Small Satellites – Entrepreneurial Paradise and Legal Nightmare

Business opportunities and legal challenges created by the advent of small satellites

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***Abstract*—** The majority of space objects now being launched into orbit come from a class of space objects that fall under the heading of small satellites. This category typically includes all satellites under 500KG and includes all nano satellites and micro satellites. Most of these are launched for scientific and educational purposes and are often used to test new technologies and products in outer space. Many such satellites can be launched as auxiliary payloads together with the launch of one big space object thereby making the cost of launch per satellite considerably less.

This paper will examine the entrepreneurial opportunities and legal complications that come with the growth of the small satellite industry globally, and within Pakistan. It will start with briefly discussing the uses, and advantages that small satellites can provide, and will look at how small satellites could be extremely helpful and beneficial to the populous and workforce of Pakistan. Additionally, it will detail the international legal and regulatory framework for small satellites and the obligations this puts on satellite launchers and launch service providers. It will cover *inter alia*, licensing, registration, insurance and questions of liability and responsibility.

This paper will also explain how the emergence of small satellites and the possibility of having large constellations consisting of numerous small satellites raises many complex legal questions that challenge well-established space law doctrines such as that of launching state, state responsibility and registration of uniquely identifiable objects. It will elaborate upon the legal regimes in place in many countries across the world to regulate small satellites; it will also look at the impact of the emergence of the small satellite industry to debris in outer space. Lastly, the paper will conclude with recommendations that Pakistan could follow in order to facilitate and encourage its own small satellite industry.

***Keywords*—** Satellite; Space Law; CubeSat; Entrepreneurship.

I. What Are Small Satellites

The global space economy is worth more than $330 billion [1] and it is growing exponentially with opportunities arising from space increasing day by day and technology getting more and more miniaturized. [2] SpaceWorks estimates that between 2016 and 2022, over three thousand nano and micro satellites will be launched into orbit [3]. These are only two of the subsets of the larger category of satellites that can be described as small satellites. There exists no legal definition for what a small satellite is but they can typically be identified according to their masses [4] as shown in Table I.

Table I. Classification of Satellites based on Mass

Classification	**Mass**
Large Satellite	> 1000 KG
Medium Satellite	500 – 1000 KG
Mini Satellite	100 – 500 KG
Micro Satellite	10 – 100 KG
Nano Satellite	1 – 10 KG
Pico Satellite	0.1 – 1 KG
Femto Satellite	< 100g

Small satellites are normally placed into the Lower Earth Orbit (LEO) and have existed ever since the dawn of the space age. The very first satellites, such as Sputnik 1 in 1957, and Explorer 1 in 1958 had masses of 83.6 and 13.9 KG respectively. [6] An additional category within nano satellites is that of the CubeSat which has now become an industry standard. A 1U CubeSat is a 10x10x10 cm cube shaped unit with a mass between 1-2 KG, with multiple 1U units being combined to form bigger CubeSats [7].

Many small satellites are made using Commercial Off-The-Shelf (COTS) components [8] and this leads to them being "Faster, Cheaper, Better and Smaller" [9]. They have short development times, require small teams, less infrastructure and cost much less than compared to bigger satellites [10].

Small satellite operators range from private universities and individuals to large commercial companies operating to make a profit. These satellites are often launched as auxiliary payloads piggybacking with larger space objects. However, many companies are presently working on specialized small satellite launch vehicles such as Virgin Galactic with LauncherOne and Zero2Infinity with Bloostar which would make the cost of launch much cheaper and would allow for more precision in their deployment. Depending upon purpose, small satellites can be launched in two formations:

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A. *Lone Satellite*

Universities, private individuals and NGO's are among the many entities that launch, or desire to launch, lone small satellites for research or experimental purposes. The Institute of Space and Technology of Pakistan also has its own small satellite in orbit. [11] Lone satellites can take the form of projects or experiments and are useful to test technologies in outer space. They can also often serve as the first test phase of a much bigger satellite to be launched in the future.

