AT DAY +120 {/* 2min after S/C Day Event */
            POINT : DAY_EIS;
}
```

Figure 4-2: *Point* Request format

As a baseline any *Point* is defined by the JAXA personnel of the Solar-B ISASC-PLN system, not by the Chief Planners and Chief Observers. The JAXA personnel will set *Point Request* based upon communication with Chief Planners and Chief Observers.

Sequence: Both spacecraft and EGSE at operation center have capabilities to hold set of commands. In ISACS-PLN, a set of commands is described in a *Sequence*. ISACS-PLN translates a *Sequence* into the capabilities of spacecraft and EGSE (Table 4-1).

There are 8 types of Sequence (REAL, OP, COMMON, OG, RQOG, ATOG, DCBC, OPSUB) in ISACS-PLN. In Solar-B, these are used in different purpose. A few types, DCBC, OG, OP, and REAL, are only available to the Chief Planners and Chief Observers. Some OGs that are related to the spacecraft safety can only be edited by the JAXA personnel for safety reasons.

Some types of *Sequence* (OG, DCBC, RQOG, ATOG, OPSUB) in ISACS-PLN are directly mapped with capability to hold command set of either spacecraft or EGSE (Figure 4-3). Sets of commands in the other types of *Sequence* (REAL, OP) are once assembled internally by ISACS-PLN (Figure 4-4). Assembled command sets in period enclosed by MAIN_START and MAIN_END events are mapped into Real time command list of EGSE. Assembled command sets in period enclosed by OP_START and OP_END events are mapped into OP in spacecraft. Commands located at out side of the specified period cause report of error in the merge process.

	Stored in	Correspondence		CP & CO
REAL Sequence	EGSE	Assemble		Available
OG Sequence	Spacecraft	Direct map		Available
OP Sequence	Spacecraft	Assemble		Available
DCBC Sequence	EGSE	Direct map		Available
RQOG Sequence	Spacecraft	Direct map		NA
ATOG Sequence	Spacecraft	Direct map		NA
OPSUB Sequence	Spacecraft	Direct map		NA
COMMON Sequence	Spacecraft or EGSE	Assemble		NA

Table 4-1: types of *Sequence*

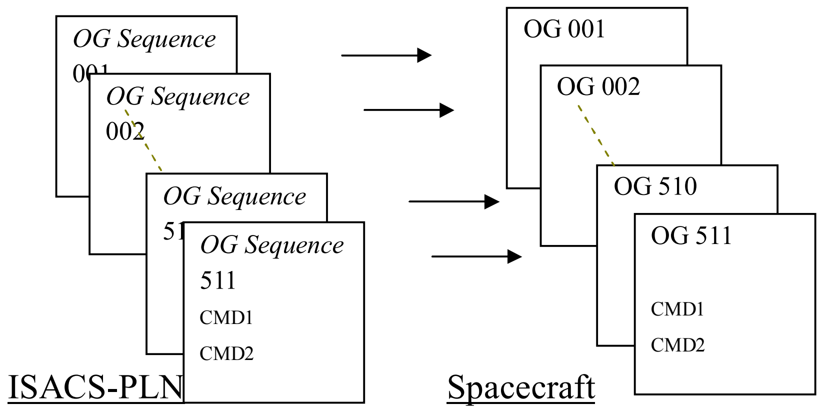

Figure 4-3: Example of direct mapping of *Sequence*

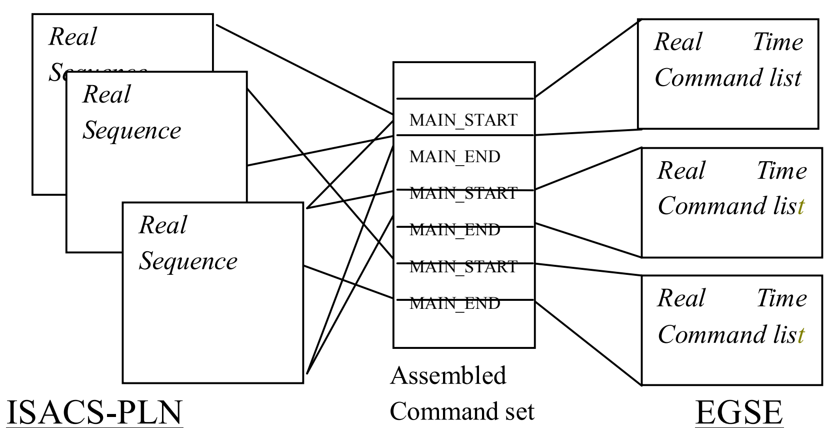

Figure 4-4: Example of assembly of command set by ISACS-PLN

REAL Sequence: A *REAL Sequence* defines a set of commands used in a real-time operation for a purpose. Commands in *REAL Sequence* are executed at operation center (#1 in Figure 2-1).

OG Sequence: An *OG Sequence* defines an OG including a command sequence with a fixed OG number (#2 in Figure 2-1). ISACS-PLN has a function called *Dynamic OG*. This function dynamically creates some OG from a set of commands without specifying OG number.

OP Sequence: An *OP Sequence* defines a sequence of OGs that are embedded in the on-board OP (#3 in Figure 2-1). When OGs are called in an *OP Sequence*, the OGs are set in a slot of OP according to the request of the *OP Sequence*. When a list of SIB commands are directly described with a certain *OP Sequence* name, an OG is automatically made with some OG number and the resultant name of OG is the *OP Sequence* name. This is called *Dynamic OG*. When a *Dynamic OG* is made from an *OP sequence*, the OG number cannot exactly be predicted. In Solar-B the use of *Dynamic OG* is not planned as baseline.

DCBC Sequence: 100 *DCBC Sequences* are available for Solar-B. *DCBC Sequences* are registered in the JAXA EGSE at operation center (#4 in Figure 2-1). This *Sequence* can only be called from *REAL Sequence*. Command procedures for recovery from emergency condition are normally stored in this *Sequence*. Some specific *Sequence* may be defined for a telescope operation in the real-time operation.

Naming method for Sequence: There are many subsystems in Solar-B and the command plan for each subsystem is made independently.

For a REAL/OP *Sequence*, the following naming method shall be adopted in Solar-B:
'Subsystem-name'_'name-of-sequence'_SEQ

For an OG *Sequence,* the following naming method shall be adopted in Solar-B:
'Subsystem-name'_'name-of-sequence'_OG

SOT_CHGOBS023_SEQ, XRT_MANU_SEQ, EIS_CHG_SEQ123_SEQ etc. in the case of SOT, XRT, and EIS, respectively. When there is no subsystem name in the name of *Sequence*, the *Sequence* is prepared for the spacecraft-level operation.

Detailed specification of each type of *Sequence* is shown later.

Execution Definition: *Execution Definition* defines start timings of *Sequences* in the spacecraft operation. Timing and name of *Event* are defined in SOE file. Those of *Point* are defined in ORL file. In an *Execution Definition,* some *Sequences* are placed at the timing of either *Event* or *Point* or absolute time (UT time). Figure 4-5 is an example. *Execution Definition* starts from START keyword. In the second *Execution Definition*, start timings of DAY_SEQ *Sequence* are defined at the timings of DAY *Events*.

When a *Sequence* is executed at a **UT time**, time of execution follows START keyword. For each START keyword, one sequence is set in the Solar-B use (, though multiple SEQ settings are possible).

solarb_2006112301.orl (solarb_YYYYMMDDpassID; passID=01)

