Simulation of the On-Orbit Construction of Structural Variable Modular Spacecraft by Robots

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This paper gives an overview on the simulation of the onorbit construction of structural variable modular spacecraft by robots using Modelica.

For this purpose, a new concept using so-called tensor bodies was developed which enables the fast and continuous simulation of complex scenarios even during structural changes. This research was part of the ESA MIRROR and EU MOSAR projects.

An overview of the modeling and simulation approach will be given. The scenarios include the on-orbit re-configuration of a modular satellite with a walking robot manipulator and the construction of a modular space antenna array platform with a walking robot with two arms and a torso (see Fig. 1 and Fig. 2).

Because of the complexity and cost of these types of missions, simulation and demonstrator studies on Earth should be performed before committing necessary resources for a real mission. Future advanced spacecraft and orbital platforms can require on orbit assembly either because of the size of the structures (e.g. large antennas, solar facilities or telescopes) or because of a desired modularity. Since on-orbit human labor is extremely expensive and dangerous, on-orbit assembly and servicing tasks should be done (mostly) autonomously by robots.

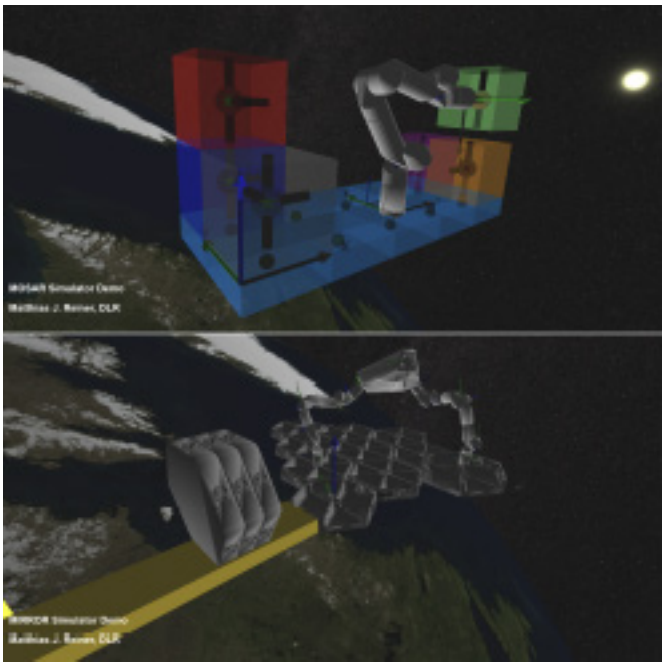

Figure 1. Visualizations generated by the developed simulators for an on-orbit assembly scenario investigated in the MOSAR and for the MIRROR project (lower half).

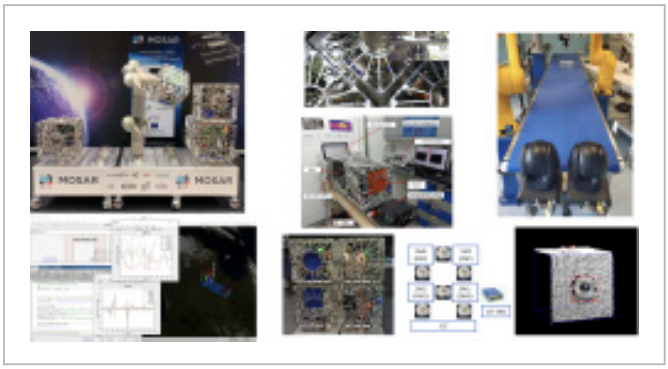

Figure 2. The mosaic overview taken from an internal MOSAR report shows some results obtained within the MOSAR project from the involved project partners SpaceApps, GMV, MAGSOAR, Thales Alenia Space (France and UK), SITAEL, Elidiss Technologies, University of Strathclyde, Glasgow and DLR (SR and RM). The top left shows the physical demonstrator setup with the WM relocating an SM. The top middle gives a closer look on the SIs and a thermal testing setup. The top right shows a setup for the visual inspection of the modules. The lower left shows a screenshot of the MATLAB interface of the FES with plotted simulation results. In the lower middle a closer view of an SM configuration and its corresponding software setup can be seen. The lower right corner shows the result of a camera-based damage inspection of an SM.