Protecting the Dark Skies of the Earth from Satellite Constellations Under International Space Law

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Abstract

Satellite Constellations are often brighter and visible in the night sky and therefore an increase in the number of satellite constellations in the Earth's orbit can threaten the dark skies of the earth. The bright trails of these satellites constellations on the Dark skies in large numbers can interfere with various Astronomical activities. Considering these interferences, this paper will discuss the legal measures under International Space law to protect Dark skies from Satellite constellations. Firstly, this paper will emphasize how an extension of the "Equitable Access principle" by the ITU to LEO and MEO will help in regulating the number of operating Satellite Constellations, thereby reducing the disturbances caused to Dark skies of the earth. Secondly, this paper will analyse how the concept of "Milestones based launching" of Satellite constellations as agreed under WRC 2019 can help in shaping mitigation measures. Thirdly, this paper will emphasize on the Role of Domestic Regulators such as FCC of U.S etc. and the development of National Policies to regulate Satellite Constellations in order to prevent their pollution of dark skies. Finally this paper will evaluate the importance of World Heritage Convention 1972 in protecting the Dark Skies.

Acronyms/Abbreviations (in order of appearance)

LEO - Low Earth Orbit
MEO - Medium Earth Orbit
AAS - American Astronomical Society
UN - United Nations
ITU - International Telecommunication Union
WARC - World Administrative Radio Conference

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WRC - World Radio Conference (formerly WARC)
GSO - Geostationary Orbit
UNCOPUOS - United Nations Committee on Peaceful Uses of Outer Space
OST - Outer Space Treaty, 1967
IAU - International Astronomical Union
STS - Scientific and Technical Subcommittee
LSC - Legal Subcommittee
MIFR - Master International Frequency Register
FCC - Federal Communication Commission (USA)
NEPA - National Environmental Policy Act (USA)
C.F.R. - Code of Federal Regulations (USA)
UNESCO - United Nations Educational Scientific and Cultural Organization
OUV - Outstanding Universal Value
AWHI - Astronomy and World Heritage Initiative
WHC - World Heritage Convention

1. Introduction

Satellite constellation comprises of a number of similar satellites having similar type and function, designed to be in similar or complementary orbits for a shared purpose, under shared control.[1] These Satellite Constellations are launched to offer high speed internet connectivity to people in all corners of the Earth. While orbiting Earth, these satellites are aligned with the Sun for extracting Solar Energy. As a result, they tend to reflect the sun rays back to the observers on Earth *known as Flares*, causing them to appear bright and visible. Thus while offering unhindered Internet connectivity in remote area these satellite constellations tend to simultaneously affect the dark skies by their bright light trails. This is the dilemma currently faced by the international scientific communities and astronomical societies.

1.1. Why are Satellite Constellations Launched?

Satellite Constellations are launched to provide constant network coverage spanning large geographical area. The Satellite constellations make formations that enable low latency communication reducing delays in communication signal.

Currently, Satellite Constellations such as Starlink operated by Space-X, promises to offer high speed broadband internet to locations where access has been unreliable, expensive, or completely unavailable.[2] Further, Softbank backed OneWeb and Amazon's Project Kuiper are also planning to launch

1 Wood, Lloyd, Satellite Constellation networks Internetworking and Computing Over Satellite Networks 13-34 (2003).
2 Starlink *at* Starlink.com *accessed* 12 July 2020.

low earth orbit satellites Constellations with an aim of offering Internet access to rural areas and even Arctic/ Antarctica.[3]
Thus the number of satellite constellations scheduled to be launched in the future is causing a concern.[4] According to AAS, innumerable launches of Satellite constellations can congest the LEO and may increase the number of objects in the space from approx. 15,000 in the last 60 years to 5 times more within 5 years.[5] It is to be believed that the operators have planned to place the innumerous satellite constellations and connect them like a web engulfing the earth.[6] Such striking numbers of Bright satellites continuously orbiting the LEO and MEO can enormously destroy the tranquility of Dark Skies.

