10.18524/1810-4215.2022.35.268799

DETERMINATION OF EXTERNAL GSS PAYLOAD FROM LIGHT CURVES

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ABSTRACT. They are offered reflective features to external surface geostationary satellites on which possible identify the separate external construction geostationary satellites. Such constructions can be; the type and forms radio antennas, solar panels, thermo film on surfaces of the platform. They are given to recommendations and specified moments of time, condition, under which possible find the external payload. The paper presents the results of colorimetric observations of 5 GSS of multi-purpose operation, on the platform of which an external payload in the form of several radio antennas was found, and in some cases the orientation and technical characteristics of the GSS were estimated.

Keywords: payload, radio antennas, multicolor photometry, light curve, GSS, color index, solar panels, thermo film, external payload.

АНОТАЦІЯ. Запропоновано світловідбивачі характеристики поверхні GSS, до яких можна визначити окремі зовнішні структури геостаціонарного супутника. Такі конструкції можуть бути; тип і форма радіо антеніни, сонячні батареї, термо-плівка на поверхні платформи. Дані рекомендації та моменти часу, умови, за яких можна знайти зовнішнє корисне навантаження. У роботі наведено результати колориметричних спостережень 5 ГСС багатоцільового призначення, на платформі яких виявлено зовнішнє корисне навантаження у вигляді кількох радіоантен, а в окремих випадках оцінено орієнтацію та технічні характеристики ГСС.

Ключові слова: Зовнішня корисна навантаження, радіо антени, багатоколірна фотометрія, світлова крива, GSS, кольоровий індекс, сонячні батареї, термо-плівка.

1. Introduction

Coordinate observations of geostationary satellites (GSS), carried out for the purposes of Space Surveillance Awareness (SSA), do not provide information about the shape of the satellite, its dynamics in orbit, the number and size of the external payload. The COSPAR Launch list also does not have such information about GSS. Under certain conditions of GSS visibility, such information can be obtained from multicolor photometric observations (non-resolved). Most modern GSS (communications, navigation, telecommunications, control over objects on the earth's surface and oceans) have triaxial stabilization, regardless of their operation in orbit. Their external payload (receiving and transmitting radio antennas, mirrors) basically does not change its orientation and direction to certain points on the planet or towards other geostationary objects. During each cloudless night, some of them, illuminated by the Sun, fall into the field of view of an earthly observer. Having special colorimetric equipment placed on telescopes, even of the middle class, it becomes possible not only to control the dynamics of the behavior of such satellites, but also to identify individual structures on their surface.

In this publication, we present the results of colorimetric observations of 5 GSS of multi-purpose functioning. On these GSS it was possible to detect external payload in the form of radio antennas, and in some cases to evaluate their orientation and technical characteristics.

2. Results

How to determine what “glare” is a radio antenna, a solar panel (SP) or a thermal film covering the GSS platform from overheating?

The answer – is according to the numerical value of the color index (B-V), (V-R). Specific values of the color index for many materials used on the surface of satellites were obtained earlier experimentally and published by A. Murtazov [1], V. Epishev [2,3], N. Cowardin [4]. But over time, materials change their reflective characteristics, or designers use new materials whose albedo is unknown to us. Therefore, when analyzing observational material, one must be careful not to make erroneous conclusions.

The GSS colorimetric is based on the transformation of the color indices of solar radiation after its reflection from the structural elements of the GSS surface. Color indices for the Sun [5]: (B-V) = 0.64, (V-R) = 0.52.

The satellite images below have been taken from online resources such as the Gunter Space Page [6] and Wikipedia [7].

1. “Intelsat 10-02”. International telecommunications GSS. Figure 1 shows the phase light curve for 12.10. 2010. Near phase angles 27^0 - 30^0 in the V-filter, there are four small, but different amplitude, brightness rises. According to the calculated color indices (B-V) and (V-R), published in [1-4], it can be argued that they are caused by four pairwise different radio antennas, since smooth metal structures most intensively reflect sunlight in the spectral region V. This conclusion is also confirmed by the appearance of the GSS, shown in Fig. 2 showing four antennas.

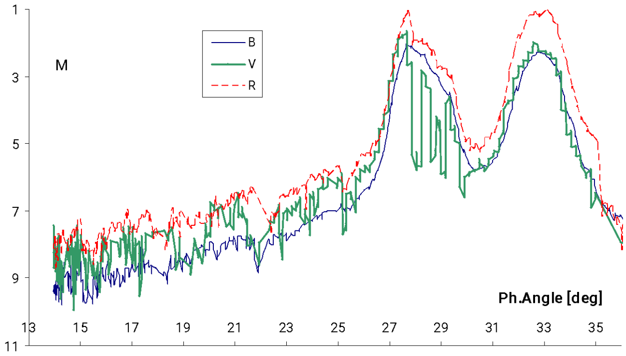

Figure 1: Phase light curve of GSS “Intelsat 10-02”, B,V,R. 12.10.2004.

