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ESA DDOR ENHANCEMENT: AGENCIES INTEROPERABILITY, WIDEBAND AND LOW-SNR FUNCTIONALITY

Abstract

Delta Differential One-way Ranging (ΔDOR) is a powerful method used for navigation of interplanetary probes. It provides a direct measurement of the angular position of a spacecraft using interferometric techniques to obtain the difference in the arrival time of a spacecraft signal received at two ground stations, using a ICRF quasar as a reference. In 2005, the University of Rome "Sapienza" developed for ESA a ΔDOR correlator, expanding the tools available to the agency for the operation of planetary and astrometric missions. Since its delivery, the correlator has been successfully used for the orbit determination of Venus Express and Rosetta. In a later release the correlator's capabilities were expanded to accept data acquired not only at ESA's ESTRACK stations, but also at VLBI and NASA's Deep Space Network antennae.

In 2011 ESA and "Sapienza" have undertaken further enhancements of the correlator, regarding the data formats, the extension of the total spanned bandwidth and the capability of correlating very-low SNR signals. The new Raw Data Exchange Format, RDEF, established by the Consultative-Committee for Space Data Systems (CCSDS) in order to increase the DDOR interoperability between different agencies has been implemented in the correlator. This enhancement will allow the direct processing of data acquired by different agencies.

The second development aimed to increase the accuracy of ΔDOR measurement by increasing the spanned bandwidth of the recorded signal. Indeed, for the broadband quasar signal the accuracy in the time delay is proportional to the inverse of the total spanned bandwidth. Due to current hardware limitations, the bandwidth at ESTRACK stations is currently limited to 28 MHz. ESA is planning to use three LDCs (Low Band Down-Converter) to acquire different portion of the signal spectrum, and route the signal to up to three IFMS receivers (Intermediate Frequency Modulation System). With this configuration the total spanned bandwidth could be increased up to 80 MHz. The enhanced version of the correlator is capable of handling this new configuration and take advantage of the wider bandwidth.

Finally, a third enhancement enabled the correlation of narrowband low-SNR spacecraft signals. The spacecraft signal correlation is currently carried on by means of a phase locked loop (PLL) on the carrier, and a second PLL, driven by frequency prediction, on the telemetry harmonics. A new PLL-free algorithm for the spacecraft data correlation allows the processing of low-SNR signals (up to 1 dBHz) that cannot be tracked by a standard software PLL.