HIRDLS TC-OXF-68

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ON THE DERIVATION AND INTERPRETATION OF THE IRD POINTING REQUIREMENTS

CONTENTS

EOS

1. Introduction

This TC addresses the ILOS altitude (elevation) pointing knowledge requirements given in the IRD. Azimuth knowledge requirements are not specifically addressed but much of this TC is applicable to knowledge of azimuth angle.

The following topics are discussed:

> the basis for the IRD-specified requirements and how they have been interpreted;
> relation between 'raw' instrument performance and post-processed performance; ground processing of ILOS angle data;
> POINTING budgets and subsystem hardware tolerances.

In what follows, the terms "smoothing", "calibration", "Level n", etc. are used in the conventional Science Data Processing sense.

2. Comments on the basis for the IRD pointing knowledge specifications

In the case of the instrument ILOS pointing requirements, it is not thought appropriate for the IRD to specify 'raw' instrument performance for a number of reasons, namely:

> pointing-related data are derived from more than one source (scan angle, gyros, s/c, etc) and need to be combined in some optimum way BEFORE USE;
> 'raw' pointing data will need to undergo ground processing as discussed below in order significantly to reduce the contribution from some instrumental error sources (e.g. gyro drift);
> 'raw' instrument pointing data will need to be calibrated (based on the pre-launch characterisation of gyros, angle encoders, etc)

It is assumed that gyro and scan encoder data (i.e. instrument pointing data) will be combined with radiance data at Level 2 (Retrieval), having first been separately smoothed and calibrated at Level 1. In fact, some kind of 'global mapping' process will need to be performed with the gyro data at Level 1 to to back out the effects of long-term drift, and to allow 'geopotential surfaces' to be constructed. It is to make this more effective that the azimuth scan range will be sufficient for elevation scans to OVERLAP on adjacent swaths.

3. Pre- and post-processed performance; the need for further analysis

The above considerations suggest that two stages are needed in order to derive the "instrument" pointing requirements from the "science" requirements. The first stage is to determine the required pointing knowledge, relative to the ORCF, as a result of end-to-end processing of the pointing data as described above. The second stage is to determine the corresponding requirements for the individual pieces of instrument or s/c hardware which must contribute 'raw' data to the above processing.

Before the instrument POINTING budgets can be finalised, further analysis and modelling will be needed to enable the effects of such processing to be estimated. This work will be identified during the course of translating the IRD into ITS requirements and budgets, and it is presumably appropriate for it to be performed by the HIRDLS Science/Data Team.

WHAT NEEDS TO BE CLEARLY ESTABLISHED AND AGREED AS A MATTER OF URGENCY is
that the requirements given in the IRD apply to the pointing data after processing as described below, and NOT to the (hypothetical) raw "instrument" data, which would not make sense for the reasons given here. Once this point has been clarified, it may be necessary to revise some of the IRD wording.
[JGW 18APR95 - this point was clarified verbally and some references to 'ground data processing' added to the ITS as mentioned previously]

4. <u>Summary of 'interpreted' IRD altitude angle knowledge requirements</u>

Note: Based on the reasons given above, it is assumed that the requirements apply AFTER data processing to Level-1

a) IRD WORDING: (2.7.5) " For a single altitude scan, the systematic error in the knowledge of angle q between the LOS and the ORCF must be at most the greater of 2.5E-3q or 0.35 arcsec. This requirement is derived from the desire for 0.25% maximum uncertainty in knowledge of the mean (vertical) spacing of tangent points during a uniform segment of an elevation scan. "

COMMENT: 'systematic error' is here taken to 'slope error' in the reconstruction of the vertical profile in the atmosphere for a set of derived tangent point altitudes during a uniform segment of a single elevation scan. "2.5E-3q" could then be interpreted as the maximum slope error (i.e. 0.25%) AT ANY POINT on the reconstructed slope (and the 0.35 arcsec limit is therefore not needed). It is understood that this is required for temperature/pressure retrieval.

