The long-term sustainability for the fledgling U.K. Space Sector: Are current regulations and legislation fit for purpose?

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Abstract

The UK has recently rekindled its space ambitions with the aim to make the UK Space sector a key part of the economy. At the heart of this push is the desire for a domestic launch capability and new legislation and regulations have recently entered into force with this motivation. In this dissertation we give an overview and update to how the UKs new legislation and regulations take into account international law as well as sustainability issues. We give a high level background on the history of the UK space sector and discuss the international space treaties. We study the Outer Space Treaty to see if it, and in particular Article IX, has any power for 21st century environmentalism. We then turn our focus to the UK domestic legal apparatus for space law, and in particular the Space Industry Act 2018 and the several statutory instruments that have come into force under this new Act. We ask if the new legislation and regulations are fit for purpose when it comes to space sustainability. We find, through the evidence of two Case Studies, that although the Act gives provisions for sustainable practices, it is unclear at this stage whether the Space Industry Regulations on their own have the ability to encourage and enforce sustainable behaviour. We offer broad suggestions on ways forward for the UK space sector noting the space industry can be hypocritical and can often suffer from 'navel gazing' and 'greenwashing.'

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Chapter 1. Introduction

Background

The Space Age - an era where activities are performed in Outer Space - is widely accepted to have begun on the 04th October 1957 with the launch of Sputnik 1 by the Union of Soviet Socialist Republics (USSR).[1] We have no quarrel with this date. There is no widely held concrete definition of where aerospace ends and "outer" space begins,[2] but with Sputnik 1 being placed in a low Earth orbit with a perigee[3] altitude of 215 km (134 miles), there is no debate the 83.6kg polished metal sphere was in space and a new era had begun.

The first British satellite, Ariel 1,[4] was launched on 26th April 1962 on an American Thor 320 Delta 9 rocket from the Cape Canaveral Space Force Station in Florida, USA. The launch of Ariel 1 established the United Kingdom as only the third country to operate a satellite, after the Soviet Union and the United States.[5] Then on 28 October 1971, the Prospero X3 satellite[6] was launched from Launch Area 5B at Woomera, South Australia, on a British Black Arrow rocket,[7] making Britain the sixth nation to place a satellite into orbit using a domestically developed carrier rocket (after the USSR, USA, France, Japan and China).[8] As such, the UK was an early leader in Outer Space activity.

After this initial surge of development in the 1960s and early 1970s, for reasons that are discussed at length elsewhere,[9] but are essentially connected to cost and successive UK

1 Information Furnished by States Launching Objects into Orbit or Beyond in Conformity with General Assembly Resolution 1721 B (XVI), UNGA A/AC.105/INF.002 [1962]

2 Robert Jastrow, 'Definition of Air Space' (Andrew G Haley and Welf Heinrich eds, Springer Vienna 1959); Alexandra Harris and Ray Harris, 'The need for air space and outer space demarcation' (2006) 22(1) Space Policy 3; Jonathan C McDowell, 'The edge of space: Revisiting the Karman Line' (2018) 151 Acta Astronautica 668; Jonathan C McDowell, 'Where does outer space begin?' (2020) 73(10) Physics Today 70

3 The point in the orbit of the satellite or moon at which it is nearest to the Earth.

4 Also known as UK-1 and 1962 Omicron 1; Information Furnished by States Launching Objects into Orbit or Beyond in Conformity with General Assembly Resolution 1721 B (XVI), UNGA A/AC.105/INF.007 [1962]

5 'Ariel 1' (*Wikipedia*, 22 June 2022) ⟨https://en.wikipedia.org/wiki/Ariel_1⟩ accessed 17 July 2022; 'The Most Important Milestones In The British Space History & The Future Potential' (*Orbital Today*, 10 December 2021) ⟨https://orbitaltoday.com/2021/12/10/the-most-important-milestones-in-the-british-space-history-the-future-potential/⟩ accessed 17 July 2022

6 UK Space Agency, *UK Registry of Outer Space Objects* (2021) p. 6

7 ibid p. 7; N Hill, *A Vertical Empire: The History of the UK Rocket and Space Programme, 1950-1971* (Imperial College Press 2001)

8 'Timeline of first orbital launches by country' (*Wikipedia*, 22 June 2022) ⟨https://en.wikipedia.org/wiki/Timeline_of_first_orbital_launches_by_country⟩ accessed 17 July 2022; Information Furnished in Conformity with General Assembly Resolution 1721 B (XVI) by States Launching Objects into Orbit or Beyond, UNGA A/AC.105/INF.240 [1971]

9 Douglas Millard, 'An Overview of United Kingdom Space Activity 1957-1987' (2005) HSR-36 ESA Publications Division; Douglas Millard, 'A review of UK space activity and historiography, 1957–2007' (2010) 66(7) Acta Astronautica 1291. Millard (2005) also references many other accounts, which we note here. Massey and Robins (1986) recount the story of UK space science (Harrie Massey and Malcolm Robins, *History of British space science* (Cambridge University Press 1986)); Morton (1989) describes the major UK launch vehicle programmes from the perspective of the Australian Weapons Research Establishment (Peter Morton, *Fire across the desert : Woomera and the Anglo-Australian Joint Project, 1946-1980* (Defence Science and Technology 1989)); UK rocketry programmes are discussed in Twigge (1993) (S Twigge (Harwood Academic Publishers 1993)), Millard (2001) (D Millard (Science Museum 2001)), Martin (2004) (CH Martin (British

Governments not placing a priority on Space, the UK divested away from a leading space programme. The UK never pursued human spaceflight, nor at this relatively early stage formed a Space Agency. Indeed, the UK holds the inauspicious title of having, to date, been the only nation to develop an indigenous satellite launching capability and then abandon it after a single successful launch.[10] Instead effort was concentrated on space science, which it has become a world leader in.[11]

The political and policy decisions and reasons for the shape of the UK Space Programme in the latter half of the 20th Century and the first decade of the 21st are intriguing in and of their own right. This includes the formation in 1985 of the British National Space Centre (BNSC) a voluntary partnership of ten British government departments, agencies and Research Councils[12] but with no independent funding, formed to coordinated the civil space activities for the UK. This also includes the Outer Space Act 1986 which, as we shall see, is primary legislation that looks to discharge the international obligations of the UK.

However, it is from around 2009/10, with the foundation of the UK Space Agency and onwards that we focus on in order to understand the contemporary landscape relevant for this dissertation. In July 2009 the UK Government embarked on a review of the status and role of the BNSC,[13] having invited and received comments from interested individuals and organisations on how UK civil space activities can best be funded and managed "to meet the challenges of the future for our civil space activities."[14] A public consultation ran from July to October 2009. No report following the consultation was ever published but interestingly, the Royal Astronomical Society (RAS)[15] was very critical of the role the BNSC played in leading UK space activity and quite strident in the formation of a UK space

Interplanetary Society 2004)) and Godwin (2005) (M Godwin, 'Skylark' (PhD thesis, University of London thesis, European Space Agency History Project 2005)). Eberle & Wallace (1987) consider the country's space activity as an aspect of UK international policy-making (J Eberle and Wallace H, 'British Space Policy and International Collaboration' (1987) 42 Chatham House Papers) and Marsh (1991) outlines the main programmes and their organisation within government (P Marsh, 'Britain in Space' in Nicholson R, CM Cunningham, and Gummett P (eds), *Science and Technology in the United Kingdom* (Longman 1991)). The early bilateral relationship with the United States (US) is listed by Logsdon (1996) in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume II: External Relationships* (SP-4407, National Aeronautics and Space Administration 1996).

10 Millard, 'A review of UK space activity and historiography, 1957–2007' (n 9)

11 National Science Foundation | National Science Board, 'Publications Output: U.S. Trends and International Comparisons' (*National Center for Science and Engineering Statistics (NCSES)*, 1 October 2021) ⟨https://ncses.nsf.gov/pubs/nsb20214/publication-output-by-country-region-or-economy-and-scientific-field⟩ accessed 3 August 2022; 'Country/territory research output table' (*Nature Index*, 31 March 2022) ⟨https://www.nature.com/nature-index/country-outputs/generate/physical-sciences/global⟩ accessed 3 August 2022 and a recent e.g. Jonathan Amos, 'Scottish astronomers push James Webb deeper back in time' (*BBC News: Science & Environment*, 26 July 2022) ⟨https://www.bbc.co.uk/news/science-environment-62311562⟩ accessed 20 August 2022

12 Department for Business, Innovation and Skills, (BIS); Department for Children, Schools and Families, (DCSF); Department for Transport, (DfT); Ministry of Defence, (MoD); Foreign and Commonwealth Office, (FCO); Department for Environment, Food and Rural Affairs, (Defra); Natural Environment Research Council, (NERC); Science and Technology Facilities Council, (STFC); Met Office; and Technology Strategy Board, (TSB).

13 Sa'id Mosteshar, 'The Establishment of the UK Space Agency' in P Hulsroj, S Pagkratis, and B Baranes (eds), *Yearbook on Space Policy 2010/2011: The Forward Look* (Springer Vienna 2013) p. 116

14 'A Department for Business Innovation and Skills Consultation on the funding and management of UK civil space activities' ⟨https://webarchive.nationalarchives.gov.uk/ukgwa/20121212135622/http://www.bis.gov.uk/assets/bispartners/ukspaceagency/docs/09-1170-consultation-funding-management-of-uk-civil-space⟩ accessed 8 August 2022

15 Which encourages and promotes the study of astronomy, solar-system science, geophysics and closely related branches of science.

agency.[16] Along with the public consultation, the Space Innovation Growth Team (IGT) report[17] in early 2010 then made the key recommendation of the establishment of a UK space agency.[18] As a consequence, an executive agency was formed, consolidating all UK civil space activities.

The creation of the UK Space Agency (UKSA) was publicly announced on December 10, 2009, during a speech by Lord Drayson, the then UK Minister of State for Science and Innovation, at the Rutherford Appleton Lab (RAL) space conference.[19] The UKSA's remit, name and logo were announced at a conference in London on 23 March 2010.[20,21]

The UKSA is an executive agency of the Department for Business, Energy and Industrial Strategy (BEIS)[22] and leads the UKs civil efforts to explore and benefit from space. The UK Space Agency was launched officially on 23 March 2010 and became a full executive agency on 01 April 2011.[23]

The UKSA was formed just over a month before the 2010 United Kingdom general election.[24] Since 2010, the UK Government, has either had a Conservative[25] Government or a Conservative-Liberal Democrat coalition and with the UKSA, has pushed in establishing the UK as a 'launching state'. There are several reasons for this. These include: building on the UK's space heritage as mentioned above; the UK's desire to be a space and 'science superpower';[26] a paradigm shift in satellite technology enabling commercially and scientifically viable smaller cubesats,[27] and with this, the making of the low-earth polar and

16 Royal Astronomical Society, 'BIS consultation on the funding and management of UK civil space activities (2009)' (2009) ⟨https://ras.ac.uk/ras-policy/science-policy/bis-consultation-funding-and-management-uk-civil-space-activities-2009⟩ accessed 8 August 2022

17 An Innovation and Growth Team report, *The Space Innovation and Growth Strategy Main Report* (2010) ⟨https://www.ukspace.org/wp-content/uploads/2020/04/Space-IGS-Main-Report_Feb2010.pdf⟩

18 Science and Technology Committee, 'Memorandum submitted by the Department for Business, Innovation and Skills (UKSA 00)' (8 September 2010) ⟨https://publications.parliament.uk/pa/cm201011/cmselect/cmsctech/445/445i02.htm⟩ accessed 8 August 2022

19 Jonathan Amos, 'UK to have dedicated space agency' (*BBC News*, 10 December 2009) ⟨http://news.bbc.co.uk/1/hi/sci/tech/8404213.stm⟩ accessed 4 August 2022

20 Jonathan Amos, "Muscular' UK Space Agency launched' (*BBC News*, 23 March 2010) ⟨http://news.bbc.co.uk/1/hi/8579270.stm⟩ accessed 4 August 2022; ESA, 'UK Space Agency announced' (24 March 2010) ⟨https://www.esa.int/About_Us/Corporate_news/UK_Space_Agency_announced⟩ accessed 3 August 2022

21 The timings are somewhat interesting here. The UKSA was first publicly discussed in December 2009, before the publication of the Space IGT Report in February 2010. Therefore, it's not correct to note that the IGT report directly led to the formation of the UKSA. Of course, there was likely some level of discussions and coordination within Whitehall to have the UKSA and IGT report appear coincidentally.

22 UK Government, 'Department for Business, Energy & Industrial Strategy' (29 July 2022) ⟨https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy⟩ accessed 4 August 2022. BEIS was formed via the merger of the Department for Business, Innovation and Skills (BIS) and the Department of Energy and Climate Change (DECC).

23 ESA, 'United Kingdom Space Agency (UK Space Agency)' ⟨https://www.esa.int/Enabling_Support/Space_Engineering_Technology/United_Kingdom_Space_Agency_UK_Space_Agency⟩ accessed 3 August 2022

24 Held on Thursday 6 May 2010

25 Officially, the Conservative and Unionist Party

26 Boris Johnson, "'We're restoring Britain's place as a scientific superpower"' (21 June 2021) ⟨https://www.gov.uk/government/speeches/prime-ministers-article-in-the-daily-telegraph-21-june-2021⟩ accessed 8 August 2022; Council for Science and Technology, 'The UK as a science and technology superpower' (22 July 2021) ⟨https://www.gov.uk/government/publications/the-uk-as-a-science-and-technology-superpower⟩ accessed 8 August 2022; Jack Grove, 'Did Boris Johnson's 'science superpower' plan misfire?' [2022] The Times Higher Education ⟨https://www.timeshighereducation.com/news/has-boris-johnsons-science-superpower-plan-misfired⟩ accessed 12 August 2010

27 A CubeSat is a small satellite, built around a one unit (1U) form factor consisting of 10 cm (3.9 in) cubes. Typically, a cubesat will have a 1U, 2U, 3U or 6U design, meaning a 'large' 6U cubesat will only be around 30cm×20cm×10cm in size.

sun-synchronous orbits (SSO) more desirable.[28] These orbits in turn are relatively easily accessible due to the geographical location of the UK.[29] With the fact the UK (and indeed Scotland alone) has the full space supply chain except launch, coupled with Brexit (for the UK) and independence (for Scotland), means there is economic and political will at multiple levels, to pursue a commercially viable and indeed potentially lucrative UK Space Programme.[30] This will include launch from the British Isles[31] and sets up potential human spaceflight. And the UK remains a leader in space, particularly as a thought leader in regulation.[32]

The UK Government announced the first UK National space policy in 2015[33] and in 2017 the UKSA announced the UK Launch initiative.[34] A detailed history of the legal and policy dimensions of the UK Spaceports is given in Newman (2021)[35] and as noted there, crucially for UK launch ambitions, the 1986 Outer Space Act does not have express provisions for the authorisation of launch from the UK. Fundamentally for our discussions, the UK Government recognised the need for an appropriate legal framework for the licensing of spaceports and the conduct of space activities for launch from UK soil and passed the Space Industry Act in 2018.[36] The Space Industry Regulations followed in 2021.[37]

Meanwhile, international Space Law had been considered and thought about prior to the launch of Sputnik 1.[38] However, it was this event that focused efforts for international space law to become more manifest.

The United Nations (UN), through the United Nations Office for Outer Space Affairs

28 Polar orbits, where satellites travel roughly over Earth's poles, are a type of low Earth orbit, as they are at low altitudes between 200 to 1000 km. Sun-synchronous orbit (SSO) is a particular kind of polar orbit. Satellites in SSO, are synchronous with the Sun meaning they are synchronised to always be in the same 'fixed' position relative to the Sun. This means that the satellite always visits the same spot at the same local time - for example, passing over the city of Newcastle every day at noon exactly. See e.g. ESA, 'Types of orbits' (30 March 2022) ⟨https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits⟩ accessed 8 August 2022

29 Where one can launch from e.g. the north of Scotland over the North and Norwegian Seas towards the North Pole and into a polar orbit.

30 The UKSA has stated an oft touted goal to "capture 10% of the global space market by 2030".UK Space Agency, 'Can you help the UK capture 10% of the global space market?' (8 September 2014) ⟨https://www.gov.uk/government/news/can-you-help-the-uk-capture-10-of-the-global-space-market-by-2030⟩ accessed 3 August 2022; House of Commons Library, *The UK Space Industry* (Briefing Paper Number CBP 2021-9202, 22 April 2021)

31 Department for Transport UK Space Agency, Defence Science, and Technology Laboratory, 'Countdown to launch: British-built satellite completes line-up for first launch from Spaceport Cornwall' (18 July 2022) ⟨https://www.gov.uk/government/news/countdown-to-launch-british-built-satellite-completes-line-up-for-first-launch-from-spaceport-cornwall⟩ accessed 1 August 2022

32 Joanne Wheeler, 'The Space Law Review: United Kingdom' in Joanne Wheeler (ed), *The Space Law Review* (3rd, The Law Review 2021)

33 UK Space Agency; UK Government, *National Space Policy* (2015) ⟨https://www.gov.uk/government/publications/national-space-policy⟩

34 'LaunchUK Prospectus' (*UK Space Agency*, 21 February 2017) ⟨https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651077/LaunchUK_Prospectus.pdf⟩ accessed 11 August 2022

35 Christopher Newman, 'Legal and Policy Dimension of UK Spaceports' in Annette Froehlich (ed), *Spaceports in Europe* (Springer International Publishing 2021)

36 Space Industry Act 2018

37 The Space Industry Regulations 2021, SR 2021/792

38 e.g., Emilie Laude, 'Comment s'appelera le droit qui regira la vie de'air' [1910] Revue Juridique de la Locomotion Aerienne; VA Zarzar, 'Public International Air Law' [1926] Problems in Air Law, A Symposium; V Mandl, 'Das Weltraum-Recht: Ein Problem dar Raumfahrt' [1932] Berlin, Eugène Korovine, 'Conquest of the stratsphere and international law' (1934) XLI Revue Générale de Droit International Public 675; Arthur C Clarke, 'The Challenge of the Spaceship (Astronautics and its Impact Upon Human Society)' (1946) 6 JBIS 66; CW Jenks, 'International Law and Activities in Space' (1954) 5 ICLQ 99

(UNOOSA) and the Committee on the Peaceful Uses of Outer Space (COPUOS), has been a longtime convener, mediator and leader on international law and space activities. This initially came in December 1958 from UN General Assembly (UNGA) Resolution 1348,[39] which established the *ad hoc* Committee on the Peaceful Uses of Outer Space (COPUOS)[40] to "encourage the fullest international co-operation for the peaceful uses of outer space" with 18 members, including the USA, USSR and the UK.[41] At the same time, the United Nations Office for Outer Space Affairs (UNOOSA) was created as a small expert unit within the United Nations Secretariat to service COPUOS. UNGA Resolution 1472 enlarged UN-COPUOS to 24 members.[42] Then UNGA Resolution 1721A (XVI) in December 1961[43] stated "international law, including the Chapter of the United Nations, applies to outer space and celestial bodies"[44] and "Outer space and celestial bodies are free for exploration and use by all States in conformity with international law and are not subject to national appropriation".[45] UNGA Resolution 1802 follows in 1962.[46] The epoch-making UNGA Resolution 1962 (XVIII) in December of 1963 declares a set of nine principles including, but not limited to: "The exploration and use of outer space shall be carried on for the benefit and in the interests of all mankind",[47] "States bear international responsibility for national activities in outerspace"[48] and "States shall regard astronauts as envoys of mankind in outer space."[49] These international soft law measures - in particular UNGA Res 1721A and UN Res 1962 - are the foundations for the seminal 1967 Outer Space Treaty[50] which remains the most famous and powerful legal instrument in the field.

The environment of Outer Space, although hostile to human life, is a delicate and generally still prestine preserve. Moreover activities involved in reaching Outer Space, i.e. launch from the Earth's surface, have immediate impact on the Earth's atmosphere and biosphere. The UN and UNOOSA has brought its power to bare on the long-term sustainability of outer space activities.

Throughout the years, COPUOS has considered different aspects of the long-term sustainability of outer space activities. Building on previous efforts, in 2010 the Scientific and Technical Subcommittee (STSC) began considering the long-term sustainability of outer space.[51] In June 2019, the Guidelines for the Long-term Sustainability of Outer Space Activ-

39 Question of the Peaceful Use of Outer Space, UNGA RES 1348 (XIII) [1958]

40 ibid 1.

41 Along with Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, France, India, Iran, Italy, Japan, Mexico, Poland, Sweden and the United Arab Republic.

42 International Co-operation in the Peaceful Uses of Outer Space, UNGA RES 1472 (XIV) [1959], with the new members being Albania, Austria, Bulgaria, Hungary, Lebanon and Romania.

43 International co-operation in the peaceful uses of outer space, UNGA RES 1721 (XVI) [1961]

44 ibid 1(a)

45 ibid 1(b)

46 International Co-operation in the Peaceful Uses of Outer Space, UNGA RES 1802 (XVII) [1962]

47 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, UNGA RES 1962 (XVIII) [1963], 1.

48 ibid 5.

49 ibid 9.

50 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (adopted 19 December 1966, signed 27 January 1967, entered into force 10 October 1967) 610 UNTS 205, 1968 UKTS 10, Cmnd 3519; 18 UST 2410; TIAS 6347; (1967) 6 ILM 386; (1967) 61 AJIL 644

51 'Long-term Sustainability of Outer Space Activities' ⟨https://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html⟩ accessed 23 July 2022; Peter Martinez, 'Development of an international compendium of guidelines for the long-term sustainability of outer space activities' (2018) 43 Space Policy 13

ities of the Committee on the Peaceful Uses of Outer Space were adopted.[52] The Guidelines for the Long-term Sustainability (GfLTS) of Outer Space Activities provide the following definition of Space Sustainability:[53]

> "The long-term sustainability of outer space activities is defined as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations."

and the 21 agreed guidelines[54] comprise a collection of internationally recognized measures for ensuring the long-term sustainability of outer space activities and for enhancing the safety of space operations.

The UN has also set up the Sustainable Development Goals (SDGs)[55] and how Space can help these (Space4SDGs).[56]

Definitions and Motivation

This is a space law disseration. As such, focus is on international space law, domestic space law and we will only very lightly touch on e.g. international environmental law. This dissertation will not discuss in any great depth sustainable, net zero or 'green' technologies, though we note these in passing. This dissertation is focused on UK regulations and policy for sustainability in the emerging UK Space economy. We critically look at the recent Space Industry Act 2018[57] and the Space Industry Regulations 2021[58] and ask what role sustainability plays in this new legislation and these new regulations.

