DESIGN OF A CARDSAT FLEXIBLE PANELS MICROSATELLITE WITH OPENING IN CLOSED ARHITECTURE

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Rezumat. *În această lucrare sunt prezentate două soluții pentru configurarea unui microsatelit alcătuit din mai multe panouri de tip CardSAT. În faza de lansare, microsatelitul este pliat astfel încât să ocupe un spațiu minim în lansator. După lansare din rachetă, structura se deschide într-o configurație prestabilită. Pentru acționarea panourilor, în faza de deschidere, au fost concepute două soluții de acționare: una cu arcuri lamelare și a doua cu un set de arcuri de torsiune și compresiune.*

Abstract. *In this paper are presented two solutions for microsatellite configuration consisting of several CardSAT panels. In the launch phase, the microsatellite is folded so that it occupies a minimum space in the launcher. After launching from the rocket, the structure opens in a preset configuration. For the operation of the panels in the opening phase, two drive solutions were designed: one with lamellar springs and the second with a set of torsion and compression springs.*

Keywords: Microsatellite, CardSAT, unfolded configuration.

1. Introduction

The aerospace field is one of the research priorities worldwide. An important segment of it is represented by microsatellites.

Microsatellites have been the focus of numerous research projects in recent years.

Microsatellites and nanosatellites are fast and cheap solutions compared to conventional satellites for space exploration, having modularized configurations and respecting the standard structures recommended by European and American space agencies.

These are also accessible to individuals, universities, and small research groups due to low costs and flexibility.

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The design of spatial structural systems is imposed by the requirements of mass, stiffness, and strength. On the one hand, stiffness is necessary to ensure the smooth behavior of the satellite, and on the other hand, by reducing weight, it is possible to increase the payload, which expands the objectives of the mission, electronic charging and, at the same time, reduces the cost of launch.

The structural aspect, regarding the material used, as well as the mechanical parts of a satellite, represents a large percentage of its mass. At the same time, it must consider a number of general constraints and requirements of stiffness and propre frequency.

The life cycle of microsatellites is between 1 and 2 years, during which time the structure decomposes and re-enters the atmosphere. The temperature profile to which the structural elements are subjected varies according to the phases of orbit.

The main role of the microsatellite structure is to support all spacecraft components and create location for payload. It must withstand the loads and vibrations experienced during launching, stage separation and deployment of antennas or any other mechanisms.

In addition, the structure represents the mechanical interfaces between the satellite and the launcher, which means that it must be designed not only according to the design requirements of the spacecraft, but also taking into account the specific launch vehicle. That is why the design of the structure must meet the requirements of external dimensions and shape of the launchers in which they are installed.

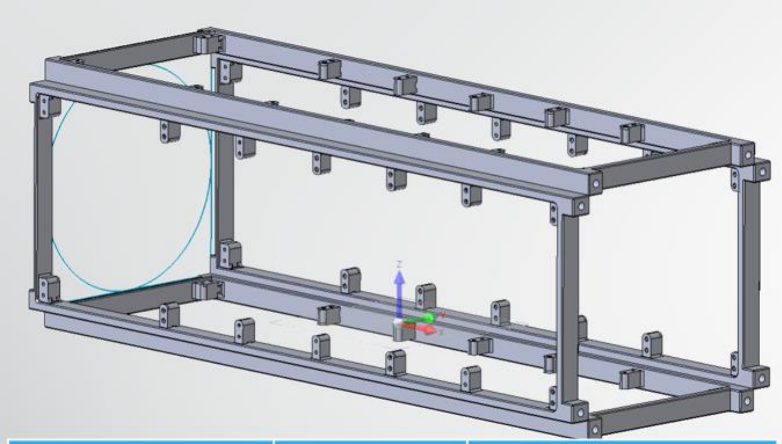
In microsatellites, the most widely used materials are aluminum alloys, which guarantee mechanical stability of the material in vacuum, mechanical rigidity and low weight.

The well-known microsatellite architecture is the CubeSAT – whose structure consists of a cube with a side of 100 mm.

2. New microsatellite design

The studies presented in this paper present an alternative to Cubesat, namely Q Cardsat and QO Cardsat and based on the CARDSAT with application patent no. 6/2018/PC form 19.02.2018.

