1. INTRODUCTION

1.1 Purpose of this Document

The purpose of this document is to describe the inputs (as described by [R01]) that will be fed by the user into a first version of (Herschel) SPOT (hereafter, SPOT1) in order to produce the observing requests for SPIRE photometric mapping observations. It is assumed that most details that are not required at this stage will be provided for a second version of (Herschel) SPOT (hereafter, SPOT2). The document is based on current assumptions for SPIRE photometer observing modes as described by [R03] and closely follows the approach adopted by [R05] for the definition of SPOT input parameters for SPIRE point source photometric observations, reporting some of its main assumptions for emphasis. More in general, the SPOT "look-and-feel" for photometric mapping observations has been kept as much as possible in line with what was established by [R05] for SPIRE photometric observations of point sources and by [R06] for SPIRE spectrometric observations.

1.2 Document History

Draft 0.1 - 11 Oct 2004 - First draft circulated within ICC (Mattia Vaccari)
Draft 0.2 - 13 Oct 2004 - Final draft circulated within ICC (Mattia Vaccari)
Issue 1.0 - 15 Oct 2004 - Delivery to ESA for SPOT1 development (Mattia Vaccari)

1.3 References

[R01] - Note on defining SPOT OR input for delivery to HSC, by Sarah Leeks (7 Sept. 2004)
[R02] - AOT Status Review, by D.L. Clements (11 August 2004)
[R03] - SPIRE PHOT AOT Definition, by M. Fox, S. Leeks, D.L. Clements (10 Aug 2004)
[R04] - Notes from the meeting on AOTs for the FTS (Paris, 17 May 2004), by M. Sauvage
[R05] - SPIRE SPOT OR Input: Point Sources, by D. Clements (Draft 0.3, 5 Oct 2004)
[R06] - SPIRE SPOT OR Input: Spectrometer, by M. Sauvage (Draft 0.2, 8 Oct 2004)

2. FRONT END OPTIONS

As specified by [R05], the first choice to be made by a (SPIRE) user will be the basic observing mode:

"PHOT" **OR** "SPEC" – the choice is mutually exclusive, one or the other (radio buttons). Choosing a button opens the PHOT or SPEC window. Choices for other instruments (and for the TBC PACS/SPIRE parallel mapping mode) might also be available in this menu. In this case "SPIRE PHOT" and "SPIRE SPEC" should label the buttons.

Once PHOT has been chosen, the user will be presented with the choice between the three fundamental types of SPIRE photometric observations:

"Point Source" **OR** "Small Map" **OR** "Large Map" – the choice is mutually exclusive, one and only one of the three (radio buttons).

If "Point Source" is chosen then we follow the point source decision tree (see [R03] and [R05]). A "Small Map" covers 4 arcmin x 4 arcmin, while a "Large Map" covers larger areas.

This information should be available to the user through a "What's a Small/Large Map?" hyperlink. "Small Map" and "Large Map" observing modes will in due time be better defined and optimized to provide the user with the most efficient map-making strategy over the required area. It might also be possible that the user will be allowed to enter further implementation details or choose between different map-making techniques (e.g. between raster jiggling and scan mapping when observing a "Large Map"). For the relatively limited scope of SPOT1 and the limited degree of control available to the user, however, most of the Logic and Visualization properties are common to the two modes.

If "Small Map" is chosen refer to Section 3

If "Large Map" is chosen then refer to Section 4

3.   "SMALL MAP" MODE

3.1   Generalities

If "Small Map" is chosen then a 4' x 4' area will be observed with full sampling adopting a 64-point jiggle map pattern. Technically, a 5.2' diameter circular area will be observed, but the region outside the 4' x 4' central region will have a lower S/N and sparse sampling. This information should be available to the user through a "What's a Small/Large Map?" hyperlink and should be clearly reminded him after choosing "Small Map". It should also be suitably taken into account when visualizing the observation. The user should also be reminded at this stage that specifying (at the following stage) a roll-angle constraint will substantially decrease the probability of his observation being successfully scheduled, and that conversely, not specifying a roll-angle constrain will only "guarantee" that a circular area of 4' x 4' centred on the specified position is observed. We assume that for SPOT1 a set of default parameters and sensitivities will be used to estimate the integration time. Once "Small Map" is selected the observing mode is thus completely defined. The observing mode name to be returned to the use and sent to the CUS translator should simply be the string **spire-phot-small-map**.