INTERPRETATION: " For any uniform segment of a single altitude scan, the slope error in the reconstruction of the vertical profile in the atmosphere for a set of derived tangent point altitudes, optimally smoothed, shall not exceed 0.25% at any point on the profile. "

b) IRD WORDING: (2.7.5.ii) " The random error must be at most 1 arcsecond (1-sigma), and preferably it should be less than 0.7 arcsecond (1-sigma). These values include the effects of the imprecision in the measurement of the LOS, the motion of the S/C and the instrument, and the vibration of the S/C and the instrument "

COMMENT: this is taken to refer to the random scatter in a set of derived tangent point altitudes relative to the best-fit curve through those points for a single elevation scan, BUT IT IS UNCLEAR WHY THIS REQUIREMENT EXISTS, given the need to meet the preceding requirement, i.e. what would be the consequence for the science of omitting it? Or does it actually apply to the 'between two scans' case ?

INTERPRETATION: The random scatter in a set of derived tangent point altitudes, optimally smoothed, relative to the best-fit curve through those points must be at most 1 arcsecond (1-sigma) and preferably less than 0.7 arcsecond (1-sigma).

c) IRD WORDING: (2.7.6) " The error in the knowledge of the relative altitude angle between LOS positions in two adjacent altitude scans must be at most 1.4 arcseconds (1-sigma). This applies whether the two adjacent altitude scans are in a single azimuth scan, in two azimuth scans that are sequential along the orbit, or in two azimuth scans at approximately the same latitude from successive orbits "

COMMENT: this is assumed to include both random and systematic errors. This requirement seems fairly straightforward to interpret since there is somewhat less scope for smoothing, etc. than would appear to be true for the 'single elevation scan' case, on the understanding that this is required for geopotential surface retrieval.

INTERPRETATION: The error in the knowledge of the relative altitude angle between LOS positions in two spatially adjacent altitude scans must be at most 1.4 arcseconds (1-sigma) within the same azimuth scan, in sequential scans in the same swath or between scans in adjacent swaths.

5. Converting IRD requirements into ITS hardware design budgets

In addition to the primary question about pre- vs. post-processing performance already addressed, important issues arise here which need to be resolved before we can feel comfortable with the requirements specified for the relevant subsystems (Gyros, Scanner, Optical Bench and Coolers) with respect to pointing accuracy, stability, mechanical noise/jitter, etc. and with the numbers in the POINTING budgets. Two questions so far identified are:

> which processes being summed in the POINTING budgets are correlated, and to what extent;

> how does the Normal Distribution (n-sigma) figure in the IRD translate (via the POINTING budgets) into engineering tolerances appropriate to the likely behaviour of each subsystem;

These questions are discussed in the following sections.

6. 'Statistical' errors and correlated budget items

The IRD pointing knowledge requirements have been carried forward more-or-less verbatim into the relevant paragraphs of the ITS, which also references the appropriate POINTING budget (of which there are three - one for long-term, one for short-term and one for jitter errors). The statistical nature of the error limits in the IRD has been preserved in the individual budget items, where generally the 3-sigma values are given.

An attempt has been made to take proper account of the degree of correlation (if any) between budget items in deciding how they should be apportioned and summed. [This section to be completed]
[JGW 18APR95 see POINTELV and POINTAZM Budgets in SPRAT]

7. 'Engineering' interpretation of statistical specifications

HIRDLS TC-NCA-16 by Doug Woodard addresses the first of the issues listed above, and suggests a methodology for converting statistical specifications (i.e. those which assume a Normal Distribution and assign a Standard Deviation) into hardware specifications which are likely to meet the performance requirement without the need for elaborate worst-case analysis. Various types of subsystem (hardware) behaviour are considered, and it should be possible, using NCA-16, to derive the appropriate hardware parameter tolerance corresponding to each item in the error budget.

(Note: TC-NCA-16 to be completed)