GLOBAL CAP AND TRADE SYSTEM FOR SPACE DEBRIS: PUTTING A PRICE ON SPACE HAZARDS

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I. INTRODUCTION AND CONTEXT

A. Space Debris

Earth orbital space is a finite natural resource which is steadily being polluted due to human space activities and the emission of different kinds of uncontrollable objects into Earth orbit. The creation of space debris is not legal nor illegal *per se*, however due to the current state of technology it is unavoidable as it is difficult to launch a space object without emitting any inoperable objects. Space debris poses a great threat to all space activities and might eventually also endanger life on Earth as big objects regularly re-enter the Earth's atmosphere.[1] According to the Kessler-Theory, even if no more debris objects are produced, the already existing pieces will multiply in a cascading effect which will lead to rendering the Low Earth Orbit (LEO) impassable.[2] Future space activities

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[1] Meaghan R. Plantz, *Orbital Debris: Out of Space*, 40 GA. J. INT'L & COMP. L. 585, 594 (2012); Nicholas D. Welly, *Enlightened State-Interest – A Legal Framework for Protecting the "Common Interest of All Mankind" from Hardinian Tragedy*, 36 J. SPACE L. 273, 275 (2010).

[2] STELLA TKATCHOVA, SPACE-BASED TECHNOLOGIES AND COMMERCIALIZED DEVELOPMENT: ECONOMIC IMPLICATIONS AND BENEFITS 213 (2011)

will thereby be precluded and the further use of existing space technologies and facilities hindered.[3] Hence, the space industry as a whole will be endangered.

Space debris is defined by the United Nations as "all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non functional".[4] There are different kinds of orbital debris, namely:[5] a) inactive payloads; b) operational debris, which is any object intentionally or accidently released during a mission (including hardware, propellant tanks, and even frozen sewage). c) fragmentation debris, consisting of very small objects from breakups of space objects; and d) microparticulate debris, consisting of minute particles.[6]

This approach, however, will only target two categories of space debris: inactive payloads and operational debris. These two categories are chosen based on the fact that these two types of debris can be more easily reduced by precautionary measures or active removal.

B. Cap and Trade Systems in General

In recent years, the climate change issue brought carbon dioxide (CO2) and other greenhouse gases, to the centre of attention. CO2 is the main pollutant responsible for global warming.[7] Although this problem is environmental in nature, it affects all spheres

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[3] Plantz, *supra note 2*, at 596, 597; Weeden, *The Non-Technical Challenges of Active Debris Removal*, IAF WORKSHOP ON ACTIVE DEBRIS REMOVAL, VIENNA AUSTRIA, 14 (Feb. 11, 2013) *available at* http://swfound.org/media/100609/bw_adr_iaf_copuosstsc_feb112012.pdf.

[4] UN Office of Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (2008) *available at* http://www.unoosa.org/documents/pdf/spacelaw/sd/COPUOS-GuidelinesE.pdf (last visited July 17, 2016)

[5] Plantz, *supra* note 2, at 592; Mark J. Sundahl, *Unidentified Orbital Debris: The Case of Market-share Liability Regime*, 24 HASTINGS INT'L & COMP. L. REV. 125, 128 (2000);

[6] Sundahl, *supra* note 6, at 128.

[7] Air pollution comes from many sources. *See generally*, National Wildlife Federation*, Effects on Wildlife and Habitat Facts About Global Warming Problems, http://www.nwf.org/Wildlife/Threats-to-Wildlife/Global-Warming/Effects-on-Wildlife-and-Habitat.aspx* (last visited June 27, 2016); Bill Chameides, *The Greenhouse Effect Explained*, ENVIRONMENTAL DEFENSE FUND: CLIMATE 411, July 25, 2007, http://blogs.edf.org/climate411/2007/07/25/greenhouse_effect/; Roberta C. Barbalace, *CO2 Pollution and Global Warming, When does carbon dioxide become a pollutant?*

of life, including poverty, economic development, population growth, sustainable development and resource management. Therefore it is not surprising that a market based and legal solution was explored in order to limit greenhouse gas production and output, namely emission trading.[8]

