ESA's Choice of Futures: Envisat Removal or First Liability Case

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In April 2012 the European Space Agency announced the sudden interruption of communications with its satellite Envisat. Envisat has a cross section of 26 meters, a mass of eight tons and is currently in a polar orbit at an altitude of about 780 km. Once exposed to natural forces and to the present space debris population in this area, there is a considerable probability that it will collide with other space objects and be dismembered. The orbital life of this satellite is estimated as 150 years. The question arises if ESA will perform a removal operation or take the risk of liability in case of damage to space objects of another State or to persons or property on board such space objects. This article will address ESA's decisions on Envisat's end-of-life procedures and analyse them under present general international law and space law.

1 Introduction

In 1993 the alarming growth of space debris in Earth orbits motivated several space agencies to establish the 'Inter-Agency Space Debris Coordination Committee' (IADC). The European Space Agency (ESA) was one of the four founding members of the IADC[1].

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1 Founding members of the IADC were the European Space Agency (ESA), the National Aeronautics and Space Administration (US), the Japanese Aerospace Exploration Agency and ROSAVIAKOSMOS (Russian Federation). Following members were Agenzia Spaziale Italiana (ASI-Italy), the British National Space Council (BNSC-UK), Centre National d'Etudes Spatiales (CNES-France), the Canadian National Space Agency, Deutsches Luft und Raumfarth Agentur (DLR-Germany), the Indian Space Research Organization (India) and the National Space Agency of Ukraine (NSAU-Ukraine).

The IADC had several goals, but the preeminent one was to identify options for debris mitigation.
Due to the large area where space debris is scattered in orbits around the Earth, the IADC decided to concentrate first in the protection of two zones that accommodate most of the operational satellites. One of these areas is the Low Earth Orbit (LEO). The LEO Protected Zone is an area which includes all the orbits from the surface of the Earth up to 2000 km.
The IADC published in 2002[2] a set of recommendations for the mitigation of space debris, which comprises the lowering of orbits of the satellites reaching their end-of-life (de-orbiting[3]). This measure aims at a reduction of the 'orbital life' of space objects to 25 years as a maximum[4].
The IADC also recommends 'passivation', which means "…the elimination of all stored energy on a space system to reduce the chance of break-up"[5].
In 1989, the European Space Agency adopted a Resolution by which it formulates its objectives "to minimize the creation of space debris to ensure the free access to space and reduce the risk for manned and unmanned space flight"[6].
Also in 2006 ESA signed the European Code of Conduct[7] which is based on the IADC Guidelines.
Finally, in 2007 the United Nations General Assembly recognized the IADC Space Debris Mitigation Guidelines by endorsing them in a Resolution[8].

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2 Inter-Agency Space Debris Coordination Committee Space Debris Mitigation Guidelines. UN Doc. A/AC.105/C.1/L.260, 29 Nov. (2002).

3 3.4.2. Definition of 'De-Orbit': '…intentional changing of orbit for re-entry of a space system into the Earth's atmosphere to eliminate the hazard it poses to other space systems, by applying a retarding force, usually via a propulsion system'. IADC Mitigation Guidelines, *ibid*.

4 'Orbital life' is the time span from the position of the satellite which will no longer use its propulsion systems to keep the orbit, until the time it re-enters the Earth's atmosphere (at approximately at 100 km altitude). The IADC has considered a 25 year de-orbiting maneuver as a 'reasonable and appropriate lifetime limit'. 5.3.2. Objects passing through the LEO region. IADC Mitigation Guidelines, UN Doc. A/AC.105/C.1/L.260, *supra* note 3.

5 3.4.1. Passivation is '…the elimination of all stored energy on a space system to reduce the chance of break-up'. IADC Mitigation Guidelines, *supra* 3.

6 ESA Council Resolution on Space Debris, ESA/C (89)24, rev.1 Paris, June (1989). Flury. W, European Activities on Space Debris, Second European Conference on Space Debris, Organized by ESA, held 17-19 March, 1997, ESOC, Darmstadt, Germany (1997), ESA-SP 393, p. 35.

