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Author(s) / Submitter(s) CHINA MSA/GMU…

Proposals on formulating technical standards for Marine Electronic Fence

# Summary

This document describes the development status of Marine Electronic Fence (MEF), including its system architecture, working principle and application cases, and analyses the irreplaceable role of Marine Electronic Fence in port waters, offshore structures, bridge waters and offshore construction areas, as well as the inevitable needs of future aids to navigation development.

Given the term of reference of IALA and the trend of future aids to navigation technology development, this paper addresses the necessity and urgency of technical and management standardization of Marine Electronic Fence, and puts forward suggestions on developing Guidelines on the application of Marine Electronic Fence.

## Purpose of the document

To share China's experience in developing and applying MEF services in several scenarios using electronic navigation technologies (AIS, VHF and virtual Aton, etc.).

And invite the ARM committee to consider the necessity of developing Guidelines on the application of Marine Electronic Fence.

## Related documents

1. IMO CIRC\MSC\01\MSC.1-CIRC.1610 Initial Descriptions of Maritime Services in The Context Of E-Navigation
2. IALA Recommendation R1001 The IALA Maritime Buoyage System
3. IALA Recommendation R1026 The Use of the Automatic Identification System AIS in Marine Aids to Navigation-Service
4. IALA Recommendation R0143 Provision of Virtual Aids to Navigation
5. IALA Guideline G1081 Provision of Virtual Aids to Navigation
6. IALA Recommendation O-113 The Marking of Fixed Bridges and Other Structures Over Navigable Waterways
7. IALA Recommendation R0139 on Marking of Man-made Offshore Structures）
8. IALA Recommendation R0148 The Need To Implement Regional E-Navigation Solutions Based On International Standards
9. IALA Guideline R1089 Provision of Vessel Traffic Services.

# Background

In recent years, the increasing of offshore projects such as wind farms, submarine pipelines, sea crossing bridges, offshore pastures, oil/gas exploitation rigs, etc, has significantly affected the planning, constructing and using of nearby navigable waters, and certainly impact on ships’ safe navigation and fishing activities, which also bring out new challenges on governing of maritime safety and environment pollution prevention.

In order to cope with these arising marine safety challenges, from 2018, CHINA MSA has organized stakeholders to carry out a series MEF application and research trials in typical coastal ports, offshore structures, bridge waters and some offshore activity areas based on the integration of radar, AIS, CCTV, VHF, VTS and other sensing information acquisition technologies. As a comprehensive aids to navigational service system, the MEF could form a virtual and vessel visible safety warning zone, which has functions that cannot be provided by conventional markers, such as:

1. Automatically record and track passing ships by using intelligent sensing technology within a designated zone, as well as analyse ships’ situation and actively transmitting risk avoidance and navigation assistance information to ships;
2. Automatically identify and roundly monitor nearby ships to acquire their real-time position and historical track data and other dynamic information at any time.

While the MEF meets the needs of users, there are also some technical problems arising, such as occupying the VHF dedicated channel, complicating the ship-to-ship communication, overloading AIS channel caused by the technical limitations of AIS itself, etc. And some management risks also came out when privately constructing or using MEF. Therefore, it is necessary to formulate the standard of the construction, utilization and management of MEF system.

International documents such as CIRC\MSC\01\MSC.1-CIRC.1610, IALA Guideline 1089 and IMO A.857(20), etc, have provided technical guidance on E-Navigation, Vessel Traffic Service (VTS), Information Service (INS), Traffic Organization Service (TOS) and Navigational Assistance Service (NAS), have also laid a good foundation of application and further development of MEF.

