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Essential space policy for small satellites-an important measure and urgencies

Abstract

The article is based on the proposed idea to The Space & Satellite Professionals International (SSPI Scholarship)-for the Satellite Futures policies. In the recent years the activities of small satellite has been increased hence the future of small satellites in space industry. There will be soaring amount of launches in the next few years. Large constellations of small satellites are in execution stage hence it is predicted that there will be rapid change in the perception standards of satellite industries. This revolution in small satellites is due to the success of scientific goal of various national space agencies. They had succeeded in improving the interests of young amateur scientists and students. This article is dedicated to the urge of space policies that provides security and secure access to space for co-existing with different satellite users for cooperation internationally. The Article is a summary of existing policy domains and emphasis on the need for an integrated policy between various satellite operators to bring functional ecosystem in various space orbits. It also discusses about the legal issues when suppliers have different regulations with respective to various non - space faring countries, space does not belong to any nation or group and that right should be protected by all.

Keywords: small satellites, earth orbit, space policy, constellations, space debris, law regulators

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Abbreviations: SAT's, satellites; LEO, low earth orbit; GER, global exploration roadmap; RR,

radio regulations; MIFR, master international frequency register; SCT, secretariat of communications and transportation; FTBL, federal telecommunications and broadcasting law; IARU, international amateur radio union

Introduction

Space is a new frontier. It has open access to humankind for any peaceful activity. Space does not belong to any government nor limited to a particular organization or an individual. This reason acknowledges that all objects in space should be considered equally significant. It could be a small satellite or a large satellite, the responsibilities and liabilities have to be same. Any satellite either small or large must not create any interference or inconvenience to the operations of other satellites. The only space mission that has to be treated with top priority and negates the above said about equality of satellites is when considering a human space flight or operations that control the safety of human. Thus, there is huge importance of satellites that operate for the safety of human space flight and the safety of life back on earth.

The article discusses about the creation of space environment that is in harmony with all types of operation for small satellites. The small satellites neither should create interference to other operation in earth orbit nor be exploited by other satellites and their operators. The newly regulated space environment will allow co-existence of small satellites with other satellites for promoting space activities and their benefits. In about a decade there will be 10,000 small satellites mostly in Sun Synchronous Orbit either in operation or in dead mode; this data is calculated on the demand need of launchers. All the CubeSats will board powerful launchers as they share their ride with larger satellites. This forces them involuntarily to stay in orbit longer. A well-structured regulation has to be made because these non-operating satellites in orbit hinder the use of particular orbit for a long period due to its incapability of de-orbiting or moving to a graveyard orbit.

An international integrity has to be maintained by providing structured policy, systematic measures and recommendations of how operating and non-operating small satellites have to be held liable. Presently, the national space agency or the local government will be held liable or will be obliged to take responsibility if any damage occurs due to the space object made by an individual or organization. However this cannot be the same for a small satellite working with amateur frequency thus a well framed legal regulation has to be created. The user/manufacturers/operators of small satellites had to be educated before the launch of their small satellites about legal policies. The main topics that are studied in depth are Maneuverability, Orbital Debris, and Orbital Designation. These are the zones where the small satellite operators and users need to be educated. They should allocate fund and budget in terms of both capital and time to learn about identifying, quantifying and prioritizing domestic/international legal risks. This is very important, as they will be able to face any legal challenges. The operator irrespective of the volume and mass of the satellite must follow internationally recognized guidelines. This will help to mitigate space debris and to function properly to coordinate with Federal Law on the Authorization of Space Activities and the Establishment of a National Registry.

Licensing, registration and documentation

The Space technologies both hardware and software has very thin distinguishing character between civil and military purpose. The use of these technologies in space has huge complications and legal hurdles due to the need of international legislation. The international treaties are to be legally binding between all countries to register

space object and an obligation for being held liable for damages. This makes it more difficult and time consuming for obtaining license and to do all documentations.

The liability of satellite is determined by national acceptance and commitment hence the small satellite manufacturers are hindered due supervision and authorization for providing registration and licensing. They are usually regulated slowly for countries that have experience in the space field while it's a great debate for countries that are still not in space business. The national government either has lack of knowledge or a time consuming process when they monitor all space activities that implicate their country on the international level. The Table 1 shows the documents needed by international regulator (Table 2).

Table 1 International level know how process

Reasons	Key considerations
Liabilities	Which country was it registered?
	Which country was it launched?
Space debris mitigation	Predicted end of life?
	Grave-yard or re-entry?
	If re-entry, is it to be completely burned or for safe landing?

