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Author: Mr. Andreas Wiegand
Astos Solutions GmbH, Germany, andreas.wiegand@astos.de

Mr. Sven Weikert
Astos Solutions GmbH, Germany, sven.weikert@astos.de

INNOVATIVE MULTI-DISCIPLINARY VEHICLE, MISSION AND GNC DESIGN

Abstract

The combination of multi-disciplinary optimization with mission and subsystem analysis is nowadays key to successful and cheap design for space missions. However, despite the improvements in computational speed, mathematical algorithms and software engineering, still the dependencies are huge and the expectations are growing. This paper presents an approach, how the European space Industry and ESA plan to achieve this challenge.

The multi-disciplinary design environment proposed in this paper is based on the ASTOS Guidance, Navigation, and Control (GNC) software, which combines several optimization methods and propagators with a flexible framework for the definition of space scenario and spacecraft. Following the workflow of project phases, the ASTOS GNC software suite allows a step by step refinement of the mathematical models including switching from rigid to flexible body dynamics or from 3-dof open loop guidance to 6-dof closed loop control. Most important for the improved efficiency is the fully integrated working environment, which allows the numerical optimization of vehicle and control parameters, optimal trajectory analysis and GNC analysis. And if necessary the analysis functions shall be used in a coupled mode, which allows the detailed analysis of complex scenarios like space robotic missions. The coupled analysis allows achieving high confidence in space missions in early project phases and this way helps to reduce costs in higher project phases as it has been shown by several studies.

ASTOS provides design capabilities for the design of GNC systems for reentry and especially launch vehicles. Beside the trajectory optimisation capability it provides the functionality to size the launcher stages automatically. The masses are estimated using regression tables. The engine performance is linked to chemical equilibrium tools and the engine efficiency depends on design criteria like low cost or high performance. The shape is parameterized and the drag coefficients are estimated analytically. Flexible body dynamics are computed using the DCAP software. The GNC environment is implemented under Simulink using the real world representation from ASTOS.

Various launcher designs have shown that no real optimal result exists. Most often fuzzy design criteria predefine certain aspects of the vehicle. Even more it is important to have a method for objective comparison of the multiple design ideas. Clear evaluation criteria and structured reporting functions support that work.

The capabilities of the software framework are presented following the design process of a launch vehicle and of a space robotics mission.