# Discussion

## Composition and function of MEF

The MEF system is a large-scale intelligent service system for marine aids to navigation, which integrates electronic chart system, AIS, radar, audible and visual early-warning, CCTV and other functional modules. It has functions that cannot be provided by conventional marine aids to navigation, and its main workflow is as follows:

1. to delineate the safety areas on the electronic chart, set early-warning areas with different levels and trigger conditions, and analyse the type, position, heading, speed and other information of ships through their AIS messages;
2. to analyse the navigating behaviours of those ships by using the intelligent perception judgment algorithm of navigation risks in real time, with making digital information exchange through software platform, radar and CCTV;
3. to send corresponding early-warning message to the related ships according to different levels of navigation risks when navigation risks from those ships;
4. to send out alarm signals to ships entering the areas in combination with the light of visual aids and the sound of audible aids, which realizes the functions of intelligent monitoring and auxiliary decision-making in the VTS-controlled waters.



1. Workflow of Marine MEF

The MEF system concludes two parts of front-end and back-end. the Front-end is the equipment installed on the site, which can realize the functions of information collection, data processing, and message transmission, while back-end is mainly the background data centre, which completes data storage, transmission (server) and centralized management (software management platform).

1. Information collection: Record and collect the AIS information of ships entering the area of MEF by using AIS modules, monitor the ships’ navigation track in the designated area in real time, and send it to the background server in real time through the communication module.
2. Data processing: When the ship enters the virtual area set by the MEF, the ship’s trend intelligent judgment module is used to analyse and process the collected ship's AIS information, judge the ship's navigating situation, and calculate data with the ship's current speed, heading, and the distance to the dangerous area, predict the risk of ships sailing in the current state, and give processing result.
3. Early-warning message transmission: According to the result gave by the data processing unit, it sends an early-warning signal to the ship through the sound, light and radio early-warning modules, and sends the signal to the background server through the communication module.
4. The background data centre: The data centre includes servers and management platform software, which plays the role of information storage and transmission. In the management platform software, it can view the navigating situations, alarm records, system telemetry information of ships in the corresponding supervision areas, and can also remotely set the system, modify alarm information, areas, etc. The supervision function can be set to prohibit anchorage, prohibit entry or off-course reminder, etc.

## Early-warning of MEF

### Main early-warning mods

1. Alarm with the light of visual aids: To set the alarm light, we can use one or more beams such as laser lights and spotlights that work synchronously. The color of the light is yellow and the characteristic of light is consistent with the physical marine aids to navigation on cordons. If there’s no physical aids, it can be set according to the characteristic of MEF and the requirements of The IALA Maritime Buoyage System. The maximum effect of light should not be greater than the range of the third-level warning area.
2. Early-warning with audible signal: The audible alarm shall be through one or more foghorns working synchronously, and its characteristic of sounding shall be Morse code signal U (··—). The period shall be 30s and the minimum duration of short sound shall be 0.75s. In addition, the range of sound hearing should not be too large, generally 0.25 n mile to 2 n mile.
3. Early- warning with AIS short message: In order to avoid a large number of AIS short messages occupying the information channel and affecting the reliability of the AIS network, it is usually only used in situations where extremely important information needs to be sent, such as waterways, weather, management instructions, and lockage scheduling.
4. Early-warning by graphically displayed on the electronic chart: It is graphically displayed on the Electronic Chart Display and Information System (ECDIS), Electronic Chart Systems (ECS), PPUs and radar equipment, which conform to the latest standards of IMO, IEC and ITU, providing detailed text information.
5. Early-warning with mobile phone call and message.

### Early-warning settings

1. Based on the actual needs, the system set cordons with the first-level, second-level and third-level. There is the supervision area from the outermost third-level cordon (guard circle). Ships entering the third-level supervision area will receive a safe navigation prompt message from the system. The second-level cordon (guard circle) in the middle is an early-warning area, and the system will give an early warning to ships entering the warning area that are at risk of collision. The innermost first-level cordon (guard circle) is a warning area, and the system will give an alarm for safe navigation to ships entering this area.
2. When a ship enters the warning area of MEF, the system can give a navigating alarm to the ship through AIS short message, light and sound signal. In waters with better conditions of public network such as offshore, the system will send message to the mobile phone of related personnel of the ship through short messaging service in mobile phone, except for broadcasting warning message by AIS short message.
3. All system-triggered alarms are turned on when the ship enters and automatically turned off when the ship leaves. At the same time, all of information will be uploaded to the background system in order that supervisors can do statistical analysis about the data information of ship’s navigation.

