1. INTRODUCTION

When planning an observing programme using Herschel an observer enters details of their observations into the Herschel Proposal Handling System (PHS). The user interface to this system is handled by a version of SPOT, the Spitzer observation planning tool, adapted for use by Herschel. This interface allows the entry of observation parameters and provides feedback of useful information (for example observing time, signal to noise ratio achieved) to allow the observer to optimise their programme. This latter action is achieved by the PHS passing the parameters entered by the observer to the AOT Logic, which is responsible for transforming the observation into an instrument observing mode as defined in RD02 and for generating the instrument parameters that are associated with this mode. As well as being stored in the observation database for use by the HCS for scheduling observations some of these instrument parameters (notably the estimate of the time taken for an observation) are returned by the AOT Logic to the PHS to be displayed in the user interface, allowing the observer to optimise his/her observing programme.

This document describes the methods and formulae used by the AOT Logic to transform the parameters entered by an observer into the instrument parameters appropriate to the instrument modes that will be used to implement SPIRE photometric observations.

1.1 Scope

This document deals with the generation of the parameters used by the instrument observing modes. The actual modes themselves are implemented in the Common Uplink System (CUS).
It is beyond the scope of this note to define how the CUS scripts implement the instrument modes.

Issue 1 of this document applies to the PHS required for the input of Phase 1 Key Programme proposals. The AOT logic described is intended to provide a good enough estimate of the observing time to allow proposals to be planned, costed and judged by the time allocation committee.

The methods used here are necessarily simple since we do not yet know the sensitivities of the flight instrument, the optimal observing methods, or the details of the instrument operations necessary to implement the observing modes. Any more sophisticated approach would, at the present level of ignorance concerning the capabilities of the instrument, be overkill. We thus keep things restricted to the simplest possible methods.

1.2 Layout

The logic for each of the SPIRE photometry modes available to the user is described in detail in the following sections:

Section 2 indicates how the AOT Logic is called from the PHS.

Section 3 provides the description of the logic for the point source photometry mode. This is currently assumed to be implemented by the 7-point jiggle map instrument mode. The simpler chop & nod

mode remains as a backup, if required. The parameters defining this mode within the PHS are detailed in AD02.

Section 4 provides the description of the logic for the "small" map observing mode. This is a 4 x 4 arcmin^2 map. The parameters defining this mode within the PHS are detailed in AD03.

Section 5 provides the description of the logic for the "large" map observing mode. This is a > 4 x 4 arcmin^2 map. The parameters defining this mode within the PHS are detailed in AD04.

1.3 Documentation

1.3.1 Applicable Documents

AD01	SPIRE PHOT AOT Definition, Fox & Clements, Draft 1.1, 10th August 2004	(SPIRE-ICS-NOT-002139)
AD02	SPIRE SPOT OR Input: Point Sources, Clements, Draft 0.3, 10th Oct. 2004	(SPIRE-ICS-NOT-002142)
AD03	SPIRE SPOT Inputs : Photometric Mapping Observations, Vaccari, Issue 1.0, 18 Oct 2004	(SPIRE-ICS-NOT-002150)
AD04	Note on defining Spot OR input for delivery to HSC, Leeks	(SPIRE-ESA-NOT-002143)

1.3.2 Reference Documents

RD01	AOT Status Review, Clements, 11 August 2004	(SPIRE-ICS-NOT-002140)
RD02	Operating Modes for the SPIRE Instrument, Swinyard, Griffin & King, Issue 3.0, 4th Jan 2002	(SPIRE-RAL-NOT-000320)

2. INTERFACE TO PHS

The AOT Logic is called from the PHS with a set of well defined parameters, which depend on the observing mode selected by the observer. In all cases a parameter 'mode' will be present to allow the Logic to deal with the remaining input. AOT Logic and its relation with PHS is described in AD02 for Point Source Photometry and in AD03 for "Small Map" and "Large Map" Photometry.

