OPTICAL TRACKING IN SUPPORT TO ROUTINE OPERATIONS AND CONJUNCTIONS ANALYSIS FOR THE EUMETSAT GEOSYNCHRONOUS FLEET

Klinc M. [(1)], **Pessina S.** [(2)]
[(1)] Milan Klinc at *EUMETSAT, address as below*
[(2)] *EUMETSAT, Eumetsat Allee 1, Darmstadt, D-64295 Germany +49-6151-807-7*
Milan.Klinc@eumetsat.int , *Stefano.Pessina@eumetsat.int*

Abstract: *As part of an internal technological investigation, EUMETSAT has completed different tracking campaigns based on optical tracking data, processing the measurements from multiple service providers.*
The telescope data have been collected for both the geosynchronous satellites of the organisation (Meteosat), and for space debris. The Meteosat on-ground Flight Dynamics software has been upgraded, to be able to ingest CCSDS Tracking Data Messages, thus allowing compatibility with any service provider collecting tracking data in this standard format. The optical data have been successfully processed in batch orbit determination runs, in combination or comparison with the operational 2-way ranging measurements from the EUMETSAT ground stations. Various trials have been performed, to evaluate the potential support of these data sets for conjunction handling; the data have been also used in actual operations, to assist the planning and execution of the first collision avoidance manoeuvre for the EUMETSAT geosynchronous fleet.
In addition, the telescope measurements have been also collected on a regular routine basis to test their potential in: supporting the operational ranging activity (in case of ground station outages), reducing the ground-stations' load, improving orbit determination accuracy and also providing independent assessment of ground-station biases.

Keywords: *Optical tracking data, telescope, geostationary, orbit determination, conjunction analysis.*

1. Introduction

This paper presents the results of the EUMETSAT independent assessment of the use of optical data in support to both, routine operations and conjunction handling, from multiple sensors. The ingestion of the data was based on standard CCSDS interfaces. The assessment of the optical tracking data accuracy was done by comparing the obtained solutions to Meteosat operational orbits, determined using 2-way ranging data from 2 alternating ground stations. Trials were performed also for the tracking of space debris of known origin (such as the Meteosat instrument/cooler covers, released during LEOP operations) and in support to conjunction handling, with one case of actual operational use for conjunction analysis. The paper is of specific interest for any operator of geosynchronous satellites, and of general interest for orbit determination based on combined observable sources.

2. EUMETSAT geosynchronous fleet and operational orbit determination

EUMETSAT is the "EUropean organisation for the exploitation of METeorological SATellites". It is an independent intergovernmental organisation created in 1986 to establish, maintain and exploit European systems of operational meteorological satellites. It currently operates a system of meteorological satellites, monitoring the atmosphere and ocean and land surfaces which deliver weather and climate-related satellite data, images and products.
EUMETSAT currently has seven operational weather satellites. The low-earth orbit (LEO) satellites Metop-A,-B and Jason-2, in addition to Meteosat-7,-8,-9,-10, that are the satellites of the geosynchronous (GEO) fleet. There are two generations of active Meteosat satellites in-flight, all spin stabilised: Meteosat-7 is the last of the Meteosat First Generation (MFG), while the other 3 satellites belong to the Meteosat Second Generation (MSG). The last satellite of the 2nd generation is MSG-4 (that will be re-named Meteosat-11 after successful in-orbit

commissioning), scheduled for launch in July 2015. A third generation (MTG) is currently being procured, they will be instead three-axis stabilised, with first launch scheduled in 2019.
For all Meteosat, the operational concept for orbit determination is based on 2-way ranging from 2 alternating ground-stations. The EUMETSAT GEO ground-stations for ranging are located in Usingen (Germany, near Frankfurt), Maspalomas (Spain, on the Canary Islands) and Fucino (Italy, near Rome). The same concept will apply in future for MTG that will use antennas in Fucino and in Cheia (Romania). The required accuracy for the dual-stations ranging for MSG is 1000m/1000m/100m in along-track/cross-track/radial direction at 1-sigma confidence level.
During mission extension phases (after the end of active inclination control), degraded mission performances are accepted using a single-station ranging solution. There is not yet a baseline operational use foreseen for telescope data, but it has been decided to perform a technological investigation, based on regular collection of optical data from various telescopes, to evaluate their potential benefit in support to both routine operations and conjunction analyses.
To allow these analyses, the Flight Dynamics System currently used on-ground for operating MSG satellites has been upgraded, to ingest angular data in CCSDS 503 standard Tracking Data Messages (TDM), not originally foreseen for the mission. The same has been done for the MTG satellites, to allow potential future use of this interface.

3. Optical data collection and accuracy assessment

In 2014, EUMETSAT completed various optical tracking campaigns, both on Meteosat satellites and space debris, using data from both industrial partners and space agencies, from 6 different telescopes: 2 in Cyprus, 2 in South France, 2 in Spain (Canary Islands and South Spain). More campaigns are planned for 2015, with some of the sensors above, and also testing new telescopes in Switzerland and South Africa. The requirements for data taking were:

- One full night of optical measurements every 2 weeks, taken on the same night
- Tracking data provided for all EUMETSAT GEO satellites, or any other Space Debris coming from specific request
- Minimum of 2 slots of measurements per object on the same night
- Minimum separation of slots for the same satellite of 2 hours
- Minimum frequency of trackless of 0.1 Hz, Minimum slot duration of 10 minutes
- Data format in CCSDS 503 TDM format, delivered within 24 hours after data collection
- Objects to be tracked communicated by EUMETSAT 48 hours before data collection

One telescope, selected from the group above, was employed continuously according to the bi-weekly regular schedule, pending weather conditions. All the other telescopes were employed asynchronously, both for cross-comparison and for specific needs driven by conjunction warning. For space debris, some tests were also performed with objects outside of possible conjunctions, of known origin, such as the instrument/cooler covers of the MSG satellites (released in-orbit during LEOP).
The assessment of the optical tracking data was performed carrying out a series of orbit determination runs, comparing the results of the operational dual-station ranging, with other solutions, either based on optical data only or on data fusion optical/ranging. This paper will present the results of the evaluation of these orbit determination schemes for the GEO Meteosat satellites, for potential routine operations support. An example of conjunction analysis with actual operational use of the optical data for collision avoidance will be provided for the case of a Meteosat-10 manoeuvre, executed in May 2013.