VaMEx-VTB – A Modular Virtual Tesbed for Multimodal Autonomous Planetary Missions

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The *"VaMEx - Valles Marineris Explorer"* initiative is part of the DLR Explorer Initiatives. As such it is an interdisciplinary research program funded by the DLR Space Administration aimed at developing new concepts, algorithms and hardware for swarm-based exploration of the Valles Marineris on Mars. This includes a hominid robotic platform (project VaMEx-VIPe), autonomous swarm navigation including ground vehicles and UAVs (project VaMEx-CoSMiC) that rely on a local positioning and landing system (project VaMEx-LAOLa) and orbital support (VaMEx-NavComNet) serving as a science data, telemetry and telecommand relay between Earth and the in-situ elements and providing near real-time position updates to the other elements.

Real validation and verification tests for such complex navigation and exploration systems are difficult, expensive and time-consuming because they require the availability of hardware as well as realistic environments.

In this paper, we present *VaMEx-VTB*, a virtual testbed (VTB) that has been developed in the project of the same name. The VaMEx-VTB enables the verification and validation of such large and complex interdisciplinary research projects during very early phases. The basic idea of VaMEx-VTB is to provide a common platform for all modules in combination with a sophisticated user definable computer simulation. Consequently, it can serve as an integration and discussion hub during the development process, thereby reducing expensive and time-consuming physical testing. The VTB allows users to configure various aspects of the test scenarios and the test environment, such as physical parameters, atmospheric conditions, or terrain features. This is essential especially for extraterrestrial planetary missions that are difficult to reconstruct on earth. Finally, a sophisticated graphical feedback, based on a state-of-the-art game engine, allows an easy and direct interaction of the engineers with the test cases in the VTB.

As a first use case, the VTB is adopted to serve as testing and integration platform for the aforementioned projects of the VaMEx initiative. Our modular design based on ROS supports consistent data access for all components. So far, we have implemented a realistic simulation of the relevant environmental parameters and created an adjustable model of the Valles Marineris terrain, based on the HiRISE data. Additionally, the VTB synthesizes realistic sensor input for several algorithms running on the swarm elements. The modular design concept also qualifies the VTB to serve as a testing platform for other extraterrestrial missions in the future.