Herschel Calibration Lessons Learned (Moderator: A. P. Marston)

Overview:

Universally across the ground segment there was great satisfaction with the way that calibrations were organised and how they were performed and several elements can be recommended for future use.

Key Points:

1. **Start considering calibrations (including observing/data taking modes) AS EARLY AS POSSIBLE.** This is particularly important if pre-launch calibration activities with ground-based or other space-based missions are needed – as was the case for Herschel. Also for the development of appropriate calibration models, such as those extensively used by the Herschel instruments.

2. **On-ground testing should be done as you expect to operate in-orbit**. Use of SCOS/CUS for ILTs and SVTs also provided essential training for operations and meant that a complete rewrite and check of instrument commanding not necessary for operations – tried and tested methods.

3. **Create a system that is flexible to changes**. On-board software changes can take time and can slow down early stages of time-limited missions. Common Uplink Software (CUS) updates in Herschel (going into mission configurations) were a flexible way of changing the modes of instrument usage.

4. **Communications are very important**. In many cases you simply can not get around personal (rather than Videocon/email) interactions. Co-location activities were found essential to provide feedback, maintain momentum and timelines. Testing requires on-site test activities. With distributed ground segments this means travel is very important – it is not a luxury!

5. **Embedding of operations scientists in instrument level test centres considered very successful and played essential role in mission success** (understanding of instrument issues and possible adjustments to operations, often saving much time, and direct testing and community support).

Some more expansive notes:

Pre-launch Activities:

- **Using as much of the operational system as soon as possible during ILTs** added some burden but was invaluable entering COP and PV. This should be repeated, especially for missions of limited lifetime.

    - Use of SCOS-like setup (please no TCL next time – direct link to CUS?) in ILTs very useful. As was use of CUS. A lot of ILT tests were simply repeated in space. Should be repeated. **Database s for use in operations and testing assessment and selection needed early**

- The full software needs of the instrument engineers/scientists needs to be defined well in advance. **A developing software system together with ILTs made for many difficulties – try to "soften" this in the future. Again, start early.**

- Herschel Calibration Steering Group work considered good way to guide the overall work of the observatory. Included calibration scientists from all instrument and ESA/NASA groups. **Recommended such a group is put in place early and coordinated by ESA.**

    - Cross-calibration is an activity to be considered here, including with other missions/observatories. Should support instrument calibration.

    - Coordinate activities with ground-based and space-based observatories pre-launch and during the missin.

    - **Central set of models and calibration development and encouragement of calibration development pre-launch was good.** But need to be able to consider how to enable quicker updates and general availability and "archiving".

    - **Continued to actively steer overall calibration and coordinated calibration activities during the nominal mission.**

- **Instrument simulators –** including science simulation not used much in Herschel pre-launch preparations.

    - **Considered useful, BUT should be aware of the limitations that any simulator will have.** Several items have limited knowledge pre-launch. Overtaken by laboratory data.

    - **Science simulator could have been useful to astronomers before launch.** Shown not to be essential.

Commisioning and Performance Verification Phase (COP and PV):

- Good and, in the end, efficient plans for start of operations (COmmissioning Phase, COP). Lots of instrument observing modes and complicated instruments. **Planning and more planning is essential. Good pre-launch understanding of planning changes possible and limitations on the rate of updates/changes.**

- **Start COP planning as early as you can. Make sure feedback for operations updates is taken into account in plans. Systems MUST be flexible** to this kind of activity in early part of the mission.

    - **Understand well what tests and calibration needs can only be done in space for planning. Make sure proper logging system exists.**

- **Availability of system to adjust to calibration needs**. Notably calibration version of HSpot (planning software for setting up observing requests).

- Calibration version of HSpot essential for COP/PV. **Allowed daily mission configuration (instrument command definition in CUS) changes. This rate of operations change rate needs to be planned for.**

During Nominal Operations:

- Cross-instrument groups and intra-instrument groups worked together well. Essential to keep interactions on what people are doing throughout mission. **A closer interaction between software developers and ICC/HSC scientists would have helped**. **Co-locations are essential**
- **Cal HSpot/CUS combination enabled calibration planning to be better done at the ICCs (not an original benchmark).**
- **Calibration and mission planning general: Decide early who is going to provide inputs to mission planning and how.** Final idea ended up being late for Herschel. Hence the full set of requirements setting and system did not exist. Try to make more of an integrated uplink system in distributed planning. Use of mission planning software at the ICCs. Took some setting up but worked very well. Coordination of updates at SOC should be done, however.
- Downlink calibration deliveries for Herschel were made too complicated. **Determine streamlined method for downlink calibration deliveries that calibration scientists can use efficiently.**

Communications:

- Communications regarding calibration across the science ground segment were very good regarding the instruments, especially considering that the ICCs were very distributed plus HSC and NHSC. ***Essential to keep communicating on regular basis.***
- **Co-locations** for dealing with particular (sets of) calibration issues over several working days found to be most effective. How does this square with future reduced travel budgets?
- **Calibration workshops across the science ground segment** very useful to consolidate current view and indicate future activities and present failings. Resetting of priorities often occurred in these meetings.
- Cross SGS working groups were essential, documentation, pointing and planning. Notably:
    - **Pointing working group** – such a group should be set up as early as possible and must have access to project/industry/FDS expertise and all relevant documentation (as defined by the pointing working group).
    - **(Weekly) schedule planning group**. More frequent in early mission phases.