```
START : OP_START {SEQ: OP_START_SEQ ; }

/* Event related SEQ Execution */
START : DAY {SEQ : DAY_SEQ ; }
START : NGT{ SEQ : NGT_SEQ ; }
START : SAA_ENTRY {SEQ : SAA_ENT_SEQ ; }
START : SAA_EXIT {SEQ : SAA_EXIT_SEQ ; }
START : HLA_ENTRY {SEQ : HLA_ENT_SEQ ; }
START : HLA_EXIT {SEQ : HLA_EXIT_SEQ ; }
/* Start of comments
   Solar Eclipse; the following two lines are not used in this ORL.
START : ECL_ENTRY{SEQ : ECL_ENTRY_SEQ ;}
START : ECL_EXIT{SEQ : ECL_EXIT_SEQ ;}
  End of comments */
/* End of Event related SEQ Execution */

/* Start of Point related SEQ Execution */
START: DAY_EIS {SEQ : DAY_EIS_SEQ ; }
START: NGT_EIS {SEQ : NGT_EIS_SEQ ; }
START: ECL_EXIT_EIS {SEQ : ECL_EXIT_EIS_SEQ ; }
START: ECL_ENTRY_EIS {SEQ : ECL_ENTRY_EIS_SEQ ; }
/* End of Point related SEQ Execution */

