Small Satellites: Chances and Challenges”

Saturday, 29 March 2014
9.30 am to 5.30 pm
Faculty of Law, University of Vienna

AUTHORIZATION OF SMALL SATELLITES UNDER NATIONAL SPACE LEGISLATION
Sa’id Mosteshar

INTRODUCTION

Typically small satellites are those with a mass of less than 1,000 kg. Definitions of different categories of small satellites are not exact, but arbitrary. In most cases they fall in the following classification.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>POUNDS</th>
<th>KG</th>
<th>NASA KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini-satellite (minisat)</td>
<td>1,100</td>
<td>500kg</td>
<td>≥ 100kg</td>
</tr>
<tr>
<td>Micro-satellite (microsat)</td>
<td>220</td>
<td>100kg</td>
<td>10kg - 100kg</td>
</tr>
<tr>
<td>Nano-satellite (nanosat)</td>
<td>22</td>
<td>10kg</td>
<td>1kg - 10kg</td>
</tr>
<tr>
<td>Pico-satellite (picosat)</td>
<td>2.2</td>
<td>1kg</td>
<td>10g - 1kg</td>
</tr>
<tr>
<td>Femto-satellite (femtosat)</td>
<td>0.22 (3.5oz)</td>
<td>100g</td>
<td>1g to 10g</td>
</tr>
</tbody>
</table>

There is a friction between reduction of cost, speed of deployment and technology advances on the one hand and the range of capabilities, control and maneuverability of satellites on the other. Small satellites bring this competition into focus by providing many cost and construction simplicity advantages to researchers, educators and countries with limited means or needs. Such satellites can also provide certain specific capabilities that may be needed for a limited period, or serve areas not well served by larger systems.

In most space active countries with relevant regulatory regimes little or no distinction is made between small and large satellites. But, the economics of small satellites differ considerably from that of other space systems. Their technical and dynamic characteristics are also largely dissimilar.

Stabilisation of small satellites affects the orientation of the solar arrays, hence its power supply. It is also important to have accurate pointing of the satellite for some applications where pointing precision of spot beams are required, such as astronomy and telecommunication. Small satellites are less capable in these respects than their larger counterparts.

STATE RESPONSIBILITY FOR SPACE ACTIVITIES

All States parties to the Outer Space Treaty are required to authorise and continually supervise their national space activities, whether governmental or private.²

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¹ Jakhu and Pelton define Minisats as those weighing less than 1000kg; Small Satellites and Their Regulation, at 2.
² OST 1967, Art VI.
States typically discharge this obligation by issuing authorisations for the relevant activities and imposing conditions on their conduct, which they will then monitor.

The activities regulated extend from launch to space operations. Usually the persons covered are nationals of the regulating State, wherever the activity is based, and those conducting activities from the territory of the State.

A State is also liable for damage caused by space objects launched from its territory or facility, or launched elsewhere but procured by the State or its nationals.

The responsibility and liability of the State would normally provide an incentive for the State to regulate and monitor the space activities of its nationals. However, as noted above, States are also keen to support their space sector and to encourage space activities, which often translate to lowering costs.

**Characteristics of Small Satellites**

International law makes no distinction between space objects on the basis of their size or function, although certain activities may be subject to specific requirements. However, the characteristics of different types of satellite present varying challenges and opportunities for the State.

Small satellites also have technical characteristics that pose problems that need particular solutions. The two most important such characteristics are the comparatively less precise orbital fidelity and more limited orientation control and pointing precision.

The first of these increases the risk of conjunctions, as the satellite has limited capability to take avoidance manoeuvres with reasonable probability. This makes small satellites more prone to the creation of debris.

**Challenge Posed by Small Satellites**

The relatively low cost and ease of construction of small satellites makes them attractive to different entities from those wishing to derive high returns from their investment in space. Those attracted by these advantages include universities and researchers, as well as the military and relief organisations. The ability to construct and launch small satellites quickly to serve immediate needs makes them attractive to the military for communications, surveillance requirements and other needs in areas that become of interest within a relatively short time and for a limited period. Disaster relief is another situation that can often be well served by the advantages of small satellites.

Another group that can be served and are attracted to small satellites are States with limited technical and economic resources. These will usually not have the regulatory and institutional structures to fully implement international law or norms.

Additionally, commercial operators and users are attracted by the advantages of small satellites, which include the ability to enjoy the benefits of technological advancement.

These benefits should be balanced with the greater risk of debris creation associated with small satellites. Recent developments are addressing methods of better orbit keeping by small satellites, as well as means of stabilising and improving pointing capabilities of such satellites. ³

³ Clyde Space has developed a Pulse Plasma Thruster for nano-satellites, using Teflon fuel to provide thrust to manipulate the satellites’ orbit.
STATE REGULATIONS

There is growing recognition and demand for easing the regulation of small satellites, driven by the disproportionate cost and delay involved in full compliance with regulations governing large and small satellites.

