3

Mega-constellations and International Law

The rapid development of satellite mega-constellations raises difficult issues of international law. Some issues are of immediate relevance; others are more distant.[1] The first section of this chapter addresses the issue of liability for collisions involving satellites, as it might play out in both international law and domestic legal systems. Establishing 'causation' – demonstrating that the actions of one satellite operator caused a specific collision with another Space object and resulted in damage – could be a challenge. This challenge could be especially difficult in the context of knock-on collisions, where debris from an initial collision later collides with one or more spacecraft, including satellites. Such a collision occurred in 2013 when debris from a 2007 Chinese anti-satellite (ASAT) weapon test collided with and disabled a Russian satellite.[2] A second challenge concerns determining, in the absence of binding international rules on the design and operation of satellites, what is reasonable behaviour, and therefore what constitutes negligence. As we will see, non-binding guidelines and industry practices could be helpful in making such determinations.

The second section of this chapter addresses the interference to astronomy that is increasingly resulting from the construction of mega-constellations. A full interpretation of the Outer Space Treaty, in

[1] One somewhat distant issue concerns the application of competition law, whether international or domestic, in the quite plausible scenario where one company, or several companies from one state, secure an effective monopoly over the provision of broadband Internet from satellites. See Lucien Rapp and Maria Topka, 'Small satellite constellations, infrastructure shift and space market regulation', in Annette Froehlich, ed, *Legal Aspects around Satellite Constellations: Volume 2* (Cham: Springer, 2021) 1. An analogous issue concerns the application of competition law to globally dominant tech firms such as Google, as to which, see Maurice Stucke and Allen Grunes, *Big Data and Competition Policy* (Oxford: Oxford University Press, 2016).

[2] Melissa Gray, 'Chinese space debris hits Russian satellite, scientists say', *CNN* (9 March 2013), online: www.cnn.com/2013/03/09/tech/satellite-hit.

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accordance with the international rules on treaty interpretation, leads us to the conclusion that states are already required to take certain steps – including conducting an environmental impact assessment – before licensing mega-constellations, because of the obligation of 'due regard to the corresponding interests of all other States Parties to the Treaty'.

3.1 Collisions Involving Satellites

Treaties and customary international law are sometimes referred to collectively as 'hard law' because they contain binding obligations that, when violated, can have direct consequences. Such consequences include empowering other states to engage in 'countermeasures' – actions such as economic sanctions that would be illegal under normal circumstances, but are rendered legal as a response to the initial violation.[3]

'Soft law' is a term used for non-binding instruments such as resolutions adopted by the United Nations General Assembly or guidelines produced by other bodies, including subsidiary organs of the United Nations, such as the Committee on the Peaceful Uses of Outer Space (COPUOS).[4] These non-binding instruments cannot be enforced and therefore, by themselves, allow for 'free riding', whereby individual actors can save costs through non-compliance while benefiting from the compliance of others. As we explained in the Introduction to this book, in the context of any shared resource, free riding can lead to a 'tragedy of the commons'.[5] This is exactly what has been happening in Earth's atmosphere as a result of greenhouse gas emissions, and what now needs to be avoided in low Earth orbit (LEO).

Soft law nevertheless remains significant, in part because non-binding instruments can still influence state behaviour, and in part because they sometimes serve as precursors to the negotiation of treaties or

[3] International Law Commission, Draft Articles on Responsibility of States for Internationally Wrongful Acts, with commentaries, UNGAOR, 56th Sess, Supp No 10, UN Doc A/56/10 (2001) at 128 et seq., online: legal.un.org/ilc/texts/instruments/english/commentaries/9_6_2001.pdf. These draft articles were commended to governments by the UN General Assembly in its resolution *Responsibility of States for Internationally Wrongful Acts*, GA Res 56/83, UNGAOR, 56th Sess, 85th Plen Mtg, UN Doc A/RES/56/83 (2001).

[4] Irmgard Marboe, ed, *Soft Law in Outer Space: The Function of Non-binding Norms in International Space Law* (Vienna: Böhlau Verlag, 2012).

[5] Garrett Hardin, 'The Tragedy of the Commons' (1968) 162:3859 *Science* 1243.

the development of customary international law.[6] For instance, the 1948 Universal Declaration of Human Rights was the precursor to numerous human rights treaties, including the 1976 International Covenant on Civil and Political Rights and the 1984 Convention against Torture. It is also widely considered to have contributed to the development of customary international law, to the point where most of its provisions are now considered to have that status. Moreover, 'soft' rules of international law are often implemented in domestic legal systems through legislation and regulations – becoming 'hard law' adopted by national and subnational governments. Domestic courts also look to resolutions and guidelines produced internationally, for instance when assessing whether a particular action was negligent.

3.1.1 Soft Law

3.1.1.1 Inter-Agency Space Debris Coordination Committee Guidelines

The Inter-Agency Space Debris Coordination Committee (IADC) is currently made up of representatives from 13 space agencies, including NASA, Roscosmos, the China National Space Administration (CNSA) and the European Space Agency (ESA). In 2007, the IADC stated that direct re-entry (i.e. atmospheric 'burn-up') at the end of a satellite's operational life is preferred, and recommended that such de-orbiting conclude within 25 years.[7] But while this 25-year guideline is widely accepted, it is poorly suited to mega-constellations made up of thousands of satellites with short operational lives. It also overlooks placement, with satellites at higher altitudes producing relatively high collision probabilities when de-orbiting timescales are long, as they pass slowly through lower orbits.[8]

The IADC also recommended that collision avoidance and end-of-life de-orbiting technologies be included in satellites. But these measures add costs, and in 2017 the IADC reported that adherence to its guidelines was

[6] Hema Nadarajah, 'Soft law and international relations: The Arctic, outer space, and climate change' (PhD thesis, University of British Columbia, 2020), online: dx.doi.org/10.14288/1.0394919.

[7] Inter-Agency Space Debris Coordination Committee (IADC), 'Space Debris Mitigation Guidelines – first revision' (2007), *United Nations Office for Outer Space Affairs*, online: www.unoosa.org/documents/pdf/spacelaw/sd/IADC_space_debris_mitigation_guidelines.pdf.

[8] Hugh G Lewis, 'Understanding long-term orbital debris population dynamics' (2020) 7:3 *Journal of Space Safety Engineering* 164.

'insufficient and no apparent trend towards a better implementation is observed'.[9] More recent analyses indicate that compliance with the end-of-life guidelines is now improving, at least on some metrics, and in 2022 the Federal Communications Commission (FCC) adopted a five-year rule for US operators.[10] Yet these improvements appear to be driven mostly by SpaceX's own practices, which may or may not be followed by other mega-constellation operators. Moreover, they do not by themselves constitute an overall change in collective behaviour, since the enormous presence of SpaceX in LEO could simply be diluting averaged metrics on non-compliance even if the absolute rate of non-compliance remains the same (i.e. if some number of satellites fail to meet de-orbiting guidelines each year).

3.1.1.2 UN Space Debris Mitigation Guidelines

COPUOS adopted seven Space Debris Mitigation Guidelines in 2007,[11] the same year as the IADC Guidelines. The titles of the UN guidelines are indicative of their content:

1. Limit debris released during normal operations.
2. Minimize the potential for break-ups during operational phases.
3. Limit the probability of accidental collision in orbit.
4. Avoid intentional destruction and other harmful activities.
5. Minimize potential for post-mission break-ups resulting from stored energy.
6. Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission.
7. Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission.

[9] IADC, 'An overview of the IADC annual activities' (presentation delivered at the 54th Session of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, Vienna, 1 February 2017), online: www.unoosa.org/documents/pdf/copuos/stsc/2017/tech-16E.pdf.

[10] ESA Space Debris Office, 'ESA's annual space environment report' (2022), European Space Agency (ESA) Ref No GEN-DB-LOG-00288-OPS-SD, online: www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf. 'FCC Adopts New '5-Year Rule' for Deorbiting Satellites', (29 Sept 2022), online: https://www.fcc.gov/document/fcc-adopts-new-5-year-rule-deorbiting-satellites.

[11] United Nations Office for Outer Space Affairs (UNOOSA), *Space Debris Mitigations Guidelines of the Committee on the Peaceful Uses of Outer Space* (Vienna: United Nations, 2010), online: www.unoosa.org/oosa/oosadoc/data/documents/2010/stspace/stspace49_0.html.

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Apart from Guideline 4, which we address in Chapter 8 in the context of anti-satellite weapons, the guidelines are couched in the general terms of 'limit' and 'minimize'. This makes measuring compliance difficult, at least in many circumstances. However, when an operator makes no effort to limit or minimise these behaviors, it will, self-evidently, not be complying and could legitimately be criticised on that basis. In this way, even these generally worded provisions can provide reasons – and justifications – for public, governmental or broader industry pressure.

The UN guidelines, moreover, were and remain very widely supported. Since COPUOS operates on a consensus basis, the guidelines were supported from the outset by all its then 67 member states, which included almost all the spacefaring states (except Israel, which joined COPUOS in 2015).[12] When the UN General Assembly endorsed the guidelines later in 2007, it stated that they 'reflect the existing practices as developed by a number of national and international organizations'.[13]

Several spacefaring states quickly implemented the 2007 guidelines within their domestic legal systems, notably China and Russia.[14] More recent follow-up developments at the domestic level include a 2019 update to NASA's Orbital Debris Mitigation Standard Practices (ODMSP),[15] and the 2018 adoption of Australia's Space (Launches and Returns) Act, which makes a Space debris mitigation strategy a launch requirement. The strategy must be based on internationally recognised guidelines or standards, such as those of the UN or the IADC.[16]

[12] If one considers spacefaring states as those which have launched orbital spacecraft, North Korea, which achieved orbital launch capability in 2012, is the only spacefaring state that is not currently one of the now 102 members of COPUOS.

