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SOLAR WIND ANALYZER - THE SOLAR ORBITER MILESTONE TOWARDS ON-BOARD INTELLIGENT DECISION MAKING SYSTEMS

Abstract

The most important challenge underpinning the transition to next generation of Space missions design is the discrepancy between the dramatic increases in observation rate and the marginal increase in downlink capacity, enforcing the shift from the traditional "acquire-compress-transmit" paradigm to highly efficient intelligent on-board processing of observations, minimizing downlink requirements while respecting the limitations in power and bandwidth resources. Solar Orbiter (SO), an ESA/NASA mission, is a milestone both in the purely technological and scientific sphere. SO is devised to study the connection between the Sun and the heliosphere, with particular interest to open issues such as the sources of solar wind streams and turbulence, the heliospheric variability, the origin of energetic particles and the solar dynamo. The science payload is designed to link in-situ and remote sensing observations, and is composed of ten suites of instruments including spectrometers, imagers, wave and particle instruments - result of a large international consortium. In particular, the plasma suite Solar Wind Analyzer (SWA) comprises: Proton-Alpha Sensor (PAS), Electron Analyzer System (EAS), Heavy Ion Sensor (HIS) together with the Data Processing Unit (DPU), and will provide high-resolution 3D velocity distribution function of ions and electrons, together with ion composition, necessary to infer the thermal state of solar wind and its source regions, identify structures such as shocks, CME's and other transients, and determine the link between particle dynamics and waves. SO will explore new distance and latitude combinations that thus far remain unexplored, even if you take into account old Helios and upcoming Parker Solar Probe observations. Such challenges leave room to heavy constraints like the limited bandwidth available to SWA for downlink, so that the whole set of particles raw data collected cannot be transmitted back to Ground. Data processing is used to evaluate concise scientific properties of the solar wind, the moments, and making feasible the transmission of full data distributions only at low frequencies. Then processing is re-adopted on these distributions to meet the required (lossless) compression rates (2-8). Another step

towards the aforementioned paradigm shift is represented by the SWA Book-Keeping Algorithm (BKA), which has been designed to ensure that the individual sensors remain within the allocated telemetry rate on an orbit-averaged basis. The philosophy of the SWA book-keeping scheme has been applied to all instruments with ESOC's Operations Team introducing the concept of Operations Telemetry Corridors (OTC) to finely tune the rate of telemetry generation by the instruments.