7 The European Code of Conduct for Space Debris Mitigation was released in 2004, Issue 1.0, 28 June (2004). ESA signed the European Code of Conduct for Space Debris Mitigation in 2006. International Regulations, ESA Portal, available at: <www.esa.int/SPECIALS/Space_Debris/SEMQHL05VQF_0.html>.

8 The UN General Assembly Resolution A/RES/62/217 (paragraph 27) is complemented by the 'Report of the Committee on the Peaceful Uses of Outer Space', Official Records of the General Assembly, 62nd Session, Supplement No. 20 (A/62/20), paragraphs 117-128 (2007). The IADC Guidelines are in this last document's annex.

All these efforts support the impression that the European Space Agency felt committed to the mitigation of space debris, at least since 1989, when it decided to minimize the creation of space debris[9]. Unfortunately, events from 2007 to 2012 raise some doubts.
Did ESA ignore the goals of the IADC? Did it prioritize the extension of the operational life of Envisat until the last drop of fuel, rather than the stability of this precious area in outer space and the welfare of the other States using this valuable orbit? If so, what are the challenges ESA will face following this decision?

2 Envisat's Birth and Death

In 2002 the European Space Agency launched the remote sensing Envisat satellite[10]. The satellite had originally an almost circular Sun-synchronous orbit with 98.55 degrees inclination in respect to the terrestrial equator (polar orbit) and an initial altitude of 800 km[11]. Envisat has a mass of 8-ton and its in-orbit configuration is 26m x 10m x 5m[12].
Envisat's operational life was planned to be five years[13]. For this purpose the satellite was launched with a tank with 390 kg of fuel[14], to allow in-orbit maneuvers. During its operational life, Envisat performed not only scheduled orbit control maneuvers, but at least seven significant space debris collision avoidance operations[15]. One of these maneuvers was undertaken in January 2010 to avoid a collision with a Chinese (3.8 tons) spent stage, which would have approached Envisat as close as 50 m[16].

9 ESA Council Resolution on Space Debris, *supra* 7.
10 Search machine in internet: Earthnet Online, Envisat, History.
11 Search machine in internet: Envisat, Satellite, Space Segment.
12 *Ibid*.
13 Search machine in internet: ESA Declares End of Mission for Envisat, 9 May (2012).
14 Envisat, Space Segment, *supra* 12.
15 De Selding, P., Preparing Envisat for Mission Extension a Major Undertaking, Space News, 12 July, (2010). ESA, Space Debris, Hazards and Dangerous Encounters, April (2005), at p. 7.
16 "Heiner Klinkrad, head of ESA's space debris office at ESOC, said here July 21 that a post-event analysis showed that the Chinese stage probably would have collided with Envisat if the avoidance maneuver had not been done". "…tracking information supplied by the U.S. military, as well as confirming German radar data, showed that the two space objects would speed by each other at a nail-biting distance of roughly 160 feet (50 meters)". Leonard David, Space Junk Mess getting Messier in Orbit, Space.com, 23 Feb (2010). De Selding P., Huge Satellite Poses 150-Year Threat of Space Debris, Space News, 26 July (2010). Kessler commented on this "…since Envisat is so massive, if the collision had occurred it would instantly produced a debris environment that, under the most optimistic conditions, we would not expect to have for at least 100 years." Andrea Gini, Don Kessler on Envisat and the Kessler Syndrome. April 2012, Space Safety Magazine.

Although Envisat was due to be decommissioned in 2007, in this year ESA researchers assessed that Envisat still had 165 kg of fuel on board[17] and recommended an extension of Envisat operations[18]. These researchers estimated that by 2010 "…no fuel will be left, which automatically means the end of mission"[19]. ESA continued operating the satellite. In 2009 ESA approved again the extension of Envisat operations for three more years (2011, 2012 and 2013)[20] to allow continuity of data supply until the start of a follow-up 'Sentinel' space system that was scheduled to be launched in 2013[21]. Envisat's orbit was then lowered approximately 20 km, to allow the extension of operations with a minimum use of hydrazine[22].

