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# DEVELOPMENT OF A DISTRIBUTED SIMULATION ENVIRONMENT AND MODEL DRIVEN ENGINEERING FRAMEWORK TO SUPPORT THE VERIFICATION & VALIDATION OF COMPLEX AUTONOMY COMPONENTS.

**Abstract**

The Harwell Robotics and Autonomy Facility (HRAF), is a facility funded by the European Space Agency (ESA) to support the integration, verification  validation of autonomy systems and associated technologies from unit up to mission level. An essential capability of the HRAF core infrastructure is the provision of software-based simulation and modelling environments. Based on a Service Orientated Architecture using the High Level Architecture (HLA), IEEE 1516-2010, the simulation environment of HRAF has been developed over a number of pilot projects. HLA is a generic and domain independent standard for interoperable distributed simulation over network connections, and used regularly in domains such as defence and security. A key feature of HLA is support of information exchange models, called Federation Object Models (FOM), which can be tailored. A FOM can be standardized (typically within a given domain) or developed from scratch.

On behalf of ESA, a number of new functionalities aimed to enhance and extend current simulation and modelling capabilities were added to the HRAF core infrastructure. A distributed simulation architecture between multiple contractor (GMV) and agency (ESA) sites was developed, based on HLA IEEE-1516-

2010, together with the SISO Space Reference FOM standard (SISO-STD-018). To validate this new architecture and required software, two representative scenarios were selected for demonstration, based on reused GNC simulators, using a manually extended Space Reference FOM: 1) Rendezvous and Capture (RVC) phase of the ESA/NASA joint MSR-ERO mission, and 2) Precision landing of a spacecraft on a low gravity Near Earth Object (NEO). For both scenarios, a configuration of the Federation was implemented and tested at Model-in-the-Loop (MIL) and Hardware-in-the-Loop (HIL) levels, the latter being also implemented at Processor-in-the-Loop (PIL) level. Additionally, a Model-Driven Engineering Framework for the semi-automated generation of any generic space domain FOM based using the Space Reference FOM was developed. The tool performs a transformation of an input SysML model using the SpaceFOM Datatype library and generates a SpaceFOM compliant FOM. This output FOM can then be used to generate the interface software for HLA distributed simulation.

This paper presents new HRAF functionalities and their validation, namely a distributed simulation architecture, based on HLA and the Space Reference FOM, and a Model-Driven Engineering framework for semi-automatic generation of the FOM. It provides an overview of the federation architecture, main components and methodologies applied in federating simulations using existing simulator elements (software and hardware) and validation the system-level tests that have been performed.