/* SEQ Execution at a specified UT Time */
                    :
                    :
                    :
START : OP_END {SEQ : OP_STOP_SEQ ; }
```

Figure 4-5: Spacecraft-level *Execution Definition* Request

5. Basic Concept for Instrument Operation using ISACS-PLN *Sequences*

The followings are shown to recall the function of basic ISACS-PLN function.

-Command sequences for real-time operations are defined in *REAL Sequence* by calling SIB commands, *DCBC Sequences*, and *OG Sequences*.

-Command sequences from OP are defined in *OP Sequences* by calling *OG Sequences*.

-Time of execution for each *REAL Sequence* or *OP Sequence* is defined in *Execution Definition*.

-All *Sequences* and *Execution Definition* for an instrument operation are prepared by the instrument team.

-For *Event & Point* related OG for an instrument operation the JAXA personnel of Solar-B ISASC-PLN shall set the required instrument commands in the *Event & Point* related OG.

All *Sequences* and *Execution Definition* for a daily operation of a Solar-B instrument team shall be contained in a single file. (ISACS-PLN itself has capabilities to divide *Sequences* into multiple ORL files, however.)

5.1 OG allocation to each instrument team

Solar-B has 512 OG areas in the on-board memory. The following allocation is assumed at present.

OG000-OG299: Spacecraft
OG300-OG399: SOT
OG400-OG449: XRT
OG450-OG499: EIS

The spacecraft related OGs are protected from the action to ISACS-PLN by users except for the JAXA personnel. OGs of an instrument are protected from the action to ISACS-PLN by others except for the instrument Chief Observers and JAXA personnel. ←This has not yet been implemented in the current system.

The task of each OG shall easily be identified by its name of *OG Sequence*.

5.2 Preparation of DCBC sub plans

100 real-time command procedures can be registered in the Solar-B ISACS-PLN. This function is used to send many fixed commands to spacecraft. When an instrument team wishes to use this capability, the JAXA personnel registers the requested command procedure. The registered names of *DCBC Sequences* will be informed from the JAXA personnel to the instrument Chief Observer.

5.3 Interfaces to SOT/XRT/EIS Planning

A command plan of an instrument will normally be made independently. Two types of data are required for daily operations: ORL files for command planning and memory data (including observation tables).

All of the file names in the interface have ten digits at the end of base name. These are information of year, month, day, and the pass ID. The daily operation starts at the fist contact around 9 UT and the pass ID of the 1st contact will be '01'. The rule to put the pass ID is not known yet, but JAXA Solar-B Project Office is planning to name it as 01, 02 (,03) for the Japanese evening passes and 11, 12 (, 13) for the Japanese morning passes. Name of interface file of each type of an instrument starts with fixed letters. Following description shows examples of file names in the interface.

ORL file: subsystemname_YYYYMMDDpassID.orl

SOT_2006120701.orl, XRT_2006120701.orl, EIS_2006120701.orl

Here each ORL file includes *REAL*, *DCBC*, *OG*, and *OP Sequences* and *Execution Definition*.

Pass ID of an ORL file specifies first contact pass in the period of command plan.

A command plan nominally covers several contact passes.

Memory data in XML format:

Observation tables : the name of interface file to each subsystem is different.

SOT : FGTBL_2006120702.xml for filtergraph

SPTBL_2006120704.xml for spectrograph

XRT : XRTTBL_2006120711.xml

(ISACS-PLN system converts observation tables in the XML format into the following Intel Hex format).

Memory data in Intex HEX format:

Observation tables : the name of interface file to each subsystem is different.

EIS : EIS_OBSTBL_2006120711.hex

Other memory tables : RAM-ID_YYMMDDpassID.hex

EIS_PRGRAM_2006120702.hex for EIS program memory.

RAM-ID has been given to each memory map.

Pass ID of a memory data specifies contact pass to be used for uploading.

5.4 File transfer to ISACS-PLN work station

The file transfer is done via ftp from EGSE of each instrument team to the ISACS-PLN work station.

Note:

The following issues are considered for naming interface files.

1. ISACS-PLN system manages all ORL files and memory files that are sent to the spacecraft commanding EGSE.
2. Two ORL files from an instrument are not used in a single uplink pass.
3. Two observation tables with the same RAM-ID are not uploaded in a single uplink pass.
4. ORL format *Request* may be prepared a few times in a day. Normally it will be once, but it may be updated after the 1st contact when operation is finished by noticing some mistakes.
5. ORL files and memory maps are managed by each instrument team. But, the input files from instrument teams that are merged and sent to spacecraft commanding EGSE are also recorded in the ISACS-PLN system.

When Chief Observers put the updated ORL files and memory maps that are to be used in the same uplink pass, the files are overwritten with the same name.

5.5 Preparation of ORL Files

Although *Sequences* and *Execution Definition* can be set in any order in an ORL file, the following format shown below is recommended. The panel below shows the conceptual setting of elements in an ORL file. An example named EIS_2007012301.orl is shown on the next two pages.

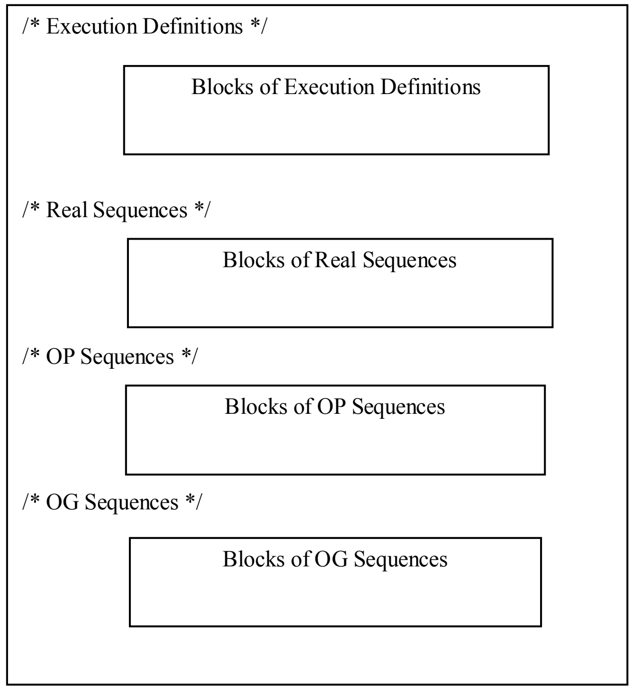

Figure 5-1: Subsystem-level Request format

File: EIS_2007012301.orl