Unfortunately, in early April 2012 the communication link between Envisat and ground stations ceased abruptly[23]. After several attempts to restore communications, ESA finally informed the world in May 2012 that Envisat had malfunctioned and its operational life had arrived at its end[24]. ESA attempted to re-establish contact with the spacecraft during the next two months but, as of September 2012, had not published any statement on the successful re-establishment of communication with Envisat[25].

In Envisat's orbit there are many operational satellites, for example 66 operational satellites of the US Iridium constellation[26].

17 Frerick J., Duesmann B., Canela M. (ESA's researchers at ESTEC), 2010 And Beyond -The Envisat Mission Extension, *Proc. 'Envisat Symposium 2007'*, Montreux, Switzerland 23–27 April 2007 (ESA SP-636, July 2007).

18 Envisat fuel budget mass in kg. Available fuel in Jan. 2007: ~165 kg; expected available fuel in Jan. 2009: ~100-110 kg. Frerick *et al*, *supra* 18.

19 It was indicated that Envisat's total consumption per year was approximately 28-38 kg and that the fuel for de-orbiting was "…a considerable amount which is equivalent to even more than one year of nominal operations. This amount seems to be not usable for operations, which is a great pity". Frerick *et al*, *supra* 18, p. 2-3.

20 ESA's Earth Observation Programme Board approved a 3-years Envisat mission extension (2011, 2012, 2013) in its 131st meeting on 26 May 2009. Search machine in internet: Envisat Mission Extension beyond 2010, 28 May (2009).

21 Search machine in internet: Envisat, ESA Mission Continuity - Earthnet Online.

22 Mission Extension beyond 2010, *supra* 21.

23 Tariq Malik, Huge Satellite Envisat is Dead in Space, SPACE.com, 9 May (2012).

24 ESA Declares end of Mission, *supra* 14.

25 ESA Declares end of Mission, *supra* 14.

26 The 66 Iridium satellites have a polar orbit at 780 km altitude. These 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". About the Iridium Network, available at: http://remotesatellite.com/networks/iridium/about-iridium.php.

3 Extension of Operational Life versus Lowering of Orbit

In 2010, when Envisat was still in operation and had propellant, the question arose if ESA would perform de-orbit procedures in conformity to the IADC Guidelines[27].
In 2010, Envisat was believed to have still 81 kg of fuel[28]. However, ESA officials described in a Conference in Norway in 2010 "…how they will use Envisat's fuel just about to the last drop"[29], that Envisat had a small tank and that the option of de-orbiting was never realistic[30].
ESA's officials also raised the point that Envisat had been developed before the IADC Space Debris Mitigation Guidelines[31]. However, ESA de-orbited the ERS-2 satellite, which was launched in 1995, seven years before Envisat was placed in orbit. It had the same orbital parameters as Envisat. During the design and manufacturing phases of ERS-2 de-orbiting was not considered. Nevertheless, it was decided to perform this action in compliance with the Mitigation Guidelines, to minimize its orbital life, to clear the orbital region from 700 to 900 km and to passivate ERS-2 before deactivating all systems[32]. In 2011 ERS-2 was passivated and de-orbited from an altitude of 780 km to 570 km, 210 km below its nominal orbit[33].

4 Envisat's Collision Risks

If Envisat is left to natural forces, its orbital life is calculated to last 150 years[34].