Sustainability is a huge, wide ranging topic. We define "sustainability" to mean: "efforts and practices that are compatible with the very long-term habitability of the biosphere" - and this complements the COPUOS GfLTS definition above. Our definition seeks to be encompassing, and indeed, although we focus on the Earth biosphere, we very much extend the concept of 'sustainability' to low-Earth orbit, orbits around the Earth in general, cislunar space, the Moon and other celestial bodies. And "space sustainability" impacts directly on the Earth. Space sustainability encompasses a number of actors and a multitude of activities, including 'Upstream' (e.g. launch and launch vehicles, payloads, spaceports), in-orbit (a.k.a. 'Midstream') space sustainability and 'Downstream' (Earth observation, navigation, telecommunications, data processing and storage, consulting). We do not have the scope to address "all of space sustainability." Instead, we keep a sharp focus on what international space law says, or moreover does not say, about space sustainability, the space-related legislation and regulations in the UK that touch on space sustainability and what levers of power, could be brought to bear in the future on the UK Space Sector. We emphasis, that our subsequent arguments are generally insensitive to the detailed and specific defintion of

52 Report of the Committee on the Peaceful Uses of Outer Space, UNGA A/74/20 [2019], 163 and Annex II

53 Guidelines for the Long-term Sustainability of Outer Space Activities, COPUOS A/AC.105/2018/CRP.20 (28 June 2018) UN Doc A/RES/51/210, 5

54 Guidelines for the Long-term Sustainability of Outer Space Activities, UNGA A/AC.105/C.1/L.366 [2018]

55 UN Department of Econmics and Social Affairs, 'UN Sustainability Goals' ⟨https://sdgs.un.org/⟩ accessed 31 July 2022

56 'Space Supporting the Sustainable Development Goals' ⟨https://www.unoosa.org/oosa/en/ourwork/space4sdgs/index.html⟩ accessed 31 July 2022

57 Space Industry Act 2018

58 The Space Industry Regulations 2021 (n 37)

sustainability or space sustainability.[59] In many circumstances, it is quite obvious whether a space activity (on the Earth, in orbit, or in deep space) is sustainable or not.

With these definitions in place, our research questions are:

"From the point of the long term sustainability of outer space activities, are the current UK regulations and legislation - namely the Space Industry Act 2018 and the Space Industry Regulations 2021 - fit for purpose? And if not, what is missing from them?

In order to make progress with our chosen question, we focus on just UK Space activities, noting this dissertation is not a jingoistic tribute to the United Kingdom's Space efforts. The scope of this dissertation and research question is focused on civilian spaceflight. The UK Space Command, the UK's Military Space effort, is not considered here.

We also want to note that a critical theme running through this dissertation will be, *"If you are a Launching State, you are very likely not environmentally friendly."* The space supply chain is a complex, energy intensive process. We currently do not have the technology to launch a 'green rocket', there is no set limit on how many satellites can operate in a given orbital region and there is a currently a lack of agreed-upon, widely adopted metrics and targets for space sustainability.

General contemporary geopolitical background

Having noted our research question, we place our work in context and give a very high-level overview of the contemporary geopolitical background, noting only the aspects that directly affect our subsequent discussions.

Russo-Ukrainian War: 2022 Russian invasion of Ukraine

This dissertation is written with the backdrop of the ongoing Russian invasion of, and war against, Ukraine. The background to the Russian agression is considerable and outside the scope of this dissertation.[60] However, there are three items of immediate relevance.

First, the Baikonur Cosmodrome is a spaceport in an area of southern Kazakhstan leased to Russia.[61] The Cosmodrome was the world's first spaceport for orbital and human launches and all crewed Russian spaceflights are launched from Baikonur. Russia's ratification of the Outer Space Treaty descends from the ratification by the USSR. Kazakhstan on the other hand acceded to the Outer Space Treaty on 11 June 1998.

The second key item to note is the fallout, both mechanically and geopolitically after the direct-ascent anti-satellite weapons (DA-ASAT) test carried out by Russia on 2021 November 15.[62] An A-235 anti-ballistic "Nudol" missile was launched from Plesetsk Cosmodrome at around 02:45 UTC[63] destroying the inactive Soviet Kosmos 1408 satellite.[64]

59 JL Ramsey, 'On Not Defining Sustainability' (2015) 28 J Agric Environ Ethics 1075; B Purvis, Y Mao, and D Robinson, 'Three pillars of sustainability: in search of conceptual origins' (2019) 14 Sustain Sci 681

60 For background to the ongoing war, see e.g, Lucan A Way, 'Authoritarian state building and the sources of regime competitiveness in the fourth wave: The cases of Belarus, Moldova, Russia, and Ukraine' (2005) 57(2) World Politics 231; Serhii Plokhy, *The Gates of Europe: A History of Ukraine* (Penguin Press 2016), Serhy Yekelchyk, *Ukraine: What Everyone Needs to Know* (2nd, OUP 2020); James A Green, Christian Henderson, and Tom Ruys, 'Russia's attack on Ukraine and the jus ad bellum' (2022) 9(1) J. Force Int. Law 4

61 'Baikonur Cosmodrome' (*Wikipedia*, 3 July 2022) ⟨https://en.wikipedia.org/wiki/Baikonur_Cosmodrome⟩ accessed 18 July 2022

62 'Kosmos 1408' (*Wikipedia*, 21 June 2021) ⟨https://en.wikipedia.org/wiki/Kosmos_1408⟩ accessed 31 July 2022

63 Jonathan C McDowell, 'The 2021 Nudol' test' (1 January 2022) ⟨https://planet4589.org/space/asat/nudol.html⟩ accessed 5 August 2022

64 William Graham, 'Russia tests anti-satellite missile, debris disrupts International Space Station' (15 Novem-

The resulting space debris orbits between 300 and 1,100 km (190 and 680 mi) above the Earth.[65] The threat of potential collision with debris caused the crew of the International Space Station (ISS) to take shelter and increased the future risk of a debris collision with the ISS and other satellites.[66] The Russian 2021 ASAT test was met with widespread international condemnation[67] as well renewed efforts not to conduct destructive, direct-ascent anti-satellite missile testing.[68]

And third, the withdrawal of the UK satellite company OneWeb[69] for all launches from Russia's Baikonur Cosmodrome, along with the use of the Soyuz launch vehicle, has left the UKs largest satellite company (by number) seeking a new route to Space.[70] This could have the effect of "super-charging" the push for sovereign UK launch ability, though it should be noted that none of the current suite of companies or rockets planned for UK launch would have the capacity to launch multiple (groups of >20) OneWeb satellites in one operation.[71]

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ber 2021) ⟨https://www.nasaspaceflight.com/2021/11/russia-anti-satellite-missile-debris/⟩ accessed 2 August 2022; 'Russian anti-satellite missile test draws condemnation' (*BBC News*, 16 November 2021) ⟨https://www.bbc.co.uk/news/science-environment-59299101⟩ accessed 5 August 2022

65 Loren Grush, 'Russia blows up a satellite, creating a dangerous debris cloud in space' (15 November 2021) ⟨https://www.theverge.com/2021/11/15/22782946/russia-asat-test-satellite-international-space-station-debris⟩ accessed 2 August 2022; Adam Gabbatt, 'US accuses Russia of 'dangerous' behavior after anti-satellite weapons test' (15 November 2021) ⟨https://www.theguardian.com/science/2021/nov/15/us-investigating-debris-event-space-reports-russia-anti-satellite-weapon-test⟩ accessed 2 August 2022; Elizabeth Howell, 'Space debris from Russian anti-satellite missile test spotted in telescope images and video' (16 November 2021) ⟨https://www.space.com/russia-anti-satellite-test-space-debris-images⟩ accessed 2 August 2022

66 'Kosmos 1408' (*Wikipedia*, 21 June 2022) ⟨https://en.wikipedia.org/wiki/Kosmos_1408⟩ accessed 18 July 2022

67 e.g. Nivedita Raju, 'Russia's anti-satellite test should lead to a multilateral ban' (*Stockholm International Peace Research Institute*, 7 December 2021) ⟨https://www.sipri.org/commentary/essay/2021/russias-anti-satellite-test-should-lead-multilateral-ban⟩ accessed 18 July 2022; Shannon Bugos, 'Russian ASAT Test Creates Massive Debris' (*Arms Control Association*, 1 December 2022) ⟨https://www.armscontrol.org/act/2021-12/news/russian-asat-test-creates-massive-debris⟩ accessed 18 July 2022, Paul Rincon & Jonathan Amos, 'Russian anti-satellite test adds to worsening problem of space debris' (*BBC News*, 16 November 2021) ⟨https://www.bbc.co.uk/news/science-environment-59307862⟩ accessed 5 August 2022

68 The United States became the first country to adopt a voluntary moratorium on the destructive testing of DA-ASAT missile systems. Kamala Harris, 'Remarks by Vice President Harris on the Ongoing Work to Establish Norms in Space' (18 April 2022) ⟨https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/04/18/remarks-by-vice-president-harris-on-the-ongoing-work-to-establish-norms-in-space/⟩ accessed 8 August 2022; Ankit Panda and Benjamin Silverstein, 'The U.S. Moratorium on Anti-Satellite Missile Tests Is a Welcome Shift in Space Policy' (*Carnegie Endowment for Internation Peace*, 20 April 2022) ⟨https://carnegieendowment.org/2022/04/20/u.s.-moratorium-on-anti-satellite-missile-tests-is-welcome-shift-in-space-policy-pub-86943⟩ accessed 8 August 2022; Sandra Erwin, 'DoD a main proponent of anti-satellite test ban: 'We are not disarming'' (*Space News*, 20 April 2022) ⟨https://spacenews.com/dod-a-main-proponent-of-anti-satellite-test-ban-we-are-not-disarming/⟩ accessed 8 August 2022

69 Legally Network Access Associates Ltd., see OneWeb, 'Privacy Notice' (19 August 2022) ⟨https://oneweb.net/privacy-policy⟩ accessed 19 August 2022; Companies House, 'Network Access Associates Ltd' ⟨https://find-and-update.company-information.service.gov.uk/company/09439890⟩ accessed 19 August 2022

70 Paul Sandle, 'UK satellite company OneWeb suspends Baikonur launches' (*Reuters*, 3 March 2022) ⟨https://www.reuters.com/business/aerospace-defense/uk-satellite-company-oneweb-suspends-baikonur-launches-2022-03-03/⟩ accessed 9 August 2022

71 A single OneWeb satellite is around 150kg. An example of one of the largest rockets in developement for UK launch is the Skyrora XL, that is expected to bring a payload of 315kg to a 500km orbit. 'OneWeb satellite constellation' (*Wikipedia*, 19 August 2022) ⟨https://en.wikipedia.org/wiki/OneWeb_satellite_constellation⟩ accessed 19 August 2022; 'Orbital Launch Vehicle: Skyrora XL' ⟨https://www.skyrora.com/skyrora-xl⟩ accessed 20 August 2022

Brexit and Scottish Independence

The withdrawal of the United Kingdom (UK) from the European Union (EU), 'Brexit' and the ongoing discussions for Scotland's independence from the United Kingdom are two huge topics, and of course, both of these issues affect the UK Space Sector.

However, we have to be ruthless in our focus in this dissertation and so do not discuss Brexit or Scottish Independence in any detail. Brexit and the UK Space Sector is discussed elsewhere.[72] As of writing, the Brexit has been completed. Though the full political, economic and social consequences are only starting to come home to roost.

As of writing, Scotland is still part of the United Kingdom, and although a second (after the first in 2014) independence referendum is proposed for October 2023, it is unclear what legal status that will carry.[73] Scottish independence and the UK Space Sector is discussed elsewhere.[74] UK outer space activities are a reserved matter.[75] Reserved matters are those exclusively within the centralised, national competence of the UK government and Parliament in Westminster.

And, as of writing, the UK is still a part of the European Space Agency. Indeed, the UKs commitment to the ESA has arguably never been stronger, at least as demonstrated by funding metrics.[76]

Timing and Outline of Dissertation

This dissertation is timely. Outside of the USA, the UK has been the launch state of the most space objects in 2020 and 2021, with 104 objects in 2020 and 289 objects in 2021.[77] This is unlikely to be the case in 2022 (for the reason noted above of the loss of Baikonur for OneWeb) but shows the preeminence the contemporary UK Space culture has achieved. With a sovereign launch capability, this position could well remain.

The outline of this disseration is as follows. In Chapter 2 we outline the international space law required for this dissertation. We focus on the UN Space Treaties, including the 1967 Outer Space Treaty (OST) and in particular pay attention to Article IX of the OST. We also note international 'soft law' practices and introduce the International Telecommunication Union (ITU). In Chapter 3 we outline UK space law discussing in detail the new Space

72 e.g. Lesley Jane Smith and Ruairidh JM Leishman, 'Up, up and Away: An Update on the UK's Latest Plans for Space Activities' (2019) 44(1) Air and Space Law 1

73 'Supreme Court receives reference on new independence bill' (*Scottish Legal News*, 29 June 2022) ⟨https://www.scottishlegal.com/articles/supreme-court-receives-reference-on-new-independence-bill⟩ accessed 19 August 2022; David Williams and Alison L Young, 'Will Scotland hold an independence referendum in October 2023?' (*ConstitutionalLawMatters, Centre for Public Law, University of Cambridge*, 29 June 2022) ⟨https://constitutionallawmatters.org/2022/06/will-scotland-hold-an-independence-referendum-in-october-2023/⟩ accessed 29 August 2022

74 N. P. Ross (2023) *in prep.*

75 House of Commons Library, *Reserved matters in the United Kingdom* (Research Briefing Number CBP 8544, 20 June 2022); Scotland Act 1998, Schedule 5, II L6; Government of Wales Act 2006, Schedule 7A, 2 191; Northern IrelandAct 1998, Schedules 2 & 3, 2 20A.

76 Peggy Hollinger and George Parker, 'UK increases funding to European Space Agency more than 15%' (*Financial Times*, 27 November 2019) ⟨https://www.ft.com/content/64926e9e-108c-11ea-a225-db2f231cfeae⟩ accessed 19 August 2022; Christopher J Newman, Space Law & Policy: The U.K. Approach to the Regulation of Space Activities, 'Oxford Research Encyclopedia of Planetary Science' (Oxford University Press March 2022) ⟨https://oxfordre.com/planetaryscience/view/10.1093/acrefore/9780190647926.001.0001/acrefore-9780190647926-e-37⟩ accessed 19 August 2022

77 'Annual number of objects launched into space' (*Our World in Data*, 2022) ⟨https://ourworldindata.org/grapher/yearly-number-of-objects-launched-into-outer-space⟩ accessed 19 August 2022; 'Online Index of Objects Launched into Outer Space' (*UNOOSA*, 2022) ⟨https://www.unoosa.org/oosa/osoindex/search-ng.jspx⟩ accessed 18 January 2022

Industry Act 2018 and the suite of Space Industry Regulations from 2021. The domestic regulators, the Civil Aviation Authority (CAA) and the Office of Communications (Ofcom) are introduced. In Chapter 4 we provide two 'case studies' in the UK space sector to help highlight the current legal and regulation provisions. We focus first on Spaceport and Launch operation licencing. And second on UK companies performing Active Debris Removal (ADR). In Chapter 5 we discuss "what is missing" from the UK regulations, while noting the international context. We suggest broad ideas on where UK efforts and regulations might go next. We conclude and offer an outlook in the short final chapter. We include several appendices for the GfLTS, the UN SDGs, sections of the Space Industry Act 2018 and all the regulation titles from the Space Industry Regulations 2021 for completeness.

Chapter 2. International Space Law

In this Chapter, we outline and make initial inquires into the relevant international space law related to space sustainability. We give an overview of international space law, the bedrock of which remains the 1967 Outer Space Treaty (OST). We explore the OST, and in particular Article IX, to understand what obligations this does or moreover does not, place on States. We quickly examine the Liability and Registration Conventions, as these motivate UK domestic space law legislation. We then move away from treaties and look at 'soft law' documents. This will include the guidelines that have been set out by international organisations mainly related to space debris. We conclude the chapter by discussing radio frequency spectrum and the International Telecommunication Union (ITU).

International Space Law Overview

There are five landmark international treaties from the mid 1960s through to the early 1980s. As noted on the United Nations Office for Outer Space Affairs 'Treaties and Principles' website,[78] the treaties commonly referred to as the 'five United Nations treaties on outer space' are:

- **"Outer Space Treaty"**
  - *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.*[79]
  - Adopted by the General Assembly in resolution 2222 (XXI),[80] opened for signature on 27 January 1967 and entered into force on 10 October 1967.
  - To date, 112 States have ratified the Outer Space Treaty (OST) with 23 signatories.[81]
- **"Rescue Agreement"**
  - *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space.*[82]

78 'Space Law Treaties and Principles' (23 May 2022) ⟨https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html⟩ accessed 13 July 2022

79 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50)

80 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1966) RES 2222 (XXI)

81 'Status of International Agreements relating to Activities in Outer Space' (10 February 2022) ⟨https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/status/index.html⟩ accessed 13 July 2022; Status of International Agreements relating to activities in outer space as at 1 January 2022, UNOOSA (28 March 2022) A/AC.105/C.2/2022/CRP.10*

82 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (adopted 19 December 1967, signed 22 April 1968, entered into force 3 December 1968) 672 UNTS 119, 1969 UKTS 56, Cmnd 3997; 19 UST 7570; TIAS 6559; (1968) 7 ILM 151; (1969) 63 AJIL 382

- Adopted by the General Assembly in resolution 2345 (XXII),[83] opened for signature on 22 April 1968 and entered into force on 3 December 1968.
- To date, 99 States have ratified the Rescue Agreement also with 23 signatories.[84]

- **"Liability Convention"**
  - *Convention on International Liability for Damage Caused by Space Objects.*[85]
  - Adopted by the General Assembly in resolution 2777 (XXVI),[86] opened for signature on 29 March 1972 and entered into force on 1 September 1972.
  - To date, 98 States have ratified the Liability Convention with 19 signatories.[87]

- **"Registration Convention"**
  - *Convention on Registration of Objects Launched into Outer Space.*[88]
  - Adopted by the General Assembly in resolution 3235 (XXIX),[89] opened for signature on 14 January 1975 and entered into force on 15 September 1976.
  - 72 States have ratified the Registration Convention with 3 signatories.[90]

- **"Moon Agreement"**
  - *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.*[91]
  - Adopted by the General Assembly in resolution 34/68,[92] opened for signature on 18 December 1979 and entered into force on 11 July 1984.
  - To date, 18 States have ratified the Moon Agreement with 4 signatories.[93]

The UK has ratified the Outer Space Treaty, the Rescue Agreement, the Liability Convention and the Registration Convention. As such, we discuss these treaties, paying the most attention to the Outer Space Treaty. We note the Liability and Registration Conventions as they motivate UK domestic legislation. The Rescue Agreement and its implications

83 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (1967) RES 2345 (XXII)

84 'Status of International Agreements relating to Activities in Outer Space' (n 81); Status of International Agreements relating to activities in outer space as at 1 January 2022 (n 81)

85 Convention on International Liability for Damage Caused by Space Objects (adopted 29 November 1971, signed 29 March 1972, entered into force 1 September 1972) 961 UNTS 187, 1974 UKTS 16, Cmnd 5551; 24 UST 2389, TIAS 7762; (1971) 10 ILM 965; (1971) 66 AJIL 702

86 Convention on International Liability for Damage Caused by Space Objects (1971) RES 2777 (XXVI)

87 'Status of International Agreements relating to Activities in Outer Space' (n 81); Status of International Agreements relating to activities in outer space as at 1 January 2022 (n 81)

88 Convention on Registration of Objects Launched into Outer Space (adopted 12 November 1974, signed 14 January 1975, entered into force 15 September 1976) 1023 UNTS 15, 1978 UKTS 70, Cmnd 7271; 28 UST 695; TIAS 8480; (1975) 14 ILM 43

89 Convention on Registration of Objects Launched into Outer Space (1974) RES 3235 (XXIX)

90 'Status of International Agreements relating to Activities in Outer Space' (n 81); Status of International Agreements relating to activities in outer space as at 1 January 2022 (n 81)

91 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (adopted 5 December 1979, signed 8 December 1979, entered into force 11 July 1984) 1363 UNTS 3, (1979) 18 ILM 1434; UN Doc. A/34/664, Nov. 1979; UN Doc A/34/20, Annex 2; UN Doc. A/RES/34/68

92 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1979) RES 34/68

93 'Status of International Agreements relating to Activities in Outer Space' (n 81); Status of International Agreements relating to activities in outer space as at 1 January 2022 (n 81)

to sustainability (if any) are outside the scope of this dissertation. There is no discussion of the Moon Agreement here, which the UK has not signed, but note the UK has signed the Artemis Accords.[94]

The UK signed the Outer Space Treaty on 27 January 1967.[95] The Rescue Agreement was ratified by the UK on the 03rd December 1968[96] and the Liability Convention was ratified by the UK on the 09th October 1973.[97] The UK signed the Registration Convention on 06 May 1975 and ratified the treaty on 30 March 1978[98] by which point the UK had launched Prospero and several other satellites, mainly on US rockets.

The Outer Space Treaty 1967

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, commonly known as the Outer Space Treaty (OST)[99] is the fundamental writing that sets up space law. The timing of the drafting of the OST places it less than 5 years after the Cuban Missile Crisis and at the height of the race to the Moon (with the uncertainty of who was going to win) and should be placed in this context. Currently 112 States have ratified, including all major spacefaring nations[100] while 23 have signed the treaty but have not completed ratification. Although designated a treaty on Outer Space, since the OST forbids the placement of nuclear weapons or other weapons of mass destruction in outer space[101] the OST can also be

94 The Artemis Accords ('The Artemis Accords' (*NASA*) ⟨https://www.nasa.gov/specials/artemis-accords/index.html⟩ accessed 16 August 2009) are bilateral agreements between the USA and other governments and organisations participating in the Artemis Program, an American-led effort to return humans to the Moon by 2025 ('Artemis Accords' (*Wikipedia*, 16 August 2022) ⟨https://en.wikipedia.org/wiki/Artemis_Accords⟩ accessed 16 August 2009). On 13 October 2020, the Artemis Accords were signed by the directors of the national space agencies of the United States, Australia, Canada, Japan, Luxembourg, Italy, the United Kingdom, and the United Arab Emirates. See also: Christopher J Newman, 'Outlaws of the Moon? Crime and punishment for a spacefaring civilisation?' (International Astronautical Federation, IAF 2020) vol 2020-October and Rossana Deplano, 'The Artemis Accords: Evolution or revolution in international space law?' (2021) 70(3) International and Comparative Law Quarterly 799.

95 The Government of the United Kingdom is one of the OSTs Depositaries along with the Governments of the then USSR and the United States of America. The OST was deposited on the 10 October 1967 in London, Moscow and Washington, D.C.; 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies' (23 May 2022) ⟨https://treaties.unoda.org/t/outer_space⟩ accessed 7 August 2022; Commonwealth & Development Office Foreign, 'UK Treaties Online' ⟨https://treaties.fcdo.gov.uk/awweb/pdfopener?md=1&did=70785⟩ accessed 6 August 2022

96 Commonwealth & Development Office Foreign, 'UK Treaties Online' ⟨https://treaties.fcdo.gov.uk/awweb/pdfopener?md=1&did=70832⟩ accessed 6 August 2022

97 Commonwealth & Development Office Foreign, 'UK Treaties Online' ⟨https://treaties.fcdo.gov.uk/awweb/pdfopener ? md = 1 & did = 70992⟩ accessed 6 August 2022; Both the Rescue Agreement and Liability Convention also has the Government of the United Kingdom as one of the Depositaries (again along with the Government of the Russian Federation and the United States of America).