Emission trading or "cap and trade" is a market-based approach used to control pollution by providing economic incentives and it consists of two parts.[9] First, there is the "cap" or limit, which defines total amount of certain greenhouse gases that can be emitted by factories, power plants and other installations in either globally and/or in one country, on a national level.[10] Second, within the cap, users receive, purchase by auction or buy emission allowances on the market (in the EU in 2016, for example, one ton of CO2 emission costs 4,75€)[11] which they can "trade" with one another as needed.[12] If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is in need of additional allowances.[13] On an intergovernmental level, dependent on the drafting of the system, companies seated in different countries, and even states themselves, can trade their remaining allowances with each other across national

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ENVIRONMENTALCHEMISTRY.COM, Nov. 7, 2006, http://environmentalchemistry.com/yogi/environmental/200611CO2globalwarming.html; NATIONAL RESEARCH COUNCIL ET AL., ADVANCING THE SCIENCE OF CLIMATE CHANGE (2010).

[8] United Nations Framework Convention on Climate Change, *Background on the UNFCCC: The International Response to Climate Change*, http://unfccc.int/essential_background/items/6031.php (last visited June 28, 2016).

[9] Robert N. Stavins, *Experience with Market-Based Environmental Policy Instruments*, Resources for the Future, Discussion Paper 01-58, 26-33 (2001) *available at* http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-01-58.pdf.

[10] *Id.*; European Commission, Emission Cap and Allowances, http://ec.europa.eu/clima/policies/ets/cap/index_en.htm (last visited June 28, 2016).

[11] European Energy Exchange, European Emmission Allowances, https://www.eex.com/en/market-data/emission-allowances/spot-market/european-emission-allowances#!/2016/07/13 (last visited, July 13, 2016).

[12] *See generally* W. David Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J. ECON. THEORY 395–418 (1972); and Cameron Hepburn, *Regulating by Prices, Quantities, or Both: A Review of Instrument Choice*, 22/2 OXFORD REV. ECON. POL'Y 226–247(2006)

[13] William D. Nordhaus, *To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming,* 1 REV. ENVIRON'L ECON. & POL'Y 26-44 (2007) and A. Denny Ellerman & Barbara K. Buchner, *The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results*, 1 REV. ENVIRON'L ECON. & POL'Y 66-87 (2007).

boundaries.[14] While companies must surrender enough allowances to cover all their emissions in order to avoid penalties, the respective state must also comply with the set overall national cap.[15]

The most successful market putting a price on the CO2 pollutant and executing the Cap and Trade System so far has been European Union (EU) with its EU Emission Trading System (EU ETS).[16] Today, it covers over 11000 big scale installations as well as airlines in 28 Member States, Iceland, Norway and Liechtenstein.[17] The trading scheme is divided into three phases since 2005 and while the current phase covers the years 2013 – 2020, a fourth phase (until 2030) is already being discussed. [18] In spite of critical opinions regarding the success of EU ETS (which mainly regard the low carbon price as a result of the surplus of allowances due to the economic crisis and other factors[19]), numbers and figures testify for an obvious cut in emissions. In 2012, emissions were reduced over 8%, even though new Member States had joined the EU and the

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[14] ZhongXiang Zhang, Using Emissions Trading to Regulate Global Greenhouse Gas Emissions in Climate Change, Human Systems and Policy (Volume 3; Antoaneta Yotova eds. 2009) 107f;

[15] Jean-Marc Burniaux et al., *The Economics of Climate Change Mitigation: How to Build the Necessary Global Action in a Cost-Effective Manner*, OECD Economics Department Working Papers No. 701 (2009); Hermann E. Ott, *Emissions Trading in the Kyoto Protocol, Finished and Unfinished Business*, 43 LINKAGES JOURNAL, http://www.iisd.ca/journal/ott.html (1998); and Joseph Kruger et al., *Decentralization in the EU Emissions Trading Scheme and Lessons for Global Policy*, 1 REV. ENVIRON'L ECON. & POL'Y 112-133 (2007).

