11º Workshop em Engenharia e Tecnologia Espaciais
18, 19 e 20 de agosto de 2020

A new point of view to Brazilian artificial satellites geometry and a disruption of paradigms

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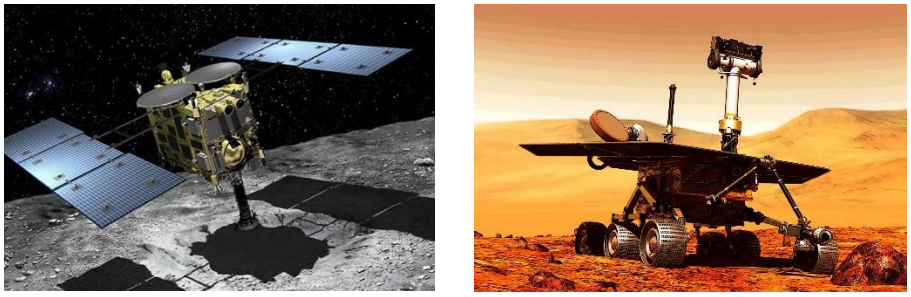
Resume. *This study sought to break paradigms about structural designs for satellites. It assumed that nature has solved many problems of space engineering with efficient and elegant projects and that the Brazilian space program can benefit from these concepts to produce a new generation of satellites with high performance and functionality. The results suggested the use of a mixture of concepts taken from several areas and among them, Biomimetics. An entirely new and audacious geometry was proposed and the arguments for its use were detailed. It is concluded that it is possible to obtain new concepts of structures for artificial satellites if scientists and engineers open their scope of vision to new innovative and audacious ideas.*

Keywords: Biomimetic, Satellites, Structure, Design

1. Introduction

The future of space exploration must be nurtured with bold and effective ideas. The breaking of paradigms regarding the traditional concepts of geometries and materials are and always will be the basis for innovative designs. Concepts previously seen as impossible, today can be explored with the advent of new technologies of production processes such as additive manufacturing. It is up to scientists to open their minds to the generation of new concepts and engineers to propose solutions so that such concepts are doable.

The story is full of products that were inspired by nature. Complex yet efficient geometric shapes that provide robust, durable designs. Other space agencies use these concepts for their projects such as JAXA, NASA and ESA. (NONO, 2018). In 2019, the Japanese probe Hayabusa2 traveled to an asterode that passed near Earth to collect and bring samples. The design inspired by the viral forms was effective in fulfilling the mission. Another biomimetic example was the Oportunity exploratory vehicle, launched by NASA in 2003. Another biomimetic example was the Oportunity exploratory vehicle, launched by NASA in 2003. The Figure 1 shows illustrations of these projects in operation during their missions.



(a) (b)

Figure 1. – (a) Japanese space probe Hayabusa2, inspired by the shape of a virus. (Source: CLAPWAY, 2020)

(b) NASA's Oportunity exploratory vehicle, inspired by the shape of insects. (METRO, 2020)

The biomimetic concept is not something innovative. Man probably began his conceptions of engineering products by observing nature. Since the cave age they used spears with sphygas, such as jellyfish, knives with saws, such as shark teeth and many other ideas from the observation of natural designs.(Soares, 2008) Perhaps this is the first method of engineering used by mankind. In the modern world, numerous designs have been inspired by natural concepts. Figure 2 shows some of them. (DETANICO, 2010)

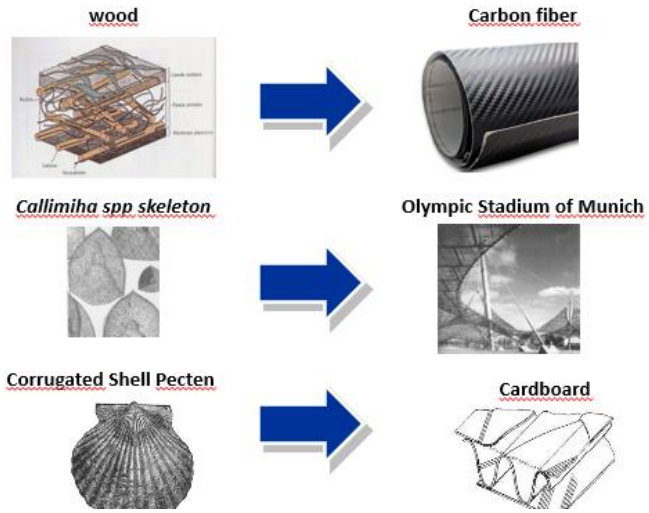


Figure 2 – Some products inspired by the biology of living creatures. (Adapted from DETANICO, 2010)