Table 2 National level know how process

Reasons	Key considerations
License	Insurance, Export/Import control regime, Registration process, Documentations.
Business/ studies	Commercial value, tax, liability contracting parties, Sponsors.

Maneuverability

Maneuverability (collision avoidance system) if collision occurs it will create more debris which creates a cascading effect and this would exponentially magnify the problem. Small sats which lacks maneuvering capabilities has inability to avoid collision. Femto satellites are also difficult to track. This is ballistic and creates a high risk factor for collision when the congestion increases in such orbits. The satellite operators and users must clearly know potential damage risk until the re-entry to the earth's atmosphere or graveyard orbit. This is for both maneuverable and non-maneuverable satellites. The small sats cost increases with Propulsive maneuvering capability as it requires stored energy and mass but they seem unsuitable or unreliable for relatively short-notice collision avoidance. Small satellites during collision course with other small satellites have no avoidance alternatives with propulsion system. Hence authorization, supervision and jurisdiction is applicable along with insurance requirement and direct financial responsibility. The larger satellites can protect themselves by using their collision avoidance from the small sats. This provides them with freedom of their space activities. Remediation is a process of technical innovation to reverse undesired outcomes or eliminate undesired risks. In Low Earth Orbit (LEO) the main contribution of orbital debris is.[1]

Orbital debris

The convergence collaboration between small sats and large sats has a huge value proposition. One such potential value is eliminating the cause of Orbital Traffic. NASA has already initiated in creating international framework for space traffic management. The framework will avoid congestion and maximize the utilization orbit efficiently. Orbital Debris Program could create awareness among all amateurs, future mission analyst to plan their missions efficiently to facilitate accurate and timely tracking of nearby space objects.

Orbital designation

The ISECG has proposed Global Exploration Roadmap (GER). In this proposal, there is a dynamic future which discusses manned lunar base and Mars exploration. These missions would require 500 to 5000 tons of materials during in-orbit assembly. This is feasible only in LEO orbit around 300-500 km. This will extensively use space tugs. Human spaceflights are the most important priority hence this altitude must be free of any space debris or unwanted satellites. It's necessary to prohibit the small and large satellite's mission from this altitude for all future space activities. This could be done only with a recommendation for a policy law between space-faring nations agreed upon orbit designation. The small sat designed at this altitude avoid de-orbiting because of the huge propellant needed thus limiting them to less than 250 km or with de-orbiting missions greater than 600 k.m.

Satellite services

There are now hundreds of satellites located in geostationary orbit and in other orbits, providing global coverage for various applications such as long-distance telephone links, satellite broadcasting, Internet links, corporate communications links and mobile telephony. Mention some. Satellite systems have led to the development of different applications under the services that can be offered by such systems, services that are regulated by the ITU RR, However, the increasing number of satellite networks generates a probability of interference between satellite services the results of the tests of loss of information, theft of information, and delay in communication, among others. Harmful interference between satellite systems must, therefore, be avoided and it has been established that States (regulation of countries) and the exploitation of natural resources that allow satellite communications, i.e. radio spectrum, and space Outermost regions.

Policy consideration for small satellites

Any communication link from satellites either small or big depends on both national and international level. The international law is followed by Radio Regulations (RR). This is accepted by the International Telecommunications Union all over the world. Apart from this, there is each localized National law that has to conform to each country's specific regulatory board. The satellite orbit plays a vital role being defined by the Radio Regulations (RR) policies for the uplink and downlink frequency band.

The small Satellites normally are in LEO due to the lack of propulsion for station keeping thus their period of operation in orbit is maximum 2 years. In this case, it is better to deorbit rather than considering graveyard orbit. Any orbits have regulations and rules which should not cause harmful interference to other services, transmission power level and etc. are permitted to use the spectrum as specified in offer service contracts. These requirements are specified in the Coordination Procedure between satellites networks. The Coordination Procedure is done in accordance with ITU. The process is integrated into three basic steps: Advance publication, Coordination section, and Notification. They are preliminarily indicated in the RR, section 1, Articles 9 and 11. This is a very important administrative procedure that needed to be recorded in the Master International

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Frequency Register (MIFR). This record registers only networks that wouldn't harm or interference with other services.

The following Table 3 shows the API for Non-Geostationary satellite network filing received since 2008.