1.2. What are the Impacts of these Satellite Constellations on the Dark Sky?

So what is Dark Sky? According to Oxford Dictionary, Dark Sky denotes or locates a place where the darkness of the night sky is relatively free of interference from artificial light.[7] Dark Skies are prerequisite for astronomers to detect distant objects in outer space.[8] They are indispensable for understanding the mysteries of the universe and are also an important cultural and natural heritage for all civilizations.[9]
According the *Report and Recommendation of Dark and Quiet Skies for Science and Society Online Workshop* released in January 2021, Bright Satellite Constellations impact dark sky reserves, astrophotography, religious and cultural practices, animal and insect life, and scientific inquiry.[10] They also impact the Nature of Results of Observatories and the view of common stargazers.

3 SpaceChain Foundation, *The Future of Satellite Constellations*, Medium, Feb 20, 2020 *at* https://medium.com/blogspacechain/the-future-of-satellite-constellations-b1516baf2756.
4 Mike Wall, OneWeb launches 34 internet satellites into orbit to boost broadband megaconstellation, SPACE.com, Feb 6, 2020 *at* https://www.space.com/oneweb-internet-satellites-launch-on-soyuz-rocket.html.
5 American Astronomical Society, *Questionnaire on Impact to Optical Astronomy of Large Constellations of Low-Earth Orbit Satellites,* December 19, 2019 *at* https://aas.org/form/aas-survey-on-satellite-constell.
6 *Satellite Megaconstellations and the Night Sky*, International Dark Sky Association June 25, 2020 *at* https://www.darksky.org/satellite-megaconstellations-and-the-night-sky/.
7 Dark Sky, Lexicon Powered By Oxford Dictionary *at* https://www.lexico.com/definition/dark-sky *accessed* June 2, 2020.
8 Sze-Leung Cheung ed., Light Pollution, International Astronomical Union (April 2018).
9 *Ibid.*
10 UNOOSA & IAU, Report and Recommendation of Dark and Quiet Skies for Science and Society Online Workshop, p.28 (2021).

Considering these impacts this paper will offer the following suggestions under the ITU regime and International Space treaties to ensure that the Dark skies of the Earth remains protected from the Satellite Constellations

2. Extending Equitable Access Principle to Low Earth Orbit and Medium Earth Orbits

2.1. Role of Orbital Slot Allocation in protecting Dark Skies

Dark skies are primarily areas above earth, starting from Karman Line and extending endlessly devoid of bounds. Therefore it is only logical that orbital slots occupied by these Satellite Constellations become inherent parts of the Dark skies and therefore protection of the Dark skies requires regulations of the Orbital slots used by these satellites under the ITU Regime.

2.2. Role of ITU in Orbital Slot Allocation

The ITU started as International Telegraphic Union in 1865 being the oldest specialized agency of UN.[11]

Ever since the launch of Sputnik in 1957, Satellites became integral for Telecommunications. Thus the ITU in 1959 added *Space activities* within its ambit and allocated orbital slots and spectrums to countries based on *"First Come First Serve Basis"*.

However the ITU in 1971 WARC considered concerns of the Non spacefaring countries that GSO, a scarce and beneficial orbit[12] will become perennially occupied by Active Space Faring countries and will deny the former, access to the GSO if status quo prevailed. Thereby in 1973, the ITU in Article 33 (now Article 44) of its Convention[13] declared GSO as limited Natural resource and that countries must have equitable access to it in based on special needs of developing countries.

Henceforth the orbital slots in the GSO belt continue to be allocated to each applicant based on *Equitable Access Principle* enshrined in Article 44 of the ITU Convention through two different Procedures namely Planned and Coordinated.

Under the Planned Procedure the ITU has divided the world into 3 regions and has reserved bandwidth and GSO slots to each country.[14] This ensures

11 History of ITU *at* https://www.itu.int/en/history/Pages/ConstitutionAndConvention.aspx.

12 Stephen E. Doyle, *Regulating the Geostationary Orbit: ITU's WARC-ORB 85-88*, 1 J. Space. L 15, 4 (1987).

13 Constitution and Convention of the International Telecommunication Union *entered into force* 1 July 1994 U.N.T.S 1825, 1826, Art. 44.

