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MISSION ANALYSIS OF THE CROSS-SCALE MULTI-SATELLITE SYSTEM

Abstract

The "Assessment Study of Cross-Scale (CS) Medium Class Mission" was carried out in the frame of the Cosmic Vision 2015–2025 plan with the primary aim to design a mission for the investigation of space plasma processes that involve dynamical non-linear coupling across multiple length scales. The consortium led by Thales Alenia Space was awarded by ESA one of the two industrial studies. In this consortium, DEIMOS Space was responsible for Mission Analysis.

To fulfil the CS scientific objectives, a constellation of spacecraft is required, flying in tetrahedron configurations around the Earth and sampling at least two characteristic plasma scale distances simultaneously, with four satellites per scale: electron kinetic (5-100 km), ion kinetic (100-2000 km), magnetospheric fluid (5000-15000 km). A constellation with 7 spacecraft has been designed and analysed in details: this configuration comprises two nested tetrahedrons sharing one satellite in a corner. During the first two mission years, the two tetrahedrons are arranged in the small and medium scales; then the constellation is reconfigured to distribute the spacecraft in two tetrahedrons in the medium and large scales during the following two years.

This multi-satellite system shall be built-up and maintained with respect to a reference near-equatorial orbit with apogee at 25 Earth radii and perigee at 10 Earth radii, which crosses the bow-shock region, the magnetosheath and visits the magnetotail each year.

From the mission analysis point of view, the key drivers are the number of S/C and the constellation configuration, the transfer and deployment strategy, the inter-S/C localization/synchronization and the mission operations.

The selected transfer and deployment scenario is based on a single launch of seven identical S/C with a Soyuz-Fregat 2-1b. A Propulsion Module provides the capability to bring the S/C to the operational orbit where they are deployed.

Inter-spacecraft localization/synchronization is an enabling technology to achieve the required timing and distance accuracy. For the CS mission, a solution with inter-S/C RF links in the small scale and ground-supported orbit determination for the medium and large scales has been put forward.

Operational streamlining and effective communications architecture are paramount to handle such a considerable number of spacecraft and instruments. The volume of data collected and the ground delivery intervals drive the S/C on-board mass memory and the necessary data transmission rate.

This paper presents a comprehensive overview of the CS mission analysis and outlines a technically feasible mission scenario for a multi-dimensional investigation of space plasma phenomena.