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*Proceeding Paper*

# Precise Positioning for Mass-Market: Optimal Data Dissemination DAB+ Demonstrator †

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**Abstract:** The main issue in the development of precise positioning is the way in which to send GNSS corrections. To handle this case, a terrestrial broadcast mechanism based on DAB+ (digital audio broadcasting) signals was chosen to overcome the scalability challenges, as it would allow a service provider to transfer assistance data based on a "one-to-many" scheme. DAB is easily widely deployed, with large coverage predictions carried using ATDI's HTZ simulator. The DAB+ reception demonstrator uses SSRZ, a compressed and compact state space representation corrections format developed by Geo++. SSRZ corrections were generated using data from Teria's CORS network and have been broadcasted over the air with DAB+ signals. To validate the SSRZ corrections, the "Record&Replay" technique was used. It consists of digitizing GNSS signals during a normal field test. Once data were collected and validated, replays were executed in the laboratory. Different scenarios were set up to validate the accuracy of the position with SSRZ corrections sent via DAB+ and the convergence to the corrected position after ambiguity loss. The results show that the accuracy was acceptable when the user remained close to the transmitting DAB+ antenna (<10 km). The lower performance might result from broadcast limitations in urban environments.

**Keywords:** SSR; DAB+; NRTK; PPP-RTK



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## 1. Introduction

Precise positioning can be achieved using one of two techniques: real-time kinematic (RTK) and precise point positioning (PPP). These two solutions were mainly developed for professional applications; the costs of dual-frequency GNSS receivers did not allow their use for mass-market applications. Currently, thanks to the commercialization of low-cost, multi-frequency GNSS chipsets, high-accuracy techniques have become ever more attractive for several applications, like the automotive industry, agriculture, and drones [1].

The main issue in the current condition is represented by the way in which GNSS corrections are sent to the user. The GNSS corrections used to compute the position are typically sent to the user via the NTRIP protocol [2] (networked transport of RTCM via Internet protocol). NTRIP is an open, non-proprietary protocol designed about 15 years ago to distribute the GNSS streaming data to a stationary or mobile receiver over the Internet. NTRIP dissemination is a proven technique, with worldwide adoption, that is based on existing internet standards. Its success is partly due to the HTTP and TCP protocols. This communication protocol, however, has a significant drawback because it involves exactly two endpoints (each characterized by a globally unique IP address), and HTTP is a standard unicast application. Thus, the current approach adopted in the GNSS community has limited scalability and, therefore, poses some limitations for mass-market applications. Currently, more and more use cases are emerging, most of them demanding accurate positioning information such as drones, Internet of Things (IoT), and autonomous driving. In this scenario, traditional GNSS data dissemination solutions may face challenges, especially when tens of thousands of devices are simultaneously requesting a response [3]. To handle this case, service operators can set up a terrestrial broadcast mechanism based on cellular signals or DAB+ signals. It can overcome the scalability challenges, as it would allow a service provider to transfer GNSS assistance data based on a "one-to-many" scheme. In this project, a DAB+ demonstrator is developed to receive GNSS corrections. Firstly, we present this demonstrator and the way to receive GNSS corrections. Then, the outcomes of different experimentations are described. In the last section, the results are discussed and analyzed for future work on the subject.

## 2. Materials and Methods

The aim is to directly broadcast the GNSS corrections from a DAB+ transmitter to a large area. During the experimentation phase, SSR corrections generated with data from Teria's own CORS (continuously operating reference station) network were broadcasted wirelessly using a DAB+ signal. DAB+ was selected because this technology has proven to be widely deployed, and because coverage predictions using ATDI's HTZ simulator have shown that the DAB+ signals have a much larger reach in rural and urban areas compared to LTE. Moreover, DAB+ has another advantage: it is a numerical signal with a data channel, and it is easier to broadcast data on DAB+ signals. The detailed configuration of the DAB+ reception is shown in Figure 1.

