SPIRE

Trend analysis system

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Document number: **SPIRE-UCF-NOT-003136**

Issue: **Issue 1** **Date:** **6th August 2008**

Contents

1 Introduction

This document specifies the requirements on the trend analysis system for SPIRE, and details the method and structure for implementation.

2 Trend analysis requirements

Within the ground segment, the prime operational responsibility of the ICC is to maintain the scientific performance of the instrument through the mission and to make possible the processing of the instrument data into scientifically useful products. It does this by continuously monitoring the health and status of the instrument, analysing its engineering and scientific performance, scheduling test and calibration observations, adjusting observational and operational procedures, generating calibration data and developing data processing software.

The initial status of the instrument and its performance in flight is ascertained during the PV and Commissioning phases of the mission. The trend analysis system is the means by which the ICC monitors its continuing operational health and performance. It does this by examining the variation, over time, of selected housekeeping parameters, calibration parameters and performance indicators derived from the instrument and spacecraft telemetry. This information may be taken directly from telemetry or data products produced as a result of Standard Pipeline Generation or Calibration processing.

Objectives of trend analysis are:

- To identify, and report on, changes to instrument operational parameters that would indicate a malfunction of the instrument
- To identify, and report on, changes to instrument operational parameters that would indicate a possible future malfunction of the instrument
- To identify, and report on, changes to instrument calibration and performance parameters that would indicate a deterioration or change of the scientific performance of the instrument
- To identify, and report on, changes to parameters that would indicate a deterioration or change of the scientific performance of the pipeline and calibration processing software
- To provide information on the variation in operational parameters that may lead to changes in operation/observing modes of the instrument
- To provide information on the variation in monitored parameters that may lead to a change in calibration strategy

3 Trend analysis system overview

The trend analysis system will have three aspects:-

- Automated "early warning" system. This system will monitor certain hardware parameters (direct measurement, and processed parameters – level 0.5/level 1) at intervals specified later in this document. It will check that parameters are within certain limits, and look for sudden changes. There will be an automated display to show the time evolution of parameters over short, medium & long timescales.
- Advanced query system for easy manual interrogation of the databases. The requirements for this system are contained within this document.
- Manual investigation and monitoring of calibration products & observations, to monitor drifts in instrument calibration.

An important point to note is that no trend analysis routines will be run as part of a pipeline. The automated trend analysis system script will be run daily and extract data from any relevant pipeline products newly generated during the previous operational day.

4 Format of this document

Section 5 describes the automated "early warning" system, section 6 details the requirements for the advanced TA database query system, and section 7 details the method by which trends in calibration may be monitored.

4.1 Terms

Data is available in three forms:

- **Raw** data is the data as held in the TM/TC or S/C databases as received/sent to the satellite
- **Converted** means the data after conversion to engineering values.
- **Processed** means data created during observation processing steps in the pipeline.

5 Automated early warning system

The automated early warning system is based around a set of tables/products generated by scripts. The tables are broken down essentially by subsystem to provide convenient monitoring of the functionality of that system. The data in these tables will be analysed weekly (TBD) by the use of scripts/IDL routines (TBD). The analysis will show evolution of parameters with time over short (e.g. 1 week), medium (e.g. 3 month) and long (e.g. whole mission) timescales. Also, where appropriate, correlation analyses will be carried out within these routines, and parameters corrected accordingly. Sudden deviations from expected parameter values will be clearly flagged for further investigation. Immediate notification / e-mail alert?

5.1 Summary of tables to be generated for trend analysis

5.1.1 300mK system trend analysis table (TASubKcooler)

This product records the parameters needed to monitor the health of the cooler and sub-kelvin thermal hardware. The output is a product containing a TableDataset, corresponding to one cooler recycle period (up to two operational days).

The heatswitch (pump & evaporator) thermal conductance (both "off" state and "on" state) may change throughout the mission lifetime. For instance, the on-state conductance may gradually change due to slow loss of ^{3}He through micro-leaks. Likewise, the thermal conductance for both states may degrade slowly with time due to joint corrosion. This can be monitored and tracked by recording the pump & evaporator temperatures at set points throughout the standard recycle sequence (i.e applied power vs. time).
There is a small, but finite possibility that the heater (pump & evaporator heatswitches, pump heater, PTC heater) impedance may drift slightly with time, due to radiation damage and/or changing contact/joint impedance. Heater applied current and voltage drop will be recorded to monitor this.
The overall thermal conductance of the 300mK strap system, and of the thermal isolation supports, may change with time. Therefore the mean array temperatures need to be recorded, as well as the level-0 and subKtemp temperatures.

5.1.1.1 TASubKcooler product format

For each cooler recycle period, there will be a single TASubKcooler product generated. It will contain a single table dataset, with the format indicated in **Table 1**.