3.2   "Small Map" Geometrical Additional Inputs

If "Small Map" is chosen then a window opens asking for:

-   **Map Centre** : RA and Dec (two boxes)
-   **Map Orientation** : a box in which to enter the position angle of focal-plane-centric "Y" direction ("Z" direction is rotated 90 degrees counter-clockwise with respect to "Y", this should be explained and visualized by clicking a "What's Orientation?" hyperlink near the box, "X" is the telescope boresight direction, which the user doesn't need to know about), is displayed, while a second check box specifying "any" orientation can be ticked to make the "Y" direction box inactive and erase its previous contents (if any)

3.3   Visualize Observation and Set Observing Constraints

At this point the observation can be visualized, displaying the map centre, size and orientation (including labelled "Y" and "Z" axis). If "any" orientation was chosen by the user, a default orientation with "Y" towards North should be assumed, and the inscribed 4' x 4' circle should also be displayed along with a warning that only this latter circular region will be "guaranteed". Observation display might be superposed on some background sky map (e.g.

IRAS 100 µm diffuse emission maps by Schlegel et al. 1998) and/or known bright FIR/Sub-mm sources (e.g. from IRAS and ISO catalogues). These and other details needed for the visualization (footprints, sizes, overlays detailing the actual execution of the observation) are TBD. The user should be able to interactively change the map centre and orientation, e.g. due to bright sources or diffuse emission within the field, and to update the visualization. No constraints on Chop/Nod directions are allowed from the user. If and when the user is happy with the way his observation looks like he should press a button to go ahead. He should alternatively be allowed to go back and choose another observing mode altogether.

3.4 Set Flux, S/N and Time

A window now opens displaying three columns of boxes for the three photometer bands: **250, 360 and 520 µm**. At its top two radio buttons let the user choose between point (default) and extended "reference" source. Each column presents three labelled boxes: **Flux, S/N, Time,** and a **CALCULATE** button. A single **CLEAR** button is also available to reset all of the fields. **Flux** is the flux of a "reference" source (expressed in mJy and MJy/sr for point and extended "reference" sources, respectively) for which a **S/N** signal to noise ratio must be achieved over the whole map within a certain **Time** (on-source integration time, excluding overheads). The three fields are always independent taken two-by-two, and the third one is uniquely determined once given the other two. A further field (common to the three bands) will be needed to show the **Total Time** (total observing time, including overheads) taken by the observation returned by the time estimator. This field cannot be modified by the user.

The user can now type into the boxes related to his selected "primary" band. The user must enter values into two of the three fields. When he presses the **CALCULATE** button, the value of the third field is calculated. One of three fields should have no value set by the user, and is thus the value we need to find. If the user should set the values of all three fields, it is assumed that **Time** is what he wants to calculate.

EX. 1 : User enters "reference" source **Flux** and desired **S/N**, required **Time** is calculated.

EX. 2 : User enters "reference" source **Flux** and desired **Time**, resulting **S/N** is calculated.

EX. 3 : User enters desired **S/N** and **Time**, the **Flux** of a "reference" source that will be observed with this **S/N** in the specified **Time** is calculated.

When the **CALCULATE** button is pressed, the fields in all three bands are updated. The **Time** value is copied across to the other bands, the **S/N** in these bands is set to 1, and the corresponding one-sigma sensitivity goes into the **Flux** field.

SPOT will need to pass the following parameters of the following type out to the time estimator when the **CALCULATE** button for a given channel is pressed:

Mode string (in this case **spire-phot-small-map**)

Band string (**PSW|PMW|PLW** - corresponding to 250, 360 and 520 µm - any other string should cause an error)

RefSrc string (**point|extended** - any other string should cause an error)

Flux double ("reference" source flux, in mJy or MJy/sr for **RefSrc** value **point** or **extended**)

S/N double (signal to noise ratio)

IntTime double (on-source integration time, excluding overheads, in s)

One of the **Flux**, **S/N** and **Time** fields should not have been set. If they are all set, the time estimator should behave as if **Time** had not been set and issue a warning. The time estimator will then return all of the above parameters for each of the three channels, copying the values that were input, and delivering the one-sigma sensitivities for this observation time in the other two bands, additionally returning the total observing time (including overheads) and, for each band, a flag indicating whether sensitivity in that band is below some nominal confusion limit. In greater detail, the time estimator will return:

Flux 3 x double ("reference" source flux, in mJy or MJy/sr for **RefSrc** value **point** or **extended**)

S/N 3 x double (signal to noise ratio)

IntTime double (on-source integration time, excluding overheads, in s)

TotTime double (total observing time, including overheads, in s)

ConfFlag 3 x boolean (flags indicating if confusion might be a problem for three bands)

A warning should also be displayed indicating for which bands confusion is likely to be an issue.