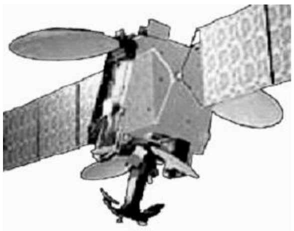
Figure 2: Appearance of the GSS “Intelsat 10-02”

2. “Cosmos-2397” (NPO of the S. Lavochkin). Russian early warning satellite. From the moment of launch in 2003, it was in an emergency condition and drifted to the east during the observations.

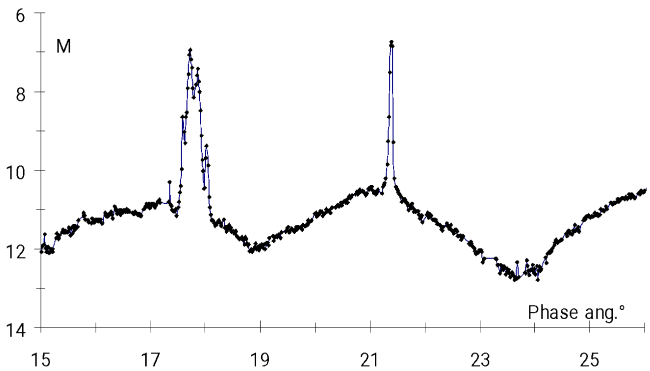

Figure 3: Phase light curve of GSS “Cosmos-2397”. V-filter. 12.09.2004

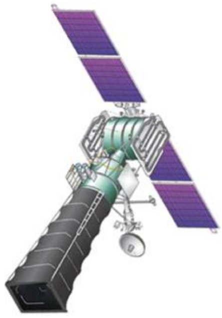
Figure 4: Appearance of the “Cosmos-2397”

Sharp almost mirror-like brightness rises are clearly generated by the solar panels of the satellite, which was rotating. Here, one filter V was enough to identify four SP. On Fig. 5 this is clearly seen when zooming in on the time interval of the first outburst on the light curve.

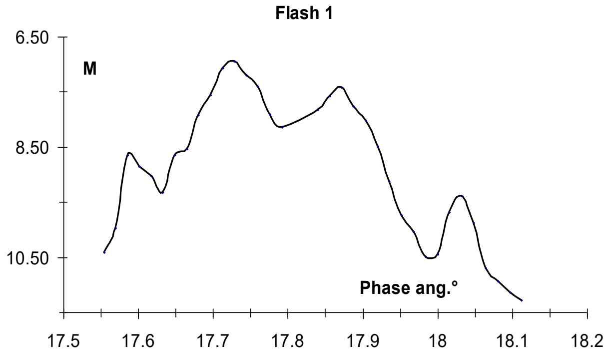

Figure 5: Zoom in on the first burst of the light curve “Cosmos 2397” 12.09.2004.

3. “SBIRS-GEO 2” (USA). GSS system for early detect of ballistic missile launches.

As a result of the studies, it was found that periodic specular flashes on the light curves (Fig. 6) were recorded from scanning mirrors, which, according to information from open sources, should be two on the GSS [8]. As can be seen from the light curves, they fluctuate with a period of P=15.66 sec. Periodic changes in the curves of the diffuse light component with P=62.64 sec. are caused, in our opinion, by oscillations of the GSS around an axis coinciding with the direction of its movement along the orbit. It is known that stabilized GSSs in the plane of the Earth's equator inspect the Earth's surface up to latitude of 83 deg. “SBIRS-GEO 2” examines it from North pole to South pole and, according to our results, it achieves this due to its oscillations with P = 62.64 sec. During this time, scanning mirrors scan the earth's surface twice in the northern hemisphere and twice in the southern hemisphere with P=15.66 sec. Thus, by estimating the directions of the mirrors, it was possible to simulate the rather complex dynamics of behavior in the orbit of this GSS as a whole.

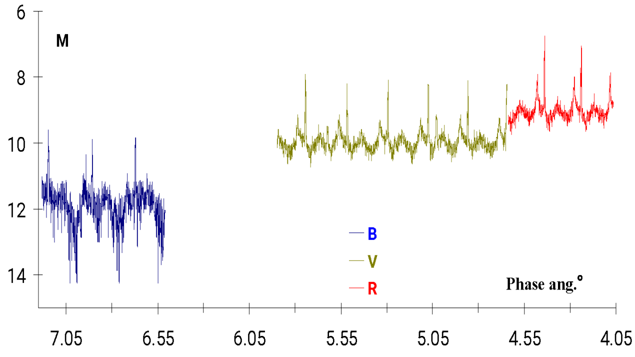

Figure 6: Phase light curve “SbirsGeo-2”. Filters B,V,R. 29.08.2014

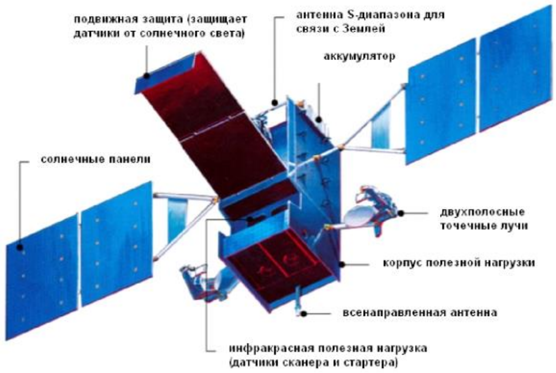

Figure 7: Appearance of the “SbirsGeo-2”