Table 1 TASubKcooler product format

Product (type= "TASubKcooler", description= "Sub-K system trend analysis output table") Class: Herschel.ia.dataset.product		
Metadata:		
String	type	(description= "Product type identification", quantity= "")
String	author	(description= "Author of this product", quantity= "")
String	creator	(description= "Generator of this product", quantity= "")
FineTime	creationdate	(description= "Creation date of this product", quantity= "UTC")
String	description	(description= "Name of this product", quantity= "")
String	instrument	(description= "Instrument", quantity= "")
String	modelName	(description= "Instrument model name", quantity= "")
FineTime	startDate	(description= "Start date of this product", quantity= "UTC")
FineTime	endDate	(description= "End date of this product", quantity= "UTC")
String	version	(description= "Version", quantity= "")
String	versionTrack	(description= "Version Track", quantity= "")
Long	versionNumber	(description= "Version Number", quantity= "")

Integer	odNumber	(description= "operational day number", quantity= "")
String	fileName	(description= "name of exported file", quantity= "")
Long	obsid	(description= "Observation ID", quantity= "")
Long	bbid	(description= "Building Block ID", quantity= "")
table dataset (key= "TAsubK", description= "SubK System TA"		
Column FineTime	sysTime	(description= "Mission clock time", quantity= "UTC")
Column FineTime	recTime	(description= "Recycle sequence time", quantity= "seconds")
Column Double1d	PUMPHTRTEMP	(description= "Pump heater temperature", quantity= "Kelvin")
Column Double1d	SPHTRV	(description= "Pump heater voltage", quantity= "Volts")
Column Double1d	PUMPHSTEMP	(description= "Pump heatswitch temperature", quantity= "Kelvin")
Column Double1d	SPHSV	(description= "Pump heatswitch voltage", quantity= "Volts")
Column Double1d	EVAPHSTEMP	(description= "Evaporator heatswitch temperature", quantity= "Kelvin")
Column Double1d	EVHSV	(description= "Evaporator heatswitch voltage", quantity= "Volts")
Column Double1d	SHUNTTEMP	(description= "Cooler thermal shunt temperature", quantity= "Kelvin")
Column Double1d	TC123TEMP	(description= "PTC temperature", quantity= "Kelvin")
Column Double1d	TCHTRV	(description= "PTC heater voltage", quantity= "Volts")
Column Double1d	TCBIAS	(description= "PTC thermistor bias", quantity= "Volts")
Column Double1d	SUBKTEMP	(description= "Evaporator tip temperature", quantity= "Kelvin")
Column Double1d	PSWtemp	(description= "PSW mean temperature", quantity= "Kelvin")
Column Double1d	PMWtemp	(description= "PMW mean temperature", quantity= "Kelvin")
Column Double1d	PLWtemp	(description= "PLW mean temperature", quantity= "Kelvin")
Column Double1d	SSWtemp	(description= "SSW mean temperature", quantity= "Kelvin")
Column Double1d	SLWtemp	(description= "SLW mean temperature", quantity= "Kelvin")
Column Double1d	EMCFILTEMP	(description= "L1 SOB temperature", quantity= "Kelvin")
Column Double1d	PL0TEMP	(description= "L0 photometer box temperature", quantity= "Kelvin")
Column Double1d	SL0TEMP	(description= "L0 spectrometer box temperature", quantity= "Kelvin")

Table 2 TASubKcooler product content

Column #	Parameter	SPIRE parameter name	Derived from?	Comment
1	sysTime	TIME		Overall mission clock time (seconds).
2	recTime		TIME	Time since initiation of current fridge recycle period. Resets to zero at start of each recycle. (seconds)
3	PUMPHTRTEMP	PUMPHTRTEMP	NHK timeline	Cooler pump heater temperature (Kelvin)
4	SPHTRV	SPHTRV	NHK timeline	Cooler pump heater voltage (Volts)
5	PUMPHSTEMP	PUMPHSTEMP	NHK timeline	Cooler pump heatswitch temperature

				(Kelvin)
6	SPHSV	SPHSV	NHK timeline	Pump heatswitch voltage (Volts)
7	EVAPHSTEMP	EVAPHSTEMP	NHK timeline	Evaporator heatswitch temperature (Kelvin)
8	EVHSV	EVHSV	NHK timeline	Evaporator heatswitch voltage (Volts)
9	SHUNTTEMP	SHUNTTEMP	NHK timeline	Cooler thermal shunt temperature (Kelvin)
10	TC123TEMP		TC1TEMP, TC2TEMP, TC3TEMP (mean)	PTC temperature (Kelvin)
11	TCHTRV	TCHTRV	NHK timeline	PTC heater voltage (Volts)
12	TCBIAS	TCBIAS	NHK timeline	PTC thermistor bias (Volts)
13	SUBKTEMP	SUBKTEMP	NHK timeline	Evaporator tip temperature (Kelvin)
14	PSWtemp		?	Mean temperature given by thermistors on the detector arrays (Kelvin).
15	PMWtemp		?	
16	PLWtemp		?	
17	SSWtemp		?	
18	SLWtemp		?	
19	EMCFILTEMP	EMCFILTEMP	NHK timeline	SPIRE SOB (level-1) temperature (Kelvin)
20	PLOTEMP	PLOTEMP	NHK timeline	SPIRE level-0 photometer box temperature (Kelvin)
21	SLOTEMP	SLOTEMP	NHK timeline	SPIRE level-0 spectrometer box temperature (Kelvin)

5.1.1.2 TASubKcooler product – rules for appending data

- Parameter 2 (recTime) is the time from the start of the current recycle operation, and should be reset to zero at the initiation of each cooler recycle.
- Values for all parameters indicated in Table 1 should be appended at the following times:-
  - At recTime = 0, i.e at the initiation of a cooler recycle operation.
  - While recTime ≤ 180 minutes, all parameters should be appended at 1 minute intervals.
  - Thereafter, all parameters should be appended at hourly intervals, in the range 3hrs < recTime < 45hrs

5.1.1.3 Storage of TASubKcooler product

The filenames of TASubKcooler trend analysis products take the generic form:
hspireta_subk<obsid>_<operational day>