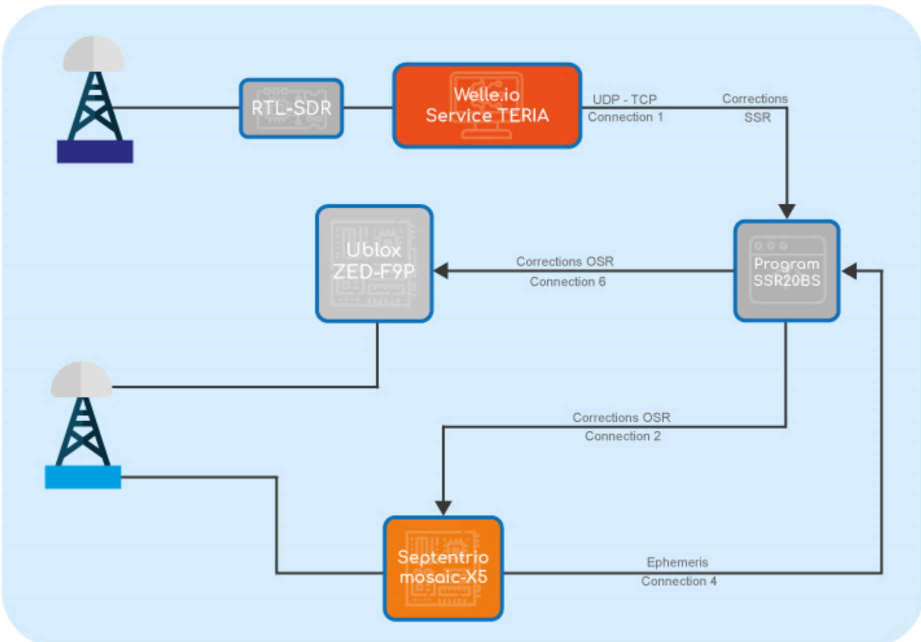


**Figure 1.** Scenario for record and replay using correction through DAB.

The DAB+ transmitter uses SSRZ, a compressed and compact state space representation corrections format developed by Geo++ [4]. The main advantage of using this type of corrections is that there are no problems with two-way server–user communication, as in NRTK. Moreover, using SSRZ corrections aims to solve the computation of the position, even if it is with latency.

In this configuration, there are three different receivers: RTL-SDR (for the DAB+ reception), Ublox, and Septentrio mosaic (GNSS receivers). Two ways to compute the position were used: with NRTK and with SSRZ corrections. The first step was to receive the data service "teria" in DAB+ with the USB stick RTL-SDR. The data service "teria" is broadcast on channel 9B (204,352 MHz). This data service contains SSRZ corrections. The next step is to convert the SSRZ corrections into OSR (observation space representation) corrections. Indeed, to compute the position with the receiver Ublox or Septentrio, OSR corrections are needed. But, for this conversion, the ephemeris from the Septentrio mosaic-X5 is necessary. For this reason, a backup link was set up between the mosaic-X5 and the SSR2OBS program. Then, the corrections were sent to Ublox and Septentrio receivers to compute the position.

To validate the proposed corrections solution, the "Record & Replay" technique was used [5]. It consisted of digitizing GNSS signals during a normal field test. During the test, a high-grade inertial navigation system was embedded to calculate, in post-processing with post-processing Kinematic (PPK) and inertial hybridization, a high-accuracy trajectory. Once the data were collected and validated, replays were executed in the laboratory. GUIDE compared the performances obtained using classical NRTK corrections and the ones obtained with the new SSRZ corrections. For this phase, corrections were replayed and broadcast using the NTRIP protocol. Once validation proved that the SSRZ corrections were able to provide similar accuracy and availability of high-precision PVT solution as the RTK, the real-life test took place.

## 3. Tests and Results of Two Scenarios

Different scenarios were set up to validate not only the accuracy of the position with GNSS corrections sent via DAB, but also the convergence to the corrected position after ambiguity loss. In this case, SSRZ corrections were broadcasted and converted on user equipment to be compatible with the RTK receiver. One scenario (Figure 2) consisted of moving in an urban environment around the transmitting antenna to observe the evolution of the position accuracy with respect to the distance from the DAB+ emitter.

