

# SATELLITE SERVICING ON-ORBIT BY AUTOMATION AND ROBOTICS: LEGAL AND REGULATORY CONSIDERATIONS

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## I. INTRODUCTION

It has been contended that, "Historically, satellites are lasting longer than projected. If a fuel replenishing capability existed, satellites could remain in orbit even longer. On the other hand, satellites become 'outdated' soon after they have been placed into orbit because of rapid technological advances".<sup>1</sup> This underscores related activity where for instance, previous manned missions of the United States space shuttle dating back to 1984, demonstrated the possibility of retrieving the Westar 6 and Palapa B-2 satellites, or salvaging the Intelsat 603 in 1992. Activity of this kind re-invent a number of legal and regulatory issues in the debate borne from the revolutionary development and simultaneously increasing involvement of private entities in space activities, within the framework of international law, principles and regulations, as well as national laws, all applicable to space activity. This debate poses the fundamental question<sup>2</sup> whether the family of aforementioned international instruments adequately balance the various interests in outer space and space activities. The purpose of this paper is not to engage in this debate, or attempt to provide solutions to the current state of affairs. This paper will highlight the potential legal

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<sup>1</sup> Yoshito Y. Smith, *2025 Aerospace Replenishment: The Insidious Force Multiplier*, 2 AIR FORCE 2025 (USAF ed., 1996), at 25.

<sup>2</sup> Frans G. Von der Dunk, *Public Space and Private Enterprise - The Fitness of International Space Law Instruments for Private Space Activities*, 1999 PROCEEDINGS OF THE PROJECT 2001 - WORKSHOP ON LEGAL ISSUES OF PRIVATISING SPACE ACTIVITIES 12.

and regulatory considerations, which may arise from automated or robotic on-orbit servicing<sup>3</sup> (OOS) by private entities, of civilian and commercially oriented satellites, within the said framework.

## II. THE HYPOTHESIS

TABLE 1<sup>4</sup>

STATUS OF SATELLITE	ON-ORBIT SERVICE PROVIDED
End of Satellite mission lifetime due to fuel/propellant depletion. All systems operational.	Re-fuelling <i>in situ</i> to extend satellite mission lifetime.
Total or partial failure of satellite mission due to defective deployment of hardware.	Repair or replacement of failed/malfunctioning part.
Erroneous injection of satellite due to launch vehicle malfunction. Satellite in nominal condition.	Re-boost satellite to transfer/operational orbit.
Extension of satellite lifetime not worthwhile. Threat to other space assets and/or earth.	De-orbit satellite.

<sup>3</sup> It has been contended that 3 (three) distinctive classes of on-orbit services can be performed, *viz*: Motion; Manipulation; and Observation. These 3 (three) classes may further involve various specific services including: re-orbiting; de-orbiting; salvage; maintenance; repair; retrofit; docked inspection; and remote inspection. See J. Joerg Kreisel, *On-Orbit Servicing of Satellites (OOS): Its Potential Market Impact*, 1<sup>st</sup> BILATERAL DLR-CSA WORKSHOP ON ON-ORBIT SERVICING OF SPACE INFRASTRUCTURE ELEMENTS VIA AUTOMATION & ROBOTICS TECHNOLOGIES (2002).

<sup>4</sup> International Space University, *Open for Business: A New Approach to Commercialisation of the ISS*, 1999 Master of Space Studies, Design Project, 133.

## III. LEGAL AND REGULATORY CONSIDERATIONS

A. *Prior Authorization and Licensing*

The Outer Space Treaty of 1967<sup>5</sup> makes provision, in its Articles VI<sup>6</sup> and VII<sup>7</sup> respectively, for the responsibility and liability of States involved in space activities. Specifically, Article VI imposes responsibility on States Parties to the Treaty to ensure that any space activity carried out by government agencies or non-governmental entities is performed safely and in conformity with the Outer Space Treaty and existing regulations of that State. Space activities performed by non-governmental entities are also subject to continual supervision by that State Party. Consequently, in case OOS activities are conducted by private commercial entities, it would be the responsibility of a State(s) Party to the Treaty to ensure that any such activity is performed in compliance with the provisions of the Outer Space Treaty and, hence according to Article III<sup>8</sup>, with international law. Therefore before any OOS activity can take place, the

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<sup>5</sup> Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410 (entered into force Oct. 10, 1967).