[16] European Commission, The EU Emissions Trading System (ETS), http://ec.europa.eu/clima/news/articles/news_2016052001_en.htm (last visited July 27, 2016) and Richard Sandor et al., SUSTAINABLE INVESTING AND ENVIRONMENTAL MARKETS: OPPORTUNITIES IN A NEW ASSET CLASS (2014), at 61 and Laing et al., *Assessing the Effectiveness of the EU Emission Trading System*, Centre for Climate Change Economics and Policy Working Paper No. 126 (2013), http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/WP106-effectiveness-eu-emissions-trading-system.pdf;

[17] European Commission, The EU Emissions Trading System (ETS), http://ec.europa.eu/clima/news/articles/news_2016052001_en.htm (last visited July 27, 2016)

[18] European Commission, The EU Emissions Trading System (ETS), http://ec.europa.eu/clima/news/articles/news_2016052001_en.htm (last visited July 27, 2016); European Commission, Revision for phase 4 (2021 – 2030), http://ec.europa.eu/clima/policies/ets/revision/index_en.htm (last visited July 27, 2016)

[19] Reforms to cut the surplus in emmissions are already being implemented. See European Commission, Structural Reform of the EU ETS, http://ec.europa.eu/clima/policies/ets/reform/index_en.htm (last accessed July 27 2016)

economic crisis had an impact on the market.[20] By 2014, EU emissions were 24 % below 1990 levels, while the economy expanded by 48% in said period of time.[21] Today, emission levels are still falling.[22] The EU ETS has been more effective than other energy-environmental policy instruments and most importantly it also has affected investment decisions.[23] The essences of EU's effective system are transparent and accurate monitoring and reporting procedures[24], as the data is annually monitored, reported and verified, which is called the "compliance cycle."[25]

The Scheme originated as a European effort within the framework of the Kyoto Protocol, which provides for Emission Trading Systems as a measure to combat global warming (see Chapter II.B). Worldwide there are many other examples of emission trading systems in force, including the schemes in the U.S (the Acid Rain Program[26], the Regional Greenhouse Gas Initiative and the California Cap-and-Trade), the Québec Cap and Trade System[27] in Canada,

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[20] The EU ETS is delivering emission cuts. *See* ENERGY AND CLIMATE CHANGE COMMITTEE, THE EU EMISSIONS TRADING SYSTEM: TENTH REPORT OF SESSION 2010-12, VOL. 1, H.C. 14761t 7 (U.K.).

[21] European Commission, Progress made in cutting emissions, http://ec.europa.eu/clima/policies/strategies/progress/index_en.htm (last visited July 27, 2016)

[22] European Commission, Slight decrease in emissions in 2015, http://ec.europa.eu/clima/news/articles/news_2016052001_en.htm (last visited July 27 2016)

[23] Laing et al., *Assessing the Effectiveness of the EU Emission Trading System*, Centre for Climate Change Economics and Policy Working Paper No. 126 (2013), http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/WP106-effectiveness-eu-emissions-trading-system.pdf

[24] Grubb et al., *Climate Policy and Industrial Competitiveness: Ten Insights from Europe on the EU Emissions Trading System*, German Marshall Fund Climate & Energy Paper Series 09 (2009), http://www.accc.gv.at/pdf/FINALCS-GMFpaper5Aug09.pdf (last visited, July 29, 2006)

[25] European Commission, Monitoring, Reporting and Verification of EU ETS Emissions, http://ec.europa.eu/clima/policies/ets/monitoring/index_en.htm (last visited July 29, 2016); European Commission, EU ETS Handbook, 101, available at http://ec.europa.eu/clima/publications/docs/ets_handbook_en.pdf (last visited July 13, 2016)

[26] Laing et al., *supra* note 24 and Steffan Brunner et al, *Emissions Trading Systems: An Overview*, Potsdam Institute for Climate Impact Research Discussion Paper (2009) *available at* http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.535.2125&rep=rep1&type=pdf.

[27] International Carbon Action Partnership Canada – Québec Cap-and-Trade System, https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=73 (last visited July 28, 2016) and

and other systems in Kazakhstan, Korea, China, Japan and New Zealand.[28]

The EU ETS (alongside other such systems) has shown that it is possible to trade in greenhouse emissions and that these emissions are falling as intended. The success of the EU ETS is an inspiration to expand this system also to other types of emissions and to launch cap and trade schemes as well for space debris.