14 International Telecommunications Union, *Radio Regulations, Vol. 2* (2016) Appx. 30A & Appx. 30B; Audrey L. Allison, The ITU and Managing Satellite Orbital and Spectrum Resources in the 21st Century 17 (2014).

that each country is reserved of an orbital slot regardless of its spacefaring capabilities.

All the Non-GSO Belts however are allocated based on the Coordinated Procedure. This follows a first come first served approach of the applicants, emphasizing on efficiency and utilization of the orbital slot by such Satellite operator applicant.[15]

Over the years, Non-GSOs became prime areas of commercialization, resulting in the increase of Satellites operating in LEO and MEO.[16]

This prompted the ITU in 1998 to amend Article 44 of the ITU convention to state that all orbits and not only GSO are scarce and limited natural resources.[17] This mandated all satellite operators to use any orbit around the earth in a Rational and efficient manner.

However it is concerning that in future there will be hordes of Satellite Constellations congesting the LEO and MEO, threatening to create innumerable space debris, increase the scope for destructive collisions and result in growing saturation of the radio-frequency spectrum and interferences.[18]

2.3. Protecting Dark Skies as a Part of Space Sustainability

Space Sustainability denotes the ability of humanity to continue using Outer Space for peaceful purposes and socio economic Benefits in the Long Term.[19] It largely focuses on preservation of space environment for both present and future generations.[20]

While Space Sustainability has often emphasized on Space Traffic Management and Active Debris Remediation, the UNCOPUOS, the UN body overseeing the implementation of International Space laws, in its recent Space Sustainability report had considered a presentation by IAU regarding the impact of Satellite Constellations on Astronomy on its Agenda for "Long

15 Yvon Henri, '*Orbit/Spectrum International Regulatory Framework*', ITU (2016) *at* https://www.itu.int/en/ITU-R/space/Presentations/Orbit_Spectrum%20International%20Regulatory%20 Framework_Henri.pdf.

16 Chris Daehnick et al., Large LEO satellite constellations: Will it be different this time? Mckinsey & Company- Aerospace & Defense May 4, 2020 *at* https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/large-leo-satellite-constellations-will-it-be-different-this-time#.

17 Constitution and Convention of the International Telecommunication Union *entered into force* 1 January 2000 U.N.T.S 1825, 1826, Art. 44.

18 Olga S. Stelmakh, *Global Space Governance for Ensuring Responsible Use of Outer Space, its Sustainability and Environmental Security: Legal Perspective*, 58 Proc. Int'l Inst. Space L. 687 (2015).

19 Space Sustainability, Secure World Foundation *at* https://swfound.org/our-focus/space-sustainability/.

20 Guidelines for the Long-term Sustainability of Outer Space Activities, UNCOPUOS at p.2 A/AC.105/2018/CRP.20 (2018).

Term Sustainability of Outer Space Activities"[21]. This inclusion indicates the relevance of protecting the Dark Skies as a part of Space Sustainability.
As a founding observer and active participant to UNCOPUOS's STS and LSC, the ITU plays key role in Long Term Sustainability of Outer Space and its Activities.[22]
As witnessed in the previous part, the ITU has been akin to transitions addressing the dual challenges of Telecommunication and Space Exploration.
In 2016 the Radio Regulations published by the ITU subsequent to the WRC 2015 stated that a filing for orbital slots is to be accompanied by "Coordinated efforts" that will consider potential stakeholders activities actively or passively impacted by a new satellite.[23] These coordinated efforts enshrined in the Radio regulation runs up to 7 years wherein the allocation of the orbit is done by the ITU in a most prudent manner.[24] This procedure obliges satellite operator to take measures that will refrain them from harming/interfering the satellite operations/space systems of another operator thereby keeping Outer Space risk free.[25]
Although these "Coordinated efforts" might increase the scrutiny on the Satellite operators to prevent frequency interferences and physical collisions, it is uncertain whether they will be enough to stop the congestion of innumerable Satellite Constellations that will be orbiting the earth in the future if status quo prevails. Subsequently it is also doubtful whether these regulations are capable of addressing the main concern regarding the Light Pollution caused by these Satellite Constellations.
Such uncertainties point for a serious reform in the Radio Regulations and also raise an argument for considering an Equitable access Principle for LEO and MEO for preserving the Dark Skies as well as meet other concerns affecting Space Sustainability.