3. POINT SOURCE PHOTOMETRY

3.1 Inputs from PHS

The following parameters will be passed to the AOT Logic:

Name	Type	Description
Mode	string	Observing mode = 'PSP'
Band	string	Primary wavelength band selected. Possible values are: 'PSW' for the 250um band 'PMW' for the 360 um band 'PLW' for the 520 um band
Flux	double	Source flux (mJy) in selected primary band
Sn	double	Signal to noise ratio required in selected primary band
pntTime	double	Observation time on source, excluding overheads, in seconds

Notes:

1. Only two of the parameters Flux, Sn or pntTime should be passed at any one call to the Logic. In the event that all three are passed, the pntTime will be ignored. Other combinations of input are deemed to be errors.
2. The input parameters relate to one detector wavelength band (the primary band) selected by the observer. The AOT Logic calculates parameters for the other bands.

3.2 Calibration Information

As well as the inputs from the PHS, the logic will need calibration information corresponding to the instrument model and mode.

For Issue 1 of the Logic this calibration information consists of the following parameters:

Name	Type	Description
Sensitivity	double[3]	Sensitivity in each band (mJy $Hz^{-1/2}$)
Overhead	double	Percentage time increase due to instrument overheads
Slew	double	Additional, fixed, time for slew to target, in seconds
confLimit	double[3]	1 sigma confusion limit for each band

3.3 Outputs

The AOT Logic returns information for the PHS to display to the observer. In this case the values of Flux, Sn and pntTime are returned for all three wavelength bands. The output values for the selected primary band are not changed, except possibly in the case of pntTime if all three values are input for this band.

The output parameters are:

Name	Type	Description
Band	string	Selected primary wavelength band. Copy of input parameter.
Flux	double[3]	Flux (mJy) in all wavelength bands. For the selected primary band this is either the input value or the calculated value if the s/n and time were given. For the secondary bands this is the calculated flux limit (1 sigma) for the calculated observation time.
Sn	double[3]	S/N in all wavelength bands. For the selected primary band this is either the input value or the calculated value if the flux and time were given. For the secondary bands this is set to 1, corresponding to the S/N obtained if the source is at the calculated flux limit.
pntTime	double[3]	Observation time on source, excluding overheads, in seconds. This is the same for all bands.
confFlag	boolean[3]	Set to TRUE if the observation in each wavelength band is likely to be affected by confusion (1 sigma sensitivity less than or equal to the confusion limit in the band).
totTime	double	Total observation time, including overheads, in seconds.

3.4 Calculation Algorithm for Primary Channel

The algorithm to determine the integration time `t` needed to reach a S/N of `n` at a flux `f` in the selected primary band is:

```
t = pntTime in band

s = Sensitivity in band

sigma = f / n

t = (s / sigma)^2
```

The algorithm may be 'inverted' to calculate any of the variables f, n or t from the other two if both the flux and signal to noise are not given. Now calculate the total observing time:

```
obsTime = t * (1 + Overheads/100)

totTime = obsTime + Slew
```

Following this calculation the confusion flag may be determined:

```
lim = confLimit in band

c = confFlag in band

If sigma <= lim then c = TRUE
```

3.5 Calculation Algorithm for Secondary Channels

For these channels we need to calculate the 1 sigma sensitivity obtained during the observation time specified for the primary channel. We assume the variable names defined above have similar meanings and types here.