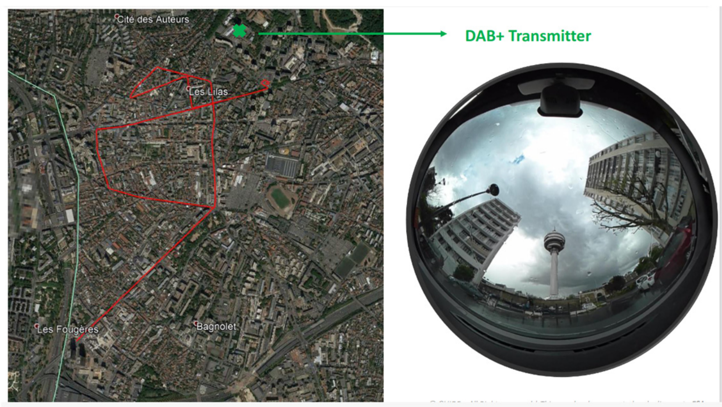


**Figure 2.** Scenario A for record and replay using correction through DAB.

The session lasted 6 km around the transmitting antenna, which was located in Romainville (France). This test session lasted 30 min. The results (Figure 3) show that, in some sections, the accuracy was acceptable when the user stayed close to the transmitting DAB+ antenna (<10 km). Lower performances might result from broadcast limitations in urban environments.

Horizontal errors were between 3 cm and 50 cm, and vertical errors were between 5 cm and 80 cm. These errors were due to the quality of the DAB+ signal. Indeed, in this scenario, corrections on DAB+ signals are often lost in urban environments. This loss is mostly due to the non-optimization of the DAB+ prototype antenna for the good reception of signals. Furthermore, the use of a single transmitter for DAB+ limited the signal coverage area and caused gaps. This can explain the different errors in the position. However, the accuracy of the position was around a few centimeters, with a convergence time of less than 5 min.

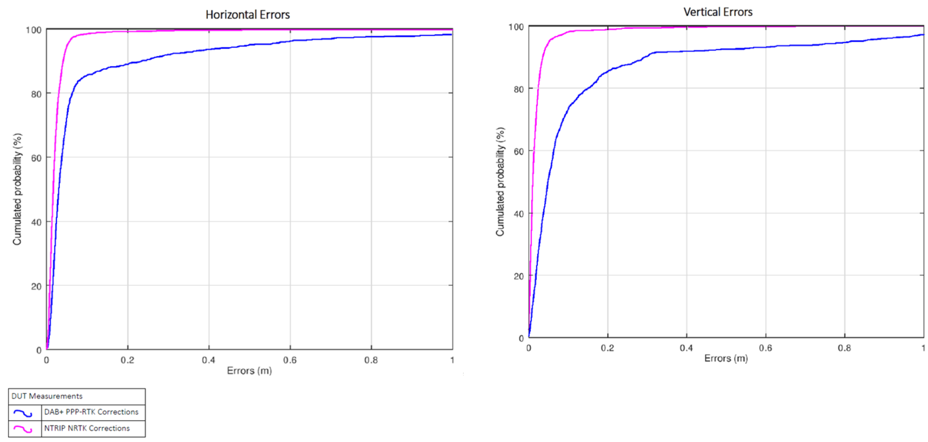


**Figure 3.** Horizontal and vertical errors in scenario A for DAB+ and NRTK solutions.

In the second scenario, B, one moved away from the antenna gradually over 28 km for 100 min (Figure 4).

