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**Author(s)/Submitter(s)** Younghoon HAN, Tae Hyun FANG (KRISO), Jongguk CHAE,

Dong Ho Lee (MOF)

status update of the korean R-mode Testbed project (trace)

# Summary

This document aims to delineate the progress of the R-Mode Testbed Project (TRACE) in the Republic of Korea and provide opinions to the committee.

# Background

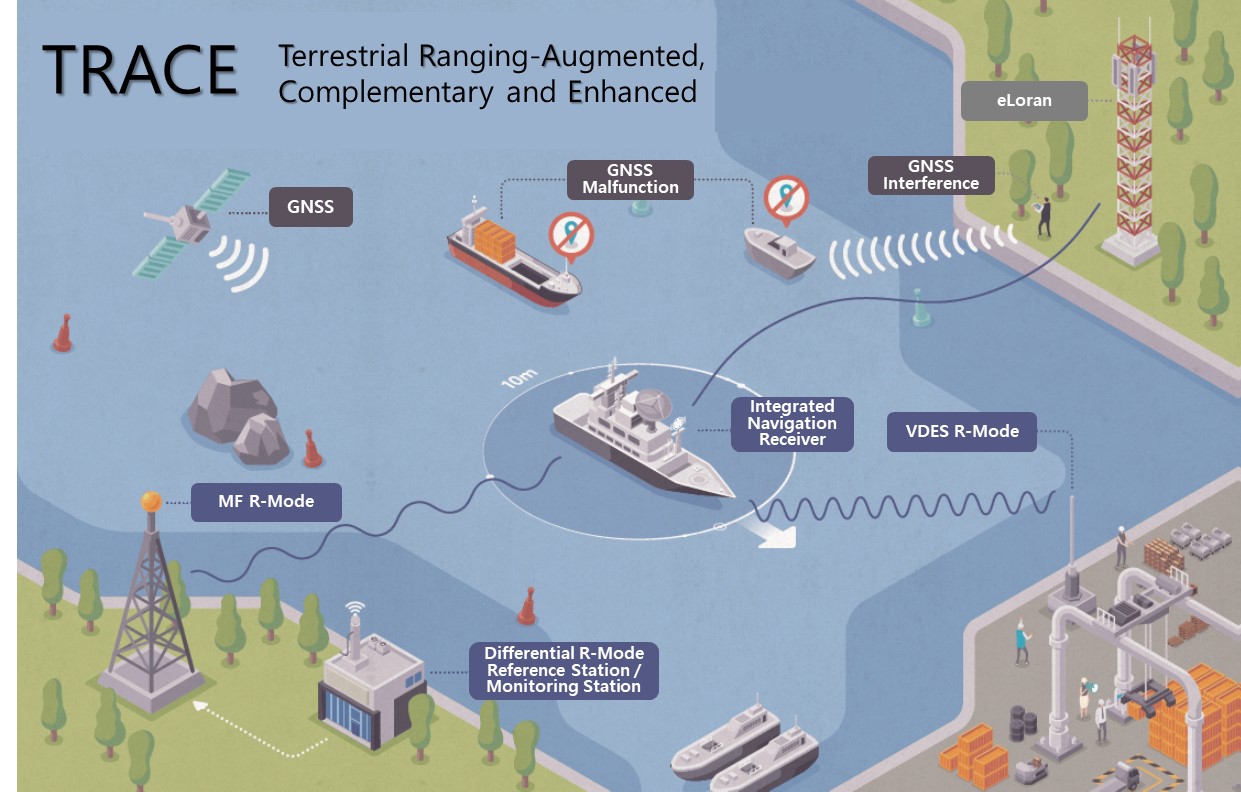
The Republic of Korea (R.O.K.) is making efforts to set up a backup navigation system to provide resilient Position, Navigation and Timing (PNT) information to maritime users in case of GNSS emergency and to prepare for GNSS vulnerability. The eLoran testbed project, initiated by KRISO in 2016 with the support of the Ministry of Oceans and Fisheries, completed its technological development in December 2020, and its test services will be provided to two major ports (Incheon Port and Pyeongtaek Port) in the north-central region of the West Sea of Korea.

