Green Propulsion to the Rescue – Solving the SmallSats Regulatory Paradox

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Abstract **- The rapid expansion of the small satellites (SmallSat) sector has revolutionized space access but has also amplified concerns about orbital congestion and space debris. This paper examines the emerging regulatory requirements, particularly in the European Union (EU), that aim to address these issues, highlighting the urgent need for SmallSat operators to adopt technologies that will enhance and support improved compliance postures. Specifically, the paper recommends that SmallSats can leverage green propulsion systems that meets key EU regulations, including helping achieve deorbiting, collision avoidance, and space debris mitigation capabilities. Dawn Aerospace's CubeDrive and SatDrive products, for example, presents a critical solution for operators seeking to enhance mission sustainability, operational efficiency, and regulatory compliance in an evolving space regulatory environment.**

Index Terms – Space Sustainability, Satellites, SmallSats, Low Earth Orbit, Green Propulsion.

1. THE SMALLSATS PARADOX

Small satellites or SmallSats (generally satellites with a mass < 1000 kgs) [1] have undeniably revolutionized space operations by making space more accessible, cost-effective, and adaptable. With the ability to deploy large constellations at a fraction of the cost of traditional satellites, SmallSats are reshaping industries such as telecommunications, Earth observation, and scientific research. Their compact size and lower launch costs facilitate rapid development cycles, driving innovation and fostering a new era of space-based services. [2] However, despite these advancements, SmallSats, and especially constelletation thereof, raised many concernes with regulators over the years. Concerns over orbital overcrowding, potential collisions, and the increasing risk of space debris were attributed to SmallSats more than other satellites, since they did not have manuevering capabilities historically. The swift proliferation of SmallSat constellations has raised serious questions about the long-term sustainability of space, prompting regulators to impose increasingly stringent and binding requirements and advocate for enhanced coordination and accountability among operators.

The time has come for SmallSats operators to recognize their pivotal role in contributing to the sustainability of space while scaling space operations. It is clear now that SmallSats are here to stay, but something must be done to mitigate any adverse effect they may cause in LEO. As the demand for cost-effective, rapid-deployment satellites continues to rise, embracing a practical safety and sustainability approach will only foster further adoption and integration of SmallSats across various space sectors. It is incumbent upon SmallSat operators to identify and implement strategies to mitigate the risks associated with orbital congestion and debris, ensuring that their technology choices do not come at the expense of space's long-term viability, and do not stand in the way of their success.

By embracing innovative solutions such as green propulsion technologies, SmallSats operators can solve the regulatory paradox by significantly reducing the risk associated with their activities, while contributing to a cleaner, more sustainable orbital environment. SmallSat operators have the opportunity to lead the way in creating a future where space operations can thrive in harmony with sustainability, ensuring the continued growth and success of space exploration and commercialization.

2. REGULATORY TRENDS

The evolution of space law in the last decade and the increased number of satellite deployments have sparked urgent conversations about the sustainability of space operations. Historically, operators of SmallSats were

exempt from some regulatory requirements on account of their compact size as a reason for not being able to control their satellites effectively. However, with advancements and miniaturisation of satellite systems and components, this reason is becoming increasingly obsolete. Regulatory frameworks, while addressing bigger challenges such as space sustainability, are conscious about the role played by SmallSats. Regulatory compliance is increasingly becoming a responsibility and legal obligation for all space actors to shoulder, including SmallSats operators.

International frameworks such as the Outer Space Treaty (1967), Convention on Registration of Objects Launched in Outer Space (1967), the Liability Convention (1972), and the UN Guidelines for Long-term Sustainability of Outer Space (2019) have established the foundations for responsible behaviour towards sustainability in outer space. [3] These frameworks do not distinguish space objects (meaning satellites in this case) based on size, and SmallSats are consequently treated in practice, by the European agencies and for the purposes of this paper, as space objects for the purposes of international law. [4] These international frameworks alone are not substantial or sufficient to deal with the many foreseen challenges of conducting space activities, including through SmallSats.[5]

Regional and national regulations and initiatives seek to build on the international commitments and offer more specific guidance to SmallSat operators. Regulatory trends in the past decade, such as the Netherlands amending the scope of its national space law to include 'unguided satellites' [6] and Belgium revising its national space law to arrive at a working framework for liability for multinational SmallSats constellations, [7] stand testimony to how States are willing to consider and guide the growth of SmallSats as an integral part of space activities, and that SmallSats are increasingly inviting regulatory scrutiny. While some States such as Austria have lowered the amount of third party liability insurance making it less burdensome for operators to launch SmallSats in certain cases,[8] other countries such as the United States of America that are dealing with large constellations of SmallSats have moved towards providing multiple licensing paths for SmallSats with varying capabilities and making licensing easier for SmallSats that can demonstrate bettern control and low orbital debris risks. [9] The European Union has indicated a growing consensus to develop stricter debris mitigation practices, and this forebodes an increasingly complex regulatory regime for both the EU space actors seeking to conduct space activities and external space actors and services providers targeting the EU market.[10]

The impending EU Space Law intends to shape a regional approach to space activities, including on sustainability and is expected to also regulate SmallSats within its ambit. The themes that are expected to be regulated by the EU space law and impacting SmallSats is described in the next section.

