COLLISION COURSE: 2009 IRIDIUM-COSMOS CRASH

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On 10 February 2009, there was an orbit collision between the operational U.S. Iridium-33 satellite and the non-functional Russian Cosmos-2251 satellite. This event created new space debris that will persist for many decades. Satellites, including other satellites of the Iridium constellation, are subject to an increased collision risk. This article presents facts, political positions and analyzes this event under existing space law. It also takes a look at the liability implications and an evolving standard of care for the mitigation of space debris.

1. INTRODUCTION

The pollution of Earth's valuable orbits with space debris[1] in outer space has enlarged the collision risk among space objects. Space debris mitigation guidelines have been created to prevent an increase. Although several space actors have adopted codes of conduct and even national legislation, there is still lack of universal binding rules to mitigate space debris. Recent events, like the Iridium-Cosmos collision[2] and the Chinese and U.S. anti-satellite tests drew attention to the need of an international network of space surveillance systems for better conjunction assessments (i.e. assessments of close approaches between space objects).

The international availability of precise conjunction assessments may lead to common practices and a standard of care for avoiding collisions. The question arises, if this standard of care to avoid liability may become another incentive for establishing a conduct of space operators and space faring nations in regard to space debris mitigation.

This article outlines some of the regulatory efforts to mitigate space debris, addresses causation and fault under the Liability Convention and discusses the elements of awareness and reasonable action under the circumstances of today's congested orbits.

2. INTERNATIONAL REGULATORY EFFORTS TO MITIGATE SPACE DEBRIS

Space law making by UN COPUOS has substantially slowed down since the 1980s. Thus it was not surprising that UN COPUOS did not draft rules on the mitigation of space debris. As a result, researchers of several space agencies met in 1993 and established the Inter-Agency Space Debris Committee (IADC), with the concern that an increasing space debris population posses a high risk for space activities.

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Following earlier recommendations, in 2002 a set of mitigation guidelines was adopted[3].

IADC members who have been involved in the drafting of the mitigation guidelines had to wait several years before the international community started to pay attention to the growing threat of space debris and the measures for mitigation.

The Iridium-Cosmos crash and the Chinese and U.S. anti-satellite tests have highlighted the importance of the mitigation guidelines.

So far, two national legislations already make the mitigation guidelines compulsory for non-governmental satellite owners/operators[4]: the U.S. and Germany[5].

There are several national codes of conduct for mitigation of space debris[6].

There is also the European Code of Conduct[7], which emphasizes the IADC mitigation guidelines through references in contracts with satellite and upper-stage integrators, inside and outside Europe[8].

The International Standardization Organization is working on the adoption of standards for the mitigation of space debris. Two of these standards will be published this year[9].

The European Union (EU) also started the process to adopt a code of conduct on space activities where space debris mitigation guidelines are included. The current draft may be adopted by 25 EU member States in some years from now[10].

Although UN COPUOS members have been reluctant to enact the mitigation guidelines as an international treaty with binding force, these guidelines were endorsed as a UN General Assembly resolution in 2007[11].

Most of these efforts to mitigate space debris are formally non-binding recommendations. But the wide spectrum of public and private institutions for the adoption of such mitigation guidelines shows that there is a growing genuine international consensus to achieve common and uniform practices.

3. Liability Avoidance as an Incentive for Space Debris Mitigation

The effects of space debris also need to be examined from the liability perspective.

Liability for space activities is governed by the Liability Convention[12], a treaty with binding force to hold States liable and to create responsibility to compensate in case of damage to space objects in outer space.

Liability for damage arises, when several conditions are met. Article III of the Liability Convention states:

> "In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible"[13].

Damage is the pre-requisite that establishes a legal link between the involved parties, even if they were not contractually related at all before the casualty (third party liability). This damage encompasses physical damage to satellite bodies through kinetic energy, as well as electromagnetic damage (e.g. by laser beams).