## Advantages of MEF

As an integrated active early warning navigation aid service system, compared with traditional warning signs, it does not occupy navigating waters, does not affect the visual lookout, and avoids problems such as difficult installation and construction of physical warning signs, high costs and difficult maintenance. It is complementary to the projects of marine aids to navigation, and it is also a supplement to the traditional projects of marine aids to navigation in the field of warning and driving away ships which enter designated waters by mistake. It plays a role in jointly guaranteeing the safety of construction and ships.

1. Integrated data collection: It collects on-site information based on radar, AIS, CCTV and other sensors, which achieves fully monitored.
2. Timely discovering targets and early warning: Arm with VHF, sound and light alarm, AIS and other equipment, it can provide timely early-warning when a ship enters a dangerous early-warning area.
3. Unified dispatches: Integrate communication systems such as VHF, single-sideband short-wave radio, IP phone, mobile phone, etc., to realize seamless IP-based dispatch and unified communication of monitoring centers, patrol boats, office networks and other jobs, and to realize automatic calling to early-warning ships.
4. Integrated display: It realizes the functions of electronic chart display platform, three-dimensional visual display platform, intelligent monitoring of protected waters and auxiliary decision-making, provides a basic data platform for monitoring of protected waters and emergency command in distress, and builds a highly intuitive and intelligent monitoring three-dimensional geographic information system.

## Typical Application Scenarios

### Offshore structures

In the restricted area of offshore structures, following the three-level alarm mode, MEF cordons with function of three-level early-warning can be set up outside structures areas. According to AIS track of ship and other navigation conditions, requirements in the waters where it is located, the three levels warning areas can be determined after comprehensive analysis by professionals.

### Safety warning for specific zone

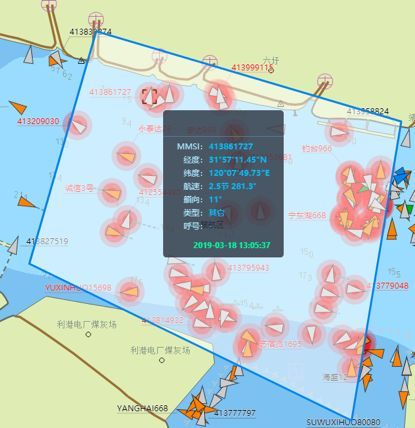
1. Send early-warning to all ships in designated zone

Before bad weather occurs, the MEF system can be used to send AIS safety reminder messages to all ships entering the designated waters, so that the ships can keep abreast of the weather conditions in the waters and take safety measures in time.

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1. Layout of MEF with three levels early-warning for offshore structures
2. Sending special warning messages to ships in key waters

Important facilities and key waters are subject to specific navigation conditions. After the delineating these key waters by MEF system, it can automatically send relevant early warning information to ships entering the designated waters, remind the on-duty personnel of VTS centre to judge the ship's movement in time and improve the supervision effect.