In spatial scope, bimimetic solutions are often interesting alternatives to complex systems such as artificial satellites. The TECAMB Group, in partnership with IAE (*Instituto de Aeronáutica e Espaço*), IAEv (*Instituto de Estudos Avançados*) and UA (*Universidade de Aveiro*) has studied this type of solution for debris impact attenuation systems and harmful effects of space radiation on embedded electronic components. The design of MBS (Multilayer Biomimetic Shields) and materials has already been developed and tested, but imagination can go further. (NONO, 2018)

This article showed a new and unusual geometry for satellites, based on the scientific method of observation and comparison with microscopic creatures called "*Radiolarians*". These microorganisms are formidable survivors in hostile environments and have existed for millions of years, validating the design of their structures. The geometric shape of their skeletons varies in according to the needs that the environment where they are inserted imposes. Figure 3 presents some complex geometries of the *radiolarians*.

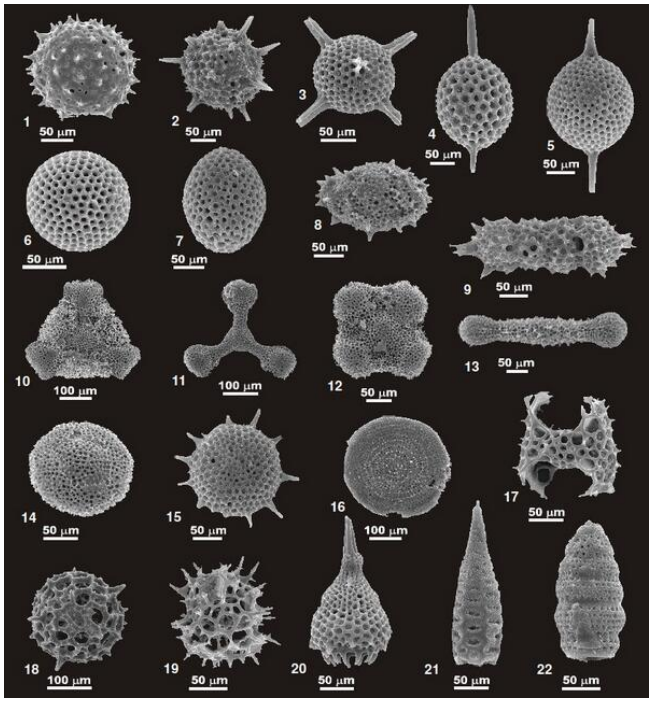


Figure 3 – Examples of the many forms of radiolarians.

(Source: MICROBIOLOGY,2020)

2. Methodology

The study used two scientific methods to validate its analysis: The method of observation of literature and databases and the method of comparison between existing satellite designs and the biomimetic designs proposed.

3. Results and Discussion

The scientific method of observing the literature from the databases provided arguments and ideas, which in other areas are old but innovative for spatial uses. It was also identified that there is a gap for innovative products in the space market. Due to the hostile environment of space, new technologies must be investigated, verified and validated to aid the human endeavor towards space. The Figure 4 shows a flowchart of this needs.