Article 1 (1) of the Liability Convention includes as 'space objects' not only intact spacecraft, but also:

> '...component parts of a space object as well as its launch vehicle and parts thereof'[14].

The preparatory works of the Liability Convention indicate that damage was conceived to relate only to operational space objects[15]. The drafters of the Liability Convention neither considered damage to the Earth's orbital environment. But this does not necessarily mean that the Liability Convention does not apply in case of damage caused by space debris. While the population of space debris was growing during the last decades, space participants may not have felt that they could be held liable, because they did not imagine that the origin of space debris could be tracked and identified. This perception has strongly contributed to the current pollution of valuable orbits.

There is no liability under the Liability Convention for the fact of creating space debris, as long as no (other) operational space object is damaged. But States continue to be liable for the damage caused by the space debris of their space objects, as if the damage were caused by the original space object itself, provided all requirements of the Liability Convention are met.

In the case of the Iridium–Cosmos collision, there is no causation of damage to the Cosmos-2251 satellite. Cosmos-2251 was at the time of impact already non-functional and thus space debris without any value.

4. Causation and Fault

The second sentence of Article III of the Liability Convention requires fault for liability in case of damage of (another) space object.

As Cheng already commented[16], fault must be accompanied by a causal connection between such fault and the resulting damage. When may a State be held to have acted with fault? So far, no case on damage due to collision among two operational satellites has occurred. The concept of damage being caused by 'fault' under the Liability Convention was never tested.

It is unlikely that a space object's owner/operator would voluntary accept its fault or would openly display the string of particulars that caused damage due to its fault. The lack of international legally binding space traffic rules makes it difficult to prove the fault of the owner/operator of a space object.

In the Corfu Channel Case, the International Court of Justice (ICJ) confirmed the importance of facts that help to understand the causation of a given event:

> "...the fact of this exclusive...control... has a bearing upon the methods of proof available to establish the knowledge of that State as to such events. By reason of this exclusive control, the other State, the victim of a breach of international law, is often unable to furnish direct proof of the facts giving rise to responsibility. Such a State should be allowed a more liberal recourse of inferences of fact and circumstantial evidence. The indirect evidence is admitted in all systems of law and its use is recognized by international decisions. It must be regarded as of special weight when it is based on a series of facts linked together and leading logically to a single conclusion"[17].

Today, in many instances damage by space debris can be tracked to the originally launched space object. Evidence of causation of damage by the operator of the original space object does not any longer appear to be a problem. Information on positions of space objects and debris are provided by space surveillance systems, among them the 'Space Surveillance Network' of the U.S. Air Force. Most

surveillance information is introduced into satellite catalogues. Based on satellite catalogues, not only functional space objects but also space debris can be tracked and the owner/operator of the original space object be identified[18]. After identification of the owner/ operator, it must be determined if he acted with fault in regard to damage caused to another space object.

5. Standard of Care

In case of damage by space debris, fault of the space operator needs to be proved, typically in the form of negligence. Negligence is rooted in the failure to use due care in a given situation.

The concept of 'care' denotes the watchful attention and caution that "...a person of ordinary prudence and reason would exercise under given circumstances"[19]. Standards of care may be established by practice among members of a community that exercise a similar activity. These may also be established with binding force through national or international legislations[20] (e.g. treaties, customary law). The degree of care denotes a spectrum of possibilities of steps to take: to be informed on the circumstances, to consider the available resources and the efficacy of an action, a timely decision to take action, to act in a skilful way, etc.

There is ample jurisprudence on the required level of care. As an example of national case law regarding the due care of maritime traffic navigating in a congested harbor, may serve a case of the U.S. Supreme Court in 1871:

In 1866, the vessel *Java* had an inevitable collision with another vessel in a U.S. crowded harbor. The U.S. Supreme Court decided that the Java "...was only bound to use that degree of care and precaution which the particular circumstances of the case demanded..." and considered that there was not "...the slightest evidence that in this regard anything was wanting, or that there was any lack of skill or vigilance on the part of the pilot and crew of the *Java*"[21].

