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Technology and knowledge reuse concepts to enable responsive NEO characterization missions based on the MASCOT lander

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ABSTRACT

The small asteroid lander MASCOT launched on-board the Japanese HAYABUSA-2 asteroid sample-return mission on December 3rd, 2014, was developed and built in a fast paced project under strict constraints of timeline and resources. Tailored model philosophies, standards, and a dynamically adapted test programme totalling more than 100 different test campaigns kept project risk under control and compressed hardware integration into 2½ years, barely feasible within a 3-year project even with the benefit of a preceding phase of lander concept studies. These were conducted for various missions and a wide range of lander sizes at the DLR Bremen Concurrent Engineering Facitlity starting in 2008.
Being a shoebox-sized 10 kg spacecraft, MASCOT carries four asteroid science instruments selected for versatility within the highly intense few hours of its mission on the unknown surface of near-Earth C-type asteroid (162173) 1999 JU_3. Many of its subsystems, notably thermal control, are highly optimized for this target asteroid, but still, first landing site selection may be subject to thermal constraints. Notably, for MASCOT small is not equal to simple: the system's fundamental complexity is comparable to similarly equipped standalone spacecraft and the need to integrate into a smaller volume adds even closer subsystem interdependency. However, for a very wide range of target objects many subsystems could still be very similar, such as orientation sensors, command and data handling, power distribution, the uprightening and relocation mechanism, and others.

With the lessons learned during the design, integration and management of MASCOT and with the background of an expanding construction set of subsystems in varying states of maturity, the study of derivative systems or "follow-ons" of MASCOT has become more and more self-evident as well as efficient. As far as knowledge and tools concerns, reuse can be made from the series of studies in the DLR Concurrent Engineering Facility (CEF) in Bremen which started off the MASCOT project, as well as the various MASCOT models which were built using Concurrent Assembly, Integration and Verification (AIV) methods. The experience gained in both can be consolidated by Model-Based System Engineering (MBSE) to facilitate future studies and projects. This set of tools becomes particularly useful when small solar system body landers need to be designed on a compressed timeline. It enables planetary scientists to use flight opportunities that arise late on the timescales of conventional space missions or, as in the case of MASCOT, adapt a design quickly from a discontinued mission to one that goes ahead – or it saves precious lead time when there is the need to meet a specific newly discovered threat.
The paper will show the different aspects of reuse of knowledge and technology in different scenarios and will provide an example for the fictional impactor 2015 PDC by designing a rendezvous and lander mission into the timeframe of the related exercise scenario, at for now fictitious short notice.

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