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

**□** ARM **X** ENG **□**PAP **□** Input

**□**ENAV **□**VTS **X** Information

Agenda item[[2]](#footnote-2) 3.1

Technical Domain / Task Number2 3.4

Working Group 3

Author(s) / Submitter(s) China MSA

**Test of Differential Loran Information Broadcast**

**Based on RBN**

# Summary

In recent years, China Maritime Safety Administration (CMSA) paid close attention to the development of e-Loran related technologies, and proposed the idea of establishing a RBN-based differential Loran C system using the resources of existing RBN-DGNSS system.

This paper introduces the experiment conducted by CMSA on broadcast of differential Loran C information via RBN stations, gives detailed technical parameters of the tests and concludes the results and future work to be done.

## Purpose of the document

The paper is intended to provide the ENG committee an overview of the test on RBN-based differential Loran C data broadcast system conducted by the CMSA.

## Related documents

None

# Background

The marine RBN-DGNSS system of China consists of 22 stations from north to south, with its signals covering major coastal ports, important waters and narrow waterways. It acts as a major system in providing positioning and navigational service for marine users within a range of 300 km offshore.

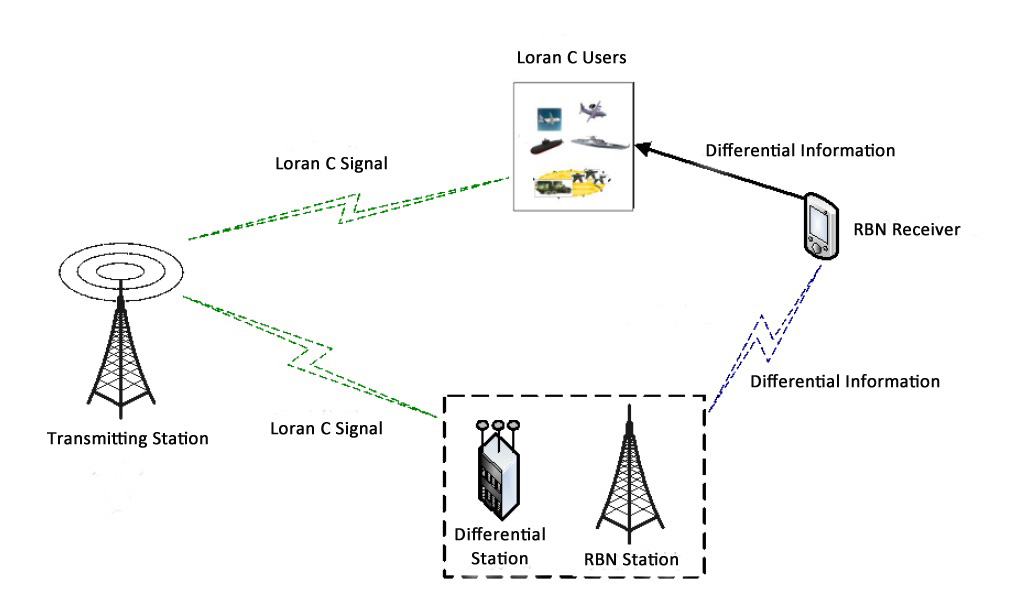
Although universally acknowledged as a potential backup and supplement to Global Navigation Satellite System (GNSS), Loran C has its shortcomings of low accuracy in both positioning and timing service. A differential Loran C system, based on above mentioned RBN-DGNSS, provides a solution to improve the positioning accuracy and availability of existing Loran-C system, enabling it a qualified GNSS backup system and effectively enhancing the resilience of coastal PNT (positioning, navigation, timing) system.

Based on the above consideration, China MSA conducted a series of tests on broadcast of differential Loran C information via RBN stations in 2019 to evaluate its performance in improving the positioning accuracy of Loran C. The test results will serve as technical reference for the future research and construction of coastal differential Loran C system based on RBN network.