5.1.1.4 Summary :-

5.1.2 Detector and PCal trend analysis tables

These tables contain parameters needed to monitor both the health of PCal itself, and the responsivity and time-constant of each detector. There are two products, one for the photometer detectors, and one for the spectrometer detectors.
It is possible (although very unlikely) that the emissivity of the source may change with time due to deterioration of the metal film on the sapphire substrate. This effect would manifest itself as a change in the optical power on all detectors for a fixed electrical power dissipation. It will be very difficult to isolate this effect from other factors which could affect detector responsivity, such as changes in background power, but may show up as a very long-term trend.
There is a very small, but finite possibility that the NTD Ge thermistor chips may experience a change in their R(T) characteristics due to radiation damage over the mission lifetime.
Noise in each detector chain may change for a variety of reasons, ageing of joints, EMI, etc.
Therefore, for all PCal flash sequences, the mean detector signal (ΔV) and standard deviation over the flash sequence should be recorded for all active detectors (photometer or spectrometer).
The impedance of the source may change over long time periods, most likely due to ageing of the indium-soldered joints, which could then in turn modify the electrical power dissipation and optical output. The

maximum expected impedance change would be of the order ~5% of the overall emitter impedance (approximate magnitude of change observed using non-flight-like silver epoxy joints). For each PCal flash sequence, the mean value of PCALCURR and PCALV should be recorded.
The detector responsivity will vary according to the photon background on the detectors. Therefore, for all PCal observations, it is essential that the telescope temperatures and the SPIRE boresight RA and DEC are recorded, in order to take account of this effect.
The time response of the detectors may change due to changes in the PCal emitter, or due to changes within the detectors. For instance, loss of material (e.g. nichrome film, solder) from the emitter will lower the heat capacity, and make the emitter faster. The presence of a superfluid helium film on the detectors will increase their heat capacity, and slow the response. This is a very important parameter to monitor regularly.

5.1.2.1 TAPCalPDet product format

There should be a single photometer detector/PCal TA product, which should have new data appended to a row corresponding to each PCal flash sequence during which the photometer detectors are active. It should contain one table dataset per photometer detector, with the format indicated in Table 3.

Table 3 TAPCalPDet product format

Product (type= “TAPCalPDet”, description= “Photometer detector and PCal trend analysis output table”) Class: Herschel.spire.ia.dataset.TBD		
Metadata:		
String	type	(description= “Product type identification”, quantity= “”)
String	author	(description= “Author of this product”, quantity= “”)
String	creator	(description= “Generator of this product”, quantity= “”)
FineTime	creationdate	(description= “Creation date of this product”, quantity= “UTC”)
String	description	(description= “Name of this product”, quantity= “”)
String	instrument	(description= “Instrument”, quantity= “”)
String	modelName	(description= “Instrument model name”, quantity= “”)
FineTime	startDate	(description= “Start date of this product”, quantity= “UTC”)
FineTime	endDate	(description= “End date of this product”, quantity= “UTC”)
String	version	(description= “Version”, quantity= “”)
String	versionTrack	(description= “Version Track”, quantity= “”)
Long	versionNumber	(description= “Version Number”, quantity= “”)
String	fileName	(description= “name of exported file”, quantity= “”)
Note:- In the table dataset definition below, “xxxxxx” refers to the detector label, e.g. “PSWG02”, or “PSWC15”. There will be one table dataset per detector.		
table dataset (key= “TAPCalxxxxxx”, description= “Detector xxxxxx and PCal TA”		
Column FineTime	sysTime	(description= “Mission clock time”, quantity= “UTC”)
Column Long	obsid	(description= “Observation ID”, quantity= “”)
Column Long	bbid	(description= “Building Block ID”, quantity= “”)
Column Integer	odNumber	(description= “operational day number”, quantity= “”)
Column Double1d	ra	(description= “actual RA of pointing”, quantity= “degrees”)
Column Double1d	dec	(description= “actual dec of pointing”, quantity= “degrees”)
Column Double1d	priTemp	(description= “Mean temperature of primary mirror”, quantity= “Kelvin”)
Column Double1d	secTemp	(description= “Mean temperature of secondary mirror”, quantity= “Kelvin”)
Column Double1d	subKTemp	(description= “Mean value of evaporator tip thermometer over flash sequence”, quantity= “Kelvin”)
Column Double1d	pswBias	(description= “Mean PSW bias voltage”, quantity= “Volts”)

Column Double1d	pmwBias	(description= “Mean PMW bias voltage”, quantity= “Volts”)
Column Double1d	plwBias	(description= “Mean PLW bias voltage”, quantity= “Volts”)
Column Float	PcalCURR	(description= “Mean “on” current over flash sequence”, quantity= “Amps”)
Column Float	PcalV	(description= “Mean “on” voltage over flash sequence”, quantity= “Volts”)
Column Float	inputPower	(description= “Input power to PCal”, quantity= “Watts”)
Column Long	nPulsesFound	(description= “Pulses found”, quantity= “”)
Column Long	currentOutOfRange	(description= “PCal current out of range flag”, quantity= “”)
Column Long	voltageOutOfRange	(description= “PCal voltage out of range flag”, quantity= “”)
Column String	pixelName	(description= “PixelName”, quantity= “”)
Column Double1d	baseMean	(description= “Mean of base level”, quantity= “Volts or Watts”)
Column Double1d	baseRMS	(description= “RMS of base level”, quantity= “Volts or Watts”)
Column Double1d	signalDiffMean	(description= “Mean of signal difference”, quantity= “Volts or Watts”)
Column Double1d	signalDiffRms	(description= “RMS of signal difference”, quantity= “Volts or Watts”)
Column Double1d	tauOnMean	(description= “Mean of flash-on time constant”, quantity= “milliseconds”)
Column Double1d	tauOnRms	(description= “RMS of flash-on time constant”, quantity= “milliseconds”)
Column Bool1d	isOnFitSuccess	(description= “Flash-on fitting flag”, quantity= “”)
Column Double1d	tauOffMean	(description= “Mean of flash-off time constant”, quantity= “milliseconds”)
Column Double1d	tauOffRms	(description= “RMS of flash-off time constant”, quantity= “milliseconds”)
Column Bool1d	isOffFitSuccess	(description= “Flash-off fitting flag”, quantity= “”)
Column Bool1d	tauOnOutOfRange	(description= “Flash-on time constant flag”, quantity= “”)
Column Bool1d	tauOffOutOfRange	(description= “Flash-off time constant flag”, quantity= “”)