```
/* This is a comment line. */
/* Execution Definitions */
/* Real-time sequence execution */
START : 2007/01/23.09:00:00 {SEQ : EIS_USC_PASS1_SEQ ; }
/* Real-time sequence execution (New EIS Sequence is uploaded.) */
START : 2007/01/23.10:40:00 {SEQ : EIS_USC_PASS2_SEQ ; }

/* OP sequence execution */
START : 2007/01/23.14:00:00 {SEQ : EIS_CHG_SEQ_TO_02_SEQ ; }
/* OP sequence execution */
START : 2007/01/24.17:00:00 {SEQ : EIS_CHG_SEQ_TO_04 _SEQ; }

/* Real-time sequence execution */
START : 2007/01/24.21:00:00 {SEQ : EIS_USC_PASS3_SEQ ; }
/* Real-time sequence execution */
START : 2007/01/24.22:40:00 {SEQ : EIS_USC_PASS4_SEQ ; }

/* ---------------------------------------------------------------------- */
/*Real Sequences */
DEFSEQ(REAL) : EIS_USC_PASS1_SEQ{
        CMD : EIS_MODE_MANU ;
        CMD :   EIS_MODE_AUTO ;
        C. : "This is a comment line that is shown on the display of S/C commanding GSE." ;
}
DEFSEQ(REAL) : EIS_USC_PASS2_SEQ{
        C. : "Stop EIS observation" ;
        CMD: EIS_MODE_MANU ;
        /* Select Sequence 0x12 */
        CMD : EIS_SELECT_SEQ 12 ;
        C. : "Start EIS observation" ;
        CMD : EIS_MODE_AUTO ;
}
DEFSEQ(REAL) : EIS_USC_PASS3_SEQ{
        /* No EIS command in this pass. */
        /* OP/OG memory data are going to be uploaded in this pass. */
}
```

Figure 5-2: Example of subsystem-level Request format

File: EIS_2007012301.orl (continued)

```
DEFSEQ(REAL) : EIS_USC_PASS4_SEQ{
        C. : "Stop EIS observation" ;
        CMD : EIS_MODE_MANU ;
        /* The next command creates the upload commands from difference of two memory maps. */
        /* Parameters should be the same in the Intel HEX memory data to be uploaded. */
        /*              RAM-ID        PassID RAM-sub-ID (in decimal) */
        ENTRY : RAM EIS_OBSTBL 01 90 ;
        C. : "Dump memory area of Sequence 3" ;
        /*                            address   size     in hexadecimal as defined in SIB */
        CMD : EIS_DUMP_OBSTBL 07 03 00 01 00 ;
        /* Select Sequence 03; 03 is a parameter. */
        CMD : EIS_SELECT_SEQ 03 ;
        C. : "Start EIS observation" ;
        CMD : EIS_MODE_AUTO ;
}
/* ------------------------------------------------------------------------------ */
/* OP Sequences */
DEFSEQ(OP) : EIS_CHG_SEQ_TO_02_SEQ{
        OG : EIS_CHG_TO_SEQ02_OG ;
}