B. *Constellations*

The second type of formation that small satellites are launched in is that of a constellation, either of a small number or a large number (often known as mega-constellations). These consist of numerous small satellites launched by the same or different operators to achieve a single purpose. These are typically launched by large companies for commercial purposes. Examples of proposed constellations include the OneWeb constellation and the O3b constellation.

II. The Importance Of Small Satellites

Small satellites bring many advantages to their users and their applications can be very broad. These applications can add value to the economy of Pakistan and highly facilitate its population.

A. *Moving from Public to Private*

The option of installing a satellite in orbit has typically been limited to State owned entities due to the extremely high cost of manufacturing and launching a satellite. With the advent of small satellites, this cost has been considerably reduced due to most satellites being constructed using COTS and little time being required in their development. This reduced cost of construction, and a potentially reduced future cost of launch with the development of specialized small satellite launchers, opens up access to space to private entities and NGOs creating numerous opportunities to make use of space applications.

B. *Entrepreneurial Opportunities*

Space based technologies provide many opportunities for entrepreneurs such that small satellites allow for the provision of services and applications not available before.

Remote sensing and Earth observation, particularly of very specific areas becomes a real possibility with the capacity to install many small satellites in orbit. This can give rise to many business opportunities.

One particular field where small satellites could be used for is to boost agriculture, which is a major part of the Pakistani economy. The future of agriculture is vested in the use of satellites to facilitate crop yields. Satellites can be used for all purposed, ranging from monitoring growth patterns to automatically operating and moving tractors [12].

Small satellites can also be used for the provision of communication and broadband facilities to areas which are difficult to reach or void of such services. This could be another major application of space to the populous of Pakistan.

Another way space technology can be used in Pakistan is for disaster relief, management and prevention. Pakistan is severely affected by floods and other natural disasters and small satellite technologies can be effectively used to create warning and monitoring systems to assist and better manage these occurrences [13].

Small satellites can also be used for other purposes such as weather research, science experiments, testing new technologies and broadcasting among other things. Moreover, the list of business opportunities in small satellites is very large and this is exactly why most space programs and countries are actively encouraging growth in small satellites and the development of the small satellite industry.

III. Legal And Regulatory Outlook

Small satellites attract two kinds of legislation towards them: International Law and then the corresponding National Law.

A. *International Law*

Space is described as the province of mankind [14] and there exists a body of international law developed by the Committee on the Peaceful Uses of Outer Space (COPUOS) of the United Nations Office for Outer Space Affairs (UNOOSA). This body of law comprises of five treaties with three of them being extremely relevant for small satellites: The Outer Space Treaty (OST) [15], the Liability Convention (LIAB) [16] and the Registration Convention (RC) [17]. These treaties elaborate upon the regime in place for all objects launched into space and establish certain doctrines that will be detailed below:

1) *Responsibility*

The OST is described as the *Magna Carta* [18] of space law; this treaty sets out the principles governing international space law. It also serves as the basis for the other treaties which expand on certain provisions of the OST.

One of the foundational elements of space law is the doctrine of State Responsibility which is enshrined in Article 6 of the OST. This stipulates that a State is internationally responsible for all activities in outer space carried out by the State itself, or by private entities from within the State. Article VI also puts an obligation on States to 'authorize' and 'continually supervise' the space activities of private entities from within its borders in order to ensure that they are in line with the international obligations imposed by the outer space treaties [19].

Essentially it is this Article along with the RC that obligates States to develop national law in order to be able to regulate the space activities of its nationals. These national laws

include provisions on issues such as licensing, registration and insurance. These will all be discussed within the next few sections of this paper.

The doctrine of State Responsibility triggers an element of caution for States when allowing private entities to partake in operations that the State may later have to be accountable for. This is one of challenges posed by the advent of small satellites such that they are often funded and operated by private entities which the States are internationally responsible for.

2) Liability

Liability naturally stems from responsibility. In a system of State Responsibility, liability also falls upon the States in the international arena. Article VII of the OST contains the provision on the liability of Launching States [20] and this provision is detailed in the LIAB which puts forth two distinct liability regimes for two different kind of activities.