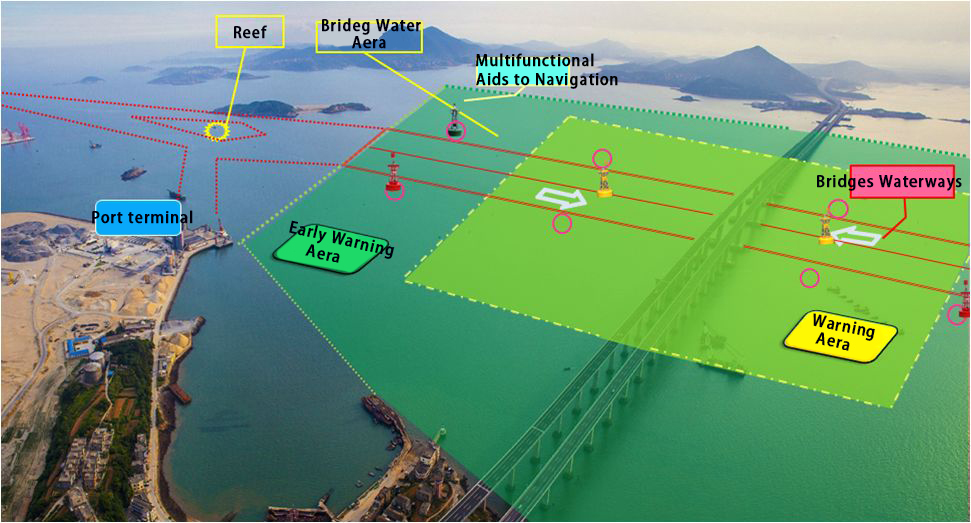


1. Delineating MEF for harbour district.

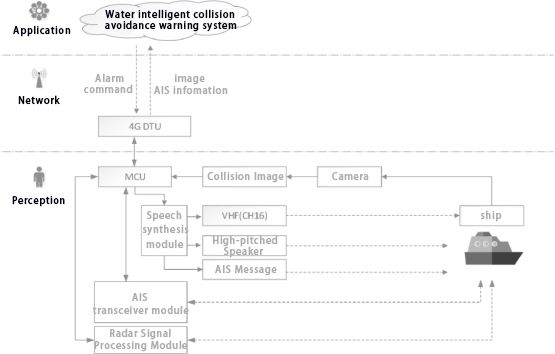


1. Marine electronic chart terminal of a ship
2. Display of Bridge Water

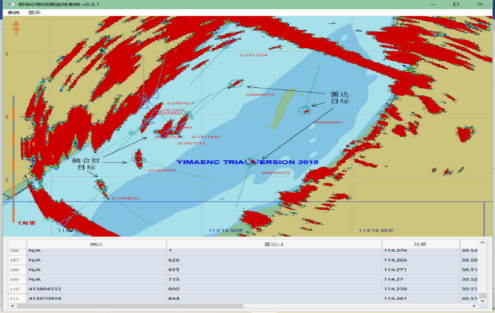
Delineate a multi-level early-warning circle for the bridge, and obtain navigational dynamic information such as position coordinates, speed, and heading of the ships near the bridge through comprehensive information from sensor terminals, radar and video. Then the system will assess the ships’ risk level as well as send control commands to alarm terminal, so that the terminal executes commands, offering early-warning for protecting ships from collision. The setting of first-level cordon for those bridges in construction period should be same as the setting of real marine aids to navigation in warning areas of constructing bridges. The setting of first-level warning area for the bridges in operation period should also be consistent with the real marine aids to navigation in conservation areas or prohibited areas on the basis of the bridge navigating management requirements. In addition, the setting of the second-level and third-level conservation areas for bridges should be based on the navigating conditions of bridge areas. Generally speaking, the third-level conservation area is set at departure point of safe guiding channel, which is shown in Figure 5.



1. Layout diagram of setting conservation areas of bridge

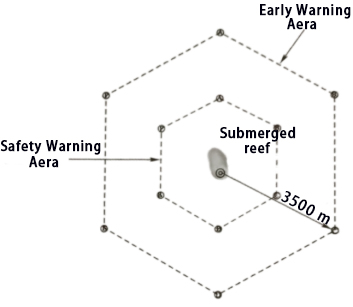


1. The workflow of early-warning of bridge



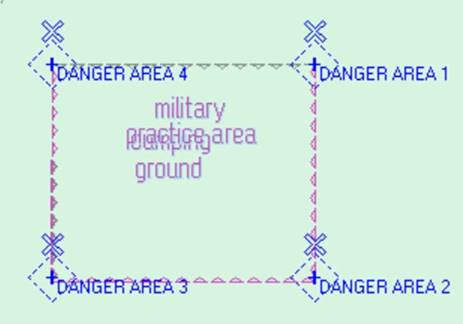
1. The Integrated display of AIS and radar signals in bridge areas.
2. Identification of Shallows and reefs

In order to warn passing ships pay attention to avoiding shallows and reefs, the restricted areas can be delineated by taking real marine aids to navigation into consideration. The MEF with second-level warning can be set in high-risk waters where the conditions of weather, terrain or hydrology are too bad to set real marine aids to navigation. The setting of second-level cordon should be determined in accordance with the mapping size of the shallows and reefs, as well as the environmental conditions of waters to navigation, as shown in Figure 8.



