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To Pascal Willis,

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Subject: creating a new ground antenna model for DORIS / response to IDS letter August 05, 2013

Dear Pascal,

The critical nature of antennas specifications for metrology applications has been taken into account very early in the DORIS system design. The current "Starec" antenna is the result of a comparative study conducted in late eighties for precise positioning applications. Two different concepts of antenna were reviewed :

- a compact one, making easier local ties surveys thanks to physical reference point close to the theoretical Antenna Electronic Reference Point (AERP), but with poor RF characteristics leading in much less accurate definition of the AERP and a position variation depending on azimuth;
- an helical type antenna with better RF characteristics leading in a better AERP definition:
  - better polarization quality avoiding complex correction taking into account relative orientation of ground and satellite polarization ellipses,
  - natural decoupling from environment,
  - shaped beam pattern allowing a better link budget leading in more accurate measurements
  - revolution symmetry of the radiation pattern avoiding azimuth alignment,

The helical type was finally chosen due to its more accurate and stable AERP. At this time the Antenna Reference Point (ARP) and also the "thickness" of the ring, were defined in cooperation with the surveyors, but the accuracy required on local ties was not at millimeter level.

Today, positioning requirements are more stringent and this reinforces the choice of the helical type antenna.
On the other hand, the local ties must also be improved and this requires a precise characterization of the vector between the AERP (2GHz phase center) and an easily accessible point for surveyors (SRP).

DORIS system team has well understood issues raised by IDS:

1) the location of the reference point is inappropriate (difficult access for sighting…);
(2) the marker of the reference point is approximate;
(3) the electronic reference point (2GHz phase center) is not materialized;
(4) there is no marker to orient the antenna.

Actions are going on to find the appropriate answer:

(1) (2) CNES will study jointly with IGN how to get accurate local ties. This includes the definition of a new SRP easier to survey and precisely defined on the antenna. However, according to conclusions of the last Prospective Group workshop about the DORIS Network, the ARP should remain the red circle painted on the antenna, consistent with 400MHz phase center. This ARP will no more be surveyed, but linked to SRP without error, since that is an arbitrary theoretical link.

(3) The AERP is complex to materialize, first of all, because it is a virtual point whose position depends on phase law correction used, and in any case, is out of reach once the antenna is installed. A complete analysis of the manufacturing process has been conducted with the manufacturer in order to ensure the reproductibility of series antennas and to find the most precise way to deduce the AERP position (which is the one measured by the DORIS system) from the SRP position (which is the one that is surveyed).

(4) An analysis of radiation pattern shows that the antenna has a revolution symmetry, the phase variation in function of azimuth angle is negligible, so it is not necessary to orient the antenna.

To summarize, CNES intends to keep, as it is, the current "Starec" antenna whose RF design is perfectly adapted to precise positioning. However we agree to continue improvements in three areas:

- with the manufacturer, in order to improve the manufacturing process to ensure the repetitivity of AERP position at the millimeter level,
- with IGN, in order to define a new SRP consistent with a precise local ties process and site installation constraints,
- internally at CNES, in order to consolidate the phase corrections to be applied.

We are confident that through these actions, maintaining carefully the stations over the years, the DORIS system should perfectly answer to very precise positioning needs and contribute efficiently to the quality of the International Reference Frame.

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