DEFSEQ(OP) : EIS_CHG_SEQ_TO_04_SEQ{
        OG : EIS_CHG_TO_SEQ04_OG ;
}
/* ------------------------------------------------------------------------------ */
/* OG Sequences */
DEFSEQ(OG) : EIS_CHG_TO_SEQ02_OG{
         NUMBER : 452 ;
        /* In this case a single OG will be created for this SEQ operation. */
        CMD : EIS_MODE_MANU ;
        CMD : EIS_SELECT_SEQ 02 ;
        CMD : EIS_MODE_AUTO ;
}
DEFSEQ(OG) : EIS_CHG_TO_SEQ04_OG{
         NUMBER : 454;
        CMD : EIS_MODE_MANU ;
        CMD : EIS_SELECT_SEQ 04 ;
        CMD : EIS_MODE_AUTO ;
}
```

Figure 5-3: Example of subsystem-level Request format

6. Language Specification of *Sequence*

DEFSEQ (*sequence-type*) : *sequence-name* {
    Keyword : *operand* ;
}

sequence-type	type of *Sequence*; REAL, OP, OG, DCBC. Other types are not opened to subsystems.
sequence-name	name of *Sequence* in capitalized characters. Use of '-' and '_' is allowed.

Keyword	Explanation <u>(Keyword has to be described in capitalized characters.)</u>
CMD	A SIB command is called by this keyword. CMD can be placed in *REAL Sequence, OG Sequence* and *DCBC Sequence.* Infinite waiting time is set before the command execution when this keyword is used in *REAL Sequence* and *DCBC Sequence.* Each command is executed one-by-one by the operator during the real-time operation. No waiting time is set before issuing a SIB command when the keyword is used in *OG Sequence*.
NP_CMD	A SIB command is called by this keyword. NP_CMD can be placed in *REAL Sequence* and *DCBC Sequence.* No waiting time (Non-Pause; NP_) is set before issuing the SIB command execution even when this keyword is used in *REAL Sequence* and *DCBC Sequence.* Each command is not executed one-by-one by the operator during the real-time operation, so that the command is automatically called within the commanding EGSE. An example of usage of NP_CMD is shown in Appendix 1.
C.	A comment line is shown on the commanding EGSE display when this keyword is used. C. can be placed in *REAL Sequence* and *DCBC Sequence.* A message to the commanding operator can be sent with this function. Infinite waiting time is set by this keyword then. For example, when 'C.' keyword is used after many real-time commands called by NP_CMD, the commanding EGSE waits for a response of the operator at the uplink station after issuing the Non-Pause commands. A comment line is added in OP when this keyword is used in *OP Sequence*.
NP_C.	A comment line is shown on the commanding EGSE display. NP_C. can be placed in *REAL Sequence* and *DCBC Sequence.*No waiting time (Non-Pause; NP_) is set when this keyword is used, so that the comment line is automatically skipped within the commanding EGSE.
OG	An OG is called by this keyword. OG can be placed in *REAL Sequence, OP Sequence* and *DCBC Sequence.* Infinite waiting time is set before issuing the OG when this keyword is used in *REAL Sequence* and *DCBC Sequence.*
NP_OG	An OG is called by this keyword. NP_OG can be placed in *REAL Sequence* and *DCBC Sequence.* No waiting time is set before issuing the OG when this keyword is used.
ENTRY	ENTRY can only be placed in *REAL Sequence.* When an operand of 'RAM' is selected, it implies the memory upload. For SOT/XRT/EIS, 'RAM' is only allowed operand.

NUMBER	NUMBER shall be placed at the first line of *OG Sequence* and *DCBC Sequence*. Contents of Sequence are registered as OG or DCBC sub-plan with a number that is specified by operand of this keyword.
INTERVAL	Time interval can be set between two OGs by this keyword. INTERVAL is only used in an OP *Sequence* for the Solar-B operation. When it is used between two OGs as "INTERVAL 3.5;", the latter OG is set in an OP slot 3.5 sec after the OP slot for the former OG. An example is shown to the right.