Desire for lighter regulation is already evident in the illegitimate use of the spectrum allocated to the Amateur-Satellite Service by many users and operators of small satellites. This service is for:

- using space stations on earth satellites for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.\(^4\)

As already noted, many small satellites are used for military or commercial purposes and amateurs using them are often not interested in radio techniques, but in other aspects of their construction and use or to conduct experiments not related to radio techniques.

NATIONAL REGULATION

Clearly, the international obligations of States in relation to space activities are not dependent on the size of the space object involved. Therefore they have the same obligation to regulate and supervise small satellites as they do larger satellites. Similarly, their international liability for damage caused does not alter with the size of the space object involved.

However, the space regulatory frameworks affecting satellite operations vary considerably even among space active States. In some cases the State regulatory regime does not extend to a particular type of activity, leaving an authorisation lacuna. A brief survey of authorisation of small satellites will illustrate the differences.

CANADA

The regulatory regime in Canada addresses remote-sensing satellites, overlaid with Orders in Council, which can extend to exempt particular activities. This occurred in the case of a small telescope satellite, the Near Earth Object Surveillance Satellite (NEOSSat), which did not fall within the Remote Sensing Space System Act because it is not a sensing satellite, but detects and tracks man-made and natural space objects. Remote sensing satellites fall to be authorised by the Department of Foreign Affairs and International Trade (DFAIT).

“remote sensing satellite” means a satellite that is capable of sensing the surface of the Earth through the use of electromagnetic waves.

FRANCE

No distinction is made between small and other satellite. Therefore, operators of small satellites need to go through the same process and carry the same insurance and other obligations applicable to satellites in general.\(^5\)

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\(^4\) ITU Radio Regulations, Article 1, 1.56 amateur service: A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.

Germay

German space activities are administered in accordance with the Basic Law\(^6\) under the jurisdiction of the Federal Ministry of Economics and Technology, who in turn entrusts it to the German Aerospace Centre, DLR.

No distinction is made between small and other satellite. Therefore, operators of small satellites need to go through the same process and carry the same obligations applicable to satellites in general. These are regulated under the relevant legislation applicable to the activity conducted by the satellite system, such as telecommunication and remote sensing operations.\(^7\)

Japan

There is currently no Japanese regulation in place, save for the establishment of JAXA.\(^8\)

Nigeria

The National Space Research and Development Agency, NASDRA, which also conducts space operations for the Government, licences non-governmental space operations.\(^9\) It operates two small satellites, NigeriaSat-X and NigeriaSat-2,\(^10\) without the need for a licence.

South Africa

In South Africa no regulatory distinctions are made based on size, capability or function of space objects for licensing purposes. All satellites are treated in the same way.\(^11\) Licence applicants are required to provide an orbital lifetime assessment and an end-of-life disposal strategy as part of the licensing process. In the case of ZA-003 (registration designator for ZACUBE-1), the Department of Science and Technology funded this university-built satellite and has accepted to bear responsibility for claims under the Liability Convention, with the exceptions for gross negligence or deliberate malfeasance on the part of the licensee.\(^12\)

Sweden

No distinction is made between small and other satellites. Therefore, operators of small satellites need to go through the same process and carry the same insurance and other obligations applicable to satellites in general.\(^13\)

It is notable that under Swedish law there is no insurance requirement for space objects launched by Sweden, but the operator has unlimited liability to indemnify the Government for any claim made as a result of damage caused by the space object.

\(^6\) Grundesetz, the German Constitution, which came into force on 23 May 1949.
\(^7\) Stephan Hobe et al, *Regulation of Space Activities in Germany*, in National Regulation of Space Activities, Springer 2010.
\(^8\) Law Concerning The National Space Development Agency of Japan (Law No. 50 of June 23, 1969, as amended)
\(^9\) Established under the National Space Research and Development Agency Act 2010.
\(^10\) These weigh 86 kg and 270 kg respectively.
\(^11\) Space Affairs Act (South Africa, 1993)
\(^12\) ZACUBE-1, 1.2 kg, named TshepisoSat (promise) was built by students at Cape Peninsula University of Technology (CPUT), launched on 21 November 2013.
\(^13\) Act on Space Activities (1982:963)
UNITED KINGDOM

As with all other space regulation regimes, those of the United Kingdom make no distinction between satellites by size. However, there are proposals for different treatment in terms of insurance for certain CubeSats. These were the outcome of a Consultation process undertaken by the Government and Proposals in the Government response. The Proposals state:

It should be noted that this proposal goes beyond capping the liability under the Act and insurance reduction. The capped liability and insurance requirement could be waived for the in-orbit operation of a CubeSat (it would remain for the launch of the mission). This is assuming CubeSat licence applicants can demonstrate scientific or educational merit, which would be assessed on a case-by-case basis and the criteria could include:

- How well does the activity advance discovery and understanding while promoting teaching, training and learning?
- To what extent will it enhance the infrastructure for research and education?
- Will the results be disseminated broadly to enhance scientific and technological understanding?
- What may be the benefits of the proposed activity to society?