Table 4 Format for detector/PCal TA table.

Column #	Parameter	Derived from?	Comment
1	sysTime		
2	obsid		Identifies the observation from which the data come
3	bbid		Identifies the building block within the observation
4	odNumber		Operational day number for the observation
5	ra		SPIRE boresight R.A.
6	dec		SPIRE boresight Dec.
7	priTemp		Mean value for primary mirror thermometers
8	secTemp		Mean value for secondary mirror thermometers
9	subKTemp	NHK timeline	Mean value of SubKTemp over flash sequence

10	pswBias	NHK timeline	Mean PSW bias voltage
11	pmwBias	NHK timeline	Mean PMW bias voltage
12	plwBias	NHK timeline	Mean PLW bias voltage
13	PcalCURR	NHK timeline	Mean "on" current over flash sequence
14	PcalV	NHK timeline	Mean "on" voltage over flash sequence
15	inputPower	=[PcalCurr]*[PcalV]	Mean PCal "on" power
16	nPulsesFound	SCalPhotPcal	Number of flashes found from SCUT
17	currentOutOfRange	SCalPhotPcal	Flag indicating PCal current is outside expected range
18	voltageOutOfRange	SCalPhotPcal	Flag indicating PCal voltage is outside expected range
19	pixelName	SCalPhotPcal	Unique name for each pixel, e.g. PLWC5
20	baseMean	SCalPhotPcal	Mean of the base (flash off) signal (units of input detector timeline)
21	baseRMS	SCalPhotPcal	Standard deviation of the base (flash off) signal (units of input detector timeline)
22	signalDiffMean	SCalPhotPcal	Mean of the on-off signal difference (units of input detector timeline)
23	signalDiffRms	SCalPhotPcal	Standard deviation of the on-off signal difference (units of input detector timeline)
24	tauOnMean	SCalPhotPcal	Mean of the flash-on time constant
25	tauOnRms	SCalPhotPcal	Standard deviation of the flash-on time constant
26	isOnFitSuccess	SCalPhotPcal	Flag indicating successful fitting of the flash-on time constant
27	tauOffMean	SCalPhotPcal	Mean of the flash-off time constant
28	tauOffRms	SCalPhotPcal	Standard deviation of the flash-off time constant
29	isOffFitSuccess	SCalPhotPcal	Flag indicating successful fitting of the flash-off time constant
30	tauOnOutOfRange	SCalPhotPcal	Flag indicating flash-on time constant is outside expected range
31	tauOffOutOfRange	SCalPhotPcal	Flag indicating flash-off time constant is outside expected range

5.1.2.2 TAPCalPDet product – rules for appending data

There should be a single photometer detector/PCal TA product, which should have new data appended to a single row corresponding to each PCal flash sequence during which the photometer detectors are active.

5.1.2.3 TAPCalSDet product format

There should be a single spectrometer detector/PCal TA product, which should have new data appended to a row corresponding to each PCal flash sequence during which the spectrometer detectors are active. It should contain one table dataset per spectrometer detector, with the format indicated in Table 3.

Table 5 TAPCalSDet product format

Product (type= “TAPCalSDet”, description= “Spectrometer detector and PCal trend analysis output table”) Class: Herschel.spire.ia.dataset.TBD		
Metadata:		
String	type	(description= “Product type identification”, quantity= “”)
String	author	(description= “Author of this product”, quantity= “”)
String	creator	(description= “Generator of this product”, quantity= “”)
FineTime	creationdate	(description= “Creation date of this product”, quantity= “UTC”)
String	description	(description= “Name of this product”, quantity= “”)
String	instrument	(description= “Instrument”, quantity= “”)
String	modelName	(description= “Instrument model name”, quantity= “”)
FineTime	startDate	(description= “Start date of this product”, quantity= “UTC”)
FineTime	endDate	(description= “End date of this product”, quantity= “UTC”)
String	version	(description= “Version”, quantity= “”)
String	versionTrack	(description= “Version Track”, quantity= “”)
Long	versionNumber	(description= “Version Number”, quantity= “”)
String	fileName	(description= “name of exported file”, quantity= “”)
Note:- In the table dataset definition below, “xxxxxx” refers to the detector label, e.g. “SSWA02”, or “SSWC06”. There will be one table dataset per detector.		
table dataset (key= “TAPCalxxxxxx”, description= “Detector xxxxxx and PCal TA”		
Column FineTime	sysTime	(description= “Mission clock time”, quantity= “UTC”)
Column Long	obsid	(description= “Observation ID”, quantity= “”)
Column Long	bbid	(description= “Building Block ID”, quantity= “”)
Column Integer	odNumber	(description= “operational day number”, quantity= “”)
Column Double1d	ra	(description= “actual RA of pointing”, quantity= “degrees”)
Column Double1d	dec	(description= “actual dec of pointing”, quantity= “degrees”)
Column Double1d	priTemp	(description= “Mean temperature of primary mirror”, quantity= “Kelvin”)
Column Double1d	secTemp	(description= “Mean temperature of secondary mirror”, quantity= “Kelvin”)
Column Double1d	subKTemp	(description= “Mean value of evaporator tip thermometer over flash sequence”, quantity= “Kelvin”)
Column Double1d	sswBias	(description= “Mean SSW bias voltage”, quantity= “Volts”)
Column Double1d	slwBias	(description= “Mean SLW bias voltage”, quantity= “Volts”)
Column Float	PcalCURR	(description= “Mean “on” current over flash sequence”, quantity= “Amps”)
Column Float	PcalV	(description= “Mean “on” voltage over flash sequence”, quantity= “Volts”)
Column Float	inputPower	(description= “Input power to PCal”, quantity= “Watts”)
Column Long	nPulsesFound	(description= “Pulses found”, quantity= “”)
Column Long	currentOutOfRange	(description= “PCal current out of range flag”, quantity= “”)
Column Long	voltageOutOfRange	(description= “PCal voltage out of range flag”, quantity= “”)
Column String	pixelName	(description= “PixelName”, quantity= “”)
Column Double1d	baseMean	(description= “Mean of base level”, quantity= “Volts or Watts”)

