**MBSE for MSR - Introducing MBSE to early phase mission design for Mars Sample Return**

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The return of samples from Mars has remained the top priority of the international Mars science community for several decades. Following the signature of a letter of intent in April 2018, ESA and NASA are exploring a potential collaboration in the implementation and execution of an international Mars Sample Return (MSR) campaign. NASA’s Mars 2020 mission is designed to perform the initial sample acquisition and caching on the Martian surface. A subsequent Sample Return Lander (SRL) mission would contain a Sample Fetch Rover (SFR) to collect these sample tubes and return them to the SRL, where a Mars Ascent Vehicle (MAV) would launch the contained samples into Mars orbit. The Earth Return Orbiter (ERO) would be in place in Mars orbit and responsible for locating and capturing the sample container, and ensuring its safe return to Earth. In the frame of this campaign, ESA initiated industrial phase A/B1 studies on the Earth Return Orbiter mission and the Sample Fetch Rover.

Following first applications of Model Based Systems Engineering (MBSE) in different project phases of ESA space missions, the aim is to capitalise on this experience by establishing a harmonised MBSE approach, suited for different lifecycle phases in the design and development of space missions. The current ESA activities for MSR have several study constraints and drivers, which appear to make the application of a dedicated MBSE approach particularly beneficial for several aspects: The necessarily short study duration favours a more model-centric than document based exchange of information; the overall short development schedule for the elements emphasizes the importance of a logical flow of requirements and their traceability from an early phase; complex interfaces with several actors including industrial contractors, NASA/JPL and ESA benefit from a collaborative definition and management; and traceability of the functional and operational allocations throughout the requirements and elements facilitates a common understanding and an efficient implementation.

Furthermore, the Harwell Robotics and Autonomy Facility (HRAF) activity, which aims to develop a MBSE framework to run simulations and semi-automated Validation and Verification, is being considered to model certain phases of MSR.

This paper will, after briefly introducing the MSR campaign, describe how the MBSE approach was tailored for the ESA MSR studies, how it was deployed throughout the different actors, its use during the activities, first experience on its usability and how the HRAF facility could be utilised during the mission development.