98 'Convention on registration of objects launched into outer space, New York, 12 November 1974' (*UNTS*, 3 August 2022) ⟨https://treaties.un.org/pages/ViewDetailsIII.aspx?src=TREATY&mtdsg_no=XXIV-1&chapter=24&Temp=mtdsg3&clang=_en⟩ accessed 3 August 2022; Commonwealth & Development Office Foreign, 'UK Treaties Online' ⟨https://treaties.fcdo.gov.uk/awweb/pdfopener?md=1&did=71247⟩ accessed 6 August 2022

99 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50)

100 Including, but not limited to the USA, Russia, China, Japan, India, Australia, Brazil, Israel, Kazakhstan, Republic of Korea (South Korea), Ukraine, France, Italy, Germany and the UK.

101 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art IV. Sa'id Mosteshar, 'Space Law and Weapons in Space' in

very much seen as belonging to the set of multilateral Nuclear Arms Control Treaties.[102]

Here we note the OST Articles applicable for our discussion.[103] The OST is binding on the State Parties and it is *not* intended to be binding on individuals or on private or public companies.

The preamble and Article I of the OST establishes Outer Space with the legal status of being a global commons.[104] Article I of the OST says "the exploration and use of outer space ... shall be carried out for the benefit and in the interests of all countries, ... and shall be the province of all mankind."[105] Furthermore, "Outer space ... shall be free for exploration and use" and "There shall be freedom of scientific investigation".[106] As such, Article I grants freedoms in relation *(i)* to explore, *(ii)* to use, and *(iii)* to conduct scientific investigation. Article I is immediately and directly relevant for our discussions due to all three of the freedoms granted: the exploration of Outer Space may (or may not) be sustainable; the usage of Outer Space may (or may not) be sustainable, as well as scientific investigations of Outer Space that may (or may not) be sustainable.

Article II has "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[107] This Article is of importance to our discussion since it bars any state from claiming or appropriating any celestial body or section of space - national appropriation of Outer Space is prohibited.[108] In particular, this relates to companies and governments viewing resource mining on celestial bodies as a realistic industry in the coming years and decades. However, Article II makes it clear that no state owns these sites.[109] However, the OST leaves the door open for unilateral proprietary claims recognisable in domestic law. This permissive silence on the question of private ownership and control over minerals and metals has refigured space as a 'new' frontier for resource extraction.[110] Thus mining rights are a contested topic. Article II sets up the "tragedy of the commons."[111] States may be abiding by the OST, but at the same time are creating a situation where the use of outer space diminishes in the long run. This is directly within the

Oxford Research Encyclopedia of Planetary Science (2017)

102 'Arms Control Treaties' (*Atomic Archive*, 2020) ⟨https : / / www . atomicarchive . com / resources / treaties / index.html⟩ accessed 22 May 2022; 'Compliance issues and the future of arms control' The Nonproliferation Review 1

103 And the language in the Treaty of "mankind" can be changed to "humankind" with absolutely no change to any intention, meaning or interpretation of the Treaty.

104 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) Preamble; Nilufer Oral, 'The Global Commons and Common Interests: Is there Common Ground?' in *The Protection of General Interests in Contemporary International Law: A Theoretical and Empirical Inquiry* (Oxford University Press August 2021); but see HR Hertzfeld, B Weeden, and CD Johnson, 'How simple terms mislead us: The pitfalls of thinking about outer space as a commons' (2015) vol 15

105 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art I.

106 ibid art I.

107 ibid art II.

108 Roger Wortman, 'Research viewpoint modernizing the outer space treaty for national appropriation' (2020) 18(2) Astropolitics 170

109 Jinyuan Su, 'Legality of unilateral exploitation of space resources under international law' (2017) 66(4) Int. Comp. Law. Q. 991

110 Cait Storr, ''Space is the only way to go': The evolution of the extractivist imaginary of international law' in (Taylor and Francis 2021)

111 E Ostrom, *Governing the commons: the evolution of institutions for collective action* (Cambridge University Press 1990); Garrett Hardin, 'The tragedy of the commons' (1968) 162(3859) Science 1243, 'Tragedy of the commons' (*Wikipedia*, 18 August 2022) ⟨https://en.wikipedia.org/wiki/Tragedy_of_the_commons⟩ accessed 18 November 2009

purview of space sustainability.[112]

Article III dictates "States Parties to the Treaty shall carry on activities ... in accordance with international law."[113] Thus States are expected to follow international law, including international environmental law, e.g. the Vienna Convention for the Protection of the Ozone Layer 1985,[114] the Montreal Protocol,[115] the UN Framework Convention on Climate Change (UNFCCC),[116] the Rio Declaration on Environment and Development,[117] the Kyoto Protocol in 1997[118] and the Paris Agreement in 2015.[119] International Law is part of Space Law and this will become applicable to our discussions via sustainability issues that are connected to international environmental law.

Article IV of the OST prohibits nuclear weapons in outer space. The article also declares that "The use of any equipment or facility necessary for peaceful exploration ... shall also not be prohibited."[120] Thus scientific, peaceful equipment can be used in outer space. However, the difficulty comes when dual-use starts to be considered. Dual-use space items

112 See also P J Blount, 'Outer Space and International Geography:Article II and the Shape of Global Order' (2018) 52(2) New Eng.L.Rev. 95 and Frans von der Dunk, 'Some remarks further to "Outer space and international geography: Article II and the shape of global order" by P. J. Blount.' (2018) 52(2) New Eng.L.Rev. 125

113 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art III.

114 Vienna Convention for the Protection of the Ozone Layer (entered into force 22 September 1988) 1513 UNTS p. 293, The Convention was adopted by the Conference on the Protection of the Ozone Layer and open for signature at Vienna from 22 March 1985 to 21 September 1985, and at the United Nations Headquarters in New York from 22 September 1985 until 21 March 1986.

115 Montreal Protocol on Substances that Deplete the Ozone Layer (entered into force 1 January 1989) 1522 UNTS, The Protocol was adopted by the Conference of Plenipotentiaries on the Protocol on Chlorofluorocarbons to the Vienna Convention for the Protection of the Ozone Layer, held in Montreal from14 to 16 September 1987. Open for signature in Montreal on 16 September 1987, in Ottawa from 17 September 1987 to 16 January 1988 and at United Nations Headquarters, New York, from 17 January 1988 to 15 September 1988, in accordance with article 15.

116 United Nations Framework Convention on Climate Change (entered into force 21 March 1994) 1771 UNTS, The Convention was agreed upon and adopted by the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change, during its Fifth session, second part, held at New York from 30 April to 9 May 1992. In accordance with its article 20, the Convention was open for signature by States Members of the United Nations or of any of its specialized agencies or that are Parties to the Statute of the International Court of Justice and by regional economic integration organizations, at Rio de Janeiro during the United Nations Conference on Environment and Development, from 4 to 14 June 1992, and remained thereafter open at the United Nations Headquarters in New York until 19 June 1993.

117 Report of the United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992 I A/CONF151/26/Rev1 (Vol I

118 Kyoto Protocol to the United Nations Framework Convention on Climate Change (entered into force 16 February 2005) 2303 UNTS 162, The Protocol was adopted at the third session of the Conference of the Parties to the 1992 United Nations Framework Convention on Climate Change ("the Convention"), held at Kyoto (Japan) from 1 to 11 December 1997. The Protocol shall be open for signature by States and regional economic integration organizations which are Parties to the Convention at United Nations Headquarters in New York from 16 March 1998 to 15 March 1999 in accordance with its article 24 (1). which ran from 2005 to 2020

119 Paris Agreement under the United Nations Framework Convention on Climate Change (entered into force 4 November 2016) 3156 UNTS CN63 2016 TREATIES-XXVII 7d of 16 February 2016 (Opening for signature) and CN92 2016 TREATIES-XXVII 7d of 17 March 2016 (Issuance of Certified True Copies), The Paris Agreement was adopted on 12 December 2015 at the twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change held in Paris from 30 November to 13 December 2015. In accordance with its article 20, the Agreement shall be open for signature at the United Nations Headquarters in New York from 22 April 2016 until 21 April 2017 by States and regional economic integration organizations that are Parties to the United Nations Framework Convention on Climate Change. Iran, Eritrea, Libya and Yemen have not ratified the agreement.

120 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art IV.

can be used for civil and military purposes and might be nuclear powered.[121] Thus, even if at the outset there is a peaceful, scientific purpose for a space object or mission, this can be a grey area. We shall see this in direct relation to Active Debris Removal (ADR).

Article VI is the 'Responsibility' article: "States ... shall bear international responsibility for national activities in outer space, ... whether such activities are carried on by governmental agencies or by non-governmental entities."[122] Critically, Article VI ensures that there is always a State that is responsbile for outer space actions and activities. States have to make sure that national activities are compliant with the OST. This allows States to benefit from the use of Outer Space (e.g. Article I) via empowering non-state, i.e. commercial company activity. However, since non-Governmental entities are not bound by the OST, States have to ensure this activity complies with the principles of the Treaty. This is usually, as is the case for the UK, accomplished by national legislation and a licensing process.

Article VII is the 'Liability' article: "Each State Party to the Treaty that launches ... is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such objects or its component parts".[123] Article VII provides for a comprehensive international state liability for damage arising from the launch of a space object or its component parts. A good definition here for 'space object' is anything that goes into space (regardless of size, purpose, or intended use) and if a space object breaks apart while in space, then those fragments are 'component parts'. Article VII also introduces the notion of 'launching state'. A State can be a launching state in four ways, which are: *(i)* to launch a space object, *(ii)* to procure a launch;[124] *(iii)* to provide territory or *(iv)* a facility from where a space object is launched.[125] Each space object has at least one, and often more than one, launching State. The launching State also does not necessarily have to be a State. It can also be an international organisation – the best example of which being the ESA.[126] Liability under the OST has no geographic or fault provision. Together, Articles VI and VII provide that States are both responsible and liable for their national space activity and for any damage caused by their space objects towards other State Parties (and their nationals).

Article VIII is the 'Registration' article. "A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object."[127] While there can be up to four launching states, there is only one state that can enter a space object on the register. Entering a space object on the register means the state party will retain jurisdiction and control over the object. Thinking about space sustainability, registration, and the consequent control over space objects, e.g. satellite end-of-life and possibly space debris, Article VIII is relevant.

Article XI is discussed in the next section. The remaining articles (V, X-XVII)[128] are not

121 Related is UNGA Res 47/68 (Principles Relevant to the Use of Nuclear Power Sources in Outer Space, UNGA A/RES/47/68 [1992]) which recognise that nuclear power sources are essential for some missions, but that such systems should be designed so as to minimize public exposure to radiation in the case of an accident.

122 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art VI.

123 ibid art VII.

124 ibid art VII.

125 ibid art VII.

126 ESA, 'What is a "Launching State"' (13 June 2017) ⟨https://blogs.esa.int/cleanspace/2017/06/13/what-is-a-launching-state/⟩ accessed 8 August 2022

127 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art VIII.

128 That deal with astronauts as envoys of mankind (art V.), on the opportunity to observe the flight of space objects (art X.), agreement to inform on space activities (art XI.), reciprocal visits of States Parties representatives (art XII.), treatment of legal and practical issues of international cooperation (art XIII.) Signature,

relevant for our discussions and discussed in detail elsewhere.[129]

Article XI of the Outer Space Treaty

We give Article IX particular attention since throughout the OST Article IX represents the most fundamental – if not the only – provision in space law for protection of the outer space environment and its preservation for peaceful uses.[130] Article I sets up the use of outer space, then the rest of the articles limit this use. Article IX is very much in that vein, but we need to examine the actual restrictions Article IX places on States. Although written as one paragraph, Article IX is usually broken down into four parts: the 'principle of Due Regard', the 'Harmful Contamination' clause, the 'International Consultation' clause and the 'May Request" clause.

The start of Article IX instructs the State Parties, "Shall conduct all their activities in outer space ... with due regard to the corresponding interests of all other States Parties to the Treaty."[131] This "Due Regard" principle[132] attempts to tackle the environmental issues in space, by creating a 'proscriptive positive legal obligation'[133] for all States to *(i)* avoid harmful contamination of celestial bodies and *(ii)* undertake international consultations in advance before any potentially harmful interference may arise from their activities.[134] However, at this stage over 50 years on from the OST entering into force, we see due regard has no legal definition. Nor has its breadth or scope been rigorously tested in court or in any public diplomatic dispute.[135]

Next, is the 'Harmful Contamination' clause: "States Parties to the Treaty shall pursue studies of outer space, ... 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."[136] Here, we initially think we see a strong declaration of environmentalism. However, on closer inspection, we find the Harmful Contamination clause is lacking in binding details, and the term 'harmful contamination' can be considered to be so wide ranging that it fails to pinpoint, and thus prevent, any specific harms. The 'adopting of appropriate measures' then gives States wide discretion in this matter.[137] This clause

accession, ratification and registration of the Treaty (art XIV.) amendment proposal and ratification, (art XV.) withdrawal from the Treaty (art XVI.) and closing protocol (art XVII.) - Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50)

129 Stephan Hobe and others (eds), *Cologne Commentary on Space Law - Outer Space Treaty* (BWV Berliner Wissenschafts-Verlag 2017)

130 Sergio Marchisio, 'Article IX' in Stephan Hobe and others (eds), *Cologne Commentary On Space Law* (Carl heymanns 2009) vol I.

131 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art IX.

132 Michael C Mineiro, 'FY-1C and USA-193 ASAT intercepts: An Assessment of Legal Obligations Under Article IX of the Outer Space Treaty' (2008) 34 J. Space L. 321

133 ibid p. 332

134 Gordon Chung, 'Emergence of Environmental Protection Clauses in Outer Space Treaty: A Lesson from the Rio Principles' (2018) 13 Studies in Space Policy (A Froehlich ed 1

135 Howard A Baker, 'The Application of Emerging Principles of International Environmental Law to Human Activities in Outer Space' (PhD thesis, McGill University, Montreal 1997) ⟨http://www.collectionscanada.ca/obj/s4/f2/dsk2/ftp02/NQ30433.pdf⟩; Vishakha Gupta, 'Critique of the International Law on Protection of the Outer Space Environment' (2016) 14(1) Astropolitics 20; Michelle Hanlon, '"Due Regard" for Commercial Space Must Start with Historic Preservation' (2021) 9 Global Bus. L. Rev 130

136 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art IX.

137 Chung, 'Emergence of Environmental Protection Clauses in Outer Space Treaty: A Lesson from the Rio

was written with the concern of extraterrestrial matter from e.g. Apollo Lunar astronauts having 'back contamination' on return to Earth, and as such, the 'adverse changes from the introduction of extraterrestrial matter' is specific but now seen not to be helpful.[138]

The third part is "International Consultation": "If a State ... has reason to believe that an activity or experiment planned by it ... would cause potentially harmful interference with activities of other States Parties ... it shall undertake appropriate international consultations before proceeding with any such activity or experiment."[139] Thus, States determine and police themselves in determining whether they are going to cause harm. There are issues on establishing the threshold of 'harm' under the OST, which gives no further guidance on this term.[140] Then the level of what constitutes 'appropriate international consultations' is not defined.

Finally the "May Request" clause: "A State ... which has reason to believe that an activity or experiment planned by another State Party ... would cause potentially harmful interference ... may request consultation concerning the activity or experiment." The same issue of what constitutes 'potentially harmful interference' is still unsolved. Further, one State may request consultation, but the other State(s) have no binding obligation and can (and do) easily deny requests with the coverall of e.g. noting national security concerns.

Thus, in summary, Art IX of the OST puts essentially no specific sustainability binding obligation or environmental duties on States. This is unsurprising given that the OST was written in the mid-1960s and Article IX is an instrument of its time, concerned with astronauts returning hazardous materials from the Moon. As such, it is ineffective as a 21st Century environmental protection provision, primarily due to the absence of more rigorous environmental standards governing space activities and the inherent uncertainties associated with its applicability.[141]

The Liability and Registration Conventions

Articles VI, VII and VIII of the OST[142] impose supervision (usually in the form of licencing), liability and registration duties on states, and the Liability Convention and Registration Conventions fill out Art VII and Art VIII, respectively.

The 1972 Convention on International Liability for Damage Caused by Space Objects - "the Liability Convention" - which the UK has ratified, is the foundation for space liability regimes worldwide.[143] Under the twenty-eight article long Convention, a 'Launching State' is internationally liable for damage arising out of its space activities to *(i)* objects owned by nationals from another state, and *(ii)* nationals of another state. A Launching State is defined in Art. I of the Convention[144] and is the same as Article VII of the OST.[145]

Principles' (n 134)

138 Mineiro (n 132) p 340

139 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art IX.

140 Lotta Viikari, *The Environmental Element in Space Law: Assessing the Present and Charting the Future* (Brill Nijhoff 2008) [p 176

141 Chung, 'Emergence of Environmental Protection Clauses in Outer Space Treaty: A Lesson from the Rio Principles' (n 134)

142 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) arts VI, VII, VIII

143 UK Space Agency, 'Spaceflight legislation and guidance' (1 June 2022) ⟨https://www.gov.uk/guidance/spaceflight-legislation-and-guidance⟩ accessed 8 August 2022

144 Convention on International Liability for Damage Caused by Space Objects (n 85) art I.

145 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art VII

Damage caused on the surface of the Earth or to an aircraft in flight carries absolute liability.[146] For damage caused elsewhere and to a space object, the Launching State is liable "only if the damage is due to its fault or the fault of persons for whom it is responsible".[147] Liability is not limited to just functioning space objects. Lack of authorisation and supervision for e.g. non-government activities does not absolve states of liability.[148]

The OST requires the creation of a space register[149] and the Registration Convention (RC) formalises this with its twelve articles. The RC provides a means by which space objects that have caused damage may be traced to the launching state. Article I of the RC has the definitions of launching state and space objects (akin to the Liability Convention).[150] Article II of the RC places a duty on the launching state to maintain an appropriate registry of space objects.[151] Article II also notes "a space object is launched in to Earth orbit or beyond",[152] and thus there is no obligation to register sub-orbital flights. In practice, a rocket is registered and the (multiple) payload(s) are registered separately, and this is done as soon as "practicable".[153] Basic orbital parameters[154] are required and there is a mandatory requirement to update the register when the space object deorbits.[155] The UK Space Registry is found here: https://www.gov.uk/government/publications/uk-registry-outer-space-objects.

Global Space Sustainability Considerations and Guidelines

In this section, we discuss the 'soft law' legal instruments that are related to international space sustainability. These are in general existing guidelines for space sustainability from international bodies. In particular, we discuss the UN Space Debris Mitigation Guidelines (SDMG), the UN COPUOS published Guidelines on the Long-term Sustainability of Outer Space Activities (GfLTS) and the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines.

UN Space Debris Mitigation Guidelines

In its resolution 62/217 of 22 December 2007, the General Assembly endorsed the Space Debris Mitigation Guidelines of the COPUOS and agreed that the voluntary guidelines for the mitigation of space debris reflected the existing practices as developed by a number of national and international organizations.[156] The Space Debris Mitigation Guidelines (SDMG)[157] should be considered for the mission planning, design, manufacture and operational (launch, mission and disposal) phases of spacecraft and launch vehicle orbital stages.

146 Convention on International Liability for Damage Caused by Space Objects (n 85) art II.
147 ibid art III.
148 Francis Lyall and Paul B Larsen, *Space Law A Treatise* (2nd Edition, Routledge 2020) p. 105
149 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art VIII
150 Convention on Registration of Objects Launched into Outer Space (n 88) art I.
151 ibid art II.
152 ibid art II.
153 ibid IV (1)
154 e.g. Nodal Period; Inclination; Apogee; Perigee; and the "General Function"
155 Convention on Registration of Objects Launched into Outer Space (n 88) IV (3)
156 International cooperation in the peaceful uses of outer space (2007) A/RES/62/217, art 26
157 United Nations Office for Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (2010) ⟨https://www.unoosa.org/pdf/publications/st_space_49E.pdf⟩ accessed 23 May 2022

This includes limiting debris released during normal operations[158] and minimizing the potential for break-ups during operational phases.[159] Then when in orbit, to limit the probability of accidental collision.[160] Avoiding intentional destruction and other harmful activities is recommended[161] which is of course broached with DA-ASAT tests. Guideline 5 - 'Minimize potential for post-mission break-ups resulting from stored energy' - is interesting since the SDMG notes "... (by far) the largest percentage of the catalogued space debris population originated from the fragmentation of spacecraft and launch vehicle orbital stages. ... The most effective mitigation measures have been the passivation of spacecraft and launch vehicle orbital stages at the end of their mission. Passivation requires the removal of all forms of stored energy, including residual propellants and compressed fluids and the discharge of electrical storage devices."[162] This statement is now well over a decade old, and with recent e.g. DA-ASAT tests may no longer be valid.

Guidelines 6 and 7 limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region[163] and the geosynchronous Earth orbit (GEO) region[164] after the end of their mission.

COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities

COPUOS is the world's leading forum for discussion for the peaceful cooperation and uses of outer space and the world's established forum for the progressive development and codification of space law. COPUOS achieves its decisions by absolute consensus.

In 2010, a Working Group on the Long-term Sustainability of Outer Space Activities was established,[165] the objectives of which included identifying areas of concern for the long-term sustainability of outer space activities, proposing measures that could enhance sustainability, and producing voluntary guidelines to reduce risks to long-term sustainability.[166] In June 2016 the Committee agreed to a first set of guidelines for the long-term sustainability of outer space activities,[167] which were expanded on in 2018.[168] And in June 2019, the Guidelines for the Long-term Sustainability (GfLTS) of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space were adopted.[169] The 21 guidelines were agreed across four topics and address:

- Policy and regulatory framework for space activities (5 guidelines);
- Safety of space operations (10 guidelines);
- International cooperation, capacity building and awareness (4 guidelines);

158 Outer Space Affairs (n 157) Guideline 1.
159 ibid Guideline 2.
160 ibid Guideline 3.
161 ibid Guideline 4.
162 ibid Guideline 5.
163 ibid Guideline 6.
164 ibid Guideline 1.
165 COPUOS, 'Working Groups of the Committee and its Subcommittees' ⟨https://www.unoosa.org/oosa/en/ourwork/copuos/working-groups.html⟩ accessed 11 July 2022
166 'Long-term Sustainability of Outer Space Activities' (n 51)
167 Report of the Committee on the Peaceful Uses of Outer Space: Fifty-ninth session, UNGA A/71/20 [2016], Annex;
168 Report of the Scientific and Technical Subcommittee on its fifty-fifth session, held in Vienna from 29 January to 9 February 2018, UNGA A/AC.105/1167 [2018], Annex III and Report of the Committee on the Peaceful Uses of Outer Space, UNGA A/73/20 [2018]
169 A/74/20 (n 52) para 163 and Annex II; A/AC.105/C.1/L.366 (n 54)

- Scientific and technical research and development (2 guidelines).

