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Author: Mr. Francesco Cacciatore
SENER, Spain

Mr. Víctor Gómez Ruiz
SENER, Spain
Mr. Gonzalo Taubmann
SENER Ingenieria y Sistemas, S.A., Spain
Mr. Jacinto Muñoz
SENER, Spain
Mr. Pablo Hermosin
Deimos Space SLU, Spain
Mr. Marcello Sciarra
Deimos Space SLU, Spain
Mr. Martiño Saco
Deimos Space SLU, Spain
Dr. Nanda Rea
Consejo Superior de Investigaciones Científicas (CSIC), Spain
Dr. Margarita Hernanz
Institut d'Estudis Espacials de Catalunya (IEEC), Spain
Mrs. Emilie Parent
Institut d'Estudis Espacials de Catalunya (IEEC), Spain
Mr. Jeroen Vandersteen
ESA - European Space Agency, The Netherlands

PODIUM: A PULSAR NAVIGATION UNIT FOR SCIENCE MISSIONS

Abstract

PODIUM is a compact spacecraft navigation unit, currently being designed to provide interplanetary missions with autonomous position and velocity estimations. The unit will make use of Pulsar X-ray observations to measure the distance and distance rate from the host spacecraft to the Solar System Barycenter. Such measurements will then be used by the onboard orbit determination function to estimate the complete orbital elements of the spacecraft. The design aims at 6 kg of mass and 20 W of power, in a volume of 150 mm by 240 mm by 600 mm. The Pulsar X-Ray navigation has been theoretically addressed in various papers and was demonstrated by SEXTANT/NICER on the International Space Station (ISS). The aim of the activity carried out by the SENER-DEIMOS-IEEC industrial consortium under ESA contract is to define a preliminary design for the unit, tackling the overall unit architecture, the optical and thermomechanical design, the unit avionics and SW, and a preliminary concept of function, performance, and operation. PODIUM is designed to minimize the impact on the mission operational and accommodation constraints. The architecture is based on a grazing incidence X-ray telescope with focal distance limited to 50 cm. The effective area shall be in the range 25 to 50 cm2 for photon energies in the range 0.2-10 keV, requiring nesting of several mirrors in the Wolter-1 geometry. Grazing incidence angles will be very small, below 2 deg. The FoV size will determine the aperture of the optics and be related to the maximum number of nested mirrors to accommodate. The current target FOV is 0.25 deg. The

pulsars' photon arrivals are detected with a single pixel Silicon Drift Detector (SDD) sensor with timing accuracy below 1μsec. This leads to an expected position accuracy of 30 m. The unit has no gimbaling to meet the applicable power, size and mass requirements. Instead, the host spacecraft shall slew and point to allow pulsar observation. The avionics architecture is based on a radiation hardened LEON4 processor, to allow a synchronous propagation task and measurement generation and orbit determination step in an asynchronous task. PODIUM will enable higher autonomy and lower cost for interplanetary missions. L2 space observatories and planetary flybys are the current reference use cases. Onboard autonomous state estimation can reduce the ground support effort required for navigation and orbit correction/maintenance computation, and reduce the turnaround time, thus enabling more accurate maneuvers, reducing the orbit maintenance mass budget.