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27 De Selding, Preparing Envisat for Mission Extension, *supra* 16.
28 "This is what we think we have on board", Statement in 2010 of Frank-Juergen Diekmann, Envisat flight manager, ESA/ESOC, Germany. De Selding, Preparing Envisat, *supra* 16. The assessment of remaining propellant on board a satellite is a difficult task due to the reduced Earth's gravitational pull on the fuel and the extreme temperatures in outer space. In order to overcome this problem, different techniques have to be considered, e.g. assessing the amount of propellant remnants by counting propellant consumption for thrusters firing through the operational life of a satellite.
29 De Selding, Preparing Envisat, *supra* 16.
30 "…given the size of the fuel tank, de-orbiting it would have meant stopping the mission just a few weeks after it started", statement of Henri Laur, director in ESA/ ESRIN Earth Observation Center, Italy". De Selding, Preparing Envisat, *supra* 16.
31 Statement of Henri Laur, director, ESA/ESRIN. De Selding, Preparing Envisat, *supra* 16.
32 Diekmann F. *et al*, A Satellite Retires - The ERS-2 De-Orbiting in Summer 2011. *Proceedings SPACEOPS*, Stockholm, Sweden, June (2012).
33 Search machine in internet: Pioneering ERS Environment Satellite Retires, 5 July (2011), ESA News. De Selding, ESA to Keep Envisat Flying Despite Low Fuel Supply, Space News, 6 July (2010).
34 De Selding, Huge Satellite Poses 150-Year Threat of Space Debris, Space News, 26 July (2010).

In 2010 it was estimated that due to the traffic density in Envisat's orbit the probability of collision with other objects was between 15% and 30%[35]. This collision risk increases constantly[36].
In addition, Envisat was not properly passivated. Envisat was in the IADC's designated LEO protected zone when the communication link was suddenly lost. This prevented proper decommissioning procedures. Propellant remnants, charged batteries, residual gases and other sorts of stored energy on board Envisat transform this huge spacecraft into a ticking bomb. A collision with another space object, natural or man-made (even small), in this crowded protected zone will irrevocably trigger a fragmentation sequence[37].
Heiner Klinkrad, head of ESA's office at ESOC, has commented that in this whereabouts there are remnants of the Chinese ASAT test of 2007 and of the Iridium-Cosmos crash in 2009[38]. He also remarked that an Envisat collision with the Chinese upper stage in 2010 would have caused a fragmentation event ten times larger than the Iridium-Cosmos crash[39].
Space debris specialists consider that the "space around an altitude of 780 km, [is] currently the most hazardous"[40]. ESA did not de-orbit Envisat out of this hazardous area after the fulfillment of the 5-year planed operational life, with the remaining fuel.
ESA's opportunity to de-orbit Envisat with its own propulsion systems is lost. A collision with other space debris and the explosion of Envisat are imminent. Is this unavoidable?
ESA's options need to be examined.

35 De Selding, Huge Satellite, ibid. "ESA notes that there is a 30 percent chance of a collision between Envisat and orbital debris", Allianz Global, Space Risks: A New Generation of Challenges, June 2012, available at: <https://www.allianz.com/media/press/documents/press_releases/agcs_space_risks_white_paper.pdf>. See also table at Darren McKnight, Donald Kessler, We've Already Passed the Tipping Point for Orbital Debris, IEEE Spectrum, September (2012), available at: <http://spectrum.ieee.org/aerospace/satellites/weve-already-passed-the-tipping-point-for-orbital-debris>.

36 Statement of Frank-Juergen Diekmann, Envisat flight manager at ESA/ESOC. De Selding, Preparing Envisat, *supra* 16.

37 De Selding, Envisat to Pose Big Orbital Debris Threat for 150 Years, Experts Say, Space News, 23 July (2010).

38 "Klinkrad told SPACE.com, that 50 percent of all the close conjunctions that Envisat faces are due to the lethal leftovers from China's January 2007 anti-satellite test, as well as chunks of junk resulting from last year's smashup between an active U.S. Iridium satellite and a defunct Russian Cosmos spacecraft". Leonard David, SPACE.com, Space Junk Mess Getting Messier in Orbit, 23 February (2010).

