SUBJECT: SPIRE AOT Implementation Document

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1.3.1 Applicable Documents

AD01 Scientific Mission Planning Pointing Modes (HERSCHEL-HSC-DOC-624), Issue 2.2

AD02 Operating Modes for the SPIRE Instrument (SPIRE-RAL-DOC-000320), Issue 3.2

1.3.2 Reference Documents

RD01 SPIRE Instrument Users Manual (SPIRE-RAL-PRJ-002395), Issue 1.3

RD02 Herschel Science Ground Segment to Instruments ICD (FIRST-FSC-DOC-0200), Issue 3.1

2. OBSERVATION IMPLEMENTATION

A SPIRE observation may be considered to be a set of instrument operations synchronised with movements of the Herschel telescope. The possible sequences of movements of the telescope have been defined in a set of Pointing Modes (see AD01) implemented in the CUS and available as part of the CUS language. Each pointing mode defines completely the sequence of telescope operations which will be carried out from a set of input parameters. The implementation of the pointing modes in the CUS allows a CUS script to call a pointing mode and then identify each time the telescope enters a state corresponding to one of the telescope pointing operations. The script can then execute the corresponding instrument operation. The available instrument operations are described in AD02, and the telescope pointing operations in AD01.

2.1 Observation Structure

All SPIRE observations follow the same basic structure, shown in Figure 2-1.

All observations start and finish in one of the standby configurations of the instrument (PHOT_STBY or SPEC_STBY) defined in RD01.

At the start of the observation the spacecraft is commanded to point to the observation target and begins to slew to that position (SLEW). During the slew up to three building blocks are executed:

- Obs_Config: the Observation is configured – the OBSID set and the STEP parameter cleared
- Serendipity (executed only if sufficient time is available) – takes detector data during the slew
- Configuration – the MODE parameter is set to the value for the observing mode to be used, Housekeeping is set to be generated at the operational rate (once per sec – see RD01) and the DRCU counters are reset.

At the end of the slew the telescope remains pointing at the target for a period (INIT_HOLD), while the instrument is initialised: at this time the detector offsets are determined and an internal calibration (PCAL Flash) may be executed.

From this point the scientific operations take place. These consist of s sequence of identical data-taking operations interspersed with telescope movements (nodding, raster pointing, scanning). The data-taking operations (such as jiggle map, chop, FTS scans etc) consist of one or more building blocks executing one or more cycles of operations. In addition, at some points in the observation (HOLD) further internal calibrations may be inserted.

At the end of the observation the telescope is held at its end position (FINAL_HOLD) while an internal calibration is executed (optional) and the instrument is reconfigured back to the Standby configuration.

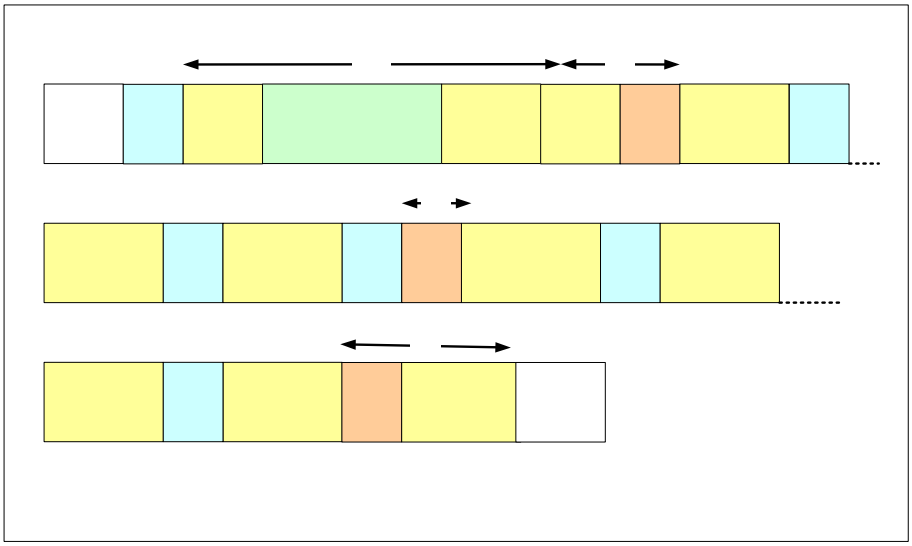

Figure 2-1 Typical Structure of an observation

2.2 Observation Identifier

The observation Identifier (OBSID) is set by command and appears in the header of every (Science, HK and Event) TM packet generated by the instrument (See RD02). This identifier is set at the start of the observation and cleared at the end and thus it defines completely the data belonging to an observation.