The full text is available[170] and comprise a collection of internationally recognized measures for ensuring the long-term sustainability of outer space activities and for enhancing the safety of space operations. They address the policy, regulatory, operational, safety, scientific, technical, international cooperation, and capacity-building aspects of space activities. The GfLTS are relevant to both governmental and non-governmental entities. They are also relevant to all space activities, whether planned or ongoing, and to all phases of a space mission, including launch, operation, and end-of-life disposal.[171]

The GfLTS are voluntary and non-binding. States will implement them in a manner that is consistent with their national needs and capabilities. And states can then decide to share their implementation experiences.[172]

The most directly relevant of the 21 guidelines for our discussion is perhaps the first, "A1. Adopt, revise and amend, as necessary, national regulatory frameworks for outer space activities". Here, "[S]tates ... When adopting, revising, amending or implementing national regulatory frameworks, States should consider the need to ensure and enhance the long-term sustainability of outer space activities."[173]

Inter-Agency Debris Coordination Committee Space Debris Mitigation Guidelines

The Inter-Agency Space Debris Coordination Committee (IADC) is an international forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space.[174] The primary purpose of the IADC is to exchange information on space debris research activities between member space agencies, to facilitate opportunities for co-operation in space debris research, to review the progress of ongoing co-operative activities and to identify debris mitigation options.[175] The IADC defines space debris as "All human-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere that are non-functional."[176]

The IADC guidelines give general guidance,[177] and a range of mitigation measures.[178] This includes Post Mission disposal from given orbits.[179] Spacecraft or orbital stages that are terminating their operational phases in orbits that pass through the LEO region, or have the potential to interfere with the LEO region, should be de-orbited (direct re-entry is preferred) or where appropriate manoeuvred into an orbit with an expected residual

170 LTSG (n 53); A/AC.105/C.1/L.366 (n 54); A/74/20 (n 52) Annex II Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space (7 June 2021) ⟨https://www.unoosa.org/oosa/en/oosadoc/data/documents/2021/stspace/stspace79_0.html⟩ accessed 13 August 2022

171 Josh Wolny, *The UN COPUOS Guidelines on the Long-term Sustainability of Outer Space Activities* (, Secure World Foundation 2018) ⟨https://swfound.org/media/206227/swf_un_copuos_lts_guidelines_fact_sheet_august_2018.pdf⟩

172 Katholieke Universiteit Leuven (KU Leuven), *Space Lecture: "UN COPUOS Guidelines for the Long term Sustainability of Outer Space Activities"* (2021) ⟨https://www.youtube.com/watch?v=joGweDEm0vQ⟩

173 Report of the Committee on the Peaceful Uses of Outer Space: Sixty-second session (12–21 June 2019) [2019] ⟨https://www.unoosa.org/oosa/en/oosadoc/data/documents/2019/a/a7420_0.html⟩, Annex II, II A.1 para 1.

174 'Welcome to the Inter-Agency Space Debris Coordination Committee Website' (31 March 2022) ⟨https://www.iadc-home.org/what_iadc⟩ accessed 20 August 2022

175 IADC Space Debris Mitigation Guidelines [2021] IADC-02-01, Foreward

176 ibid 3.1

177 ibid 4

178 ibid 5

179 ibid 5.3

orbital lifetime of 25 years or shorter.[180] This is the "25 year" rule, the length of which is somewhat arbitrary. Indeed, the guidelines continue saying that for specific operations such as large constellations, a shorter residual orbital lifetime and/or a higher probability of success may be necessary. Retrieval is also a disposal option.[181]

Other Space Debris Commitments

We note the Requirements on Space Debris Mitigation for European Space Agency Projects,[182] and the ISO standard "Space Debris Mitigation Requirements BS ISO 24113–2019"[183] are also international commitments that the UK has signed up to.

The International Telecommunication Union

The International Telecommunication Union (ITU) is a specialized agency of the United Nations responsible for matters related to information and communication technologies.[184] Through its Radiocommunication Sector (ITU-R), and its executive arm, the Radiocommunication Bureau (BR), the ITU is the global agency responsible for management of the radio-frequency spectrum and satellite orbit resources.[185]

Radio waves are electromagnetic waves of frequencies arbitrarily lower than 3,000 gigahertz, propagated in space without artificial guide.[186] The ITU designates the radio spectrum to cover frequencies from 3 kilohertz (kHZ) to 3000 gigahertz (GHz)[187] and divides this radio spectrum into nine bands of decade frequency width, starting with Band 4 covering 3 to 30 kilohertz (kHz) and extending to Band 12 covering 300 to 3,000 GHz.[188] Telecommunications related to space activities are generally Band 10.[189]

The radio frequency spectrum is a limited natural resource and must be used in a manner such that countries and groups of countries may have equitable access to it. Modern telecommunications need certain sections of the radio spectrum (bandwidth). As a very rough example, with a typical bandwidth for an e.g. 5G mobile phone being 10 MHz,[190]

180 IADC Space Debris Mitigation Guidelines [2021] IADC-02-01, 5.3.2.

181 ibid 5.3.2.

182 'Mitigating space debris generation' (*ESA Space Safety*) ⟨https : / / www . esa . int / Space _ Safety / Space _ Debris / Mitigating _ space _ debris _ generation⟩ accessed 25 August 2022; 'Requirements on Space Debris Mitigation for ESA Projects' (*ESAs Space Safety Office*) ⟨http : / / emits . sso . esa . int / emits - doc / estec / ad4requirementsspacedebrismitigationesa_projects.pdf⟩ accessed 25 August 2022

183 ISO/TC 20/SC 14 Space systems and operations, 'ISO 24113:2019 Space systems — Space debris mitigation requirements' [2019] (3) ISO ⟨https://www.iso.org/standard/72383.html⟩. This ISO standard contributes to the UN SDG #9

184 'ITU: Committed to connecting the world' ⟨https://www.itu.int/en/Pages/default.aspx⟩ accessed 16 August 2022; 'International Telecommunication Union' (*Wikipedia*, 10 July 2022) ⟨https://en.wikipedia.org/wiki/International_Telecommunication_Union⟩ accessed 16 August 2022

185 'ITU Radiocommunication Sector' ⟨https://www.itu.int/en/ITU-R/Pages/default.aspx⟩ accessed 16 August 2022

186 ITU, 'The Radio Regulations, Edition of 2020' ⟨https://www.itu.int/pub/R-REG-RR-2020⟩ accessed 16 August 2022, Art I, 1.5. The hertz (Hz) is the SI unit of frequency. 1 Hz is one event (or cycle) per second. Giga is the prefix for billion. Thus, the radio frequency spectrum is for EM waves with 3,000 billion cycles or fewer per second. Waves of frequency 3,000 GHz or lower have wavelengths of 0.1 mm or longer.

187 ibid Art 2, 2.1

188 Technically, 'Band N', where N is the band number, extends from 0.3×10^{N} Hz to 3×10^{N} Hz.

189 3 - 30 GHz. The Institute of Electrical and Electronics Engineers (IEEE) designated S-, C-, X-, K_u-, K- and K_a-bands are all in ITU Band 10.

190 '5G NR frequency bands' (*Wikipedia*, 16 August 2022) ⟨https://en.wikipedia.org/wiki/5G_NR_frequency_bands⟩ accessed 16 August 2009

this would mean for e.g. Band 10, there are approximately 2700 'channels' that can be used.[191]

The radio spectrum of frequencies is divided by the ITU and the Radio Regulations[192] are the international treaty governing the use of radio frequencies worldwide, including outer space. The Radio Regulations contain the international Table of Frequency Allocations.[193] The Table is organized into three Regions of the world[194] and is supplemented by assignment and allotment plans for some bands and services, and/or by mandatory coordination procedures. Within these regions, frequency bands are allocated to various satellite services, although a given service may be allocated different frequency bands in different regions.

The mission of the ITU Radiocommunication Sector is, *inter alia*, to ensure rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including those using satellite orbits, and to carry out studies and adopt recommendations on radiocommunication matters.[195]

In order to meet the ever growing radio spectrum needs of the satellite sector (and of all other sectors using radio frequencies), ITU oversees regular updates of the Radio Regulations. These regular updates are performed through the convening of World Radiocommunication Conferences every four years. The next World Radiocommunication Conference is in 2023 (WRC-23).[196]

191 Band 10 is from 3-30 GHz, hence 27 GHz in width. 27 GHz is 27,000 MHz with 10 MHz per channel. Modern telecommunications is of course more complicated than this, and a given bandwidth can, and does have a 'primary' and a 'secondary' use, increasing the number of channels. However, this demonstrates that radio spectrum is a finite resource.

192 ITU (n 186)

193 ibid Art 5

194 Region 1: Europe, Africa, the Middle East, what was formerly the Soviet Union, and Mongolia; Region 2: North and South America and Greenland and Region 3: Asia (excluding region 1 areas), Australia, and the southwest Pacific

195 'Mission statement' ⟨https://www.itu.int/en/ITU-R/information/Pages/mission-statement.aspx⟩ accessed 16 August 2022

196 'ITU World Radiocommunication Conference 2023 (WRC-23)' (*ITU-R*) ⟨https://www.itu.int/wrc-23/en/⟩ accessed 20 August 2022

Chapter 3. Domestic Space Law

In this Chapter, we outline the relevant domestic space law as applies to the contemporary United Kingdom space sector. We note the historical legislation for the UK, the Outer Space Act 1986, and focus on the recent legislation and regulations from the UK. In particular this is the Space Industry Act 2018 and the Space Industry Registrations 2021, and we also note the associated UK Space Guidelines standards and Licensing rules. The key roles of the two UK regulators most directly responsible for space and satellite actions, the Civil Aviation Authority (CAA) and the Office of Communications (Ofcom) are given. We also note other regulatory bodies, both at a UK and local level, that are involved in environmental and spaceflight activity.

Domestic Space Law Overview

As outlined on the 'Spaceflight legislation and guidance' webpage from the UK Government[197] and on the Legislation and regulations webpage from the Civil Aviation Authority,[198] there are three main legal instruments in the UK that cover spaceflight activities:

1. The Outer Space Act 1986 (OSA)[199] plus the amendments made to the OSA by the Deregulation Act 2015[200] applies to UK nationals and UK companies intending to launch or procure the launch of a space object, or operate a space object outside the UK.

2. The Space Industry Act 2018 (SIA) applies to anyone intending to carry out space activities, sub-orbital activities, and associated activities in the UK. Several statutory instruments have been made under the SIA.
    - The Space Industry Regulations 2021 (SIR) which make provision to enable the licensing and regulation of spaceflight activities, spaceports, and range control service.[201]
    - The Spaceflight Activities (Investigations of Spaceflight Accidents) Regulations 2021 which establish a spaceflight accident investigation body and make provision about the conduct of accident investigations.[202]
    - The Space Industry (Appeals) Regulations 2021 which outline the decisions made by the regulator that may be appealed by a licence applicant or licence holder. They also create the decision-making body to hear appeals and, set the procedures and timescales for making and deciding appeals.[203]

197 'Spaceflight legislation and guidance' (*UK Space Agency*, 1 June 2022) ⟨https://www.gov.uk/guidance/spaceflight-legislation-and-guidance⟩ accessed 2 August 2022

198 Civil Aviation Authority, 'Legislation and regulations: Information on the laws that apply to spaceflight' ⟨https://www.caa.co.uk/space/the-role-of-the-caa/legislation-and-regulations/⟩ accessed 29 July 2022

199 Outer Space Act 1986

200 Deregulation Act 2015

201 The Space Industry Regulations 2021 (n 37)

202 The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021 2021, SR 2021/793

203 The Space Industry (Appeals) Regulations 2021 2021, SR 2021/816

- The Regulator's Licensing Rules which support the regulator's power relating to the granting and renewal of operator, spaceport and range control licences under the SIA.[204]

3. The Air Navigation Order 2016[205] applies to anyone intending to carry the launch of a vehicle in the UK that is not capable of operating above the stratosphere (circa 50km altitude).[206]

Outer Space Act 1986

The Outer Space Act 1986 (OSA)[207] is an Act of Parliament that implements the United Kingdom's international obligations with respect to space launches and operations. The Outer Space Act received Royal Assent on 18 July 1986 and came into force three years later on the 31st July 1989.[208]

As originally enacted, the OSA had only 15 sections[209] (and in its current form still only has 17 sections[210]) and was created in light of the UK's treaty obligations,[211] to clarify and formally establish a legislative regime in this area. In particular, the OSA sets out the framework for the licensing of spaceflight activities.[212] Section 4 of the Act broadly caters for the safeguarding of obligations under Article VI of the Outer Space Treaty[213] while Section 7 deals with the registration of space objects.[214] Under Section 10 of the OSA, operators must indemnify the UK Government for claims brought against the latter other than in circumstances set out in that section.[215] This requirement became subject to industry-driven criticism, notably from the growing small satellite sector.[216]

In 2015, Section 12 of the Deregulation Act[217]amended the OSA to ensure licences specify the licensee's liability to indemnify the government regarding space activities authorised by the licence. The Deregulation Act 2015 placed a limit on the liability of licensees under Section 10(1A) of the OSA. This also led to the (third-party) liability being capped at €60million for standard missions.[218]

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204 The Regulator's Licensing Rules

205 The Air Navigation Order 2016, SR 2016/765, Art 96

206 ibid; Civil Aviation Authority, 'Air Navigation Order 2016: Information regarding the Air Navigation Order (ANO) 2016 and updates' ⟨https://www.caa.co.uk/general-aviation/working-with-you/air-navigation-order-2016/⟩ accessed 18 August 2022

207 An Act to confer licensing and other powers on the Secretary of State to secure compliance with the international obligations of the United Kingdom with respect to the launching and operation of space objects and the carrying on of other activities in outer space by persons connected with this country, Outer Space Act 1986

208 'Outer Space Act 1986' (*Wikipedia*) ⟨https://en.wikipedia.org/wiki/Outer_Space_Act_1986⟩ accessed 2 August 2022

209 'Outer Space Act 1986 Original (As enacted)' ⟨https://www.legislation.gov.uk/ukpga/1986/38/contents/enacted⟩ accessed 2 August 2022

210 'Outer Space Act 1986 Latest available (Revised)' ⟨https://www.legislation.gov.uk/ukpga/1986/38/contents⟩ accessed 2 August 2022

211 The Department for Business, Innovation and Skills, *Review of the "Outer Space Act (1986)": Impact Assessment (IA)* (2013) ⟨https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/493187/OSA_Impact_Assessment_FINAL_BIS0067.pdf⟩

212 Outer Space Act 1986, s 3-6

213 ibid s 4

214 ibid s 7

215 ibid s 10

216 Smith and Leishman (n 72) 9

217 Deregulation Act 2015, s 12

218 'Spaceflight legislation and guidance' (*UK Space Agency*, 16 April 2014) ⟨https://www.gov.uk/guidance/

The Outer Space Act 1986 continues to regulate activities carried out overseas by UK entities, including the procurement of the overseas launch of a space object and the operation of a satellite in orbit from an overseas facility by a UK entity.

For our discussions, we highlight two clauses in Section 5(2) of the OSA:[219] "A licence may in particular contain conditions requiring the licensee to conduct his operations in such a way as to—" "(e)(i) prevent the contamination of outer space or adverse changes in the environment of the earth."[220] and "(g) governing the disposal of the payload in outer space on the termination of operations under the licence and requiring the licensee to notify the Secretary of State as soon as practicable of its final disposal."[221] These two provisions come down from the international treaties, Art IX OST and the Registration Treaty, and may have a role to play in space sustainability.

Space Industry Act 2018

The Space Industry Act 2018 (SIA) created the high-level framework to enable launches to take place from the UK from the early 2020s.[222] The Space Industry Regulations 2021,[223] the Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021,[224] the Space Industry (Appeals) Regulations 2021,[225] and the associated guidance documents and Regulator's Licensing Rules[226] all provide detailed provisions required to implement the Act.

Newman (2017), Newman (2018) and Simmonds (2019) all give excellent overviews of the SIA[227] and the UK Government has produced "Understanding the Space Industry Act."[228] We rely heavily on these works. As noted by Simmonds (2019), the SIA drastically expands the domestic legislative framework, with 72 sections and 12 comprehensive schedules, plus a wave of changes to existing legislation. A deep critical look at each of the 72 sections and 12 schedules is left for other studies. Here, we do investigate the first sections and then give a summary overview of the SIA and focus on the aspects connected to sustainability.

Regulation of spaceflight

Sections 1, 2, 3, 4 and 16 of the SIA cover regulation of spaceflight.[229]

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apply-for-a-license-under-the-outer-space-act-1986⟩ accessed 3 August 2022; Wheeler (n 32)

219 Outer Space Act 1986, s 5(2)

220 ibid s 5(2)(e)(i)

221 ibid s 5(2)(g)

222 'Spaceflight legislation and guidance' (n 197)

223 The Space Industry Regulations 2021 (n 37)

224 The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulations 2021 2021 (n 202)

225 The Space Industry (Appeals) Regulations 2021 2021 (n 203)

226 Civil Aviation Authority, 'Space: Information on rocket launches, space flight and associated activities' ⟨https://www.caa.co.uk/space/⟩ accessed 29 July 2022

227 Christopher J Newman, 'The Draft UK Spaceflight Bill 2017: Bold Vision or Future Imperfect?' (2017) XI The Precis 28; Christopher J Newman and Mark Williamson, 'Space Sustainability: Reframing the Debate' (2018) 46 Space Policy 30; Alexander Simmonds, 'The Space Industry Act 2018: a giant leap?' (2019) 24(2) Coventry Law Journal 95

228 UK Space Agency, *Understanding the Space Industry Act* (2021) ⟨https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/777686/190208_Understanding_the_SIA_-_Final_For_Publication_-_Legal_Cleared_-_Initial_Publication.pdf⟩

229 Space Industry Act 2018, s1, 2, 3, 4, 16; *Understanding the Space Industry Act* (n 228)

Section 1(1) of the Act notes what is regulated. This includes: "space activities",[230] "sub-orbital activities",[231] and "associated activities,"[232] carried out in the United Kingdom.

"Space activity" is defined[233] as "launching or procuring the launch or the return to earth of a space object or of an aircraft carrying a space object,"[234] "operating a space object"[235] or "any activity in outer space."[236] This defintion of "space activity" is very wide ranging and encompasses actions from launch of a nanosat to crewed lunar or Martian landings.[237]

"Sub-orbital activity" means launching, procuring the launch of, operating or procuring the return to earth of either *(i)* "a rocket or other craft that is capable of operating above the stratosphere,"[238] or *(ii)* "a balloon that is capable of reaching the stratosphere carrying crew or passengers,"[239] or *(iii)* "an aircraft carrying such a craft,"[240] "but does not include space activity." This allows for sub-orbital flights of high-altitude balloons, and also for horizontal launch activities.

The SIA then gives "Space activities and sub-orbital activities are referred to in this Act as "spaceflight activities"."[241]

Starting from the Earth's surface, the stratosphere is the second layer of the atmosphere, located above the troposphere and below the mesosphere.[242] The stratosphere starts at an altitude of about 7 km (23,000 ft; 4.3 mi) near the Earth's Poles, while near the equator, the lower edge of the stratosphere is as high as 20 km (66,000 ft; 12 mi). The upper boundary of the stratosphere is around 50-60 km. Weather ballons tend to operate in the stratosphere, while Sounding Rockets tend to operate in the (lower) mesosphere. Having the stratosphere be the demarcation is an interesting move for national space legislation. The top edge of the stratosphere is not a steady altitude, but offers a somewhat scientific and quantifiable way (due to the temperature inversion with changing altitude) of demarcating the invisible boundary in the sky between aerospace and outer space.[243]

Section 2 gives the duties and supplementary powers of the regulator which include exercising the regulator's functions to take into account: any environmental objectives set by the Secretary of State;[244] any international obligations of the United Kingdom[245] and any space debris mitigation guidelines issued by an international organisation in which the government of the United Kingdom is represented.[246]

As noted in "Understanding the SIA", Paragraph 2(2)(e) requires the regulator to take

230 Space Industry Act 2018, s1(1)(a)
231 ibid s1(1)(b)
232 ibid s1(1)(c)
233 ibid s1(4)
234 ibid s1(4)(a)
235 ibid s1(4)(b)
236 ibid s1(4)(c)
237 Simmonds, 'The Space Industry Act 2018: a giant leap?' (n 227)
238 Space Industry Act 2018, s 1(5)(a)
239 ibid s 1(5)(b)
240 ibid s1(4)(b)
241 ibid s 1(6)
242 'Stratosphere' (*Wikipedia*, 11 August 2022) ⟨https://en.wikipedia.org/wiki/Stratosphere⟩ accessed 16 August 2009
243 Simmonds, 'The Space Industry Act 2018: a giant leap?' (n 227). Interestingly, McDowell (2018) (McDowell, 'The edge of space: Revisiting the Karman Line' (n 2)) investigates the inner edge of outer space from historical, physical and technological viewpoints and propose 80 km as a boundary between aero and outer space.
244 Space Industry Act 2018, s 2(2)(e)
245 ibid s 2(2)(g)
246 ibid s 2(2)(h)

into account the Government's environmental policy. In addition, the regulator cannot grant a launch vehicle operator licence or spaceport licence unless an assessment of environmental effects has been submitted. Paragraph 2(2)(g) refers to any international obligations of the United Kingdom. These obligations are not limited to those in the UN Space Treaties, but include any obligation arising as a matter of international law. Paragraph 2(2)(h) is intended to capture the guidelines issued by the Inter-Agency Debris Coordination Committee (IACD) of which the UK via the UK Space Agency is a member.[247]

Section 3 defines a "spaceport" as a site from which spacecraft or carrier aircraft are launched or (as the case may be) are to be launched, or[248] a site at which controlled and planned landings of spacecraft take place or (as the case may be) are to take place.[249]

As with the OSA, unlicensed spaceflight activities or unlicensed operation of a spaceport are prohibited.[250] Section 16 effectively appoints the Civil Aviation Authority (CAA) to carry out certain functions of the regulator, though certain functions can be reserved to the Secretary of State.[251]

Range

Sections 5, 6 and 7 of the SIA covers Range,[252] Range control services[253] and provision of range control services.[254] A range is a zone (or zones) consisting of a volume of airspace and area of land and/or sea, in relation to which warnings, restrictions or exclusions are put in place.[255]

Licences and Granting of Licences

Sections 8-11[256] covers Grant of licences, Conditions of licences and other licence issues. This includes general notes on granting licences,[257] granting an operator licence,[258] granting a spaceport licence[259] and critically for this work, the assessments of environmental effects associated with granting a spaceport[260] or operator licence.[261]

From Section 11, we see that the regulator may not grant an application for a licence unless the applicant has submitted an assessment of environmental effects.[262] An "assessment of environmental effects" (AEE) in relation to a spaceport licence, means *an assessment of the effects that launches of spacecraft or carrier aircraft from the spaceport in question, or launches of spacecraft from carrier aircraft launched from the spaceport, are expected to have on the environment*[263] (our emphasis). In relation to an operator licence

247 'Inter-Agency Space Debris Coordination Committee' (31 March 2022) ⟨https://www.iadc-home.org/⟩ accessed 6 August 2022 (and we note there is an incorrect URL in the "Understanding the SIA" document here.)
248 Space Industry Act 2018, s 3(2)(a)
249 ibid s 3(2)(b)
250 ibid s 3
251 ibid s 16
252 ibid s 5
253 ibid s 6
254 ibid s 7
255 ibid s 5(1)
256 ibid s 8-11
257 ibid s 8
258 ibid s 9
259 ibid s 10
260 ibid s 11(1)(a)
261 ibid s 11(1)(b)
262 ibid s 11(2)
263 ibid s 11(3)(a)

authorising launches of spacecraft or carrier aircraft, means *an assessment of the effects that those launches are expected to have on the environment*[264] (our emphasis). We discuss in more detail, and see examples of, AEE submissions in the next chapter.