The Ministry of Oceans and Fisheries planned to promote the R-Mode service along with the eLoran service to expand the backup PNT system to all maritime areas in Korea and provide the harbour entrance and port approach requirements for maritime users as required by the IMO Resolution A.915(22) Requirement for a future GNSS. KRISO, the supervising agency of the Terrestrial Ranging-Augmented, Complementary and Enhanced (TRACE) project, commenced the R-Mode testbed project of the Republic of Korea in April 2020 and will develop the core technology and demonstrate its performance in the test ports by 2022.

# Progress of the trace Project

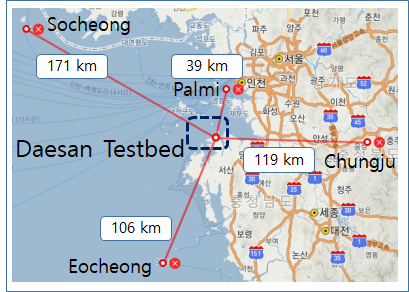
## Overview of the TEstbed System

The TRACE project plans to utilize the medium-frequency (MF) R-Mode, VDES R-Mode signal, and eLoran signal currently in service to achieve the project goals. Therefore, the testbed system will consist of a transmitting station for MF R-Mode signals, the VDES R-Mode signals, and eLoran signals and an integrated receiver that receives and integrates each signal to determine its position. The integrated receiver receives GNSS signals and terrestrial navigation signals. Furthermore, the system consists of a monitoring station for integrity information generation, a differential R-Mode reference station system for generating correction data to improve the positioning accuracy for MF R-Mode users, and an operating system to monitor and control the status of each system.



1. TRACE Project System Configurations

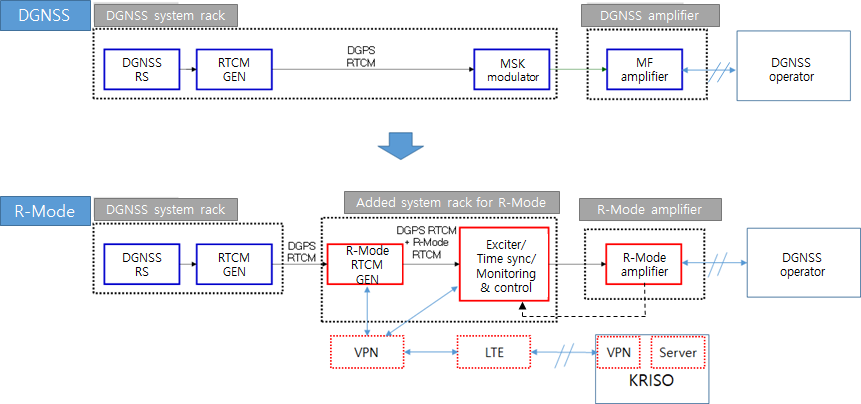
The Daesan Port located in the north-central region of the West Sea, Korea was selected as the testbed area for the actual performance, where eLoran signal reception is possible along with the signals of the MF R-Mode transmitting station. Therefore, the plan is to upgrade the So-Cheong, Pal-Mi, and Eo-Cheong Island DGNSS marine reference stations and the Chung-Ju DGNSS inland reference station to MF R-Mode transmitting stations. The VDES R-Mode transmitting station will be installed at a location where it can complement the HDOP as a temporary transmitting station. The differential R-Mode reference station will be located near the Daesan Port, and the monitoring station will be installed on Nanji Island to monitor the anomalies from the user's perspective and generate integrity information.

