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Author: Dr. Mathieu Deremetz
Space Applications Services, Belgium, mathieu.deremetz@spaceapplications.com

Dr. Gerhard Grunwald
German Aerospace Center (DLR), Germany, Gerhard.Grunwald@dlr.de
Dr. Francesco Cavenago
Leonardo Spa, Italy, francesco.cavenago@leonardocompany.com
Dr. Maximo Roa
DLR (German Aerospace Center), Germany, Maximo.Roa@dlr.de
Mr. Marco De Stefano
DLR (German Aerospace Center), Germany, Marco.DeStefano@dlr.de
Mr. Hrishik Mishra
DLR (German Aerospace Center), Germany, Hrishik.Mishra@dlr.de
Dr. Matthias Reiner
DLR (German Aerospace Center), Germany, Matthias.Reiner@dlr.de
Mr. Shashank Govindaraj
Space Applications Services N.V./S.A, Belgium, shashank.govindaraj@spaceapplications.com
Mr. Alexandru But
Space Applications Services, Belgium, Alexandru.But@spaceapplications.com
Ms. Irene Sanz Nieto
Space Applications Services N.V./S.A, Belgium, irene.sanz-nieto@spaceapplications.com
Dr. Jeremi Gancet
Space Applications Services, Belgium, jeremi.gancet@spaceapplications.com
Dr. Pierre Letier
Space Applications Services, Belgium, pierre.letier@spaceapplications.com
Mr. MICHEL ILZKOVITZ
Space Applications Services NV/SA, Belgium, michel.ilzkovitz@spaceapplications.com
Mr. Levin Gerdes
European Space Agency (ESA), The Netherlands, levin.gerdes@esa.int
Mr. Martin Zwick
ESA - European Space Agency, The Netherlands, martin.zwick@esa.int

CONCEPT OF OPERATIONS AND PRELIMINARY FLIGHT MODEL DESIGN OF A MODULAR MULTI-ARM ROBOT USING STANDARD INTERCONNECTS FOR ON-ORBIT LARGE ASSEMBLY

Abstract

The capability of assembling large structures in space is essential to meet the requirements of the future space exploitation and exploration missions. Whether for collecting solar power, or reflecting radio signals or light, dimensions matter. In fact, large structure are continuously increasing in size to bring increased scientific benefits. The studies conducted today foresee structures that will be too large to launch into orbit as a single self-deploying piece that can be contained in standard launcher fairings.

While few concepts exist to perform self-deployment of large structures in space, the approach taken here is that large structures will be broken down into standard modules that will be assembled in space by a robotic system that is launched with the modules. Furthermore, it is assumed that the spacecraft structure and modules will be equipped with Standard Interconnects (SI) that will allow them to be mated to each other and to the robot system for manipulation/transport, or to allow the robot system to move across them. This paper introduces the concept of operations and preliminary flight model design of a novel modular multi-arm robot (MAR). The MAR is composed of three modules - a torso and two symmetrical 7-DOF anthropomorphic arms with non-spherical wrists - that are functionally independent and can be connected by the means of SIs to form the MAR. The torso is the main body of the robot. This is a mechanical hub that can mate with three other modules (arms and/or payloads). The torso can also be attached directly to the spacecraft structure. It provides the required power, synchronizes and forwards high-level information to its connected modules and hosting spacecraft. The torso is also equipped with exteroceptive sensors for monitoring purposes. The two 7-DOF manipulators are the limbs of the MAR: they serve as arms or legs depending on the desired configuration and are used to manipulate payloads or to relocate the robot. The MAR modular approach aims at reducing the burden of developing and launching a complex, large and monolithic robotic system by splitting it into a smaller number of more manageable components. By taking advantage of separating and recombining the manipulators in different configurations, this approach extends the range of possible operations and provides an intrinsic system redundancy that reduces the overall mission risk. The MAR concept introduced in this paper is developed within the European Space Agency's MIRROR (SA) project.