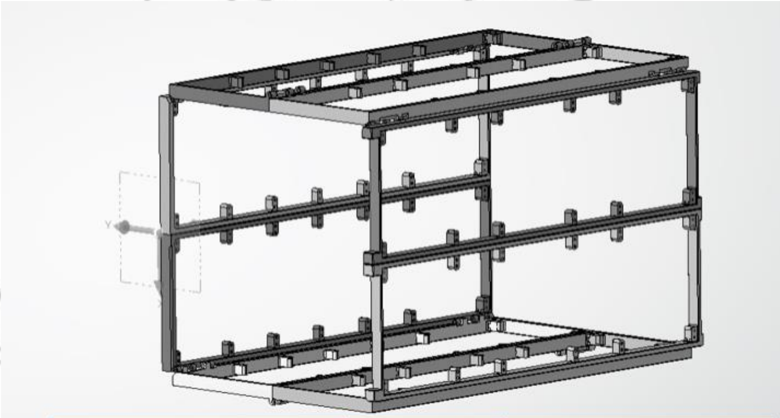
The structure of Q Cardsat (Quadri Cardsat) consists of 4 CardSat panels. In open format it has a rectangular structure with panels at 90 degrees. It is the simplest microsatellite structure based on the concept presented (Fig. 1).



Type	Edges	Angle (deg)
Quadri	4	90

Fig.1. Microsatelite Q CARDSAT.

The QO CardSat - Quadro-Octo CardSat structure consists of 8 panels that in open format has a rectangular architecture. Each side consisting of two panels. Specific to this structure are the joints through which the panels open at 180 degrees and 90 degrees. (Fig. 2)



Type	Edges	Angle (deg)
QO-Cardsat	8	90-180

Fig.2. QO CardSat

Other possible structure of microsatellite are: Penta (P CardSat), Hexa (H CardSat), Hepta (He CardSat), Octa (O CardSat), Nona (N CardSat) (Fig. 3).

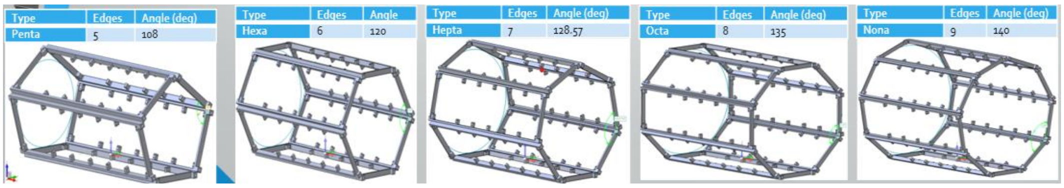


Fig. 3. Different CardSat microsatellite architecture.

3. Design and manufacturing of the frame structure

To materialize the mechanical structure of microsatellite for both studied solution Q Cardsat and QO Cardsat_ (Fig.1 and Fig. 2) some aluminum frames were designed and machined.

The frame respects the dimensions imposed by standard launcher used in ESA. So in folded state the maximum dimensions of the microsatellite are 100mm x100mm x340 mm (Fig. 4). For this, a CUBESAT launcher could be used.

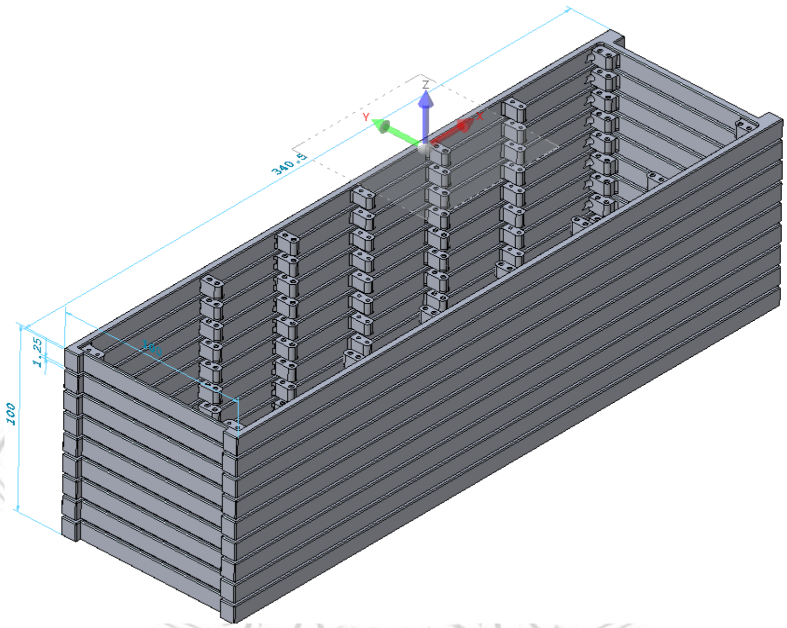


Fig. 4 Folded structure dimensions of microsatellite.