Table 3 The API for Non-Geostationary satellite network filing received since 2008

	2008	2009	2010	2011	2012	2013
Amateur-satellite service	5	7	8	14	26	24
Not amateur-satellite service	31	31	33	37	36	31
All services	36	38	41	51	62	55

Source: Report ITU-R SA.2348-0; Current practice and procedures for notifying space networks currently, applicable to nano-satellites and pico-satellites (05/2015).

As can be seen from the tables mentioned above, the number of APIs and notifications has increased to increase over the years, mainly in bands that are not attributed to the amateur satellite service, that is, the operators of these bands have profit objectives, therefore are to provide communication services and not for research. The nationalized procedure is different for example the national law of Mexico describes who are the regulatory authorities and are their capacities attributions. The Secretariat of Communications and Transportation (SCT) is a federal entity that does the coordination procedure face the ITU and it will be the contact point. The procedure continues in parallel with another federal entity which is the Federal Institute of Telecommunications that grants orbital resources licenses. According to the Federal Telecommunications and Broadcasting Law (FTBL)[2] in article 76 there are four types of Orbital Resources licenses such as Commercial Use, Private Use, Public Use and Social Use. The assigning depends on the service to offer, frequency bands to use and the procedure of coordination with another satellite network. This task of obtaining various permissions and licenses from both national and international recognition keep the small satellite manufacturer shy away.

Small satellite policy

Recent advances in satellite design, launch service capabilities and user terminal technology bring the benefits within reach to provide broadband services by satellite networks in harmonized bands. Thanks to these recent technological advances, next-generation small satellite systems are currently being developed that can provide high-capacity broadband services to end users in locations around the world. These next-generation small satellite systems could deliver affordable, advanced communication services with high capacity thanks to antenna designs, spectrally-efficient frequency re-use, greater antenna directivity, and other advanced communication techniques. Further, due to the relatively low altitude in which these systems operate, these systems are able to operate with low latency–a key factor for real-time broadband communications.

The satellite regulation ecosystem plays an important role in achieving coordination between different users of space technology, in order to avoid harmful interference between different satellite systems. Some of the actors involved in the ecosystem operate at the national level and others at the international level. It is also important to keep a record of all objects sent to space and to ensure that each space-related project has peaceful purposes.

Regulatory mechanisms are important to mediate a negotiation between the administrations of different countries. In this way, the different satellites and earth stations are not affected. The ecosystem of regulation of small satellites, within which there are actors related to the contracting of the launch, to the registry of space debris and to the granting of orbital resources and coordination of frequencies. The technical team in charge of the construction of the satellite interacts directly with the regulatory bodies at the national level; through these, reaches the international level. Actors Access to orbital resources is a complex process in which different national and international entities intervene. International entities seek equitable and non-interference access of the orbital resources that are requested by the countries as well as the sustainable use of space. In the national context, governments establish the mechanisms by which individuals and public entities will have access to orbital resources allocated to the country.

International actors

International organizations involved in the regulatory process for satellite systems are the United Nations Organization through the United Nations Office COPUOS, the ITU) and, if the amateur-satellite service is used, the International Amateur Radio Union (IARU). Derived from the actors involved in the regulatory process of satellite communications, the regulatory framework contains an international component and a national component. At the international level, the United Nations and ITU have implemented procedures and regulations that allow the access of orbital resources to countries that require them always seeking non-interference to existing systems as well as the reduction of space debris. On the other hand, national administrations have established administrative procedures that allow companies and citizens to use exploit and exploit these resources in an efficient manner and, at the same time, contribute to the socioeconomic development of the population.

For example: in Canada, There are no specific policies or procedures related specifically to small satellites. The current satellite regulatory framework in Canada is governed by the following Act, Regulations and Innovation, Science and Economic Development Canada's Policies and Procedures. The Minister of Innovation, Science and Economic Development is responsible for all aspects related to spectrum management in Canada, including issuing authorizations for the use of frequencies by satellites. Global Affairs Canada is responsible for the regime governing remote sensing and administers permits to remote sensing systems, including those using small satellites. Innovation, Science and Economic Development Canada and the Canadian Space Agency have some funding programs related to innovation, technology development and/or space. While these are not geared to small satellites, in particular, those types of projects would be eligible for funding. There is no domestic launch industry in Canada.

Important aspects of the launch

At present, there is a notable interest in entering into spatial development by academic institutions, industry, government and military groups. Large-scale space missions require a very long development time and represent a significant cost, from the design, construction, and launching of the satellites. With the emergence of small satellites, it has been possible to reduce costs and time in the development of space technology. Through small satellites experiments can be carried out whose results can later be applied in

larger scale missions; Small satellites can also be used in applications similar to those used on large-scale satellites, at lower cost and in less development time.