39 De Selding, Envisat to Pose Big Orbital Debris Threat, *supra* 38.

40 McKnight & Kessler, We've Already Passed the Tipping Point, *supra* 36.

5 The Removal Option

The IADC Space Debris Mitigation Guidelines, as adopted by the UN General Assembly in 2007, specify mitigation measures which include "…the end-of-life procedures that remove decommissioned spacecraft…from regions populated by operational spacecraft"[41]. Guideline 6 states that "spacecraft…that have terminated their operational (life) should be removed from orbit (to) avoid their long-term presence in the LEO region"[42]. Not only the maneuvering of space objects "…into an orbit with a reduced lifetime" is proposed, but also 'retrieval' of space systems terminating their operational life[43].

An aggravating factor of space debris in Earth's orbits is the cascading effect. Present space debris in outer space will collide, fragment and produce more space debris (Kessler Syndrome). This has motivated space debris researchers to address the possibility of developing 'Active Space Removal' technology in order to stabilize the space debris population. This encompasses the use of external mechanisms as nets, tugs and other techniques.

All space debris in outer space bear the potential of collisions. Nevertheless, researchers consider that large and massive space debris objects in highly congested orbits have the highest priority to be removed by external systems[44]. It is unquestionable that Envisat fits exactly the description of a high priority object. This is confirmed by German space debris specialists Carsten Wiedemann *et al* who made a list of the most dangerous objects in LEO[45]. No names of targets are included in this list. Due to the given orbital parameters and size it is yet possible to infer that the second priority for removal is Envisat[46].

The retrieval and removal of valuable and non-valuable space objects have already been conducted directly by astronauts (with physical contact or with the help of remotely controlled devices) or by remote controlled systems operated from Earth. These maneuvers are expensive and dangerous to astronauts, their spaceships and other operational space objects.

The removal of Envisat presents a new challenge, not only from the technological perspective, but also in regard to the financial aspect.

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41 1. Background. Space Debris Mitigation Guidelines, UN Doc A/62/20, Dec. 21 (2007), p. 47.

42 Guideline 6: Limiting the Long-Term Presence of Spacecraft and Launch Vehicle Orbital Stages in the Low-Earth Orbit (LEO) Region after the End of their Mission. Space Debris Mitigation, *ibid*, p. 50.

43 5.3.2. Objects passing through the LEO Region. IADC Mitigation Guidelines, *supra* 3, p. 10.

44 Liou J. & Johnson N., A Sensitivity Study of the Effectiveness of Active Debris Removal in LEO, IAC-07-A6.3.05, (2007), at 1.

45 The first top 20 space debris objects in LEO with the 'highest probability of catastrophic collision' are in Wiedemann C. *et al*, Space Debris Mitigation Measures and Cost Issues, IAC-11.Et.6.-E3.5.2 (2011), at 5.

46 Inclination: 98.6°, Perigee: 787.8 km, Apogee: 789.2 km, Mass: 8 111 kg. Wiedemann C. *et al*, *ibid*.

Wiedemann *et al* have calculated that an active removal of a space body of 8 tons from a circular polar orbit at about 780 km altitude costs approximately 479 Million USD (FY 2011)[47].
Due to the danger of the stored energy left onboard Envisat, the estimated cost will very likely increase. Removal technics need to be developed and tested, to reduce the risk of an explosion of Envisat during an active removal to a minimum. Without passivation, it is no longer sufficient to reduce Envisat's orbital life to 25 years, as the IADC recommends[48]. It will be required to remove the satellite in such a controlled manner that it reaches the Earth's surface at an unpopulated area as soon as possible. However, an active space debris removal from 780 km to the surface of the Earth would require a great amount of fuel and would be technical challenging. The question arises if such operation is at all feasible.
Can ESA finance such an operation? The costs for the development of Envisat were $2 900 Million of today's US dollars[49]. The annual operational costs of Envisat were 40 Million Euros[50]. ESA should consider spending financial resources for the development of active removal technology to be applied to its satellite, to demonstrate the international community its willingness to remove this danger. If ESA does not undertake these efforts, which repercussions will arise?