2.4. Can the Extension of Equitable Access Principle to LEO and MEO help in Protecting the Dark Skies of Earth?

Despite the reference to term "Equitable" in many International Treaties, there hasn't been an attempt to define it and it does make sense why is it so.[26]

21 Report of the Committee on the Peaceful Uses of Outer Space (STS), U.N. GAOR 57th Sess., U.N. Doc. at p.29 A/AC.105/1224 (2020).
22 Yvon Henri, The ITU Radio Regulations & Space Sustainability, The Brussels Space Policy Round Table, Brussels, Belgium November 29, 2012 *at* https://swfound.org/media/96609/2012_ssi_yvon%20henri.pdf.
23 International Telecommunications Union, *Radio Regulations, Vol. 1* (2016) Art. 9.
24 *Ibid* Art. 11.44.
25 Matteo Cappella, The Principle of Equitable Access in the age of Mega-constellations *in* Legal Aspects around Satellite Constellations 15 (Annette Froehlich eds. 2019).
26 Milton L. Smith, *Equitable Access to the Orbit/Spectrum Resource*, 30 Proc. on L. Outer Space 263, 264 (1987).

Equity as a concept differs with countries, legal systems and even Time, thus there cannot be a general and all-encompassing definition.[27]

However the simple meaning, according to Black's Law Dictionary, "Equitable" means "Just, fair, and right, in consideration of the facts and circumstances of the individual case".[28] So an approach can be termed "Equitable" if it is "Fair" and "Just" based on the circumstance in hand.

For example, during 1970s, it was ascertained *Equitable* by the ITU to preserve the GSO to enable access for each country regardless of its concurrent space abilities. Thus, The Equitable access principle under Article 44 ensured that countries lacking space faring capabilities aren't denied an opportunity to access space in the future.

Moving to present, commercialization of Telecommunications has become LEO centric.[29] Research indicates that LEOs and MEOs to be occupied by swarms of Satellite Constellations in the next 10-20 years.[30] This huge shift requires an *Equitable* approach in order to ascertain what remains Fair and Just for the above circumstances.

In such a case it's contrary to *Equitable* if Satellite constellations continue impacting Ground Astronomy, thereby impeding the primary access developing countries have to Outer Space, i.e. through Observatories and Ground Based Telescopes.[31] Simultaneously it is not *Equitable* if an approach hinders Satellite Constellation Industry having potential to become a panacea to global connectivity.

It is also clear that ITU cannot replicate the same practice of Planned Procedure it adopted for GSO Satellites under Article 44 of the ITU convention since GSO and LEO/MEO are characteristically distinct and the functions of satellites in both of these orbits are varied.[32] Nor can the ITU continue to allocate Non-GSOs based on the first come first served approach, neglecting the concerns in hand.

In that case the author suggests that the ITU must allocate Non-GSOs based on an *Equitable Access Principle* wherein the allocation will strictly be based on case to case evaluation and 2 factors namely;

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27 *Ibid.*

28 Black's Law Dictionary 632 (4th eds. 1968).

29 Gagan Agrawal, A (LEO) RACE TO THE BOTTOM? Northern Sky Research, May 15, 2019 *at* https://www.nsr.com/a-leo-race-to-the-bottom/.

30 Caleb Henry, LEO and MEO broadband constellations mega source of consternation SPACE NEWS March 13, 2018 *at* https://spacenews.com/divining-what-the-stars-hold-in-store-for-broadband-megaconstellations/.