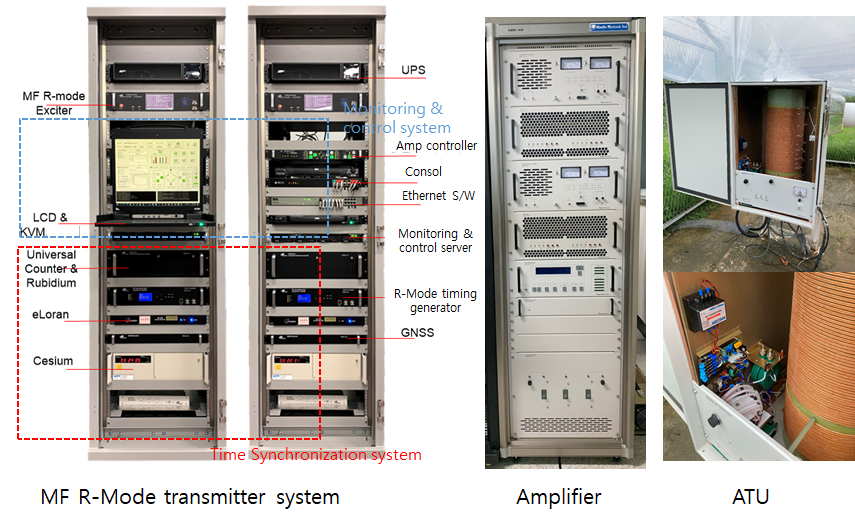
1. Korean R-Mode testbed configuration(Left) and differential R-Mode reference station (Right)

## Current Status of Mf R-Mode Testbed Development

The system configuration of the MF R-Mode transmitting station is shown in Figure 3. The red boxes indicate the parts that have been changed or added to the existing DGNSS system. The R-Mode RTCM generator for correction and integrity information transmission for MF R-Mode and the R-Mode time synchronization system have been added. The MSK modulator has been replaced by the Exciter for R-Mode signal generation and the high-power amplifier replaced for R-Mode as well. Additionally, a monitoring and control system for R-Mode transmitting system was added. Figure 4 shows the shape of the actual MF R-Mode system implemented. As of August 2021, the installation of Chungju and Eo-Cheong Island MF R-Mode transmitting stations has been completed, and two additional MF R-Mode transmitting stations are planned to be installed by October 2021.