Sections 12-15 give the terms of the licenses,[265] the conditions of licences,[266] the length of time and renewal of licences,[267] and the transfer, variation, suspension or termination of licences.[268]

Liabilities, indemnities and insurance

Sections 34-38 cover: Liabilities of an operator,[269] Power or duty of Secretary of State to indemnify,[270] the obligation to indemnify government against claims,[271] Regulator liability[272] and insurance.[273]

These sections are in direct response to the UKs treaty obligations, and specifically for Art VII of the OST and the Liability Convention.[274] The SIA places a liability on persons performing spaceflight activities to indemnify the Government for any claims brought against the Government for loss or damage caused by those activities. There is a similar liability for operators under the OSA. One of the reasons for the inclusion of this indemnity is because under the UN treaties, the Government is ultimately liable for the space activities of its nationals.[275] This indemnity applies to any claims brought against the Government including claims brought under the Liability Convention.

The discusion of liabilities, indemnities and insurance is a key new part of the UKs Space legislation, but is not of further direct interest for our discussion. The remainder of the SIA sections are also not of direct relevance to our sustainability discussions, but we include them in the Appendix for completeness.

Schedules

The is some interesting detail included in the Schedules of the SIA, in particular Schedule 1. This gives 'Particular conditions that may be included in licenses', and has a condition to be in compliance with space debris mitigation guidelines.[276]

Schedule 1 also includes "conditions requiring the licensee to conduct the licensee's activities in such a way as - to prevent the contamination of outer space or adverse changes in the environment of the earth,[277] to avoid interference with the activities of others in the peaceful exploration and use of outer space.[278] This language is familiar to us from Article IX of the OST.

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264 Space Industry Act 2018, s 11(3)(b)
265 ibid s 12
266 ibid s 13
267 ibid s 14
268 ibid s 15
269 ibid s 34
270 ibid s 35
271 ibid s 36
272 ibid s 37
273 ibid s 38
274 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) Art VII; Convention on International Liability for Damage Caused by Space Objects (n 85)
275 'Spaceflight legislation and guidance' (n 197)
276 Space Industry Act 2018, Schedule 1, 1(g)
277 ibid Schedule 1, 14(a)
278 ibid Schedule 1, 14(b)

The remainder of the Schedules are not relevant for the sustainability discussion and are reported in the Appendix for completeness.

Space Industry Regulations 2021

Simmonds (2021) gives an excellent overview of the Space Industry Regulations 2021[279] and Wheeler (2021) also gives an comprehensive digest of the SIR. There is also the Explanatory Memorandum to the Space Industry Regulations 2021.[280]

The SIR has 17 Parts, broken down into Chapters and a total of 287 Regulations along with 8 Schedules. The epilogue of the SIR has an Explanatory Note. The SIR is mainly concerned about the criteria that need to be satisfied to grant one of the given licences. The focus is on training, safety, security, informed consent,[281] monitoring and enforcement.

The Space Industry Regulations 2021 (SIR) make provisions to enable the licensing and regulation of spaceflight activities (including launch and in-orbit operations), spaceports and range control services.[282] Different types of licences as per the SIA:

- "operator licence" means a licence under this section authorising a person to carry out spaceflight activities;[283] An operator licence can include:
  - launch operator (in relation to launching a launch vehicle, or a carrier aircraft and a launch vehicle);
  - return operator (in relation to returning a launch vehicle, launched elsewhere than the UK, to land in the UK or UK territorial waters);
  - orbital operator (in relation to procuring the launch of a space object into orbit, operating a space object in orbit or conducting any other activity in outer space (including lunar activities));
- "spaceport licence" is a licence under this section authorising a person to operate a spaceport.[284]
- " range control licence."[285]

with the definitions of spaceport and range as above.

Closer inspection of the SIR reveals that there are regulations that touch on sustainability and environmental concerns. In particular, Regulation 101 that states, "The spaceflight operator must after a launch vehicle has reached a stable orbit—take reasonable steps to—prevent contamination of outer space arising from the launch vehicle in orbit or adverse changes in the environment of the earth from that vehicle in orbit."[286] Again, we recognise

279 Alexander Simmonds, 'The Space Industry Regulations 2021: another giant leap?' (2021) 26(2) Coventry Law Journal 69

280 The National Archives UK Government, 'Explanatory Memorandum The Space Industry Regulations 2021 (2021 No. 792) and The Spaceflight Activities (Investigation of Spaceflight Accidents) Regulatsion 2021 (2021 No. 793) and The Space Industry (Appeals) Regulations 2021 (2021 No. 816)' ⟨https://www.legislation.gov.uk/uksi/2021/792/memorandum/contents⟩ accessed 14 August 2022

281 See Simmonds (2021) for a detailed discussion on the informed consent regulations; Simmonds, 'The Space Industry Regulations 2021: another giant leap?' (n 279)

282 The Space Industry Regulations 2021 (n 37); Authority, 'Legislation and regulations: Information on the laws that apply to spaceflight' (n 198)

283 Space Industry Act 2018, s 3(2)

284 ibid s 3(2)

285 ibid s 7(1)(b)

286 The Space Industry Regulations 2021 (n 37) reg 101(c)(iii)

this language from Art IX of the OST. One question is whether this regulation should be placed in a 1960s 'extraterrestrial material' context or a 2020s space sustainability manner.

Further Spaceflight Guidances

As noted above and on the CAA website, alongside the SIR, there are a suite of additional spaceflight Regulations, licensing rules and guidances.

Guidances

The CAA gives a list of Spaceflight Publications.[287] Walker (2022) discusses how "as low as reasonably practicable" (ALARP), is a fundamental concept in UK health and safety law,[288] guidance Reducing Risks: Protecting People (R2P2) [10], and HM Treasury's 'Orange Book: Tolerability of Risk Framework'. and now applies to the space sector as a proportionate approach to safety risk management. As Wheeler notes,[289] the UK government has also published the following:

- Applying for a licence under the Space Industry Act 2018;[290]
- Guidance for Orbital operator licence applicants and licensees;[291]
- Guidance for Range control licence applicants and licensees;[292]
- Guidance for Spaceport licence applicants and licensees;[293]
- Guidance for Launch and Return operator licence applications and licensees;[294]
- Guidance on duties for all licensees under The Space Industry Act 2018;[295]
- Guidance for the assessment of environmental effects;[296]

287 Civil Aviation Authority, 'List of Spaceflight Publications' ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=list&type=subcat&id=42⟩ accessed 19 August 2022

288 The Health and Safety Executive (HSE), *Reducing risks, protecting people: HSE's decision-making process (R2P2)* (2001); Mark Ripley, *The Orange Book Management of Risk - Principles and Concepts* (, HM Government 2020)

289 Wheeler (n 32)

290 'CAP2209: Applying for a licence under the Space Industry Act 2018' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=10550⟩ accessed 28 July 2022

291 'CAP2210: Guidance for orbital operator applicants and licensees' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10545⟩ accessed 28 July 2022

292 'CAP 2211: Guidance for range control licence applicants and licensees' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10546⟩ accessed 28 July 2022

293 Civil Aviation Authority, 'CAP 2212: Guidance for Spaceport licence applicants and Spaceport licensees' (29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=10547⟩ accessed 28 July 2022

294 'CAP 2213: Guidance for launch operator and return operator licence applicants and licensees' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10564⟩ accessed 28 July 2022

295 'CAP 2214: Guidance on duties for all licensees under The Space Industry Act 2018' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10560⟩ accessed 28 July 2022

296 'CAP 2215: Guidance for the assessment of environmental effects' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10561⟩ accessed 28 July 2022

- Guidance on appealing decisions made under The Space Industry Act 2018 and The Outer Space Act 1986;[297]
- Guidance on security matters for applicants and licensees;[298]
- Guidance on liabilities and insurance;[299]
- Guidance on the investigation of spaceflight accidents;[300]
- Principles and guidelines for the spaceflight regulator in assessing ALARP and acceptable risk;[301]
- Regulator's licensing rules;[302]
- Appendix C Block A Initial screening checklist.[303]

Guidance for the assessment of environmental effects

The Space Industry Act 2018 regulates all spaceflight activities taking place from the United Kingdom, and associated activities. Spaceflight activities are space activities and sub-orbital activities.[304] This guidance explains the process for completing an assessment of environmental effects (AEE) as part of a licence application under the Act. It explains what an AEE is, what the regulator requires the AEE to include (in line with its power under section 11(6) of the Act), the process for submitting an AEE and the way the regulator will consult on the submitted AEE.[305]

The AEE must identify, describe and assess the potential direct and indirect significant effects of the proposed spaceflight activities on the following environmental features, including interaction among those features:[306]

- population and human health
- biodiversity (for example, ecology, flora and fauna)

297 'CAP 2216: Guidance on appealing decisions made under The Space Industry Act 2018 and The Outer Space Act 1986' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10562⟩ accessed 28 July 2022

298 'CAP2217: Guidance on security matters for applicants and licensees' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10563⟩ accessed 28 July 2022

299 'CAP2218: Guidance on liabilities and insurance' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10556⟩ accessed 28 July 2022

300 'CAP2219: Guidance on the investigation of spaceflight accidents' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=10555⟩ accessed 28 July 2022

301 'CAP2220: ALARP acceptability policy' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10557⟩ accessed 28 July 2022

302 'CAP2221: Regulator's licensing rules' (*Civil Aviation Authority*, 29 July 2021) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=10559⟩ accessed 28 July 2022

303 'CAP2381: Appendix C Block A Initial screening checklist' (*Civil Aviation Authority*, 8 July 2022) ⟨https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=10559⟩ accessed 24 August 2022

304 Assets Publishing Service, *Guidance for the assessment of environmental effects* (2021) ⟨https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904454/guidance-for-the-assessment-of-environmental-effects..pdf⟩ para 1.1

305 ibid para 1.4

306 ibid para 4.1

- air quality
- noise and vibration
- water (for example, quantity and quality)
- marine environment
- climate (for example, greenhouse gas emissions, impacts relevant to adaption)
- land, soils and peat
- landscape and visual impact
- material assets and
- cultural heritage (including architectural and archaeological aspects)

How this works in practice, we examine in the next Chapter.

UK Regulators

The Civil Aviation Authority

A major outcome of the SIR was the appointment of the Civil Aviation Authority (CAA) as the regulator for UK Space activities.[307] Since its formation in 2010, the UKSA had been the body in charge previously, but moving space regulation to the CAA is an important move as it puts 'clear blue water' between the agency advocating, promoting and funding space activity (the UKSA) and the statutory body that independently regulators space actions (the CAA).

The CAA is classed as a public corporation, established by statute, in the public sector. The CAA is the statutory corporation which oversees and regulates all aspects of civil aviation in the United Kingdom.[308]

Office of Communications

The Office of Communications, commonly known as Ofcom, is the government-approved regulatory and competition authority for the broadcasting, telecommunications and postal industries of the United Kingdom.[309] The regulator was initially established by the Office of Communications Act 2002 and received its full authority from the Communications Act 2003.[310] Section 5 of the Communication Act 2003 gives Ofcom directions 'in respect of networks and spectrum functions.'[311]

Some of the main areas Ofcom presides over are licensing, research, codes and policies, complaints, competition and protecting the radio spectrum. Ofcom represents the UK in

307 The Space Industry Regulations 2021 (n 37) Part 2

308 Civil Aviation Authority, 'Civil Aviation Authority (United Kingdom)' ⟨https://en.wikipedia.org/wiki/Civil_Aviation_Authority_(United_Kingdom)⟩ accessed 10 August 2022

309 'Ofcom: Making Communications work for everyone' ⟨https://www.ofcom.org.uk/home⟩ accessed 19 August 2022; 'Ofcom' (*Wikipedia*, 15 August 2022) ⟨https://en.wikipedia.org/wiki/Ofcom⟩ accessed 15 August 2022

310 Communications Act 2003, s 1

311 ibid s 5

a number of ITU activities balancing the needs of various UK based stakeholders and UK consumers alike.[312]

Ofcom consults on space spectrum strategy, which sets out Ofcom's proposed strategy for the management of spectrum. The Ofcom Space Spectrum Strategy covers the use of spectrum by the satellite and space science sectors, including meteorological and earth observation satellites.[313]

Ofcom submits and manages all satellite filings to the ITU on behalf of organisations registered in the UK.[314] Ofcom also has directly acknowledged the UK's National Space Strategy, noting that Ofcom's space spectrum strategy complements the Government's aims by supporting innovation and creating a transparent and predictable regulatory framework.[315]

Summary

So, there are some level of provisions in the SIA, which filters through to the SIRs, with regards space sustainability and environmentalism. Unsurprisingly, given the major motivation of the SIA (and SIRs) was to provide the legislative framework for UK domestic launch, the focus is on the environmental impacts of the spaceports. This is of course important, but is a specific part of the full space supply chain and space sector. Very interestingly, the SIA legislation speaks to space debris mitigation guidelines (e.g. Section 2(2)(h); Schedule 1(1)(g)), and then the current SIR regulations give a nod to this (Regulation 101(c)(iii)).

The national regulators (CAA and Ofcom) have to liaise with each other, and as well shall see, should in an ideal world, also communicate with the local planning and environmental authorities. We shall note how this does, or does not work, in the next two chapters.

312 'Ofcom at the International Telecommunication Union (ITU)' ⟨https://www.ofcom.org.uk/about-ofcom/international/spectrum/itu⟩ accessed 19 August 2022

313 'Consultation: Space spectrum strategy' (24 May 2022) ⟨https://www.ofcom.org.uk/consultations-and-statements/category-2/space-spectrum-strategy⟩ accessed 19 August 2022

314 ibid 2.21

315 ibid 2.32

Chapter 4. Sustainability and the contemporary U.K. Space Sector: I. Case Studies

In Chapter 2, we gave an overview of the international space law instruments and in Chapter 3, we gave a detailed summary of the contemporary suite of UK Space legislation and regulations. Of particular focus for the domestic legislation is the Space Industry Act 2018 and the set of Space Industry Regulations and Guidelines in 2021. These regulations had the motivation for the UK to become a launching State, and are as such geared towards facilitating spaceflight activities, spaceports, and range control services. There is also provision in the UK regulations for launch-and-return operations as well as orbital operations.

From this point of view, the Regulations are encompassing and provide detail on how organisations, including spaceport operators and launching entities, can proceed with obtaining the licences and authorization for spaceflight activity from UK soil. However, although the regulations are detailed in certain areas, they are almost completely silent in others. These elements include, but are not limited to, Space Traffic Management (STM), Space Situational Awareness (SSA) and End-of-Life (EoL) procedures.

In this Chapter, we take the approach of looking at the UK SIA and SIRs via two 'Case Studies.' The first case study focuses on the proposed UK Spaceports and launchers. The second case study focuses on UK based private companies that are addressing the issue of active debris removal (ADR). We also touch on STM and SSA.

Case Study: Spaceports, Launchers and Ranges

The following sections, and indeed a considerable part of our overall motivation, draws inspiration from Riordan (2021).[316] Riordan (2021) investigate and explore in detail the environmental considerations required for licensing UK spaceports and launch activities. We refer the interested reader to this study for a fuller discussion about environmental effects, environmental impact assessments (EIA) and EIA in a Transboundary Context (TEIA). One aspect that our work is able to directly extend Riordan (2021) is to update the AEE and license application statuts.[317]

UK Spaceports and Launchers Assessments of environmental effects

There are currently seven locations proposed for UK Spaceports.[318] These are (in decreasing northerly order):

316 Nancy Riordan, 'UK Spaceports and Launch Services: An Overview of the Assessment of Environmental Effects and Environmental Impact Assessment' in Annette Froehlich (ed), *Spaceports in Europe* (Springer International Publishing AG 2021)

317 ibid Table 1

318 LaunchUK, 'Brochure: A guide to the UK's commercial spaceports' (*UK Space Agency*, 23 March 2021) ⟨https://www.gov.uk/government/publications/brochure-a-guide-to-the-uks-commercial-spaceports⟩ accessed 11 August 2022

- SaxaVord Spaceport, Lamba Ness, Unst, Shetland Islands, Scotland
- Space Hub Sutherland, A'Mhòine peninsula, Sutherland, Scotland
- Spaceport 1, Scolpaig Farm, North Uist, Outer Hebrides, Scotland
- Spaceport Machrihanish, Campbeltown, Argyll, Scotland
- Prestwick Spaceport, Prestwick, South Ayrshire, Scotland
- Spaceport Snowdonia, Llanbedr, Gwynedd, Wales
- Spaceport Cornwall, Cornwall Airport Newquay, Cornwall

The top three in the list are aiming to build new facilities to perform vertical launch, while Machrihanish, Prestwick, Snowdonia and Cornwall are looking to repurpose existing aerodromes for horizontal launch.[319] Five out of the seven spaceports have one, or more, launchers associated with them. These include:

- SaxaVord Spaceport: Lockheed Martin/ABL Space Systems,[320] HyImpulse[321] and probably Skyrora
- Space Hub Sutherland: Orbex[322]
- Spaceport 1: QinetiQ[323]
- Prestwick Spaceport: Astraius[324]
- Spaceport Cornwall: Virgin Orbit[325]

Spaceport Machrihanish and Spaceport Snowdonia are currently in negotiation with launch providers.

319 A conventional aircraft, usually a Boeing 747, takes-off and carries a rocket up to a flight altitude of 30-40,000 ft. The rocket is then released, fires up its own engine and accesses outer space from there. The airplane then returns to the aerodrome.

320 Hannah Lavery, 'All Systems Are Go: Lockheed Martin Welcomes Approval From Shetland Islands Council For SaxaVord Spaceport Construction' (*Lockheed Martin UK*, 28 February 2022) ⟨https://lockheedmartinuk.mediaroom.com/index.php?s=2429&item=122569⟩ accessed 20 August 2022; Jeff Foust, 'Lockheed Martin selects ABL Space Systems for UK launch' (*SpaceNews*, 7 February 2021) ⟨https://spacenews.com/lockheed-martin-selects-abl-space-systems-for-uk-launch/⟩ accessed 20 August 2022

321 'German rocket maker plans to launch from Unst' (*SaxaVord General News*, 2 February 2021) ⟨https://saxavord.com/german-rocket-maker-plans-to-launch-from-unst/⟩ accessed 20 August 2022

322 Paul Bate, 'On the ground with Space Hub Sutherland and Orbex' (*UK Space Agency blog*, 16 March 2022) ⟨https://space.blog.gov.uk/2022/03/16/on-the-ground-with-space-hub-sutherland-and-orbex/⟩ accessed 22 August 2022

323 'First vertical launch spaceport planned for Outer Hebrides' (11 June 2019) ⟨https://www.insider.co.uk/news/first-vertical-launch-spaceport-planned-16502888⟩ accessed 22 August 2022

324 'Prestwick Spaceport Moves Closer to Lift Off with Astraius Partnership' (*Astraius News*, 22 September 2021) ⟨https://www.astraius.com/2021/09/prestwick-spaceport-moves-closer-to-lift-off-with-astraius-partnership/⟩ accessed 22 August 2022; Stuart Wilson, 'Prestwick Spaceport takes giant leap towards launch with exciting new deal announced' (*Daily Record*, 28 July 2022) ⟨https://www.dailyrecord.co.uk/ayrshire/prestwick-spaceport-takes-giant-leap-27589639⟩ accessed 23 August 2022

325 Natalie Clarkson, 'Virgin Orbit to launch first Welsh satellite from Spaceport Cornwall' (*Virgin*, 9 March 2022) ⟨https://www.virgin.com/about-virgin/latest/virgin-orbit-to-launch-first-welsh-satellite-from-spaceport-cornwall⟩ accessed 20 August 2022

Several of the spaceports and launchers have filled for a change to the design of UK airspace necessary for spaceflight activities.[326] The stages for the airspace change of the various spaceports and sponsor organisations are given in Appendix C.

To date, the following companies have filled for licences with the CAA:

- Orbex (launcher)[327]
- SaxaVord Spaceport (spaceport)[328]
- Skyrora (launcher)[329]
- Spaceport Cornwall (spaceport)[330]
- Virgin Orbit (launcher)[331]

If you are applying for a launch operator or spaceport licence under the SIA, you need to complete an assessment of environmental effects (AEE).[332] The AEE is the only publicly available part of the Spaceport licence.

Guidance for the assessment of environmental effects is given in CAA document CAP 2215.[333] As noted in Chapter 3, the AEE must address a range of specific environmental topics.[334] We have only been able to locate one AEE application.[335] This is the joint

326 Civil Aviation Authority, 'Airspace change process: Guidance on changes to the use or classification of airspace in the UK' ⟨https://www.caa.co.uk/Commercial-industry/Airspace/Airspace-change/Airspace-Change/⟩ accessed 31 August 2022; Civil Aviation Authority, 'Airspace change portal' ⟨https://airspacechange.caa.co.uk/⟩ accessed 31 August 2022

327 Caroline McMorran, 'Orbex applies for licence to enable commercial rockets to be launched from Space Hub Sutherland' (*The Northern Times*, 3 February 2022) ⟨https://www.northern-times.co.uk/news/orbex-applies-for-licence-to-allow-rockets-to-be-launched-fr-264896/⟩ accessed 20 August 2022

328 'SaxaVord Spaceport submits licence applications to the CAA' (*ADS Advance*, 10 March 2022) ⟨https://www.adsadvance.co.uk/saxavord-spaceport-submits-licence-applications-to-the-caa.html⟩ accessed 20 August 2022

329 'Skyrora submits Vehicle Licence Application to Commence Launch Operations' (*Skyrora Media Our News*, 4 August 2022) ⟨https://www.skyrora.com/post/skyrora-submits-vehicle-licence-application-to-commence-launch-operations⟩ accessed 20 August 2022

330 'CAA launches space consultation' (*Business Cornwall*, 22 July 2022) ⟨https://businesscornwall.co.uk/news-by-industry/roads-and-transportation/2022/07/caa-launches-space-consultation/⟩ accessed 20 August 2022; 'Access Alert | UK CAA Consultation on Environmental Effects of First UK space Launch from Cornwall' (*Access Partnership*, 25 July 2022) ⟨https://accesspartnership.com/access-alert-uk-caa-consultation-on-environmental-effects-of-first-uk-space-launch-from-cornwall/⟩ accessed 20 August 2022

331 'First UK Rocket Launch Faces Uncertainty Over Licensing Schedule' (*Orbital Today*, 4 February 2022) ⟨https://orbitaltoday.com/2022/02/04/first-uk-rocket-launch-faces-uncertainty-over-licencing-schedule/⟩ accessed 20 August 2022

332 Civil Aviation Authority, 'Environmental effects: Helping you understand how to complete an Assessment of Environmental Effects (AEE)' ⟨https://www.caa.co.uk/space/guidance-and-resources/environmental-effects/⟩ accessed 19 August 2022

333 'CAP 2215: Guidance for the assessment of environmental effects' (n 296)

334 ibid

335 Civil Aviation Authority, 'Public Consultation on the Assessment of Environmental Effects: Virgin Orbit and Spaceport Cornwall' (22 July 2022) ⟨https://consultations.caa.co.uk/corporate-communications/aee-consultation-virgin-orbit-spaceport-cornwall/⟩ accessed 22 August 2022; We emailed the CAA asking if the other applications have had their AEE open for public consultation yet. A reply was received noting "We [the CAA] cannot comment on individual licence applications but guidance on the CAA's approach to public consultation for AEEs is documented in CAP 2352. In particular, the guidance explains when and how the CAA will consult on AEEs, including where information may be viewed, how comments can be made and the timescales for a consultation, as well as how the CAA will publicise consultations."

submission from Virgin Orbit and Spaceport Cornwall.[336]

This AEE is a fairly significant document (over 150 pages) with some level of economic detail.[337] Interestingly however, the Cornwall/Virgin AEE notes early on that its scope will be limited; "... the following environmental topics were not evaluated further because the proposed Virgin Orbit activities at Cornwall Airport Newquay and over the Atlantic Ocean would not affect these environmental resources: population and human health; water resources; land, soils and peat; biodiversity (terrestrial ecology, flora, and fauna); noise and vibration; landscape and visual impact; material assets and cultural heritage; and air quality."[338] Thus it appears there are a substantial number of areas which will not be addressed in this AEE. There is also no discussion in the AEE - nor was there expected to be - of satellite end-of-life or discussions about what happens once the payload is in space.

