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TAKING GARBAGE OUTSIDE: THE GEOSTATIONARY ORBIT AND GRAVEYARD ORBITS

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Abstract

The Geostationary Orbit has been recognized as a limited natural resource. Taking into consideration the dynamic development of technology and the finite nature of the geostationary ring, it is not possible to denominate a definitive number of orbital slots. Currently about 350 operational satellites, distributed in an uneven way, use this limited space resource. The particular 'stationary' position of satellites in this orbit makes it a commercially attractive resource, not only for governments and international governmental organizations, but also for the private sector. Geostationary satellites coming to the end-of-life must free their slot in order to leave it to the next satellite. But where are the decommissioned satellites going?

This paper addresses the concept of graveyard orbits and decommissioned geostationary satellites. It also addresses to what extend the graveyard orbit concept is becoming a binding legal regime.

1. INTRODUCTION

1.1. Physical Principles of the Geostationary Orbit.

The Geostationary orbit is a circular orbit, approximately 36,000 km. away from the Earth's surface, positioned exactly above the Earth's equator, with 0° of inclination. Objects positioned in this orbit, complete one revolution in approximately 24 hours. Synchronized with Earth rotation, geostationary objects will appear fixed to a point in the celestial Earth's equator. This particular position enables a large coverage of our planet and satellite owners and operators[1] save the costs of location and tracking antenna systems.

Already the Russian theorist Tsiolkovsky and the Germans Hermann Oberth and Herman Potocnik made reference to the Geostationary Orbit[2]. But in 1945, the British Arthur Clarke was the one who first presented calculations for the placement of a satellite in this part of outer space, addressing the potential utility of the Geostationary Orbit[3].

These theoretic calculations could not be put into practice until 1964, when

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the technology was mature enough for placing the first geostationary satellite, the US Syncom III. At the beginning, only governments used this natural space ring. But as the commercial capabilities became more evident, international governmental organizations and private companies started to enter the scene and contracted satellite manufacturers and launching services, to place their own satellites in the Geostationary Orbit.

1.2. The Geostationary Orbit as a Limited Resource.

As the time passed by, the interest in placing satellites in this orbit became more intense and it was clear that it was necessary to set rules. Through the International Telecommunications Union, States started to coordinate their satellite positioning in slots (nominal positions) and the use of electromagnetic frequencies. Interestingly, in the ITU both, slot and frequency coordination, were primarily conceived as a means to avoid harmful interference. Then, the threat of physical satellite collisions was not a priority.

But satellites, as humans, are mortal. As a result of several factors, such as solar radiation pressure and the Earth' gravitation, most satellites in the Geostationary Orbit tend to leave their nominal position. In order to keep them in their slots, satellites have on board fuel tanks which enable them to fire small rockets, from time to time, for correcting their positions. Most geostationary satellites require course corrections for this type of station-keeping once every two weeks.

Long-term geostationary satellites have a fuel capacity sufficient for keeping them 15 years in their nominal position. But once the fuel has been used up, satellites start to drift and leave their slots. These satellites are then considered to be space debris, even if all the instruments on board are still intact.

With the time, the Geostationary Orbit became a crowded place, which is not only used by operational geostationary satellites. Some other functional satellites have orbits that intersect the geostationary ring. Also uncontrolled satellites, as well as rocket stages that delivered satellites to the Geostationary Orbit, are crossing this ring. On top of this, broken satellite parts need also to be considered, which originate from satellite explosions or collisions.

In January 2006, 1089 objects of significant mass have been detected in this orbit[4], of which 344 are operational satellites in their nominal positions.

Space researchers noted that space debris in the geostationary ring was increasing, putting in danger operational satellites. But for several years, their warnings did not move States to take counter-measures.

2. A TECHNICAL PROPOSAL AND A COMMERCIAL WORRY.

2.1. Origin of the Graveyard Orbit Concept.

Some years ago, when a geostationary satellite was approaching its end-of-life, satellite owners and operators typically reserved no or only a small amount of satellite's propellant to free the slot for the follow-on-satellite. In some cases, satellite owners and operators just abandoned dead satellites in their positions. But such abandoned satellites in their nominal position or some km. away from the slot, tend to drift in an orbit "...slightly above the geostationary Orbit",[5] which crosses the Geostationary Orbit

constantly, putting in danger operational satellites in the geostationary belt.