CubeSat licence applicants would also be expected to demonstrate they will adhere to space debris mitigation guidelines which propose a 25 year maximum orbital lifetime.

The Impact Assessment provides details of the analysis underpinning the proposals and also the risks and benefits. However, the extract below provides a picture of what the net impact in monetary terms could be. It should be noted that within the Impact Assessment policy option 2 deals with capping the unlimited liability (including insurance reduction) and policy option 3 deals with the capped liability and insurance requirement being waived for the in-orbit operation of CubeSats.

Costs and benefits of policy options 2 and 3 and the combined impact

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<tr>
<th></th>
<th>Costs</th>
<th>Benefits</th>
<th>Full Impact</th>
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<tbody>
<tr>
<td>Option 2</td>
<td>£1.3m + £110 per 1U</td>
<td>£7.4m + £23.5k per 1U</td>
<td>£6m + £23.5k per 1U</td>
</tr>
<tr>
<td>Option 3 per 1U</td>
<td>£130</td>
<td>£95k</td>
<td>£95k</td>
</tr>
<tr>
<td>Option 2 &amp; 3</td>
<td>£1.3m + £130 per 1U</td>
<td>£7.4m + £95k per 1U</td>
<td>£6m + £95k per 1U</td>
</tr>
</tbody>
</table>

Note: The values presented in this table are Net Present Values of the typical lifespan of a satellite. This is 11 years for a standard satellite. So, for example, the net impact of options 2 & 3 together is £6m over 11 years plus £95K per CubeSat, assuming the CubeSat is in orbit for two years.

Completion of the Impact Assessment has highlighted that there are a few areas that would benefit from being explored further.

The Government has sought further public comment to fully address the questions that arise.
ESA

ESA has recently issued a RFP in the following terms:

NANO SATELLITES FOR COMMERCIAL TELECOMMUNICATIONS SERVICES

The miniaturisation of reliable and cheap space (mechanical and electronic) components, together with the availability of low cost and frequent access to launch services, have led to the emergence of new actors proposing the delivery of nano-satellite based infrastructures. Typically, a platform may deliver up to 10 W of average power to a payload not exceeding 10 kg mass (some products may exceed these performances). The design lifetime of these satellites is also limited to few years. The rather low cost of these satellites have made them attractive for amateur or educational purpose for instance [and to others].

[This activity aims] to identify if the nano-satellite industry can be partly sustained by commercial activity in the telecommunication sector. This activity shall .. assess if nano-satellites can contribute delivering telecommunication satellite services in a commercially competitive environment where similar conditions shall be applied to service providers delivering services based either on nano-satellites or on any other types of infrastructures, be it LEO or GEO satellites, including Machine-to-Machine (M2M) and other services.

The following approach shall be implemented (1) A regulatory analysis shall be performed (access to spectrum, code of conduct for accessing to space), to assess initial conditions to market access and requirements on design (2) The user terminals, propagation channels, multiple access scheme and air interface shall be defined, taking into account the on board limitations (3) A combined top down and bottom up architectural and system design shall be performed (4) Technical, Financial and Commercial budgets shall be evaluated (5) A business sustainability shall be performed (in particular from the procurement point of view (launchers, components,) (6) For the same services, a competitive analysis with classical LEO and GEO satellite-based solutions shall be performed based on metrics to be agreed with service providers (7) A Research and Development roadmap shall be defined for implementation in ARTES (8) Cooperation scheme with non-ARTES participating states industries (space and non space) shall be identified, if needed.

It is evident that ESA will play an active role in developing and promoting the use of small satellites, initially in the telecommunication sector.

CONCLUSION

If illustration were needed, both the UK's focus on regulatory changes to encourage development and use of small satellites, and ESA's interest in exploring technology and regulatory options for the growing use of small satellites, underline the need to address the characteristics of sound authorisation regimes.

The professional space community recognises the importance of developing sound national regimes as the best and most effective approach to sustainable use of outer space. Let us hope that the pursuit of profit and short-term solutions do not frustrate the need for healthy regulatory schemes.

Emphasis and Note added.