4. ГСС “Cosmos-2520”. A Russian military communications satellites of the heavy class "Blagovest".

The presented light curves show the results of observing the right side with respect to the observer of one of the “Cosmos 2520”. The large-amplitude periodic brightness changes on the curve are caused by the movement of the sun glare along the cruciform solar panels. In the last section of the curve, when the glare reached the body of the satellite, its slight changes are visible at the minimum brightness, caused precisely by the presence of radio antennas. At least three larger receiving radio antennas were recorded from this side. To estimate the number of radio antennas on the other side of the object, it was necessary to observe the satellite after it left the Earth's shadow.

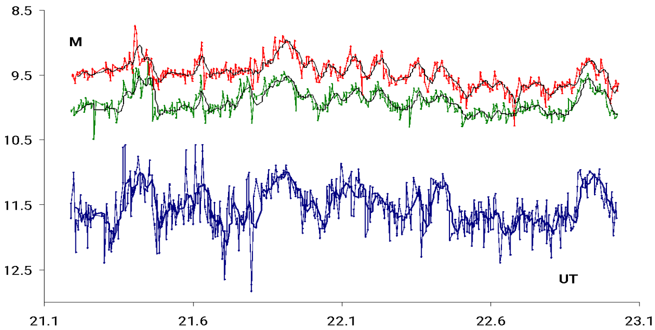

Figure 8: Phase light curve „Cosmos-2520”. B,V,R - filters. 12.08.2018

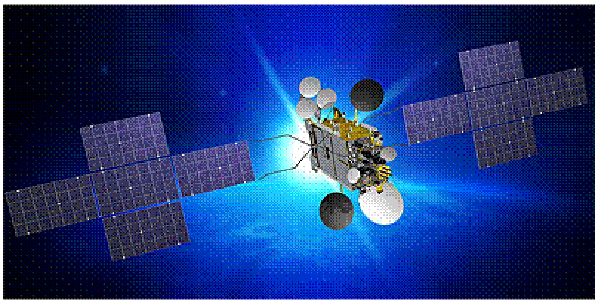

Figure 9: Appearance of the GSS “Cosmos 2520”

5. “Thuraya –2”, GSS mobile communication.

The brightness of this GSS is caused mainly by the reflection of sunlight from two large SP. The presence of a radio antenna is seen from small-amplitude brightness fluctuations along the curve. Such changes are typical for fine-structure antennas of the "fishing net" class. Similar low-amplitude brightness fluctuations from metal mesh radio antennas have been observed previously [9].

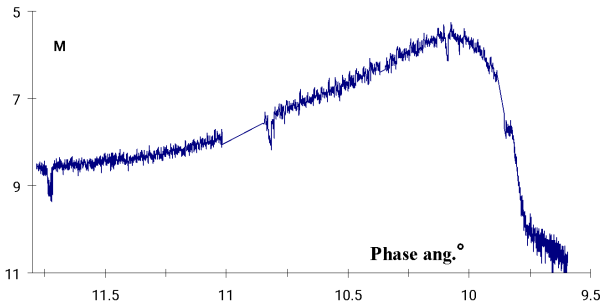

Figure 10: Phase light curve “Thuraya-2”. V-filter, 17.09.2014

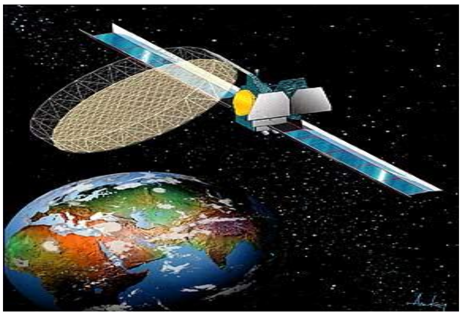

Figure 11: Appearance of the “Thuraya-2”

3. Conclusions

Estimating the number of radio antennas on the GSS is a rather difficult task. Not all of them are illuminated by the Sun during the observation session. Their visibility in most cases is possible closer to the epoch of the equinoxes and at small phase angles.

To increase the resolution of detecting small structures on the external GSS platform, it is necessary to reduce the accumulation time of a single measurement.

In the case of using large telescopes, this problem can be solved more qualitatively and quantitatively. Calorimetric allows this.

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