Column Double1d	baseRMS	(description= "RMS of base level", quantity= "Volts or Watts")
Column Double1d	signalDiffMean	(description= "Mean of signal difference", quantity= "Volts or Watts")
Column Double1d	signalDiffRms	(description= "RMS of signal difference", quantity= "Volts or Watts")
Column Double1d	tauOnMean	(description= "Mean of flash-on time constant", quantity= "milliseconds")
Column Double1d	tauOnRms	(description= "RMS of flash-on time constant", quantity= "milliseconds")
Column Bool1d	isOnFitSuccess	(description= "Flash-on fitting flag", quantity= "")
Column Double1d	tauOffMean	(description= "Mean of flash-off time constant", quantity= "milliseconds")
Column Double1d	tauOffRms	(description= "RMS of flash-off time constant", quantity= "milliseconds")
Column Bool1d	isOffFitSuccess	(description= "Flash-off fitting flag", quantity= "")
Column Bool1d	tauOnOutOfRange	(description= "Flash-on time constant flag", quantity= "")
Column Bool1d	tauOffOutOfRange	(description= "Flash-off time constant flag", quantity= "")

Table 6 Format for spectrometer detector/PCal TA table.

Column #	Parameter	Derived from?	Comment
1	sysTime		
2	obsid		Identifies the observation from which the data come
3	bbid		Identifies the building block within the observation
4	odNumber		Operational day number for the observation
5	ra		SPIRE boresight R.A.
6	dec		SPIRE boresight Dec.
7	priTemp		Mean value for primary mirror thermometers
8	secTemp		Mean value for secondary mirror thermometers
9	subKTemp	NHK timeline	Mean value of SubKTemp over flash sequence
10	sswBias	NHK timeline	Mean SSW bias voltage
11	slwBias	NHK timeline	Mean SLW bias voltage
12	PcalCURR	NHK timeline	Mean "on" current over flash sequence
13	PcalV	NHK timeline	Mean "on" voltage over flash sequence
14	inputPower	=[PcalCurr]*[PcalV]	Mean PCal "on" power
15	nPulsesFound	ScalSpecPcal	Number of flashes found from SCUT
16	currentOutOfRange	ScalSpecPcal	Flag indicating PCal current is outside expected range
17	voltageOutOfRange	ScalSpecPcal	Flag indicating PCal voltage is outside expected range
18	pixelName	ScalSpecPcal	Unique name for each pixel, e.g. PLWC5
19	baseMean	ScalSpecPcal	Mean of the base (flash off) signal (units of input detector

			timeline)
20	baseRMS	ScalSpecPcal	Standard deviation of the base (flash off) signal (units of input detector timeline)
21	signalDiffMean	ScalSpecPcal	Mean of the on-off signal difference (units of input detector timeline)
22	signalDiffRms	ScalSpecPcal	Standard deviation of the on-off signal difference (units of input detector timeline)
23	tauOnMean	ScalSpecPcal	Mean of the flash-on time constant
24	tauOnRms	ScalSpecPcal	Standard deviation of the flash-on time constant
25	isOnFitSuccess	ScalSpecPcal	Flag indicating successful fitting of the flash-on time constant
26	tauOffMean	ScalSpecPcal	Mean of the flash-off time constant
27	tauOffRms	ScalSpecPcal	Standard deviation of the flash-off time constant
28	isOffFitSuccess	ScalSpecPcal	Flag indicating successful fitting of the flash-off time constant
29	tauOnOutOfRange	ScalSpecPcal	Flag indicating flash-on time constant is outside expected range
30	tauOffOutOfRange	ScalSpecPcal	Flag indicating flash-off time constant is outside expected range

5.1.2.4 TAPCalSDet product – rules for appending data

There should be a single spectrometer detector/PCal TA product, which should have new data appended to a single row corresponding to each PCal flash sequence during which the spectrometer detectors are active.