II. PROPOSAL FOR A GLOBAL CAP AND TRADE SYSTEM FOR SPACE DEBRIS

A. Economic Aspects

At the very heart of emissions trading lays the desire for a market based, economically efficient scheme which will be adhered by grand scale polluters as it grants powerful incentives. In direct comparison to other policy instruments like taxes, tax-payer-funded programmes or command and control regulation, emission trading is preferable, as it encourages operational excellence and provides exactly for the needed stimulus.[29]

As pollution rights (allowances) are made tradable within the cap and trade system, they gain value, which raises awareness for environmental matters, triggers behavioural changes and makes "going green" profitable.[30] Those who emit less greenhouse gases need to spend less for allowances and/or can profit from selling spares. The sourced savings or profits can be invested in green technologies which in turn allocate further savings and profits. If the price for allowances persists on a robust and high level, clean, low-carbon technology will be additionally promoted.[31]

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[28] Laing et al., *supra* note 24 and International Carbon Action Partnership, Emissions Trading Worldwide: Status Report 2015, at 8, available at https://icapcarbonaction.com/images/StatusReport2015/ICAP_Report_2015_02_10_online_version.pdf;

[29] International Emissions Trading Association, Emissions Trading, http://www.ieta.org/Emissions-Trading (last visited July 27, 2016);

[30] Laing et al., *supra* note 24 and International Carbon Action Partnership, Emissions Trading Worldwide: Status Report 2015, at 8, available at https://icapcarbonaction.com/images/StatusReport2015/ICAP_Report_2015_02_10_online_version.pdf;

[31] European Commission, The EU Emissions Trading System (ETS), http://ec.europa.eu/clima/news/articles/news_2016052001_en.htm (last visited July 27, 2016)

The flexibility of the system ensures that emissions can be cut where it costs least, which is an additional important profit-incentive to major corporations.[32] All these incentives are important in order to ensure, that environmental protection does not come with decreases in economic growth.

Finally, it should be noted that cap and trade has the ability to adjust to the new prices automatically in the case of inflation and no further legislative or regulatory action is needed.[33]

B. Legal Aspects

There are no binding legal documents explicitly addressing the problem of space debris and non-binding guidelines have proven to be inefficient.[34] However, in international law, a general obligation to avoid harmful long-term contamination of outer space does exist in the regime of the Outer Space Treaty and customary international law.[35] Article I of the Outer Space Treaty enshrines the duty to use Space for the benefit of all and space debris hinders other states' free access to polluted areas of outer Space.[36] Article IX of the Outer Space Treaty stipulates that states should avoid harmful contamination, and space debris is perceived as such a form of contamination.[37] Article IX of the Outer Space Treaty also requires states to adopt appropriate measures to help avoid contamination,

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[33] TOM TIETENBERG & LYNNE LEWIS, ENVIRONMENTAL & NATURAL RESOURCE ECONOMICS (10th ed.) at 369 (2016)

[34] Martha Mejia-Kaiser, *Informal Regulations and Practices in the Field of Space Debris Mitigation*, 34 J. AIR & SPACE L. 21, 23 (2009).

[35] GEORGE T. HACKET, SPACE DEBRIS AND THE CORPUS IURIS SPATIALIS, at 115 (1994); Treaty on Principles Giverning the Activities of States in the Exploration and use of Outer Space, Including the moon and Other Celestial Bodies, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205, Art. IX [hereinafter Outer Space Treaty]; Declaration of the United Nations Conference on the Human Environment, U.N. Doc. A/Conf.48/14/Rev. 1, Princ. 21 (1973) [hereinafter Stockholm Declaration]; 1992 Rio Declaration on Environment and Development, UN Doc. A/CONF.151/26 (vol. I), Art. 3 (June 14, 1992) [hereinafter Rio Declaration]; and Mejia-Kaiser, *supra* note 35, at 30.

[36] Outer Space Treay Art. 1; FRANCIS LYALL & PAUL LARSEN, SPACE LAW - A TREATISE 307 (2009).