[13] *International Cooperation in the Peaceful Uses of Outer Space*, GA Res 62/217, UNGAOR, 62nd Sess, 79th Plen Mtg, UN Doc A/RES/62/217 (2007) at para. 27.

[14] Yun Zhao, *National Space Law in China* (Leiden: Brill Nijhoff, 2015) at 218. Russian Federation, 'National Standard of the Russian Federation GOSTR52925–2008', cited in Y Makarov, G Raykunov, S Kolchin, S Loginov, M Mikhailov and M Yakovlev, 'Russian Federation activity on space debris mitigation', Federal Space Agency of Russia (2010), online: www.tsi.lv/sites/default/files/editor/science/Conferences/SPACE/makarov.pdf.

[15] National Aeronautics and Space Administration (NASA), 'US Government Orbital Debris Mitigation Standard Practices, November 2019 update' (2019), *NASA*, online: orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf. The first version of the ODMSP was adopted in 2001. See NASA Orbital Debris Program Office, 'Debris mitigation' (2022), *NASA*, online: orbitaldebris.jsc.nasa.gov/mitigation.

[16] UNOOSA, 'Compendium – Space debris mitigation standards adopted by states and international organizations' (17 June 2021) at 8–9, *UNOOSA*, online: www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_17_june_2021.pdf.

The 2007 guidelines also found their way into legally binding requirements via the International Organization for Standardization (ISO), a non-governmental organisation that in 2010 adopted a stringent set of Space Debris Mitigation Requirements for all unmanned satellites and spacecraft 'launched into, or passing through, near-Earth space'.[17] These requirements, which were updated in 2011 and again in 2019, are 'intended to reduce the growth of space debris by ensuring that spacecraft and launch vehicle orbital stages are designed, operated and disposed of in a manner that prevents them from generating debris throughout their orbital lifetime'.[18] Among other things, all new satellites must be able to de-orbit to Earth, or boost themselves into graveyard orbits at the end of their lifespan (which, while an improvement, is not a sustainable practice[19]). The ISO Space Debris Mitigation Requirements are not legally binding. However, in 2015 they were adopted by the European Cooperation for Space Standardization, an initiative, led by the 22-member-state European Space Agency, that seeks to develop a coherent, single set of user-friendly standards for use in all European Space activities.[20] And the standards adopted by the European Cooperation for Space Standardization are applied – in a binding manner – to all ESA projects.[21]

[17] International Organization for Standardization (ISO), 'ISO 24113:2010, space systems – space debris mitigation requirements' (July 2010), *ISO*, online: www.iso.org/standard/42034.html.

[18] ISO, 'ISO 24113:2011, space systems – space debris mitigation requirements' (May 2011), *ISO*, online: www.iso.org/standard/57239.html; ISO, 'ISO 24113:2019, space systems – space debris mitigation requirements' (July 2019), *ISO*, online: www.iso.org/standard/72383.html.

[19] When GEO satellites reach the end of their life, they are manoeuvred into an orbital region at least 200 kilometres above GEO. A satellite in this fairly stable region is said to be on a 'graveyard orbit'. While this removes the spacecraft from highly desirable GEO locations, the decommissioned satellites are left uncontrolled. The collision risk between them is currently small, but material at that altitude does not clear easily and thus will continue to build, and could eventually threaten the GEO region. Moreover, break-up events and meteoroid strikes in nearby orbits could create problematic debris for GEO. See European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), 'Where old satellites go to die', *Phys.Org* (3 April 2017), online: phys.org/news/2017-04-satellites-die.html.

[20] ESA, 'European cooperation for space standardization (ECSS)' (2022), *ECSS*, online: ecss.nl.

[21] ESA, 'Mitigating space debris generation' (2022), *ESA*, online: www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation.

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3.1.1.3 UN Guidelines for the Long-Term Sustainability of Outer Space Activities

In 2019, COPUOS adopted 21 'Guidelines for the Long-Term Sustainability of Outer Space Activities'.[22] Although the text below each guideline contains permissive language (e.g. 'should'), the guidelines themselves still provide markers against which an absence of effort at debris avoidance or mitigation can be measured. For example, the following five guidelines can be used to assess whether a satellite operator took reasonable measures to prevent collisions in orbit:

B.1 Provide updated contact information and share information on space objects and orbital events.
B.2 Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects.
B.3 Promote the collection, sharing and dissemination of space debris monitoring information.
B.4 Perform conjunction assessment during all orbital phases of controlled flight.
B.5 Develop practical approaches for pre-launch conjunction assessment.

In addition to providing reasons – and justifications – for applying pressure on non-compliant satellite operators, these and other international guidelines could become highly relevant after a collision or some other event causing damage, when the issue of liability arises.

3.1.2 Liability for Collisions

In other domains, such as the world's oceans, major disasters have led to policy changes, law-making and litigation at both the national and international levels. As we explain in Chapter 4, the 1989 *Exxon Valdez* oil spill prompted the United States and then the International Maritime Organization to require that new oil tankers be constructed with double hulls. This safety measure increased the cost of shipbuilding but reduced the prevalence of spills, which of course carry their own environmental and economic costs. In the domain of climate change, a combination of

[22] Committee on the Peaceful Uses of Outer Space, 'Guidelines for the Long-term Sustainability of Outer Space Activities', Annex II in *Report of the Committee on the Peaceful Uses of Outer Space, Sixty-second session (12–21 June 2019)*, UNGAOR, 74th Sess, Supp No 20, UN Doc A/74/20, online: www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf.

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damaging effects and improved scientific understandings has led to litigation in domestic courts based on the fast-developing ability of climate scientists to establish causation between, for instance, the historic greenhouse gas emissions of a fossil-fuel company, and a precise portion of global sea level rise.[23] No plaintiff has won such a case in the United States, yet, due to courts deferring to executive action on these issues.[24] But as with lung cancer victims and the tobacco industry, which fought off legal actions for decades before agreeing to large settlements,[25] the ability to establish causation offers those who have suffered losses from sea level rise, such as coastal municipalities, the possibility of obtaining similar settlements or damage awards.

All this prompts us to consider the legal consequences that would flow from a collision in LEO that resulted in substantial financial losses to one or more satellite operators. And let us be clear: the losses could be very substantial indeed. In a worst-case scenario involving a collisional cascade, hundreds, perhaps even thousands, of satellites could be disabled or destroyed, although this outcome might take considerable time to develop.

3.1.3 Establishing Fault

One major issue concerns the establishment of fault, since under Article III of the 1972 Liability Convention, liability in orbit is fault-based:

> 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 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.[26]

This therefore leads us to ask, what constitutes fault in the design, construction and operation of satellites? For example, would failing to

[23] Michael Byers, Kelsey Franks and Andrew Gage, 'The internationalization of climate damages litigation' (2017) 7:2 *Washington Journal of Environmental Law and Policy* 264.

[24] See e.g. Jonathan Stempel and Sebastien Malo, 'Oil companies defeat New York City appeal over global warming', *Reuters* (1 April 2001), online: www.reuters.com/article/us-global-warming-new-york-idUSKBN2BO5O0.

[25] Michael Givel and Stanton A Glantz, 'The "global settlement" with the tobacco industry: 6 years later' (2004) 94:2 *American Journal of Public Health* 218.

[26] Convention on International Liability for Damage Caused by Space Objects, 29 March 1972, 961 UNTS 187 Art. III (entered into force 1 September 1972) (Liability Convention).

include active de-orbiting technology in a satellite, or failing to retain sufficient propellent for this purpose, constitute fault if the satellite later collided with another satellite after running out of fuel? Or would following the IADC's 25-year guideline for de-orbiting relieve the company of fault, even if the satellite was involved in a collision after spending many years in orbit with its propellent exhausted, unable to manoeuvre out of the way of incoming trackable debris?[27] International guidelines could help to determine liability, depending on what they say, which may in turn depend on when they were adopted. Again, the IADC guidelines were adopted in 2007, before mega-constellations dramatically increased the surface area of material in LEO and therefore the collision risk, particularly from small but still lethal non-trackable debris.

Can we measure a company's behaviour against that of other companies, especially if there is a widespread and consistent practice in the industry, to determine whether it was acting reasonably? Could negligence be established on the basis that a company's satellites had an anomalously high failure rate, leading to a higher-than-normal risk of collisions with other satellites and trackable debris?

What constitutes fault will be continually evolving, due in part to new technologies, and to greater risks associated with a higher density of satellites and debris, growing concerns about Space debris among governments, and changing practices – including on the part of Space agencies, national regulators and other state actors.[28]

3.1.4 Liability for Indirect Damage?

Another important question concerns whether liability will be limited to direct damage only, or whether indirect damage is included. Indirect damage could arise from a knock-on collision, in other words a piece of debris from the first collision striking another satellite in a secondary collision – as, again, has happened already. It might also include the costs incurred by other operators as they seek to avoid such knock-on collisions by, for instance, engaging in more frequent manoeuvres which thereby use up more thruster fuel, shortening the operational lifespan of their satellites. In the case of satellites that are not part of a large constellation, indirect damage could also include the loss of services

[27] IADC, 'Space Debris Mitigation Guidelines – first revision', op. cit.