5.1.2.5 Derivation of detector/PCal data

The majority of the parameters required for these tables are derived from the nominal housekeeping timeline, and the data processing pipeline PCal module (module #41). Four spacecraft-level parameters are also required. These are:-

- Telescope primary mean temperature
- Telescope secondary temperature
- SPIRE Ra (boresight)
- SPIRE Dec (boresight)

These spacecraft parameters are required, as the background on the detectors will have a significant effect on the responsivity, and must be known.

5.1.2.6 Storage of detector/PCal data

The filenames of TAPCalPDet trend analysis products take the generic form:
hspireta_pcalp<obsid>_<operational day> TBD – talk to Steve/Tanya
TAPCalSDet

5.1.3 Spectrometer calibration source (SCal) trend analysis table (TAScal)

Each SCal source has a heater, which is a high-reliability 500Ω chip resistor. Although not observed during accelerated life tests, there is a possibility that the overall impedance may change slightly, due to ageing of the soldered joints. The current applied to each source, and the resulting voltage-drop will be recorded for each SCal operation.

It is possible that the high-emissivity black coating could degrade with time, affecting the overall source emissivity. This will be a very difficult effect to monitor. If the emissivity of a source did change slightly, then the following effects would be evident:-

- Change in the required source temperature to null the central maximum of the interferogram for a certain astronomical source (preferably, patch of blank sky).
- Change in the source spectrum.

The thermal conductance of the Torlon legs of the sources may change very slightly with time due to radiation damage. This can be monitored by recording the applied power vs. equilibrium temperature of the sources. This effect should not impact SCal operation, unless the magnitude of the effect is large (highly unlikely). This is because SCal is operated under PID control, and a slight change in thermal conductance will simply cause a small change in power dissipation at level-1.

5.1.3.1 SCal TA table requirements

There should be a single SCal TA product for each observation during which SCal is switched on. It should contain one table dataset, with the format indicated in **Table 7**

Table 7 TAScal product format

Product (type= “TAScal”, description= “Spectrometer calibrator trend analysis output table”) Class: Herschel.ia.dataset.product		
Metadata:		
String	type	(description= “Product type identification”, quantity= “”)
String	author	(description= “Author of this product”, quantity= “”)
String	creator	(description= “Generator of this product”, quantity= “”)
FineTime	creationdate	(description= “Creation date of this product”, quantity= “UTC”)
String	description	(description= “Name of this product”, quantity= “”)
String	instrument	(description= “Instrument”, quantity= “”)
String	modelName	(description= “Instrument model name”, quantity= “”)
FineTime	startDate	(description= “Start date of this product”, quantity= “UTC”)
FineTime	endDate	(description= “End date of this product”, quantity= “UTC”)
String	version	(description= “Version”, quantity= “”)
String	versionTrack	(description= “Version Track”, quantity= “”)
Long	versionNumber	(description= “Version Number”, quantity= “”)
Integer	odNumber	(description= “operational day number”, quantity= “”)
String	fileName	(description= “name of exported file”, quantity= “”)
Long	obsid	(description= “Observation ID”, quantity= “”)
Long	bbid	(description= “Building Block ID”, quantity= “”)
table dataset (key= “TAScal”, description= “Scal TA”		
Column FineTime	sysTime	(description= “Mission clock time”, quantity= “UTC”)
Column FineTime	scalTime	(description= “Time from initiation of SCal operation”, quantity= “seconds”)
Column Double1d	SCAL2TEMP	(description= “SCal 2% source temperature”, quantity= “Kelvin”)
Column Double1d	SCAL2CURR	(description= “SCal 2% source current”, quantity= “Amps”)
Column Double1d	SCAL2V	(description= “SCal 2% source voltage”, quantity= “Volts”)
Column Double1d	SCAL4TEMP	(description= “SCal 4% source temperature”, quantity= “Kelvin”)
Column Double1d	SCAL4CURR	(description= “SCal 4% source current”, quantity= “Amps”)
Column Double1d	SCAL4V	(description= “SCal 4% source voltage”, quantity= “Volts”)
Column Double1d	SCALTEMP	(description= “SCal interface temperature”, quantity= “Kelvin”)
Column Double1d	SL0TEMP	(description= “L0 spectrometer box temperature”, quantity= “Kelvin”)

Column Double1d	EMCFILTEMP	(description= “L1 SOB temperature”, quantity= “Kelvin”)

Table 8 Format for SCal TA table.

Column #	Parameter	Derived from?	Comment
1	sysTime		Overall mission clock time (seconds?).
2	scalTime		Time from commencement of SCal operation (seconds)
3	SCAL2TEMP	NHK timeline	SCal 2% source temperature (Kelvin)
4	SCAL2CURR	NHK timeline	Current applied to SCal 2% source (Amps)
5	SCAL2V	NHK timeline	Voltage drop across SCal 2% source (V)
6	SCAL4TEMP	NHK timeline	SCal 4% source temperature (Kelvin)
7	SCAL4CURR	NHK timeline	Current applied to SCal 4% source (Amps)
8	SCAL4V	NHK timeline	Voltage drop across SCal 4% source (V)
9	SCALTEMP	NHK timeline	Temperature of SCal body thermometer (Kelvin)
10	SL0TEMP	NHK timeline	SPIRE level-0 temperature
11	EMCFILTEMP	NHK timeline	SPIRE level-1 temperature

5.1.3.2 TASCal product – rules for appending data

One SCal table dataset product will be produced for each observation during which an SCal source is switched on. Rows should be appended to this table in the following manner:-

- At the initiation of an SCal operation, i.e. at the moment current is first applied to an SCal source, set scalTime=0.
- Record all parameters listed in table 3 (i.e. add a row to the SCal TA table) at 30 second intervals, until the active source (2% or 4%) achieves the commanded temperature ±0.2K.
- Then record all parameters at 10 minute intervals, unless the commanded or monitored temperature of the active source changes by more than 1K.
    - If the commanded or monitored temperature changes by more than 1K, then revert to 30 second recording intervals until the monitored & commanded temperatures agree to within 0.2K.
- If SCal is switched off, i.e. at the end of an SCal operation, record all parameters at 10 minute intervals for 2 Hrs after termination of the operation. This is to enable the cool-down to be properly monitored.
- No action needs to be taken whilst SCal is not active.