# Discussion

## System structure

The test system was mainly composed of Loran C transmitting station, differential station, RBN communication links and user equipment. The process was designed as follows: the Loran C transmitting station transmits Loran C signals, and the differential station received and processed the signal to produce differential data, which was then broadcast via the RBN station. Marine users within the coverage received the differential information using their RBN receivers, which then sent the information to Loran C receiver. With the differential information, users can correct their positioning and timing information, thus to improve the accuracy of Loran C system.



*Figure 1: Structure of the test system*

## Test zones

Beitang RBN station in Tianjin was selected as the differential station in the tests, which was designed to receive Loran C signals from China North Sea Chain (GRI 7430). Figure 2 shows the positional relationship between Beitang RBN station and the three Loran C stations of China North Sea Chain. Although Beitang station was far away from Helong station, field test results showed that the signal was available and stable. The test lasted for 10 days, mainly conducted in Nanjiang Dock, Nandagang Dock and the adjacent waters within a range of 10-60 km from Beitang RBN station.



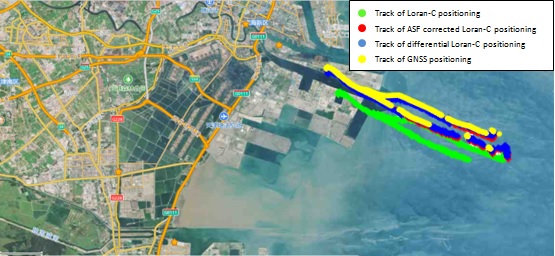
*Figure 2: Positional relationship of Beitang RBN station and Loran-C stations of North China Sea chain*

## Contents of the tests

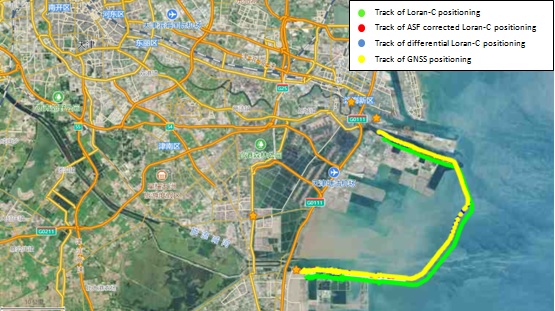
Tests were conducted to evaluate the basic performance of Loran C signals, performance of differential Loran C signals both at fixed-point and during navigation, performance of existing RBN-DGPS performance before and after the addition of differential Loran C data transmission. During the test at fixed-point, Nanjiang Dock was selected as a user position , which was 25.1km away from Beitang station.The tests during navigation were carried out four times on a buoy tender during its operations, covering a range of 10-60 km away from Beitang station.

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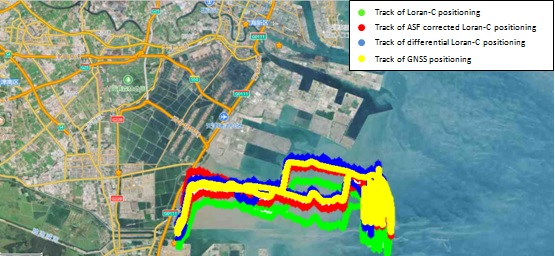
*Figure 3: Sailing track of the first test at sea*



*Figure 4: Sailing track of the second test at sea*



*Figure 5: Sailing track of the third test at sea*



*Figure 6: Sailing track of the fourth test at sea*

## Test Results

1. Basic performance test of Loran C signals

Although Tianjin Port was far away from Helong station of China North Sea Chain, the signal was available and stable, with its minimum field strength higher than 60dBμv and the signal-to-noise ratio (SNR) generally higher than -10dB, which basically met the requirements for differential application of Loran C signals.