This case highlights that due care is an important pre-requisite in performing risky activities in a crowded environment.

But, at present, in outer space it is difficult to determine the exact standard or level of care required to meet the requirements of due care in a given situation, for example when operating a satellite in a congested low Earth orbit. The increasing congestion of man-made space objects around our planet is raising the risk of collision. But what is the degree of care that a satellite owner/operator shall take in order to avoid liability?

The concept of care consists of two main elements, awareness and the possibility to undertake reasonable action. Was the operator or owner in the given circumstance aware, or could he have been aware, of the risk and were there measures he could reasonably have undertaken to avoid the damage? This approach is not only dependent on the specific situation, but also on the development of awareness systems, timely availability of conjunction information and the possibility to initiate a course correction.

6. The Element of Awareness

To exercise due care, the space object owner/operator must have been timely aware of the potential collision. How can satellite owners/operators get the relevant orbital data, so-called conjunction information, of other space objects on collision course?

For a considerable time, the U.S. Air Force used to provide to the public for free

a low precision version of its catalogue of identified space objects tracked by its 'Space Surveillance Network'. This catalogue serves to assess space objects conjunctions situations[22]. In specific cases, satellite owners/operators could request the U.S. Air Force to check in the high accuracy database for an increased collision probability, necessary for decision-making on satellite evasive maneuvers[23].

How does this work in practice? Let's have a closer look at the situation around the time of the Iridium-Cosmos crash.

The Air Force granted Iridium LLC[24] access to its low quality catalogue. Iridium had also the possibility to request the Air Force for high accuracy information for specific conjunctions. It is not clear if Iridium fully took advantage of such information. Iridium used to get hundreds of conjunctions each week for its satellite fleet, but complained that conjunctions information was not reliable enough[25]. It is not known if Iridium stopped at some point to discuss and verify with the Air Force dangerous satellite close approaches[26].

Right after the Iridium-Cosmos collision, researchers consulted the specific Iridium-33 data and found that this spacecraft had 13 conjunctions and, for the specific moment of the collision, there was a prediction of an encounter as close as 600 meters with the Cosmos-2251 spacecraft[27]. The U.S. Air Force data "...suggested that the likelihood of a collision between the Iridium and Cosmos satellites was 1 in 10,000"[28]. A specialist of the French space agency indicated that a warning with such a probability requires a more-detailed analysis, if to initiate action[29]. However, Iridium's spokeswoman Lis DeCastro said "Iridium didn't have information prior to the collision to know that the collision will occur..." and that "...if the organizations that monitor space had that information available, we are confident they would have shared it with us"[30]. The question is left open, if Iridium could have reasonably known the threat.

But there is another important factor. The awareness of the launching State is decisive, because only States are party to and liable under the Liability Convention. Even if a private entity, licensed and supervised by the launching State, has no awareness of an imminent collision risk, the launching State can be held liable, if it has the awareness. An insufficient information flow between the launching State and its licensee has no effect on the claim for third party liability under the Liability Convention.

After the Iridium-Cosmos crash, the U.S. started a new procedure to provide more reliable and accurate data to civilian users. Since then, the U.S. Air Force created a Commercial and Foreign Entities (CFE) program that updates the procedures for getting access to this data[31]. U.S. private satellite owners/operators who want to take advantage of this system need to go through this process. Besides access to space surveillance data, there will be also conjunction assessment[32] support, as the satellites of each company will be daily screened by the U.S. military. The commercial entities, as customers, may also provide information such as ephemeris and planned maneuvers[33]. Nevertheless, the U.S. Government does not accept any responsibility on the commercial entities decision-making when "...determining and implementing courses of action to avoid on-orbit collisions"[34]. The Government, as service provider, only agrees "...to make best efforts to supply Customer the Data and Services submitted on a CFE Space Support Request Form"[35] and "Provider and Customer provide the

Data and Services 'as is' and neither makes any warranty, either express or implied, as to the condition or suitability of the Data and Services, nor its fitness for a particular purpose"[36].

