Input paper: [[1]](#footnote-1) ENG17-3.1.2.5

Input paper for the following Committee(s): Purpose of paper:

**□** ARM X ENG **□** PAP X Input

**□** DTEC **□** VTS **□** Information

Agenda item [[2]](#footnote-2) n.n

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New RTCM Message Proposal for MF R-Mode

# Summary

## Purpose of the document

The medium frequency (MF) R-Mode RTCM navigation message was proposed in ENG15. The Republic of Korea (R.O.K) conducted the R-Mode testbed project, and during that process, additional RTCM messages for enhancing MF R-Mode performance were derived. This message include correction data for accuracy improvement and UDRE information for user integrity. This work was performed one of the item in intersessional meeting.

# Background

From April 2020 to September 2023, the R.O.K conducted the R-Mode testbed project. The architecture of the Korean R-Mode testbed consists of a transmitting station, differential R-Mode station, and monitoring station from the MF R-Mode perspective. The differential R-Mode station generates error correction near the users. Users can achieve more accurate positioning solution through the application of this correction. Additionally, the monitoring station monitors the performance of R-Mode signals and differential correction near the users and generates UDRE (User Differential Range Error) information. UDRE information is utilized by user receivers through techniques such as RAIM (Receiver Autonomous Integrity Monitoring) to ensure integrity in their navigation.

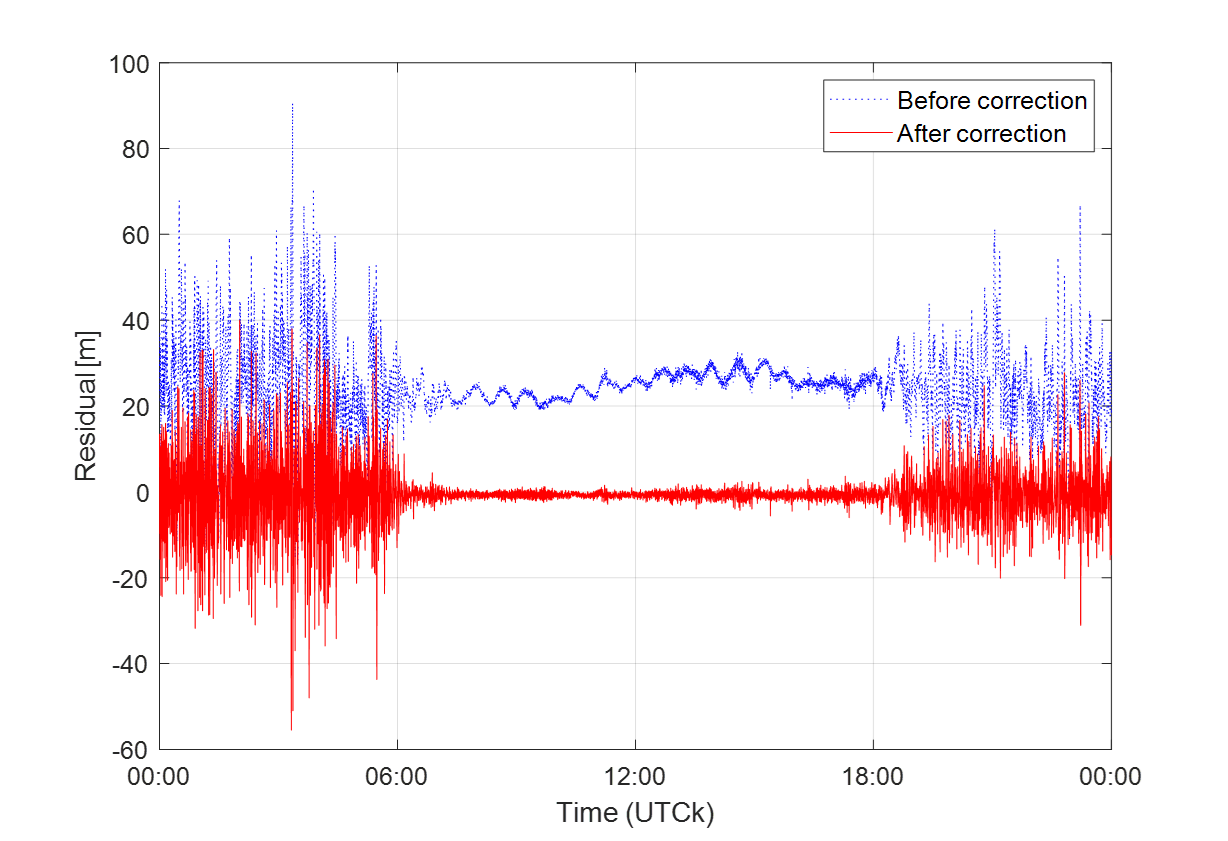
# Discussion

## MF R-Mode RTCM message for CW corrections and UDREs

The MF R-Mode utilizes ground wave in the vicinity of the 300 kHz frequency band, exhibiting propagation characteristics similar to the 100 kHz terrestrial radio navigation signal, eLoran. Therefore, it is possible to consider a propagation delay error model similar to those used in eLoran. In particular, ground wave are subject to variations in propagation time due to factors such as conductivity and weather, which can be compensated to enhance positioning accuracy.

