THE DOVE SATELLITE AS A PRECURSOR OF SMALL SATELLITES AND THEIR ENVIRONMENTAL IMPACT IN OUTER SPACE

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ABSTRACT

Small satellites are present since the dawn of the space era, without calling too much attention until recently. Particularly, Brazil took part in the DOVE small satellite, the 17th of the OSCAR series, launched with other "brothers" of this series, "free riding" a big Spot-2 satellite launch. But, since recently, this picture began to change dramatically: they began growing in number, purposes, and importance, due to a variety of reasons. Most of them have environmental impact in outer space but have no provisions for their avoidance or removal. This includes damage or destruction by interference, contamination, collision or other types of damage of: 1) a single natural resource that is *res communis omnium*; 2) a useful object in orbit; 3) an orbit niche; 4) an orbit; 5) damage or interference in ground activities (by risk of re-entry, fall, impact on the soil, on humans, on human facilities, on air, maritime, and even terrestrial traffic); 6) damage or disuse of activities (communication, sensing, meteorology etc.) and even their objects.

THE DOVE SATELLITE

DOVE is a precursor of the "cubesats", made by Dr. Júnior José de Castro (Figure 1). It weighted 12, 92 kg and its shape was a box of 22,6 X 22,6 X 22,3 cm (Figure 2). It was "designed to provide synthesized voice messages of telemetry for educational institutions". It operated in a Low Earth Orbit (788 km X 750 km; 98.71º, heliosynchronous) until March 1998. Although Brazil has ratified the 1975 Convention on Registration of Objects Launched into Outer Space, or simply Registration Convention, DOVE was never registered with the UN. The North American Aerospace Defense Command (NORAD) shows that DOVE has not decayed after all these years. It is clear from both UNOOSA and NORAD online indexes that Brazil is the designated Launching State of DOVE. Consequences of such link will be discussed in the Conclusion. It is a "microsatellite", as shown below.

Figure 1 – Dr. Júnior Torres de Castro.
Source: Folha de São Paulo.

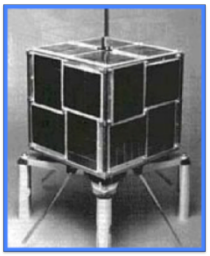

Figure 2 – OSCAR 17.
Source: Nova Eletronica.

SMALL SATELLITES CLASSIFICATION

Minisatellite, 100 to 180 kg	Small satellites: < 500 kg
Microsatellite, 10 to 100 kg	Minisatellites: 100 to 500 kg
Nanosatellite, 1 to 10 kg	Microsatellites: 10 to 100 kg
Picosatellite, 0.01 to 1 kg	Nanosatellites: 1 to 10 kg
Femtosatellite, 0.001 to 0.01 kg	Picosatellites: 100 g to 1 kg
(NASA, 2018)	Femtosatellites: 10 g to 100 g
	Attosatellites: 1 g to 10 g
The European Space Agency (ESA).	Zeptosatellites: 0.1 g to 1 g
asserts: "the best criterion for defining a	CubeSat sizes:
small mission is cost, from which all other	From ~ 0.2 kg to ~ 40 kg
parameters may be inferred".	From 0.25 U to 27 U
EUROPEAN SPACE AGENCY (ESA).	(NANOSATELLITE DATABASE, 2018).

ENVIRONMENTAL IMPACT

The 2030 Agenda for Sustainable Development encourages States to adopt the 17 Sustainable Development Goals (SDGs) to "end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind". By accessing space, the humankind is able to improve the quality of life on Earth either through the development of new technologies, the progress of science, the investment in high quality education and capacity building in technological areas, or by providing access to data that will help better understand and manage its territory, avoid catastrophic events, maximize and sustainably use its natural resources, etc. But, the exploration and use of outer space need the availability of useful orbits for satellites to operate adequately. The number of objects in orbit (Figure 3) and of cubesat launches (Figure 4) grows steadily; and, sooner or later, these become space debris – that is, non-functional space objects or fragments of such space objects – or rarely decay. This limits the access to space for the benefit of all, as advocated by the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, the Outer Space Treaty, and compromises the freedom of exploration and use of outer space by all States. Such limitation includes damage or destruction by interference, contamination, collision or other types of damage of: 1) a single natural resource that is *res communis omnium*; 2) a useful object in orbit; 3) an orbit niche; 4) an orbit; 5) damage or interference in ground activities (by risk of re-entry, fall, impact on the soil, on humans, on human facilities, on air, maritime, and even terrestrial traffic); 6) damage or disuse of activities (communication, sensing, meteorology etc.) and even their objects; and implies responsibility and liability.

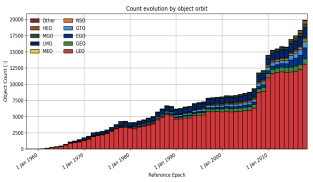

Figure 3 – Count Evolution by Object Orbit.
Source: ESA (2018).

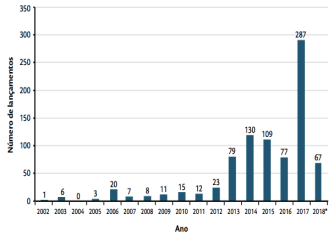

Figure 4 – Cubesat Launches per Year.
Source: CGEE (2018).

The 1972 Convention on International Liability for Damage Caused by Space Objects, or simply Liability Convention (LIAB), foresees a double system for compensation of damage based on the location of the incident. On its Article II, the Convention establishes that if damage (caused by a given Launching State's space object to a third party) occurs on the surface of the Earth or to aircraft in flight, the State is absolutely liable; whereas, Article III prescribes that if damage happens elsewhere (than on the surface of the Earth or to aircraft in flight), the launching State is only liable if fault is proven (fault liability), a complex requirement to fulfill in certain cases. In both cases, the Launching State is liable, not the individual or the institutions.

CONCLUSION

The currently boom in small satellite launches allows all States, irrespective of their economic and scientific development, to become part of the space team. Such access is in line with the provisions of the 1967 Outer Space Treaty, particularly the non-discriminatory principle and the principle of cooperation. Additionally, by being part of the space team, States may ultimately take advantage of some benefits of space exploration that were, until then, mostly restricted to the super powers. But some questions remain: are all States prepared to deal with the consequences of such a risky activity? Are the new space actors aware of their States' legal obligations? How to safeguard the States and the society's interest? How to democratize the access to outer space while protecting its environment and its finite resources? The DOVE microsatellite: 1) is a precursor in the democratization of space; but, 2) as others, after decades of life, has not decayed; 3) adrift occupies; 4) may collide; and so, 5) damage a single natural resource that is *res communis omnium*.

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