At present, there are approximately 10 private companies who are part of the new CFE procedures, including Iridium[37]. The disclosure of information by the military to U.S. and foreign entities is also result of the tendency of the U.S. military to diminish military satellites by increasing the use of transponders on commercial satellites[38] and of remote sensing images, not only from national, but also from foreign systems[39].

Under the present circumstances, better sources of information on conjunctions have only sense if they can be used by satellite owners/operators. The surveillance and conjunction assessment capacity of the U.S. military may expand by networking with other institutions already giving conjunctions assessment to private and government satellite owners/operators, inside and outside the U.S.[40]. This could lead to an international global conjunction analysis for all satellites[41] and create a truly global Space Situational Awareness (SSA) system, with all satellite owners/ operators participating.

Being part of such a SSA network should also require satellite owners/ operators to provide orbital parameters and positions of (their) satellites and verify conjunction warnings. It is possible, that in the future governments may demand owners/operators running satellites under their national licenses to be part of the SSA network. With such a licensing obligation they would not only get access to the information, but also be deemed to have known all available conjunctions information.

Creating an internationally networked space situational awareness system, directed to assist proper decision-making for satellite evasive maneuvers, may then also become an indicator that the space community is establishing a 'duty to be informed' by the SSA system as a minimum standard of care for satellite owners/operators.

The current level of awareness derived from existing surveillance systems allows already assessments and accident investigations. Starting this year, the operational performance of the satellite owner and operator and other information providers will be under intense international scrutiny. Should a next satellite collision occur, satellite owners/operators may already be deemed to have known the conjunction information available under the U.S. CFE program.

7. The Element of Reasonable Action

The exercise of due care requires not only awareness, but also the possibility to undertake reasonable measures in the given circumstances to avoid the damage.

Evasive maneuvers are the most plausible action to avoid a collision in orbit. Currently, there is no rule to require such a maneuver. The only driver of such a step is "...a cost-benefit decision that each operator needs to make based on what their level of risk is"[42]. Liability risks have the potential of changing this equation. Nevertheless, the IADC has established a (non-binding) recommendation on such reasonable action:

> "Guideline 3: Limit the Probability of Accidental Collision in Orbit.
>
> In developing the design and mission profile of spacecraft and launch vehicle stages, the probability of accidental collision with known objects during the system's launch phase and orbital lifetime

should be estimated and limited. If available orbital data indicate a potential collision, adjustment of the launch time or an on-orbit avoidance maneuver should be considered"[43].

No doubt, owners/operators of non-maneuverable operational or malfunctioned space objects or of de-commissioned space objects (which have exhausted their fuel), cannot undertake such evasive maneuvers. In this instance, the owner/operator seem to have no choice.

A different light is shed on this situation, if the owner/operator earlier had a choice to reduce the probability of a collision by re-orbiting or de-orbiting the space object before it reached its end-of-life, but decided not so. In the U.S. this is partly already required under domestic law[44]. This U.S. statute applies only to geostationary satellites launched after 18 March 2002[45]. Unfortunately, it covers neither geostationary satellites launched before that deadline, nor low Earth orbit satellites, like those of Iridium.

Nevertheless, the growing practice[46] of satellite owners/operators to keep low Earth orbits useful, by investing resources (fuel and potential earnings) for the removal of satellites approaching end-of-life, may set a standard of care among space participants. Non compliance with such standard of care may be treated as negligence when it results in damage to an operational space object.

CONCLUSIONS

Due to increasingly congested valuable orbits, there is an urgent need to establish binding rules on the mitigation of space debris and the avoidance of on-orbit collisions. The space debris mitigation guidelines of the IADC were a big step forward. Unfortunately, they are not legally binding – although there are indications that space participants follow the guidelines and a common practice is emerging.