5.1.4 Beam steering mirror trend analysis table (TABSM)

The overall drive coil circuit impedance may change slightly over the mission lifetime, due to ageing of electrical joints. As the coils are driven with a current drive, a change in the coil impedance would have the effect of altering the power dissipation for a certain commanded current. The magnetic flux generated by the drive coils should not be affected, as the drive current is the same.
The chop/jiggle position of the mirror for a certain drive current may drift with time due to two possible effects:-

- Loss of flux from permanent magnets. This would alter the flux linked by the drive coil, and therefore the force generated by a certain drive current.
- Change in material properties of flex pivots. The stiffness of the flex pivots may change over the mission lifetime, therefore changing the magnetic force (therefore drive current) required for a certain chop/jiggle position.

5.1.4.1 BSM TA table requirements

There should be a single BSM TA product for each observation during which the BSM is utilised. It should contain one table dataset, with the format indicated in **Table 9**

Table 9 TABSM product format

Product (type= "TABSM", description= "BSM trend analysis output table") Class: Herschel.ia.dataset.product		
Metadata:		
String	type	(description= "Product type identification", quantity= "")
String	author	(description= "Author of this product", quantity= "")
String	creator	(description= "Generator of this product", quantity= "")
FineTime	creationdate	(description= "Creation date of this product", quantity= "UTC")
String	description	(description= "Name of this product", quantity= "")
String	instrument	(description= "Instrument", quantity= "")
String	modelName	(description= "Instrument model name", quantity= "")
FineTime	startDate	(description= "Start date of this product", quantity= "UTC")
FineTime	endDate	(description= "End date of this product", quantity= "UTC")
String	version	(description= "Version", quantity= "")
String	versionTrack	(description= "Version Track", quantity= "")
Long	versionNumber	(description= "Version Number", quantity= "")
Integer	odNumber	(description= "operational day number", quantity= "")
String	fileName	(description= "name of exported file", quantity= "")
Long	obsid	(description= "Observation ID", quantity= "")
Long	bbid	(description= "Building Block ID", quantity= "")
table dataset key= "TABSM", description= "BSM TA")		
Column FineTime	sysTime	(description= "Mission clock time", quantity= "UTC")
Column Double1d	CHOPMOTRES	(description= "Chop motor resistance", quantity= "Ohms")
Column Double1d	CHOPSENSSIG	(description= "Chop sensor signal", quantity= "Volts")
Column Double1d	CHOPMOTORCURR	(description= "Chop motor current", quantity= "Amps")
Column Double1d	CHOPMOTORVOLT	(description= "Chop motor voltage", quantity= "Volts")
Column Double1d	JIGGMOTRES	(description= "Jiggle motor resistance", quantity= "Ohms")
Column Double1d	JIGGSENSSIG	(description= "Jiggle sensor signal", quantity= "Volts")
Column Double1d	JIGGMOTORCURR	(description= "Jiggle motor current", quantity= "Amps")
Column Double1d	JIGGMOTORVOLT	(description= "Jiggle motor voltage", quantity= "Volts")

Table 10 Format for BSM TA table.

Column #	Parameter	Derived from?	Comment
1	sysTime		Overall mission clock time (seconds?).
2	CHOPMOTRES	NHK timeline	Chop motor resistance
3	CHOPSENSSIG	NHK timeline	Chop sensor signal
4	CHOPMOTORCURR	NHK timeline	Chop motor current
5	CHOPMOTORVOLT	NHK timeline	Chop motor voltage
6	JIGGMOTRES	NHK timeline	Jiggle motor resistance

7	JIGGSENSSIG	NHK timeline	Jiggle sensor signal
8	JIGGMOTORCURR	NHK timeline	Jiggle motor current
9	JIGGMOTORVOLT	NHK timeline	Jiggle motor voltage

5.1.4.2 TABSM product – rules for appending data

One BSM table dataset product will be produced for each observation during which the BSM is utilised. Rows should be appended to this table in the following manner:-

- Throughout a BSM operation (chop and /or jiggle sequence), assuming an approximate square-wave 2 Hz chop sequence (bearing in mind control loop tuning), all parameters listed in **Table 9** should be recorded as follows:-
    - 200ms after CHOPMOTORCURR transitions from maximum to minimum value, or from minimum to maximum.
    - 200ms after JIGGMOTORCURR transitions from maximum to minimum value, or from minimum to maximum.
    - Following completion of AOT, record BSM all above values for BSM rest position (chop & jiggle motors un-powered) at 10 second intervals for 1 minute.
- No action needs to be taken whilst BSM is not active.

5.1.5 Spectrometer mechanism trend analysis table (TASMec)

The overall drive coil circuit impedance may change slightly over the mission lifetime, due to ageing of electrical joints. As the coils are driven with a current drive, a change in the coil impedance would have the effect of altering the power dissipation for a certain commanded current. The magnetic flux generated by the drive coils should not be affected, as the drive current is the same.

