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Determination of GNSS satellite transmit power and impact on orbit determination

Peter Steigenberger (1), Steffen Thölert (2), and Oliver Montenbruck (1)

(1) German Space Operations Center, Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany, (2) Institute of Communications and Navigation, Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany

Precise orbit determination of GNSS satellites requires a best possible modeling of forces acting on the satellite. Antenna thrust is a small acceleration caused by the transmission of navigation signals of a GNSS satellite. It depends on the mass of the satellite and the total power of the transmitted signals and results in a mainly radial force changing the orbital radius by up to 2 cm.

Within the International GNSS Service (IGS), antenna thrust is currently only considered for GPS and GLONASS. Transmit power levels for the different types of GPS satellites are based on the minimum received power near the Earth's surface as specified in the GPS interface control document. Empirical scaling factors take into account deviations from observed power levels resulting in IGS model values between 76 and 249 W. For GLONASS, a transmit power of 100 W is assumed. However, antenna thrust is currently ignored within the IGS for the emerging navigation systems Galileo, BeiDou, and QZSS due to unknown transmit power levels.

The effective isotropically radiated power (EIRP) of a GNSS satellite can be measured with a high gain antenna. Based on the gain pattern of the satellite antenna, the transmit power can be obtained. EIRP measurements were gathered with a 30 m high gain antenna operated by Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center, DLR) at its ground station in Weilheim (Germany). In this presentation, we discuss the measurement setup and present the transmit power estimates for GPS, GLONASS, Galileo, and BeiDou satellites in the L1, L2, L5/E5 and E6 frequency bands. Differences of the various satellite types as well as the scatter of the individual satellites within one type are analyzed. The GPS results are compared to the values of the current IGS model. Finally, the impact of taking into account antenna thrust based on the estimated transmit power on precise orbit determination is assessed.