The creation of the CubeSat standard has given way to the increase in the number of nano-satellite developments. This standard was the result of collaboration between the California Polytechnic State University and Stanford University, both institutions of the state of California in the United States of America. The standard refers to creating units in the form of a cube of 10cm x 10cm x 10cm, weighing approximately 1 kg; An important feature is that these units can be concatenated, so if we join three of these units, the final dimensions of the nano-satellite will be 10 cm x 10 cm x 30 cm and an approximate weight of about 3 kg. The emergence of this standard allowed the increase of nano-satellite projects since it facilitates the acquisition of components, structures, and subsystems.

There is a lack of a space launch provider in Latin America Taking into account that Latin American countries turn to foreign spaceflight companies for the launch of satellites, they have to take some risks about it such as satellite launch failures. These problems, from the point of view of countries like Mexico and Colombia, affect the economy and the time to develop space missions, so they have less space development than countries like the United States of America or Russia.[3]

The data obtained through small satellites can be very useful for different applications, and in some cases have similar characteristics to the data obtained by large-scale satellites. Although the cost of developing and constructing small satellites has been considerably reduced, there is still no consistency with the cost of launching them, as these are sent as secondary loads in large-scale satellite launch vehicles or sent To the International Space Station. For this reason, some developers have been motivated to investigate the possibility of building smaller rockets. Although this service is not currently available, it is expected that the cost of small satellite launching will soon be further reduced. In addition to obtaining an economic benefit, the development of this type of launcher would allow greater freedom of choice both launch date and the positioning orbit, since so far, this decision depends on the demands of the part Team developer of primary vehicle launcher cargo. An important aspect of the operation of a satellite has to do with the end of the life of the satellite. Although the satellite will no longer function, it will continue to orbit the Earth. Satellites in this condition are also known as "space debris", or "space scrap."

Garbage or scrap is considered to be an artificial object in orbit on Earth that has no use, and may consist of objects as varied as ships or space stations old or out of service, old satellites whole or in parts, as well as parts of Rockets, explosions or rocket remains and satellites, such as dust or small paint particles. It may include capsules, scientific equipment, communications or measurement equipment, as well as remains and parts of ancient space missions to the moon or to other planets in the solar system, as long as they are no longer in operation. The main problem this causes is the possibility of very high-speed collisions between such space debris and some device or satellite still in operation or, worse still, some manned spaceships. Recall that any external object that complies with the laws of Kepler and Newton can be kept in orbit for a long time, and that involves a high risk for other useful objects that are in their direction in nearby orbits.

Although most of the objects of space debris are in low orbit, where there is a greater gravitational attraction because of the Earth's proximity, it is also where those objects have the highest speed and can cause more damage. This is the orbit in which the vast majority of small satellites operate, which is why UNOOSA request this information from those requesting a concession, and who register of these objects. For this, it is asked to declare the physical characteristics of the satellites to be launched, their size and weight, their height and orbital plane, as well as an estimate of their useful life.

Conclusion

The main goals of this policy had been formulated on the principles of promoting international co-operation between the operators and users of different sizes of satellites, for the betterment of proposed future human space flight, preventing damages caused by man-made debris and improving the life of humans by continuing space exploration in a mutual peaceful environment. The policy outcome is to protect all the users of space and prosperity of human society.

There are fleets of satellites formation flying in close range are working with standards along with space database association. Orbit data exchange format standard. When we lose control of the satellite it creates fear on other spacecraft operators nearby. Or optimizes the satellite by using drag force may have impacts on nearby satellites. Hence satellite servicing is important in constellations. It is very important to know international and national rules for small satellites because the space missions should not cause harmful interference to other services or another satellite network, as a result, all frequencies should be recording in the MIRF after doing the coordination process face to ITU.

The nationalized procedure is different for example the national law of Mexico describes who are the regulatory authorities and are their capacities attributions. The Secretariat of Communications and Transportation (SCT) is a federal entity that does the coordination procedure face the ITU and it will be the contact point. The procedure continues in parallel with another federal entity which is the Federal Institute of Telecommunications that grants orbital resources licenses. According to the Federal Telecommunications and Broadcasting Law (FTBL) in article 76 there are four types of Orbital Resources licenses such as Commercial Use, Private Use, Public Use and Social Use. The assigning depends on the service to offer, frequency bands to use and the procedure of coordination with another satellite network. These tasks of obtaining various permissions and licenses from both national and international recognition keep the small satellite manufacturer shy away.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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