[28] Note, also, that this 'state practice' can, over time, contribute to the development or change of customary international law.

provided by a satellite that has been disabled by a collision. Imagine, for instance, a small country with a single Earth-imaging satellite (perhaps used to support food production) that is forced to buy expensive imagery from foreign commercial operators after its satellite is disabled by a collision.[29]

As it happens, liability for damage from knock-on collisions is addressed in Article IV of the Liability Convention, which reads:

1. 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 space object of another launching State, *and of damage thereby being caused to a third State or to its natural or juridical persons*, the first two States shall be jointly and severally liable to the third State, to the extent indicated by the following:
   (a) If the damage has been caused to the third State on the surface of the earth or to aircraft in flight, their liability to the third State shall be absolute;
   (b) If the damage has been caused to a space object of the third State or to persons or property on board that space object elsewhere than on the surface of the earth, their liability to the third State shall be based on the fault of either of the first two States or on the fault of persons for whom either is responsible.
2. In all cases of joint and several liability referred to in paragraph 1 of this article, the burden of compensation for the damage shall be apportioned between the first two States in accordance with the extent to which they were at fault; if the extent of the fault of each of these States cannot be established, the burden of compensation shall be apportioned equally between them. Such apportionment shall be without prejudice to the right of the third State to seek the entire compensation due under this Convention from any or all of the launching States which are jointly and severally liable.[30]

Article IV thus captures situations where the initial collision is the result of fault on the part of just one operator, as well as situations where both

[29] This example, while hypothetical, has already been prefigured. In 2013, Ecuador partially lost its first satellite (of two) to debris due to a presumed collision with Russian space junk. See 'Ecuador tries to fix satellite after space debris crash', *BBC News* (27 May 2013), online: www.bbc.com/news/world-latin-america-22678919.

[30] Liability Convention, op. cit., Art. IV, added emphasis.

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operators are at fault. In the former situation, the single operator is solely liable for the damage caused by the knock-on collision, while in the latter situation, the two operators share responsibility, with the 'burden of compensation' being apportioned between them 'in accordance with the extent to which they were at fault'.

3.1.5 At the International Level, States Are Liable, Not Companies

The picture is further complicated by the fact that, under the Liability Convention, states are the ones liable for damage caused by a 'space object', not the satellite companies themselves. This is because, under Article III, liability attaches to the 'launching state'. This is consistent with Article VI of the Outer Space Treaty, the first sentence of which stipulates that 'States Parties to the Treaty shall bear international responsibility for national activities in outer space . . . 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.'

There can be up to four launching states associated with any Space object, namely the state that launches the Space object, the state that procures the launch, the state from whose territory a Space object is launched, and the state from whose facility a Space object is launched. For instance, in 2007 Russia launched a satellite for Canada from the territory of Kazakhstan and specifically from Russia's Baikonur Cosmodrome, which is located there; in this case, there were three launch states, with Russia fulfilling two of the criteria.

It is also important to note that there is no time limit on liability.[31] Once a state has become a launching state, it remains so until the Space object is no longer capable of causing damage – including if that damage occurs after the object has become defunct, and even if it breaks into multiple fragments. Finally, the launching state(s) remain the same even if the Space object is later sold to another state, with 'on-orbit' transfers occurring with some frequency today.[32]

[31] The only time limits concern the making of a claim for compensation, which must take place within one year of the occurrence of the damage, or within 'one year following the date on which the State could reasonably be expected to have learned of the facts through the exercise of due diligence'. Ibid., Art. X.

[32] There is nothing in the 1972 Liability Convention on the transfer of ownership of Space objects between states or non-governmental actors from different states; as a result, the launching states remain responsible for any damage occurring after a sale. Launching

For all these reasons, most spacefaring states have domestic laws that entitle the government to recover, from the private owner or operator of the Space object, some portion of the compensation the state must provide under the Liability Convention after a fault-based accident in Space or for any damage caused by a Space object on the Earth's surface.[33] These 'indemnification regimes' also provide clarity to industry on how much insurance is required and whether the government will pursue Space companies to recover all or part of the financial loss. Most spacefaring states require Space companies to carry third-party liability insurance to a specified amount, and then cover any claims that exceed that level.

Enforcement might, however, pose a challenge. To date, there is only one known instance where a state has submitted a claim to another state under the Liability Convention. The claim was made by Canada against the Soviet Union after Kosmos 954 re-entered the atmosphere in 1978 and spread radioactive debris across the Northwest Territories. The claim, as it turns out, was settled, as envisaged under the Liability Convention, through negotiations between the two parties.[34] The Liability Convention does, however, enable a party to request the establishment of a claims commission if negotiations fail, though disputing

states can protect themselves against this risk, for example, by insisting that an indemnification agreement is part of any contract of sale. In some instances, such as when the 'launch state' status was acquired solely by procuring the launch, they might be able to transfer that status through the conclusion of a bilateral treaty. Finally, the regular rules of 'state succession', which apply when states merge, break apart or decolonise, will apply to 'launch state' status because it is treaty-based. For various scenarios and possible solutions, see Setsuko Aoki, 'Satellite ownership transfers and the liability of the launching states' (presentation delivered at the IISL/ECSL Symposium at the 51st Session of the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space, Vienna, 19 March 2012), online: www.unoosa.org/pdf/pres/lsc2012/symp-03E.pdf. On state succession and treaties in general, see Matthew Craven, *The Decolonization of International Law: State Succession and the Law of Treaties* (Oxford: Oxford University Press, 2009).

33 See e.g. Space Activities Act 1998 (Australia); Law of 17 September 2005 on the Activities of Launching, Flight Operations, or Guidance of Space Objects (Belgium); Tort Law of the People's Republic of China, Art. 76 (China); Space Operations Act 2008 (France); Law Concerning Japan Aerospace Exploration Agency, Law No. 151 of 13 December 2002 (Japan); Law of the Russian Federation No 5663-1 of August 20, 1993 on Space Activities (Russia); Space Liability Act, Law No. 8852 of December 21, 2007 (South Korea); Act on Space Activities, 1982:963 (Sweden); Outer Space Act 1986 (United Kingdom); 51 USC Ch 509, Commercial Space Launch Activities (United States).

34 Olga A Volynskaya, 'Landmark space-related accidents and the progress of space law' (2013) 62 *Zeitschrift für Luft -und Weltraumrecht* (German Journal of Air and Space Law) 220.

parties are not required to accept the commission's decision. As Article XIX explains, 'The decision of the Commission shall be final and binding if the parties have so agreed; otherwise the Commission shall render a final and recommendatory award, which the parties shall consider in good faith.' This was not a problem in 1978, when a mutually agreed outcome was achieved between Canada and the Soviet Union.

3.1.6 Liability and National Courts

The infrequent use of the Liability Convention and the potential enforcement challenges make it likely that national courts will eventually become involved when satellites are damaged due to alleged fault on the part of other operators. The involvement of national courts is made more likely by the dramatic increase in the number of private operators, who might prefer to seek their own remedies rather than trust national governments to do so on their behalf. In common law systems such as the United States, the United Kingdom, Canada, Australia and New Zealand such suits would be grounded in tort law and specifically the tort of negligence[35] – a failure to behave with the level of care that someone of ordinary prudence would have exercised under the same circumstances.[36]

As we explained above, international guidelines and industry practices can help national courts to determine whether a satellite operator was acting reasonably. For instance, an operator launching mega-constellation satellites today without end-of-life de-orbiting technology might well be acting irresponsibly and therefore negligently.

Assessing the 'reasonableness' of behaviour is one thing, but determining 'causation' for damage is another. Establishing causation can be especially difficult for the secondary and tertiary effects of a negligent action, for example damage caused to satellites by debris from a previous collision, or damage caused to governments, companies or individuals on Earth from the loss of the services provided by those satellites. But again, just as advances in medical science opened the door to litigation against

[35] Tort law concerns acts or omissions that give rise to injury or harm to others and amount to civil (as opposed to criminal) wrongs.

[36] For an interesting analysis of how negligence might be determined in the event of damage caused during a 'rendezvous and proximity operation', and specifically the on-orbit servicing of a satellite, see Christopher Newman, Ralph Dinsley and William Ralston, 'Introducing the law games: Predicting legal liability and fault in satellite operations' (2021) 67:11 *Advances in Space Research* 3785.

tobacco companies, and advances in climate science are now opening the door to climate change litigation against fossil-fuel companies, we can expect that advances in Space situational awareness (SSA) will dramatically reduce uncertainties concerning causation for secondary collisions involving trackable debris, and thus strengthen the role of liability as an incentive for good behaviour in Space. For example, the California-based company LeoLabs uses its own network of ground-based phased-arrayed radars to provide SSA to satellite companies, including 'conjunction' warnings that can enable satellites to be moved out of the way of an impending collision.[37] A similar, more recent entrant is Hawaii-based Privateer, backed by Apple co-founder Steve Wozniak and significantly involving Space environmentalist and aerospace engineer Moriba Jah, which is developing 'knowledge graph technology' to provide satellite operators a comprehensive real-time map of Space objects.[38] The SSA obtained and catalogued by these companies could be used to supplement data obtained and catalogued by national governments, most notably USSPACECOM, in determining causation for an actual collision. In other words, it could be employed not only prospectively to predict possible collisions and thus help prevent them, but also retrospectively to determine what happened.

