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SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Novel Concepts and Technologies for Enable Future Building Blocks in Space Exploration and Development (3)

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DEVELOPMENT AND VALIDATION OF A MODULAR PARAMETRIC ANALYTICAL TOOL FOR SYSTEM ENGINEERING OF PLANETARY EXPLORATION ROVERS

Abstract

In System Engineering and preliminary design of planetary exploration rovers, model-based tools are an attractive alternative to rover testing. They allow to asses the locomotion performance and thus provide relevant inputs for sizing the mechanical and electrical sub-systems. Multi-body simulation tools (MBS) are commonly used in the industry for this purpose and a significant amount of research was conducted to adapt those tools for projects such as ExoMars (ESA).

However, the development, implementation and validation of those tools are very complex in particular in relation to flexible metallic wheel interaction on loose soils. In addition the simulation time is significant and the MBS require a detailed CAD model and expertise - thus making a detailed parametric analysis and dealing with changed mission requirements difficult. Another promising approach based on quasi-static equations and wheel level test data was therefore presented by RUAG Space at ASTRA-2011. This tool has demonstrated its capability during the engineering phase of the ExoMars LSS with an overall prediction accuracy of 10% for the dimensioning driving cases. However, it did not provide full simulation capabilities.

This paper hence presents the architecture and correlation of the Rover Parametric Analytical Tool (RPAT) based on the same methodology. Standardized and automated database-interfaces, a Horn-Method based Odometry-Module and an enhanced quasi-static-local-force-equilibrium-approach provide full 3D simulation capabilities based on Digital Elevation Maps (DEM). The approach results in simulation times up to 150x faster than real time on a standard PC. RPAT features high modularity through consistent object oriented design and thus provides the capability to parametrically analyze the locomotion performance of a variety of rovers, among them ESA-ExoMars, ESA-NEXT, NASA-MER and NASA-MSL. In contrast to existing approaches, the paradigm is to rely on wheel-level testing or a wheel soil interaction module like the one to be developed within the ESA SWIFT activity.

Based on single level test data, the overall RPAT approach is validated through a comparison with the ExoMars-LSS breadboard test campaign performed on the Martian soil simulant ES-3. RPAT deviates less than 5% for the required power and energy and less than 25% for the maximum wheel torques in the LSS-dimensioning test cases. It therefore reduces the dependence on rover-level prototypes in Phase A/B and promises a significant cost reduction for every new rover development, thus potentially improving the feasibility of future rover missions on Mars and Moon.