1. Layout diagram of obstacles like shallows and reefs.
2. Marking Maritime activities

When there are operations, structures, military actions, accidents, shipwrecks and other situations at sea, MEF can be set up to temporarily restrict navigating, as shown in Figure 9.



1. Layout diagram of temporary restricted areas.

## The necessity of formulating standard for MEF

### Problems concerned on the application of MEF

1. MEF has not constructed and released in accordance with the technical and management requirements of navigation aids even if it has played the functions of marine aids to navigation and occupy navigational resources;
2. Issued from setting of VHF broadcasting range and occupation of channel resources: the VHF broadcasting range of some MEF systems generally exceeds the range of MEF itself, which lead to ships that outside the range can also receive relevant alarm information, which interfere with the navigation of other ships. In addition, in the sea area with few ships, the problem of MEF occupying VHF resources is not so prominent, but in the area with dense ships, the occupation of VHF resources is very prominent, which may interfere with the communication required by sudden accidents and have an adverse impact.
3. Problems of audible and visual alarm: As for audible and visual alarm, some equipments work through directional horn and directional searchlight, while some equipments work through flash light and foghorn. Inconsistent forms and requirements make different effect. Some audible and visual alarms even directly illuminate the ship bridge by light to warn ships, resulting in light pollution.
4. Lack of professional supervision and approval units: Since there are no professional supervision and approval units, at present, most MEFs are constructed and put into use by enterprises or units without administrative permission. There are issues that construction standards is inconsistent, the reliability and perfection of the system have not been fully demonstrated by experiments and system operation is not standardized and so on.

### The importance of developing construction standard for MEF

1. The comprehensive application of various navigation aid systems (such as AIS, VHF, VTS, ECDIS and CCTV) has become the inevitable needs of the shipping industry and the development direction of navigation aid intelligence. The MEF is only the achievement of the initial stage of the comprehensive application of these systems, with broad application prospects. It is necessary to have relevant technologies and management standards to standardize its application and development, coordinate and solve problems in the process of development.
2. Due to different offshore service requirements, the owner has developed MEFs with different functions. In the construction process, due to the lack of relevant technical guidance documents, the technical performance and application effect of the built MEF system are different.
3. For the existing mature offshore systems, such as electronic chart system, VTS system, AIS system, VHF system, CCTV system, etc., through continuous research and improvement, perfect construction technical standards have been formed. However, how to make the technology application of these systems more intelligent and integrated on board, on shore and between ship and shore needs to review and improve these technical standards from the perspective of new application requirements.
4. MEF integrates the application of these systems and faces the challenge of standardization. The existing standard documents only guide the construction and management of the corresponding applicable systems. For the new technical problems after the application and integration of different systems (as described in 3.7.1 of this document), it is also necessary to have a globally unified construction and management standard, so that all national authorities, various stakeholders can construct and manage a globally coordinated and unified MEF system in accordance with the standard.

## New Guideline development

When developing new guidelines for the MEF, the following technical and management elements shall be particularly taken into account:

* + Setting principle of MEF area rules;
  + Performance requirements;
  + Integration of AIS, VHF, ECDIS, VTS and other different systems;
  + VHF channel broadcasting standard;
  + Audible and visual alarm standard;
  + ASM broadcasting standard;
  + Reliability, completeness and monitoring standard of MEF system;
  + Management requirements of national authorities.

# References

N/A

# Action requested of the Committee

The Committee is invited to note the above information and consider the necessity of developing Guidelines on the application of Marine Electronic Fence.

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