3. THE EU SPACE LAW

The EU space law is expected to regulate space activities, to mainly address safety, resilience and sustainability of space activities. The following themes are important for SmallSats operators. It is noted that as of the date of writing the present paper, no official draft law was made publically available by the European Comission ("Comission"). As such, the following sections are based on public information relating to the draft-law.

3.1 Space Labels. The EU space labelling initiative is envisioned as multiple labels for safety, sustainability, dark and quiet skies, etc, and the development of the labels is expected to adhere to ISO/IEC 17000:2020 for conformity assessments, and will be awarded at the mission-level. [11] While the Commission has accepted feedback from the industry during consultations held in May 2024, that space labels should also be available to companies and components, it remains to be seen how the labelling schemes will be structured. Companies holding EU space labels are expected to be preferred for public procurement, as it indicates a superior compliance posture with the EU's requirements. The Commission has already proposed a tentative space labels system (akin to the EU Ecolabels), to develop sustainability standards for EU-owned assets or EU Member States' assets delivering space services in the EU.[12]

3.2 Preserving Dark Skies. In addition to considering a dark and quiet skies label within the EU space labelling scheme, the EU has been vocal in recent times about international cooperation for achieving dark and quiet skies, and has encouraged development of practical solutions to address unintended impacts of satellites on astronomy. [13] Dark and quiet skies are already considered under the ESA's zero debris

approach,[14] and is expected to be covered as a theme within the EU space law.

3.3 Mandatory In-Orbit Servicing. The EU space law may advise mandatory inclusion of in-orbit satellite servicing components in the design of satellites, with a view to encourage space debris clean-up at the end-of-life stage of missions. Recent updates to the French space laws, are seen as a reliable model for the EU space law. France, which has one of the most detailed and developed European space laws from 2008, and has regularly updated the law and technical standards under the law, with the most recent update being in 2024 with regard to standards for rendezvous and proximity operations in space.[15] The law requires space objects to be designed to facilitate capture by service vehicles,[16] and space systems are required to be designed and implemented with operational capabilities to manage risk manoeuvres and limit collision risks.[17]

4. GREEN PROPULSION SOLUTIONS

As SmallSat operators face mounting pressure to comply with an increasingly stringent regulatory climate, the question becomes how can they remain compliant and ensure that their satellites contribute to the long-term sustainability of space operations? The answer lies in advanced and innovative propulsion systems like Dawn Aerospace's CubeDrive and SatDrive solutions. CubeDrive is specifically designed to help CubeSats, up to and including 12U, with small masses on average below 30kg. CubeDrive addresses the core concerns raised by these new regulations, providing the tools needed to navigate the regulatory landscape while ensuring operational success.

CubeDrive represents a significant advancement in CubeSat propulsion. Traditionally, small satellites have been constrained by limited propulsion capabilities due to their compact size. However, with CubeDrive, operators now have access to a propulsion system that offers precision and reliability within a highly compact form factor, as small as 0.8 Cube Unit ("U"). This small size does not come at the expense of performance; CubeDrive delivers proven capabilities for orbit control, collision avoidance, and deorbiting, which are all essential features that SmallSat operators can rely on for regulatory compliance. SatDrive on the other hand is a customisable adnd scalable propulsion system offering turnkey thrusters, tanks, tubing temperature and pressure sensors, and control electronics for satellites weighing more than 30kgs.

As EU space laws continue to tighten, compliance is no longer a matter of "if," but "when." Operators that delay adopting the necessary technologies for regulatory compliance will find themselves at a significant competitive disadvantage. Not only will they face potential fines and penalties, but they may not be able to obtain needed licenses for their mission and may in fact risk their missions being delayed or even canceled if found to be non-compliant with the evolving regulations. Furthermore, the market for space-based services is growing rapidly, and with it, the demand for compliant, reliable, and sustainable space solutions. In this competitive landscape, early adoption of solutions like CubeDrive and SatDrive can give operators the following strategic advantages.

4.1 Green Propulsion System. CubeDrive and SatDrive utilizes non-toxic, environmentally friendly propellants such as nitrous oxide and propylene. These propellants not only reduce the environmental footprint of satellite operations but also align with growing global standards for sustainability. As space regulations evolve to include environmental stewardship as a key metric, Dawn Aerospace's green propulsion systems ensure that operators remain ahead of the curve.

4.2 End-of-Life (EoL) Deorbiting. One of the most pressing regulatory changes anticipated in the EU's space law is the obligation for operators to safely deorbit their satellites within a set timeframe. In 2022, the United States of America, adopted new rules requiring satellite operators in LEO to dispose their satellites within 5 years of completion of its mission, as opposed to the 25 years time period that prevailed before this change.[18] The European Space Agency adopted a 5 years standard for its own activities in its 2023 update to its Space Debris Mitigation Standard, and has noted in its 2025 Space Environment report that it encourages the adoption of the 5 years standard for other space activities as well.[19] Given the trend in the USA and within ESA, and the increasing focus on sustainability in the EU space law, it is likely that the EU may consider revising the end of life operations standards to provide for a shorter post-mission lifetime limit in orbit for non-ESA space activities as well. Post-mission disposal and space debris mitigation, is also a key focus area being explored in the development of the Product Environment Footprint Category Rules (PEFCR) for Space, which is currently in its early stages of development.[20] CubeDrive propulsion systems which can also be used as bolt-on collision avoidance kits can

be used for precise manouvreing and efficient deorbiting operations, reducing the satellite's risk of contributing to space debris. Operators can ensure that their satellites are removed from orbit within the stipulated timeframes, thereby staying compliant with EU regulations.