At the point, when a geostationary satellite has suffered a malfunctioning and can not be or is not worth to be kept in its slot, some satellite owners and operators make a public statement declaring such as 'decommissioned'. The same declaration may be done, when a healthy satellite reaches its end-of-life, after its fuel is completely used up and it is not longer under control. These declarations are a kind of warning to other satellite operators, which must take into account that decommissioned satellites will drift and may endanger operational satellites in the proximity.

Taking into account that no concept existed for the proper satellite disposal, the Inter-Agency Space Debris Coordination Committee (IADC), which encompasses representatives of governmental space agencies of space fairing countries[6], decided to create some guidelines in this respect. In 1997 the IADC representatives reached a consensus on 'Mitigation Guidelines' to reduce space debris in general[7].

One of these recommendations is about the removal of operational geostationary satellites, approaching their end-of-life, from the geostationary ring to one of the graveyard orbits[8]. Such graveyard orbits should not intercept the geostationary ring and are supposed to be a safe place to keep non-operational satellites far away from useful orbits. The recommendation also requires disposed satellites in a graveyard orbit to be 'passivated', which means fuel remnants are to be depleted, batteries discharged, pressure vessels relieved, etc., in order to avoid satellite explosions that may interact with other disposed satellites.

It seems that, although 'soft law', such recommendations are an easy and logical step to take, but several satellite owners and operators are reluctant to follow them. Why?

2.2. The Value of Fuel.

The economic potential of communication satellites can be measured by their number of transponders. Transponders are devices on board which receive electromagnetic signals (up-link), convert them into another frequency[9], enhances their power and send them back to Earth (down-link). Each transponder may canalize hundreds of telephone calls or several television channels in one electromagnetic signal. Today 'small satellites' have 24 transponders, while 'big' satellites may have around 50. Currently, the annual average profit for one transponder is 2 million US dollars[10].

The amount of fuel required to move a satellite to a graveyard orbit, equals approximately the fuel that a satellite would use to keep its nominal position approximately during 4 months. If an operating satellite comes to its end-of-life four months earlier as calculated by the space owner or operator, this will result in loss of several millions of US dollar in earnings. As in most commercial enterprises, time is valuable, which is the main reason why for-profit satellite owners and operators are reluctant to move a healthy satellite into a graveyard orbit.

Nonetheless, the IADC recommendations are being followed by some satellite owners and operators.

3. CUSTOMARY LAW.

Although the IADC Mitigation Guidelines were meant to be non-binding, this does not mean that satellite disposal

into graveyard orbits cannot evolve into a legally binding international custom.

International Custom is being formed by two elements, the exercise of a practice by the members of the international community and their conviction that such exercise is an obligation (*opinio iuris sive necessitatis)*[11].

In respect to the time and intensity of a practice, Verdross and Simma consider that in the current high organized and technical international relations, the particularity of a custom must not be analyzed by the duration of the practice but, as already the International Court of Justice affirmed, under the specific situation that defines if a practice is "extensive and virtually uniform"[12].

In respect to the *opinio iuris*, repetitive practice may create in some cases the conscience among the members of the international community that they are obliged by such behavior and that such behavior is expected from the other members of the international community. In other cases, the wills of the members of the international community may not be based in the conviction of obligation but, as Verdross and Simma affirm, also on the usefulness or fairness of a practice[13] and, in this case, as a preventive measure.

Taking into consideration this two elements, in the case of geostationary satellite disposal, it is necessary to analyze if satellite owners and operators are exercising a repetitive practice in an uniform manner and if the psychological aspect, the *opinio iuris*, is fulfilled.

