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Technical Domain / Task Number 2 Radionavigation services

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Development of Advanced eLORAN Technology in the Republic of Korea

# Summary

## Purpose of the document

This input contains the research and development of the advanced eLoran technology conducted in Republic of Korea. The results of this research are expected to serve as a reference when developing new guidelines for future resilient PNT system and its implementation.

## Related documents

* IALA Recommendation R0129, GNSS Vulnerability and Mitigation Measures, Edtion 3.1, December 2012.
* IALA Guideline G1125, The Technical Approach to Establishing a Maritime eLORAN Service, June 2017.

# Background

The Republic of Korea (ROK) is making efforts to set up a backup navigation system to provide resilient Position, Navigation, and Timing (PNT) information, which is a critical national infrastructure resource used across various sectors, including finance, energy, and transportation, in both public and private domains. However, since it relies entirely on the Global Navigation Satellite System (GNSS), represented by the Global Positioning System (GPS), disruptions or interference with satellite navigation signals could cause significant damage across industries. As an alternative, the Ministry of Oceans and Fisheries (MOF) of the Republic of Korea, in collaboration with the Korea Research Institute of Ships and Ocean Engineering (KRISO), has developed a ground-based PNT system known as enhanced Long Range Navigation (eLoran). This system can counteract radio interference, such as signal jamming and spoofing, in satellite navigation systems. Through this development, the potential of eLoran has been confirmed not only as a backup for GNSS but also as a key infrastructure for the utilization of PNT information in essential national services.

Building on its successful development, the MOF plans to implement a project from 2024 to 2027 to enhance the functionality and performance of the existing eLoran technology. The final goal is to establish a national PNT system that can be applied not only to the maritime sector but also to various fields, including public safety and socio-economic sectors.

This paper aims to introduce the technological developments related to the enhancement of the eLoran system to provide resilient PNT information in the event of satellite navigation system failures or similar disruptions. It will cover advancements in improving eLoran’s timing reference, increasing transmitter output, enhancing positioning accuracy, expanding wide-area coverage, and extending service areas (maritime, aviation, and inland), as well as potential future applications of the system.

# Discussion

## Advanced process of Terrestrial Radionavigation System (eLoran)

The terrestrial radionavigation system, eLoran, determines a user’s position by receiving high-power Loran pulse signals of 100 kHz transmitted from ground stations. In South Korea, the existing Loran-C system was upgraded to the eLoran system (from May 2016 to December 2020), improving positioning accuracy from approximately 400 meters to within 20 meters, thereby confirming its potential as a backup navigation system for GPS.

Based on this potential, KRISO is working to further enhance the functionality and performance of eLoran to provide a more stable and extensive terrestrial radionavigation service. The development stages of the terrestrial radionavigation system (eLoran) can be categorized into three phases: the existing Loran-C, the current eLoran, and the advanced eLoran (A-eLORAN) systems. A comparison of these phases based on user position determination, monitoring and reference stations, correction maps, correction information delivery methods, positioning accuracy, and the type of information provided is summarized in Table 1.

1. Development Stages of the Terrestrial Radionavigation System (eLoran)

|  |  |  |  |
| --- | --- | --- | --- |
| Category | LORAN-C (Legacy) | eLoran (Current) | A-eLORAN (Advanced) |
| Transmitting Signal | 3 transmitters favorable for measurement | Signals from all available transmitters | Signals from all available transmitters |
| monitoring & reference station | Manual error adjustment at the central control center | Differential eLoran  station | Reference station |
| Position determination | TDOA: Time Difference Of Arrival | ToA: Time of Arrival | ToA: Time of Arrival |
| Correction Map | - | ASF  (Manually measured, local) | ASF  (Based on correction model, wide area) |
| Data Channel | - | LDC  (50bps) | LDC+  (100bps, encrypted) |
| Position accuracy | 460m | 8-20m | 10m |
| Service | P/N | P/N/T&D | P/N/T&D+ |

Notes:

ASF: Additional Secondary Factor

P/N/T&D+: Enhanced Positioning, Navigation, Timing, and Data

## Development of Advanced eLoran system

The development of advanced eLoran technology aims to fully meet the performance criteria for transmission power (W), positioning accuracy (P), integrity support (N), time synchronization (T), and data provision (D) by enhancing the eLoran transmission system and developing a wide-area augmentation system, along with field testing, to provide a stable nationwide PNT service for ground-based navigation systems. Specifically, the output power of the eLoran transmitter will be increased from the current 50kW to over 150kW, and positioning accuracy will be improved from within 20 meters to within 10 meters. Additionally, the time synchronization accuracy of the transmission stations will be enhanced from 50ns to 10ns, and the data transmission rate will be increased, including the implementation of data encryption.