The OBSID is a 32 bit number containing the following fields:

Site ID	bits 28 to 31	Identifies the phase of the mission from ILT to Operations. The following values are used for SPIRE observations: 0011 SPIRE ILT 1011 SPIRE IST 1100 Multiple instrument IST (scheduled) 1101 Multiple Instruments IST (manual commanding) 0101 HSC – scheduled operation of the instrument during operations 0000 MOC – manual commanding of the instrument during in-flight operations
Observation Execution Counter	Bits 0 to 27	Identifies the observation number. It is unique for each site, ensuring that the OBSID is unique for every observation performed with the instrument across all mission phases. This value starts at 1 for the first observation and is incremented subsequently

Outside of observations the OBSID has the following values (see RD02):

Ox00000000	At first switch on of instrument, or in-flight during manual commanding when instrument not performing an observation
0x30000000	ILT SPIRE not performing an observation
0xB0000000	IST SPIRE not performing an observation
0xC0000000	IST Multiple instruments (Parallel Mode) (scheduled) not performing an observation
0xD0000000	IST Multiple instruments (Parallel Mode) (manual commanding) not performing an observation
0x50000000	In-flight SPIRE (scheduled) not performing an observation
0x00000000	In-flight SPIRE (manual commanding) not performing an observation

2.3 Building Blocks

Each observation is made up of a series of building blocks corresponding to a discrete operation of the instrument. A Building Block Identifier (BBID), set by command during the observation, is reflected in the header of every (Science, HK and Event) TM packet generated by the instrument (See RD02). Thus all telemetry data corresponding to a particular operation of the instrument can be collected together by searching on the BBID.

The BBID is a 32 bit number containing the following fields:

Instrument	bits 30 to 31	Identifies the instrument (SPIRE = 10)
BBType	Bits 16 to 29	Identifies the type of Building Block. This is unique for each SPIRE operation
BB Execution Counter	Bits 0 to 15	A counter of the number of times each BB type is used during an observation. This counter starts at 1 and increments each time the same BB type is executed

Outside of observations the BBID has the following values (see RD02):

Ox00000000	At first switch on of instrument, or in-flight during manual commanding when instrument not performing an observation
0x80000000	ILT, IST, in-flight Instrument not performing an observation

2.4 The STEP parameter

During an observation the STEP housekeeping parameter is set to reflect the current telescope pointing status in the observation. It indicates whether the telescope is on-target, at the on-source (A) or off-source (B) nodding position, the current raster position or the current scan line.

Note: for scan mapping observations the telescope is moving all the time, even during, scientific operations. However, the STEP parameter still reports the telescope as being 'on-target'.

More detailed information is given in each of the Operational Types sections below.

3. OBSERVATION TYPES

Each observation type is currently implemented as one operating mode of the instrument. In the future it may be implemented in more than one way and a selection between modes will be made based on user input or instrument related criteria.

3.1 Point Source Photometry

3.1.1 STEP Parameter

For this mode the STEP parameter is divided into two parts

msb	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	lsb
	OTF	Nod															

On Target Flag (OTF)	bit 15	Set to 1 when telescope is pointing (jiggling of PCAl Flash), otherwise generally set to 0
Nod	bit 14	Set to 0 when telescope in on-source position, set to 1 when telescope in Nod position

3.1.2 Building Blocks

The following building blocks are used:

	OTF	Nod	Point Number	Comments
OBSConfig	0	0	0	
PhotSerendipity	0	0	0	
POF2Config	0	0	0	
POF2Init	0	0	0	
PCalFlash	1	0	np	This BB is only executed if PCAL flashes are requested Note: np is the number of the next telescope pointing
Jiggle (on-Source)	1	0	0	
Jiggle (nod position)	1	1	0	
Move	0	0	0	This BB occurs during the movement between telescope positions
POF2End	0	0	0	

3.1.3 Notes

- The telescope pointing number for jiggle BBs can be found in the BB execution counter field (starts from 1)

3.2 Small Photometric Map

3.2.1 STEP Parameter

For this mode the STEP parameter is divided into three parts

msb	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	lsb
	OTF	Nod	Point Number														

On Target Flag (OTF)	bit 15	Set to 1 when telescope is pointing , otherwise generally set to 0
Nod	bit 14	Set to 0 when telescope in on-source position, set to 1 when telescope in Nod position
Point Number	Bits 0-13	Set to the number of the telescope pointing. Starts from 0.