3.1. Practice.

In the 9 years since the IADC recommendations were issued in 1997, 49 out of 135 satellites that arrived to their end-of-life were reorbited in full accordance with the IADC recommendations. Statistics show that since 2002 there is a steady increase in correct deorbiting practices. From 1997 to 2005, 8 Intelsat, 6 Japanese, 10 US, 3 Russian and 22 satellites from other countries and international organizations, were deorbited in compliance with the IADC recommendations[14].

Statistics show also that a number of decommissioned satellites are deorbited to orbits below the IADC recommendations, i.e. no more than 150 km. from the Geostationary Orbit. Many of these satellites could not reach a IADC graveyard orbit as a result of anomalies or because they were relatively old and not enough fuel was reserved for a higher graveyard orbit. Nonetheless, several of these satellites will not intersect the geostationary belt for at least 200 years or more[15].

Another question is, if the deorbiting practices according to IADC recommendations of private companies or international organizations owning and/or operating geostationary satellites, can be considered as 'State practice' in the formulation of international custom. In this context, art. VI of the Outer Space Treaty[16] provides the link by spelling out that States are responsible for national activities in outer space "...carried by governmental agencies or by non-governmental entities...and international organizations"[17]. Consequently, if a State licenses and supervises space activities of private companies and international organizations, their activities can be attributed to be the practice of the respective State.

3.2. *Opinio Iuris.*

As already indicated, customary law also requires *opinio iuris*, a second

element of subjective nature. *Opinio Iuris* is the explanation of the reasons why a subject is exercising certain practice. But, as judge Tanaka expressed[18], in most of the cases the motives that make States to perform certain practice are not explicit. Such motives must be then inferred from facts as the very acts themselves, declarations and national legislations encompassing such practices.

Practices of satellite disposal in graveyard orbits in accordance to IADC recommendations or in lower graveyard orbits, are *per se* an evidence of *opinio iuris*. But there are other indications on the presence of this element, for example national legislation and declarations.

3.2.1. National Legislations in Graveyard Orbits

3.2.1.1. The United States. According to US legislation, satellite owners and operators need an authorization (license) to operate a satellite[19]. Such licenses do not only serve to monitor the space activities of satellite owners and operators, but they serve also to share compensation costs in case of damage provoked by an accident. Thus, licenses are granted if the applicant demonstrates financial backing and a liability insurance.

In order to reduce liability risk, US government recommended satellite owners and operators to move their geostationary satellites in graveyard orbits, before they reached the end-of-life. But such recommendations where not observed as the government wished. From 30 geostationary satellites under US license that reached their end of life between 1997 to 2005, only 10 were correctly disposed in graveyard orbits[20]. Because the United States is one of the major users of the Geostationary Orbit (besides Russia), it became evident that the US was contributing to the pollution in a way that "...could shut down the space industry..."[21].

When the Federal Communications Commission (FCC) drafted legislation on the disposal of satellites in graveyard orbits, satellite owners and operators as PanAmSat Corp. (US), EchoStar Communications Corp. (US) and Americom (US), protested when they learned that such legislation was directed to be applicable in a retroactive manner[22]. They claimed that such legislation would have a strong impact in their financial performance.

In order to reach a compromise with the private sector, in 2004 the FCC agreed to bind only those owners and operators who launched their satellites after the 18th. of March, 2002. Owners and operators who launched their satellites before that date are requested to follow this rule as recommendation.

In respect to satellite disposal, the US regulation mandates that licensed satellite owners and operators submit a statement with substantial information on satellite disposal. Such information must address the amount of fuel reserved for orbit transference, the passivation of satellites[23] and, for geostationary satellites, the targeted graveyard orbit[24].

The legislation is now integrated into the Code of Federal Regulations under Title 47[25]. The Federal Communications Commission is the government body to authorize and supervise satellites life (even before they arrive) to the launching pad until the graveyard orbit. With this regulation, the United States becomes the first country to make the disposal of geostationary satellites in graveyard orbits compulsory.

3.2.1.2. Germany. Under the 'Procedures for the Registration of Satellite Systems before the International Telecommunications Union and the Assignment of German Rights for the Use of Orbits and Frequencies'[26], Germany introduced regulation relating to graveyard orbits.