Chapter 5 of the AEE is the "Environmental Baseline Conditions and Assessment of Effects" where the impacts on climate change as a result of greenhouse gas (GHG) emissions from proposed Spaceport Cornwall and Virgin Orbit operations are not only discussed by quantified.[339] In summary, over the 8 year, 17 launch proposed operation period of Spaceport Cornwall and Virgin Orbit, there are a total of 5,352 tonnes of carbon dioxide equivalent (tCO_2e) emissions, at an average of 315 tCO_2e per launch. To put this in context, the UK average carbon footprint is about 10 tCO_2e per person per year.[340] Over 85% of these emissions are from the Virgin Orbit rocket activities.[341]

Spaceport Cornwall intends to be carbon neutral by 2030. A Sustainability Steering Group is being established.[342] There are further discussions in Chapter 5 of the AEE regarding the Marine Environment[343] and population, human health and socio-economic impact.[344] This chapter definitely has thought and effort put towards understanding, and potentially even mitigating, the activities associated with the spaceport and launcher. In the Conclusion to the AEE, however, there are many issues that are deemed 'Not significant' or simply 'n/a' in the summary of the effects of proposed Virgin Orbit operations at Spaceport Cornwall and within airspace over, and the marine environment of the Atlantic Ocean to the west, north, and south of the UK.[345]

Outside of the CAA AEE requirement, SaxaVord[346], and Space Hub Sutherland[347] have

336 *Assessment of Environmental Effects Virgin Orbit, LLC LauncherOne Operations from Spaceport Cornwall, Cornwall Airport Newquay, United Kingdom* (v2 AEE-Virgin Orbit/Spaceport Cornwall, 2022) ⟨https://consultations.caa.co.uk/corporate-communications/aee-consultation-virgin-orbit-spaceport-cornwall/user_uploads/virgin-orbit-spaceport-cornwall-aee--13jul22--1.pdf⟩ accessed 18 August 2022

337 For example, "Virgin Orbit proposes to conduct a maximum of two launches per year over the next 8.5 years (2022-2030), with one launch in 2022 and 2 launches/year for 2023-2030" (ibid 3.1.2).

338 ibid ES.4.1

339 ibid 5.2

340 'UK average footprint' (*Carbon Independent*, 26 November 2021) ⟨https://www.carbonindependent.org/23.html⟩ accessed 24 August 2022

341 'Scope 1+Scope 2' vs. 'Scope 3' in *Assessment of Environmental Effects Virgin Orbit, LLC LauncherOne Operations from Spaceport Cornwall, Cornwall Airport Newquay, United Kingdom* (n 336) Table 5.2-3

342 ibid 5.2.34

343 ibid 5.4

344 ibid 5.2

345 ibid Table 8.1-1

346 as Shetland Space Centre Limited; ITPEnergised, 'Shetland Space Centre - Environmental Impact Assessment' (*https://wwwitpenergisedcom/portfolio/shetland-space-centre-environmental-impact-assessment/*, 10 January 2021) ⟨https://lockheedmartinuk.mediaroom.com/index.php?s=2429&item=122569⟩ accessed 20 August 2022

347 Highlands and Islands Enterprise, 'Space Hub Sutherland Environmental Impact Assessment Report: Volume 1: Non-Technical Summary February 2020' (10 February 2020) ⟨https://www.hie.co.uk/media/7788/environmental-impact-assessment.pdf⟩ accessed 22 August 2022

made strong and welcome efforts to provide public EIAs. Spaceport 1 has provided a link to its EIA[348] but contrary to information on the Comhairle nan Eilean Siar planning website, is not immediately available. Prestwick Spaceport has submitted its EIA Screening Report to South Ayrshire Council[349] but this document is not public. Spaceports Machrihanish, Cornwall and Snowdonia have not submitted EIAs.

Space Hub Sutherland has perhaps had the most interaction with national and local environmental considerations. The peninsula includes two special sites of scientific importance (SSSIs) designated by the UK government, and sits within an EU-designated special protection area (SPA). When discussing planning there was local support and opposition to the spaceport in Mhoine[350] though legal challenges from extremely wealthy individuals have been dismissed.[351] Permission to build the spaceport has been opposed by a holding objection from the Wildland company[352] who argue that the area is protected under the Ramsar Convention,[353] a 1971 treaty covering internationally important wetlands, ratified by the UK in 1976. The argument was rejected by the Court of Session in Edinburgh. Lord Doherty rejected the legal challenge brought by Wildland Ltd against Highland Council, saying he was "not persuaded" the local authority had breached any law,[354] and considered that "none of the grounds of challenge is well-founded".[355]

To date, this challenge[356] of a decision of a local council granting planning permission for the construction of a launch spaceport is the only UK legal case that is a result of the SIA or SIRs.

UK Licensing for Range, Return and Orbital operators

As stated on the CAA website, "The Space Industry Act 2018 (SIA) and Space Industry Regulations 2021 allow for the licensing and regulation of a wide range of commercial spaceflight activities, including the provision of range control services. The Act and the Regulations set out general requirements for all licence holders and contain specific requirements for the provision of range control services."[357]

To operate and carry out range control services, one must apply to the CAA for a range control operator licence. The information that is required when applying for a range con-

348 'Spaceport 1 Environmental Impact Assessment' (*Comhairle nan Eilean Siar Online Services*, 25 February 2022) ⟨https://www.cne-siar.gov.uk/news/2022/february/spaceport-1-environmental-impact-assessment/⟩ accessed 24 August 2022

349 'Prestwick Spaceport Files Environmental Screening Report' (*Prestwick Aerospace*, 22 July 2021) ⟨http://www.prestwickaerospace.com/prestwick-spaceport-files-environmental-screening-report/⟩ accessed 24 August 2022

350 One can view the planning application, the committee report, public comments and decision at The Highland Council's planning portal here. The application reference is 20/00616/FUL.

351 *The Highland Council v Wildland Ltd* (2021) CSOH 87 P901/20; 'Billionaires' challenge to Highlands space port fails' (*BBC News: Highlands & Islands*, 20 August 2021) ⟨https://www.bbc.co.uk/news/uk-scotland-highlands-islands-58281005⟩ accessed 22 August 2022, Tereza Pultarova, 'Scottish court rejects billionaire's challenge against UK spaceport' (*Spacecom*, 23 August 2021) ⟨https://www.space.com/space-hub-sutherland-billionaire-complaint-dismissed⟩ accessed 22 August 2022

352 Of billionaire Danish couple Anne and Anders Povlson

353 Convention on wetlands of international importance especially as waterfowl habitat (21 December 1975) 996 UNTS 245

354 *The Highland Council v Wildland Ltd* (n 351) 18

355 ibid 55

356 ibid

357 Civil Aviation Authority, 'Applying for a range control licence: Information on how to apply for a range control operator licence' ⟨https://www.caa.co.uk/space/launch-return-range-and-spaceport-operators/applying-for-a-licence/applying-for-a-range-control-licence/⟩ accessed 28 July 2022

trol licence is set out in Table A and Table F of the Regulator's Licensing Rules.[358] Similarly, for a Return Operator Licence, it is Table A and Table C in CAP 2221 and for an Orbital Licence, Table A and Table D.

Studying these tables, one sees that for these three licences, no assessment of environmental effects is required. In fact, incredibly little environmental documentation of any kind is requested. The Orbital licence asks for "Safety and sustainability information pertaining to the mission, including disposal operations" as an option in a general set of 'tick boxes'. Outside of this, there are no direct requirements related to sustainability for the Range, Return and Orbital operator licences.

Case Study: UK Active Debris Removal companies

Our second case study is a high-level look at the UK companies involved in Active Debris Removal (ADR). Our defintion of ADR is, "The removal of an existing space object from orbit such that it either burns up in the Earth's atmosphere or is placed in an orbit of little operational value."[359]

We focus on ADR, since there is currently no explicit directive from the UK legislation or regulations (e.g. in the SIA or SIRs) but the UK has signed the COPUOUS Guidelines for LTS of Outer Space as well as the IADC and ESA Space Debris Guidelines. As such, we can look to see if there are examples of Best Practice in these soft law regimes.

Astroscale and ClearSpace

Orbital congestion and space debris remains one of the biggest global challenges facing the space sector. There are currently an estimated 1 million space debris objects 1 cm to 10 cm in size, and 36,500 space debris objects greater than 10 cm contributing to the over 10,000 tonnes of space objects in Earth orbit.[360] Space debris can stay in orbit for hundreds of years and present a real danger to the rapidly increasing number of new satellites being launched each year.

We examine two companies, Astroscale[361] and ClearSpace[362] whose mission and goal is to remove debris from Earth orbit.

Astroscale is a private company founded in 2013 to mitigate the growing and hazardous build-up of debris in space. Astroscale has a range of missions, including the ELSA-M and ELSA-d,[363] with ELSA-d already in orbit and comprising a spacecraft servicer demonstrating debris capture technology of a test satellite.[364] A highlight came in August 2021, when the main "servicer" spacecraft released and recaptured a small "client" spacecraft; a critical demonstration of the ELSA-d spacecraft and technology.[365] ELSA-d is one of several initia-

358 'CAP2221: Regulator's licensing rules' (n 302) (CAP 2221)

359 P.J. Blount

360 'Space debris by the numbers' (*ESA's Space Debris Office*, 11 August 2022) ⟨https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers⟩ accessed 23 August 2022

361 'Astroscale: The only company solely dedicated to on-orbit servicing across all orbits' ⟨https://astroscale.com/⟩ accessed 23 August 2022

362 'ClearSpace - A mission to make space sustainable' (2022) ⟨https://clearspace.today/⟩ accessed 23 August 2022

363 End-of-Life Services by Astroscale (ELSA), with -d for demonstration and -M for Multiple (satellites in a single mission).

364 'ELSA-d: Launched March 22, 2021 06:07 UTC' ⟨https://astroscale.com/missions/elsa-d/⟩ accessed 23 August 2022

365 Jeff Foust, 'Astroscale complete first test of satellite capture technology' (*Spacenewscom*, 25 August 2021) ⟨https://spacenews.com/astroscale-complete-first-test-of-satellite-capture-technology/⟩ accessed 23 August

tives by Astroscale, and the issue of space debris and its active removal is a critical one that has rightly been much discussed.[366]

ClearSpace UK are leading the development of in-orbit services to shape the future of sustainable space operations. This includes ClearSpace-1, a pioneering mission to remove debris from Earth orbit.[367]

We pinpoint these two ADR companies in particular, since they were the focus of a major UK Space Agency political announcement in October 2021[368] and were awarded UKSA funding to research a UK led mission "supporting the [UK] government's ambitions to be a leading nation in tackling space debris."[369] Thus, the "carrot" approach of offering funding to private companies that are aiming to tackle the challenges outlined in the UN Guidelines for Long-Term Sustainability is a very tangible one.[370]

However, issues for Active Debris Removal remain. Companies or space agencies that are deploying ADR techniques and satellites will have to be open to broader concerns. For example, as soon as you have a satellite that can 'capture' another satelite, then this technology could be used for interfering with an active satellite from a non-friendly State. The dual-use of ADR technology becomes rapidly apparent. Indeed, there is already much legal academic discussion on ADR.[371] Thus, the regulation and governance of outer space becomes a complicated international relations issue with minimal hard law to offer guidance.

"A state cannot 'cease to be responsible for' or avoid any correlative duties by abandoning a space object"[372] - there is no "Law of Abandonment" in Outer Space (cf. the High Seas).

2022

366 e.g., Robin Biesbroek, *Active debris removal in space: how to clean the Earth's environment from space debris* (Robin Biesbroek Publishing 2015); Jonas Radtke, Christopher Kebschull, and Enrico Stoll, 'Interactions of the Space Debris Environment with Mega Constellations—Using the Example of the OneWeb Constellation' (2017) 131 Acta Astronautica 55; FCC, 'Draft Rule Seeks to Limit Space Debris' [2020] IN11342

367 'ClearSpace-1' (21 August 2022) ⟨https://en.wikipedia.org/wiki/ClearSpace-1⟩ accessed 23 August 2022

368 ESA, 'UK Space Agency announced' (26 October 2021) ⟨https://www.gov.uk/government/news/uk-working-with-global-partners-to-clear-up-dangerous-space-debris⟩ accessed 20 August 2022

369 UK Space Agency, 'UK working with global partners to clear up dangerous space debris' (26 October 2021) ⟨https://www.gov.uk/government/news/uk-working-with-global-partners-to-clear-up-dangerous-space-debris⟩ accessed 22 August 2022

370 Though some might say splitting awards of £1 million to help track and remove debris in space is just a 'band-aid for a bullet wound'.

371 Valentin Degrange, 'Active Debris Removal: A Joint Task and Obligation to Cooperate for the Benefit of Mankind' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (Springer Nature 2019); Valentina Nardone, 'Dispute Resolution in the Context of ADR: A Public International Law Perspective' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (Springer Nature 2019); Gordon Chung, 'Jurisdiction and Control Aspects of Space Debris Removal' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (Springer Nature 2019); Matteo Frigoli, 'Between Active Debris Removal and Space-Based Weapons: A Comprehensive Legal Approach' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (Springer Nature 2019); Annette Froehlich, 'The Right to (Anticipatory) Self-Defence in Outer Space to Reduce Space Debris' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (Springer Nature 2019); Anton de Waal Alberts, 'The Degree of the Lack of Regulation of Space Debris Within the Current Space Law Regime and Suggestions for a Prospective Legal Framework and Technological Interventions' in Annette Froehlich (ed), *Space Security and Legal Aspects of Active Debris Removal* (Springer Nature 2019)

372 Lyall and Larsen (n 148) p. 84

OneWeb

OneWeb is a communications company that aims to build broadband satellite Internet services. OneWeb currently has 426 satellites in orbit[373] and as such is the UK company with the largest space presence by number of satellites by a distance and would be conspicuous by its absence if we did not mention it.

OneWeb satellites are in generally higher orbits than other communication satellite constallations, operating at a 1,200km polar low Earth orbit.[374] This means OneWeb satellites will not passively deorbit in a reasonable timeframe (cf. deorbit timescales of $\lesssim$5 years at 500-550 km altitudes).[375] As such, each OneWeb satellite has fuel allocated to be able to actively deorbit at its end of life. OneWeb satellites are also equipped with a magnetic grappling fixture, to make it possible for another spacecraft to attach and change the orbit (including de-orbiting) of the satellite at the end-of-life. However, there currently is not a commercial service in place to carry out this method of ADR.[376]

Duties and supplementary powers of the regulator and space debris mitigation

Section 2 of the SIA notes "The regulator must exercise the regulator's functions under this Act in the way that the regulator thinks best calculated to take into account — any space debris mitigation guidelines issued by an international organisation in which the government of the United Kingdom is represented."[377]

As noted in Wheeler (2021),[378] "The Guidance for orbital operator licence applicants and licensees lists the standards that comprise the criteria by which licence applications are assessed. This includes various international space systems' standards defined by the International Organization for Standardization, international guidelines related to space debris mitigation defined by the Inter-Agency Space Debris Coordination Committee and safety standards defined at the European level by the European Cooperation for Space Standardization."

Wheeler (2021) continues, "Despite the Guidance requiring applicants to describe any design feature of the spacecraft in terms of impact protection from debris or micrometeoroids, this is not to be interpreted as a licence condition for satellites to be designed with space debris shields or to have any other impact protection measures. This information is requested as part of the licensing process for information only, rather than to establish a specific requirement for operators, which would be beyond the international debris mitigation measures."

Returning to Riordan (2021), we note from there, "While the debris guidelines are not legally binding on the UK or any other signatory, the Space Industry Act 2018 places responsibility on the regulator (CAA) to take account international space debris mitigation

373 Jonathan C McDowell, 'OneWeb Statistics' (24 August 2022) ⟨https://www.planet4589.org/space/stats/owx/stats.html⟩ accessed 24 August 2022

374 'OneWeb satellite constellation' (n 71)

375 'OneWeb satellite constellation: Concerns' (*Wikipedia*, 19 August 2022) ⟨https://en.wikipedia.org/wiki/OneWeb_satellite_constellation#Concerns⟩ accessed 19 August 2022

376 Timothy Maclay and others, 'The development of commercially viable ADR services: Introduction of a small-satellite grappling interface' (2020) 7(3) Journal of Space Safety Engineering 364 (Space Debris: The State of Art)

377 Space Industry Act 2018, s 2(2)(h)

378 Wheeler (n 32)

guidelines when carrying out its functions under Sect. 2(2)(h),[379] and the Space Industry Regulations 2021, give the regulator the power to place conditions on any license to address debris mitigation (Schedule 1, paragraph 1(g)) "These provisions have been included to ensure the safety, security and sustainability of the orbital environment. The regulator's duties with regard to debris mitigation sit alongside its duty to take account of the environmental objectives set by the Secretary of State."

Our analysis agrees with Riordan; it is very unclear how the current licencing and the current activities of the CAA are accomplishing e.g. debris mitigation. As seen in the previous chapter, the SIA legislation speaks to action on space debris, but then the regulations, including the SIR and the environmental requirements therein, do not 'follow through' in a signifcant manner. There seems to be something of a disconnect here that can be addressed in the future.

Space Situational Awareness (SSA) and Space Traffic Management (STM)

Further related to the the discussion of space debris and space debris mitigation is Space Situational Awareness (SSA) and Space Traffic Management (STM). As space technology continues to push new frontiers in applications from Earth orbit, congestion of the space environment will only increase. This means that an STM system will be necessary to coordinate the numerous spacecraft operators. These standards in turn need to be based on a strong technical foundation to ensure that those regulated by the system also trust it.[380]

Space Situational Awareness (SSA) refers to keeping track of objects in orbit and predicting where they will be at any given time and as such, can be consider if not a passive activity, certainly a post-fact responsive one.[381]

SSA takes a holistic approach towards the main space hazards, including collision between satellites and space debris, space weather phenomena, and near earth objects (NEOs). Discussion of space weather and NEOs is outside the scope of this dissertation.[382]

Space traffic management (STM) is defined as "the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference."[383] The global community has been slow to develop a common set of rules for - or understanding of - STM despite the urgent need to develop regulations and support capabilities to manage proliferating spacecraft and debris. Indeed, the language and consensus terminology for STM is still lacking.

A full debate and debate about SSA and STM is outside the scope of this dissertation, but of course is a critical piece of the space sustainability discussion. There is no mention of SSA or STM in the SIA or SIR.

Blount (2019) argues, "As the rules that emerge solidify into best practices, it will become easier for states to come to consensus on the norms, rules, and protocols that will

379 Space Industry Act 2018, (2)(2)(h)

380 PJ Blount, 'Space Traffic Management: Standardizing On-Orbit Behavior' (2019) 113 AJIL Unbound 120

381 Space Foundation Editorial Team, 'Space Briefing Book: Space Situational Awareness' (*Space Foundation*, 2022) ⟨https://www.spacefoundation.org/space_brief/space-situational-awareness/⟩ accessed 29 August 2022

382 'An EU Approach for Space Traffic Management: For a safe, secure and sustainable use of Space' (*European Commission: Defence Industry and Space*, 2022) ⟨https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-programme/eu-approach-space-traffic-management_en⟩ accessed 29 August 2022

383 Corinne Contant-Jorgenson, Petr Lála, and Kai-Uwe Schrogl, *Cosmic Study on Space Traffic Management* (International Academy of Astronautics (IAA) 2006)

govern STM at the international level. A gradual emergence of the law, especially in a highly technical and militarily strategic domain, will be more palatable to states. It will, of course, require leadership from one of the larger space actors - such as the United States - that is willing to maintain an open model of the space environment."[384] We agree, but note that while the United States is very much the pacesetter here, the UK, if it wanted and had the gumption, could be a key player in building international technical standards and standard best practice. Although a complex issue, there is precedent here. The internet has organically evolved a set of international standards and practices, in so much as protocols have been suggested, adopted and then modified as necessary. While it can be aruge that perhaps the optimal technical or enginneering solution was not always implemented, the internet, and the 'internet of things', with now 100s of billions of interconnected devices generall *just works*. It would be a resounding positive achievement if the international space community could be ambitious and cooperative with SSA and STM in a similar manner.

384 Blount, 'Space Traffic Management: Standardizing On-Orbit Behavior' (n 380)

Chapter 5. Sustainability and the contemporary U.K. Space Sector: II. What is missing? What is needed?

In Chapter 4 we looked at two UK space sector based Case Studies to see how current legislation and regulations are playing a role in making space activity sustainable. In this chapter, we aim to tie threads together and then suggest directions for future policy and legislation.

Until recently, environmental impacts of space activities had often been omitted from key legislative and regulatory requirements, with the result being that the environmental impacts of industry activities were traditionally overlooked.[385] For example, when the Montreal Protocol[386] was introduced in 1987, it completely left out the space industry despite rocket propulsion being the only source of anthropogenic emissions to inject ozone destroying compounds directly into all layers of the atmosphere.[387]

Although this situation has changed, the 'joined-up' holistic planning and considerations that should be in both space and environmental law still need substantial work. We make suggestions as to what should be included in future UK legislation and regulation that more directly address space sustainability. This is absolutely not an exhaustive list, but suggestions about possible future directions. We also continue to note that *"if you are a Launching State, you are very likely not environmentally friendly."* The space sector supply chain is incredibly energy intensive, so we approach current sustainability claims with the appropriate amount of scepticism.