31 Space versus Ground Telescopes, University of Arizona June 7, 2016 *at* https://research.arizona.edu/stories/space-versus-ground-telescopes.

32 Types of Orbit, European Space Agency, March 30, 2020 *at* https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits.

a) A capping on orbital slots per Satellite based on the bare minimum requirement by the satellite operators to efficiently operate the Satellite constellation network.
b) The capabilities of the Satellite operators to perform Mitigation measures to protect the Dark Skies from their Bright trails as well as minimize interference to safeguard Radio Astronomy.

For smooth transition, these obligations can be incorporated with other steps under Article 9 and 11 of RR. The orbits can be reserved by the ITU for the applicant and based on their minimum requirement and their abilities to demonstrate mitigation each Satellites of the proposed Satellite Constellation can be recorded under the MIFR, thereby signaling successful allocation and deployment. Such an approach by the ITU will ensure that only trustworthy and capable satellite operators can place their satellite constellations in the Orbits.

3. Adopting a Milestone Based Approach

As discussed above, an "equitable approach" should be fair and just. This means that it should ensure every relevant stakeholder such as the ITU, Satellite Operator, Astronomical community and People etc. adequate time and opportunity to resolve disputes.
In WRC 2019, Sharm el Sheikh, a *Milestone based launching approach* was agreed to regulate the deployment of Non-GSO Satellite constellations. Considering the large number of satellites under Satellite constellations, the ITU felt that with just one satellite recorded, it could be treated as full deployment of all these satellites, regardless of whether the recorded orbits and frequencies are occupied and used.[33] Such events would encourage practices such as Spectrum Warehousing, leading to accumulation of Paper Satellites in the orbit.
Thus in order to protect the rights of satellite operators to the assigned orbits and simultaneously mandate full deployment of satellites to prevent Spectrum warehousing, after the 7 years period of regulations involving Advance Publication Information Filing (API), Coordination Request, Notification Filing and Declaration of Bringing into Use (BFIU), it was decided that operators will follow The Milestone Based approach spanning for the next 7 years wherein these Satellite operators will ensure 10% deployment of total satellites within 2 years of BFIU, 50% deployment within 5 years of BFIU

33 Draft CPM Report, Conference Preparatory Meeting for WRC-19, Geneva, Doc No CPM19-2/1-E, 18-28 February 2019.

and finally 100% within 7 years of BFIU.[34] It is basically (7 years of regulation + 7 years of milestone based launching).
The inability of the satellite operator to meet these milestones will have necessary implications with the MIFR Recordings done by ITU under Article 13.6 of the RR.
Although the Milestone based approach was brought to prevent Frequency Radio Spectrum Warehousing and ensure proper coordination and operational requirement of Satellite constellations, the author believes that the basic concept of this approach can be helpful in tackling the light pollution caused by these Satellite Constellations.

3.1. How Can Milestone Based Launching Help in Mitigation Efforts by Satellite operators?

a) Offer necessary intervals for the satellite operators to coordinate with ITU, National Administrations, observatories and astronomical societies. Analyzing the case of Starlink Constellations operated by Space-X, initially neither the observers in earth nor the operators considered this impact.[35] Only after deployment in the night sky that people grew attentive about such disruptions. It implies that regardless of innumerable simulations, the actual impact of the light pollution can only be ascertained when satellites are deployed and thus for coordination and mitigation, deployment must be followed by sufficient time period for these stakeholders.
b) Offers time for the operators to ascertain the impact of light pollution caused by their first batch of satellites and reduce the brightness by making necessary amends to the subsequent batches. Time intervals are important when Satellite operators are working on a trial and error basis just like how Space-X claimed while working to darken their satellites[36]. Considering the cost of satellite designing, such intervals also help Satellite operators to allocate the necessary finance for mitigation.
c) Prevent simultaneous/ single launch of all the Satellites, deterring congestion of the LEO and MEO and preventing exacerbation of light pollution in the dark skies. It is suggested by Satcon Report that