```
OG : EIS_TASK1_OG;
INTERVAL 3.5;
OG : EIS_TASK2_OG;
```

Operand for Each Keyword

Keyword	*operand*	
CMD / NP_CMD	Name of SIB command. When parameters are contained in a SIB command, parameters in hexadecimal format are added after the name of command.	
C. / NP_C.	"comment" ; comment is described with double quotation marks.	
OG / NP_OG	Name of an OG *Sequence*	
ENTRY	RAM *RAM-ID Version RAM-sub-ID*	
	'RAM' implies a memory upload.	
	RAM-ID	Name of Memory Map
	PassID	Two digit number for Solar-B identifying the uplink contact pass ID.
	RAM-sub-ID	ID number of *RAM-ID* (in decimal number)
NUMBER	0 – 511 for *OG Sequence* and 0-99 for *DCBC Sequence*	
INTERVAL	0.5-8191.5 in step of 0.5 sec. When it is set to be 1.25 (1.55), it is interpreted as 1.0 (1.5).	

7. ISAS Network System for Solar-B Command Planning

The network system in ISAS/JAXA is shown below (Figure 7-1).

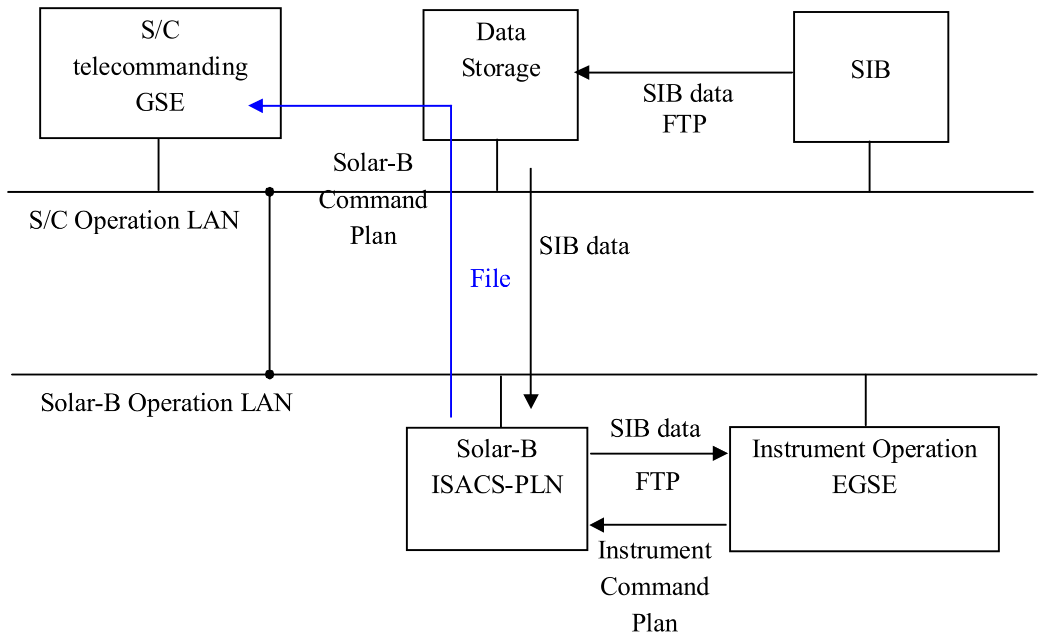

Figure 7-1: ISAS/JAXA network system for S/C operation

8. Flow of Command Preparation for SOT/XRT/EIS Operation

The following issues need be considered to make a command plan for SOT/XRT/EIS operation.
1. Uplink contact time for OP/OG upload
2. Time of uplink/downlink contacts; see Appendix 1-B
3. Time of spacecraft-level events; see Appendix 1-C
4. Preset commands in OG *Sequence* for *Point* and DCBC *Sequence*; see Appendix 1-D
5. Allocated data rate for each instrument; see Appendix 2 (in separate file)
6. Schedule of spacecraft pointing; see Appendix 3-1, 3-2 (in separate file)
7. Spacecraft orbit and spacecraft pointing for SOT operation; see Appendix 3-3 (in separate file)
8. Merging all orl and soe files to create OP/OG and real-time commands

8.1 Uplink contact for OP/OG upload

This will nominally be the first contact in the evening time (~9 UT = ~18 JST).

8.2 Time of uplink/downlink contacts

In the nominal Solar-B operation Uchinoura Space Center (USC) in Japan is the nominal uplink contact. Four or five USC contacts will be available in a day. Half comes in the local morning time (~6 JST) and the latter half does in the local evening time (~18 JST).The downlink of Solar-B data can be done at USC and Svalbard in Norway. The final available contacts will be determined a week before the operation. Crude contact time of potential downlink contacts can be estimated from a set of orbital elements beforehand.

The format of file[informing final downlink contacts is in Appendix 1-B. A contact event file (downlink_YYYYMMDD_Ver.soe) for the spacecraft operation is also made in this process by Chief Planners with software that JAXA prepares. The Chief Observer will not need to recognize the time of Svalbard contacts.

8.3 Time of spacecraft-level events

Spacecraft–level events are shown in Appendix 1-C. An event (.soe) file is created by Chief Planners with software that JAXA prepares.

8.4 Preset commands in OG *Sequence* for *Point* and DCBC *Sequence*

Appendix 1-D shows how to use Point for the instrument planning.

For some specific operation, there may be a command sequence in which fixed combinations of many SIB commands are listed.

For infrequent unexpected reboot of CPU a recovery procedure to a normal operation will be required, for example. Such procedures can clearly be defined and should be preset in the EGSE of spacecraft operation to prohibit a mistake by a Chief Observer. By calling the preset DCBC *Sequence* from REAL *Sequence* the recovery procedure will easily be performed. The registration of DCBC Sequence is done by the super-user of ISACS-PLN system. Each instrument team needs to submit a command procedure to the super-user if there is.

8.5 Allocated data rate for each instrument

MO&DA and Science working group have to discuss this issue in detail. An idea is given in Appendix Ope-B. The duration of downlink contacts is directly related to the allocation. Chief observers need to make observation plans from information in a file shown in Appendix 2-B.

8.6 Schedule of spacecraft pointing

The spacecraft pointing is performed through a memory upload to the Solar-B attitude control system (AOCS). The re-pointing information for a day is summarized in a file containing information of re-pointing plan. The Chief Observer needs to use this file for each instrument planning. See Appendix 2-E for details.

8.7 Spacecraft orbit and spacecraft pointing for SOT operation

The narrow band pass filter observation of SOT requires a fine tuning of its band pass center by the tunable filter during an orbit. The Doppler shift by relative motion between the spacecraft and target has to be considered. Three systems are associated with the compensation of the Doppler shift: (1) spacecraft pointing controlled by the attitude control system (AOCS), (2) band pass center control in MDP according to the SOT observation table, (3) SOT planning system to make SOT observation table and SOT command plan. See Appendix 2-F for details.

8.8 Merging all orl and soe files to create OP/OG and real-time commands

After Chief Observers finish the instrument planning for a day, the instrument planning files (ORL files, Observation Tables, and Intel Hex memory maps) are sent to the ISACS-PLN workstation via FTP (see Figure 7-1).

All Sequences are combined in the ISACS-PLN system when the Chief Planners run a job in the system. Outputs from the task are (1) real-time command sequence for each uplink contact, (2) OG, (3) OP, and (4) DCBC sub-plan, those of which are shown in the bottom of Figure 2-1. The outputs are sent with Intel Hex memory maps to the uplink station by the Chief Planners.

Appendix 1-A: Example of Non-Pause Command (NP_CMD)

The command sequence shown below was used for an XRT operation in the Solar-B EIC/MIC test. The ISAS commanding EGSE waits for a response of a commanding operator before executing a single command like ‘CMD : MDP_DUMP’ and ‘CMD : MDP_XRT_ROI_SET’. When the ‘CMD : MDP_XRT_ROI_SET’ is executed, all commands up to the last ‘NP_CMD: MDP_XRT_ROI_SET’ are automatically executed one by one. ‘CMD : MDP_XRT_MODE_OBSV’ is executed after the action of the commanding operator.