In eLoran, the corrections which are temporal additional secondary factors (ASFs) is generated at dLoran station to compensate errors caused by time varying changes. Therefore, based on the experience gained from eLoran project, the R.O.K has added the differential R-Mode station to the MF R-Mode system to improve positioning accuracy. In addition, UDREs are generated and transmitted at the monitoring station near the differential R-Mode station so that users who receive the corrections and the UDREs can check the integrity.

Figure 1 shows the test results on a very short baseline, showing the residual before and after applying the differential corrections of the Eocheong signal observed at the monitoring station. It can be seen that measurement accuracy improves after applying the corrections. During the day, the change in measurement is slow and the variance is small, and at night, the change in measurement is fast and has a large variance due to the influence of sky-waves. Therefore, performance can be maintained even if corrections are sent slowly during the day. However, fast transmission of corrections is required to reduce the influence of sky-waves during the night.



1. Residual before and after applying the differential corrections

Considering the above matters, we propose a new Submessage 5 that includes corrections and UDREs. Submessage 5 is a message aimed at improving positioning accuracy and providing integrity information, and can be optionally applied depending on the system architecture. This message is requested to broadcast within a minute, and for better performance during night, it should be broadcast shortly than a minute. However, in order to not affect DGNSS RTCM message broadcasting, the R-Mode RTCM transmission period must be set to an optimal value according to the transmission period of each country.

1. MF R-Mode RTCM message for CW corrections and UDREs

|  |  |  |
| --- | --- | --- |
| Information | Part of R-Mode message | Minimum update rate |
| Differential R-Mode corrections\* | Submessage 5 | 1 / 1 min\*\* |

\* Optional message when you consider the correction data and the UDREs

\*\* Higher update rate is required to mitigate the sky wave effect during night-time

## Submessage 5: Differential R-Mode corrections and UDREs

The details of the proposed submessage 5 are shown in Table 2. Corrections and UDREs must be provided for lower CW and higher CW respectively. And since there may be multiple Differential R-Mode stations within the transmitting station coverage, Station ID information is also provided. Age of correction information is also provided to check the update time of corrections.

1. Content of R-Mode submessage 5: Differential R-Mode corrections and UDREs

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Number of bits | Scale factor and units | Range |
| Correction for lower CW | 12\* | 1 ns | ± 2,047 ns |
| Correction for higher CW | 12\* | 1 ns | ± 2,047 ns |
| UDRE for lower CW | 4 | TBD |  |
| UDRE for higher CW | *4* | TBD |  |
| Differential R-Mode station ID | 10 |  |  |
| Age of correction for lower CW | 3 | See the Table 3 |  |
| Age of correction for higher CW | 3 | See the Table 3 |  |

\* Parameters so indicated are two’s complement, with the sign bit (+ or -) occupying the Most Significant Bit (MSB).

**Correction for CWs**: Time varying correction data of signal propagation delay for each CW, generated at the Differential R-Mode station

**UDREs**: UDREs are calculated after applying MF R-Mode corrections for each CW at the monitoring station

**Differential R-Mode Station ID**: Station ID which generates the corrections

**Age of correction for CWs**: Indicating time since last each CW correction was updated

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1. R-Mode submessage 5: Differential R-Mode corrections and UDREs
2. Correction age indicator and values[1]

|  |  |
| --- | --- |
| Indicator | Correction age |
| 0 | < 6 minutes |
| 1 | 6-20 minutes |
| 2 | 20-60 minutes |
| *3* | 1-3 hours |
| 4 | 3-6 hours |
| 5 | 6-12 hours |
| 6 | 12-24 hours |
| 7 | > 24 hours |

# References

1. USCG Loran Supports Unit, “Loran Data Channel Communications using 9th Pulse Modulation, version 1.3, October 2006

# Action requested of the Committee

The Committee is requested to:

1. Note the information provided.
2. Discuss the proposal and include the information into the IALA Guideline on MF R-Mode signal structure and navigation message.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)