6 The Liability Option

In case Envisat collides with another space object and causes damage to space objects or to persons or property on board, ESA could be held liable to pay compensation. This liability could even extend to the States which participated in the Envisat Program.

6.1 Responsibility

The Outer Space Treaty states in its Art. VI that "…when activities are carried on in outer space…by an international organization, responsibility for compliance with this Treaty shall be borne by the international organization and by the States Parties to the Treaty participating in such organization" [51]. All ESA Member States are States Parties to this Treaty and thus are 'internationally responsible' for the space objects launched by ESA[52], in the terms of Outer Space Treaty Arts. VI and XIII.

47 Wiedemann C. *et al*, *supra* 46, p. 6.
48 IADC Mitigation Guidelines, *supra* note 3.
49 De Selding, Envisat to Pose Big Orbital Debris Threat, *supra* 38.
50 "Operating Envisat costs about 40 million euros per year including data distribution", De Selding, ESA to Keep Envisat Flying, *supra* 34.
51 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty) 27 Jan. 1967, 18 UST 2410, TIAS 6347; 610 UNTS 205 (entered into force on 10 Oct. 1967).
52 Resolution of the Council of the European Space Agency on the Agency's Legal Liability (1977) ESA/C/XXII/Res.3.

This Treaty and the other four space treaties do not include a provision on the need that international organizations sign and ratify such legal instruments. Nevertheless, aside of the Outer Space Treaty, the other space treaties allow that international organizations place 'declarations of acceptance' by the depositary governments of the treaties. ESA submitted 'Declarations of Acceptance' to the Liability Convention[53] and the Registration Convention[54] and registered itself as 'launch authority' of Envisat with the UN Secretary-General[55].
Envisat is an optional program of ESA. Under ESA rules, Member States may decide in which space programs they want to contribute by directly participating and financing. From the current 19 Member States, only Belgium, France, Germany, The Netherlands and United Kingdom became 'Participating States' of the Envisat Program. All these ESA Member States have ratified the Outer Space Treaty and the Liability Convention. Although only five Member States of ESA contributed to the Envisat program, the present analysis is based on the premises that ESA as an international governmental organization and these Participating States are jointly internationally responsible for Envisat.

6.2 Liability

Art. VII is the key provision of the Outer Space Treaty on liability and states that a State Party to the treaty which "…launches or procures the launching of an object into outer space…is international liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts…"[56]
This article of the Outer Space Treaty became the basis for the Liability Convention, whose articles III and IV are relevant for the analysis of this case.
Art. III of the Liability Convention reads that "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 a space object by a

53 Convention on International Liability for Damage Caused by Space Objects (Liability Convention), Art. XXII; 29 March 1972, 24 UST 2389; TIAS 7762; 961 UNTS 187 (entered into force on 9 Oct. 1973). ESA's Declaration of Acceptance to the Liability Convention was submitted on 23 Sep 1974 in London and Moscow.

54 Convention on Registration of Objects Launched into Outer Space, Art. VII; 14 Jan 1975, 28 UST 695; TIAS 8489; UNTS 15 (entered into force on 15 Sep 1976). The Declaration of Acceptance to the Registration Convention was submitted by ESA on 2 February, 1979, at United Nations.

55 Information furnished in conformity with the Convention on Registration of Objects Launched into Outer Space, Letter dated 11 August 2003 from the Head of the Legal Department of the European Space Agency to the Secretary-General. UN COPUOS Doc. ST/SG/SER.E/432, at p. 3. Interesting reflections on the jurisdiction and control of international organizations over space objects can be found at: Schmidt-Tedd and Mick, Art. VIII, Cologne Commentary on Space Law, Vl. 1, Outer Space Treaty, Hobe, Schmidt-Tedd, Schrogl (ed.) (2009).