```
C.:"********************************" ;
ENTRY: RAM MDP_OBS_X 41 41 ;
C.:"********************************" ;
CMD: MDP_DUMP_XRTTBL 00 00 00 48 00 ;
CMD: MDP_XRT_ROI_SET 01 80 80 06 06 ;
NP_CMD: MDP_XRT_ROI_SET 02 24 8E 08 08 ;
NP_CMD: MDP_XRT_ROI_SET 03 1C 92 06 06 ;
NP_CMD: MDP_XRT_ROI_SET 04 14 96 04 04 ;
NP_CMD: MDP_XRT_ROI_SET 05 7F 81 08 08 ;
NP_CMD: MDP_XRT_ROI_SET 06 80 80 20 20 ;
NP_CMD: MDP_XRT_ROI_SET 07 64 9E 18 18 ;
NP_CMD: MDP_XRT_ROI_SET 08 44 9E 10 10 ;
NP_CMD: MDP_XRT_ROI_SET 09 34 9E 0C 0C ;
NP_CMD: MDP_XRT_ROI_SET 0A 80 08 20 02 ;
NP_CMD: MDP_XRT_ROI_SET 0B 1C 9E 06 06 ;
NP_CMD: MDP_XRT_ROI_SET 0C 14 9E 04 04 ;
NP_CMD: MDP_XRT_ROI_SET 0D 80 9E 20 08 ;
NP_CMD: MDP_XRT_ROI_SET 0E 24 80 08 20 ;
NP_CMD: MDP_XRT_ROI_SET 0F 80 80 06 06 ;
NP_CMD: MDP_XRT_ROI_SET 10 80 80 04 04 ;
CMD: MDP_XRT_MODE_OBSV ;
```

Appendix 1-B: File format of a file showing downlink stations

File name: dst_start-date-and-time_end-date-and-time_version

Examples: dst_20060105_20060112_00
dst_20060425_20060504_00
dst_20061230_20070106_02

Format: ASCII characters

Contents: TBD; this depends on what is delivered from JAXA (**Need investigation**)

Date1, Time1, Date 2, Time2, Name of downlink station;

Date1: entry Date in UT. 2006 01 15, which means 2006 Jan 15

Time1: entry time in UT. 123456, which means 12:34:56 UT

Date2: exit Date in UT.

Time2: exit time in UT.

Name of downlink station: USC, which means Uchinoura Space Center, Japan
SVA (TBD), which means Svalbard downlink station
Others, not yet defined.

File: dst_20070224_20070306_02