International Space Law and Connection to International Environmental Law

As we have seen, the 1967 Outer Space Treaty remains the central trunk of international space law. It notes that all States shall enjoy free access to space, for use, exploration and scientific investigation.[388] No State shall appropriate outer space or celestial bodies[389] and space law is part of international law.[390] No nuclear weapons (or any weapons of mass destruction) are allowed in outer space, and space will be used exclusively for peaceful

385 Martin Ross and others, 'Limits on the space launch market related to stratospheric ozone depletion' (2009) 7(1) Astropolitics 50; Martin Ross and James A Vedda, 'The Policy and Science of Rocket Emissions' [2018] Center for Space Policy and Strategy, The Aerospace Corporation

386 Montreal Protocol on Substances that Deplete the Ozone Layer (n 115)

387 Ross and others (n 385); Andrew Ross Wilson, 'Estimating the CO_2 intensity of the space sector' (2022) 6 Nature Astronomy 417; Andrew Ross Wilson and others, 'Ecospheric life cycle impacts of annual global space activities' (2022) 834 Science of the Total Environment

388 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art I.

389 ibid art II.

390 ibid art III.

purposes.[391]

With Articles VI, VII and VIII, a State bears international responsibility[392] for its activities (and the activities of its nationals) in outer space, States are liable for damage cause by their space objects[393] and states that register an object retain jurisdiction and control of that object.[394]

When we come to Article IX of the OST, we think we see a declaration of environmentalism. However, this turns out not to be the case with the vague language and soft ideals leading to an article that places no constraints on States and is ineffective as a source for 21st century environmental law.

However, it may not be the OST's job to be an environmental lever of power. Yes, we (very much) want outer space to be a sustainable resource, but a lot of 'space activity' is carried out on Earth. As such, international environmental law is applicable to these Earth-located space activities, and Article III of the OST is applicable.

The Vienna Convention for the Protection of the Ozone Layer 1985[395] (number of parties: 198[396]), the Montreal Protocol[397] (number of parties: 198), the UN Framework Convention on Climate Change[398] (UNFCCC; number of parties: 198), the Convention on Biological Diversity[399] (number of parties: 196), the Kyoto Protocol[400] (number of parties: 196),[401] and the Paris Agreement in 2015[402] (number of parties: 193),[403] are significant international environmental treaties. These agreements are indications of very strong international committments by states and actors. Indeed, it is seen as abnormal to not be signed up to these treaties, e.g. the uproar when the USA left the Paris Agreement.[404] Yet even with close to full international cooperation and agreement, progress is still considered too slow by many. But there is huge international 'buy-in' to environmental treaties. This is not so for space. Given the current and indeed near future geopolitical landscape, whether an international environmental treaty that has a space component to it would ever achieve a similar buy-in is hard to see.

391 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (n 50) art III.

392 ibid art VI.

393 ibid art VII.

394 ibid art VIII.

395 Vienna Convention for the Protection of the Ozone Layer (n 114)

396 192 UN, Cook Islands, Vatican City, Niue, the State of Palestine and the EU

397 Montreal Protocol on Substances that Deplete the Ozone Layer (n 115)

398 United Nations Framework Convention on Climate Change (n 116)

399 Convention on Biological Diversity (entered into force 29 December 1993) 1760 UNTS CN 29 1996 TREATIES-2 79, The Convention was adopted by the Intergovernmental Negotiating Committee for a Convention on Biological Diversity, during its Fifth session, held at Nairobi from 11 to 22 May 1992. The Convention was open for signature at Rio de Janeiro by all States and regional economic integration organizations from 5 June 1992 until 14 June 1992, and remained open at the United Nations Headquarters in New York until 4 June 1993.

400 Kyoto Protocol to the United Nations Framework Convention on Climate Change (n 118)

401 Signed by the European Union, Cook Islands, Niue, and all UN member states except Andorra, Canada, South Sudan, and the United States

402 Paris Agreement under the United Nations Framework Convention on Climate Change (n 119)

403 Iran, Eritrea, Libya and Yemen have not ratified the agreement.

404 'United States withdrawal from the Paris Agreement: Reactions' (*Wikipedia*, 19 August 2022) ⟨https://en.wikipedia.org/wiki/United_States_withdrawal_from_the_Paris_Agreement#Reactions⟩ accessed 24 August 2022

Space Debris

For the ever growing issue of space debris, international environmental law is still not in place. There is no international treaty minimizing space debris. While there is no shortage of agreed-upon space debris guidelines these are not legally binding and rely on the voluntary goodwill of satellite operators and, therefore can often lack the strong motivation required for this global, 'tragedy of the commons' issue.

The recent SIA legislation is applicable to the protection of Earth's environment from the detrimental effects of launch activity, but how effectual this will be is still unclear. And the absence of specific legislation, space based or otherwise, that targets space debris for Earth and Low Earth Orbit is another hurdle to overcome if pursuing a sustainable space industry.

The GfLTS are voluntary, non-binding guidlines. So States will implement them in a manner that is consistent with their national needs and capabilities. States should then share their implementation experiences and promote awareness of the guidelines to their National Space communities. Regulators can, and perhaps should, include guideline implementation in their considerations and processess concerned with the authorization and ongoing supervision of national space activities. Non-binding does not have to imply mean non-legal. The UK has reported to COPUOS its progress on implementing the GfLTS measures in both 2020 ("Voluntary Implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities and Proposed Reporting Approach by the United Kingdom"[405]) and in 2021 ("United Kingdom: Update on our reporting approach for the voluntary implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities"[406]). However, one can feel there is a level of hypocrisy here since the UK space sector, including the public sector of the UK (and the CAA), as of yet has not actively instigated any regulatory measures that actively go towards long-term sustainability.

Suggestions for the UK Space Sustainability effort

Here we offer something of a smörgåsbord of ideas for pushing forward the UK Space Sustainability effort.

Encouraging Best Practice via international norms

The UK-sponsored resolution 75/36 "Reducing space threats through norms, rules and principles of responsible behaviours"[407] was adopted by the UN General Assembly on 07th December 2020. The UK tabled a new resolution on 'reducing space threats through norms, rules and principles of responsible behaviours,' which galvanised a global discussion on what constitutes responsible space behaviour. Those threats are against the satellites, ground infrastructure and the signals and data that make up space systems. The UN General Assembly's First Committee approved the UK's push to tackle threatening space behaviour in November 2021. The resolution passed the UNGA First Committee vote, with

405 Voluntary Implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities and Proposed Reporting Approach by the United Kingdom, Committee on the Peaceful Uses of Outer Space (7 February 2020) A/AC.105/C.1/2020/CRP.15

406 United Kingdom: Update on our reporting approach for the voluntary implementation of the Guidelines for the Long-term Sustainability of Outer Space Activities, Committee on the Peaceful Uses of Outer Space (19 April 2021) A/AC.105/C.1/2021/CRP.16

407 Resolution adopted by the General Assembly on 7 December 2020: 75/36 Reducing space threats through norms, rules and principles of responsible behaviours, UNGA A/RES/75/36 [2020]

150 voting Yes, 12 voting No, and 8 abstentions in a strong endorsement of the initiative. However, China, the Democratic People's Republic of Korea (North Korea), Iran and Russia were four of the No votes, with India and Israel as two of the abstentions.[408]

Through the UN Office of Disarmament Affairs, a report of the Secretary-General on reducing space threats through norms, rules and principles of responsible behaviors has also been prepared.[409] This is an encouraging move by the UK, and in particular the Foreign Commonwealth and Development Office (FCDO), who have not previously initiated meaningful engagement in the UN community relating to responsible behaviours and norms in outer space. This includes helping to improve transparency and confidence-building measures in respect of space activity. Pursuant to General Assembly resolution 76/231[410] an Open-Ended Working Group on reducing space threats convened earlier in 2022.[411]

Building on these recent efforts, further leadership by the UK on the international stage encouraging best practices would be welcome. Working through not only the First Committee (disarmament aspects of Outer space) but also the UNGA Second Committee (Sustainable development) and the Fourth Committee (COPUOS) would be nicely ambitious.

Encouraging Best Practice via insurance

With the introduction of the SIA and SIR, there is continued asks from Government as to how to continue to make the UK an attractive prospect for spaceflight. An example of this, is the UK government has committed to review key concerns and proposals raised by respondents to the consultation document entitled "Unlocking commercial spaceflight for the UK: consultation on draft insurance and liabilities requirements to implement the Space Industry Act."[412] Interestingly, in this consultation and responce, the idea of "Decommissioning bonds" is suggested.[413] This type of approach is already used in other sectors (for example in the decommissioning of oil and gas infrastructure) and was flagged in a number of responses to the consultation. While this idea is motivated for alternative financial instruments or approaches to traditional third-party liability insurance to cater for certain types of risks, there is a connection to sustainability since this links to satellite end-of-life disposal. Decommissioning bonds would provide a resource and assurance that funding for satellite decommissioning would be available to cover the decommissioning costs throughout the period of the decommissioning activity. This would better aid commercial companies plan for safe and sustainable satellite end-of-life procedures.

408 Jessica West, 'The UK process on norms and space security' (*Project Ploughshare*, 6 November 2020) ⟨https://ploughshares.ca/pl_publications/the-uk-process-on-norms-and-space-security/⟩ accessed 24 August 2022

409 Reducing space threats through norms, rules and principles of responsible behaviours: Report of the Secretary-General, UNGA A/76/77 [2021]; 'Report of the Secretary-General on reducing space threats through norms, rules and principles of responsible behaviors (2021)' (*UN Office of Disarmament Affairs*) ⟨https://www.un.org/disarmament/topics/outerspace-sg-report-outer-space-2021/⟩ accessed 24 August 2022

410 Resolution adopted by the General Assembly on 24 December 2021: 6/231 Reducing space threats through norms, rules and principles of responsible behaviours, UNGA A/RES/76/231 [2021]

411 'Open-ended working group on reducing space threats' (*UNODA Meetings Place*) ⟨https://meetings.unoda.org/meeting/oewg-space-2022/⟩ accessed 24 August 2022

412 UK Space Agency, 'Consultation outcome: Call for evidence to inform orbital liability and insurance policy' (23 June 2022) ⟨https://www.gov.uk/government/consultations/call-for-evidence-to-inform-orbital-liability-and-insurance-policy/call-for-evidence-to-inform-orbital-liability-and-insurance-policy⟩ accessed 22 August 2022

413 ibid 6.1.1

Encouraging Best Practice via grant funding

As we have seen with the case of Astroscale and ClearSpace, another "carrot" would be to encourage Best Practice via grant funding. The UK Space Agency Corporate Plan 2022-25 has 'Sustainability' as one of eight 'delivery Priorities.'[414] What the corresponding funding envelope looks like will determine how seriously the UKSA are really taking space sustainability.

All Politics is Local

Outer Space matters were reserved, but the national UK regulatory bodies need to liaise closely with local environmental and planning authorities. From Riordan (2021), "... [w]hile the UK Parliament leads on the legislation to enable space activities in the UK, there are significant powers that are devolved to the Scottish Parliament for instance. These include matters of the environment and land use planning (led in Scotland by the relevant local planning authorities (LPA)) ... it would not be expected that the UK Parliament would legislate on these matters that affect Scotland without the consent of the Scottish Parliament. The study[415] also noted that both Scottish Natural Heritage and Scottish Environmental Protection Agency would need to be consulted prior to any application being considered."[416]

The Scottish Environment Protection Agency (SEPA) is Scotland's environmental regulator and its main role is to protect and improve Scotland's environment. The SEPA does this by helping business and industry to understand their environmental responsibilities, enabling customers to comply with legislation and good practice and to realise the economic benefits of good environmental practice.

The only appeal to date has been towards a local planning council, though there is now Guidance from the CAA on appealing decisions made under the Space Industry Act 2018 and the Outer Space Act 1986.[417] The interaction between national regulatory bodies and local planning councils is currently siloed. While this may be a good thing for different perspectives, it leads to a lot of overhead for the spaceports and launchers with regards the required bureaucracy.

Space Sustainability Metrics and Ratings

Improving the sustainability of the space sector in orbit requires a complicated, interrelated set of technical, economic, and political challenges that need to be addressed. Some existing legislation will be applicable to the protection of Earth's environment from the detrimental effects of launch activity, but the absence of space specific legislation for Earth and Low Earth Orbit is a key blocker to pursuing a sustainable space industry.

There is a lack of agreed-upon, widely adopted metrics and targets for space sustainability. There is no set limit on how many satellites can operate in a given orbital region and even the definition of space sustainability is debated. While some rules have been adopted,

414 'UK Space Agency Corporate Plan 2022-25' (18 July 2022) ⟨https://www.gov.uk/government/publications/uk-space-agency-corporate-plan-2022-25⟩ accessed 24 August 2022

415 DEIMOS Space UK Ltd, 'SCEPTRE Final Report (Code: SCEPTRE-DMU-FR v1.1)' (17 February 2017) ⟨https://www.hie.co.uk/media/6626/sceptre-final-report-february-2017.pdf⟩ accessed 23 July 2022

416 Riordan (n 316) p.86

417 'CAP 2216: Guidance on appealing decisions made under The Space Industry Act 2018 and The Outer Space Act 1986' (n 297)

such as the IADC "25 year" rule for Low Earth Orbit (LEO)[418] no targets analogous to CO_2 ppm or the 1.5°C of the IPCC yet exist.[419]

Quite what these space sustainability metrics and subsequent targets would be is not immediately clear. However, carbon footprints of the e.g. space sector supply chain, if it could be quantified in an agreed upon manner, would be a huge first step to holding actors accountable. ISO standards could help here. Discussions of how many or what types of satellites can inhabit various Earth orbits is a tricky one, both technically and geopolitically. However, having those difficult conversations, with some States likely to be asked to take lead roles, should not be shied away from and now have to happen. Even if stringent targets are not immediately forthcoming, a relatively simple quantifiable manner to grade space activity should look to be adapted universally. Indeed, this may already be in motion, albeit without any UK involvement.[420]

The Global Network on Sustainability in Space (GNOSIS) Network

The Global Network on Sustainability In Space (GNOSIS) Network brings together scientists and industry to understand and solve problems related to the ever growing problem of space debris and the challenges of safeguarding spacecraft set to launch into this environment.[421] To succeed in achieving sustainability in space requires an understanding the nature of space debris and the application of law to the space environment. Through a cross disciplinary approach the GNOSIS Network aims to bring together teams of scientists and expose them to the problems faced by industry and help them apply their knowledge in tackling problems associated with space debris.

The GNOSIS Network is UKRI STFC[422] funded and headquartered in the Physics Department at the University of Warwick. While world-leading space-scientists contribute to GNOSIS, no real 'full time equivalent' (FTE) is provided by e.g. the UKSA to make a broader, considerable impact. Enhancing the GNOSIS Network to 'national laboratory' status, in the same manner as the Rutherford Appleton Laboratory or Daresbury Laboratory, and with the corresponding support and infrastructure, would be a game-changing step forward here.

418 IADC Space Debris Mitigation Guidelines [2021] IADC-02-01, 5.3.2

419 Rebecca Lindsey, 'Climate Change: Atmospheric Carbon Dioxide' (*NOAA*, 23 June 2022) ⟨https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide⟩ accessed 25 August 2022; 'Ste 5: World Targets' (*CO2 Earth*, 24 August 2022) ⟨https://www.co2.earth/step-5-world-targets⟩ accessed 25 August 2022; Intergovernmental Panel on Climate Change (IPCC), *IPCC 2018: Global Warming of 1.5° C. An IPCC Special Report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development,and efforts to eradicate poverty* (8932, IPCC 1953)

420 e.g., the new Space Sustainability Rating; WEF, 'Space Sustainability Rating' (*World Economic Forum*) ⟨https://www.weforum.org/projects/space-sustainability-rating⟩ accessed 25 August 2022; Stephanie Parker, 'A new rating for space sustainability' (*eSpace, the EPFL Space Center*, 4 August 2022) ⟨https://espace.epfl.ch/2022/08/04/a-new-rating-for-space-sustainability/⟩ accessed 25 August 2022; 'Space Sustainability Rating: Leading the path towards a more sustainable use of space' ⟨https://spacesustainabilityrating.org/⟩ accessed 25 August 2022

421 'GNOSIS: The Global Network on Sustainability in Space' (*GNOSIS Network*) ⟨https://gnosisnetwork.org/⟩ accessed 24 August 2022

422 'Science and Technology Facilities Council (STFC)' (*UK Research and Innovation*) ⟨https://www.ukri.org/councils/stfc/⟩ accessed 30 August 2022

Scottish Space Sustainability Roadmap

The Scottish Space Strategy[423] has identified sustainability as a key thread of Scotland's approach to space. In 2019 Space Scotland established an Environmental Task Force working group,[424] which aims to better understand the true impact of the space industry on both Earth and LEO as part of its wider remit of catalysing a collective approach to ensuring the fledgling UK and Scottish space sector develops in a sustainable manner. The "Scottish Space Sustainability Roadmap" will address this intent.[425] The Scottish Space Sustainability Roadmap is an ambitious and welcome addition to the space sustainability discussion. However, only upon publication will it be able to be scrutinised for actionable items to see if it will make rapid and substantial changes to the (Scottish/UK) space sector. Persuading e.g. large American aerospace and defense corporations with worldwide interests and determination to launch, to get on board will be a challenge.

The UK Plan for Space Sustainability

In June 2022, then Science Minister George Freeman launched a new "Plan for Space Sustainability", "a raft of measures which will demonstrate the UK's commitment, ambition and drive to improve the UK's sustainable use of space."[426] Outlining the UK's global ambitions, further government investment were announced to support Active Debris Removal (ADR) in cleaning up space debris in Earth's orbit, and the minister confirmed that the government's existing ADR programme will receive £5 million funding for its latest phase.

Also announced was UK Government's investment to support Phase 3 of the implementation of the UNOOSA GfLTS of outer space. Phase 3 of the project will help to build on the successful work of earlier phases in building awareness of the guidelines among UN member states and identifying barriers to their adoption. However, outside of this announcement, the details of the Plan for Space Sustainability is yet to be forthcoming at this point.

Greenwashing, Maunakea and hypocrisy

While innovative efforts to improve space sustainability should be applauded there is also a danger of 'greenwashing' fundamentally unsustainable activities. Greenwashing is when an organization spends more time and money on marketing itself as environmentally friendly than on actually minimizing its environmental impact. The Space Sector is particularly bad when it comes to greenwashing. Companies, organisations, and individuals making claims of sustainability must provide transparent, convincing evidence of their claims. Fostering a culture of healthy constructive criticism of sustainability claims in the Space Sector will be vital to achieving this aim.

423 Scottish Space, *A Space Strategy for Scotland* (2021); Scottish Government, *Scottish Space Strategy launched* (2021) ⟨https://www.gov.scot/news/scottish-space-strategy-launched/⟩ accessed 10 August 2022

424 'Environmental Task Force' (*Space Scotland*) ⟨https://scottishspace.org/space-sustainability/⟩ accessed 20 August 2022

425 Stephen Wilkie, 'Scottish space sector charts path to a sustainable future' (*The Scotsman*, 24 February 2022) ⟨https://www.scotsman.com/news/environment/experts-seek-to-create-sustainability-roadmap-for-scotlands-space-sector-3582432⟩ accessed 24 August 2022; 'Scottish Space sector introducing roadmap for a sustainable future' (*Spacewatch Global*, 23 February 2022) ⟨https://spacewatch.global/2022/02/scottish-space-sector-introducing-roadmap-for-a-sustainable-future/⟩ accessed 24 August 2022

426 'Government announces package of new measures to drive space sustainability' (*Department for Business, Energy & Industrial Strategy, UK Space Agency, and George Freeman MP*, 23 June 2022) ⟨https://www.gov.uk/government/news/government-announces-package-of-new-measures-to-drive-space-sustainability⟩ accessed 8 August 2022

For example, the IAC 2022 meeting is boasting that it is holding its annual meeting in Paris[427] according to the ISO 20121: 2012 "responsible event" standard. ISO 20121[428] offers guidance and best practice to help manage the event and control its social, economic, and environmental impact. And yet, thousands of people are going to fly to France for this meeting.

An interesting, further and somewhat hypocritical example here are research astronomers. Detailed estimates have tCO2e calculated as $\geq$37 tCO2e per year per astronomer.[429] To put this in context, if astronomers were a country, they would be joint top of world emissions per capita,[430] with Qatar the current worst emitter per capita at 37.2 tCO2e per year. A large proportion of this is from high-performance computing[431] and travel.[432]

There is also the ongoing issue of the colonisation of Maunakea.[433] Therefore, although research astrophysics, in particular ground based optical and radio astronomy[434] faces growing challenges, it is difficult to feel sorry for the professional astrophysics community as long as these very high carbon and colonisation efforts continue.[435]

We note that essentially any space sector activity is also compute intensive and involves large amounts of travel. Baking in methods to offset this GHG/CO_2 production has to become second nature in future space practices.

427 'IAC 2022 Goes Green!' (31 July 2022) ⟨https://iac2022.org/sustainability/⟩ accessed 20 August 2022

428 ISO/TMBG Technical Management Board - groups, 'ISO 20121:2012 Event sustainability management systems — Requirements with guidance for use' [2012] (1) ISO ⟨https://www.iso.org/standard/54552.html⟩

429 Adam R H Stevens and others, 'The imperative to reduce carbon emissions in astronomy' (2020) 4 Nature Astronomy 843; Jürgen Knödlseder and others, 'Estimate of the carbon footprint of astronomical research infrastructures' (2022) 6 Nature Astronomy 503

430 'CO2 Emissions by Country' ⟨https://www.worldometers.info/co2-emissions/co2-emissions-by-country/⟩ accessed 19 August 2022; 'CO2 Emissions by Country' ⟨https://www.worldometers.info/co2-emissions/co2-emissions-by-country/⟩ accessed 19 August 2022; Hannah Ritchie, Max Roser, and Pablo Rosado, 'CO_2 and Greenhouse Gas Emissions' (*Our World in Data*, 2020) ⟨https://ourworldindata.org/co2-emissions⟩ accessed 19 August 2022

431 Simon Portegies Zwart, 'The ecological impact of high-performance computing in astrophysics' (2020) 4 Nature Astronomy 819

432 Leonard Burtscher and others, 'The carbon footprint of large astronomy meetings' (2020) 4 Nature Astronomy 823

433 Maunakea is part of land that was taken from the Hawaiian Kingdom during its colonization in the late 1800s. Numerous, large telescopes are now on the summit of Maunakea, an area with significant cultural significance; 'Pathways to Discovery in Astronomy and Astrophysics for the 2020s.' [2021] National Academies of Sciences, Engineering, and Medicine. See also: Rosalyn LaPier, 'The legacy of colonialism on public lands created the Mauna Kea conflict' (*High Country News*, 6 June 2019) ⟨https://www.hcn.org/issues/51.15/tribal-affairs-the-legacy-of-colonialism-on-public-lands-created-the-mauna-kea-conflict⟩ accessed 15 August 2022; Nithyanand Rao, 'Astronomers May Not Like It but Astronomy and Colonialism Have a Shared History' (*The Wire*, 2 February 2020) ⟨https://thewire.in/the-sciences/thirty-meter-telescope-native-hawaiians-mauna-kea-astronomy-colonialism⟩ accessed 15 August 2022 and

434 Andy Lawrence and others, 'The case for space environmentalism' (2022) 6 Nature Astronomy 428

435 'Astronomy's carbon footprint is sky-high' (2022) 603(7903) Nature 768

Conclusions and Outlook

Long term sustainability and UK space regulations: Tying things together

We restate our research question:

"From the point of the long term sustainability of outer space activities, are the current UK regulations and legislation - namely the Space Industry Act 2018 and the Space Industry Regulations 2021 - fit for purpose? And if not, what is missing from them?

