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Author: Mr. Thiago Weber Martins
TU Darmstadt, Germany

Mr. Stefan Kugler
TU Darmstadt, Germany
Prof. Reiner Anderl
TU Darmstadt, Germany
Mr. Oliver Ruf
Zentrum für Telematik, Germany
Prof. Klaus Schilling
University of Würzburg, Germany
Mr. Aaron Pereira
TU Muenchen, Germany
Mr. Alessandro Massimo Giordano
Technical University of Munich, Germany
Mr. Ribin Balachandran
DLR (German Aerospace Center), Germany
Mr. Fabian Benedikt
German Aerospace Center (DLR), Germany
Dr. Thomas Hulin
DLR (German Aerospace Center), Germany
Prof. Alin Albu-Schäffer
TU Muenchen, Germany
Mr. John Lewis
Telespazio VEGA Deutschland GmbH, Germany

SPACE FACTORY 4.0 - NEW PROCESSES FOR THE ROBOTIC ASSEMBLY OF MODULAR SATELLITES ON AN IN-ORBIT PLATFORM BASED ON INDUSTRIE 4.0" APPROACH

Abstract

Manufacturing in Space is fast becoming a reality, with the commercialization of space operations - the so-called NewSpace - leading to a sea-change in the space industry and the emergence of new business models. Inspired by the new opportunities related to NewSpace, the project Space Factory 4.0 has been founded with the objective of establishing new processes and technologies for rapid satellite assembly on an in-orbit platform. To make a significant step towards reaching this visionary goal, this paper discusses: (i) the establishment of new processes based on an Industrie 4.0 approach, (ii) the design of highly modular satellites, and (iii) their robotic assembly.

The basics of Industrie 4.0 relies on cyber-physical systems with the objective to enable flexibility, modularity, and adaptability of production systems. Based on these promising capabilities, an overall process for Space Factory 4.0 is proposed. Although the specific case of robotic assembly of modular satellites is focused, this approach is applied to abstract new business models. One of the key features of the overall process is the seamless use of the Digital Twin approach which provides detailed models

representing the actual state of its physical counterpart. Use-cases such as test and digital product documentation are described to discuss the benefits of such technology.

Implementing fast development cycles and modern manufacturing concepts requires modular systems that enable automated integration and verification processes. Space Factory 4.0 aims at establishing a highly modular design for small satellites that increases efficiency and scalability during production and testing. Based on this design, automated integration and verification of small satellites will be demonstrated and prepared for a future in-orbit factory.

Although autonomous integration and assembly are clear long-term goals, currently the possibilities for visual tracking and for modeling the physical interaction between the satellite components, the platform and the robotic manipulators are limited and this in turn affects the reliability of autonomous systems. As an alternative solution, Space Factory 4.0 aims at developing a bilateral controller which allows for teleoperation of the assembly robot by a human operator using a Human-Machine-Interface (HMI), providing force feedback with the support of virtual fixtures. The paper discusses a concept of such a haptic telerobotic system, which aims at combining the capabilities for reaching remote environments with human intelligence.

This paper outlines the methods and the results obtained within Space Factory 4.0 and draws conclusions to discuss its benefits and potentials for the space industry.