3.2.2 Building Blocks

The following building blocks are used:

	OTF	Nod	Point Number	Comments
OBSConfig	0	0	0	
PhotSerendipity	0	0	0	
POF3Config	0	0	0	
POF3Init	0	0	0	
PCalFlash	1	0	np	This BB is only executed if PCAL flashes are requested Note: np is the number of the next telescope pointing
Jiggle (on-Source)	1	0	0	
Jiggle (nod position)	1	1	0	
Move	0	0	0	This BB occurs during the movement between telescope positions
POF3End	0	0	0	

3.2.3 Notes

- The telescope pointing number for jiggle BBs can be found in the BB execution counter field (starts from 1)

3.3 Large Photometric Map

This observation type is currently implemented as a scan map as described in AD02 as the SPIRE POF5 observing mode. Observers have the option to make the map by scanning the telescope in the direction along the SPIRE detector array; in the direction orthogonal to this; or in both directions. The first two options are implemented using the line_scan_pointing Herschel pointing mode, the latter uses the cross_scan_pointing mode.

3.3.1 STEP Parameter

For these modes the STEP parameter is divided into three parts

msb	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	lsb
	OTF	Nod	Line Number														

On Target Flag (OTF)	bit 15	Set to 1 during a line scan and during a PCAL flash, otherwise generally set to 0
Nod	bit 14	Not Used – set to 0
Line Number	bits 0 to 13	Contains the number of the current line during a line scan, the number of the next line during a PCAL flash and otherwise 0. This parameter starts at 0 and increments at the end of each line scanned. The map repeat number may be found by dividing by the number of lines per map. The maximum value for this parameter is 15000 (corresponding to 100 repeats of 1500 lines)

3.3.2 Building Blocks

The following building blocks are used:

	OTF	Nod	Line Number	Comments
OBSConfig	0	0	0	
PhotSerendipity	0	0	0	
POF5Config	0	0	0	
POF5Init	0	0	0	
PCalFlash	1	0	nl	This BB is only executed if PCAL flashes are requested Note: nl is the number of the next telescope scan line
StartDCUData				
StopDCUData				
ScanLine	1	0	nl	This BB corresponds only to the time of constant scan velocity Note: nl is the number of the current telescope scan line
Move	0	0	0	This BB occurs during the movement (including deceleration and acceleration) between scan lines Detector data sampling continues
POF5End	0	0	0	

3.3.3 Notes

The telescope scan line number for ScanLine BBs can be found in the BB execution counter field (starts from 1)

3.3.4 Single scan observations

Error! Reference source not found. gives an example of the order of BB execution for a single scan direction scan map