4. "LARGE MAP" MODE

4.1 Generalities

If "Large Map" is chosen then an area larger than 4' x 4' will be observed with full sampling adopting either a raster of 64-point jiggle maps or scan mapping. We assume that in SPOT1 the user will be given no control over this alternative. As a matter of fact, the user won't even be told about this alternative, since the instrument team reserves his best judgement on how to best produce a map of a given size for SPOT2. It should also be suitably taken into account when visualizing the observation. The user should also be reminded at this stage that specifying (at the following stage) a roll-angle constraint will substantially decrease the probability of his observation being successfully scheduled, and that conversely, not specifying a roll-angle constrain will only "guarantee" that a circular area of diameter equal to the minimum between the "Y" and "Z" required sides of the map (see below) and centred on the specified position is observed. For SPOT1 we assume that a set of default parameters and sensitivities (e.g. in the form "square degrees per hour mapped down to 5-sigma on a 1 mJy source") will be used to estimate the integration time. Once "Large Map" is selected the observing mode is thus completely defined. The observing mode name to be returned to the use and sent to the CUS translator should simply be the string **spire-phot-large-map**.

4.2 "Large Map" Geometrical Additional Inputs

If "Large Map" is chosen then a window opens asking for:

- **Map Centre** : RA and Dec (two boxes)
- **Map Orientation** : : a box in which to enter the position angle of focal-plane-centric "Y" direction ("Z" direction is rotated 90 degrees counter-clockwise with respect to "Y", this should be explained and visualized by clicking a "What's Orientation?" hyperlink near the box, "X" is the telescope boresight direction, which the user doesn't need to know about), is displayed, while a second check box specifying "any" orientation can be ticked to make the "Y" direction box inactive and erase its previous contents (if any)
- **Map Size** : two boxes are shown to enter map sides along "X" and "Y" directions as defined by map orientation

4.3 Visualize Observation and Set Observing Constraints

Everything goes as in Section 3.3, but now the "guaranteed" area for a map with "any" orientation is a circle centred on the specified position whose diameter is the lower value between map sides along the "X" and "Y" directions.

4.4 Set Flux, S/N and Time

All of the logic and interactions discussed for the "Small Map" mode in Section 3.4 apply to the "Large Map" Mode as well, the only difference being that the size of the map now enters the time estimation process as well.

A window now opens displaying three columns of boxes for the three photometer bands: **250, 360 and 520 µm**. At its top two radio buttons let the user choose between point (default) and extended "reference" source. Each column presents three labelled boxes: **Flux, S/N, Time,** and a **CALCULATE** button. A single **CLEAR** button is also available to reset all of the fields. **Flux** is the flux of a "reference" source (expressed in mJy and MJy/sr for point and extended "reference" sources, respectively) for which a **S/N** signal to noise ratio must be achieved over the whole map within a certain **Time** (on-source integration time, excluding overheads). The three fields are always independent taken two-by-two, and the third one is uniquely determined once given the other two. A further field (common to the three bands) will be needed to show the **Total Time** (total observing time, including overheads) taken by the observation returned by the time estimator. This field cannot be modified by the user.

The user can now type into the boxes related to his selected primary band. The user must enter values into two of the three fields. When he presses the **CALCULATE** button, the value of the third field is calculated. One of three fields should have no value set by the user, and is thus the value we need to find. If the user should set the values of all three fields, it is assumed that **Time** is what he wants to calculate.

EX. 1 : User enters "reference" source **Flux** and desired **S/N**, required **Time** is calculated.

EX. 2 : User enters "reference" source **Flux** and desired **Time**, resulting **S/N** is calculated.

EX. 3 : User enters desired **S/N** and **Time**, the **Flux** of a "reference" source that will be observed with this **S/N** in the specified **Time** is calculated.

When the **CALCULATE** button is pressed, the fields in all three bands are updated. The **Time** value is copied across to the other bands, the **S/N** in these bands is set to 1, and the corresponding one-sigma sensitivity goes into the **Flux** field.