1. Fixed-point test of differential Loran-C performance

Test results of differential Loran C performance at the fixed-point are shown in the following table:

|  |  |  |
| --- | --- | --- |
| **Differential range** | **Positioning accuracy（m）** | **Timing accuracy（ns）** |
| Same site | 18 | 8 |
| Different sites | 32 | 37 |

Table 1: Test results of differential Loran C performance at fixed point

1. Dynamic test of differential Loran performance during voyages

Test results of differential Loran C performance at ships under navigation are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Distance from shipborne user terminal to differential station (km)** | **d<30** | **30<d<40** | **40<d<50** | **50<d<60** | **60<d<63** |
| Positioning accuracy with original Loran C time difference（m） | 204 | 257 | 441 | 389 | 307 |
| Positioning accuracy after ASF correction of time difference（m） | 11 | 32 | 60 | 45 | 24 |
| Positioning accuracy after differential correction of time difference（m） | 6 | 27 | 12 | 7 | 10 |

Table 2: Main results of differential Loran C performance test during navigation

1. Comparison of RBN-DGNSS system performance before and after adding differential Loran data

Based on the tests of GNSS performance of the RBN-DGNSS system before and after adding broadcast of differential Loran C data, the relevant data were obtained as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Addition of differential Loran C data broadcast** | **Positioning accuracy（%）** | | | **Data age** |
| **≤1m** | **≤3m** | **≤5m** |
| Before | 100 | 100 | 100 | 11.95 |
| After | 100 | 100 | 100 | 12.70 |

Table 3: Comparison of RBN-DGNSS performance before and after adding differential Loran data

## Conclusion

It was the first time that RBN stations were used to broadcast differential Loran C information in real time in China. The test results showed:

1. The signals in Tianjin area satisfied the requirements for conduction of differential Loran C tests in terms of their field strength, SNR, ECD (envelope to circle difference), and time effectiveness, etc.;
2. The three sets of Loran C receivers used in the test had good performance consistency, and the trend of TOA-ASF value change has a good spatial-temporal correlation, which provided basic conditions for development of differential Loran C applications in this area;
3. By analyzing the monitored time difference, the differential value of time difference calculated under different broadcasting frequencies (1 minute, 5 minutes, 10 minutes) was obtained. After differential correction of time difference, the positioning accuracy of the Loran C system at a fixed point (25.1 kilometers away from the differential station) was better than 50m;
4. By analyzing the monitored TOA-ASF, the differential value of timing information calculated under different broadcasting frequencies (1 minute, 5 minutes, 10 minutes) was obtained. After differential correction, the timing accuracy of the differential Loran C system was within 50ns;
5. The addition of differential Loran C information broadcast at the RBN station has no obvious influence on the performance of the original RBN-DGPS system;
6. The tests conducted on ships under navigation verified that the solution of broadcasting differential Loran C information via RBN stations to improve the positioning accuracy of Loran C was feasible;
7. The positioning accuracy of the Loran C user terminal was effectively improved with the differential correction value broadcast by the differential station during the tests at sea from 10 to 60 kilometers away from the differential station. The positioning accuracy reached an average of 53 meters, with the best of 6.3 meters.

## Future Plan

The use of existing RBN-DGNSS system resources to build a differential Loran C system has the advantages of low investment, high cost-effectiveness, and rich experience in technical and operational management. It is an ideal and feasible solution for quickly and efficiently realizing GNSS backup capabilities. In the future, the following aspects need to be considered in the study and construction of the RBN-based differential Loran C system:

1. To improve the performance of satellite navigation reference equipment to ensure the continuous availability of high-precision positioning and timing data in all-time periods, and provide better reference data for subsequent data processing and accuracy analysis.
2. To conduct differential Loran C performance tests on a larger area for longer period to collect differential correction data of Loran C, study the correlation of differential Loran C information with time and space information, and verify the effective range and application effectiveness of differential Loran C.
3. To carry out researches on the related standards of broadcasting differential Loran C information via RBN stations.
4. To propose a feasible plan for upgrade of RBN stations to broadcast differential Loran C information, laying the technical foundation for the future construction of a national marine differential Loran C system based on 22 RBN stations.

# References

None

# Action requested of the CommitteE

1. The Committee is requested to note the information provided in the input paper.
2. The Committee is requested to explore the feasibility of the scheme under the tasks of “Review of existing DGNSS infrastructure and provision of guidance for current system” and “Monitor developments in GNSS, DGNSS, radar, resilient PNT, e-Pelorus, terrestrial systems, R-Mode, inertial and any other relevant areas etc.”

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