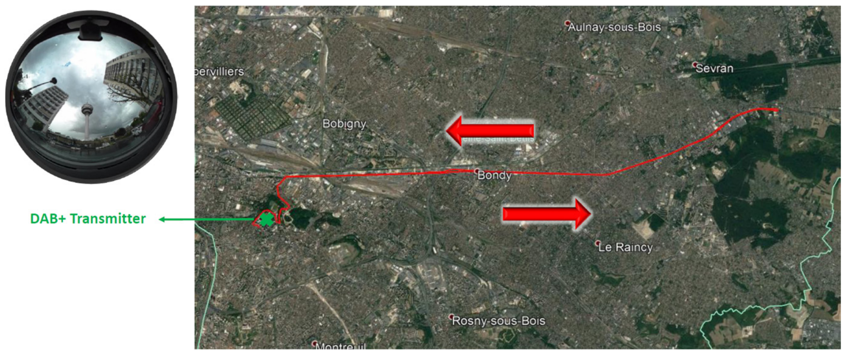


**Figure 4.** Scenario B for record and replay using correction through DAB+ compared with NRTK solutions. In red the trajectory of the car.

In scenario B, GNSS corrections on the DAB+ signal were lost at a distance of approx. 10 km (Figure 5). The horizontal and vertical accuracy with SSRZ corrections, broadcast through DAB+ signals, was on the centimeter level whenever phase measurement ambiguities could be solved. The accuracy was about the same as for the NRTK service. The results obtained are in line with those obtained in the preliminary study, which was conducted by relaying GNSS signals and sending both NRTK and PPP RTK corrections to an NTRIP server. DAB+ transmitter networks are an interesting way to broadcast PPP RTK corrections for all devices without LTE connection, such as IoT.

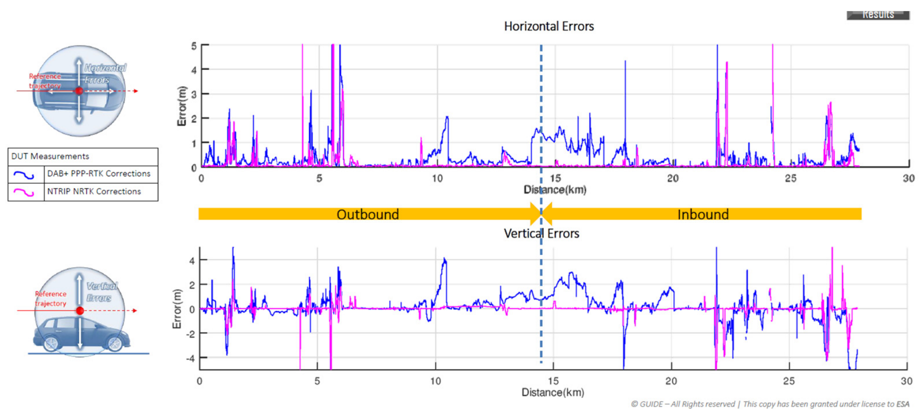


**Figure 5.** Scenario for record and replay using correction through DAB.

## 4. Discussion and Conclusions

The reception of DAB+ signals, in all scenarios, was strongly impacted by different factors. Firstly, the hardware and software utilized had purely a demonstrator scope. They were not optimized to be used in dynamic conditions and/or far from the transmitter. Moreover, a unique transmitter was used for the broadcast of corrections. It limited the coverage of DAB+ signals and the quality of the data once the distance was greater than 10 km. However, the outcomes of both scenarios are quite encouraging in terms of convergence time and accuracy. Indeed, the accuracy was centimetric, and when the ambiguity was lost, the convergence was fast: just a few minutes. This experimentation reveals the possibility to send GNSS corrections differently with the same performance in NRTK solution. The main advantage is the ease of broadcasting GNSS data in DAB+ over longer ranges. In addition, the DAB+ broadcast of GNSS corrections would allow several devices to calculate their positions directly without a bi-directional link between the transmitter and the receiver. In the future, it could be possible to implement this GNSS broadcast system with several antennas to improve the availability of the DAB+ signal and to improve the position calculation. In addition, other channels, such as LTE via 3GPP protocol, could be used to broadcast GNSS corrections.

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