The aluminum frame was machined by milling technology on a milling center. The technology was optimized to achieve a minimum machining time with minimum necessary tools. It was obtained 26 min and 3 cutting tools for one frame. (Fig. 5). Also a FCS System was used for clamping in order to minimize the number of part orientation needed.

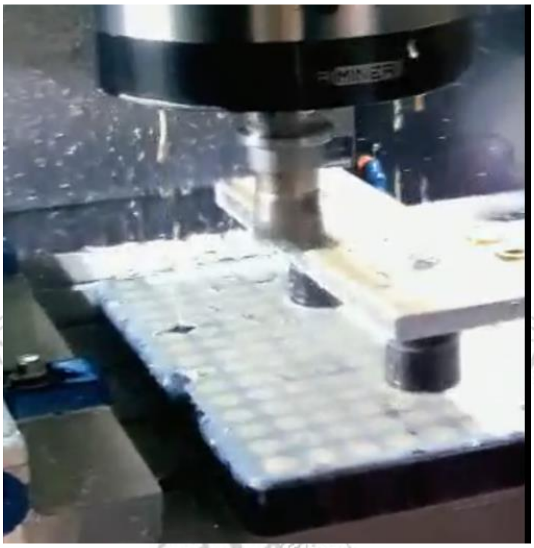


Fig. 5. Frame machining.

For the first tests, were made 8 panels, part of them can be seen on the Fig. 6.

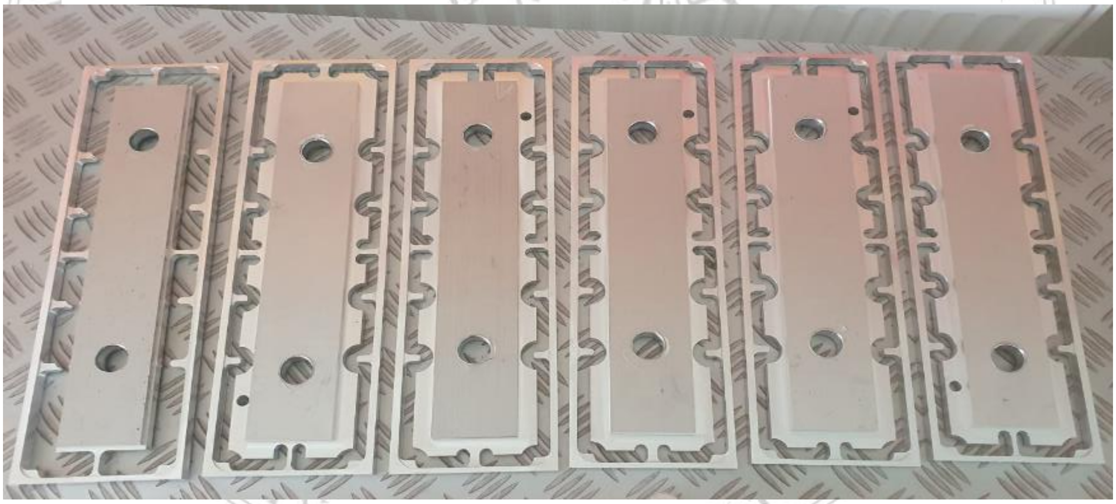


Fig. 6 CardSat aluminium frames.

4. Q CARDSAT with lamellar arcs prototype

For the first structure Quadri CardSat 4 frames were used and linked together by using lamellar springs. On the Fig. 7 are presented the design of Q CardSat prototype.

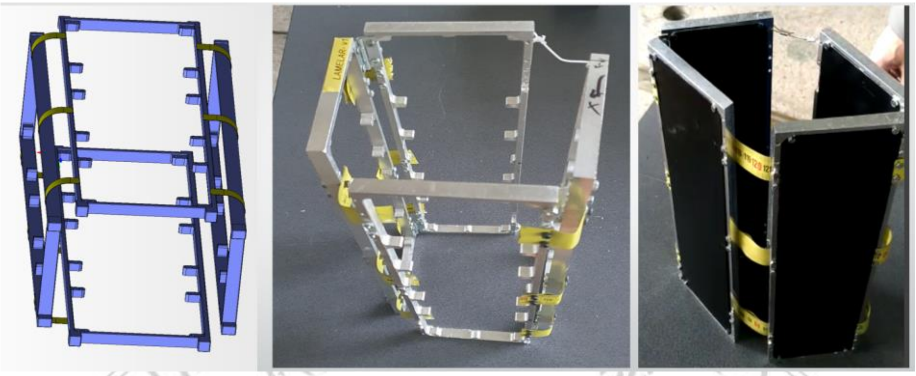


Fig.7. Q Cardsat prototype.