34 ITU Members agree to new milestones for non-geostationary satellite deployment, ITU News, November 20, 2019 *at* https://news.itu.int/itu-members-agree-to-new-milestones-for-non-geostationary-satellite-deployment.
35 Mike Wall, Why SpaceX's Starlink satellites caught astronomers off guard, SPACE.com, January 10, 2020 *at* https://www.space.com/spacex-starlink-satellites-megaconstellation-surprise-astronomers.html.
36 Sandra Erwin, SpaceX working on fix for Starlink satellites so they don't disrupt astronomy, SPACE NEWS, December 7, 2019 at https://spacenews.com/spacex-working-on-fix-for-starlink-satellites-so-they-dont-disrupt-astronomy/.

satellites at orbital altitude of 600kms or greater are likely to cause problems to the Dark skies. Thus avoiding simultaneous launches will temporarily reduce the number of satellites above the 600km orbital altitude threshold.[37]

d) Dilutes the argument for a Moratorium on such projects by offering sufficient time for both the regulators and the Satellite operators to develop consensus on some legislation/regime. An availability of time will lead to all stakeholders to converge [for ex: the Satcon1 indicated the desire of all stakeholders to cooperate] rather than confront each other with legal suits. Further considering the heavy cost and time involved in manufacturing and operating a Satellite constellation,[38] a concept for Moratorium will not be "equitable" in protecting the Right to exploration, use and free access of Outer Space as enshrined under Article I OST.[39]

This Milestone based approach currently has been planned only for Non-GSO satellites for specific frequency bands and services and is intended to tackle spectrum warehousing. In the Future, the ITU can try to suitably modify and extend this approach to all the Non-GSO frequency bands and services to tackle the light pollution caused by these Satellite constellations.
Also reiterating the aforementioned example, it needs to be understood that whatever mitigation Space-X did to reduce the brightness of their satellites (Darkened the coating of Satellite to reduce albedo effect) was out of goodwill.[40] While this posture indicates the willingness of Companies to help towards the cause of protecting the Dark skies, it also signals a lack of an obligation on the part of Satellite operators to protect it.

4. Emphasizing the Role of Domestic Regulators and National Policies

Over the last two decades, Private industries have considerably grown in Space Industry, with various companies acquiring capabilities that were once attainable only by States with deep pocket. However for the sake of regulation, responsibility and liability, *Corpus Juris Spatialis* retained Space activities as National Activities. Article VI OST mandates State parties to

37 Satellite Constellations 1 (SATCON1) workshop Report, Impact of Satellite Constellation on Optical Astronomy and Recommendation towards Mitigations, August 25, 2020 at p.5.

38 *Supra* (n.16).

39 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, entered into force Oct. 10, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205; Art. I.

40 Satellite Megaconstellations and the Night Sky, International Dark Sky Association, June 25, 2020 *at* https://www.darksky.org/satellite-megaconstellations-and-the-night-sky/.

authorize and continuously supervise Space exploration performed by both Governmental and Non-Governmental Organization including Private organizations.[41] Similarly the ITU regime under Article 1.2 of RR also defines the role of National Administrations to discharge any obligation under the Constitution of the ITU.[42]

4.1. The Case of Federal Communications Commission in the U.S.A.

Currently private companies in the U.S.A such as Space-X and Amazon have acquired approval from their National Administration, FCC to launch more than thousand Satellites over the next decade.[43] This has placed the role of FCC under spotlight. The FCC like all Federal agencies in USA is required to review the environmental impact of any project or act it authorizes as per NEPA 1970 under C.F.R.[44]

Instead the FCC didn't perform environmental impact assessment of satellite projects for their impact on Earth's orbital environment and Astronomy.[45] This lack of review by the FCC has unsettled the Astronomical and Legal community and here is why they feel so.