For each secondary band:

```
obsTime = totTime - Slew

pntTime = obsTime / (1 + Overheads/100)

flux =  s / (pntTime)^1/2

sn = 1

If flux <= lim then c = TRUE
```

4. "SMALL MAP" PHOTOMETRY

4.1 Inputs from PHS

The following parameters will be passed to the AOT Logic:

Name	Type	Description
Mode	string	Observing mode = 'spire-phot-small-map'
Band	string	Primary wavelength band selected. Possible values are: 'PSW' for the 250um band 'PMW' for the 360 um band

		'PLW' for the 520 um band
refSrc	string	Chosen kind of reference source. Possible values are: 'point' for point reference source 'extended' for extended reference source
Flux	double	Reference source flux (in mJy or MJy/sr if refSrc is 'point' or 'extended' respectively) in selected primary band
Sn	double	Signal to noise ratio required for reference source in selected primary band
pntTime	double	Observation time on reference source, excluding overheads, in seconds

Notes:

1. Only two of the parameters Flux, Sn or pntTime should be passed at any one call to the Logic. In the event that all three are passed, the pntTime will be ignored. Other combinations of input are deemed to be errors.
2. The input parameters relate to one detector wavelength band (the primary band) selected by the observer. The AOT Logic calculates parameters for the other bands.

4.2 Calibration Information

As well as the inputs from the PHS, the logic will need calibration information corresponding to the instrument model and mode.

For Issue 1 of the Logic this calibration information consists of the following parameters:

Name	Type	Description
Sensitivity	double[3]	Sensitivity in each band (mJy $Hz^{-1/2}$)
Overhead	double	Percentage time increase due to instrument overheads
Slew	double	Additional, fixed, time for slew to target, in seconds
confLimit	double[3]	1 sigma confusion limit for each band

4.3 Outputs

The AOT Logic returns information for the PHS to display to the observer. In this case the values of Flux, Sn and pntTime are returned for all three wavelength bands. The output values for the selected primary band are not changed, except possibly in the case of pntTime if all three values are input for this band.

The output parameters are:

Parameter Name	Type	Description

Band	string	Selected primary wavelength band. Copy of input parameter.
Flux	double[3]	Flux (mJy) in all wavelength bands. For the selected primary band this is either the input value or the calculated value if the S/N and time were given. For the secondary bands this is the calculated flux limit (1 sigma) for the calculated observation time.
Sn	double[3]	For the selected primary band this is either the input value or the calculated value if the flux and time were given. For the secondary bands this is set to 1, corresponding to the s/n obtained if the source is at the calculated flux limit.
pntTime	double[3]	Observation time on source, excluding overheads, in seconds. This is the same for all bands.
confFlag	boolean[3]	Set to TRUE if the observation in each wavelength band is likely to be affected by confusion (1 sigma sensitivity less than or equal to the confusion limit in the band).
totTime	double	Total observation time, including overheads, in seconds.

4.4 Calculation Algorithm for Primary Channel

The algorithm to determine the integration time `t` needed to reach a S/N of `n` at a flux `f` in the selected primary band is:

```
t = pntTime in band

s = Sensitivity in band

sigma = f / n

t = (s / sigma)^2
```

The algorithm may be 'inverted' to calculate any of the variables f, n or t from the other two if both the flux and signal to noise are not given. Now calculate the total observing time:

```
obsTime = t * (1 + Overheads/100)

totTime = obsTime + Slew
```

Following this calculation the confusion flag may be determined:

```
lim = confLimit in band

c = confFlag in band
```

```
If sigma <= lim then c = TRUE
```

4.5 Calculation Algorithm for Secondary Channels

For these channels we need to calculate the 1 sigma sensitivity obtained during the observation time specified for the primary channel. We assume the variable names defined above have similar meanings and types here.

For each secondary band:

```
obsTime = totTime - Slew

pntTime = obsTime / (1 + Overheads/100)

flux =  s / (pntTime)^1/2

sn = 1

If flux <= lim then c = TRUE
```

5. "LARGE MAP" PHOTOMETRY

5.1 Inputs from PHS

The following parameters will be passed to the AOT Logic:

Name	Type	Description
Mode	string	Observing mode = 'spire-phot-large-map'
Band	string	Primary wavelength band selected. Possible values are: 'PSW' for the 250um band 'PMW' for the 360 um band 'PLW' for the 520 um band
Area	double	Overall map area, in square degrees
refSrc	string	Chosen kind of reference source. Possible values are: 'point' for point reference source 'extended' for extended reference source
Flux	double	Reference source flux (in mJy or MJy/sr if refSrc is 'point' or 'extended' respectively) in selected primary band
Sn	double	Signal to noise ratio required for reference source in selected primary band
pntTime	double	Observation time on reference source, excluding overheads, in seconds