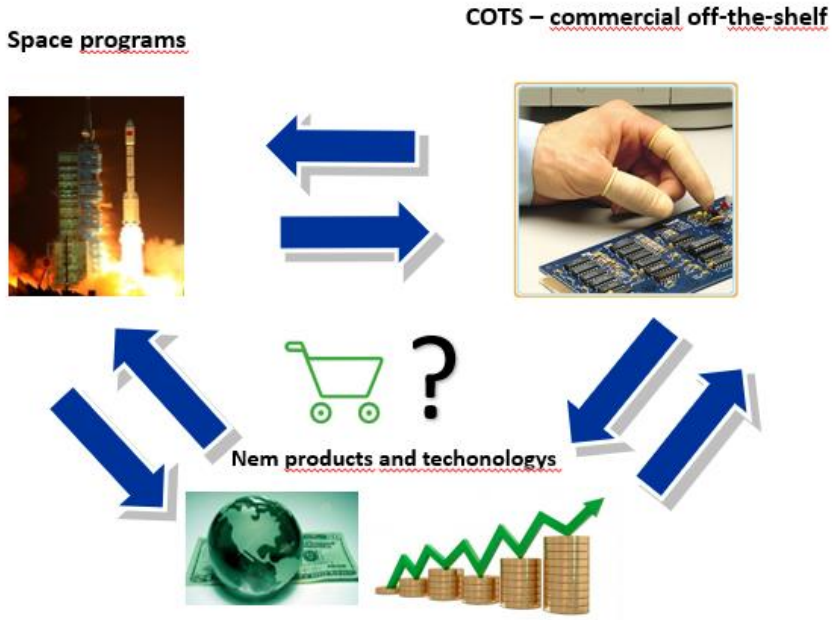


Figure 4 – Flowchart of spatial market needs

Tilted armor began to be used in T34 tanks from World War II and have the advantage of increasing the average distance traveled by the projectile inside the protective material. Another significant advantage is the ability to deflect the direction of the projectile. Taking these principles as a basis, it clear that the application of this concept to mitigate impacts with space debris is an efficient alternative. Current designs are usually flat and monolithic walls. This type of design is inefficient in braking debris at high speed.

The geometry of the radiolarians always present, on some axis at least, a circular symmetry. Circular shapes are efficient for attenuating radiation because they have no corners. Corners tend to accumulate electromagnetic field lines and thus be structural holes for radiation to invade systems. Current projects use cubic or quadrangle geometries, which leads to the invasion of radiation.

Bees produce their combs in a specific geometry called honey-comb. They are hexagons that are already widely used in the military armor industry because they are most efficiently to cover surfaces. The adoption of this concept together with the spherical shape leads to a geometric solution similar to the fullerene structure, an allotropic form of carbon.

Then, adding the concepts of inclined shielding and spherical geometry, the hexagonal geometry of bees and the natural solution of fullerene, it possible to propose a structure that

resembles the geometry of the radiolarians, proving that it is an organic and functional concept. The Figure 5 exemplify this new concept.

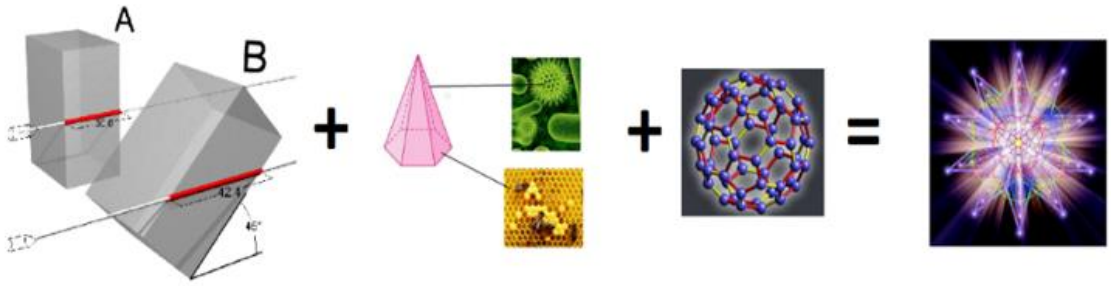


Figure 5 – An example of the concept of biomimetics applied to the geometry of satellites.

table 1 presents some correlations between the advantages and disadvantages of the designs compared in this study.

Table 1. Advantages and disadvantages of geometries.

Design	Advantages	disadvantages
Cubic or similar	- Compact packaging; - Relative ease of subcomponents allocation within the structure; - Structural simplicity.	-Permeable to radiation; -Inefficient in protecting from debris impacts.
Biomimetic (Radiolarium)	-Practically impervious to radiation; -Efficient to impacts with debris -Ability to allocate a large volume of embedded components with a relatively smaller surface area.	-Inefficient packaging; -Need for a shift of paradigm and component production technologies.

4. Conclusion

Often, breaking paradigms can be a difficult process. However, the space race requires new concepts that challenge scientists and engineers. This study sought to open the scope of view of Brazilian scientists and engineers with a propose of a complex geometry based on a series of biomimetic and relatively ancient ideas. The radiolarians structure can be an efficient solution to the challenges of space engineering. New concepts should always be encouraged, debated and presented so that in the future, the Brazilian space program becomes increasingly efficient in fulfilling its missions.

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