Title: Development of Precise Point Positioning algorithm to support advanced driver assistant functions for inland vessel navigation
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TOPICS:
- Inland, Sea-River, River and Pilot Navigation Systems; Inland Shipping; Canals and Inland Waterways; River Information Services (RIS); Inland ECDIS
- Precise Point Positioning (PPP); Real-Time Kinematic (RTK) Positioning; Location-Based Services (LBS); Positioning Infrastructure; Alternatives to GNSS

Inland shipping is an important pillar of the European transport system. Nevertheless, it needs to compete with other modes of transport like road and rail transport. In order to increase both efficiency and safety of inland navigation, advanced driver assistant functions are currently 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 using signals of Global Navigation Satellite Systems (GNSS) is not sufficient anymore. Hence, phase-based positioning 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). For PPP 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 (2018-2021) aims the application of PPP for the automatic entering/exiting of a waterway lock. This is a pilot project for the usage of SSR corrections provided by the SAPOS (Satellitenpositionierungsdienst der deutschen Landesvermessung) reference station network. The correction data will be broadcasted by using the new communication channel of VDES (VHF Data Exchange System) – the next generation of the AIS (Automatic Identification System).
This paper will give an overview of the current status of the developments of the PPP algorithm in the SCIPPPER project including the definition of requirements, the overall system design and first test trials.
This includes the derivation of the requirements for the determination of position, velocity and heading based on the requirements of the driver assistance systems for both bridge and lock passing. The system design includes the land-based components together with the onboard systems and the required communication channel. In the main part of the paper the developed PPP algorithm will be described in detail and compared against other state-of-the-art PPP algorithms. Due to the fact that the accuracy of the determined velocities at bow and stern is of most importance for the motion control of the vessel, the paper will discuss different options for GNSS based velocity calculation.
In the conclusions further planned developments and activities on the advanced driver assistant functions will be mentioned.