Notes:

1. Only two of the parameters Flux, Sn or pntTime should be passed at any one call to the Logic. In the event that all three are passed, the pntTime will be ignored. Other combinations of input are deemed to be errors.
2. The input parameters relate to one detector wavelength band (the primary band) selected by the observer. The AOT Logic calculates parameters for the other bands.

5.2 Calibration Information

As well as the inputs from the PHS, the logic will need calibration information corresponding to the instrument model and mode.

For Issue 1 of the Logic this calibration information consists of the following parameters:

Name	Type	Description
arealSensitivity	double[3]	Areal sensitivity in each band (mJy $Hz^{-1/2}$ deg^{-1})
Overhead	double	Percentage time increase due to instrument overheads
Slew	double	Additional, fixed, time for slew to target, in seconds
confLimit	double[3]	1 sigma confusion limit for each band

5.3 Outputs

The AOT Logic returns information for the PHS to display to the observer. In this case the values of Flux, Sn and pntTime are returned for all three wavelength bands. The output values for the selected primary band are not changed, except possibly in the case of pntTime if all three values are input for this band.

The output parameters are:

Name	Type	Description
Band	string	Selected primary wavelength band. Copy of input parameter.
Area	double	Overall map area, in square degrees. Copy of input parameter.
Flux	double[3]	Flux (mJy) in all wavelength bands. For the selected primary band this is either the input value or the calculated value if the S/N and time were given. For the secondary bands this is the calculated flux limit (1 sigma) for the calculated observation time.
Sn	double[3]	For the selected primary band this is either the input value or the calculated value if the flux and time were given. For the secondary bands this is set to 1, corresponding to the s/n obtained if the source is at the calculated flux limit.
pntTime	double[3]	Observation time on source, excluding overheads, in seconds.

		This is the same for all bands.
confFlag	boolean[3]	Set to TRUE if the observation in each wavelength band is likely to be affected by confusion (1 sigma sensitivity less than or equal to the confusion limit in the band).
totTime	double	Total observation time, including overheads, in seconds.

5.4 Calculation Algorithm for Primary Channel

The algorithm to determine the integration time `t` needed to reach a S/N of `n` at a flux `f` in the selected primary band is:

```
t = pntTime in band

s = arealSensitivity in band

sigma = f / n

t = (s / sigma)^2 * Area
```

The algorithm may be 'inverted' to calculate any of the variables f, n or t from the other two if both the flux and signal to noise are not given. Now calculate the total observing time:

```
obsTime = t * (1 + Overheads/100)

totTime = obsTime + Slew
```

Following this calculation the confusion flag may be determined:

```
lim = confLimit in band

c = confFlag in band

If sigma <= lim then c = TRUE
```

5.5 Calculation Algorithm for Secondary Channels

For these channels we need to calculate the 1 sigma sensitivity obtained during the observation time specified for the primary channel. We assume the variable names defined above have similar meanings and types here.

For each secondary band:

```
obsTime = totTime - Slew
```

```
pntTime = obsTime / (1 + Overheads/100)

flux =  s * (Area / pntTime)^1/2

sn = 1

If flux <= lim then c = TRUE
```

NOTES

1. **For consistency, pntTime was adopted for all photometry modes even though in AD03 this was intTime (for Integration Time) for small and large maps. This must be reflected in AD03.**
2. **How is one going to define pntTime for maps, e.g. when scanning? Is this (and the ration pntTime/totTime) going to be different for different bands? If so, should we reflect by allowing pntTime to be different for the three bands and in the requirements for calibration information? Given the rather uniform beam/bolometer size ratio across bands, this is probably too much detail at this stage.**