The Legal Experts cite Title 40 Section 1508.8 of C.F.R to contend that approval of Satellite Constellation Projects must only be done subsequent to an Environmental Assessment by the FCC as these projects have shown to cause "Detrimental Effects" on aspects of our Ecology *inter-alia* Aesthetics, Culture etc.[46]

Whereas, the FCC cites *Categorical Exclusions* under Title 47 Section 1.1306 of C.F.R as the legal reason for not performing environmental review prior to the approval of such projects. This Provision mandates Environmental Review by the FCC only for specific circumstances *inter-alia* causing High intensity Lighting and Human Exposure to excessive Radio Frequency.[47]

Considering contentions from both sides, it is clear that current domestic regulations require reforms.

The FCC must regulate satellites through a comprehensive Environmental Review to protect the Dark Skies in a similar way it protects Radio Astronomy from Frequency Interferences.

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41 *OST* Art. VI.

42 *RR* Art. 1.2.

43 Alun Williams, Amazon gets FCC approval for Project Kuiper satellite constellation, Electronics Weekly.com August 5, 2020 *at* https://www.electronicsweekly.com/news/amazon-gets-fcc-approval-project-kuiper-satellite-constellation-2020-08/.

44 Protection of Environment, 40 C.F.R.

45 Jonathan O'Callaghan, The FCC's Approval of SpaceX's Starlink Mega Constellation May Have Been Unlawful, Scientific American, January 16, 2020 *at* https://www.scientificamerican.com/article/the-fccs-approval-of-spacexs-starlink-mega-constellation-may-have-been-unlawful/.

46 *Supra* 40 C.F.R. §1508.8.

47 Telecommunications, 47 C.F.R. § 1.1306.

Currently Satellite manufacturers have been mandated to design spacecraft to minimize orbital debris.[48] Similarly, National Administrations must ensure similar measures mandating Satellite manufacturers to minimize/neutralize the negative impact they are causing to the Dark Skies.
The regulations must focus on:

(i) Capping the Orbital Altitude of the Satellite Constellations. [Higher the Satellite greater the threat] Satcon 1 Report offers a threshold of 550-600kms as an ideal Orbital Altitude.[49]
(ii) Reviewing the Apparent Magnitude of each Satellite in the Sky at both Dusk and Dawn.[50] [Apparent Magnitude measures the brightness of the Satellite].
(iii) Licensing and approval based on the capabilities of the satellite operators to adhere to the aforementioned mitigation measures.

Thus the Author believes that reforms in Domestic regulation are necessary as they can offer "A Bottom to top approach" leading to creation of an International regime, considering that there are no regulations on Brightness of Satellites or to prevent their negative impact on astronomy. One must remember the adoption of NASA Act in 1958 provided impetus to the adoption of the OST in 1967. Thus enacting a domestic legislation for the protection of dark skies may lead to a formulation of a clear guideline at an international level.

5. Considering Dark Skies as World Heritage

The Dark skies are one of the few phenomena that have journeyed through all epochs of the earth and a feature inherited from ancestors. This was reiterated by UDHRFG, which emphasizes on the right of future generations to Pure Skies.[51] Therefore it would be undermining if the dark skies are not protected for Mankind and its subsequent Generations.
Protection of World Heritage is monitored by the World Heritage Committee under UNESCO. The Committee operates under WHC, ratified by 194 countries.[52] The role of the committee is to implement the convention, manage the World Heritage fund, decide the World Heritage list, monitor the conservation of the enlisted Heritages and take actions when these Heritages

48 Academy of Program/Project & Engineering Leadership, Orbital Debris Management and risk Mitigation, NASA *at* https://www.nasa.gov/pdf/692076main_Orbital_Debris_Management_and_Risk_Mitigation.pdf.
49 *Supra* (n.37) at p.18.
50 *Ibid.*
51 Universal Declaration of Human Rights for Future Generation, UNESCO Executive Board, 145th session, Doc no. 145 EX/41, Sept 22 1994; Art. 1.
52 State Parties Ratification Status, UNESCO WHC *at* https://whc.unesco.org/en/statesparties/.

