README file - first-order corrected pointing products

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1.- Background information

A main component of the Attitude Control and Measurement System (ACMS) is the star-tracker (STR; two units present on-board Herschel, prime and backup). The STR is a small optical CCD camera plus an image processing unit that, starting from an image of the sky, extracts the attitude information measured with respect to the J2000 inertial reference system and delivers it to the Attitude Control Computer (ACC). At the start of the mission, the STR CCD reference temperature was 20 deg C. An effect that was observed along the first months of S/C operations was the sporadic occurrence of distortions in the scan map patterns accompanied by variations in the tracking angular rate (the so-called 'speed bumps'). These events were eventually tracked to the existence of transitory 'warm pixels' (not flagged as 'hot' ones in the defective pixel table). In order to reduce the number of warm pixels, the STR CCD reference temperature was lowered in operational day (OD) 320 from 20 to -10 deg C. The 'speed bumps' were eventually corrected, but at the price of augmenting the STR plate scale errors that produced systematic but boresight-dependent offsets.

The new (low) temperature setting had a negative impact on the S/C absolute pointing accuracy due to increased plate scale errors in STR. In OD 762, a simple, 1D correction (i.e. the same linear correction factor in the Y and Z STR axes) was uploaded to the S/C ACMS and the performance was substantially improved. In OD 858 an enhanced 2D correction (different linear factors in the Y and Z axes) was successfully tested; the change was made permanent in OD 866. Eventually, in OD 1011, a full STR focal plane (FP) distortion correction was made operational. Moreover, in OD 1032 the STR catalogue was purged by removing 73 'dubious' stars from the tracking list.

Several groups within the Herschel Ground Segment are currently working in the a posteriori improvement of the S/C attitude, coordinated by the Herschel Pointing Working Group. This is specially important for observations obtained in the period OD 320 - OD 761, as explained above.

The pointing products produced by the software described in this note intend to provide a first, yet crude correction of the systematic, boresight-dependent effects introduced by the STR plate scale errors.

2.- Scope of applicability

The current version of the software is mainly intended to alleviate the problems derived from the large STR plate scale errors existing in the period OD 320 - OD 761. A correction has been computed for the period OD 762 - OD 865 (excluding OD 858), but its actual usefulness is

still under evaluation and no new pointing products have been made available in the ftp area for that range of ODs.

If your observation has been gathered in OD 858 or OD >= 866, no correction is required (since either the 2D or the full STR FP correction has been already applied).

Finally, for ODs before 320, no STR FP correction is available yet but it is expected in a near future. As soon as it is included in the processing software, new pointing products will be generated. Nevertheless, it is advisable to use it only in extreme cases, where large pointing offsets are suspected.

It is intended to use the new pointing products in the upcoming (v9.x, TBD) HSA bulk reprocessing. Therefore, no pointing product replacement will be required for products retrieved from the HSA processed with SPG v9.x.

3.- Processing steps

The current processing software applies the following steps:

(a) Load the STR guide stars' catalogue
(b) Open the pointing product and read records in a loop. For each attitude sample:
  b.1 Read filtered attitude and STR quality flag (number of stars tracked)
  b.2 Get the catalogue information for stars within the FoV of the STR at the current S/C filtered
    attitude: X,Y,Z, magnitude, and trackability status.
  b.3 For trackable the stars within the FoV, determine the direction vectors using the
    STR "focal length" correction factors provided by Flight Dynamics.
  b.4 Determine the tracked stars by means of the same algorithm used in the STR (but limited to a maximum
  of nine stars, i.e. the "interlacing mode" is not implemented)
  b.5 For the tracked stars, given the direction vectors and the inertial
    (reference) vectors, determine the best attitude using the "q-Method" (Davenport 1968).
  b.6. Replace the filtered quaternion by the modified quaternion computed by the q-method.

The applied correction does not add noise to the attitude samples since is a purely geometric one. When the correction factors are set to 1.0, one recovers exactly the input attitude (within ~1.0e-10 arcsec).

In the current implementation, the processing script is not distributable to end- users since it requires the proprietary STR catalogue.

4.- Limitations

(a) Only up to 9 stars are used, i.e. no interlacing is considered
(b) The stars' selection algorithm uses the same logic as the STR. But there is no check that the stars used within the script are the same as those actually used for tracking. In particular, if one of the 73 bad stars was used for tracking, it will replaced by a different one in the script.

(c) The 2-D, linear correction is implemented (rather than the full one).

5.- Future improvements

The software described here is just a first step in a long-term strategy to improve the S/C attitude estimation and hence the astrometry of the science products. It is expected to have further releases of the current software that will include things like:

- New coefficients for the early phases of the mission
- New STR star selection algorithms based on the guide stars _actually_ selected by the ACMS
- Implementation of the interlacing algorithms
- Implementation of the STR full FP correction

Future software tools will include a more sophisticated processing based on batch attitude estimators. The construction of such software is currently being started.

6.- Final remark

Do not apply the new pointing products blindly. If you are happy with the current astrometry of your observations, it is probably not worth to reprocess the data. In case of doubt, contact the HSC Helpdesk for advice.