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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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Author: Dr. Tharek Mohtar
Politecnico di Torino, Italy

Dr. Stefano Mauro
Politecnico di Torino, Italy
Prof. Stefano Pastorelli
Politecnico di Torino, Italy
Prof. Massimo Sorli
Politecnico di Torino, Italy

PRE-DESIGN OF AN ACTIVE CENTRAL MECHANISM FOR SPACE DOCKING

Abstract

This paper discloses the design procedure of a docking mechanism for space applications. The mechanism has to recover the misalignments between the spacecrafts, as well as to dissipate energy due to speed difference that is involved by the precision limits of GNC systems, during docking maneuvers.

The proposed mechanism is composed by an active part mounted on a chaser spacecraft and a passive one mounted on a target spacecraft. The active part is equipped with a variable length probe made of a linear actuator hinged by an active two degrees of freedom rotational joint; a couple of linear actuators conveniently installed control the orientation movement of the main one, in order to point it towards a specific housing integral to the target during the approaching phase between the spacecrafts. The pointing movements are controlled by means of an optical system. A clasping device is placed on the tip of the probe to accomplish the soft docking with a conical seat mounted on the target side. The seat is hinged by a passive two degrees of freedom rotational joint so as to allow it to be oriented under the action of the active probe. Once the rod is inserted inside the conical seat, the probe is retracted, to get the spacecrafts progressively closer, and oriented toward central position, to perform spacecrafts alignment, to let a set of hooks to provide final hard docking.

Both main probe actuator and the couple of linear actuators are effective in relative kinetic energy dissipation during the maneuver between spacecrafts.

The paper describes the system layout and the different control phases. It examines the design parameters in order to provide a preliminary configuration of the mechanism, as well as the main requirements for mechanical components, actuators and sensors.

Moreover, details on a 3D mathematical model of the target and chaser interaction during docking maneuver are presented. Dynamic simulations has been used to design proper geometries for the mechanical interfaces, to design and tune the parameters of the system components, as well as to define sensors requirements.