are improperly protected by the State parties.[53] Thereby the World Heritage committee ensures that State parties take active steps to protect the listed World Heritages. This obligation of the State Parties is mentioned under Article 5 of the WHC.[54]

For this purpose the WHC defines 2 types of Heritages namely, Cultural Heritage[55] and Natural Heritage.[56] Any Heritage under contention must satisfy at least 1 of the 10 OUV criteria given under the Operational Guidelines to be enlisted as World Heritage.[57]

Considering the above criteria, groups like UNESCO's AWHI have been working on emphasizing the importance of Astronomical Heritage and whether Dark skies satisfy these criteria to be enlisted as World Heritage Site. The AWHI formed in 2004, signed a MOU with IAU in 2008. As a part of the MOU, the IAU established a Working Group on Astronomy and World Heritage that conducted "Thematic studies on Heritage sites of Astronomy" in 2010 and 2017.

The Thematic Studies of 2017 found a few challenges in designating Dark skies as World Heritage as per the WHC namely;

- The Dark Skies lack Physical Boundaries and are limitless.
- They don't belong to a Particular State Party or any of its territory.
- Dark skies themselves lack cultural or scientific value under WHC.
- Can't be afforded an OUV status under WHC as it implies an anthropogenic approach of affording the OUV status to the Universe, resulting in a paradox.[58]

For this purpose, the study suggested in considering certain Sites/ Observatories across the world having potential OUV relevant to the practice of Astronomy for the World Heritage list.[59] Potential Astronomical Heritage sites such as Aoraki–Mackenzie Dark Sky Reserve in New Zealand etc. are properties located within territories of countries, intersecting both cultural and scientific value.[60] The Study concluded that while Dark skies in

53 World Heritage Committee, UNESCO WHC *at* https://whc.unesco.org/en/committee/.

54 Convention for the protection of the world cultural and natural heritage entered into force, Dec 17, 1975 Art. 5 U.N.T.S 1037 (p.151).

55 *Ibid* Art. 1.

56 *Ibid* Art. 2.

57 Operational Guidelines for the Implementation of the World Heritage Convention, UNESCO, Doc no WHC.19/01 Jul 10, 2019 77.

58 ICMOS & IAU Heritage Sites of Astronomy and Archaeoastronomy in the Context of the World Heritage Convention Thematic Study no. 2 (Clive Ruggles eds. 2017) p.7-16.

59 What is Astronomical Heritage? Portal of Heritage to Astronomy UNESCO WHC *at* https://www3.astronomicalheritage.net/index.php/about/what-is-astronomical-heritage.

60 *Supra* (n.58) at pp.17-291.

themselves cannot be afforded World Heritage Site status, their protection is essential to preserve the OUV of such Astronomical Heritage Sites, potential to be listed as World Heritage site in Future.[61]
Thus designating an Astronomical Heritage Site as a World Heritage will ensure that State parties are mandated to adopt policies as per Article 5 of the WHC to protect them from light pollution caused by these Satellite Constellations.[62] Such policies would primarily require them to regulate their National Space Activities under Article VI of OST. Further Article 6 of the WHC obligates all State parties to refrain from directly or indirectly damaging the World Heritage Sites situated in another Country.[63] This implies that even other countries must regulate their national space activities to ensure that they don't damage these Astronomical Heritage Sites.

6. Conclusion

The way forward looks clear for the Regulators and Satellite Operators. The Space Community must start addressing these challenges at relevant International Forum – The UNCOPUOS 63rd Session in 2021, World Radio Conference 2023, 45th Session of the World Heritage Committee- to develop International consensus and guidelines. Further foreseeing the potential congestion of LEOs, the ITU as well as National Administrations must develop an equitable approach to ensure that Dark Skies as well as the Satellite Constellation Industry is Safeguarded. Finally, an attempt to enlist Astronomical sites as World Heritage will encourage countries to implement measures that will preserve the value of Dark Skies for humanity.

61 *Ibid* p.9-16.
62 Convention for the protection of the world cultural and natural heritage, Art.5.
63 *Ibid* Art.6.