Smaller non-trackable debris will, however, remain a lethal threat to satellites, notwithstanding advances in SSA, and establishing causation for a collision will be impossible in some circumstances. But in a growing number of instances improved SSA will help with event-linking, even if only on the balance of probabilities – which, as it happens, is the standard required in tort cases in the United States and other common law countries.

3.1.7 International Law-Making before, Not after, a Major Disaster

Collisions are still infrequent enough that satellite operators might continue to treat them, and the even smaller risk of having to pay compensation, as simply a 'cost of doing business' in an inherently risky domain.[39] And with a tragedy of the commons emerging quickly, it seems unwise to

[37] See 'LeoLabs – The Mapping Platform for Space' (2022), *LeoLabs Inc.*, online: www.leolabs.space.

[38] See 'Privateer' (2022), *Privateer Space Inc.*, online: www.privateer.com.

[39] See e.g. Kenneth S Abraham, 'Environmental Liability and the Limits of Insurance' (1988) 88:5 *Columbia Law Review* 942 at 957: 'Ordinary strict liability is a cost of doing business that enterprises and their insurers can anticipate and finance, even when the damages imposed are not worth avoiding.'

count on litigation in national courts to ensure the global adoption of best practices in time to ward off a major disaster. Strong regulatory action is required on the part of most, if not all, national governments. The best way to achieve this 'collective action' and to prevent 'free riding' and the emergence of 'flag-of-convenience' states is through multilateral agreements that set clear standards and provide transparency and accountability for them. Skeptics of this approach should once again consider the double-hull requirement for oil tankers, which has been adopted by all the major shipping states and is now followed, without deviation, by the shipbuilding industry worldwide.

We should not have to wait for a major disaster like the Exxon Valdez oil spill to generate the political will necessary for effective international law-making. Collisions involving mega-constellation satellites are entirely foreseeable. They have the potential to create vast amounts of long-lasting debris, including debris that is untrackable but still lethal, with severe consequences for the future use of LEO, for the global economy and even for human safety. The time to act is now.

3.2 Astronomy, Mega-constellations, and International Law

Astronomy is the oldest way humanity has explored the cosmos. It is a science that cultivates an understanding of Earth's place in the universe and has a long and continuing history of testing fundamental laws of physics. There is a direct connection between Tycho Brahe's early observations, analysed and understood by Johannes Kepler, and the development of Newtonian gravity. 'Newton's cannonball', a thought experiment that Newton used to demonstrate the principles of an orbit, is really just an artificial satellite. Astronomy later provided the primary tests for Einstein's 'general relativity', a more complete theory of gravity, and played a critical role in understanding processes such as nuclear fusion.

It is already well established that mega-constellations threaten astronomy.[40] Astronomers have been pushing for reductions in the

[40] Robert Massey, Sara Lucatello and Piero Benvenuti, 'The challenge of satellite megaconstellations' (2020) 4 *Nature Astronomy* 1022; Aparna Venkatesan, James Lowenthal, Parvathy Prem and Monica Vidaurri, 'The impact of satellite constellations on space as an ancestral global commons' (2020) 4 *Nature Astronomy* 1043; Miroslav Kocifaj, Frantisek Kundracik, John C. Barentine and Salvador Bará, 'The proliferation of space objects is a rapidly increasing source of artificial night sky brightness' (2021) 504:1 *Monthly Notices of the Royal Astronomical Society: Letters* L40; American Astronomical Society (AAS), 'Impact of satellite constellations on optical astronomy and recommendations

number and brightness of Starlink satellites since an image from a telescope in Chile was ruined in 2019.[41] SpaceX responded by adding visors to its satellites, which has reduced their brightness but still left them bright to telescopes and visible to the naked eye for a non-trivial amount of time.[42] Especially vulnerable are both next-generation sky surveys, which seek to catalogue all visible bodies, and observations close to the horizon, especially near sunrise and sunset. These surveys and observations are critical for detecting and tracking near-Earth objects for planetary defence.

Radio astronomy is also threatened since mega-constellations will require frequencies additional to those traditionally used by communications systems on the ground.[43] Portions of spectrum that are protected for radio astronomy could be encroached upon through 'out-of-band emissions'. The vast number of fast-moving transmitting stations (i.e. individual satellites within mega-constellations) will cause further interference. Although new analysis methods could mitigate some of these effects, data loss is inevitable, increasing the time needed for each radio astronomy study and limiting the overall amount of science that can be done.

The figure at the beginning of Chapter 2 shows how satellites have already created bright streaks across telescope images. There are also transient moments of interference, such as visual flares from specular (mirror-like) reflections – essentially, sunlight glinting brightly off a satellite's surface. The first commercial constellation, launched by Iridium in the 1990s to provide global satellite phone coverage, produced flares that were so bright and predictable that they became widely referred to as 'Iridium flares'. Radio astronomy has also already experienced interference from terrestrial and Space-borne sources, including communications satellites in both geosynchronous (GEO) and low Earth orbit (LEO).

towards mitigations' (2020), ed. Constance Walker and Jeffrey Hall ['SATCON1 Report'], online: aas.org/sites/default/files/2020-08/SATCON1-Report.pdf; AAS, 'Report of the SATCON2 workshop' (2021), ed. Constance Walker and Jeffrey Hall ['SATCON2 Report'], online: baas.aas.org/pub/2021i0205/release/1; International Astronomical Union (IAU) and UNOOSA, 'Dark and quiet skies for science and society – Report and recommendations' (2021), ed. Constance Walker and Simonetta Di Pippo ['Dark and Quiet Skies I Report'], online: www.iau.org/static/publications/dqskies-book-29-12-20.pdf; IAU and UNOOSA, 'Dark and Quiet Skies II for Science and Society – Working Group Reports' (2022), ed. Constance Walker and Piero Benvenuti ['Dark and Quiet Skies II Report'], online: doi.org/10.5281/zenodo.5874725.

41 IAU, announcement, ann19035, 'IAU statement on satellite constellations' (3 June 2019), online: www.iau.org/news/announcements/detail/ann19035.

42 AAS, 'SATCON1 report', op. cit.

43 Ibid.

Mega-constellations could magnify these problems to the point where the effects on astronomy become intolerable. Several major astronomy-led initiatives have emerged in response, including SATCON 1 and 2, as well as the International Astronomical Union and UN Office for Outer Space Affairs co-sponsored Dark and Quiet Skies.[44] In what follows, we focus on the effects of mega-constellations on optical astronomy, in part because visual interference also threatens natural and cultural heritage. This includes the ability – perhaps even the right – of every human being to observe and enjoy the night sky.

3.2.1 Astronomical Concerns

The principal concern for astronomers is that satellites are bright and there are increasing numbers of them. Data loss from a single streak is one thing, but some satellites are so bright that imaging taken by some of the world's major astronomical facilities will develop detector-specific artefacts. One example is 'ghost' streaks, which are additional streaks in the image caused by the response of the detector electronics to localised overexposures of light.[45] Moreover, wide-field, long-exposure work will experience real multiple streaks per image.[46] Data will be lost, while the extra 'noise' from all these bright sources will make it more difficult to detect faint objects, including asteroids and comets.

Satellites also increase the potential for misidentified phenomena through transient features such as 'rare flares' – flares that occur only infrequently with a single satellite but could be quite common with a constellation comprising thousands of satellites. Even satellites and other large objects in high orbits will create noise. This is not hypothetical; some claims of new discoveries about the universe have already been based on misidentified Space debris.[47]

44 Ibid.; AAS, 'SATCON2 report', op. cit; IAU and UNOOSA, 'Dark and quiet skies I report', op. cit; IAU and UNOOSA, 'Dark and quiet skies II report', op. cit. See also Giuliana Rotola and Andrew Williams, 'Regulatory Context of Conflicting Uses of Outer Space: Astronomy and Satellite Constellations' (2021) 46:4/5 Air and Space Law 545.

45 AAS, 'SATCON1 report', op. cit.

46 Samantha Lawler, Aaron Boley and Hanno Rein, 'Visibility predictions for near-future satellite megaconstellations: Latitudes near 50° will experience the worst light pollution' (2022) 163:1 *Astronomical Journal* 21.

47 Tereza Pultarova, 'The oldest gamma-ray burst ever discovered was just a piece of space junk', *Space.com* (7 October 2021), online: www.space.com/oldest-gamma-ray-burst-space-junk-mistake.

The unseen might also be problematic for astronomy: satellites that are in Earth's shadow can still pass in front of stars and other astronomical objects, blocking their light in what astronomers call 'occultations'. Although most research programmes will be unaffected, at least for now, rapid time-domain astronomy[48] could eventually suffer in some cases.[49] In a related issue, satellites transiting in front of the Sun in sufficient numbers could interfere with ground-based solar observing.

Astronomers have been co-ordinating with the satellite industry to establish a set of informal guidelines to address some of the above issues. Based on modelling how satellites can affect observing facilities and amateur sky watchers, several important recommendations have been made.[50] We reproduce two of these guidelines here, followed by additional explanation:

I. Priority No. 1: Address the visible brightness of the satellites as seen from the ground.
   A. Objective: Reduce brightness to minimize impact on astronomy and night sky observers
   B. Guidelines:
      1. Endeavor to reach the fainter of these in all phases of a constellation:
         a) Unaided eye visibility: $V > 7.0$ mag where V is the photopic vision sensitivity curve.[51] Or

[48] Time-domain astronomy is a broad field that explores how properties of astronomical objects, such as brightness and light spectrum, vary with time.