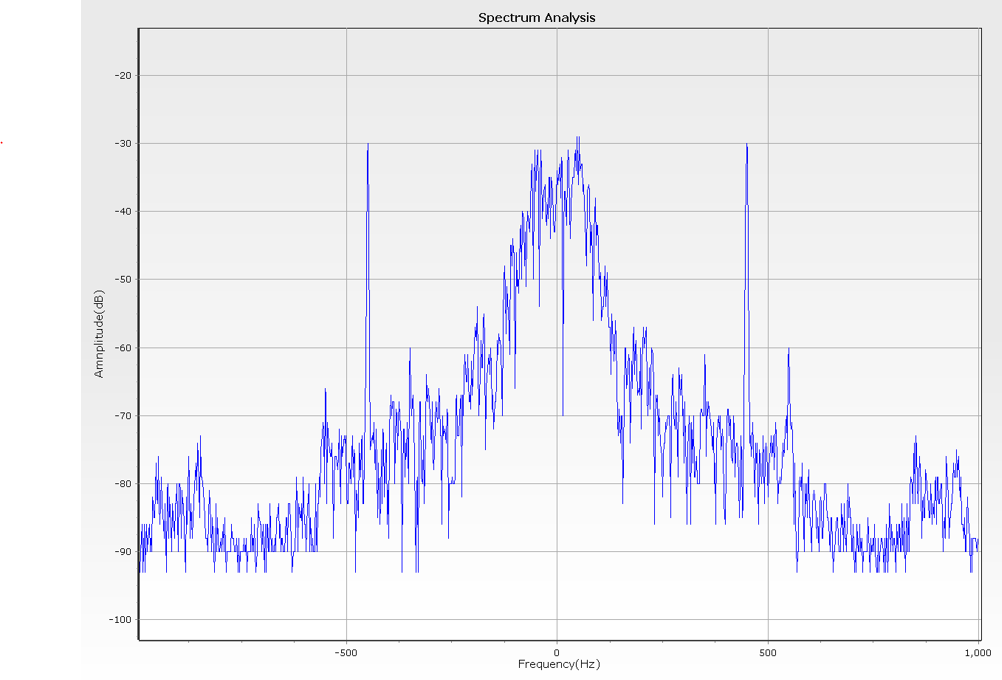
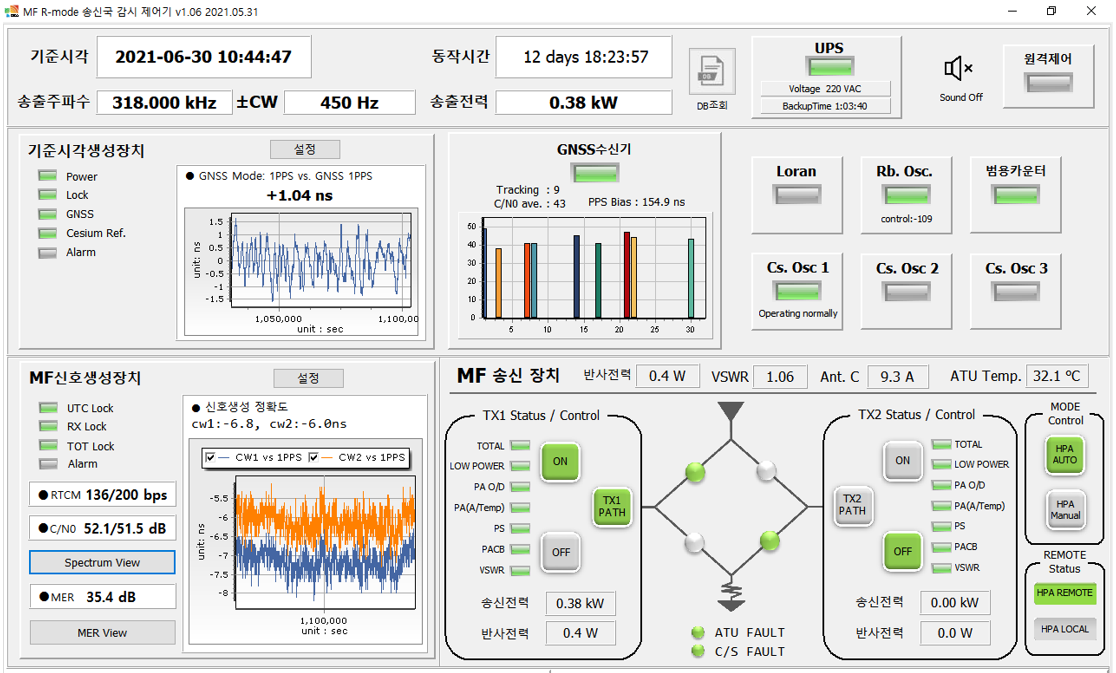


1. MF R-Mode transmitting system architecture



1. MF R-Mode system

Figure 5 shows the MF R-Mode signal performance from the transmitting station, confirmed by the monitoring and control system of the transmitting station. The results from the Chungju transmitting station showed that the CW signal is located at a frequency of ±450 Hz from the central frequency of 318 kHz. For the frequency spacing setting of the CW signal, we have two candidate groups, ±450 Hz and ±250 Hz, and we plan to select the appropriate frequency after considering the actual state of the service. The status information including the transmitter and its output signal can be checked, and it can be confirmed that the synchronization accuracy of the GNSS-based time synchronization system is maintained. The synchronization accuracy among the output signals, one of the main performance parameters of the MF R-Mode transmitting station, can also be confirmed, and the CW1 and CW2 signals are synchronized within a few ns.



1. MF R-Mode transmitter performance monitoring

# next step for the project

The TRACE project, implemented from 2020 to 2022, comprises two phases. In the first year (2020) of Phase 1, one testbed port was selected for the actual sea performance demonstration and the system design proceeded. In the second year (2021), the plan included fabricating the system and proceeding with testing and evaluation at the system unit. In the second half of the year, we will focus on the development of VDES R-Mode transmission and R-Mode receiver technologies. In the third year (Phase 2), we plan to integrate all systems and demonstrate their performance in the test port.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
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