SPOT will need to pass the following parameters of the following type out to the Time Estimator when the **CALCULATE** button for a given channel is pressed:

Mode string (in this case **spire-phot-large-map**)

Area double (overall map area, in square degrees)

Band string (**PSW|PMW|PLW** - corresponding to 250, 360 and 520 μm - any other string should cause an error)

RefSrc string (**point|extended** - any other string should cause an error)

Flux double ("reference" source flux, in mJy or MJy/sr for **RefSrc** value **point** or **extended**)

S/N double (signal to noise ratio)

IntTime double (on-source integration time, excluding overheads, in s)

One of the **Flux**, **S/N** and **Time** fields should not have been set. If they are all set, the time estimator should behave as if **Time** had not been set and issue a warning. The time estimator will then return all of the above parameters for each of the three channels, copying the values that were input, and delivering the one-sigma sensitivities for this observation time in the other two bands, additionally returning the total observing time (including overheads) and, for each band, a flag indicating whether sensitivity in that band is below some nominal confusion limit. In greater detail, the time estimator will return:

Flux 3 x double ("reference" source flux, in mJy or MJy/sr for **RefSrc** value **point** or **extended**)

S/N 3 x double (signal to noise ratio)

IntTime double (on-source integration time, excluding overheads, in s)

TotTime double (total observing time, including overheads, in s)

ConfFlag 3 x boolean (flags indicating if confusion might be a problem for three bands)

A warning should also be displayed indicating for which bands confusion is likely to be an issue.

5. FINALIZING AN OBSERVATION

For both the "Small Map" and "Large Map" mode, once the user is happy with his observation, he should press a button called **Commit Observation**. This uploads the current observing description, including User and Instrument Parameters and the total observing time, to the OR

	Technical Note	**Ref:**	SPIRE-ICS-NOT-002150
		Issue:	1.0
SPIRE	**SPIRE AOT Inputs**	**Date:**	15 October 2004
	Photometric Mapping Observations	**Page:**	7 of 8
	Mattia Vaccari		

database where it is now ready for translation to CUS language. The controlling quantity at this point is the observing time, since this is what will finally be scheduled. The nominal flux and S/N will also need to be stored so that we can monitor the effects of changes in sensitivity on the programme, but the time taken for the observation will be what controls scheduling and allocation of time. The user should alternatively be allowed to go back to any of the previous steps, including choosing another observing mode altogether.

6.   OPEN ISSUES

1) **For both "Small Map" and "Large Map" modes, a slight change in the current logic of setting "Flux, S/N, Time" might accommodate the possibility of setting a different "Flux" in each band and being returned for each band the "S/N" corresponding to the specified "Flux" and the cross-band "Time". This would require changing the "Flux" input to SPOT from a double-precision scalar into a 3-element double-precision array.**

2) **For both "Small Map" and "Large Map" modes, should we allow the mapping of solar system objects? This is already implemented for other types of observations, along with entering the object by name of ephemeris and querying external databases, so implementation is going to be rather straightforward**

3) **For "Small Map" mode, should we simply guarantee a 4' diameter circular map and thus not allow any control on orientation from the user? This would allow a much easier scheduling of relatively short mapping observations and would free "windows" to properly observe "oriented" large maps.**

4) **For "Large Map" mode, do we want to leave map size (single variable, in solid angle units) as a variable for the user to play with when using the time estimator? This would help e.g. large-area survey planners but would require going back and redefine the map sides? Also, it would change the time estimator, albeit in a straightforward way (i.e. by adding an "Area" field common to the three bands).**

5) **For "Large Map" mode, should we impose some upper limit on the size of the map, size along each direction and/or Y/X ratio? One might issue warnings when particularly narrow sky strips are asked for, certainly when less than "a few" (e.g. 4?) arcmin along either direction is asked for. This will ensure that "unreasonable" observations are prevented at a very early stage.**

6) **In the not-so-distant future, we might want to merge the two documents on "Point Source Photometry" and "Photometric Mapping" observations into a single "Photometric Observations" document. The two documents already share most of the nomenclature and logic. This would ensure both a common look-and-feel, avoid excessive cross-referencing and simplify document maintenance and update.**

A.   SPOT Decision Tree for SPIRE Photometric Mapping Observations

The figure below shows the decision tree and interactions the user will be presented with when trying to input an AOR for SPIRE photometric mapping observations through SPOT.