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PAPER SATELLITES AND SPACE NETWORKS

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Abstract

A Comparative Table of notified space networks and satellites present at or near nominal orbital positions illustrates the occupation of the geostationary orbit. Clear distinction has to be made between a network as transmission of information on one hand and a satellite as a solid body orbiting the Earth on the other hand. Paper satellites do not exist but there is an overabundance of over 2500 separate requests for transmission frequencies. The situation has been made transparent by showing which networks are fit to transmit by having both, a notification by the ITU as well as an active satellite in a correct orbital position. There are 802 notified networks and at least 84 networks in the Broadcasting Satellite Service operated on 372 satellites. More than 165 notified networks do not have a satellite at relevant orbital position.

1. INTRODUCTION

The term "paper satellites" gives the impression that some satellites are not real but exist on paper only. In fact, the number of active satellites in the most populated region, the geostationary orbit, **GEO**, at the end of June 2008 was 372.

On the other hand, the number of requests for frequency bands for radio transmissions from satellites to ground stations exceeds 5000. The requests exist only on paper until they have passed successfully through a coordinating process initiated by the International Telecommunication Union (ITU) and became "notified" space networks enjoying international recognition and protection. The ITU sieve is strict. In June 2008 only 802 networks in SNL, Section A1, made it and were supposed to transmit. The coordinating process is an attempt to prevent possible harmful interferences and eliminate interferences detected at a later stage.

In order to understand the problem at hand better, it is necessary to compare notified networks with reality, i.e. with active satellites in orbit. For that reason a Comparative Table has been set up listing side by side the "paper situation" of space communication networks with the "physical situation" of satellites in the geostationary orbit.

Also, the distinction between a network and a satellite has to be well understood. A space network is an electromagnetic transmission of information between radio stations in space and on the ground. A satellite is a solid body in outer space, in an orbit around the Earth. Official terminology, as well as its popular counterpart, evolved historically in such a way that the word "satellite" stands sometimes for the material body, sometimes for its function as the space component of a communication network. The present paper provides understanding. It is not a proposal for changing a widely used terminology.

2. THE COMPARATIVE TABLE

The operation of a space network depends on the presence of a satellite near the nominal orbital position of the network. There is tolerance in position because a transmission lobe covers with sufficient intensity a certain area. The ITU passed a rule that a satellite operating a space network has to be within an angle of 0.1 degree in latitude as well as longitude from the nominal orbital position.

The Comparative Table[1] shows the relation between **"notified space networks"** which enjoy international recognition and protection, and **active satellites** which are close to the nominal orbital position. Networks appear on the left, satellites on the right. The reference date for Networks is 3 June 2008, i.e. the date of issue of the ITU Space Network

List. For satellites it is the end of June 2008.

The main parameter in the table is the nominal position **(Nom. long.)** shown in the first column in bold characters. All notified networks operating at the same nominal position are contained within horizontal lines. On the right, between the same horizontal lines, are satellites which could operate networks on the left.

Data on space networks have been taken from the ITU Quarterly Publication of the Space Network List[2] (**SNL**), Section A1, issue of 3 June 2008. The columns show a symbol for the notifying administration **(Adm)**, for the organization operating the network **(Ntw org)**, and the **Space Network Name**. The heading of that column in the SNL is **"Sat_name"**. As explained in the preface to the SNL, it identifies the space network, not the satellite. Names of networks are sometimes changed by operators, and some networks are known under more than one name. The last column shows the symbol for **frequency bands** according to table 1 of the preface to the SNL. E.g., the C band corresponds approximately to numbers 43 - 49, the K_u band to 53 – 65, the K_a band to 75-80.

For satellites in the Broadcasting Satellite Services, BSS, Sections A10 and A11 of the SNL were used to supplement data of Section A1, in particular in cases when a satellite operates mostly networks in the BSS.

The right-hand half of the Comparative Table shows spacecraft launched before the end of June 2008. The first column gives the COSPAR international designator **(COSPAR Int. Desig.)** indicating the year of launch, the serial number of the launch in the year, and the serial letter of the object in the launch. The designator identifies the satellite in a unique way and for its entire lifetime.

