2021 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB) | 978-1-6654-4908-3/21/$31.00 ©2021 IEEE | DOI: 10.1109/BMSB53066.2021.9547147

RTK Correction Data Transmission Service for Autonomous-Driving via ATSC 3.0 in South Korea

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***Abstract*— This paper introduces data broadcasting technology and cm-level precision positioning technology, which are contributing to taking one step further into the era of autonomous driving. How 'broadcasting' and 'positioning' can be the best combination will be explained. Furthermore, the performance of RTK (Real-Time Kinematic) correction data for cm-level accuracy will be verified through ATSC 3.0 test-service in South Korea.**

***Index Terms*— RTK, GNSS, Correction Data, ATSC 3.0**

I. INTRODUCTION

In July 2017, MBC [1] transmitted RTK (Real-Time Kinematic) correction data, which enables cm-level precision positioning, through the T-DMB (Terrestrial Digital Multimedia Broadcasting) network in South Korea. It was the world's first service to provide national-wide coverage correction data using a terrestrial broadcasting network. MBC RTK[2] is the brand name of MBC's high-precision positioning service. Now, three years later, autonomous vehicles and drones and many related companies and research institutes, such as agriculture, construction, robots, and marine, starting with the name of "autonomous," are using MBC RTK services. This paper presents RTK transmission and reception through the latest ATSC 3.0 network and verifies its performance in the real field environment.

II. CONCEPT OF RTK TECHNOLOGY

Since GPS operates by receiving signals from satellites above the sky, hundreds of meters' errors may occur when buildings or trees partially obscure the sky. Even in the open sky, GPS has an average error of about 5-10 meters due to various causes, as shown in Fig. 1. Most of these error-causing components commonly occur in adjacent spaces within several tens of kilometers and have similar characteristics. It means that when GPS receiver A, B are in similar locations, the GPS error of both occurs similarly. Therefore, if the error of receiver A is calculated, correction data is generated. And this data is transferred to GPS receiver B to remove the common error, then receiver B can also obtain a more accurate position

Suppose a very precise GPS antenna and receiver that knows the absolute coordinates[3] are installed at a fixed location [2]. In this case, the error of the GPS every second via comparing GPS

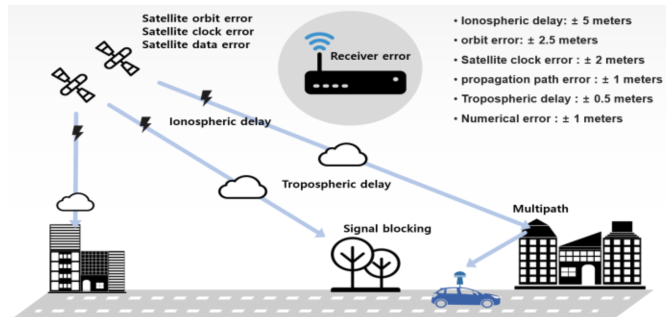

Fig. 1. Error sources of GPS [1].

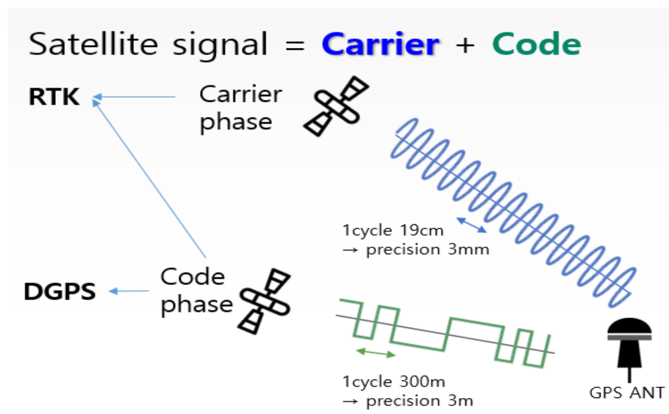

Fig. 2. Precise distance measurement using carrier-phase signal.

measurements with the absolute coordinates can be obtained. A facility that generates correction data using this error is called a reference (or base) station. If the correction data generated by the reference station is transferred to a GPS receiver (or Rover) moving in an adjacent space, and then a correction operation to cancel the common error is performed so that a 1m-level accurate position can be obtained. This is called DGPS (Differential GPS) technology.

The RTK is one of the DGPS technologies. Since it uses not only the code-phase of the satellite signal used by general GPS but also the carrier-phase that is 1000 times more precise, it can acquire a position with an error level of 1~2 cm in real-time, as shown in Fig. 2. Although it is not straightforward to understand how the RTK can have centimeter-level precision, it can be considered as a method of measuring the distance

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[1] MBC (Munhwa Broadcasting Corporation) : A nationwide terrestrial public broadcaster in South Korea since 1961

[2] MBC RTK website : http://rtk.mbc.co.kr/en/

[3] Absolute Coordinates : Very precise Latitude, longitude, and elevation coordinates in millimeter-level in the WGS84. For example, MBC's Sangam reference station coordinates is latitude: 37.58074561°, longitude: 126.89220992°, altitude: 106.946m

between the satellite and the GPS antenna with a much finer ruler.

