GNSS – Signals in Space
Verification and Analysis

The 30-meters Antenna

In the early seventies DLR built up a 30-meters dish for the HELIOS-A/B satellite missions at the DLR site Weilheim. HELIOS was the first US/German interplanetary mission launched in 1974. Later the antenna was used to support other scientific deep space missions like for example Giotto, AMPTE and Equator-S as well as for various scientific experiments.

This impressive antenna is based on a shaped Cassegrain design. It is characterized by its high antenna gain (around 50 decibels) and a very small beamwidth (0.5 degrees in the L-band). A prerequisite for using this antenna for GNSS signal analysis is the adaption of the existing equipment to the used frequency bands in the navigation field.

Since 2005 the Institute of Communications and Navigation of the German Aerospace Center (DLR) established an independent monitoring station for the analysis of GNSS signals using a deep space antenna at the DLR site Weilheim. For the IOV test campaigns a new measurement setup was installed including a highly accurate calibration system.

The combination of the high gain antenna – which raises GNSS signals above the noise floor – and the performed calibrations allow detailed and very precise analysis of the transmitted satellite signals.

Measurement Setup

The signals received by the 30-meters dish and a new developed circular polarized L-band feed are amplified by two low noise amplifiers (LNA) with a total gain of around 70 decibels in each of the two independent receiving chains to reach a high input power level for the vector signal analyzer. A set of band pass filters reduces the bandwidth to the used GNSS bands and minimizes possible interferences. The measurement system contains not only the signal acquisition via vector analyzers, also a receiver captures the Galileo signals and the installed calibration and interference detection systems are new features to ensure the high quality of the raw data.

The calibration system consists of an arbitrary waveform signal generator – AWG – which is both connected to the input of the receiving chains and also directly to the vector signal analyzers. A remotely controlled switch allows signal injection into the direct path or the receiving chains. The calibration routine uses wideband chirp signals in order to characterize the actual frequency response of the system and perform constant calibration of all measurements.

At the 21st of November 2011, the first two fully operational Galileo satellites concerning the "Open Service" – PFM & FM2 – were launched. These satellites carry payloads for all three frequency bands E1, E5, and E6 and take over GIOVE-A&B's mission to secure the frequency filing in the Galileo frequency bands. With the upcoming two IOV satellites FM3 and FM4 the In Orbit Validation – IOV-phase can start to validate the performance of the Galileo system.

The 30-meters antenna at Weilheim

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Signal Analysis

The used vector signal analyzers allow real time monitoring of the received spectra and provide fast-lookup functionality. For detailed analysis the received data are recorded and further processed offline using a signal-in-space analysis facility. Based on the performed analysis different results and representations like spectra, time-domain plots, correlation functions, and IQ-diagrams can be derived. These representations are used for evaluating the signal quality in different aspects.

Consequently, it is possible to check compliance of the signals-in-space to all important system requirements and to detect for example spectral asymmetries and gain imbalances of the satellite signal. These results will be used for the development of the new European Navigation System Galileo to gain maximum performance and will act as input to further research on the future evolution of the Galileo system.

DLR at a glance

DLR is Germany’s national research centre for aeronautics and space. Its extensive research and development work in Aeronautics, Space, Energy, Transport and Security is integrated into national and international cooperative ventures. As Germany’s space agency, DLR has been given responsibility for the forward planning and the implementation of the German space program by the German federal government as well as for the international representation of German interests. Furthermore, Germany’s largest project management agency is also part of DLR.

Approximately 7000 people are employed at 16 locations in Germany: Cologne (headquarters), Augsburg, Berlin, Bonn, Braunschweig, Bremen, Goettingen, Hamburg, Juelich, Lampoldshausen, Neustrelitz, Oberpfaffenhofen, Stade, Stuttgart, Trauen, and Weilheim. DLR also operates offices in Brussels, Paris, and Washington D.C.