This paper has tackled the problem from a different angle: The avoidance of liability as an incentive to prevent on-orbit collisions and the creation of space debris. The technical development of systems for tracking functional and non-functional space objects can play a key role in providing evidence for the identification and causation of orbital collisions. Additionally space participants gain more situational awareness about the traffic situation in orbit with sufficient lead time for potential reactions. It is exactly this awareness of the space participants, which is a requirement for their exercise of due care in the conduct of their space activities. Once they have the knowledge about a potential collision, they cannot disregard it any longer. Making space surveillance data and conjunction information accessible to space participants, creates their (legal) awareness, which is an element of due care. Acting without due care, makes them negligent and thus liable, if this conduct causes damage.

But that is not the entire story, when we speak about liability in space law. International liability under the Liability Convention (and of course Outer Space Treaty art. VII[47]) relates to States. Consequently, it is sufficient that the (launching) State is aware of the collision threat. States, whose authorities are involved in the networking of space situational awareness data, can be deemed to have had the awareness.

The liability assessment of the Iridium–Cosmos collision remains diffuse. The destruction of the Cosmos-2251 satellite was not a compensable damage under the

Liability Convention, because it was decommissioned and without value. Regardless thereof, it is unclear, what Iridium LLC knew or could have known in advance of the crash. But the U.S. Government must have been aware of the critical conjunction information. On the Russian side the level of awareness is uncertain.

At the bottom line, the technical developments in the field of space situational awareness and the increasing cooperation and networking of orbital data and conjunction information, raises the awareness of space participants and their standard of care for space activities.

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1 According to the Inter-Agency Space Debris Committee (IADC), 'space debris' are '...all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional'. UN Doc. A/AC.105/C.1/L.260, 29 Nov. 2002, 3.1. Space Debris.

2 After the impact, two clouds of space debris were created that will merge with the existing space debris in low Earth orbits. Wiedemann C., Flegel S., Vörsmann P., Zwei Satelliten kollidieren, *Sterne und Weltraum*, April (2009), p. 1.

Iridium-33 was launched from the Russian Baikonur Cosmodrome, on 14 September 1997. The United States have ratified the Outer Space Treaty (OST). OST art. VI provides that States are responsible for national activities in outer space "...carried by governmental agencies or by non-governmental entities...and international organizations". Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 27 Jan. 1967, 18 U.S.T. 2410, T.I.A.S. 6347, 610 U.N.T.S. 205 (effective 10 Oct. 1967). As the U.S. licenses and supervises the space activities of Iridium Limited Liability Company (LLC), its activities can be attributed to be the practice of the U.S. under the OST art. VI. Also, as the U.S., through Iridium LLC, procured the launching of Iridium-33, the U.S. is the 'launching State' under Liability Convention art. I. Convention on International Liability for Damage Caused by Space Objects (liability Convention), 29 March 1972, 24 U.S.T. 2389, T.I.A.S. 7762, 961 U.N.T.S. 187 (effective 9 Oct. 1973). As for Jan. 2009, 87 States have ratified this Treaty, where space faring States are included. UN Doc. A/AC.105/935 (2009).

The Russian Cosmos-2251 was launched in June 1993 from the Plesetsk Cosmodrome and became non-operational in 1995. Harwood W., Two satellites collide in orbit, <www.spaceflight.com/news>, 11 Feb. (2009) and <www.tbs-satellite.com/tse/online/sat_cosmos_2251.html> (last visited: Sep.2009).

3 UN Doc. A/AC.105/C.1/L.260, *supra* n. 1.

4 Here the words 'owners/operators' address governmental institutions, international organizations and private companies who own a satellite and also entities who are hired to operate a satellite.

5 Code of Federal Regulations, U.S. Government Printing Office, Title 47-Telecommunications (US 47CFR), Sec. 25.283, End-of-life disposal (as of Sep. 10, 2009).