[49] Most satellite occultations will be too rapid to cause substantial interference with observing programmes. However, as astronomers push the limits of observatories to detect ever-faster variability in the sky, satellite occultations could become a major source of noise. One near-future program might already stand to be affected as soon as it comes online – the TAOS II search for small astronomical bodies orbiting beyond Neptune. See Academia Sinica Institute of Astronomy and Astrophysics (ASIAA), 'TAOS II: The transneptunian automated occultation survey' (2021), *ASIAA*, online: taos2.asiaa.sinica.edu.tw.

[50] IAU and UNOOSA, 'Dark and quiet skies II report', op. cit., ch 4.

[51] An astronomical magnitude ('mag') is a measurement of the brightness of an object based on the logarithm of the flux. Specifically, the magnitude is defined as $m = -2.5 \ \log_{10}(F) + C$, where C is a constant and F is the observed flux in a bandpass (region of the spectrum). A larger magnitude signifies a fainter source. For example an object with a magnitude of 10 is fainter than an object with a magnitude of 5, and an object with a magnitude of –5 is brighter still.

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b) $V > 7 + 2.5\ log_{10}\left(\frac{r_{\text{orbit}}}{550\ \text{km}}\right)$, equivalent to $44\times\left(\frac{550\ \text{km}}{r_{\text{orbit}}}\right)$ watts/steradian,[52] where r_{orbit} is the mean altitude of the satellite orbit in kilometres and V in this case is the Johnson V bandpass at 550 nanometres.[53]

. . .

II. Priority No. 2: Address the visibility impact on astronomical sciences of large constellations of LEO satellites with altitudes above 600 kilometres

A. Objective: Navigate the balance between constellation size and altitude to allow achievement of satellite service objectives while minimizing impact on astronomy

B. Guidelines

1. Endeavor to have satellite constellations operate in orbits with altitudes below about 600 kilometres, if practicable, when consistent with operational and safety objectives and constraints, in order to minimize the rate of sunlight streaks in the dark hours between evening and morning twilight for the largest-aperture telescopes.
2. If the constellation cannot be planned for altitudes below ~600 kilometres, the impact on astronomical observations would still be reduced on balance if the constellation designers were to choose a lower rather than higher operational altitude.[54]

. . .

The motivation behind these recommended guidelines can be understood as follows. Guideline 1a under Priority No. 1 is just a statement that the satellites should be undetectable by the unaided eye. Guideline 1b, also under Priority No. 1, is a little more complicated, but can be understood conceptually. All other things being equal, a satellite's brightness will depend on the square of the inverse distance between the observer and the satellite; satellites on lower orbits are brighter than satellites on more distant orbits. However, the speed of a satellite's motion across the sky also depends on the orbit and the observer–object distance, with satellites in lower orbits 'moving' faster. If a bright object moves across a detector

[52] Watt is a measure of energy per time and steradian is an angular area (in this case, square radians).

[53] IAU and UNOOSA, 'Dark and quiet skies II report', op. cit. at 237.

[54] Ibid. at 238.

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quickly, its impact on the detector is reduced, as compared to when that same object is moving slowly or is stationary. In other words, spreading the light out reduces the negative effects, and a bright satellite with a dim streak is preferred over a dim satellite with a bright streak. This is part of the rationale for the brightness limit and why the satellite's mean altitude is included in the equation in the way that it is. The goal of the limit is to minimise the creation of 'ghost' features at major astronomical facilities, as mentioned above. The limit is still far from optimal, as satellites that meet this requirement could still be easily observable in even small telescopes.

The reason for Priority No. 2 and associated guidelines is that keeping satellites below 600 kilometres will tend to limit the number of satellites that are sunlit – i.e. not in Earth's shadow – between twilight hours, at low latitudes nearer the equator throughout the year. Although science such as the detection of near-Earth objects (and therefore planetary defence) will continue to be affected, most observing plans will see limited adverse effects.

Not all astronomers agree with a 600-kilometre altitude limit for mega-constellations, with at least three concerns having been voiced. First, placing satellites at lower altitudes than what might be optimal from an engineering perspective could have an unintended consequence – namely that operators might need more satellites to provide the same level of service. The reason for this is that a satellite at a lower altitude will have a smaller coverage area ('beam footprint') on Earth's surface. Second, it is not clear what effect a 600-kilometre limit might have on other issues of Space sustainability. On the one hand, because it would ensure that satellites are placed in the region of LEO most strongly influenced by gas drag and therefore orbital decay,[55] over time this could help ensure a clean orbital environment after satellites become defunct or other debris is generated. On the other hand, however, a 600-kilometre limit would increase the densification of orbits, thus increasing – potentially quite dramatically – the likelihood and consequences of collisions.

A third concern is with the brightness of the satellites in an absolute sense. If brightness limits are not achieved, then the preference indicated above for placing mega-constellations at lower altitudes could lead to larger numbers of satellites visible to the naked eye. And even if the brightness limits are followed, they may be met only part of the time due to variability. Moreover, these recommended limits are heavily

55 Earth's upper atmosphere extends into LEO, albeit with very low gas densities. An object moving through gas feels a resistance against its motion, called 'gas drag'.

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biased towards astronomical facilities at low latitudes. At moderate and high latitudes, the 600-kilometre threshold is of little assistance, with bright satellites visible throughout the night during summer.[56] This has additional substantial implications for natural and cultural heritage.

Already, most people have lost nearly all visible contact with the night sky due to terrestrial light pollution. However, many can still escape cities and their attendant light pollution to experience skies that are almost as dark as our ancestors once knew them. To those who have not experienced it, it is difficult to describe the impact that seeing the Milky Way can have on one's sense of self. Seeing a sky replete with stars can inspire one to imagine a universe of possibilities. Yet if the proposed mega-constellations are completed as planned, without steps taken to reduce their visibility, those of us who live at moderately high latitudes will no longer be able to retreat to the countryside to see a dark, star-filled sky. Instead of the night sky as we have known it for millennia, one out of every ten stars will be a satellite streaking across the sky.[57]

As mentioned, several satellite companies, notably SpaceX and Amazon, are now taking the concerns of astronomers seriously and working with them towards brightness mitigation, with some moderate success. However, the proposed brightness limits have not yet been achieved, with measurements of on-orbit satellites demonstrating significant brightness variations.[58] Some companies are concerned that if some licensing states impose rules on brightness and others do not, this could lead to a competitive disadvantage for themselves – assuming that the measures necessary to reduce brightness require operational compromises. But seen from a broader perspective, these sorts of concern are hardly new.

[56] Recent work by Lawler and colleagues has demonstrated that the Starlink 550-kilometre shell will heavily impact the night sky at close to 50° latitude and that the satellites are indeed observable all night long. See Lawler, Boley and Rein, op. cit; and Aaron C Boley, Ewan Wright, Samantha Lawler, Paul Hickson and Dave Balam, 'Plaskett 1.8 metre observations of Starlink satellites' (2022) 163:5 *Astronomical Journal* 199. This issue was recognised in the Priority No. 2 guidelines of the 'Dark and quiet skies II report' through a note: 'The altitude of the LEO satellite constellation does not have a uniform impact on observations around the world. Lower orbit altitudes impact programs disproportionately at latitudes outside of +35 and −35 [deg], and increasing the number of satellites on orbit impacts programs that depend on observations in twilight, such as those for planetary defense. Further, if the satellites are not dimmer than naked-eye brightness natural and cultural heritage may be affected'. See IAU and UNOOSA, 'Dark and quiet skies II report', op. cit. at 238.

[57] Lawler, Boley and Rein, op. cit.

[58] IAU and UNOOSA, 'Dark and quiet skies II report', op. cit.; Boley et al., op. cit.

Over time, comparable concerns have been voiced in nearly every industry that operates internationally, with a common response being multilateral negotiations leading to internationally agreed rules. Done well, these rules ensure that every actor is subject to the same standards, thus discouraging 'free riding' and the emergence of 'flags of convenience'. However, before recommending the establishment of such standards, we first need to ask whether international law already requires states to prevent, or at least reduce, the interference caused to astronomical observatories located in – or operated by – other countries?

3.2.2 Astronomy and International Law

In previous chapters, we interpreted relevant provisions of the Outer Space Treaty[59] in accordance with the customary international law rules on treaty interpretation, as codified in the Vienna Convention on the Law of Treaties.[60] We will do so again here. Our interpretation will lead to several conclusions. First, mega-constellations and astronomical observatories constitute two competing exercises of the freedom of 'exploration and use' of Space. Second, this situation engages a duty of 'due regard' on the part of states receiving licensing requests for mega-constellations. The duty is owed to states that operate, host, supervise or otherwise contribute to telescopes that could be impeded by light pollution from satellites. Since the Outer Space Treaty does not tell us what the duty of 'due regard' entails, we will – in accordance with the Vienna Convention – look to the ordinary meaning of the term, to its context – including the preamble and other articles of the treaty – as well as to the object and purpose of the treaty. We will also look to general rules of international law, such as the duty not to cause harm to other states, as well as more recent legal advances such as the precautionary principle.

[59] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 27 January 1967, 610 UNTS 205 (entered into force 10 October 1967) (Outer Space Treaty).