RTK technology has three challenging characteristics that are different from general GPS-based positioning. The first is that the conditions of use are problematic. In order to use a carrier-phase, the GPS antenna must be directional in the form of looking at the sky, and the satellite signal strength must be secured at a level capable of performing RTK calculations. The built-in GPS antenna of a smartphone is not directional, and since the satellite signal strength is weak, RTK technology cannot be applied. This is why RTKs are primary used in vehicles and drones.

The second is that the location accuracy is not always on the cm-level. The RTK GPS receiver transitions into three modes: STAND-ALONE, FLOAT, and FIX, depending on the surrounding environment. STAND-ALONE mode is in the same state as general GPS without correction data. In FLOAT mode, RTK is operating, but it cannot determine the exact position value. FIX mode refers to the state in which positioning has been determined, and guarantees cm-level errors. That means RTK is cm-level precision only in FIX mode.

The third characteristic is that availability and convergence time are essential in RTK technology. Availability is a measure of how many FIX states appear while using RTK, and convergence time refers to the time it takes to derive the result of the FIX state through RTK calculation. For example, the RTK GPS attached to an autonomous vehicle is FIX state when driving on a wide highway, but it will be challenging to drive autonomously if it is not FIX state on an urban road where a building is located. In addition, if the exact location of the vehicle exiting through the tunnel can be known in FIX state within a short time, it will be more advantageous for autonomous driving. So availability and convergence time are key performance indicators in RTK technology, which are determined by the performance of the RTK GPS receiver and the quality of correction data.

MBC RTK is providing a service that achieves 95% availability while guaranteeing 2~3 cm precision in urban roads through technology development over the past several years. The high-quality correction data of MBC RTK shows excellent performance not only in expensive brand RTK-based GPS terminals, but also in mid- and low-priced RTK receivers.

III. Characteristics of GNSS Correction Data

Until now, while explaining RTK technology, no broadcast-related content has ever appeared. What is a correlation between RTK technology and broadcasting? In conclusion, data broadcasting technology can be used as a delivery method for GNSS correction data. GNSS correction data is binary-based the RTCM standard. So this data can be transmitted to any communication medium. Then why use the broadcasting network? Because the characteristics of GNSS correction data match very well with data broadcasting service, as shown in Fig. 3.

The first is small data but a continuous update. RTK correction data is very small with an average size of 1 KB per second, but must be continuously updated. This is because the error components that affect GPS continually change little by little. Assuming that correction data is received 24 hours a day and 31 days through mobile communication, a considerable fee will be incurred with a data capacity of 2.5 GB per month.

The second is a delay time of seconds. The GPS error does not change rapidly, and there is no need to transmit correction data without delay because there is a constant change pattern. Academia generally regards the correction data as sufficient to obtain cm-level precision if it satisfies the update period of 1 second and the transmission delay of less than 10 seconds. Sometimes it is asked if correction data needs to be transmitted with ultra-low latency in order to calculate the exact position of a fast-moving object in real-time. The correction data plays a dominant role in canceling the error, but the real-time position calculation is performed with the real-time satellite signal received by the RTK-based GPS receiver. As mentioned earlier, the GPS error does not change significantly within 10 seconds. Therefore, there is no problem in performing the correction data transmission service via data broadcasting technology, which has a transmission delay of about 5 seconds.

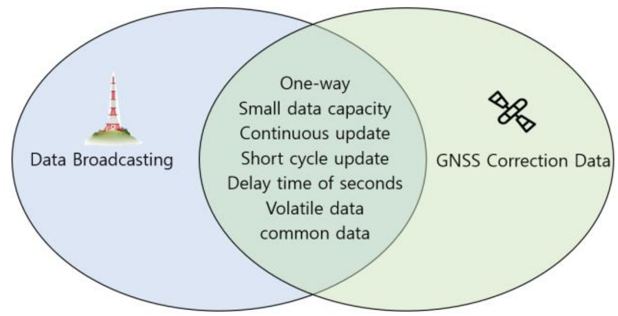

Fig. 3. Common characteristics between data broadcasting and GNSS correction data.

The third is common data. The correction data can be used effectively for 10 to 20 km from the reference station where the error is observed. MBC RTK correction data with high quality can be covered with one data even in a radius of over 30km, and coverage can be further extended by packaging and transmitting several correction data. All users in a large area can receive the same data and use the RTK service. This means that unlike video content, which has become more personalized due to the recent technology advances, anyone can use the correction data for positioning purposes.

Due to these characteristics, data broadcasting and GNSS correction service are well suited to each other. Of course, this does not mean that using a broadcasting network is technically superior to using a communication network. However, if the market demand for correction data explodes in the future, it is expected that a broadcasting service capable of transmitting the common data to an unspecified number of people will play an important role. In preparation for this, MBC is steadily developing a correction data transmission service through ATSC 3.0 mobile network as well as the existing Internet and T-DMB networks.