Verfahren zur Anmeldung von Satellitensystemen bei der Internationalen Fernmeldeunion und Übertragung deutscher Orbit-und Frequenznutzungsrechte, Amtsblatt Reg. TP Nr. 6/2005, 6 April (2005), p. 239 et seq.

6 Mejía-Kaiser, Martha. 'Informal Regulations and Practices in the Field of Space Debris Mitigation'. *Air and Space Law* 34, no. 1 (2009): 21-34.

7 The European Code of Conduct for Space Debris Mitigation was developed in

cooperation amongst the space agencies of Italy, France, Germany, the UK and the European Space Agency. European Code of Conduct for Space Debris Mitigation, Issue 1.0, 28 June (2004).

8 *Ibid,* 2.2. Applicability.

9 Ailor, W., Director, Center for Orbital and Re-entry Debris Studies, The Aerospace Corporation. Personal communication, May 9 (2009). Mejía, *supra* n. 6, p. 26.

10 Council conclusions and draft Code of Conduct for outer space activities, Council of the European Union, 1175/08, 17 December (2008).

11 UNGA Res. 62/217, 10 January (2008), see also Report of the Committee on the Peaceful Uses of Outer Space, Official Records of the General Assembly, 62nd Session, Supplement No. 20 (A/A/62/20), (2007), paras 117-128. The IADC Guidelines are in this document's annex.

12 Liability Convention, *supra* n. 2.

13 Liability Convention, *supra* n. 2, art. III.

14 Liability Convention, *supra* n. 2. art. III.

15 Jasentuliyana N. & Lee R., *Manual on Space Law*, (New York: Oceana, 1981), v. III, p. 209 et seq.

16 *Ibid*, p. 119.

17 In the Corfu Channel Case (UK v Albania), the ICJ held Albania responsible of damage to military British ships in an international stretch, within Albanian territorial sea, for failing to exercise due care over its sea mines and to inform the British ship about them. Albania denied knowledge of the mine laying. Corfu Channel Case (UK v Albania) (Merits), ICJ Rep 1949 4, reproduced in Dixon M. & McCorquodale R., *Cases and Materials in International Law*, 4th edn. (Oxford, 2003), p. 411.

18 The U.S. Air Force catalogue data includes the launching States of identified space debris. The unidentified space debris are not entered into this catalogue (several thousands). Weeden, B., The Numbers Game, <www.thespacereview.com/article/1417/1>, 13 July (2009), p. 13.

19 Gifis, S., Dictionary of Legal Terms, (New York: Barron's, 1983), p.144.

20 "In order to make the principle of...due diligence, more concrete and predictable, States have in many instances agreed on certain international minimum standards, sometimes on a very detailed level. By living up these...standards, States can be certain they are fulfilling the requirement of diligent conduct". Viikari, L., *The Environmental Element in Space Law*, Studies in Space Law, (Leiden: Martinus Nijoff, 2008) v. 3, p. 165.

21 Mr. Justice Bradley, delivering the opinion of the U.S. Supreme Court, The Java, 81 U.S. (14 Wall.) 189 (1871).

22 Kaiser, Stefan, Space Situational Awareness: Key to a new Space Security Architecture, *Proc. 52nd Colloquium on the Law of Outer Space*, Daejeon (2009).

23 Weeden, B., Billiards in Space, part 2, p. 2, <www.thespacereview.com/article/1314/2> 23 Feb. (2009) and De Selding, P., Satellite Collision Avoidance Methods Questioned After Space Crash, Space News, 27 February 2009 <www.space.com/news/090227-space-collision-questions.html> 27 Feb. (2009).

24 Iridium LLC is a U.S. private entity who owns 66 satellites and in-orbit spares in a near-polar orbit at an altitude of 780 km. "The 66 active satellites fly in formation in six orbital planes, evenly spaced around the planet, each with 11 satellites equally spaced apart from each other in that orbital plane" <www.iridium.com> (last visited, Sep. 2009).

