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ASTROMETRY AND GEOSTATIONARY SATELLITES IN VENEZUELA

E. Lacruz[1] & C. Abad[1]

RESUMEN

Presentamos el estado actual y los resultados preliminares del proyecto astrométrico para el seguimiento de satélites geoestacionarios CIDA-ABAE. Este proyecto tiene como finalidad determinar órbitas preliminares para el satélite venezolano VENESAT-1, usando posiciones astrométricas obtenidas desde telescopios ópticos. Los resultados presentados aquí están basados en las observaciones realizadas desde la estación de seguimiento espacial Luepa en Venezuela, las cuales han sido procesadas usando procedimientos astrométricos.

ABSTRACT

We present the current status and the first results of the astrometric project CIDA - ABAE for tracking geo-stationary satellites. This project aims to determine a preliminary orbit for the Venezuelan satellite VENESAT-1, using astrometric positions obtained from an optical telescope. The results presented here are based on observations from the Luepa space tracking ground station in Venezuela, which were processed using astrometric procedures.

Key Words: astrometry

1. OBSERVING SITE

The relative motion of a geostationary satellite can be observed by medium-size telescopes (Montojo et al. 2011). In a reference system attached to the Earth, such satellite appears as a fixed point with a magnitude between 6 and 12 in the visual band, depending on the phase angle with the Sun and also on the shape of the satellite.

We are observing from the Luepa space tracking ground station, located at $61^\circ 26' 20.'' 40$ W longitude and at $5^\circ 50' 13.'' 11$N latitude, at an altitude of 1396 m above sea level. At this location we have installed a Celestron CGE PRO 1400 EDGEHD telescope and CCD, $3\,\mathrm{k} \times 3\,\mathrm{k}$, FLI ProLine PL09000 camera. The first observational campaign took place in March, 2013, and lasted eight days. We obtained a set of astrometric observations of the satellite VENESAT-1, where the longest continuous observation during this campaign was six hours. Due to weather factors we could not observe all night every night, but in spite of this, we have enough observations to detect the relative motion of the satellite.

2. ASTROMETRIC REDUCTIONS

By combining exposures it is possible to detect the satellite motion over the CCD (Figure 1). Astronomical coordinates must be extracted from the exposure through the method given in Abad et al. (2004). The telescope used shows a strong distortion problem which can be seen clearly in Figure 2. We can determinate this distortion through the use the overlap method given in Stock (1981) applied to the data corrected by no-linear terms (Abad 1993), as shown in Figure 2. Correcting for this distortion, we can get final errors better than those obtained by telemetry alone.

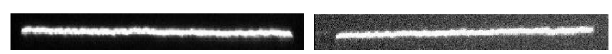

Fig. 1. Typical image of star trails: Left and right trails are located in the left upper and right upper corner of the CCD, respectively.

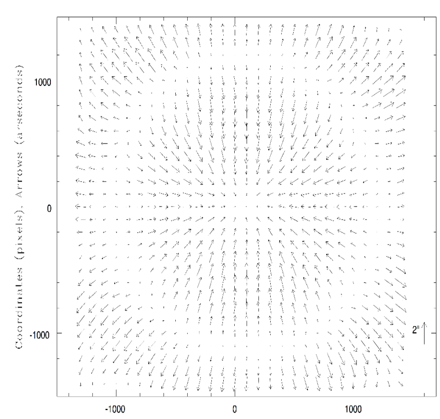

Fig. 2. A vectorial representation of the distortion introduced by the CGE PRO 14 00 EDGEHD telescope.

[1]Centro de Investigaciones de Astronomía, CIDA, La Hechicera, Apartado Postal 264, 5101, Mérida, Mérida, Venezuela (elvis@cida.gob.ve).

Table 1 shows the final errors by coordinate as a function of magnitude for stars down to 12 magnitude from the UCAC4 catalog, where a match with the catalog yielded 18,382 stars and a match between observations yielded 30,922 stars.

TABLE 1

ERROR DISTRIBUTION BY COORDINATE AS A FUNCTION OF MAGNITUDE.

Mag (m_v)	Error $\alpha_\star$ (^{s})	Error $\delta_\star$ ($''$)	# Stars
5	0.088	0.31	2
6	0.089	0.27	4
8	0.026	0.15	154
9	0.026	0.16	1747
10	0.030	0.17	4331
11	0.035	0.18	7072
12	0.045	0.21	3536

The relative motion of the satellite from March 23rd to 30th, 2013 is shown in Figures 3 and 4. Black points represent the telemetric tracking measurements and red points represent the optical tracking. The plot of Azimuth (**A**) vs. Universal Time (**UT**) and Elevation (**h**) vs. **UT** are seen in Figures 3 and 4, respectively. We can clearly see that each topocentric coordinate contains a sinusoidal libration of the period that lasts one sidereal day, since the orbital period of this satellite is equivalent to the period of rotation of the Earth (Soop 1994).

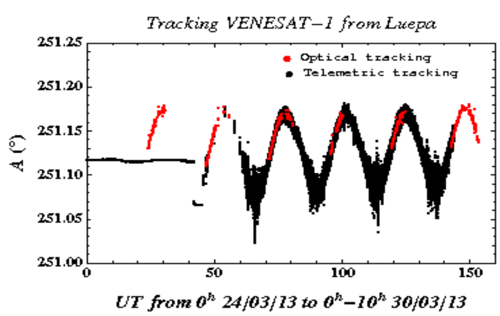

Fig. 3. Azimuth, in degrees, vs. **UT**, in hours, relative to tracking station.

3. RELATIVE ORBITS

The combined influence of conservative and non-conservative forces make the satellite position change over the time. This becomes evident in the non-stationary relative orbital motion, as shown in Figure 5. The relative motion of the VENESAT-1 satellite is shown in Figure 5. In this plot, black points correspond to measurements performed by telemetric tracking on March 28th, 2013.

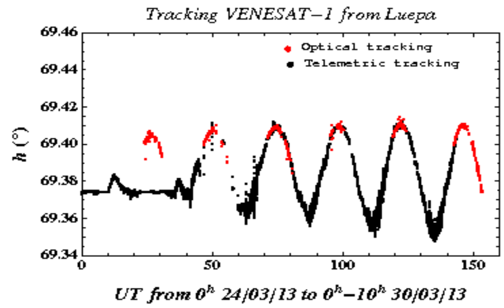

Fig. 4. Elevation, in degrees, vs. **UT**, in hours, relative to tracking station.

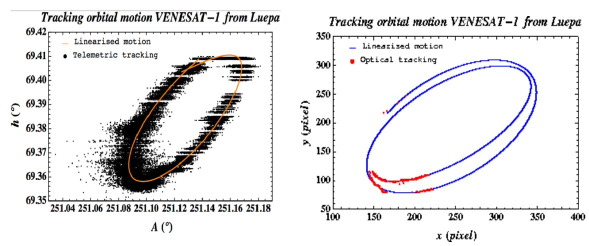

Fig. 5. Orbital motion projected on the horizontal plane (topocentric coordinates). Left plot represents telemetric tracking while right plot represents optical tracking where the vertical and horizontal axes correspond to Elevation and Azimuth.

The orange curve represents the linearized motion of the satellite obtained from telemetric data as a first approximation for the geostationary orbit determination. Likewise, we obtain the linearized motion represented by the blue curve from optical tracking (red points) on March 27th and 28th, 2013 as show in Figure 5 over the CCD coordinates (right plot). This motion is constrained to an area $0.^\circ 037 \times 0^\circ.046$, the scale being 1 pixel $\simeq 0''.67$.

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