IV. ATSC 3.0-Based RTK Technology

Since 2017, South Korea has started the terrestrial UHD broadcasting service with ATSC 3.0 specification [3]. By now, Korea only supports fixed UHD service, but Korean terrestrial broadcasters have tested the technical experiments to simultaneously transmit both fixed UHD and mobile service on the same frequency. And with that, they are also interested in new services using mobile data broadcasting.

Accordingly, Since 2019, MBC has tested the MBC RTK service using ATSC 3.0 network as shown in Fig. 4. The primary test process is as follow:

① MBC transmits RTK correction information with data service protocol of ATSC 3.0 specification

② RTK receiver connected with ATSC 3.0 tuner receives MBC RTK correction data and makes the cm-level precision positioning information.

③ Several application services (Drone, Tractor, etc.) utilize high-precision GPS information with an RTK receiver

In order to verify the feasibility of RTK service through the ATSC 3.0 network, a field test was performed in Seoul and the metropolitan area. RTK correction data was delivered by the dedicated mobile PLP (Physical Layer Pipe) to provide robust performance in a harsh mobile environment [4][5]. Especially, ATSC 3.0 NRT (Non-Real Time) service was used for delivering RTK correction data [6]. To observe the service utilization of MBC RTK, possible service coverage in a high-speed environment was measured.

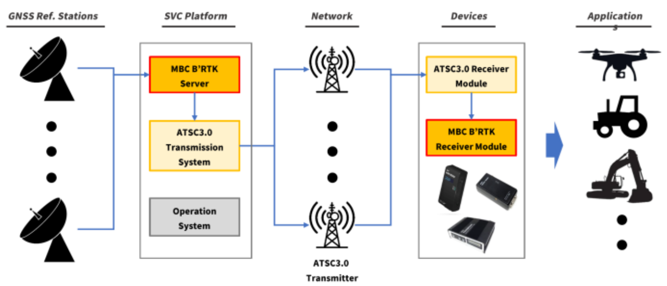

Fig. 4. MBC RTK signal flow through ATSC 3.0 network.

Fig. 5. MBC RTK Test Environment in October 2019

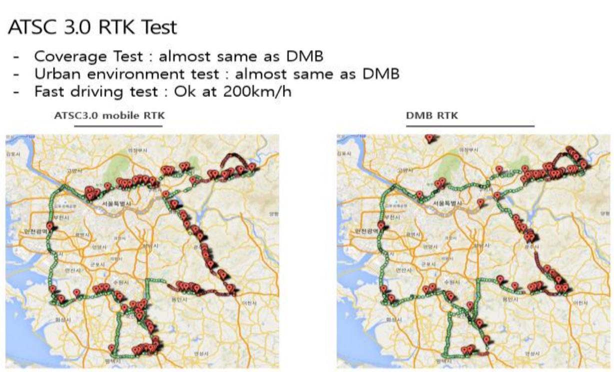

Fig. 6. MBC RTK service coverage in a high-speed mobile .

Fig.5 shows the test environment for verifying the RTK service performance between ATSC 3.0 and T-DMB network. The scenario is as follow:

① MBC transmit RTK correction information through ATSC 3.0 and T-DMB network, simultaneously.

② MBC mounts two RTK receiver in measuring car. The one is based on ATSC 3.0 mobile network, the other is based on T-DMB network. MBC meatured the coverage of RTK service in Seoul and metropolitan area with above two receiver.

③ With same environment, MBC performed the “Fast driving feasibility test” of RTK service over 200Km/h speed.

Test result is shown in Fig.6. Left picture is the result based on ATSC 3.0 mobile network & the other is based on T-DMB one. Green color shows the valid service area & red one means invalid area. As the test result, MBC RTK service based on the ATSC 3.0 network proves an acceptable reception performance which is similar to the existing T-DMB network. Note that T-DMB coverage is already matured while ATSC 3.0 coverage is still expanding. Furthermore, the ATSC 3.0 receiver used in this field test is equipped with an early chipset manufactured in 2016, so its performance is somewhat limited. Since ATSC 3.0 reception performance is constantly improved, it is expected that ATSC 3.0-based RTK will be more feasible than T-DMB-based RTK. It is obvious that terrestrial broadcasting-based RTK service, especially the ATSC 3.0 network, is more feasible than cellular-based RTK because it is free to charge and wider coverage.

V. Conclusion

This paper introduced the terrestrial broadcasting-based MBC RTK technology for cm-level precision positioning and verified its feasibility through ATSC 3.0 network.

Several application services (Drone, Tractor, etc.) utilize high-precision GPS information with an RTK receiver. Since the cm-level precision positioning technology is essential for autonomous driving, precision drone operation, and autonomous farming using tractors, the MBC RTK can be the most cost-effective solution.

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