[60] Vienna Convention on the Law of Treaties, 23 May 1969, 1155 UNTS 331 (entered into force 27 January 1980) (Vienna Convention). The International Court of Justice has often stated that the Vienna Convention codifies customary international law. See e.g. *Case Concerning Kasikili/Sedudu Island* (*Botswana* v. *Namibia*), [1999] ICJ Rep 1045 at 1059, para. 18; *Legal Consequences of the Construction of a Wall in the Occupied Palestinian Territory*, Advisory Opinion, [2004] ICJ Rep 136 at 174, para. 94; *Armed Activities on the Territory of the Congo* (*Democratic Republic of the Congo* v. *Rwanda*), [2006] ICJ Rep 6 at 51–52, para. 125. For the pre-existing rules of customary international law, see Lord McNair, *The Law of Treaties* (Oxford: Oxford University Press, 1961) (republished 1986).

As we will explain, the precautionary principle, as accepted and applied today, includes a requirement to conduct environmental impact assessments of any planned project having potentially deleterious international effects, and then, when necessary, to take action to protect against the assessed harm. In the case of Starlink, the US government never conducted an environmental impact assessment of the potential for tens of thousands of satellites in LEO to cause harm, including to astronomy, even though, under the Outer Space Treaty, the Liability Convention and customary international law, governments are responsible for all 'national activities' in Space. The United States might not be alone in acting contrary to international law here: other states, such as the United Kingdom, with its OneWeb project, could well be engaged in similar violations.

This chapter will conclude with a consideration of how states that have licensed mega-constellations without environmental impact assessments could be brought into compliance with international law. This includes pausing the construction of mega-constellations until such assessments can take place.

3.2.3 Interpreting the Outer Space Treaty

3.2.3.1 Is Astronomy a Form of 'Exploration and Use'?

Article I of the Outer Space Treaty reads,

> The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all [hu]mankind.
>
> Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.
>
> There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.[61]

The terms 'exploration' and 'use' are not defined in the Outer Space Treaty. Nobody disputes that operating communications satellites in LEO constitutes 'use', but what about astronomy conducted from

[61] Outer Space Treaty, op. cit., Art. I.

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ground-based telescopes? In accordance with Article 31 of the Vienna Convention, we look first to 'the ordinary meaning to be given to the terms of the treaty'.

3.2.3.1.1 Ordinary Meaning According to the *Merriam-Webster Dictionary*, the noun form of 'use' has many definitions, with the first of the normal usages being the most relevant here:

1 a: the act or practice of employing something
  b: the fact or state of being used
  c: method or manner of employing or applying something.[62]

Several entries for the transitive verb form of 'use' are also of relevance:

1: to put into action or service: avail oneself of: employ
2: to expend or consume by putting to use – often used with *up*
. . .
5: to carry out a purpose or action by means of.[63]

Astronomy has long had the practice of putting Space 'into service' for understanding natural phenomena, discovering and testing physical laws, and enjoying the cosmos. Indeed, for many states, including space-faring states, astronomy remains the primary means by which Space is explored.

This brings us to 'exploration'. The verb is more helpful here, as exploration is just the act of exploring. We turn again to the *Merriam-Webster Dictionary*:

Transitive
1 a: to investigate, study, or analyze: look into
  b: to become familiar with by testing or experimenting
2: to travel over (new territory) for adventure or discovery
3: to examine especially for diagnostic purposes
Intransitive
1: to make or conduct a systematic search.[64]

[62] Merriam-Webster, 'Use' (2022), *Merriam-Webster.com Dictionary*, online: www.merriam-webster.com/dictionary/use.
[63] Ibid.
[64] Merriam-Webster, 'Explore' (2022), *Merriam-Webster.com Dictionary*, online: www.merriam-webster.com/dictionary/explore.

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Before analysing 'to explore' further, we should also consider the definition of 'astronomy'. The same *Merriam-Webster Dictionary* defines it as 'the study of objects and matter outside the earth's atmosphere and of their physical and chemical properties'.[65] In practice, an astronomer would likely describe astronomy as an observational science that seeks to understand and study the Solar System, the galaxy and the universe, as well as to understand Earth's place in all of these. It is also used to test physical laws.

Astronomy fulfils the above first and third definitions of 'exploration' for the transitive mood, as well as the definition of the intransitive. In ordinary usage, it seems uncontroversial that astronomy is a form of exploring Space; indeed, it is the original and oldest way that this has been done.

3.2.3.1.2 The Context of the Terms Article 31 of the Vienna Convention further requires that we look to the 'ordinary meaning to be given to the terms of the treaty in their context', which includes the full text of the treaty, including its preamble.

Of relevance here, two similar but different phrases are found throughout the Outer Space Treaty: 'activities in the exploration and use of outer space' and 'activities in outer space'. The former phrase appears in Articles III, IX (twice) and XIII, while the latter appears in Articles V, VI (three times), IX and XI. There is nothing to suggest that the terms were employed interchangeably or accidentally – the drafting of these provisions took place over a considerable period of time, with many international lawyers involved. We can therefore be confident that the drafters of the Outer Space Treaty intended them to mean different things, with the most logical explanation being that 'activities in the exploration and use of outer space' can include activities on Earth's surface, such as astronomy.

To highlight this point, here are a few examples of the different terms as they are used in the Outer Space Treaty. The first part of Article III reads, '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'. In contrast, the middle paragraph of Article V reads, 'In carrying on activities in outer space and on celestial bodies, the astronauts of one State Party shall render all possible assistance to the astronauts of other States Parties.' The

65 Merriam-Webster, 'Astronomy' (2022), *Merriam-Webster.com Dictionary*, online: www.merriam-webster.com/dictionary/astronomy.

astronaut activities referred to in Article V take place in Space, while the terminology in Article III is more encompassing. This, and our analysis of the context of the term more broadly, indicate that 'exploration and use' includes Earth-based activities such as astronomy.

3.2.3.1.3 The Object and Purpose of the Treaty Article 31 of the Vienna Convention further requires that we look to the ordinary meaning to be given to the terms of the treaty 'in the light of its [the treaty's] object and purpose.' The object and purpose of the Outer Space Treaty are made clear in its preamble, which includes the following lines:

> Recognizing the common interest of all [hu]mankind in the progress of the exploration and use of outer space for peaceful purposes,
>
> Believing that the exploration and use of outer space should be carried on for the benefit of all peoples irrespective of the degree of their economic or scientific development,
>
> Desiring to contribute to broad international co-operation in *the scientific as well as the legal aspects of the exploration and use of outer space* for peaceful purposes . . .[66]

The object and purpose of the Outer Space Treaty accordingly include the advancement of knowledge about Space, with 'exploration and use' explicitly encompassing 'scientific . . . aspects' as declared in this preamble. Given that astronomy is the original and oldest way that humanity has studied Space and continues to provide significantly more scientific knowledge to our understanding of it than spacecraft and astronauts, this treaty's object and purpose convincingly support an interpretation of 'exploration and use' that includes astronomy.

3.2.3.1.4 Supplementary Means of Interpretation Under Article 32 of the Vienna Convention, recourse may be had to 'supplementary means of interpretation', including 'the preparatory work of the treaty and the circumstances of its conclusion'. But such recourse may only be had

> to confirm the meaning resulting from the application of article 31, or to determine the meaning when the interpretation according to article 31:
>
> (a) leaves the meaning ambiguous or obscure; or
> (b) leads to a result which is manifestly absurd or unreasonable.[67]

[66] Outer Space Treaty, op. cit., preamble, emphasis added.
[67] Vienna Convention, op. cit., Art. 32.

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The Article 31 interpretation we have conducted above does not fulfill the criteria in Article 32(a) or (b), in that the resulting meaning is both clear and reasonable – i.e. astronomy is a form of 'exploration and use'. For this reason, we can only look to 'the preparatory work of the treaty and the circumstances of its conclusion' to confirm our interpretation. As it happens, the circumstances of the Outer Space Treaty's conclusion provide this confirmation. We discuss two aspects of those circumstances here: the 1959 Antarctic Treaty and the West Ford experiment of 1961–1963.

The 1959 Antarctic Treaty is relevant to the conclusion of the 1967 Outer Space Treaty for three reasons.[68] First, both treaties were unusual for their time because they concerned an 'area beyond national jurisdiction'. Second, the negotiators of the Outer Space Treaty had deep knowledge of the Antarctic Treaty. They drew directly on its language and readily admitted its influence on their thinking.[69] Third, the Antarctic Treaty places considerable importance on a 'freedom of scientific investigation' (Preamble; Art. II), including by requiring co-operation and transparency between the parties in their scientific research (Art. III). It reflects a broad conception of scientific investigation unlimited by sovereignty or boundaries.[70] The Antarctic Treaty thus supports an interpretation of 'exploration and use of outer space' that includes astronomy.