<sup>6</sup> "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization." *Id.* at art. VI.

<sup>7</sup> "Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air or in outer space, including the moon and other celestial bodies." *Id.* at art. VII.

<sup>8</sup> "States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding." *Id.* at art. III.

commercial entity wishing to perform such operations would have to fulfil any Outer Space Treaty requirements as well as other requirements established by the State Party to the Outer Space Treaty responsible for the activities of that commercial entity. One writer<sup>9</sup> recommends that amongst the most important would be the receipt of prior authorization (also referred to as a license or permit<sup>10</sup>).

### *B. Liability and Risk Mitigation*

The hypothetical scenarios listed in Table 1 above presuppose that OOS, when construed in its simplest form, would give rise to a contractual relationship involving the provision (OOS service provider) of a service to an operator (customer) of a satellite in need of servicing. In other words, the relationship agreed upon would be governed by a service contract. As with any other commercial arrangement, the parties thereto should necessarily be able to, with a degree of certainty, predict, limit and insure against the burden of civil liability, which can result from the failure of the product or "negligence" in the services provided. This assertion can be further justified as contemporary business practice dictates that, persons or entities providing negligent services or participating in the placement of "defective products" in the stream of commerce become exposed to civil liability for damages which result from the services negligently performed, or from the product defect<sup>11</sup>. This form of liability is synonymous with "first party liability" which may be assumed by the OOS service provider with respect to damages suffered by the customer. Likewise, in the course of conducting servicing operations on-orbit, damages caused by the OOS service provider may result in "third party liability" for injuries suffered by owners of other spacecraft.

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<sup>9</sup> See Nandasiri Jasentuliyana, *Regulation of Space Salvage Operations: Possibilities for the Future*, 22 J. SPACE L. 5, 5-21 (1994).

<sup>10</sup> See PAMELA L. MEREDITH & GEORGE S. ROBINSON, *SPACE LAW: A CASE STUDY FOR THE PRACTITIONER - IMPLEMENTING A TELECOMMUNICATIONS SATELLITE BUSINESS CONCEPT*, 42 (Martinus Nijhoff Pub., 1992).

<sup>11</sup> Mariagrazia Spada, *Quality Control in Production of Space Objects and Liability in Outer Space Law*, in *OUTLOOK ON SPACE LAW OVER THE NEXT 30 YEARS 191, 191-99* (Gabriel Lafferranderie, & Daphne Crowther, eds., 1997).

The risks of damage and liability are traditionally allocated contractually, or otherwise to all the parties involved in the transaction. To date, the commercial space industry has developed innovative practices in managing these risks<sup>12</sup> (usually in the form of tightly worded contracts and insurance cover) albeit within the framework of the Liability Convention of 1972<sup>13</sup>. The provisions of that Convention impose international liability on States involved in the launching of an object into outer space which causes damage on earth, in air, or in outer space, caused by an object launched into outer space from the territory of that State<sup>14</sup>. Liability in this form will also embrace third party damage caused by space objects launched on behalf of commercial entities that have been authorized or licensed by States Parties to the Treaty. Amongst other things, innovation will be a key element in the contractual terms and conditions to be agreed upon in contracts for the provision of OOS services, alongside the possible inclusion of potential OOS's within existing on-orbit insurance policies<sup>15</sup>.

### C. Dispute Settlement

It has been contended<sup>16</sup> that although the Outer Space Treaty in its Article IX does not provide much guidance on the question of how States should settle disputes concerning the application of the Treaty, the Liability Convention does indeed contain some provisions on dispute settlement. Consequently, if no settlement of a claim is arrived at through diplomatic negotiations as provided for in Article XI of the Liability Convention

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<sup>12</sup> MEREDITH & ROBINSON, *supra* note 10 at 249-302, 335-36.

<sup>13</sup> Convention on International Liability for Damage Caused by Space Objects, opened for signature Mar. 29 1972, 24 U.S.T. 2389.

<sup>14</sup> *Id.* at arts. II and III.

<sup>15</sup> In-Orbit Insurance commences after a satellite reaches orbit, completes the initial functionality testing, and actual operation begins. The life expectancy of a satellite is approximately 10 years and ends when the satellite's fuel cell depletes. In-Orbit Coverage protects against the risk of a complete or partial failure of the satellite while operating in space. The owner or operator of the satellite is the insured, and the cover is usually a 1-year renewable policy.