[37] Michael Gerhard, *National Space Legislation – Perspectives for Regulating Private Space Activities* in Essential Air and Space Law, (Benkö et al. eds. 2005), 85; Martha Mejia-Kaiser, supra note 35, at 23

which is interpreted by some as an obligation to mitigate space debris.[38] Additionally, Article 21 of the Stockholm Declaration and Article 2 of the Rio Declaration, which are seen by most as customary obligations[39], state that States have to ensure that activities within their jurisdiction and control do not damage areas beyond national jurisdiction, such as outer space.[40]

As for a legal basis for implementing cap and trade regarding the mitigation of space debris on an international level, one possibility would be to create a legal obligation for the majority of space faring nations through drafting an international treaty. Models for this can be found in the international conventions on Climate Change, such as the Kyoto Protocol[41] or the new Paris Agreement[42]. The Kyoto Protocol is an international treaty, which commits State parties to reduce emissions to a previously agreed level.[43] Under this Protocol countries must reach these levels primarily through their national mechanisms or alternatively through three market-based methods[44], first of them being the International Emission Trading. In this way, the Kyoto Protocol explicitly underlined the significance of a cap and trade system for a successful emission reduction on a national level, as well as on an international. Furthermore, the Paris Agreement is the newest adopted agreement regarding climate change. This Agreement is still not in force, nonetheless, it is already seen as historic, since 195 states pledged to reduce greenhouse gas emissions on a (non-binding) level that

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[38] Outer Space Treaty Art. IX; UN Comm. on the Peaceful Uses of Outer Space, Technical Report on Space Debris, U.N. Doc. A/AC.105/720, at B.III.12 (2005) and K. Gorove, *Protection of the Space Commons: New Customary Law*, 26 J. SPACE L., 208, 209 (1998); S Marchisio, Article IX, *Cologne Commentary of Space Law* (Hobe et al.eds.), 2012, Chapter 11;

[39] Dinah Shelton, Stockholm Declaration (1972) and Rio Declaration (1992) (2008) Max Planck Encyclopedia of Public International Law [MPEPIL] IX:602 ,para 17, 42 , Stockholm Declaration, *supra* note 36 and Rio Declaration, *supra* note 36.

[41] Kyoto Protocol to the United Nations Framework Convention on Climate Change UN Doc FCCC/CP/1997/7/Add.1, Dec. 10, 1997;

[42] Paris Agreement, *FCCC/CP/2015/L.9/Rev.1*

[43] UNFCCC, Kyoto Protocol, unfccc.int/kyoto_procol/items/2830.php (last visited July 29, 2016)

[44] these are (i) International Emission Trading, (ii) Clean Development Mechanism (iii) Joint Implementation. See UNFCCC, The Mechanisms under the Kyoto Protocol: Emissions Trading, the Clean Development Mechanism and Joint Implementation, http://unfccc.int/kyoto_protocol/mechanisms/items/1673.php (last visited July 30, 2016)

will limit the rise in global temperatures.[45] The Paris Agreement leaves it to States' discretion to adopt adequate national measures in order to reach these goals, and already about 90 countries have included some form of carbon pricing in their plans.[46] These examples testify that there is a global willingness among States to adopt measures in order to reduce emissions and that there is also a common view regarding the best way to achieve this, namely by using cap and trade system. This current momentum should be used to start negotiating a separate international treaty, which would expand emission reduction to space debris as well.

Alternatively, if drafting a new treaty is seen as a too lengthy and complex process, another possibility to find a legal basis for the implementation of the cap and trade system for space debris could be through amendments to the two above mentioned legal documents. Articles 20 and 21 of the Kyoto Protocol offer possibility to adopt amendments, and for the Paris Agreement it is anticipated that it will have amendments in the future. Therefore, the scope of these documents for climate protection could be extended to space environment protection, and articles could be added that address the mitigation of space debris.