The West Ford experiment, conducted by the US military from 1961 to 1963, involved the launch and release of millions of small copper needles into LEO for the purpose of creating an artificial belt around the Earth to reflect long-range radio waves from ground stations. The Soviet Union and other states complained that no prior consultation with the global scientific community had taken place. Radio astronomers complained that the experiment had the potential to interfere with their observations, with the International Astronomical Union expressing 'great concern' about 'the grave danger that some future space projects might seriously interfere with astronomical observations in the optical as well as in the radio domain' and maintaining that 'no group has the right

[68] The Antarctic Treaty, 1 December 1959, 402 UNTS 71 (entered into force 23 June 1961).
[69] US, *Treaty on Outer Space: Hearings before the Committee on Foreign Relations United States Senate*, 90th Cong (1967) at 80 (Deputy Secretary of Defense Cyrus R Vance).
[70] Although slightly off point, it is interesting to note that Antarctica has served as a base for major astronomical operations. See Michael G Burton, 'Astronomy in Antarctica' (2010) 18:4 *Astronomy and Astrophysics Review* 417.

to change the Earth's environment in any significant way without full international study and agreement'.[71]

These concerns led to the Scientific and Technical Subcommittee of COPUOS recommending, in May 1963, that COPUOS turn its attention 'to the urgency and the importance of the problem of preventing potentially harmful interference with peaceful uses of outer space'.[72] The Soviet Union and the United States then negotiated a draft declaration, which was adopted without change by COPUOS in November 1963 and shortly thereafter was adopted by the United Nations General Assembly as the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space ('Resolution 1962').

Principle 6 of Resolution 1962 reads,

> In the exploration and use of outer space, States shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space with due regard for the corresponding interests of other States. If a State has reason to believe that an outer space activity or experiment planned by it or its nationals would cause potentially harmful interference with activities of other States in the peaceful exploration and use of outer space, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State which has reason to believe that an outer space activity or experiment planned by another State would cause potentially harmful interference with activities in the peaceful exploration and use of outer space may request consultation concerning the activity or experiment.[73]

Some three years later, Principle 6 became the basis for Article IX of the Outer Space Treaty, thus creating a direct originating connection between the threat posed to astronomy by the West Ford experiment and Space being 'free for exploration and use'. It is difficult to imagine a clearer confirmation that the term 'exploration and use of outer space' in its international law context has therefore always included astronomy and continues to do so.

[71] IAU, 'Resolution No. 1' (XI General Assembly of the IAU, Berkeley, 1961) at 4, online: www.iau.org/static/resolutions/IAU1961_French.pdf.

[72] US, Department of State, *US Participation in the UN: Report by the President to the Congress for the Year 1961* (Pub 7675) (International Organization and Conference Series 51, August 1964) at 30; See also Sergio Marchisio, 'Article IX', in Stephan Hobe, Bernhard Schmidt-Tedd and Kai-Uwe Schrog, eds., *Cologne Commentary on Space Law: Volume 1* (Cologne: Carl Heymanns Verlag, 2009) 169.

[73] *Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space*, GA Res 1962 (XVIII), UNGAOR, 18th Sess, 1280th Plen Mtg, UN Doc A/RES/1962(XVIII) (1963) at 15.

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3.2.3.2 The Duty of 'Due Regard'

So far, our application of the rules on treaty interpretation has determined that mega-constellations and astronomical observatories constitute two competing exercises of the freedom of 'exploration and use' of Space. This now takes us, again, to Article IX of the Outer Space Treaty, and particularly the obligation of 'due regard'.

Article IX reads in full,

> *In the exploration and use of outer space, including the moon and other celestial bodies, States Parties* to the Treaty shall be guided by the principle of co-operation and mutual assistance and *shall conduct all their activities in outer space*, including the moon and other celestial bodies, *with due regard to the corresponding interests of all other States Parties to the Treaty*. States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, may request consultation concerning the activity or experiment.[74]

3.2.3.2.1 The Ordinary Meaning of the Terms The *Merriam-Webster Dictionary* identifies 'with due regard to' as an idiom meaning 'with the proper care or concern for'.[75] *Black's Law Dictionary* defines 'due regard' as 'to give a fair consideration to and give sufficient attention to all of the facts'.[76] Both these definitions indicate that the duty is one of care and that it likely extends across different and potentially changing circumstances.

[74] Outer Space Treaty, op. cit., Art. IX, emphasis added.

[75] Merriam-Webster, 'with due regard to' (2022), *Merriam-Webster.com Dictionary*, online: www.merriam-webster.com/dictionary/with%20due%20regard%20to.

[76] *Black's Law Dictionary*, 'What is due regard?' (2022), *The Law Dictionary.org*, online: thelawdictionary.org/due-regard.

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3.2.3.2.2 The Context of the Terms For the purposes of treaty interpretation, the context includes the rest of Article IX, which tells us what 'due regard' means – namely not causing 'potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space'. Although Article IX adds a further requirement to 'undertake appropriate international consultations' if there is reason to believe that a planned 'activity or experiment' will cause such interference, there is nothing in the Outer Space Treaty to suggest that a state that undertakes consultations is thereafter free to proceed with its 'potentially harmful' plans as originally designed, or is somehow excused from legal responsibility if harm does in fact arise. As a result, the obligation of due regard is not to cause 'potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space', full stop.

3.2.3.2.3 The Object and Purpose of the Treaty The preamble to the Outer Space Treaty, including the passages quoted above, indicates that its object and purpose are to ensure that Space remains open to all states through the maintenance of peace and the pursuit of international co-operation. This supports a broad and meaningful interpretation of 'due regard'.

3.2.3.2.4 Relevant Rules of International Law Article 31(3)(c) of the Vienna Convention stipulates, 'There shall be taken into account, together with the context . . . (c) any relevant rules of international law applicable in the relations between the parties.'

These relevant rules are not limited only to those that existed when the Outer Space Treaty was concluded in 1967 but also include rules that have developed since. Indeed, what is required by 'due regard' under international law will almost always evolve over time due to new knowledge, circumstances and technologies. 'Due regard' is what Lord McNair referred to as a 'relative term'. As the author of the definitive *The Law of Treaties* explained, 'Expressions such as "suitable, appropriate, convenient", occurring in a treaty are not stereotyped as at the date of the treaty but must be understood in the light of the progress of events'.[77]

The duty of due regard, interpreted in accordance with developments since 1967, engages the now well-established rule of customary

[77] McNair, op. cit. at 467.

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international law set out in Principle 21 of the 1972 Stockholm Declaration: 'States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction'.[78] This was reaffirmed by Principle 2 of the 1992 Rio Declaration.[79] Many multilateral environmental treaties now include the obligation not to cause damage to the environment of other states or of areas beyond the limits of national jurisdiction,[80] and the International Court of Justice has referred to this rule on numerous occasions.[81]

The duty of due regard, interpreted in accordance with developments since 1967, also engages the precautionary principle. Principle 15 of the Rio Declaration reads, 'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'.[82] Similarly, Article 3(3) of the 1992 UN Framework Convention on Climate Change reads, 'Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full

[78] *Report of the UN Conference on the Human Environment ('Stockholm Declaration')*, Stockholm, UN Doc A/CONF48/14/Rev1 (1972) at 3.

[79] *Report of the United Nations Conference on Environment and Development* ('Rio Declaration'), Rio de Janeiro, UN Doc A/CONF.151/26/Rev.1(Vol. I) (1992) at 3.

[80] See e.g. United Nations Convention on the Law of the Sea, 10 December 1982, 1833 UNTS 397 Art. 194(2) (entered into force 16 November 1994): 'States shall take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights in accordance with this Convention'; Convention on Biological Diversity, 5 June 1992, 1760 UNTS 79 Art. 3 (entered into force 29 December 1993): 'States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.'

[81] See, e.g.: *Legality of the Threat or Use of Nuclear Weapons*, Advisory Opinion, [1996] ICJ Rep 226 at 241, para. 29; *Case Concerning the Gabčíkovo-Nagymaros Project* (*Hungary* v. *Slovakia*), [1997] ICJ Rep 7 at 41, para. 53.

[82] Rio Declaration, op. cit. at 6.

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scientific certainty should not be used as a reason for postponing such measures.'[83]

Today, the precautionary principle entails a responsibility to conduct an environmental impact assessment prior to authorising an activity that could cause damage to the environment of areas beyond the limits of national jurisdiction.[84] Space is the quintessential area beyond national jurisdiction. Yet the US government, and specifically the FCC, did not conduct an environmental impact assessment for Starlink before issuing a licence for 12,000 satellites. That omission, in our assessment, violates both the Outer Space Treaty and customary international law. Other states, such as the United Kingdom when it licensed OneWeb's mega-constellation, may have engaged in similar contraventions. To avoid ongoing and further violations of international law, the construction of these mega-constellations should be paused until environmental impact assessments can take place.

Although the existence of a legal requirement to pause the construction of mega-constellations might seem surprising to non-lawyers, 'cessation' is a well-established remedy in public international law. As Francesca Capone recently explained in the *Max Planck Encyclopedia of Public International Law*,

> The State responsible for the commission of a wrongful act is under an obligation to cease the conduct and to offer appropriate assurances, normally given verbally, and guarantees of non-repetition, such as preventive measures to be taken to avoid repetition of the breach. The function of cessation is twofold: to end the violation and protect the continuing validity and effectiveness of the primary rule. Thus, it safeguards both the rights of the State injured and the interests of the international community as a whole.[85]

All that being said, the conduct of an environmental impact assessment will not necessarily prevent a violation of international law. A government

83 *United Nations Framework Convention on Climate Change*, 9 May 1992, 1771 UNTS 107 Art. 3(3) (entered into force 21 March 194).

84 See *Case Concerning Pulp Mills on the River Uruguay* (*Argentina* v. *Uruguay*), [2010] ICJ Rep 14 at 79, para. 197; *Certain Activities Carried Out by Nicaragua in the Border Area* (*Costa Rica* v. *Nicaragua*), 2015 ICJ Rep 665 at 706, para. 104. See also Ulrich Beyerlin and Thilo Marauhn, *International Environmental Law* (Oxford: Hart, 2011) at 54.

