ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation, and Control (5)

Author: Mr. Jean-Claude Berges
Centre National d'Etudes Spatiales (CNES), France, Jean-Claude.Berges@cnes.fr

Mrs. Angélique Gaudel
Centre National d'Etudes Spatiales (CNES), France, Angelique.Gaudel-Vacaresse@cnes.fr
Mrs. Sophie Djalal
France, Sophie.Djalal@EXCHANGE.CST.CNES.FR
Mr. Pierre-Yves Guidotti
Centre National d'Etudes Spatiales (CNES), France, Pierre-Yves.Guidotti@cnes.fr
Mr. Michel Delpech
Centre National d'Etudes Spatiales (CNES), France, michel.delpech@cnes.fr

CNES FORMATION FLYING EXPERIMENT ON PRISMA: SPACECRAFT RECONFIGURATION AND RENDEZVOUS WITHIN FFIORD MISSION

Abstract

PRISMA mission is a "technology in-orbit testbed mission" for demonstrating formation flying and rendezvous technologies, funded by the Swedish National Space Board with Swedish Space Corporation as prime contractor. This multilateral project involves additional contributions from CNES, the German DLR and the Danish DTU. It is composed of two satellites, MANGO and TANGO, that will be sent in a 700 km sun synchronous orbit to perform various rendezvous and Formation Flying experiments. CNES' contribution to the PRISMA mission, called FFIORD (Formation Flying In Orbit Ranging Demonstration), is based on two specifically developed components: a radiofrequency based relative sensor system as well as a piece of flight software implementing various GNC algorithms performing rendezvous, proximity operations and collision avoidance manoeuvres. The PRISMA launch is expected in April 2010 and the first CNES in-flight experimental slot is planned in May 2010, with the first GNC experiments to take place in August 2010. This timeline should enable us to present the relative rendezvous function in a total way: from design to flight tests. After a brief summary of PRISMA and the complete FFIORD experiment, the paper details the relative rendezvous function: - The design of the algorithms: the model of the relative motion used by the rendezvous function is based on the Yamanaka-Ankersen state transition matrix, closed-form solution to the Lawden differential equations, because it is a good candidate to cope with the eccentricity effects. Then guidance algorithm is based on MPC like method: the step for obtaining the next control action by solving a finite horizon open-loop optimal control problem in real time. This implies solving an optimization problem with quadratic criteria (for the minimization of the consumption) and linear equality constraints to optimize impulsive manoeuvre components, with fixed manoeuvres dates. The rendezvous function, as other GNC functions, is coded in the native Matlab/Simulink language. - Numerical simulations are performed at functions level in order to access the performances and the sensitivity of the rendezvous algorithm. - In-flight closed loop operational scenarios results: the first CNES GNC experimental slot is the one of three slots for which CNES overtakes orbit control in closed loop using the FFRF sensor. This scenario aims at checking for the first time in closed loop the behaviour of GNC functions. In this slot, the rendezvous function is tested over two approach and recede trajectories. Comparison with expected performances will be performed, and potential discrepancies will be analysed