SMEC position vs. drive current

The position of the mirror mechanism for a certain drive current may drift with time due to two possible effects:-

1. Loss of flux from permanent magnets. This would alter the flux linked by the drive coil, and therefore the force generated by a certain drive current.
2. Change in material properties of flex pivots. The stiffness of the flex pivots may change over the mission lifetime, therefore changing the magnetic force (therefore drive current) required for a certain SMEC position.

5.1.5.1 Spectrometer mechanism (SMec) TA table requirements

There should be a single SMec TA product for each observation during which the SMec is utilised. It should contain one table dataset, with the format indicated in **Table 11**

Table 11 TASMec product format

Product (type= "TASMec", description= "SMec trend analysis output table") Class: Herschel.ia.dataset.product		
Metadata:		
String	type	(description= "Product type identification", quantity= "")
String	author	(description= "Author of this product", quantity= "")
String	creator	(description= "Generator of this product", quantity= "")
FineTime	creationdate	(description= "Creation date of this product", quantity= "UTC")
String	description	(description= "Name of this product", quantity= "")
String	instrument	(description= "Instrument", quantity= "")
String	modelName	(description= "Instrument model name", quantity= "")
FineTime	startDate	(description= "Start date of this product", quantity= "UTC")
FineTime	endDate	(description= "End date of this product", quantity= "UTC")
String	version	(description= "Version", quantity= "")

String	versionTrack	(description= "Version Track", quantity= "")
Long	versionNumber	(description= "Version Number", quantity= "")
Integer	odNumber	(description= "operational day number", quantity= "")
String	fileName	(description= "name of exported file", quantity= "")
Long	obsid	(description= "Observation ID", quantity= "")
Long	bbid	(description= "Building Block ID", quantity= "")
table dataset key= "TASMec", description= "SMec TA")		
Column FineTime	sysTime	(description= "Mission clock time", quantity= "UTC")
Column Double1d	SMECMOTORRES	(description= "SMec motor resistance", quantity= "Ohms")
Column Double1d	SMECENCPOSN	(description= "SMec encoder position", quantity= "TBD")
Column Double1d	SMECENCSIG1	(description= "SMec encoder signal #1", quantity= "Volts")
Column Double1d	SMECENCSIG2	(description= "SMec encoder signal #2", quantity= "Volts")
Column Double1d	SMECENCSIG3	(description= "SMec encoder signal #3", quantity= "Volts")
Column Double1d	SMECLVDTPOSN	(description= "SMec LVDT position", quantity= "TBD")
Column Double1d	SMECLVDTACSIG	(description= "SMec LVDT AC signal", quantity= "Volts")
Column Double1d	SMECLVDTDCSIG	(description= "SMec LVDT DC signal", quantity= "Volts")
Column Double1d	SMECMOTORCURR	(description= "SMec motor current", quantity= "Amps")
Column Double1d	SMECMOTORVOLT	(description= "SMec motor voltage", quantity= "Volts")

Table 12 Format for SMec TA table.

Column #	Parameter	Derived from?	Comment
1	sysTime		Overall mission clock time (seconds?).
2	SMECMOTORRES	NHK timeline	
3	SMECENCPOSN	NHK timeline	
4	SMECENCSIG1	NHK timeline	
5	SMECENCSIG2	NHK timeline	
6	SMECENCSIG3	NHK timeline	
7	SMECLVDTPOSN	NHK timeline	
8	SMECLVDTACSIG	NHK timeline	
9	SMECLVDTDCSIG	NHK timeline	
10	SMECMOTORCURR	NHK timeline	
11	SMECMOTORVOLT	NHK timeline	

5.1.5.2 TASMec product – rules for appending data

One SMec table dataset product will be produced for each observation during which the SMec is utilised. Rows should be appended to this table in the following manner:-

- Throughout a SMec operation, all parameters listed in **Table 11** should be recorded as follows:-
    - Whenever SMECENCPOSN reaches it's maximum or minimum value.
    - Whenever SMECENCPOSN passes through ZPD position during a scan.
- No action needs to be taken whilst SMec is not active.

5.1.6 Spectrometer-specific TA – Talk to Lethbridge

5.1.7 JFET trend analysis table (TAJFET) – Talk to JPL

Temperature. Source / Drain voltages.

6 Data analysis and presentation

This section is still a work in progress at time of issue of this document…..

6.1 General description

Each operational day, the scripts that produce and update the trend analysis tables will be run as a scheduled task. These scripts will also produce plots, based on the data in these tables. The plots will be displayed on a dedicated trend analysis web page.

6.1.1 Plot format

6.1.1.1 Time evolution of parameters

Certain parameters may be displayed as a function of time, showing their evolution over the previous month, three months, and whole mission (TBC). These three plots, on different time resolutions, will be updated and replaced on the web page whenever the relevant trend analysis parameters / products are updated.

6.1.1.2 Standard curves

Some parameters may be plotted to show conformance to a typical procedure. A good example would be the cooler recycle sequence, where the standard heating and cooling profiles of heat switches and cryopumps should be consistent and repeatable. Deviations from these standard curves will be highlighted where appropriate.

6.2 Cryogenics

Details of data analysis and presentation will go here……

6.3 Detectors

6.4 PCal

6.5 SCal

6.6 BSM

6.7 SMec

6.8 JFETs

6.9 300mK system

7 Calibration TA

Analysis of the evolution of instrument calibration observations will be carried out manually by the SPIRE calibration scientist/team.

8 Notes