The remaining columns show the **Satellite Name,** which sometimes is subject to a change[3], and **Status of Orbit** (see section 5). Notes concerning functions performed by the satellite, printed in red, appear on the same line or the line below, or in the left part of the table, wherever convenient. The notes are very brief in order not to extend the length of the table. More details on the satellite appear in the Encyclopedia of Satellites and Probes of the Czech Academy of Sciences[4].

3. SPACE NETWORKS

The total number of entries in the **SNL,** Section A1, has grown rapidly in the past. It attained around 3000 entries back in 1998, it slightly exceeded 4000 entries in 2001 and attained 5770 in March 2007. Since that time, possibly reflecting new measures by the ITU, the number declined to 5164 entries in December 2007. It increased to 5507 in June 2008. Some networks are listed separately at different stages of coordination, thus the number of separate networks is smaller than the number of entries. In the December 2007 issue of the SNL, there are 2940 separate networks only, a reduction of the "paper population" by 43%.

An administration wishing to bring a network into use has to submit an advance announcement to the ITU. The announcement appears in the SNL as class **A**. When a coordinating process to avoid possible harmful interference with existing networks is initiated, the network is denoted as class **C**. Its entry as class **A** is, in most cases, retained. If and when the process is successfully completed, the network is notified in the Master International Frequency Register and denoted as category **N**. As before, entries of the same network in classes **A** and **C** are frequently retained. A possible reason may be to preserve a record of changes which the network was subjected to in the course of the coordinating process. Thus, in the June 2008 issue of the SNL, Section A1, 802 networks were notified in the

Master International Frequency Register and received international recognition and protection. From Sections A10 and A11, 84 networks in Broadcasting Satellite Service have been added, making thus a total of 886 Networks.

4. DUE DILIGENCE

The ITU has adopted measures, termed Due Diligence, to restrict the growth of space networks. Without these steps, the present number would have been even larger. A significant reduction is, however, in the hands of launching and operating agencies.

Administrations have to provide evidence of seriousness of intentions to establish a space network[5] according to the ITU Resolution 49, Annex 2, of the World Radio Conference 2003. Among the many data required are (i) Identity of the satellite network, (ii) Name of the satellite, and (iii) Orbital characteristics.

Item (i) refers to the term "space network" used in the title of the SNL.

Item (ii) refers to a satellite as a material body. Its unique identification is desirable. Launching names have the disadvantage of rather frequent changes. The COSPAR international designation is the best option for objects in orbit. It is unique, does not change but it is rarely used. It is assigned after a successful launch, therefore it is not available as pre-launch announcement.

Item (iii) refers, in the case of a GEO, to the geographic longitude of the nominal orbital position.

A summary of the data appeared in a table provided by the courtesy of the ITU[6]. The table lists the "ITU Name" as well as the "Commercial Name". These two names are in most cases identical with the name of the space network and only rarely with the name of the satellite. The table lists networks in all three classes, A, C, N. That means, that only some of the networks have completed the coordinating process at the date of publication of the list.

The Administrative Due Diligence, together with the fees introduced in the Financial Due Diligence and Cost Recovery, and with the time limit of bringing into use, are very efficient measures adopted by the ITU for limiting the excessive number of applications for transmission frequencies.

5. SATELLITES IN THE GEO

For a meaningful comparison of space networks and satellites a reliable list of spacecraft and their positions in the GEO is required. The most authoritative information on objects launched into outer space is provided by launching states. It appears in the UN Register in the form of governmental announcements[7]. Unfortunately it is not complete. An online searchable index listing all objects announced to the UN, as well as those not announced, appears at the same website. Additional information is, however, needed for computing actual positions of space objects at a given time. The best available and most reliable source of actual positions of objects in the geostationary orbit is the "Classification of Geosynchronous Objects" referring to situation at the end of each year[8]. It is based on the DISCOS database[9] which uses as source of information the NASA Two-Line Elements[10]. These, in their turn, are based on observations of physical presence of satellites in orbit. Only objects larger than 1m can be tracked on a regular basis at the distance of the geostationary orbit. All active satellites can be tracked but small inactive objects cannot be routinely detected. The most recent issue of the "Classification" refers to the end of 2007. Results can be summarized as follows, showing the complexity of the population of the geostationary orbit:

• The total number of objects in and reasonably close to the geostationary orbit was 1150, 29 more than the year before, 68 more than two years before.