25 John Campbell, Iridium's executive Vice-president, commented in 2007: "Even if we had a report of an impeding direct collision, the error would be such that we might maneuver into a collision as well as move away from one". Wolf, J., Iridium says in dark before orbital crash,

<www.reuters.com>, 12 Feb. (2009).

26 A conjunctions analyst affirms that the military "...terminated the collision screening for the Iridium constellation at some point between July 2007 and the collision in February 2009..." Weeden, Billiards...part 2, p. 2, *supra* n. 23.

27 Weeden, B., Presentation at the International Interdisciplinary Congress on Space Debris, Montreal, 7-9 May (2009).

28 De Selding, *supra* n. 23. For a better understanding of conjunction information, Weeden explains that NASA has defined a warning box for the International Space Station of "...5 km by 25 km by 5 km...in which corresponds to a probability of collision of 1 in 100,000. The box within which evasive maneuvers will be considered is 2 km by 5 km by 2 km. These boxes are different from those NASA applies to unmanned scientific payloads...". Weeden, B., Billiards in Space, part 1, p. 6 <www.thespacereview.com/article/1314/1> 23 Feb. (2009).

29 Statement of Monique Moury, of the operational flight dynamics directorate at CNES. De Selding, *supra* n. 23.

30 Wolf, *supra* n. 25.

31 Commercial and Foreign Entities legal Agreement (CFE Legal Agreement), available at <http://www.space-track.org/orbitaldatarequestprocess.html> (last visited: Sep. 2009).

32 "'Conjunction assessment' is the process of determining and reporting the close approaches between orbiting objects or between launch vehicles and orbiting objects. Close approach information can include miss distance related information and/or a probability of collision metric. Conjunction assessment is not the process of determining and implementing courses of action to avoid on-orbit collisions". CFE legal Agreement, Section II: Definitions, 2.2., *ibid.*

33 CFE legal Agreement, Section II: Definitions, 2.3., *supra* n. 31.

34 CFE legal Agreement, Section II: Definitions, 2.2., *supra* n. 31 .

35 CFE legal Agreement, Section VI: Space Surveillance Data Support, 6.1., *supra* n. 31.

36 CFE legal Agreement, Section VIII: No Warranties, 8.1., *supra* n. 31.

37 Weeden, B., Technical Advisor, Secure World Foundation, personal communication, 3 Sep. (2009).

38 Jakhu R. & Singh K., Space Security and Competition for Radio Frequencies and Geostationary Slots, *ZLW* 58, 1/2009, p. 82.

39 U.S. military uses imagery from French SPOT satellite. Day, D., The Gun Pointed at the head of the universe, <www.thespacereview.com/article/1394/1>, June 15 (2009). Approximately 80% of the military space activities are performed by commercial satellites. Taylor, Michael (U.S. Air Force), personal communication, 9 May (2009).

40 As the MIT Lincoln Laboratory and the Aerospace Co. At the moment, the Aerospace Co. has no contracts with satellite owners/operators for conjunctions/collisions predictions, but in the past it had contracts with Intelsat and PanAmSat. In case of a satellite collision due lack of precision of the conjunction/collision predictions, the liability is contractually limited in relation to the value of the contracted service and not the satellites' actual value. Ailor, W., Director, Center for Orbital and Re-entry Debris Studies, The Aerospace Corporation. Personal communication, May 9 (2009).

41 Buttler A., Collision Avoidance, Aviation Week & Space Technology, July 6 (2009), p. 18.

42 Weeden, B., Technical Advisor, Secure World Foundation, personal communication on 2 Sep, 2009.

43 UN Doc. A/AC.105/C.1/L.260, *supra* n. 1.
44 47CFR25.283, *supra* n. 5.
45 47CFR25.283, *supra* n. 5.
46 Mejía, *supra* n. 6, p. 28.
47 As of Jan. 2009, 98 States have ratified the Outer Space Treaty, including space faring States. *Supra* n. 2. UN Doc. A/AC.105/935 (2009).