```
2007 02 24 060123 2007 02 24 060742 USC;
2007 02 24 091200 2007 02 24 091958 SVA;
2007 02 24 180241 2007 02 24 181031 USC;
              ⋮
```

Note 1) An event file to operate the spacecraft at/near the uplink station and at downlink stations will be created from the file of downlink stations described above. The file is only used for the spacecraft operation. Some events showing the start and end of uplink contacts are also made from the file of downlink stations.

Note 2) Detailed negotiation among different spacecraft groups will not be necessary as far as Solar-B only uses USC and SVR stations. (TBD)

Appendix 1-C: Spacecraft event file

Type of event:

DAY, NGT, SAA_ENTRY, SAA_EXIT, HLA_ENTRY, HLA_EXIT, ECL_ENTRY, ECL_EXIT

DAY: entry of Solar-B day time during a period in which Solar-B experiences day and night.

NGT: entry of Solar-B night time

SAA_ENTRY: entry of Solar-B for the South Atlantic Anomaly (radiation belt)

SAA_ECXIT: exit of Solar-B for the South Atlantic Anomaly (radiation belt)

HLA_ENTRY: entry of Solar-B for the High Latitude Anomaly (radiation belt)

HLA_EXIT: exit of Solar-B for the High Latitude Anomaly (radiation belt)

ECL_ENTRY: entry of Solar-B for the solar eclipse

ECL_EXIT: exit of Solar-B for the solar eclipse

OP_START: start of OP

OP_END: end of OP

Format: ASCII characters

Users: Chief Planner and Chief Observers.

File: orbevt_20061103_03.soe

Name of *Event* : Year/MM/DD hh:mm:ss ;

```
DAY         : 2006/11/03 11:32:44 ;
NGT         : 2006/11/03 12:36:34 ;
   ⋮
SAA_ENTRY   : 2006/11/03 12:21:45;
SAA_EXIT    : 2006/11/03 12:28:34;
HLA_ENTRY   : 2006/11/03 12:45:21;
HLA_EXIT    : 2006/11/03 12:55:21;
   ⋮


/* Start and Terminate of a daily plan */
OP_START    : 2006/11/03 18:12:34;   /* Reference time for all timing of OP-command execution */
OP_END      : 2006/11/04 21:45:00;

/* Information of Solar Eclipse is explicitly contained in all Event files not to forget it */
ECL_ENTRY   : 2008/06/21 13:21:22;
ECL_EXIT    : 2008/06/21 13:30:01;
```

Appendix 1-D: Preset commands in OG *Sequence* for *Point*

Point

The functionality of *Point* need be used for the instrument operation. The following Point will be pre-set. The registration of *Point* to ISACS-PLN will be done by the super-user of the ISACS-PLN system. Each instrument team shall inform the super-user of required commands. Since the author does not follow all the instrument commands, an example shown below is given for the EIS operation.

Note that 'DAY_EIS' is a name of *Point*. A *Sequence* called by this *Point* is defined in *Execution Definition*. See Figure 4. "START: DAY_EIS {SEQ : DAY_EIS_SEQ ; }" is contained there, for example.

```
POINT-AT DAY +120 {/* 2min after S/C Day Event */; POINT : DAY_EIS; }
POINT-AT NGT -120 {/* 2min before S/C Night Event */; POINT : NGT_EIS; }
POINT-AT ECL_EXIT +120 {/* 2min after S/C Solar Eclipse Event */; POINT : ECL_EXIT_EIS; }
POINT-AT ECL_ENTRY -120 {/* 2min before S/C Solar Eclipse Event */; POINT : ECL_ENTRY_EIS; }

/* OG Sequences */
DEFSEQ(OG) : DAY_EIS_OG {
        NUMBER : 250;
        C. : "Resume/Start EIS Automatic Sequence Operation" ;
        CMD : EIS_RESUME_SEQ ;   /* Resume EIS Sequence. "CMD : EIS_MODE_AUTO ; " for Start */
}
DEFSEQ(OG) : NGT_EIS_OG {
        NUMBER : 255;
        C. : "Pause/Terminate EIS Automatic Sequence Operation" ;
        CMD : EIS_PAUSE_SEQ ;   /* Pause EIS Sequence "CMD : EIS_MODE_MANU ; " for Termination */
}
DEFSEQ(OG) : ECL_EXIT_EIS_OG {
        NUMBER : 260;
        C. : "Resume/Start EIS Automatic Sequence Operation" ;
        CMD : EIS_RESUME_SEQ ;   /* Resume EIS Sequence. "CMD : EIS_MODE_AUTO ; " for Start */
}
DEFSEQ(OG) : ECL_ENTRY_EIS_OG {
        NUMBER : 265;
        C. : "Pause/Terminate EIS Automatic Sequence Operation" ;
        CMD : EIS_PAUSE_SEQ ;   /* Pause EIS Sequence "CMD : EIS_MODE_MANU ; " for Termination */
}
```