On a regional level, the above-mentioned EU ETS is enforced by the European Commission and finds its legal basis in the European Parliament's Directive of 2003.[47] Concerning a European effort for space debris mitigation, it would be possible to promulgate a legislation similar to the amendment to the EU ETS of 2008, adding norms for the regulation of aviation-emissions.[48] The legal basis for such legislation is to be found in accordance with Article 191 Treaty on Functioning of the EU (TFEU), namely the obligation to a prudent and rational utilisation of natural resources such as the

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[45] Thomson Reuters, Has Paris deal injected life into carbon market?, http://blog.financial.thomsonreuters.com/has-paris-deal-injected-life-into-carbon-market/ (last visited July 30, 2016)

[46] C. Davenport, "Carbon Pricing Becomes a Cause for the World Bank and I.M.F., The New York Times, April 23, 2016

[47] Parliament and Council Directive 2003/87/EC, O.J. (L 275) 32 (EU).

[48] Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, OJ L 8, 13.1.2009, p. 3–21

Earth orbit, and the procedural requirements under Article 192(1) TFEU.[49]

C. Proposed Objectives

1. Global Limit for Debris Emission

In order to find a sensible cap to successfully mitigate space debris, the number of space debris produced globally on an annual basis has to be found. However, sources offer no consistent numbers, depending on what is presumed to be space debris by the tracking service. On average, according to most sources from the 1980s and 1990s, around 200-250 debris pieces per year were produced.[50] One has to take into consideration that since then, the number of space debris has increased with the number of space activities.[51] In 2006, for example, 517 new debris objects were tracked and categorized.[52] A year later, a single event caused a major contribution to the number of debris, namely, the Chinese anti-missile test which created more than 3300 tracked fragments.[53] The first in orbit collision ever between the Russian Kosmos satellite and the American Iridium satellite caused more than 2200 tracked fragments.[54] In 2013 around 70 new debris objects caused by launching alone were tracked by the online service Space-Track.org. It can be concluded that certain specific events, such as major launches, in-orbit accidents and missile tests in space can substantially increase the number of debris objects at a single stroke. However, it is estimated that during an average mission, approximately 7.5 objects are categorized per launch.[55]

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[49] *Id.*

[50] U.S. Congress, Office of Technology Asessment, *Orbiting Debris: A Space Environment Problem - Background Paper*, at 34 (1990).

[51] *Id.*

[52] UN INSTITUTE FOR DISARMAMENT RESEARCH, CELEBRATING THE SPACE AGE: 50 YEARS OF SPACE TECHNOLOGY, 40 YEARS OF THE OUTER SPACE TREATY, 121, (April 2007).

[53] ESA, Space Debris FAQ: Frequently Asked Questions, http://www.esa.int/Our_Activities/Operations/Space_Debris/FAQ_Frequently_asked_questions (last visited July 30, 2016)

[54] ESA, Space Debris FAQ: Frequently Asked Questions, http://www.esa.int/Our_Activities/Operations/Space_Debris/FAQ_Frequently_asked_questions (last visited July 30, 2016)

[55] NICOLAY N. SMIRNOV, SPACE DEBRIS: HAZARD EVALUATION AND DEBRIS MITIGATION 61 (2001)

All of these numbers might not strike as overwhelmingly shocking, however, the rate of space debris will increase rapidly due to natural processes of collision in orbit as there are already estimated 29,000 debris objects in orbit, which are sized larger than 10cm.[56]

The proposed market based approach seeks to limit the active and intentional emission of space debris annually.[57] This approach, on the one hand, sets the allowed cap for the numbers of debris emitted during launch activities and, and on the other hand, also sets a limit for the number of inactive payloads in orbit. The emission of space debris is categorized, depending on the kind of debris – i.e. operational debris and inactive payloads. On a national level there would be a cap limiting debris emission from both private industry and national agencies, and on an international level there will be a cap limiting debris emission globally.

In effect, this system would be divided into three or more phases, following the EU ETS model. Phase One is a three to five year pilot phase where, in the absence of reliable debris data, caps are set on the basis of best estimates. A suggestion for the cap for launch debris would be at seven categorized objects per launch, which is near the number of objects averagely emitted per launch. Regarding inactive payloads, all newly launched payloads have to have the capacity to be de-orbited and, at the end of their life-span have to be actually de-orbited. In phase two, the cap for launch debris will be decreased to a suggested 3-4 objects, depending on the state of technology. Additionally, a cap for inactive payloads in orbit is introduced, depending on the number of existing inactive satellites per member state. The proposed cap could be introduced at 2/3 of the existing payload debris per country.