Table1, Objects with recently updated orbital elements:

• **Status C1**: 243 objects are controlled in longitude and latitude. These are suitable for transmissions to fixed antennas. Five satellites launched towards the end of 2007 were supplemented with data obtained in 2008 and have been added to that group. Launchings in the 12 years, 1996-2007, averaged 19 per year. In years 1993-1995 the rate was lower.

• **Status C2**: 75 objects are controlled in longitude only, requiring movable ground antennas. These objects have been launched in the 23 years 1985-2007. One satellite, ATS 3, survives from 1967.

• **Status D**: 458 objects are in a drift orbit passing through all longitudes. These could obviously not been associated with a nominal orbital position, just as the following group,

• **Status L1, L2, L3**: 145 objects are at a libration orbit, oscillating around the Eastern (92), Western (36), or both (17) stable points in the orbit,

Table 2, Objects without orbital elements determined during the last 6 months of 2007:

• **Status C**: 47 objects under control. Their recent orbital elements are not available in the NASA Two-Line Elements. Orbits of 36 objects out of those 47 can be determined from amateur observations. Most of these objects are used for governmental uses, such as reconnaissance or verification of international treaties. There are thus at least 11 active satellites in controlled orbits at unknown positions,

• **Status D, L1, L2**: a total of 7 objects, mostly retired satellites.

• **Status U**: Uncontrolled: 99 objects, mostly rocket stages and debris, a few payloads, without available orbital elements. These objects are old. The most recent three objects have been launched in 1998, 1994, and 1992 respectively.

• **Status UU**: uncontrolled un-catalogued: 67 objects, all of them debris, such as covers and restraint cables, or rocket bodies,

• **Status UI**: 146 unidentified objects which have been repeatedly observed but not correlated to a specific launch. 22 of these objects have provisional identification coinciding with objects of status C. and finally,

• **Status Ind**: 9 objects launched or maneuvered close to the end of 2007 of indeterminate status. Positions of five of the objects, all launched in November and December 2007, have been computed by P. Lála[11]. ,from one or more orbital elements determined in 2008. In the Comparative Table they appear under Status of Orbit **PL**.

Of interest to the problem of paper satellites are active objects at their nominal positions within ITU tolerances (Status C1), those controlled in longitude only (Status C2), objects of Status C, and objects of Status Ind.

Also considered were objects launched in the first half of 2008. Positions have been computed and listed by P. Lála, Status **PL,** as above, and/or by A. Vítek and published in the Encyclopedia (see ref. 3), Status **Enc**. The physical presence of all 372 satellites listed in the Comparative Table has been confirmed by data derived from observations.

The number of notified space networks in the ITU tables is larger than the number of active spacecraft in orbit. Allowance, however, has to be made to the fact that more than one space network can be operated on one satellite.

6. RELATING NOTIFIED SPACE NETWORKS WITH SATELLITES

Operators know which satellites operate which of the networks but do not always publish the fact. If such information is available, e.g., on the web, or if the name of the satellite is sufficiently close to the name of the network, a bullet • was put near the central line of the Comparative Table. An example is at nominal position 0.00 E. An ESA Meteosat network is operated by satellite 2006-049B, Meteosat 9. Very helpful in this respect was, e.g., the List of Satellites Approved to Provide Fixed-satellite Services in Canada[12].

In other cases, a possible match is a matter of conjecture. An example is at nominal position 4.00 E. Satellite 1997-049A, Hot Bird 3 = Eurobird 4, providing regional services in Europe in band K_u, may be operating networks EUTELSAT 2-4E or EUTELSAT 3-4E or both. Without more detailed information we cannot say if it operates also network EUTELSAT-KA-4E transmitting in band K_a or network TELECOM-4E transmitting in band C.

In case there is no satellite at a nominal position of a network, the network cannot transmit. Possibly a satellite is being prepared to take up the position and will be launched at a future time. An example is at nominal position 5.70 E, where network MEASAT-SA1 has no satellite to transmit from. In the Comparative Table are 83 nominal positions with a total of 165 networks with no satellite at the relevant position. In other words, almost 19% of all notified networks could not operate at the end of June 2008.