Article II of the LIAB relates to liability for damage to third parties on the ground and in airspace as a consequence of space activities. The regime in place for such damage is one of absolute liability; this means that the launching State is absolutely liable in all cases, whether fault or no fault, for all damages on the ground and in airspace, unless there is contributory negligence on part of the injured party.

Article III of the LIAB relates to liability for damage to third parties in outer space. The regime in place for this kind of damage is one of fault liability such that it must be proven that the accused State was at fault for the damage caused to the injured party in order for damages to be awarded. One must be reminded at this time of the fact that in every situation of damage, the liability falls upon the State deemed to be the launching State of a particular space object [21] and henceforth, States must secure their interest by way of imposing mandatory insurance requirements when small satellites are launched under their garb. This will be discussed in the next few sections of this paper.

The damages on the ground, or in airspace are normally consequences of the launch of the small satellite. In case of regular satellites, this damage regime is also noteworthy on occasions where the satellite is re-entering the Earth's atmosphere [22]. However, small satellites burn up in the atmosphere upon re-entry and henceforth this is not relevant. The question of Article III type damages is however much more valid for small satellites; this is typically why States impose insurance requirements.

As pointed out in Chapter 1, small satellites are normally launched into LEO. With the number of small satellites expected to increase greatly, each additional small satellite increases the risk of a collision in outer space [23]. In case of such a collision, one party will have to be deemed to be at fault in order to proceed with any claim.

At this point, it is imperative to look at the issue of debris. All objects launched into space turn into 'space junk' at the end of their useful life. Currently there are over 720,000 objects within the range of 1 to 10 centimetres [24] in orbit, with a majority of them being in LEO. This is a major problem, not only in terms of making space a more dangerous environment to operate in [25], but also making States more vulnerable to claims of compensation for damage caused in space by pieces of debris that it can be deemed internationally responsible for.

The relevant provision dealing with this matter is Article VIII of the OST which gives States indefinite jurisdiction over space objects on its registry. The definition of a space object is provided in Article I of the LIAB and is not dependent upon functionality. Hence, even when a satellite turns into debris, the State of registry [26] will be held responsible, and consequently liable for damage caused by it. The issue of debris and orbital collision is greater with small satellites as they are often non-maneuverable and hence cannot be deorbited. They are dependent upon being pulled by the Earth's gravity and consequently burning up into the atmosphere; this process can often take much longer than expected or predicted [27].

B. National Law

Keeping in mind that international law makes States responsible for the activities of its nationals when it comes to space, it is essential for States to develop national laws to regulate their domestic space industries. This can also be deemed to be an obligation of States considering their duty to authorize and supervise private operators under Article VI of the OST. UNOOSA keeps a database of all the national laws that have been enacted by States [28] and so far 22 States have developed national law to regulate their space industries. All of these national space laws typically serve to incorporate the international obligations of the State into the national legislature in order to ensure that all private operators are in line with international law. Alongside codifying the international obligations of the State, the national laws have some common elements which will now be highlighted and which are very important for small satellites and the growth of the commercial small satellite industry.

1) Licensing

It is imperative that the national space law of a State has provisions to license space activities. This provision can take several different forms such as their being either an obligation to seek licensing when setting up a company deemed to be partaking in space activities (as defined by national law), thiss is the case in Australia [29]; or simply seeking a license when a company is planning on launching an object into space as is the case currently in Spain [30]. Moreover, licensing can be per launch as is the case in France [31]; or it can be a launch license issued to an operator for an extended period of time to conduct activities during the period of validity of that license as is the case in the USA [32].

The setting up of a law to license space activities fulfils the international obligation of the State to 'authorize' space activities of private entities within its jurisdiction as put forth in Article VI of the OS It also ensures that the State is aware of the space activities going on within its territory. It is essential that if an entity wants to launch a small satellite, that it has the support of its State such that the satellite is licensed and accepted by the State.

2) Registration

International space law by means of the RC obligates States to register space objects in two ways, one under a national register and the second with the UN. This means that the State is under an obligation to set up a national register for space objects and hence all countries with national space law also set up a national register for space objects that the State is accepting itself to be the launching State for. This system of registration under a national registry is what allows space objects of one State to be launched from the territory or launchers of another State since ultimately the object will be registered by the State that owns the object and not the State that owns or operates the launch site. Hence, responsibility will fall upon the registering State as per Article VIII of the OST.