￭ Concept of A-eLORAN system

The A-eLORAN system consists of a transmitter system based on new signal specifications, a wide-area augmentation system interfaced with integrated monitoring systems, and a performance verification platform for Resilient PNT. The overall system configuration is shown in Figure 1.

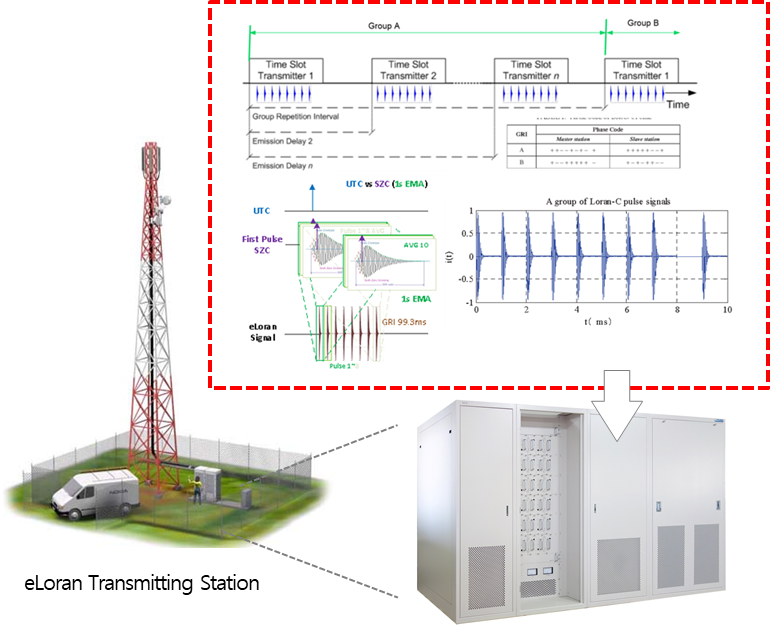


Figure 1 Entire configuration of A-eLORAN system.

￭ Transmitting Station Advancement

To enhance the time synchronization performance of advanced eLoran system in the event of GPS signal interference, two-way time transfer technology is being developed. To enhance the time synchronization performance of terrestrial radionavigation systems in the event of GPS signal interference, two-way time transfer technology is being developed. Additionally, a high-power transmitter of 150kW or higher, compliant with the existing 137-meter TLM antenna specifications, is being developed to expand the coverage of eLoran signals and ensure operational efficiency. Furthermore, new signal specifications that are robust and efficient, while remaining compatible with existing eLoran pulse specifications, are being developed.

The demodulation and modulation methods for LDC (Low Data Rate Communications) are also being advanced to improve effective data transmission rates, and new techniques are being explored to enable encrypted and stable signal reception.

