Autonomous Inland and Short
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Title:

Current Status of Precise Point Positioning algorithm development for highly automated inland vessel navigation

Abstract:

Inland waterway transport is the transport mode with the lowest CO2 emission per tonne kilometre. However, the full capacity for inland vessel transport is not exploited so far. There is a substantial potential for modal shift from road and rail to inland vessel transport. Automation of inland vessels could be a key enabler for this modal shift. In order to increase the grade of automation step by step currently advanced driver assistant functions are being developed. Two of the most challenging phases of inland navigation are the bridge passing and the passing of waterway locks. For the automation of these critical phases a highly accurate and reliable determination of position, navigation and timing (PNT) information is required.

Here, the application of code-based positioning at meters level using signals of Global Navigation Satellite Systems (GNSS) is not sufficient anymore. Hence, phase-based precise positioning at centimetres level needs to be applied. One can distinguish between relative positioning by means of RTK (Real Time Kinematic) using correction data of a nearby real or virtual reference station and absolute positioning by means of PPP (Precise Point Positioning). More importantly, multi-constellation GNSS and PPP ambiguity resolution can remarkably improve the positing stability and reliability, especially in the waterway lock where only limited GNSS satellites are observed. To achieve high-precise multi-GNSS PPP with ambiguity resolution, so called State Space Representation (SSR) correction data of individual error components like satellite clock and orbit, tropospheric and ionospheric errors as well as code and phase biases need to be provided by a reference station network. Due to the fact that the service area is significantly enlarged for PPP (100-1000 km) compared to RTK (1-20km) while also requiring a smaller data rate, PPP is seen as the key enabler for highly automatic driving for both road and inland waterway transport.

The project SCIPPPER (2018-2022), which aims the automatic entering of a waterway lock is a pilot project for the usage of SSR corrections provided by SAPOS (Satellitenpositionierungsdienst der deutschen Landesvermessung) reference station network. The correction data will be sent via the new VDES (VHF Data Exchange System), the next generation of AIS (Automated

Identification System). VDES includes, compared to AIS, additional frequency channels for new applications. For the transmission of SSR correction a broadcast service is envisaged, which uses the existing AIS base station infrastructure of German Waterway and Shipping Administration. In order to not overload the VDE channel just by this one service, the number of massages used for this serviced need be minimized. In cooperation with the Working Committee of the Surveying and Mapping Agencies of the States of the Federal Republic of Germany (AdV) and Geo++, a SSR correction data stream has been prepared for the VDES transmission in the Main-Danube-Channel area. It contains only the minimum number of required corrections at a largest possible time update interval.

This paper will give an overview of the current status of the developments of the multi-GNSS PPP algorithm by using the optimized SSR corrections from the SAPOS network. The corresponding PPP algorithm and processing strategies will be introduced and validation results of static as well as dynamic measurements from measurement campaigns on the Main-Danube-Channel will be presented.