For the first question, we find that the current UK legislation and regulations lay out the relevant and necessary schedules and licences that spaceport and launch operators will need in order to move to actual launching activities. The main, and in some instances only, hard requirements for sustainability and environmental considerations (at a national regulator level) come in the form of the "Assessment of environmental effects" (AEE) form. We have been able to locate one of these forms (from 5 submitted applications) and although the form we studied was substantial, key parts of the AEE look to not have been addressed. Whether this is an issue for the CAA regulator, we wait to see. It was reassuring to see a substantial chapter of the AEE dedicated to Climate issues, with e.g. quantifiable estimates on tCO_2e production.

Following on from this, for the first question, in many ways, we are still at too premature a stage to provide a satisfactory answer. The initial suite of CAA licencing applications have only been submitted in the last 8-9 months, and so far no spaceport or operator licence has been granted. However, the sustainability and environmental considerations at this stage seem relatively light touch. We see something of a disconnect. It seems, in the SIA primary legislation that there *are* provisions, e.g. Sections 2(2)(e), 2(2)(h), Section 11(2) and Schedule 1 for space sustainability actions that can speak directly to environmental concerns. However, when it comes to the secondary legislation of the SIR, there is really only one regulation (Regulation 101) that is direct in its line to sustainable action.

For the second question we suggest several options for next steps. This includes e.g. a financial scheme (direct grand funding or e.g. 'decommissioning bonds') that address sustainability issues (especially those related to upstream and in-orbit actions). We welcome the Best Practice efforts via introducing UN resolutions and solidifying international norms. And we note that while space is an international effort, the discussions for UK spaceports can be a very local one that directly affects a small number of remote communities.

The (UK) space sector would greatly benefit from both direct, structured guidance and financial support and incentives to support space sustainability. However, developing a sustainable UK space sector will also require legislative or financial means of deterring unsustainable behaviour. It may be impossible at present to compel space companies to behave sustainably, but by providing funding and support for sustainable initiatives it is possible to encourage sustainable behaviours. Ongoing consultation is welcome here, but all stakeholders need to be involved. The (UK) Space sector has to stop 'navel gazing' and

engage and properly listen to its biggest critics. Greenwashing and hypocrisy have to be avoided if real progress is going to be made.

Outlook

In this dissertation we have discussed space sustainability in a manner that suggests some international treaty or some national legistlation can 'magically' make the Space sector into a non-polluting, net-zero endeveour. This is incredibly wishful thinking. And simply not true. Yes, treaties, especially widely adopted ones, and national regulations that are stricly applied, can make a difference. But we must be absolutely clear that essentially any and all space activity as of 2022 is an energy intensive industy with a high production of GHGs and CO_2 emissions. However, that is not to say we do not try.

From this commentators perspective, there seems to be the move towards potentially adequate requirements, legislation and regulations domestic in UK launch. However, it remains to be seen what this leads to in practice. The calendar years 2022 and 2023 will be very interesting as spaceports and launchers proceed through the regulatory steps for the first time. There will be learning curves and growing pains, but the experience gained both by the regulator, local and national government and the local enterprise agencies and private companies should bode well for future endeveours. It seems, at least at this juncture that all concerned in UK spaceflight are very trying to avoid the "if you fail to prepare, prepare to fail" adage. And we remain skeptical. It is not until you actually start launching that you realize what the *real* environmental impacts are. *Ad astra* indeed, but at *quid sumptus ad Terram et ad Future?*

Activities in outer space are generally the result of bold actions. Space Sustainability across the full space supply sector from the manufacturing mines to the depths of deep space now has to boldly act. To paraphrase and borrow from almost exactly 60 years ago, we reach for the stars. We reach for the stars and do the other things. And we do this not because it is easy. But because this goal will serve to organize and measure the best of our energies and skills. Because this challenge is one that we have to accept and one we are unwilling - and now unable - to postpone.

Appendix A: UN Sustainable Development Goals and Guidelines

The Guidelines on Long-term Sustainability of Outer Space Activities

21 guidelines were agreed A. Policy and regulatory framework for space activities

- Guideline A.1 Adopt, revise and amend, as necessary, national regulatory frameworks for outer space activities
- Guideline A.2 Consider a number of elements when developing, revising or amending, as necessary, national regulatory frameworks for outer space activities
- Guideline A.3 Supervise national space activities
- Guideline A.4 Ensure the equitable, rational and efficient use of the radio frequency spectrum and the various orbital regions used by satellites
- Guideline A.5 Enhance the practice of registering space objects

B. Safety of space operations

- Guideline B.1 Provide updated contact information and share information on space objects and orbital events
- Guideline B.2 Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects
- Guideline B.3 Promote the collection, sharing and dissemination of space debris monitoring information
- Guideline B.4 Perform conjunction assessment during all orbital phases of controlled flight
- Guideline B.5 Develop practical approaches for pre-launch conjunction assessment
- Guideline B.6 Share operational space weather data and forecasts
- Guideline B.7 Develop space weather models and tools and collect established practices on the mitigation of space weather effects
- Guideline B.8 Design and operation of space objects regardless of their physical and operational characteristics
- Guideline B.9 Take measures to address risks associated with the uncontrolled reentry of space objects

- Guideline B.10 Observe measures of precaution when using sources of laser beams passing through outer space

C. International cooperation, capacity-building and awareness

- Guideline C.1 Promote and facilitate international cooperation in support of the long-term sustainability of outer space activities
- Guideline C.2 Share experience related to the long-term sustainability of outer space activities and develop new procedures, as appropriate, for information exchange
- Guideline C.3 Promote and support capacity-building
- Guideline C.4 Raise awareness of space activities

D. Scientific and technical research and development

- Guideline D.1 Promote and support research into and the development of ways to support sustainable exploration and use of outer space
- Guideline D.2 Investigate and consider new measures to manage the space debris population in the long term

The Sustainable Development Goals

This list of Sustainable Development Goals (SDG) targets and indicators provides a complete overview of all the targets and indicators for the 17 Sustainable Development Goals. The global indicator framework for Sustainable Development Goals was developed by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) and agreed upon at the 48th session of the United Nations Statistical Commission held in March 2017. The official indicator list below includes all the refinements made up to March 2020.

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries

11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Appendix B1: The Space Industry Act 2018

The Space Industry Act 2018 (SIA) has 77 sections and 12 schedules. In this appendix, we note each of these sections and schedules that were not refered to in the main text.

Individuals taking part in spaceflight activities and Safety

Section 17 and 18 of the SIA covers Informed consent[436] and the training, qualifications and medical fitness for people taking part in spaceflight and associated activities.[437] Sections 19-21 discuss safety regulations,[438] investigation of accidents[439] and assistance with performance of regulator's safety functions (e.g. from a qualifying health and safety authority).[440]

Security and Enforcement

Security regulations[441] connect to Schedule 5.[442] Spaceport byelaws are given in section 24[443] and section 26 gives provision of advice and assistance on security matters.[444] In addition, the holder of a spaceport licence can make byelaws regulating that spaceport for the purposes of ensuring security. However, these have to be confirmed by the Secretary of State.[445] Sections 26-33 of the SIA covers monitoring and enforcement by the regulator,[446] who has power to give certain directions (usually either the regulator or Secretary of State)[447] and Enforcement authorisation.[448]

Powers in relation to land

To enable the safe operation of spaceports, particularly during launch, the SIA makes provision to allow a qualifying person (i.e. the Secretary of State, holder of a range control licence or a holder of a spaceport licence) rights over land. It is important to note that this does not give the Government powers to acquire land on behalf of licensees.[449] Sections 39-46 of the SIA covers land powers with attention to: obtaining land rights,[450] temporarily

436 Space Industry Act 2018, s 17
437 ibid s 17
438 ibid s 19
439 ibid s 20
440 ibid s 21
441 ibid s 23
442 ibid Schedule 5
443 ibid s 24
444 ibid s 26
445 *Understanding the Space Industry Act* (n 228)
446 Space Industry Act 2018, s 26
447 ibid s 27-32
448 ibid s 33
449 *Understanding the Space Industry Act* (n 228)
450 Space Industry Act 2018, s 39-40

testricting the use of land,[451] power of entry for purposes of survey,[452] and appeals and compensation.[453]

Sections 46-50[454] then discuss how people can also claim compensation in the following cases: should the value of their land be diminished due to an order; if land has been damaged in the exercise of obtaining land rights or due to a survey conducted in relation to an order if they sustain damage because they have been disturbed in their use of land or water as a result of an order restricting the use of land or water. Decisions about any compensation disputes will be taken in the Upper Tribunal in England and Wales, and in the Lands Tribunals for Scotland and for Northern Ireland respectively.[455]

Offences, civil sanctions and Appeals

Section 22 notes offences against the safety of spacecraft[456] as outlined in Schedule 4.[457]

Sections 51-59 of the SIA and covers offences created by the SIA and offences created by regulations. The application of criminal law to spacecraft is given in Section 51.[458] and section 52 is a supplementary section for offences on board spacecraft.[459] Section 53 gives the penalties for offences under the SIA.[460] Sections 54 and 55 gives the offences under regulations[461] and those with extended time limits in case of accident investigation.[462]

Section 56 outlines the defences for a person charged with an offence under a provision of this Act to show that the person exercised all due diligence and took all reasonable precautions to avoid committing the offence.[463] This cycles back to Sections 9(4)(a) and 10(a) with regards risks to the health, safety and property of persons the applicant must have taken all reasonable steps to ensure that those risks are as low as reasonably practicable (ALARP)[464] and the regulator must not grant an application for a spaceport licence unless satisfied that the applicant has taken all reasonable steps to ensure that risks to public safety arising from the operation of the spaceport are ALARP.[465]

Section 57 applies where offences are carried out by corporate bodies[466] and section 58 applies when offences are carried out by partnerships.[467] Section 59 notes civil sanctions[468] and the Regulatory Enforcement and Sanctions Act 2008[469] Section 60[470] and Schedule 10[471] make provision for appeals.

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451 Space Industry Act 2018, s 41
452 ibid s 42
453 ibid s 43-45
454 ibid s 46-50
455 *Understanding the Space Industry Act* (n 228)
456 Space Industry Act 2018, s 22
457 ibid Schedule 4
458 ibid s 51
459 ibid s 52
460 ibid s 53
461 ibid s 54
462 ibid s 55
463 ibid s 56
464 ibid s 9(4)(a)
465 ibid s 10(a)
466 ibid s 57
467 ibid s 59
468 ibid s 22
469 Regulatory Enforcement and Sanctions Act 2008 2008
470 Space Industry Act 2018, s 22
471 ibid Schedule 10

Miscellaneous Provisions

The final sections of the SIA, sections 61-72 and covers: Register of launches;[472] charging schemes[473] (to be made in order for regulators to recover their costs in respect of the performance of functions under the SIA); Provision of advice and assistance by or to an appointed person;[474] Co-operation between Secretary of State and other public authorities;[475] Agreements with other countries;[476] Use of records and documentary evidence;[477] Minor and consequential amendments;[478] Regulations;[479] Interpretation;[480] Commencement;[481] Extent;[482] and the Short title of the Act.[483]

Schedules

In addtion to Schedule 1, there are: Further provions on training regulations[484] and Safety Regulations.[485] Offences Against the Safety of Spacecraft etc.,[486] further provions on security regulations,[487] and orders under Section 39 and 41.[488] Powers in Relation to Land for Quashing of Orders are given in Schedule 7,[489] Compensation,[490] and Special Provisions Relating to Statutory Undertakers[491] Schedule 10 is Appeals in Connection with Spaceflight activities[492] Schedule 11 the Charging Schemes[493] and Schedule 12 makes the necessary (minor) amendments to other legislation.[494]

472 Space Industry Act 2018, s 61
473 ibid s 62
474 ibid s 63
475 ibid s 64
476 ibid s 65
477 ibid s 66
478 ibid s 67
479 ibid s 68
480 ibid s 69
481 ibid s 70
482 ibid s 71
483 ibid s 72
484 ibid Schedule 2
485 ibid Schedule 3
486 ibid Schedule 4
487 ibid Schedule 5
488 ibid Schedule 6
489 ibid Schedule 7
490 ibid Schedule 8
491 ibid Schedule 9
492 ibid Schedule 10
493 ibid Schedule 11
494 ibid Schedule 12

Appendix B2: The Space Industry Regulations 2021

PART 1: General

PART 2: Appointment of the regulator

PART 3: Grant of a licence – general

Chapter 1: Eligibility criteria and prescribed roles for licensees

Chapter 2: Operator licences: exemptions

Chapter 3: Grant of a licence: general

PART 4: Grant of a spaceflight operator licence: risk

Chapter 1: Interpretation

Chapter 2: Risks to persons who are not crew or spaceflight participants

PART 7: Training, qualifications and medical fitness

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55. Interpretation
56. Specified roles and criteria
57. Specified capacities and criteria
58. Responsibility of licensees
59. Training resources
60. Records

Chapter 2: The training manager
61. The training manager
62. The training manager (application for approval)
63. The training manager's functions
64. Approval of the appointment of training manager
65. Termination of the training manager's approval

Chapter 3: Training manual
66. Training manual
67. Approval of the training manual
68. Changes to the training manual

Chapter 4: Training programme
69. Training programme
70. Training and assessments
71. Training equipment

Chapter 5 Medical Fitness
72. Medical obligations
73. Certificates and confirmation of medical fitness
74. Illness, injury and related conditions
75. Disability
76. Validity of medical certificate
77. Medical records

PART 8: Safety of operator's spaceflight activities

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78. Interpretation

Chapter 2: A spaceflight operator's safety duty
79. A spaceflight operator's safety duty

Chapter 3: Review and revision of safety case and risk assessment
80. Safety case and risk assessment review and revision requirements
81. Steps required after review, or review and revision, of the safety case
82: Steps required after review, or review and revision, of the risk assessment

Chapter 4: Other safety requirements

SUBSECTION 1 *Demonstrating requirements*
83. Demonstration of compliance with safety requirements

SUBSECTION 2 *Requirements about a spaceflight operator's organisation and management*
84. A spaceflight operator's organisation
85. Safety management system

SUBSECTION 3 *Requirements about a spaceflight operator's organisation and management*
86. Responsibilities of the safety manager

PART 10: Spaceport safety

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151. Interpretation
Chapter 2: A spaceport licensee's safety duty
152. A spaceport licensee's safety duty
Chapter 3: Horizontal spaceport location requirement
153. Horizontal spaceport location requirement
Chapter 4: Safety case: retention, review and revision
154. Requirement to retain the safety case
155. Safety case review and revision requirement
156. Steps required after review, or review and revision, of safety case
Chapter 5: Safety clear zones
157. Safety clear zone requirement
Chapter 6: Hazardous material, testing areas and safety equipment at spaceports
158. Hazardous material storage facilities: location requirements and plan
159. Hazardous material: handling and venting areas
160. Propellants etc.: fit for purpose requirement
161. Static engine test area
162. Safety equipment
Chapter 7: Requirements about the spaceport licensee's organisation and management
163. Safety management system requirement
164. Spaceport manual requirement
Chapter 8: Emergencies
165. Emergency response plan requirement
166. Spaceport rescue and fire-fighting provision
167. Powers of spaceport firefighters in an emergency

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168. Interpretation
Chapter 2: Physical and personnel security
169. Responsibilities of a security manager
170. Space site security programme
171. Operator security programme
172. Access control to space sites: sufficient security measures
173. Access control to space sites: further provisions
174. Space site security restricted area and controlled area
175. Access control to space sites: emergency services
176. Security controls for prohibited articles
177. Security controls for supplies
178. Security controls for payloads and launch vehicles
179. Access control to space sites: approval of suppliers
180. Surveillance of space sites
181. Security controls: hazardous material
182 Protection of carrier aircraft, launch vehicle or payload: pre-integration
183.Protection of carrier aircraft, launch vehicle or payload: post-integration
184. Security controls for flight safety systems

Chapter 3: Cyber security
185. Spaceflight cyber security strategy
186. Duty to report a notifiable incident to the regulator
Chapter 4: Vetting, clearance, training and qualifications
187. National security vetting procedures
188. Appropriate security training and qualifications
189. Training records and qualifications
190. Renewal of security training
Chapter 5: Critical national infrastructure and essential services
191. Spaceflight activities: critical national infrastructure and essential services
Chapter 6: Security provisions for the protection of US technology
192. Segregated areas
193. Control of access to segregated area
194. Control of access to imported US technology
195. Monitoring and oversight of US technology
196. Monitoring and oversight of launch activities
197. Restrictions on the use of and access to US technology
198. Restrictions on importing US technology
199. Security training for spaceflight activities involving US technology
200. Return of US technology if export licence etc. is revoked
201. Processing of US technology after a normal launch
202. Information about nationality of contributors to launch activities etc.

PART 12: Informed consent

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203. Interpretation
Chapter 2 Prescribed matters
204. Prescribed role or capacity
205. Prescribed criteria with respect to age and mental capacity
Chapter 3 The consent form
206. Details to be included in the consent form
207. Statements to be included in the consent form
208. No derogation from statements in the consent form
209. Information about operator's spaceflight activities carried out by the spaceflight operator
Chapter 4 Information to be given to a human occupant before the consent form is signed
210. Information about the operator's spaceflight activities
211. Opportunity for questions
Chapter 5 Procedural requirements with regard to the signification of consent
212. Who prepares the consent form
212. When a human occupant signs the consent form
212. What happens after the consent form is signed
Chapter 6 Evidential requirements with regard to the information and the signification of consent
215. A written record of the information provided to the human occupant
216. The signification of consent
217. The consent form as evidence of signification of consent

PART 13: Liabilities and indemnities

218. Prescribed description of individuals to whom subsection 34(2) does not apply
219. Prescribed cases or circumstances under which a limit on the operator's liability to government does not apply
220. Limit on the amount of operator's liability
221. Duty of the Secretary of State to indemnify

PART 14: Monitoring and enforcement

Chapter 1: General
222. Interpretation
223. Offence to obstruct inspector or regulator
224. Penalty for obstructing inspector or regulator
225. Offence to impersonate inspector
226. Penalty for impersonating inspector
Chapter 2: Obligation to provide information to the regulator
227. Persons to whom obligation applies
228. Information notices
229. Obligation to provide information to regulator
230. Offence of failing to comply with information notice
231. Penalty for failing to comply with information notice
232. Offence of providing false information
233. Penalty for providing false information
234. Offences of false recording
235. Defence to offences of false recording
236. Penalty for false recording
Chapter 3: Inspectors
Subsection 1 *Appointment and powers*
237. Appointment of inspector
238. Duties of inspector
239. Powers of inspector
240. References to inspector
Subsection 2 *Powers exercisable by inspectors*
241. Power of entry
242. Power to take persons and equipment etc. onto premises or vehicle
243. Powers of inspection and examination and to take samples
244. Powers to require information and documents
245. Powers exercisable in relation to particular articles or substances
246. Power to require the use of facilities and assistance
247. Power to issue contravention notice
248. Power to issue warning notice
249. Power to issue prohibition notice
250. Appealing against notice under regulation 249
251. Supplementary powers
252. Protection for documents subject to legal professional privilege etc.
Chapter 4 Sharing of information between regulator and other bodies
253. Regulator may share information
Chapter 5 Restrictions on disclosure of information
Subsection 1 *Prohibition against disclosure of protected information*

254. Meaning of "protected information"
255. Prohibition on disclosing protected information
256. Offence of disclosing protected information
257. Defences to offence of disclosing protected information
258. Penalty for disclosing protected information
SUBSECTION 2 *Exceptions to prohibition against disclosure of protected information*
259. Disclosure with consent
260. Disclosure by the regulator, inspectors etc.
261. Disclosure to authorities
262. Disclosure required under legislation
263. Legal proceedings, inquiries and investigations
264. Anonymised information

PART 15: Civil sanctions (stop notices)

265. Stop notices
266. Contents of stop notice
267. Completion certificate
268. Compensation
269. Offence of failing to comply with stop notice

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Chapter 1: Interpretation
270. Interpretation
Chapter 2: Duty to report an occurrence and the objective of that report
271. Duty to report an occurrence
272. Objective of an occurrence report
Chapter 3: Events elsewhere which could threaten safety
273. When an event elsewhere which could result in an accident is an occurrence
Chapter 4: Contents of the occurrence report
274. Contents of the occurrence report
275. Categories of occurrence
Chapter 5: The regulator's actions when it receives an occurrence report
276. What the regulator must do on receipt of an occurrence report
Chapter 6: Confidential information
277. Protection of information and permitted disclosures
278. Court application for disclosure
Chapter 7: Offences and penalties
279. Providing false information
280. Failure to protect confidential information
281. Penalties

PART 17: Miscellaneous

282. Duty on licensee to inform regulator of changes
283. Offence of failure to inform regulator of changes
284. Penalty for failure to inform regulator of changes
285. Sending of notices and other documents
286. Use of records and documentary evidence: prescribed persons

287. Review

Appendix C: Spaceport and Airspace Change Tables

CAA Air Space Change

A summary of which Airspace Changes are being asked for with regards U.K. Spaceflight are given in Table 1. This information was gathered by querying the CAA Airspace change portal found at https://airspacechange.caa.co.uk/.

Sponsoring Organisation	Associated Spaceport	CAA Airspace Change ID	Created	Last updated	CAA Stage
HyImpulse Technologies GmbH	SaxaVord Spaceport	ACP-2021-058	20 September 2021	11 May 2022	Step 5
Shetland Space Centre Limited	SaxaVord Spaceport	ACP-2021-090	21 December 2021	29 July 2022	Step 5
Shetland Space Centre Limited	SaxaVord Spaceport	ACP-2017-079	15 October 2018	02 August 2022	Step 2a
Highlands and Island Enterprise	Space Hub Sutherland	ACP-2019-004	12 February 2019	31 August 2022	Step 2a
QinetiQ Ltd	Spaceport 1	ACP-2021-012	11 February 2021	30 August 2022	Step 2a
QinetiQ Ltd	Spaceport 1	ACP-2021-037	20 April 2021	25 April 2022	Step 5
-	Prestwick Spaceport	-	-	-	-
-	Spaceport Machrihanish	-	-	-	-
-	Spaceport Snowdonia	-	-	-	-
Virgin Orbit UK Ltd	Spaceport Cornwall	ACP-2021-031	17 May 2021	18 May 2022	Step 4
Gravitilab Aerospace Services	-	ACP-2020-093	18 November 2020	09 May 2022	Step 2a

Table .1: A summary of which Airspace Changes are being asked for with regards UK Spaceflight

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495 'Space: Achieving Sustainability and Net Zero' (*Fieldfisher*, 4 July 2022) ⟨https://www.youtube.com/watch?v=1ZYoKFkA8Yk⟩ accessed 12 August 2022

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