4.3 Collision Avoidance. With the increasing density of space debris in LEO, the risk of satellite collisions is higher than ever. CubeDrive propulsion systems which can also be used as bolt-on collision avoidance kits offer CubeSats the ability to execute precise orbital maneuvers, including collision avoidance. Dawn's off the shelf and customised SatDrives also offer these benefits. This capability is not just a technical advantage, it is a legal requirement under some current national laws and forthcoming EU laws. Dawn's green propulsion systems ensure that operators can avoid collisions with other objects in orbit, reducing the risk of generating debris and ensuring that they meet the legal standards for safe operations in space.

4.4 Compact and Scalable: CubeDrive is designed for scalability, making it ideal for a wide range of CubeSat configurations. Whether it is a 2U CubeDrive or a 0.8U CubeDrive, the structures which are 3D printed as a single monolithic piece using Inconel, includes fuel and oxidiser tanks. The compact design ensures that operators can integrate it into their systems without compromising space or weight limitations. This versatility makes CubeDrive an invaluable tool for SmallSat operators looking to meet their regulatory obligations. Similarly, SatDrive systems consist of various building blocks that lend the system to customisation as per the operator's mission design and configuirations, offering flexibility and scalability to meet a wide range of technical and non-technical requirements.

5. CONCLUSION

The landscape for space operations is rapidly evolving, with regulatory bodies like the EU taking historical decisive action to ensure the sustainability of space activities. The introduction of stricter laws regarding space debris, collision avoidance, and satellite deorbiting places unprecedented motivation on SmallSat operators to comply with emerging requirements. Adopting green propulsion systems like Adoption of green propulsion systems is critical for regulatory compliance and long-term operational success of SmallSats.

Operators that fail to act risk not only facing legal and financial consequences but also falling behind in an increasingly competitive market. Dawn Aerospace's line of CubeDrive and SatDrive systems offer a powerful, scalable, and environmentally friendly solution to meet these challenges, ensuring that operators remain compliant with the latest regulations while enhancing the performance and sustainability of their missions.

Further, green propulsion systems such as SatDrive which provide in-built capabilities for refuelling and in-space services are a critical enabler for satellite operators to future-proof their missions. As more propulsion systems become refuellable by design, operators who adopt them early will be better positioned to support sustained operations in orbit, benefit from Government and commercial-led in-space services, and respond flexibly to emerging opportunities.

By choosing Dawn Aerospace's green propulsion systems, operators are not just purchasing a product, they are investing in the future of SmallSats in space.

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[2] *Ibid*, p. 8-10

[3] Article I of the Outer Space Treaty (1967) notes that space must be used for the benefit of all countries, and Article IX requires states to avoid harmful contamination and conduct activities with due regard to the interests of others. Article II of the Convention on Registration of Objects Launched in Outer Space (1967) obliges launching states to provide space objects to the UN, with an intent to facilitate tracking and collision avoidance. Articles II and III of the

Liability Convention (1972) sets out the state-level liability for damage caused to objects on Earth and in space. The UN Guidelines for Long-term Sustainability of Outer Space (2019), while non-binding, provides a globally recognised framework for debris mitigation and end of life disposal.

[4] A/AC.105/C.2/2016/CRP.19, UN COPUOS Legal Subcommittee, General exchange of views on the application of international law to small satellites, ESA's statement on 'The European Space Agency and Small Satellite Activities', p.2

[5] *Supra fn.1,* see Chapter 2 on Small Satellite Activities Within the Framework of International Space Law and Recent Regulatory Developments

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[8] The Austrian Outer Space Act (Article 4) sets out the conditions for authorization, which includes a mandatory third-party liability insurance at 60.000.000 Euros per insurance claim.

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[12] *Id*

[13] The EU's statement at the 62nd Session of the Scientific and Technical Sub-Committee of the United Nations Committee on the Peaceful Uses of Outer Space, 3 February 2025.

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[16] *Ibid,* Article 39-4 and Article 38-1

[17] *Ibid,* Article 41

[18] Space Innovation IB Docket No. 22-271 Mitigation of Orbital Debris in the New Space Age IB Docket No. 18-313

[19] *Supra fn.10*, p.

[20] Presentation on PEFCR for Space by the European Commissions' department for Defence Industry and Space (DG DEFIS) at Clean Space Days 2024, p.3 available at https://indico.esa.int/event/516/contributions/10042/attachments/6253/10757/CSD2024_Pinto_ShapeTheFutureEngagewitPEFCRforSpace.pdf (Last accessed on 11 April 2025)