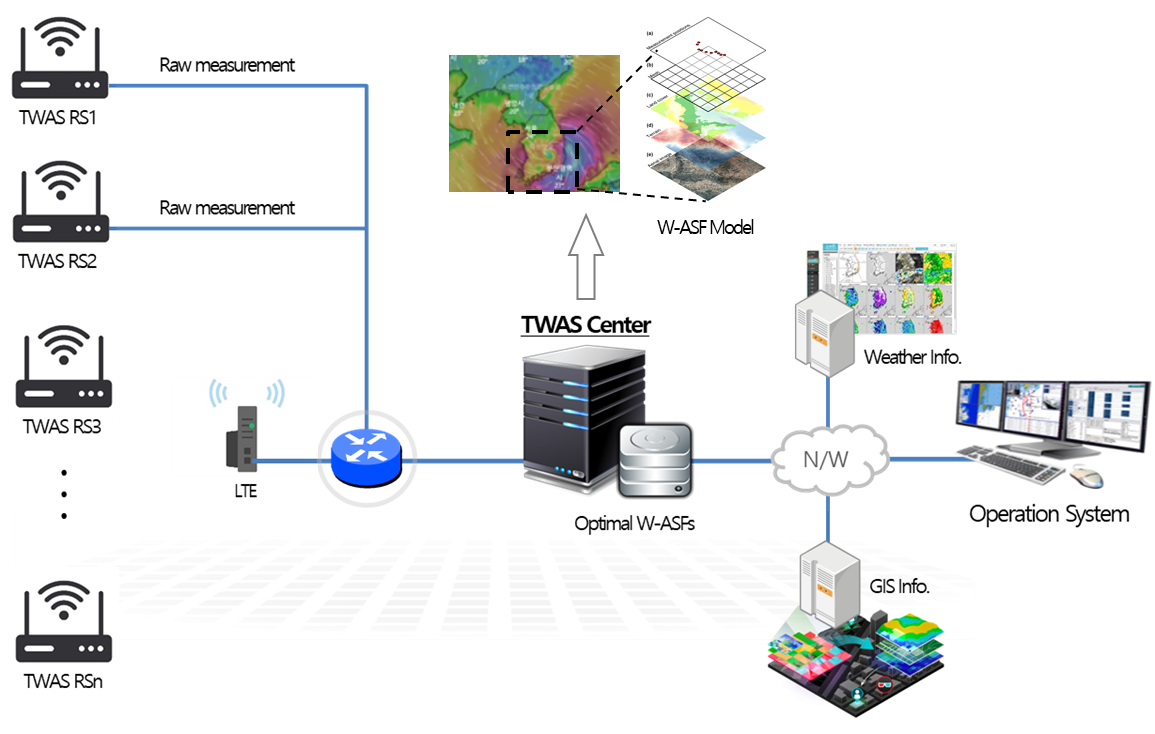


1. Advanced eLoran transmission station

￭ Terrestrial Wide Area Augmentation System

The Terrestrial Wide area Augmentation System (TWAS) is a technology designed to enhance positioning accuracy by developing an intelligent, learning-based, ground-wide correction model. This model generates wide-area correction information, which is then provided to users through an integrated monitoring network. The TWAS technology reduces the existing maritime positioning error from 20 meters to 10 meters and enables nationwide service coverage. First, an intelligent wide-area correction model is designed to enhance the positioning performance of the existing ground-based navigation system, improve the efficiency of correction map measurements, and expand service coverage. Next, a network is established for integrated monitoring and information processing to efficiently control and monitor the signals of transmission stations. The system includes the development of an integrated operation system for monitoring transmission stations and reference stations, an integrated correction model, and navigation information processing, which are all implemented in the field. Through this approach, the digitization and efficiency of correction map data measurement can be achieved, and by utilizing available communication links\*, diversification of correction data provision and the expansion of service coverage can be realized.

\* Communication links refer to the various means by which data is transmitted between stations and users.



