Paper ID: 21092
oral
student

SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

Author: Mr. Lorenzo Olivieri
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, olivieri.lrnz@gmail.com

Mr. Andrea Antonello
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, andrea.antonello.it@gmail.com
Ms. Livia Savioli
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, livia_savioli@libero.it
Prof. Alessandro Francesconi
University of Padova - DII/CISAS, Italy, alessandro.francesconi@unipd.it

DYNAMIC BEHAVIOR OF A SEMI-ANDROGYNOUS SMALL SATELLITE DOCKING INTERFACE

Abstract

Since the first mating manoeuvre performed in 1966 between the Gemini VIII and the Agena Target Vehicle, many different docking mechanisms were developed, although the few systems dedicated to small satellites have never been verified in space nor scaled to CubeSat size. In the near future, small spacecraft docking procedures could acquire great importance, since the significant cut in the cost of development and access to space due to current advancements on miniature satellites technology, that is creating a new market, dedicated to commercial low risk application, low budget scientific missions and educational purposes. In this context, this paper presents a novel docking system to provide small spacecraft with the ability to join and separate in space, to realize multi-body platforms able to rearrange, be repaired or updated, thus overcoming the actual on board resources limitations of single small-scale satellites. Possible implementations include many different examples, from small and low cost space tugs to segmented mirror telescopes, making nano-satellite market competitive with respect to traditional vehicles. As for now, proposed docking ports present (1) simple probe-drogue interfaces or (2) androgynous geometries, with complex and non-axis-symmetric latches, but with the ability to dock with same-gender ports. The proposed solution overcomes the aforementioned drawbacks, using a semi-androgynous shape-shifting mechanism that actuating one interface changes the port into a "drogue" configuration, letting the other port penetrate it and closing around to create a solid joint. Main advantages of this solution lie in the possibility to conjugate the shape shifting actuation and the solid joint creation, thanks to a cam mechanism able to preload the structure. The mechanism design through the requirement definition and a trade-off between different concepts is presented in this paper, followed by the dynamic behaviour of the selected solution, numerically analysed with particular attention to two aspects, i.e. the loads transmitted between the mating ports and the alignment tolerances requested to perform successful docking manoeuvres. Such analysis led to the definition of instrumented prototypes to verify the solution through simple validation tests.