The first tests aimed to check the unfolded phases of the satellite into imposed configuration (Fig. 8).

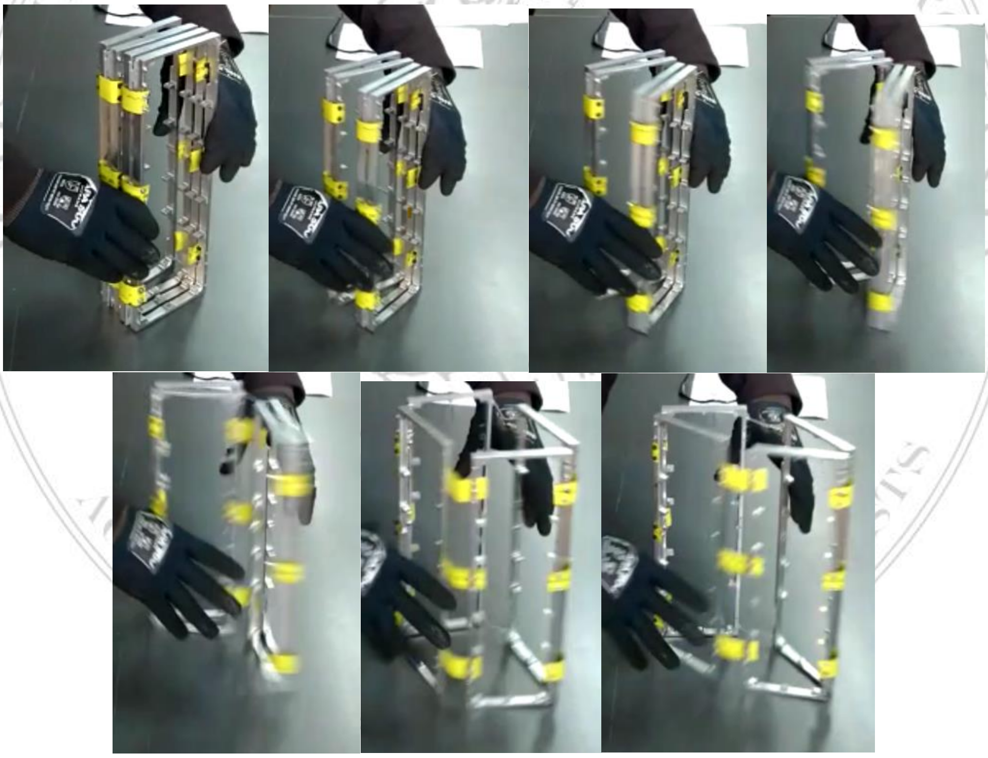


Fig. 8. Unfolded phases of Q CardSat

5. QO CARDSAT with new hinge prototype

For the second configuration of QO CardSat, the first solution was used special design hinges due to more complex requirements.

In this case it is necessary to control the opening phases of the panel in order not to have collisions between panels. On eac panels are solar cells which can be damage in case of collision.

To control the opening of QO CARDSAT a hinge with double arcs was designed. (Fig. 9) There is a torsion arc to assure the torque necessary for opening and a second compression arc with double role: to control the torque of first arc and second to compensate the thermal dilatation.

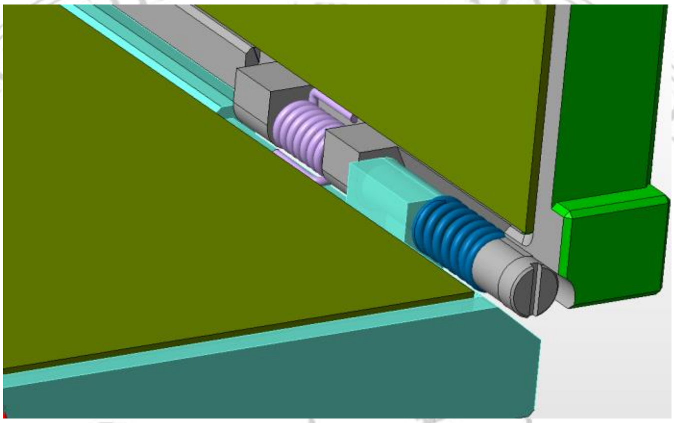


Fig.9. Double springs hinge.

