Robot field calibration for multi-GNSS receiver antennas at ETH Zurich

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Introduction

GNSS antennas suffer from direction-dependent errors, which are due to the physical properties of the antenna. These errors affect the satellite transmitter antennas as well as the receiver antennas. The transmitter antennas of the Galileo spacecraft were precisely calibrated in specifically designed anechoic chambers before the launch of the spacecraft. The calibrations are publicly available. In order to exploit the full potential of the Galileo constellation, receiver antennas should be calibrated as well.

State of the art

Antenna calibrations have been studied since the very beginning of GPS in the 80s, for instance by Sims (1985). Nowadays, two methods are well established: the calibration in anechoic chambers using an artificial signal source (Zeimetz 2002) and the robot calibration in the field using real GNSS signals (Willi 2019, Menge 2003).
In the case of the robot calibration, a device is used to rotate the antenna in the field while real GNSS data is acquired. This is necessary, in order to de-correlate the Phase Center Corrections (PCC) from the Phase Center Offsets (PCO) and from multipath effects. Typically, an industrial robot with five or six axes is used to rotate the receiver antenna.
Various groups perform field calibrations with industrial robots. The most prominent system was developed at the Leibniz University Hannover (Menge 2003) and is now commercially operated by the German company Geo++ (Wübbena et al. 2000). Currently, this system is able to deliver calibration values for the GPS L1 and L2 and the GLONASS G1 and G2 frequencies. An implementation of Galileo E5 calibrations has been announced for 2019[1]. Other groups are working on antenna field calibrations as well (Bilich et al. 2018, Hu et al. 2015, Riddell et al. 2015), but none of them reportedly performed calibrations for Galileo signals.

Receiver antenna calibration at ETH Zurich

The Institute of Geodesy and Photogrammetry at ETH Zurich developed a field calibration method for GNSS receiver antennas (Willi 2019). The system uses a six axes industrial robot of brand KUKA. One calibration sequence consists of 2000 to 4000 antenna orientations and lasts for 1-4 hours. The acquired data is then processed in a triple-difference approach (Willi et al. 2018). In principle, the system is able to generate PCC for all Code Division Multiple Access (CDMA) signals. It has been tested so far for GPS and Galileo.

Anticipated results

In order to validate the approach, a validation dataset has been acquired on short baselines. Four antennas were placed on four geodetic pillars for at least 24 h. In total, four sessions were measured, permuting the antennas between the different sessions. The coordinates of the geodetic pillars were precisely surveyed beforehand, resulting in a very accurate ground truth (standard deviation of about 0.2 mm). The GNSS data was then processed with a development version of the Bernese GNSS Software (Dach et al. 2015). In this contribution, the results from this campaign will be presented and discussed in detail, as well as the resulting consequences for the Galileo science community.

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[1]See IGS AWG mail 508 from 15.11.2018 by Michael Moore, available at www.igs.org/mail for registered users

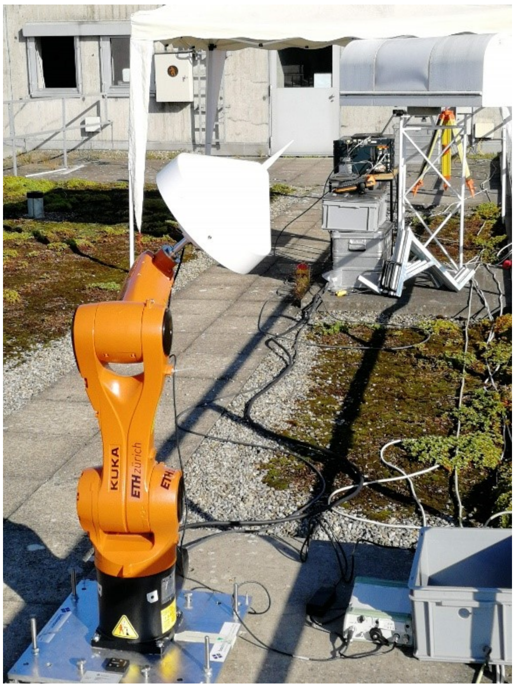

Figure 1: Absolute field calibration system for receiver antennas developed at ETH Zurich

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