Paragraph 3.7. stipulates that according to international standards, the use of satellites approaching their end-of-life must be done in such a way that enough reserves of energy, fuel and functionality remain, as to enable the satellite a transfer to a graveyard orbit. Special attention is to be paid to the necessity of changing to a graveyard orbit, for the protection of other satellite systems in the Geostationary Orbit. Authorized users may be given operational orders for the implementation of international standards for avoidance of space debris. The German regulatory authority (*Bundesnetzagentur*) may issue adequate orders to users for the operation at the end-of-life time in order to enforce the international standards in specific situations.

As it can be seen, the German legislation on graveyard orbits does not directly require satellite owners and operators to move their satellites to a graveyard orbit upon exhaustion of the resources. However, the responsible regulatory authority is expressly authorized to issue orders for the enforcement of the (non-binding) international standards. The use of the words 'orders' and 'enforcement' indicates that the compliance with the IADC recommendations is for German owners/operators not just a mere voluntary measure[27].

3.2.1.3. The Effect of National Legislations on *Opinio Iuris*. These two national legislations have a direct (US) or indirect (Germany) binding force for satellite owners and operators. Both national legislations provide evidence about the acceptance of these States to implement at the national level the IADC measures for the protection of the Geostationary Orbit. Such legislations reflect the thoughts that, as Judge Sorensen expressed: "...it is characteristic of our time that new problems and circumstances incessantly arise and imperatively call for legal regulation"[28]. The *opinio iuris* of both States are based on the logic that if today no measures are taken in the proper disposal of geostationary satellites, such commercially valuable celestial belt may become useless.

3.2.2. State Declarations. *Opinio iuris* can also be inferred from the activities of the European Network of Centres on Space Debris that issued an 'European Code of Conduct for Space Debris Mitigation', which contains recommendations for satellite disposal in graveyard orbits. Such code of conduct has been already signed by the *Centre National d'Etudes Spatiales*, the space government agency of France[29]. Also JAXA, the space agency of Japan, has formulated its own code of conduct for space debris mitigation[30] and its current deorbiting practice shows that it is observing the IADC guidelines.

The introduction of compulsory regulations in the US and Germany and the declarations of other States in this respect, clearly reflects that there is an emerging *opinio iuris* in favor of the deorbiting geostationary satellites according to IADC measures. In addition to this emerging *opinio iuris*, the current practice clearly shows that international custom for the deorbiting of dying satellites in graveyard orbits is evolving in what may become a

customary norm, of compulsory observance for all members of the international community. In few words, it is clear the *opinio iuris* of this practice is that those States performing such practices agree that the Geostationary Orbit is a precious place, worth to invest resources (fuel and potential earnings) in order to keep it useful.

But before asserting if a new international custom is in the entrance door of the International Public Law, dissenting opinions on the deorbiting of geostationary satellites in graveyard orbits must also be observed.

3.3. Dissenting Positions?

In 1994 the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (hereinafter COPUOS) started to devote some attention to space debris, but no rules for the mitigation of space debris evolved. In the following years, IADC representatives developed bonds with COPUOS and information on up-dated space debris situation started to flow to this UN organ.

After the IADC Mitigation Guidelines were issued, a COPUOS Working Group on space debris dedicated its time to draft a text based on the IADC recommendations. Unfortunately, such efforts were degraded by the COPUOS representatives who stressed that if a document is adopted, such would not be legally binding under international law[31]. In 2005, the Working Group presented a report to COPUOS, which states that space debris mitigation practices remain "...voluntary and should be carried out through national mechanisms" and that the Guidelines "...would not be legally binding under international law"[32].

Following the perception in COPUOS that its work products are legally not binding, COPUOS members attempt to counteract the evolving *opinio iuris*. This is a sad aspect of COPUOS, an UN organ that was established for the development of International Space Law. Instead of establishing rules and standards, it tries to dilute emerging customary law.

The contradictory position of States represented in COPUOS and the same adhering to the IADC recommendations, can not be explained. On one hand, States start to create binding regulation at national level and declare at international level to observe the IADC recommendations, but on the other hand such States reject to be legally bound at international level. If States perform a practice but at the same time declare not to be legally bound by it, can we speak of this as an evolving rule of international customary law?