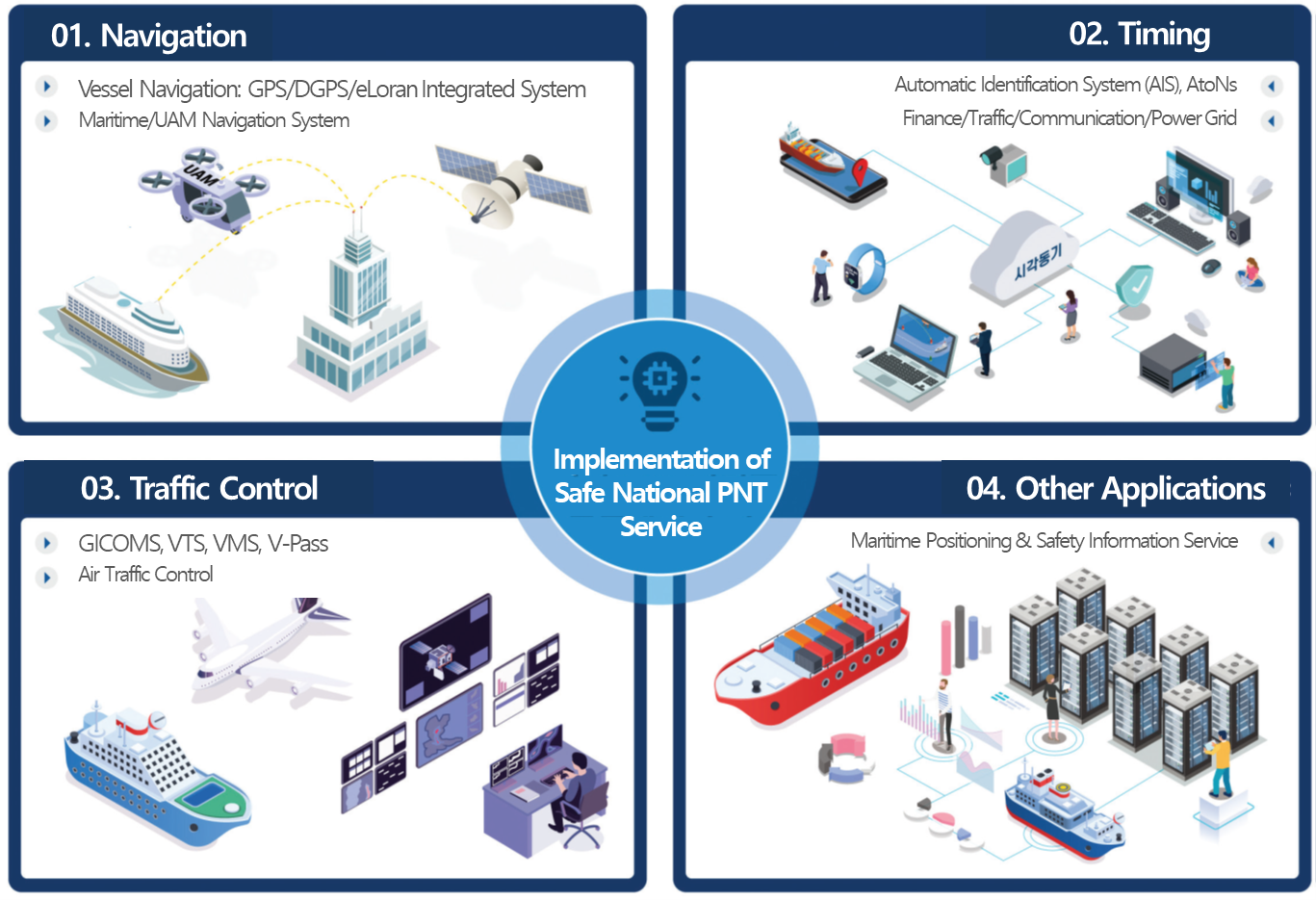
1. Concept of terrestrial wide area augmentation system (TWAS)

￭ Performance Verification Platform for Resilient PNT

The development of Performance Verification Platform Technology for Resilient PNT involves creating an integrated performance verification system that can test and validate the functionality and performance of ground-based PNT equipment required during the research, development, and commercialization stages. This system is designed to support testing and verification of new and existing signal standards, as well as to predict the signal quality and performance of future eLoran transmission stations under various scenarios and signal environments.

## Applications & Expectations

With the development of advanced eLoran system, the future marine navigation service system will integrate satellite navigation systems and terrestrial radionavigation systems to provide a safer and more resilient PNT service in case of signal anomalies. By advancing the functionality and performance of terrestrial radionavigation systems, the technology is expected to support commercialization and the establishment of a nationwide service network, enabling stable PNT services in navigation (maritime and aviation) and time synchronization fields. In the field of navigation, this system is expected to serve as a secure alternative navigation solution, especially for autonomous vehicles such as autonomous ships (by 2030) and Urban Air Mobility (UAM, by 2030), considering the geographical characteristics of the Korean Peninsula. Additionally, in the field of time synchronization, it can be utilized as a national time synchronization source to improve the reliability of critical national infrastructures, such as finance, broadcasting, power, and communications (land and maritime). It can be particularly utilized as a national time synchronization source for public safety, socio-economic sectors, and critical infrastructure such as the national maritime disaster network, Automatic Identification System (AIS), maritime communication equipment, and financial, power grid, and telecommunications systems. Additionally, the ground-based PNT performance verification platform can be used for defining new standards and technical specifications for ground-based navigation equipment, developing procedures and guidelines for navigation equipment, and conducting testing, certification, and conformity assessments of ground-based PNT equipment under various signal environment scenarios. By building a PNT ecosystem that integrates ground-based and satellite-based navigation systems, it is expected to establish a robust national disaster PNT system and enhance public safety as well as socio-economic functions.



1. Applications of terrestrial radio navigation system.

# Action requested of the Committee

The Committee is requested to consider the development of advanced eLoran technology in the Republic of Korea, and take action as appropriate.

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