56 Outer Space Treaty, *supra* 52.

space object or another launching State, the later shall be liable only if the damage is due to its *fault*…"[57].
Under article III of the Liability Convention 'fault' is the main prerequisite for the attribution of liability to a State. Fault needs to be proven in the specific circumstances of the case.

6.3 Two Different Paths Towards 'Fault'

'Fault' can be proven in two principally different ways: either by breach of a rule, which establishes an order to prevent damage, or by proving intent or negligence.

(a) Legally Binding Norms. At present there are no legally binding traffic rules in outer space. In case of a collision between space objects of two different States it may be difficult to prove fault of one or both, as could be seen in the Iridium-Cosmos case[58]. Also, the IADC Space Debris Mitigation Guidelines and the UN Resolution on this matter are of a recommendatory nature, thus not legally binding…yet[59].
(b) Negligence. Due to the lack of such legally binding rules, it is necessary to analyze if ESA's conduct could be considered as negligent in case of a collision that causes damage.

Negligence may be defined as "[t]he failure to use such care as a reasonable prudent and careful person would use under similar circumstances"[60].
The Croatian/Canadian scholar Ivan Vlasic indicated in this respect "The important question is, of course, what acts or omissions will be considered "fault"…in absence of…specific rules, obvious intentional misconduct or recklessness on the part of the operator of one of the spacecraft involved in the collision would similarly be considered as fault"[61].
Crucial is the 'standard of care' to be applied by a prudent and careful person in order to avoid or mitigate the foreseeable damage. The standard of care is not static, it develops with the practice of the actors[62].

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57 Liability Convention, *supra* 54.
58 Mejía-Kaiser, M., 'Collision Course: The 2009 Iridium-Cosmos Crash'. *Proc. 5*2nd *Colloquium on the Law of Outer Space*, Daejeon, Rep. of Korea (2009).
59 Due to the evolving State Practice and opinio iuris of the IADC Mitigation Guidelines, this author is convinced that the Guidelines are on their way to crystallize in a set of norms of customary law, thus legally binding for the whole international community. Mejía-Kaiser, Martha. 'Informal Regulations and Practices in the Field of Space Debris Mitigation'. Air and Space Law 34, no. 1 (2009): 21-34.
60 Negligence. Black's Law Dictionary, 6th ed., West Publishing, St. Paul Minn. (1991), p. 716.
61 McDougal M., Lasswell H., Vlasic I., Law and Public Order in Space, Yale Univ. Press (1963), p. 624.
62 In the case at hand, the space operators practice, which determines prudence, evolves more rapidly than and independently of the evolving State Practice & *opinio iuris* which forms international customary law.

The standard of care in respect to mitigation of space debris kept evolving during the operational life of Envisat[63], but ESA did not adapt its Envisat operations policy to such development.
Someone who takes risks has to comply with an elevated standard of care in case a reasonably foreseeable damage occurs. In this instance, it is not sufficient that such actor applies the same standard of care as others, whose activities are less prone to lead to damage.

6.4 Circumstantial Evidence

A hypothetical collision between Envisat and an operational space object must be analyzed considering reasonable and predictable damages in the presently acceptable space operator's risk environment: if the spacecraft's operator fails to undertake evasive maneuvers, if he executes an incorrect maneuver or if his space object has no systems to perform evasive maneuvers (e.g. Hubble Space Telescope).
There are several facts which might imply negligence by ESA in regard to future damage caused by a potential Envisat collision:

1. ESA was aware of the traffic congestion and risks of collision in this area when Envisat was launched and knew thereafter that abandoning this spacecraft in this region would endanger operational space objects and astronauts for 150 years.
2. ESA was aware that the mass of 8 tons can cause a debris cloud of unparalleled size in case of collision[64].
3. ESA decided to extend Envisat's operational life longer after its expected life was already 'doubled' and when there was still fuel on board to bring this satellite out of the most hazardous 780 km altitude[65], to reduce its collision risk. As of October 2012, Envisat' elliptical orbit had an apogee of approximately 795 km (South Pole region) and perigee of 768 km (equatorial region)[66].