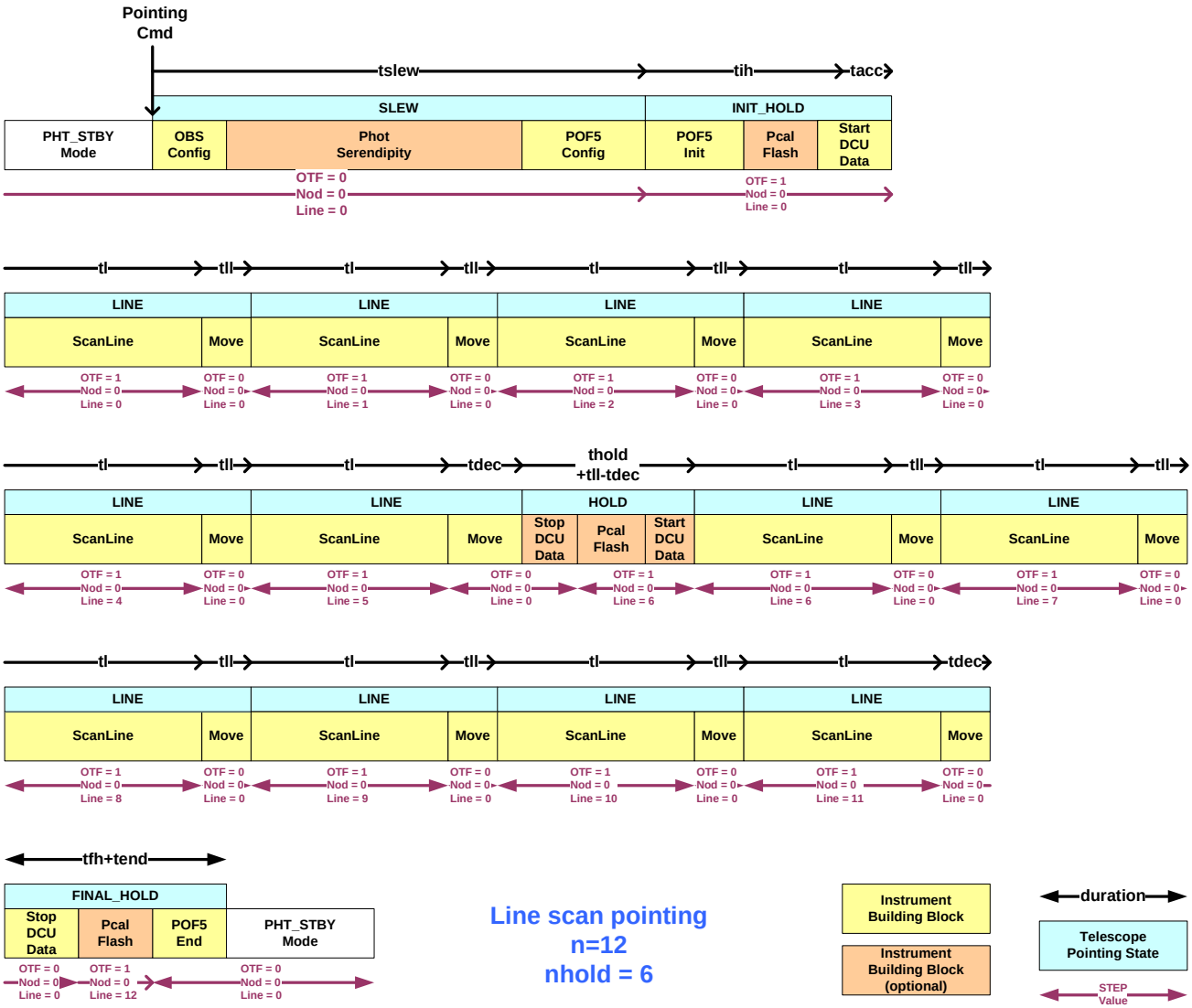

Figure 3-1 Example of a single scan direction Large Photometric Map Observation

3.3.5 Cross scan observations

3.4 Point Source Spectrometry

This observation type carries out a set of FTS scans at a series of BSM pointing positions (a jiggle position). The number of jiggle positions depends on the observer selected spatial sampling. For sparse sampling the observing mode is SOF1 and only 1 jiggle position is used. For intermediate and full spatial sampling the observing mode is SOF2 and several (>1) jiggle positions are used .

3.4.1 STEP Parameter

For these modes the STEP parameter is divided into three parts

msb	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	lsb
	OTF	Nod								Jiggle Number							

On Target Flag (OTF)	bit 15	Set to 1 during a line scan and during a PCAL flash, otherwise generally set to 0
Nod	bit 14	Not Used – set to 0
Jiggle Number	bits 0 to 6	Contains a count of the jiggle positions

3.4.2 Building Blocks

The following building blocks are used:

	OTF	Nod	Jiggle Number	Comments
OBSConfig	0	0	0	
SpecSerendipity	0	0	0	
SOF1(2)Config	0	0	0	
SOF1(2)5Init	0	0	0	
PCalFlash	1	0	nj	This BB is only executed if PCAL flashes are requested Note: nj is the number of the next jiggle position
BsmMove	0	0	nj	Note: nj is the number of the next jiggle position
FtsScan	1	0	nj	Note: nj is the number of the current jiggle position
SOF1(2)End	0	0	0	

