RTK-based height provision for a reliable bridge collision warning systems for inland vessel navigation

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Abstract

Inland shipping is an important pillar of the German transport system; however the challenges of inland navigation due to dense traffic, increasing ship dimension, reduced maneuver space and visibility are multifaceted and increasing. About 20 to 30 collisions per year, partially caused by carelessness, demonstrate the necessity of driving assistance systems for inland waterway applications.

The project LAESSI (Guiding and assistance systems to improve safety of navigation on inland waterways) is developing efficient navigation assistance functions for inland waterway transport which aim the reduction of risk of collisions by supporting the skipper in its task. Therefore, nautical information like position, height and heading has to be determined. One focus here is a bridge collision warning system, which provides a timely alert to the skipper, whenever the vessel, particularly the wheelhouse or radar mast, will not safely pass the bridge.

A feasibility study has identified Global Navigation Satellite System (GNSS) technologies as basis for the reliable height determination for such a bridge collision warning system. This approach requires information about the vertical clearance of the bridge superstructure as well as precise height information at least 300 m before the vessel will pass the bridge. The high accuracy level of less than 10 cm in the vertical position necessitates the Real Time Kinematic (RTK) as suitable GNSS method.

RTK is a phase-based differential GNSS technique and uses additional observations from permanent reference stations to mitigate or eliminate effects like atmospheric delays or satellite clocks and orbit errors. As bridge collision warning system is a safely critical application, this means that beside the provision of accurate height information also an integrity monitoring for the complete RTK procedure has to be introduced. The shore-based architecture is designed in such a way that correction data will be checked for their integrity before they are broadcasted (Pre-Broadcast Monitoring) to the vessel. Furthermore, several station dependent effects like signal interferences, signal losses or multipath effects, caused due to obstacles near the inland waterways, impact the GNSS signals, which hamper or falsify the ambiguity fixing and finally the position results. To prevent the provision of faulty results a further integrity monitoring for the shipborne architecture has to be applied.

The paper will present the derived requirements for inland waterway assistance functions, an overview about the system architecture and a communication concept based on VHF Data Exchange System (VDES) communication channels. The main focus, however, is an RTK-algorithm which not only estimate position, velocity and heading, but also provides integrity information. This concept considers in a first realization internal statistical parameters from the RTK adjustment, other observations (e.g. Doppler shift) and physical information (e.g. baseline length of two GNSS antennas).

A first measurement campaign was done in July 2016 in Koblenz on the river Moselle. This test area is characterized by three bridges in a relatively short distance of only 300 m which make the provision of reliable and precise RTK position data rather challenging. The preliminary analyses based on three hours GPS and GLONASS observations showed a high rate (> 85%) of evaluated position results, which fulfilled the cm-level accuracies. The internal integrity check could detect and eliminate faulty results. Fig. 1 illustrates the height profile determined by the DLR-RTK algorithm compared with two commercial receivers. The reference solution was realized by two simultaneous tachymeter measurements. Beside a good height performance also fast provision of the heights after the vessel sailed through the bridges is recognizable. This position data between the bridges allows a provision of information to the skipper to check or adjust the wheelhouse or radar mast height before the next bridge will be passed.

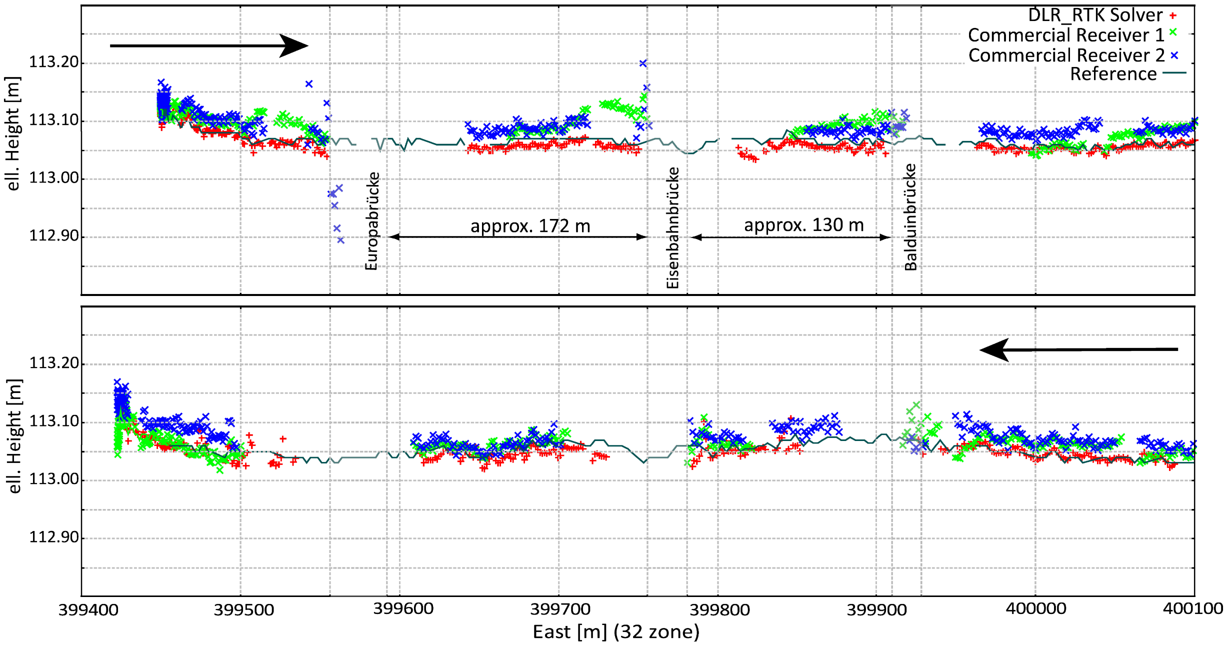

Fig. 1: Height profiles based on the DLR-RTK solution and of two commercial receivers compared with a reference solution. The black arrow indicates the driving direction of the vessel.