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63 Kessler commented "Envisat is probably one of the best examples of a satellite that should have followed either NASA's 1995, or ESA's 2002 debris mitigation guidelines". Andrea Gini, Don Kessler on Envisat, *supra* 17.

64 Andrea Gini, Don Kessler, *supra* 17.

65 McKnight & Kessler, We've Already Passed the Tipping Point, *supra* 36.In 2010 Pierre Vogel, commented in a conference that two kg of hydrazine were required to lower Envisat's orbit for each km. Pierre Vogel, principal engineer, ESA/ESTEC, The Netherlands. De Selding, Preparing Envisat, *supra* 16.

66 There were several instances where Envisat had enough fuel for de-orbiting out of the most hazardous area at an altitude of approximately 780 km: in January 2007 Envisat had 165 kg of fuel on board; in January 2009, 100 kg on board; in July 2010, 81 kg on board.
As of October 2012, Envisat' elliptical orbit had an apogee of approximately 795 km (South Pole region) and perigee of 768 km (equatorial region). Real Time Satellite Tracking of Envisat at www.n2y.com. Last visited: 25 October 2012.

4. ESA took the decision to extend the operation of Envisat with the risk that this older space object could more likely suffer a malfunction and later proper passivation may become impossible.
5. Regardless of Envisat's design and manufacturing[67] before the IADC Mitigation Guidelines were released in 2002, the decision to use all of Envisat's fuel (2009)[68] was taken *after* the ESA signed the European Code of Conduct (2006)[69] and the IADC Guidelines were adopted by a UN General Assembly Resolution (2007)[70].

All these facts indicate that ESA was aware of the collision risks for other space actors, but did not undertake reasonable action to reduce them[71].
ESA's attitude in the management of the extension of Envisat operational life could be qualified as negligence, in case of damage to operational space objects of other States in this area.
The mentioned facts can constitute circumstantial evidence also in the event of damage due to a collision with space debris resulting from a fragmentation event of Envisat's break-up and/or collision with another space object. In case debris resulting from a collision of Envisat with another space object causes further damage to a third State, then the "…liability to the third State shall be based on the *fault* of either of the first two States…" (Liability Convention, Art. IV 1. (b)).
If there is no proof of negligence by other States involved in a collision that suffer damage or the causes of an accident are unknown or in dispute[72], then ESA' negligence may be decisive in the attribution of fault to this organization. Such fault will then impose liability and an obligation for compensation on ESA.

7 Final Considerations

In the past years ESA had several options. The option is gone to passivate Envisat at its current altitude, as initially planned by ESA. The option is gone to descend Envisat with own propulsion systems to a lower altitude (and passivate), out of the hazardous area.
ESA's choice of futures is reduced to the expensive options: to actively remove Envisat or to become liable and pay compensation in case of damage to space

67 "Final negotiations were completed with industry in mid-1995 and the PPF phase C/D contract for the development and integration of the Polar Platform with the Envisat instruments was signed in July 1995". Search machine in internet: Earthnet Online, Envisat, History.
68 Envisat Mission Extension was approved on 26 May 2009. *Supra* 21.
69 ESA signed the European Code of Conduct in 2006. *Supra* 8.
70 The UN General Assembly Resolution A/RES/62/217, December (2007), *supra* 9.
71 Mejía, Collision Course, *supra* 59.
72 McDougal *et al*, *supra* 62, at 621.

objects of another State or to persons or property on board such space objects. ESA may decide to take the liability risk for future damages as a cheaper option, in contrast to the expensive active removal operation of Envisat.
ESA's actions and omissions seem to contradict its long-time commitment with the IADC's work of 20 years and the efforts of States that follow the Mitigation Guidelines.
ESA took the decision to take risks by abandoning a huge satellite in a valuable area in outer space for 150 years. If ESA does not perform active space removal of Envisat, can it be sure that no damage claim arises in the next 150 years?