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ASTROMETRIC POSITIONING OF GEOSTATIONARY SATELLITES (PASAGE)

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RESUMEN

Se describen las líneas básicas del proyecto PASAGE del Real Instituto y Observatorio de la Armada (España), cuyo objetivo es obtener efemérides precisas de satélites geoestacionarios mediante observaciones visuales astrométricas desde tierra. A priori, se trata de una técnica más precisa que las utilizadas habitualmente y supondrá una nueva e importante aplicación de la astronomía basada en tierra.

ABSTRACT

The main lines of PASAGE Project of the Real Instituto y Observatorio de la Armada (Spain) are described. The goal of this project is to generate precise ephemeris of geostationary satellites by means of ground based visual astrometric observations. It would be a more precise technique than the techniques used at present and it will be a new and important application of ground based astronomy.

Key Words: **ASTROMETRY — EPHEMERIDES — SPACE VEHICLES, INSTRUMENTS**

1. INTRODUCTION

The geostationary satellites must be operated according to their assigned nominal position in order to keep them inside their windows of operation. Otherwise, they can get out of them due to the perturbations that they are exposed to, like for instance, the Earth's gravitational attraction, the gravitational attraction of Sun and Moon and the solar radiation pressure, among the most important ones (Soop 1994). Therefore, it is necessary to have available the precise ephemeris for correct planning and performance of these manoeuvres, specially when various satellites can be operated in the same window.

Nowadays, this problem has been handled through diverse methods. For example, Hispasat obtains the positions of its satellites by combining azimuth and elevation goniometry and the distance measurements obtained from the radio signals. The achieved angular precision is 5 millidegrees, while the distance is obtained with an error of 10 meters.

The goal of the PASAGE project is to develop a technique that generates precise ephemeris of geostationary satellites from astrometric observations. The first steps of this project are described in López Moratalla et al. (2005).

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2. THE ASTROMETRY OF GEOSTATIONARY

It is logical that the visual observation of geostationary satellites is limited by the atmospheric conditions. Therefore, this positioning technique must operate together with other alternatives that permit to determine the position of satellite despite the meteorological conditions. The astrometric positioning can be used as a redundant and extraordinarily precise system, as well as calibration support for other systems.

Many efforts have been devoted in the field of the visual observations of geostationary satellites. Among them, Rudenco (1995, 1997), Hugentobler et al. (1997), Kawase (2000) and Escane et al. (2001) used this kind of observations, even though they employed different techniques and goals than those described in this project.

For an observer, the hour angle of a geostationary satellite is nearly fixed, whereas the common celestial objects drift with sidereal time. This difference requires a special observational technique.

The geostationary satellites exhibit different brightness along the year. The brightest magnitudes are reached nearly the equinoxes (normally between V=5 and 6) and the faintest ones are around the solstices (they can oscillate between V=11 and 14). Eclipses of satellites are also produced around the equinoxes, and they last for a maximum of 71 minutes, during which time the object is not visible.

3. EPHEMERIS GENERATION

The ephemeris of the geostationary satellites are based on observations performed by the following instruments: the new CCD camera that will be attached to the Gautier astrograph at the Real Instituto de la Armada (ROA), Spain, and the 1-m J. Stock Schmidt telescope, the 1-m reflecting telescope and 0.65-m refracting telescope at the Observatorio Astronómico Nacional de Llano del Hato (CIDA), Venezuela.

Through the observations with a single telescope we will obtain uranographic topocentric coordinates of satellite with an estimated error is lower than 0.1 arcsec. Acquiring a sufficient number of observations, the orbit of the satellite can be rebuilt through the classical methods of orbit determination. This process will be much more effective after combining the observations obtained from different telescopes, which will permit to minimize the errors in three-dimensional coordinates.

4. OBSERVATIONAL TECHNIQUE

As the first step, we considered the use of two observational techniques, depending on the telescope employed: the driftscan or the point-and-shoot observation method. The first one produces star images as points and satellite images as linear traces. Using the second method the process is the other way around. We will employ the Gautier astrograph and the Schmidt telescope using the former method, and the remaining mentioned instruments for the latter method.

Irrespective of the method used, the position of the satellite in contrast with the star background must be referred to a specific epoch. A possible solution is to halt the reading process of the image regularly. Consequently, the beginning and finishing integration time must be controlled. Thus, the trace of the satellites or the stars will appear as aligned segments in the image, whose extremes correspond to the positions at known epochs. This procedure assumes an excellent time control of the shutter.

We do not recommend to use a shutter sequence in the Schmidt telescope; on the other hand, this instrument keeps accurate control on declination movement. Using this resource, time-controlled jumps between 3 and 5 arcmin will be produced during the observation. Thus, easily separated overlapping fields in the same observation will be obtained. The intersection of the satellite traces in the image determines its position in the jump epoch. This technique was employed in the INTELSAT 706 satellite to study the feasibility of this project in August 2003 (López Moratalla et al. 2003).

5. TWO WAY SYSTEM

The astrometric observations can be combined with distance measures obtained using a Two Way System Time and Frequency Transfer (TWSTFT). This method is employed by ROA to obtain the distance of the satellite.

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