These hinges are also a subject for a patent request documentation filed by POLITEHNICA University of Bucharest.

It can be two approaches for this design:

1. Integrated hinges on the frames of CardSat and
2. Independent hinges which can be attached to the frame.

In our research were created a few models of independent hinges (Fig. 10… Fig. 12), to validate the concept.

Fig.10 First solution of independent hinge.

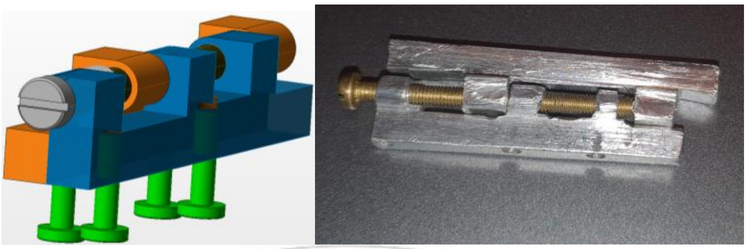


Fig.11. Second solution of independent hinge.

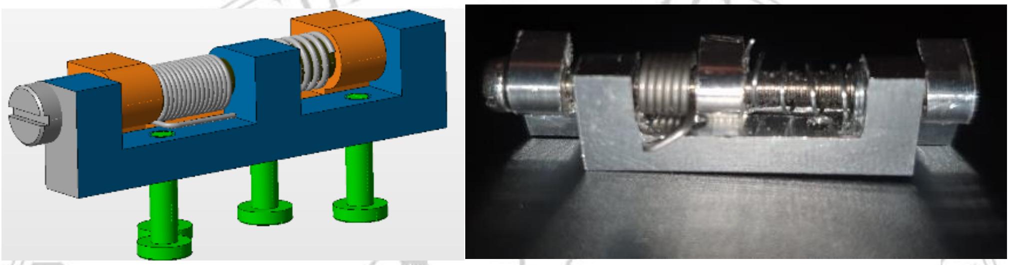


Fig.12. Optimum solution of independent hinge.

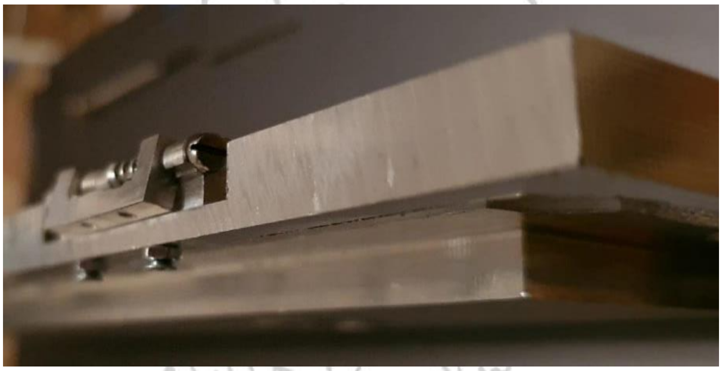


Fig.13. Optimum solution mounted on the frame.

For the optimum hinge solution the first attached on the frame was done. The hinge can be mounted on a frame with small screws (Fig. 13).

Conclusion

The microsatellites are more and more accessible to small and medium research companies and universities. To keep the product to a low price and also to expand the application field of microsatellite research is important to find modular equipment with different electronic components. Also, the structure of assembly is important.

Now a CubeSat are well known structure, but it reaches his limits.

New structures are demanded on the market to respond to the new requirements. A CardSat concept is a solution of it. Due to its concept the CardSat unit represents the base for more complex microsatellite structures.

Q Cardsat represents a new solution for increase the CardSat capabilities by multiplying by 4 the space for electronics. Also, it is a simple and reliable solution of it.

QO CARDSAT is the most complex structure which can be achieved by using CARDSAT and can be launch from a standard CUBESAT launcher.

Using the lamellar springs is a good solution to unfold the CardSat structure, but complex calculus and an additional number of tests is necessary.

A double springs hinges represent the solution for controlled opening torque in multiple CARDSAT structures. It can be easy to be manufacturing and mounting on CardSat frames. Due to possibility of torque control, it can be standardized and used in a various application of satellite panel deployment without any collision risk. Because it is a mechanical part with simple components, the risk of malfunction is reduced.

Acknowledgements

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