IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

Author: Mr. Alvaro Martinez
SENER Aeroespacial, Spain, alvaro.martinez@aeroespacial.sener

Mr. Jesús Ramírez
SENER Aeroespacial, Spain, jesus.ramirez@aeroespacial.sener
Mr. Francesco Cacciatore
SENER, Spain, francesco.cacciatore@aeroespacial.sener
Mr. Pablo Gonzalez Hierro
SENER Aeroespacial, Spain, pablo.gonzalez@aeroespacial.sener
Mr. Alejandro Lazaro
SENER Aeroespacial, Spain, alejandro.lazaro@aeroespacial.sener

GUIDANCE, NAVIGATION AND CONTROL FOR THE AUTONOMOUS RENDEZVOUS AND DOCKING OF COOPERATIVE TARGETS

Abstract

The relevance of In-Orbit Servicing (IOS) missions for sustainable space exploration is growing exponentially. A wide range of applications is starting to flourish, including in-orbit refuelling and active debris removal. These missions pose tight requirements on the performance of the GNC subsystem and on the autonomy level for the operation of the spacecraft.

This contribution presents SENER Aeroespacial solution for rendezvous and docking GNC based on onboard convex optimization and optical navigation, which demonstrates improvements in performance, efficiency and robustness with respect to classical approaches. Several rendezvous and capture scenarios have been assessed, focusing on cooperative and controlled targets, but also addressing non-cooperative and tumbling ones. This flexibility has been reflected in the development of an in-house generic rendezvous and docking GNC tool, the SENER Rendezvous Tool (SERVO), which is already being employed in the frame of ESA In-Space Logistics Proof-of-Concept 1 mission.

The guidance and control architecture is based on optimization for the trajectory generation and the actuator dispatching, and is flexible to electric, chemical or hybrid propulsion systems. The non-linear optimal control problem is solved onboard by means of Sequential Convex Programming. The optimization is further exploited by implementing it in a Model Predictive Control (MPC) scheme working in real-time, improving the robustness of the control. Such implementation is based on the in-house autocodable optimization toolbox for onboard guidance, the SENER Optimization Toolbox (SOTB). The navigation architecture greatly depends on the rendezvous scenario and the degree of cooperativeness of the target. For the cooperative case, the relative state solution is obtained by means of inter-satellite link to exchange the absolute state estimation of both spacecraft and is aided by optical navigation, especially for the close-range and capture phases.

The cooperative rendezvous and docking GNC is designed and simulated accounting for overall system performances and operations. The GNC is sized to ensure compatibility with SENER Aeroespacial docking and refuelling interface (SIROM) capture requirements, to guarantee the feasibility of the mating scenario.

Monte Carlo campaigns carried out on the SERVO System Concept Simulator demonstrate that the implemented GNC architecture is robust when subject to uncertainties in the system. Furthermore, the MPC scheme developed results in cost-efficient manoeuvres in terms of propellant consumption, when

compared to classical control techniques or feedforward control architectures based on offline optimal guidance. The algorithms developed have been shown to be compatible with cooperative and non-cooperative rendezvous and docking/capture scenarios with few modifications required.