3.5 Spectral Mapping

This observation type carries out a set of FTS scans at a series of BSM pointing positions (a jiggle position) at a series of pointing positions on the sky. The sky positions are chosen to minimise the number of pointings to cover the requested area. The number of jiggle positions depends on the observer selected spatial sampling. For sparse sampling the observing mode is SOF1 and only 1 jiggle position is used. For intermediate and full spatial sampling the observing mode is SOF2 and several (>1) jiggle positions are used .

3.5.1 STEP Parameter

For these modes the STEP parameter is divided into three parts

msb	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	lsb
	OTF	Nod	Point Number							Jiggle Number							

On Target Flag (OTF)	bit 15	Set to 1 during a line scan and during a PCAL flash, otherwise generally set to 0
Nod	bit 14	Not Used – set to 0
Point Number	Bits 7 to 13	Contains a count of the telescope pointings
Jiggle Number	bits 0 to 6	Contains a count of the jiggle positions

3.5.2 Building Blocks

The following building blocks are used:

	OTF	Nod	Point Number	Jiggle Number	Comments
OBSConfig	0	0	0	0	
SpecSerendipity	0	0	0	0	
SOF1(2)Config	0	0	0	0	
SOF1(2)5Init	0	0	0	0	
PCalFlash	1	0	np	nj	This BB is only executed if PCAL flashes are requested nj is the number of the next jiggle position np is the number of the next pointing position
BsmMove	0	0	np	nj	nj is the number of the next jiggle position np is the number of the next pointing position
FtsScan	1	0	np	nj	nj is the number of the current jiggle position np is the number of the current pointing position
SOF1(2)End	0	0		0	

Appendix A Building Blocks

The table gives the building block types (bits 16-29 of the BBID) which are used by the AOT implementations described in this document

BB Type (Hex)	BB Type (Decimal)	Name	Decsription
2010	8208	POF1Config	Not Used
2011	8209	POF1Init	Not Used
2012	8210	POF1End	Not Used
2020	8224	POF2Config	
2021	8225	POF2Init	
2022	8226	POF2End	
2030	8240	POF3Config	
2031	8241	POF3Init	
2032	8242	POF3End	
2050	8272	POF5Config	Sets the MODE to 0x350 (POF5) and moves the BSM to its Hold position It also performs a time synchronisation
2051	8273	POF5Init	Sets the Detector Offset values and dumps these in telemetry
2052	8274	POF5End	Sets the MODE to 0x300 (PHT_STBY) and moves the BSM to its Hold position. It also clears the BBID and OBSID, effectively ending the observation
20B0	8368	SOF1Config	
20B1	8369	SOF1Init	
20B2	8370	SOF1End	
20C0	8384	SOF2Config	
20C1	8385	SOF2Init	
20C2	8386	SOF2End	
2100	8448	PCALFlash	Executes a standard (photometer or Spectrometer) PCAL Flash It also performs a time synchronisation
2101	8449	Chop	Perform a Chop Cycle
2102	8450	Jiggle	Perform a Jiggle Cycle
2103	8451	ScanLine	Executed during a single scan line of a scan map. This BB corresponds to the time of scanning with constant velocity
2104	8452	PhotSerendipity	This building block collects data from the photometer channels, while the telescope is slewing. The detector offsets remain as set during the last observation. This BB is only executed if there is sufficient time during the slew to the target
2105	8453	SpecSerendipity	
2106	8454	FTSScan	Execute a set of FTS Scans
2107	8455	BsmMove	Move BSM to a given position
2108	8456	StartDCUData	Start generating Detector data TM packets
2109	8457	StopDCUData	Stop generating Detector data TM packets
2321	8993	Jiggle	Perform a Jiggle Cycle
2801	10241	PCalFlash	Execute PCAL Flash. This BB I sonly executed if flashes are requested
2F00	12032	Move	BB set during telescope movement. No changes are made to detector sampling

2F01	12033	ObsConfig	This is the BB that defines the start of the observation. It sets the OBSID and also performs a time synchronisation