Currently Pakistan has 3 objects registered with the UN [33]. Pakistan has also established a national register for its space objects since 2008 [34] however there must be a process created to put a space object on this register and to obtain licenses for private entities to partake in space activities. Without this, small satellites cannot be securely launched through a Pakistani private entity as there could be a chance that the State would not register the satellite and hence this would put the operator in a legal limbo.

3) Insurance

Lastly, one of the most important elements of national space law is the provisions on insurance. This is because of the fact that as elaborated earlier, international space law has a system of State responsibility and liability when it comes to damage caused by space objects belonging to private entities. Hence, if a small satellite causes damage to a third party, the State associated with it will be internationally liable. Hence, the State must secure itself against this potential liability by imposing mandatory third party liability insurance requirements on satellite owners/operators/manufacturers in order to indemnify itself.

This insurance requirement has often been described by academics and professionals to be one of the aspects that has limited the growth of the small satellite industry. This is because most current national space laws were set up with large satellites in mind and hence impose very high minimum sums for mandatory insurance [35] acting as a roadblock for small satellite operators. Moreover, many entities desiring to launch small satellites are universities and NGO's which do not possess the financial capacity to attain and maintain such a large insurance policy.

IV. Conclusion And Recommendations

A. The Need for National Law

A national law must be developed in order to encourage, facilitate and offer certainty to entities willing to enter this sector. There has been a lot of activity in the space industry in the subcontinent. India currently has 66 objects registered with the UN as active objects [36] and is planning on implementing a national space law in the near future [37]. Despite there being some speculation that Pakistan is developing its national space law [38], there is not enough concrete political will currently in place to expand this sector.

It is the author's opinion that this must be changed, it has been said that even to achieve the 2040 objectives set by the Pakistani government, [39] very extensive legal regulations will have to be brought into place [40] however this needs to be expedited. National space law is an urgent necessity in order to encourage investment into this sector and it is a necessity to drive growth.

B. Recommendations

It is recommended that the Government of Pakistan work towards establishing a national space law as soon as possible and that the Government support this with a comprehensive space policy that drives growth in the sector.

One must understand that the advent of small satellites brings with it a very tricky legal dilemma for governments. This is because of the fact that small satellites still qualify as space objects under international law and hence attract the same liability and responsibility regime as that of a larger satellite, hence governments are often inclined to put the same regime applicable for large satellites onto smaller ones and this highly affects the industry and acts as a roadblock.

In drafting this national space law, Pakistan must take into account the fact that this law must be consumer friendly towards entities willing to undertake small satellite ventures and that this law is not just tailored towards large corporations.

Moreover, the law must address some of the other legal challenges that small satellites bring. The problem of debris must be noted and addressed in the law and all operators must be required to abide by the Inter-Agency Space Debris Coordination Committee (IADC) Debris Mitigation Guidelines in order to ensure space sustainability.

C. Conclusion

It is extremely important that the Pakistani government catches on to the global trend in favor of small satellites. The civil uses and advantages that space brings are innumerable and must be exploited to benefit the masses. It is the responsibility of the government to drive growth in this sector and this can only be done by means of investment and favorable regulation to facilitate new entrants. The world is now experiencing what has been labelled as the 'democratization' of space access. This is such that low cost access to space through small satellites is enabling States who could not have had space objects in orbit in the past to launch numerous satellites for remote sensing and other purposes [42]. There are 'satellite kits' available online for less than

10,000 USD that will allow a party to have its own satellite in orbit [43] and the market is expanding very rapidly. In 2013, 92 small satellites were launched altogether whereas is 2014, 122 were launched just between January and August, this sum is expected to be between 410 and 542 by the year 2020. [44] Pakistan must not lag behind in this industry and must capitalize upon the advantages and benefits that small satellites offer. Moreover, it must ensure that if there are entities willing to work towards space in Pakistan, they are facilitated by a safe and secure legal premise for their proposals and plans and that Pakistan does indeed become a space superpower.

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