In phase three, contingent upon success of the prior phases, the state of technology and the compliance of the Member States, these caps will be marginally increased.

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[56] ESA, How many Space Debris Objects are currently in orbit? http://www.esa.int/Our_Activities/Space_Engineering_Technology/Clean_Space/How_many_space_debris_objects_are_currently_in_orbit (last visited July 13, 2016)

[57] DAVE BAIOCCHI & WILLIAM WELSER IV, CONFRONTING SPACE DEBRIS: STRATEGIES AND WARNINGS FROM COMPARABLE EXAMPLES INCLUDING DEEPWATER HORIZON 42 (2010).

2. Tradable Permits

Space debris permits (or allowances) would work in such a way that they would make the producers of debris pay for the emissions they cause in outer space. After agreeing on the socially acceptable global cap and respective national caps of the space faring nations, permits would be issued in correspondence to these numbers. Modelled after existing schemes, permits can be issued for free in a primary transition period and auctioned in later periods. The total number of allowances has to be limited in order to ensure their value.[58] Over time, the global and national caps will be reduced in total so that a reduction in the annual debris output can be reached.

Space agencies, companies and private individuals that wish to pursue space activity which will create debris must hold permits corresponding to their pollution quotes.[59] Consequently, they will choose their contractors and subcontractors depending on the "sustainability" of their products in space. This encourages all space actors and the space industry to be more efficient when they are creating and launching space objects or parts of them. Furthermore, space actors will try to avoid fines, which would be substantial.

As a result, cleaner agencies and private actors benefit more. Not only do they save money and are able to invest in new technologies but also they save their reputation, which plays a big role when it comes to tenders and contractors. This creates an additional pressure for companies if they want to maintain their competitiveness.[60]

Therefore, as mentioned earlier, this approach gives the necessary economic incentives and triggers behavioral changes[61] in order to minimize the creation of non-functional objects in space.

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[58] European Commission, The EU Emissions Trading System (EU ETS), http://ec.europa.eu/clima/policies/ets/index_en.htm (last visited July 3, 2016).

[59] Thierry Senechal, *Orbital Debris: Drafting, Negotiating, Implementing a Convention*, masters thesis, Massachusetts Institute of Technology, at 66 (June 2007) available at http://web.mit.edu/stgs/pdfs/Orbital%20Debris%20Convention%20Thierry%20Senechal%2011%20May%202007.pdf.

[60] Senechal, *supra* note 60,, 66; W. David Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J. ECON. THEORY 395–418 (1972).

[61] Montgomery, *supra* note 61, 395–418.

3. Penalty System

Enforcement is the most significant aspect since without an affective enforcing system the value of allowances is forfeited.[62]

In order to enforce a sanction, one has to once again consider the overall limit. The first cap is determined on a global level, however national legislation regulates caps and allowances within domestic systems. Therefore, the penalty system has two levels. First, the national level, where the State has to make sure that their respective national space agencies and private actors stay within the cap. In cases where a private entity has not fulfilled its obligations, a State must levy a sanction upon the entity. Sanctions are enforced by domestic law and can be either of administrative or judicial, civil or criminal nature.[63] For example, substantial penalty payments or deductions from future (e.g. next year's) allowances can be imposed.[64] These two measures can also be combined.[65] In case of the national agencies, cuts in budget and other means can be used to ensure compliance.

Second, at the international level, the whole emissions of a state are measured which consequently also observes the performance of the national space agencies and impedes preferential treatment of state-owned actors. States must follow the globally accepted cap, otherwise the state will suffer a penalty for overstepping the cap, which can again be monetary or a reduction in future allowances[66]. The (in an optimal situation legally binding) interna-

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[62] Ott, *supra* note 16.