<sup>16</sup> Karl-Heinz Bockstiegel, *The Settlement of Disputes Regarding Space Activities After 30 years of the Outer Space Treaty*, in *OUTLOOK ON SPACE LAW OVER THE NEXT 30 YEARS* 237, 237-49 (Gabriel Lafferranderie, & Daphne Crowther, eds., 1997).

at the request of either party, a Claims Commission (CC) has to be established. Articles XV to XVII deal with the details of the appointment and the procedure of this CC in a similar way, as it is known from international arbitration. Article XVIII provides that the CC shall decide the merits of the claims for compensation and determine the amount of compensation payable, if any. The decision remains binding only if both parties agree. Bearing the above in mind, it has further been argued<sup>17</sup> that in a relative perspective, dispute settlement plays a greater role for private enterprises than for State institutions, because private enterprises do not have available diplomatic and political means and because private enterprises rely much on calculating the exposure to costs and risks on the fulfilment of contractual obligations and, if necessary, on the enforcement for the other party to fulfil the contract or pay damages. Thus the basic option available to private enterprises (and impliedly, entities wishing to conduct OOS activity) is that between adjudication by State courts and arbitration. While adjudication by courts is available without any specific agreement between the parties, arbitration is only mandatory if chosen by the parties in an arbitration agreement or in an arbitration clause in the contract.

#### *D. Protection of Intellectual Property Rights<sup>18</sup>*

Intellectual Property Rights (IPR), defined within the provisions of Article 2 of the Convention establishing the World Intellectual Property Organisation<sup>19</sup>, include,

the rights relating to: literary, artistic and scientific works; performances of performing artists, phonograms, and broadcasts; inventions in all fields of human endeavour; scientific discoveries; industrial designs; trademarks, service marks, and commercial names and designations; protection against unfair

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<sup>17</sup> *Id.*

<sup>18</sup> See Albert Tramposch, *International Aspects of Protection of Inventions Made or Used in Outer Space*, in PROCEEDINGS OF THE WORKSHOP - INTELLECTUAL PROPERTY RIGHTS AND SPACE ACTIVITIES A WORLDWIDE PERSPECTIVE 187, 187-97 [hereinafter Tramposch].

<sup>19</sup> Convention Establishing the World Intellectual Property Organisation, July 14, 1967, 828 U.N.T.S. 3 (amended on September 28, 1979).

competition; and all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields.

An IPR is the right to forbid third party exploitation, or to allow the exploitation by license on terms dictated by the registered IPR owner or his/her designated successor. The filed instruments, such as the claims of a patent, define the scope of IPR protection. The geographical scope of the protection is that of the territory of the State, which has registered the IPR. IPR's have limited lifetimes (e.g. twenty years after the filing date for patents) and possess the dual nature of being both national and international.

In the international context, a patent may not be granted on an invention which had been previously disclosed (perhaps by publication) anywhere in the world. Moreover, a single patent application filed in one country may obtain patents in many countries under certain international treaties and conventions. This dual nature of patent protection, is nowhere more apparent than in the area of protecting inventions made or used in outer space, bearing in mind the fact that an act of invention is made up of two parts *viz*: (1) the complete idea of how to solve the problem; and (2) the building of a working model that actually carries out the solution. Particular problems and questions would arise for inventions made or used in outer space especially because they must be posed within the scope of the two major systems for the protection of IPR's worldwide, traditionally referred to as the "first to file"<sup>20</sup> and "first to invent"<sup>21</sup> systems<sup>22</sup>. For instance there may not be the presumption that a space experiment, designed and tested successfully on the ground will work exactly as expected in space. Thus under the "first to invent" system, in the context of OOS related activity, in the event that specific OOS hardware and procedures work or perform as expected in space, would such hardware and procedures be considered as inventions made in space, or were they

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<sup>20</sup> Under this system, the invention belongs to the first inventor who files a patent application, irrespective of the time or place of invention.

<sup>21</sup> Under this system, the time and place of invention are critical.

<sup>22</sup> See generally Tramosch, *supra* note 18, at 187-97 (giving a detailed comparison of the "first to file" and "first to invent" systems).

completed inventions when they were successfully tested on the ground.