As aforementioned, for the *opinio iuris* of an international custom it is not necessary that States performing a practice only have the conviction of an obligation. They may also consider that such practice is useful, fair or of preventive character, among other considerations.

States taking a contrary position, elevating continuous protests against a practice that looks as if may be transformed into a customary rule, are known as 'persistent objectors'[33]. Such States can not stop the creation of a international customary norm, but may achieve that such norm does not apply to them when the time comes for the recognition as a norm with binding effects. In order to qualify as persistent objectors, States have the burden to present the evidence that they continuously opposed that practice through public declarations. In the present case, on satellite deorbiting

practices, States represented at COPUOS that insist that such practices are of no binding nature, so far have not raised protests and many of them even exercise such deorbiting practices. Those States do not qualify as 'persistent objectors'.

Even if in the framework of COPUOS States declare not to be ready for binding regulations on the disposal of geostationary satellites, in some years such declarations will be voided, if the practice of the same States and others increases. In this event, the deorbiting of geostationary satellites according to IADC recommendations will be elevated to a new norm of international customary law with binding effects.

CONCLUSIONS

To solve the problem of the growing congestion of the Geostationary Orbit with operational satellites and space debris, the IADC made technical recommendations for the mitigation of space debris. One of this recommendations deals with the deorbiting of geostationary satellites to graveyard orbits.

The State practice of satellite deorbiting according to these IADC recommendations that started in 1997, is increasing steadily since 2002. This practice demonstrates that the awareness of the protection of the Geostationary Orbit is growing among satellite owners and operators. Such awareness through practice, declarations and implementation of national legislations in some countries, are evidence of the presence of *opinio iuris*. With State practice and the additional *opinio iuris,* a new norm of international custom is in the process of formation.

But in this process, States are captured in a legal contradiction. On one side they perform a practice, implement national legislations and make public declarations to observe such practice, on the other side they declare not to be legally bound by such practice. As the time passes by, and more and more States, international organizations and private companies continue to properly deorbit satellites, a new norm of international custom will crystallize. In this instance, States declarations that the deorbiting of satellites in graveyard orbits according to IADC recommendations are not binding, will have no relevance.

Besides fuel amount considerations for safe arrival of the satellite to the nominal position, for station-keeping and for evasive maneuvers, owners and operators of geostationary satellites will compulsorily have to consider to reserve enough fuel for proper disposal maneuvers.

Once this new international customary rule has solidified, the status of the Geostationary Orbit will rise to a new category of legally protected area.

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1 Here the words 'owners and operators' are addressing governmental institutions, international organizations and private companies that own a satellite and also entities that are hired to operate a satellite.

2 Kelso T.S., Basics of the Geostationary Orbit, Satellite Times (2004), at www.celestrak.com/columns/v04n07.

3 Clarke Arthur, Extraterrestrial Relays, Wireless World, October (1945).

4 Jehn R. and Klinkrad H., Trends in Reorbiting of Geostationary Satellites, ISTS 2006-r-2-13. (2006).

5 Ib. at p. 4.

6 The Inter-Agency Space Debris Coordination Committee is a non-governmental organization comprising at the present the space agencies of China, France, Germany, India, Italy, Japan, Ukraine, United Kingdom,

