Prototyping and Testing an Inflatable Robot for On-Orbit Servicing

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Abstract:

With the recent economic trend that opens the doors of the space market also to private individuals, an exponential growth in the number of satellites in orbit and the construction of large structures directly in orbit is expected. To sustainably cope with this trend, all space agencies and many private companies are developing technologies for the maintenance of spacecraft and the in-orbit assembly and construction of large systems (In-space Servicing, Assembly and Manufacturing, ISAM).
In order to extend the service life of satellites and space systems in general, research in this field is aimed, among other things, at making possible the maintenance, refuelling and upgrading of in-orbit devices as well as the proper recovery and disposal of debris.

This is the context for the POPUP project, which aims to build a robotic arm for space applications and whose main characteristic is that it is made with inflatable links that allow it to be deployed and retracted. This feature allows reduced space requirements on the launcher and in its loading bay, while guaranteeing a large working space in orbit, making the component an optimal tool to be installed on satellites for their maintenance and upgrade.

This work continues the work carried out previously to study the theoretical basis for the design and dimensioning of this subsystem, with the aim of increasing the TRL previously achieved and to develop the preliminary design and an engineering prototype of an inflatable robotic arm. A mechanism is introduced to control the geometry of the links during the deployment phase and to make it possible to retract the same link into its charging bay when deployment is complete. This solution makes it possible to preserve the arm from potential damage resulting from exposure to space debris impact and radiation; appropriate thermal management of the satellite can also preserve the arm from the effects of excessive thermal oscillations.

The work therefore summarises the activities carried out for the development of an engineering prototype built for the purpose of performing function tests under microgravity conditions. The design of its main components is described, with particular attention to the inflatable chambers and the withdrawal and control mechanism of the deployment phase, as well as the criteria for the selection of components for the construction of the prototype.
The design of the experimental bench and the way in which the experimentation was carried out are also described.
Finally, the construction of the prototype is described, and a numerical model is set up, which will form the basis for the development of its digital twin.