*E. Compliance with Debris mitigation Standards and Regulations<sup>23</sup>*

On the issue of compliance with debris mitigation standards and regulations, the hypothesis stated in Table 1, confronts one with an international debate currently taking place within an embryonic international legal and regulatory framework. On the one hand, OOS activity desirous of extending the lifetime of satellites would probably serve to reduce the number of derelict or abandoned spacecraft in orbit. Conversely, in the event that such activity is geared at de-orbiting a satellite, with the attendant possibility of creating debris, capable of causing damage to third parties in outer space or on the surface of the earth, a private entity wishing to engage in commercial OOS related activity would necessarily need to consider, and perhaps comply (as applicable) with the international legal and regulatory obligations<sup>24</sup> placed upon the State that authorizes, licenses or permits it to conduct such activity.

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<sup>23</sup> See Tare Brisibe & I. Pessoa-Lopes, *The Impact of Orbital Debris on Commercial Space Systems*, PROCEEDINGS OF THE 44TH COLLOQUIUM OF THE INTERNATIONAL INSTITUTE FOR SPACE LAW, 52<sup>nd</sup> IAF Congress (2001).

<sup>24</sup> In practice, applicable regulations, policies and standards have evolved in a heterogeneous fashion, giving rise to a patchwork of national and intergovernmental rules. Of note are the national regulations, policies and standards of: (i) the United States ("U.S."). U.S. Government Orbital Debris Mitigation Standard practices (1997), aimed at limiting orbital debris generation by launch vehicle upper stages. The standards are applicable to U.S. Orbital stages (Athena, BA-2, Centaur, Delta, Boeing Inertial, Minotaur, Pegasus, Taurus and Titan). They were also applied to the re-entry of the Compton Gamma Ray Observatory on 4<sup>th</sup> June 2000; (ii) The Federal Republic of Russia (Russia). See the Russian Federation Law on Space Activity (1993) (RF); (iii) The member States of the European Space Agency (ESA). See the Resolution for a European Policy on the Protection of the space environment from Debris. Adopted by the Council of the ESA on 20 December 2000 (ESA Resolution); and the Draft European Space Debris Safety and Mitigation Standard; (iv) see the non-binding Draft International Instrument on the Protection of the Environment from Damage Caused by Space Debris at <http://www.uni-koeln.de/jur-fak/instluft/draft3.html>.

*F. Efficient use of the geostationary orbit and frequency spectrum*

OOS envisages the lengthening of the operational lifetime of satellites in orbit. Though there are several orbits from where a satellite system can operate, the geostationary satellite orbit (GSO) is the most used orbit. Furthermore, satellites rely on radio frequencies (radio waves), the use of which is regulated by the International Telecommunications Union (ITU). It must be noted that the GSO and radio frequency spectrum have always been regarded as a limited natural resource. Therefore the conduct of OOS activity will necessarily require adherence, by any licensed or authorized private entity, with the general legal principles applicable to international management of radio frequencies and the GSO positions as set forth in the provisions of Article 44, paragraph 2 (formerly Article 33 paragraph 2) of the 1994 ITU Constitution as amended by the 1998 ITU Plenipotentiary Conference.

That Article specifies,

In using frequency bands for radio services, Member States shall bear in mind that radio frequencies and any associated orbits, including the geostationary-satellite orbit, are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulations, so that countries or groups of countries may have equitable access to those orbits and frequencies taking into account the special needs of the developing countries and the geographical situation of particular countries.

It has been stated<sup>25</sup> that though Article 44(2) emphasizes the obligation to use the spectrum/orbit resource “efficiently” and “economically”, it does not define the said terms. Consequently, it is left to the discretion of each ITU Member State to interpret what is efficient and economic. This discretion will most certainly apply and would require careful consideration

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<sup>25</sup> Ram Jakhu, & Virginia Serrano, *International Regulation of Radio Frequencies for Space Services*, PROCEEDINGS OF THE PROJECT 2001 WORKSHOP ON TELECOMMUNICATION 72 (2000).

when taking steps to embark on commercially oriented OOS related activity.

#### IV. CONCLUSION

The successful deployment of any commercial space project does not depend solely on the technical capability of the system and the attractiveness of the commercial proposal. Therefore, servicing satellites on-orbit by robotic and/or automated means would also need to address a number of complex but not necessarily insurmountable legal and regulatory considerations. The provision of legal opinions, performance of legal and regulatory audits, appropriate insurance cover, cumulated with an aggressive public policy involvement strategy, may bring solutions.