85 Francesca Capone, 'Remedies', in Anne Peters, ed, *Max Planck Encyclopedia of Public International Law* (Oxford: Oxford University Press, article last modified Oct 2020), online: opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1089.

that conducted an environmental impact assessment and then licensed a mega-constellation in defiance of its findings would be contravening the obligation of due regard, as would one that conducted an environment impact assessment in a manner that was not objective or scientifically rigorous. A state negatively impacted by a mega-constellation (for instance, a state that hosted, operated, or otherwise supported astronomical observatories) would still be entitled to protest, make a claim, seek third-party dispute settlement or engage in countermeasures, just like any state suffering damage because of a violation of any other rule of international law.

3.2.3.3 Conclusion to the Treaty Interpretation

In the absence of environmental impact assessments, the continued operation of mega-constellations violates international law. This is because harm is being caused to astronomy, and therefore to other states' freedom of exploration and use of Space, in a manner that contravenes the obligation of due regard.

Diplomatic negotiations will be needed to find mutually agreeable solutions for mega-constellation licensing states and those states that host, operate or otherwise support astronomical observatories. In the meantime, licensing states will need to mitigate the harm being caused, with respect to both satellites in orbit and any satellites they plan to launch. Regarding the latter, environmental impact assessments are required, followed by licensing conditions that significantly reduce light pollution from single satellites as well as their cumulative effects. This requires a pause on further mega-constellation development until assessments and mitigation plans can be put into place.

At the same time, the needs of astronomy do not pose an absolute impediment to the use of LEO. Mega-constellations also constitute an exercise of the freedom of 'use' and exploration of Space. The two activities must therefore occur in balance, and there is presently no consensus on what that balance should look like. Until a consensus is found, international law favours astronomy, and not the further development of mega-constellations – since we know that the latter causes harm to the former, but not the other way around.

3.2.4 Mega-constellations in US Courts

The US government's failure to conduct an environmental impact assessment before licensing Starlink has also given rise to a case currently

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progressing through the US federal courts, although this litigation concerns US domestic law and not the international law discussed above.

In 2018, the FCC granted SpaceX approval to place 4,408 Starlink satellites at altitudes of 1,100 to 1,300 kilometres.[86] One year later, it granted a licence modification allowing SpaceX to reduce the orbital altitude of 1,584 of those satellites by half. In April 2021, the FCC issued another licence modification allowing the remaining 2,824 satellites to be lowered to altitudes of 540 to 570 kilometres. A separate and further 7,518 Starlink satellites, also approved in 2018, did not require a licence modification because their initial FCC approval was for altitudes of 335 to 346 kilometres.

At no point did the FCC conduct an environmental impact assessment prior to any of these approvals or licence modifications. It later justified this approach on the basis that satellites fall into a category of actions 'that normally do not have a significant effect on the human environment'.[87] In other words, a categorical exclusion was claimed, deeming an environmental assessment unnecessary without further consideration. While such exclusions are permitted under the US National Environmental Policy Act, it was done under the incorrect premise that satellites would not have an impact on the environment.

Viasat is a long-established company based in Carlsbad, California that specialises in providing secure communications for Western militaries and Internet services for passengers on commercial airliners from satellites located in GEO. The company's more than US$2 billion in annual revenue reflects the almost insatiable demand of the US military and intelligence services for Space-based broadband, including for the operation of armed drones. However, as discussed in Chapter 2, communications from satellites in GEO have a certain amount of 'latency' (i.e. signal delay) compared to satellites in LEO. The difference is about 240 milliseconds versus 10 milliseconds or less, enough to be of importance for some applications. This, along with the relatively low cost of mass-produced satellites launched on reusable rockets, makes Starlink a major commercial threat to Viasat's established business model. This

86 The history of the Starlink approvals is summarised in FCC, 'Federal Communications Commission's opposition to Viasat's motion for stay pending judicial review', in *Viasat Inc.* v. *Federal Communications Commission*, US Court of Appeals, DC Circuit, USCA Case #21-1123, Document #1902327 (14 June 2021), online: docs.fcc.gov/public/attachments/DOC-373276A1.pdf.

87 Ibid., at 5–6.

threat was confirmed in September 2021, when the US Department of Defense's Commercial Satellite Communication Office released a draft request for proposals (RFP) for 'Proliferated Low Earth Orbit Satellite-Based Commercial Services'.[88] Under this RFP, up to US$875 million worth of US government orders for satellite-based services operating from LEO will be made available.

In May 2021, Viasat sought judicial review of the FCC's licensing decisions on Starlink before the US Court of Appeals, District of Columbia Circuit, arguing that the licences were improperly granted. At the same time, the company requested a 'stay' which, if granted, would have prevented SpaceX from launching more satellites until the court could determine whether the licences had been wrongly issued. In July 2021, the court denied the stay but granted a motion to expedite the appeal, with final briefs submitted in October 2021 followed by oral arguments. A similar case, brought by satellite television provider Dish Network, was consolidated with Viasat's action by the court.

Viasat contended that the FCC had failed to comply with the US National Environmental Policy Act because it refused to conduct *any* environmental assessment before approving the Starlink mega-constellation. Viasat argued that such an assessment was necessary because of several identifiable environmental risks, including light pollution, orbital debris and climate impacts from both launches and satellite re-entries.

In their responses before the court, neither the FCC nor SpaceX addressed the substance of Viasat's complaints. They instead focused on the question whether Viasat has 'standing' to bring the case, given that it operates in GEO rather than LEO and therefore, arguably, is not affected by Starlink's plans. In response, Viasat asserted that it has plans for satellites in LEO, satellites that will be threatened by the large number of satellites that SpaceX is launching. It also claims that communications from its satellites in GEO could be substantially affected by having to broadcast through an increasingly radio-busy LEO to reach Earth. Surprisingly, Viasat has not argued that its satellites destined for GEO are threatened by Starlink satellites in the several weeks immediately following their launch when they are passing through LEO each 'GEO transfer orbit'. Nor has it argued that it is being detrimentally affected by

88 Sandra Erwin, 'DoD eager to leverage LEO broadband constellations', *SpaceNews* (15 November 2021), online: spacenews.com/dod-eager-to-leverage-leo-broadband-constellations.

the launch windows to GEO becoming ever more constrained by the proliferation of satellites in LEO. As we explain in Chapter 7, a collision between a satellite on a GEO transfer orbit and another satellite in LEO would be problematic for all orbits.

The currently ongoing Viasat versus SpaceX case is important because of the issues it raises, and because of the US federal courts' ultimate decision on the matter. This importance extends to the influence of these proceedings on international law. The Statute of the International Court of Justice identifies 'judicial decisions' as 'subsidiary means for the determination of rules of law',[89] and this is generally understood to include the decisions of national courts.[90] Those same national court decisions can also contribute as state practice to the making or changing of customary international law.[91]

Just as significantly, the proceedings and decisions of national courts can expose and elaborate issues that need to be dealt with internationally, and thus serve as an impetus for intergovernmental negotiations and treaty-making. Although Viasat is arguably not the ideal litigant for what could be an important test case, due to the issue of standing, law is not always made and changed by perfect plaintiffs. More important is that this US domestic case is drawing unprecedented attention to the environmental risks associated with mega-constellations, which can only be a positive in terms of promoting international action.

3.2.5 Bringing Licensing States into Compliance with International Law

The effort to bring licensing states into compliance with international law will likely require several strategies, one diplomatic, the other legal. The issue of mega-constellations and astronomy would benefit greatly from having national governments raise concerns, issue diplomatic protests,

[89] *Statute of the International Court of Justice*, 26 June 1945, Can TS 1945 No 7 Art. 38(1)(4) (entered into force 24 October 1945).

[90] Hugh Thirlway, *Sources of International Law*, 2nd ed (Oxford: Oxford University Press, 2019) at 140. See also 'Draft conclusions on identification of customary international law', in *Report of the International Law Commission Seventieth Session*, UNGAOR, 73rd Sess, Supp No 10, UN Doc A/73/10 at 121 (conclusion 13(2)) – 'Regard may be had, as appropriate, to decisions of national courts concerning the existence and content of rules of customary international law, as a subsidiary means for the determination of such rules.'

[91] Thirlway, op. cit. at 140.

propose resolutions at international organisations and engage dispute settlement measures. International law applies principally between states, not scientists, scientific associations or satellite companies. In the absence of a state champion, astronomers are just experts identifying problems; they themselves suffer from an issue of standing in the international context as they have no ‘international legal personality’.

To date, policy advocacy on this issue has focused on the satellite companies themselves, on national regulatory agencies such as the FCC, and soon – we expect – on highly specialised sub-bodies of international organisations such as the Scientific and Technical Subcommittee of COPUOS. It may be time to raise the profile of this issue further by convincing one or more states to advance a draft United Nations General Assembly resolution on mega-constellations and light pollution. Potentially, such a resolution could include a request for a non-binding but still authoritative ‘advisory opinion’ from the International Court of Justice (ICJ), which would constitute the first time a case concerning issues of international Space law was determined by this court. Since the ICJ deals only with public international law – i.e. the law that applies primarily between nation states – that request should focus on the harm caused to states that host, operate or support major observatories, though it could also usefully emphasise that the harm is caused to all humankind.