There are also cases of satellites without a notified network at its nominal position. Such a satellite may have terminated its activities, or it may be a spare to be brought into use at a later date. In fact, most of satellites having no corresponding notified network, have a pending application in the coordinating process. An example is satellite 1997-071A, Sirius 2, at 31.5 E. It was moved from its previous position at 4.80 E, where it had its network SIRIUS 2. Its services at 4.80 E have been taken over by 2007-057A, Sirius 4, in May 2008. At the same time Sirius 2 was moved to its new position at 31.5 E, where corresponding networks have classes A and C, but have not been "notified" at the time of the shift of position. The annexed Comparative Table shows that a total of 23 satellites had no notified network at the critical date. Evidently, commercial reasons are in some cases stronger than discipline in complying with agreed rules.

In general, the table restricts considerably the number of possibilities of matching networks with satellites. In some cases, however, more detailed information is desirable.

7. CONCLUSIONS

There are no "Paper Satellites". There is, however an overabundance of over 2500 separate requests for transmission frequencies. Many requests appear in the lists repeatedly, according to their status in processing and coordinating with existing space networks. The ITU instituted administrative and financial measures, called Due Diligence, to curb the excessive number of applications. Only networks which do not interfere with earlier comers receive international recognition and protection. The work of the ITU is essential for preventing harmful interference among space telecommunication networks and for providing a forum for removing interference whenever it appears. A Comparative Table listing both, space networks and satellites, illustrates the situation at occupied nominal orbital positions. It is proposed to maintain and regularly update the Comparative Table.

At the end of June 2008, there were 372 satellites in orbit operating not more than 886 networks duly notified or

planned. The actual communication traffic is considerably less than the numbers would suggest because 165 networks are at nominal positions with no satellite present. Moreover, even if a satellite is present, there is no confirmation that it operates **all** networks at the relevant position.

There are 23 satellites without a notified network, some of them very likely to transmit without international recognition and protection

The situation is in constant change and evolution for several reasons. New ventures have been undertaken, some networks or satellites have been sold to other operators of networks or owners of satellites and acquired new names in the process.

The term "satellite" should be used in reference to a material body only. The heading "Sat_name" in tables listing space networks may lead to confusion.

References

[1] The Comparative Table is too long to annex it here. It is available on the DVD distributed to participants at the IAC 2008 under the title of the Session. It is available also on request to perek@ig.cas.cz.
[2] ITU Space Network List, Section A1, Editions of 3 December 2007, 3 March and 3 June 2008, Sections A1, A10 and A11 for Broadcasting SatelliteServices. See at www.itu.int/ITU-R/space/snl.
[3] E.g., the satellite at 121W, EchoStar 9, is also known as Telstar 13, or Intelsat Americas 13, or Galaxy 23, or G 23.
[4] Encyclopedia of Satellites and Probes of theCzech Academy of Sciences, author A. Vítek, at www.lib.cas.cz/space40.
[5] Ram Jakhu: Legal Issues of Satellite Telecommunications, the Geostationary Orbit, and Space Debris, Astropolitics, 5, p.173-208.
[6] ITU Space Network Systems Online, Special Query System: Administrative Due Diligence Information (Res, 49), List of Geostationary and Non-geostationary Satellite Networks.
[7] See at www.unoosa.org/oosa/SORegister/index.html.
[8] Classification of Geosynchronous Objects, Issue 10 by R. Choc and R. Jehn, February 2008, European Space Operations Centre, Darmstadt, Germany. Preceding issues cover years 1999-2007. For years 1990-1999 see Log of Objects Near the Geostationary Ring, Issues 1 to 20, also at ESOC, Darmstadt.
[9] Established at the European Space Operations Centre in Darmstad, Germany.
[10] See at ghrc.msfc.nasa.gov/orbit/tleformat.html.
[11] P. Lála, Private communication. Computed from CelesTrak elements and published in the Encyclopedia, ref. 3.
[12] See www.ic.gc.ca/epic/site/smt-gst.nsf/en/sf02104e.html.