[63] T. H. Tietenberg, EMISSIONS TRADING, PRINCIPLES AND PRACTICE (SECOND EDITION), 170 (2010)

[64] UNFCCC, An Introduction to the Kyoto Protocol Compliance Mechanism, http://unfccc.int/kyoto_protocol/compliance/items/3024.php (last visited July 13, 2016), UN Framework Convention on Climate Change, *Bodies*, https://unfccc.int/bodies/items/6241.php (last visited July 3, 2016) and International Carbon Action Partnership, Linking https://icapcarbonaction.com/en/about-emissions-trading/linking (last visited July 27, 2016)

[65] International Carbon Action Partnership, Linking https://icapcarbonaction.com/en/about-emissions-trading/linking (last visited July 27, 2016)

[66] UNFCCC, An Introduction to the Kyoto Protocol Compliance Mechanism, http://unfccc.int/kyoto_protocol/compliance/items/3024.php (last visited July 13, 2016)

tional agreement on which the cap and trade system would be established, the rules of international relations and reciprocity, and public annual reports would additionally ensure compliance[67].

4. Compliance System

In order to implement and monitor the mitigation of space debris pursuant to the present approach, a two-stage compliance system is proposed, which involves reporting at both, the national and international levels.

Private space actors and operators are required to have an approved monitoring plan, according to which they monitor and report their emission of space debris during the year to the national organ in charge. The monitoring and the reports must follow a certain style and guidelines, in order to simplify inspections. In the style of the EU ETS, a 'compliance circle' could be installed, which includes in addition to the monitoring plan and the reporting system, an annual verification of the submitted numbers by an accredited verifier.[68]

The annual total of the debris emissions of private space actors and national space agencies of each participating state is then forwarded to an international monitoring organ, which processes and catalogues the numbers. One possibility would be to consign the Secretary-General of the United Nations with this position, as it also maintains the registry for space objects.[69]

5. Investment in Innovative Technologies

According to the "Kessler Syndrome"[70], the current extent of space debris in orbit may already render LEO impassable.[71] Even if no more debris objects are emitted, dysfunctional objects could

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[67] T. H. Tietenberg, EMISSIONS TRADING, PRINCIPLES AND PRACTICE (SECOND EDITION), 170 (2010)

[68] European Commission, *Monitoring, Reporting and Verification of EU ETS Emissions*, http://ec.europa.eu/clima/policies/ets/monitoring/index_en.htm (last visited July 3, 2016).

[69] Convention on the Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15, Art III.

[70] Donald J. Kessler and Burton G. Cour-Palais, *Collision Frequency of Artificial Satellites: The Creation of a Debris Belt*. JOURNAL OF GEOPHYSICAL RESEARCH **83**: 2637–2646 ((1978)..

[71] Tkatchova, *supra* note 3, 213.

multiply in a cascading effect through collisions and break-ups.[72] According to Prof. Klinkrad, head of ESA's Debris Office, "only the active removal of five to 10 large objects per year can reverse the debris growth".[73] Therefore, revenues and collected penalties from the cap and trade system would be used to promote scientific research and funding for innovative projects for active space debris removal. Monetary penalties would be paid into a compliance fund to be used for remediation, for example with the creation of a "Clean Space Fund," depending on how the cap and trade System will be legally implemented.

Similarly, the system has a remedial effect on the national level as the private Space operators will be able to use their revenues from selling emission permits as investments into "greener technologies," i.e. debris-neutral launches, the use of material which prevents the creation of minute particles or bigger break-ups in orbit, and de-orbiting capacities for all the launched payloads.

III. CONCLUSION

The market-based approach of a cap and trade system in Space is the most cost-effective solution for long-term sustainability. It provides economic incentives for decreasing the emission of space debris and in the contrary to existing cap and trade systems it doesn't offer an easy "buy-out" as there would also be an obligation to invest. This is made possible as the resulting profits from saved allowances are to be used for investment in new technologies which will substantially improve mitigation efforts. This system enables to set a clear time frame for the targeted level of reduction. A global cap and trade system for space debris is thus warranted and would benefit the society as a whole.

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[72] Tkatchova, *supra* note 3, 213.

[73] Jonathan Amos, *'Urgent Need' to Remove Space Debris*, BBC NEWS, Apr. 25, 2013, http://www.bbc.com/news/science-environment-22299403.