4 Jehn R. & Klinkrad H., *Trends in Reorbiting of Geostationary Satellites*, ISTS 2006-r-2-13. (2006).
5 *Id.* at 4.
6 The Inter-Agency Space Debris Coordination Committee is a non-governmental organization comprising at the present the space agencies of China, France, Germany, India, Italy, Japan, Ukraine, United Kingdom, USA, Russian Federation, the European Space Agency and the Scientific and Technical Subcommittee of COPUOS. *Space Debris-Spotlight*, ESA, Mar. 31 (2005), at 3.
7 Jehn R. & Klinkrad H., supra note 4, at 1.
8 IADC guideline 7, directed to diminish the population of non-operational satellites in the Geostationary Orbit, states "spacecraft(s)...that have terminated their operational phases...should be left in orbits (graveyard orbits) that avoid their long-term interference with the Geostationary Region", Perek L., *Current Status of Mitigation Measures on Space Debris*, n. 32 ECSL News, May (2006), at 4.
The parameters of such graveyard orbits are calculated to take into consideration the satellite mass, its average cross-sectional area and the solar radiation pressure. Jehn & Klinkrad, supra note 4, at 1.
Graveyard orbits are between 245 and 435 km. above the geostationary ring. Robotic Geostationary Orbit Restorer, Final Report-Executive Summary, EADS Space Transportation, June 10 (2003), at 1.
9 The frequency has to be converted in order to avoid interference to the same transponder when the signal is sent to a terrestrial station.
10 Robotic Geostationary Orbit Restorer, supra note 8, at 1.
11 VERDROSS A. & SIMMA B., UNIVERSELLES VÖLKERRECHT 346 (3 Auf., 1984).
12 *Id.* at 361.
13 *Id.* at 356.
14 Jehn & Klinkrad, supra note 4, at 4.
15 Jehn & Klinkrad, supra note 4, at 4.
16 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, T.I.A.S. 6347, 610 U.N.T.S. 205 (effective Oct. 10, 1967).
17 Akehurst considers that State practice can be inferred from "...practice of international organizations and (in theory at least) by the practice of individuals". Akerhurst M., Custom as a Source of International Law (1974-75) BYBIL 53, cited after DIXON M. & MCCORQUODALE R., CASES AND MATERIALS ON INTERNATIONAL LAW 26 (2d. ed., 1995).
18 Judge Tanaka, dissenting opinion on the North Sea Continental Shelf Cases, I.C.J. Reports 1969, at 3, cited after in HARRIS D., CASES AND MATERIALS ON INTERNATIONAL LAW 35-36 (4th. ed., 1991).
19 Code of Federal Regulations, US Government Printing Office, cite 47CFR25.283, Title 47, vol. 2, Chapter I, § 25.102 Station authorization required (2004).
20 Jehn & Klinkrad, supra note 4, at 4.
21 De Selding, P., *FCC Enters Orbital Debris Debate,* Space News, June 28 (2004), *available at* www.space.com/spacenews.
22 *Id.*
23 The applicant shall inform if "...stored energy will be removed at spacecraft's end of life", e.g. releasing residual fuel, leaving fuel valves open, and leaving batteries in a permanent discharge modus. US 47 CFR § 25.114 (14), Applications for space station authorizations.
24 US 47 CFR § 25.114 (14) Applications for space station authorizations.
25 US 47 CFR § 25.283 End-of-life disposal .
26 *Verfahren zur Anmeldung von Satellitensystemen bei der Internationalen Fernmeldunion und Übertragung deutscher Orbit-und Frequenznutzungsrechte, Amtsblatt Reg. TP Nr. 6/2005,* Apr. 6 (2005), S. 239 ff.
27 *3.7. Betrieb am Ende der Lebensdauer: „Der Betrieb von Satelliten bis Ende der Lebensdauer ist so einzurichten, dass für Bahnmanöver zur Auserbetriebnahme (Decommissioning) gemäß internationalen Standards genügend Reserven (an Energie, Treibstoff und Funktionalität) verbleiben". Id.*
"Auf die Notwendigkeit, zum Schutz anderer Satellitensysteme vom geostationären Betriebsorbit auf eine sichere Friedhofsbahn zu wechseln...wird besonders hingewiesen". Id.
„Dem Nutzungsberechtigten können betriebliche Vorgaben zur Umsetzung von internationalen Standards zur Vermeidung von Weltraummüll (Space Debris) gemacht werden. Die Reg. TP kann dem Nutzer zum Betrieb am Ende der Lebensdauer in angemessenem Umfang Weisungen erteilen, um die vorgenannten internationales Standards konkret durchzusetzen".. Id.
28 Sorensen, dissenting Opinion on the North Sea Continental Shelf cases, quoted in. HARRIS, supra note 18, at 38.