DORIS RADAR CALIBRATION METHOD

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ABSTRACT

Following the interest expressed by ESA and FGAN, it was decided to realise some evaluation of the DORIS calibration method with the TIRA radar. This paper, organised in four parts, describes :

- the importance of radar calibration in the space debris domain
- the principle of the DORIS calibration method
- the results obtained with the TIRA FGAN radar using the DORIS reference
- the advantages of the DORIS calibration and the future uses of this method in an European exercise involving for the ESA benefit both French and German radars.

1. INTRODUCTION

Radar calibration is an important subject, in particular when radar measurements are used :

- to evaluate the collision probability of a debris object with an operational satellite;
- to take eventually a decision to carry out an avoidance manoeuvre (which uses propellant and reduces the lifetime of the operational satellite).

In case of risk of collision, an avoidance procedure may be considered. Many models and tools are employed to estimate the probability of impact on spacecraft. Even if models are more and more sophisticated, a significant uncertainty remains primarily due to the inaccuracy of orbital elements. One way to reduce this uncertainty is to use existing radar facilities to get a better knowledge of the real danger. The accuracy of the probability risk will then depend only on the accuracy of the radar measurements delivered, that means the better the calibration is, the better the risk will be evaluated.
So we can easily appreciate the importance of an efficient radar calibration method.

This paper will present the DORIS calibration method, developed by French test centres to evaluate radar accuracy on satellite tracking .

2. GENERAL INTRODUCTION ON DORIS SYSTEM

The DORIS radar calibration method was presented in the past during the 17-th IADC meeting in Springs [2]. The DORIS system (Doppler Orbitography and Radio positioning Integrated by Satellite) was designed and developed by CNES, the National Geographic Institute, IGN (Institut Géographique National), and the Space Geodesy Research Group, GRGS (Groupe de Recherches de Géodésie Spatiale – CNES/CNRS/Université Paul Sabatier) to meet new needs for the precise determination of satellite positions on their orbit and for precise positioning of terrestrial beacons.

This system was initially developed to support the TOPEX-POSEIDON oceanographic altimetry mission. It is an up-link radio-electrical system based upon precise Doppler measurements and using two frequencies, 2 GHz and 400 MHz, well suited to correct for ionospheric effects. This system has been carried since 1990 on the French SPOT 2 satellite, since 1992 on the French/American satellite TOPEX-POSEIDON, and since 1998 on the French SPOT 4 satellite.

The DORIS system is compounded of :

- a network of about sixty stations located all around the world, broadcasting a radio-electrical signal,
- DORIS receivers on board satellites picking up the signal broadcast by the stations and measuring the Doppler shift between the emitted and received frequencies (Doppler effect),
- A DORIS multi-mission Ground Segment where Operational and Precise Orbit Determination are computed with various delays.

Orbit determination : The DORIS system provides three orbit products :

- Real time: SPOT 4 is equipped with a DORIS receiver embedding a navigator computing on-board (real time, accuracy < 4 m RMS on 3 components). Position data are included in the auxiliary data transmitted with the payload image telemetry to SPOT direct receiving stations.
- Operational: DORIS multi-mission Ground Segment (CNES/CLS Toulouse) which determines satellite orbits with an accuracy < 20 cm RMS in the radial component and with a delay of 24 to 48 hours.
- Precise: Precise orbit determination Service provides precise orbit with an accuracy < 5 cm

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month (delay resulting mainly from external data availability such as solar flux, earth rotation parameters).

3. PRINCIPLE OF THE DORIS CALIBRATION METHOD

The general principle of a calibration consists always in comparing tracking system primary measurements (noisy) with a reference (of well known accuracy).

In our case, the reference used is the DORIS reference delivered by the onboard DORIS receiver (on SPOT2 and SPOT4 satellite), which is the position and velocity of the satellite with a centimeter or meter accuracy depending on delay treatments.

The principle of the DORIS calibration is based on the use of DORIS reference and consists in the comparison of measurements with the DORIS reference. Elevation, azimuth and range are computed as functions of time and compared with the DORIS reference. A statistical study of residuals allows to estimate accuracy and biases of the measurements.

4. PRESENTATION OF SOME RECENT RESULTS OBTAINED WITH FGAN TIRA RADAR DURING AN EUROPEAN EVALUATION

For the application of the DORIS calibration method to the German TIRA radar, two tracking campaigns were performed on SPOT 2 and SPOT 4 with the TIRA radar from FGAN. The measurements were recorded and sent two DCE/CEM for processing. The results obtained during this campaign allowed to estimate the accuracy and biases of the TIRA radar. The obtained values corroborate well the results obtained in the past with others methods.

5. CONCLUSION

The advantages of the DORIS calibration method are:
1 – short delivery time of the DORIS reference (one or two day(s))
2 - multiplicity of satellites (two targets and more in the future with SPOT5)
3 – real time calibration possible due to the on board computed orbit down-loading in the S band telemetry of SPOT4.

The DORIS calibration method is now of interest in a European frame. DORIS European calibration campaigns under an ESA/DCE contract, involving the French ARMOR radar located on French ship MONGE and German TIRA radar, are carried out during 2000/2001.

6. REFERENCES

[1] Ameline P, "Doris calibration method", Proceedings of the 17th IADC meeting, Darmstadt, 1999.

[2] Ameline P, "Near real time calibration of tracking system using DORIS/SPOT 4 on-board computed orbit", Proceedings of the 18th IADC meeting, Colorado Springs, 2000.