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

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Agenda item [[2]](#footnote-2) 3.2

Technical Domain / Task Number 2 …………………………………

Author(s) / Submitter(s) …China MSA………………

Application of Bridge Collision Prevention Warning System in China

# Summary

As the scale of man-made structures such as offshore wind farms and cross-sea bridges continue to expand, the existing visual physical aids to navigation can no longer provide effective collision avoidance warning for ships in time (collision here mainly refers to the collision between ships and structures), which leads to the increase of navigation safety risk of water in the vicinity of man-made structures.

In addition to the traditional visual physical AtoN used to mark man-made structures in navigable waters, China has widely adopted electronic technology means as supplemental and enhanced safety measure in many cross-sea bridges and offshore wind farms to give early collision warning, which helps navigators to improve situational awareness and ensure the safety of both ship’s navigation and buildings.

A Bridge Collision Prevention Warning System(BCPWS) was developed as the mentioned electronic technology means which had been applicated in Hong Kong-Zhuhai-Macao Bridge(HZM Bridge) to send timely warning to shore-base and ships of entering the bridge zone, and it is particularly effective when visibility is poor.

## Purpose of the document

China MSA is willing to share experience of utilizing advanced technology with IALA members in Marking of Fixed Bridges Over Navigable Waterways, and hope this information could be a valuable reference in developing or revising relevant guidelines.

## Related documents

IALA Recommendation R-0139 on Marking of Man-made Offshore Structures

IALA new Guideline GXXXX on Marking of Man-made Offshore Structures

IALA Recommendation O-113 The Marking of Fixed Bridges and Other Structures Over Navigable Waterways

# Background

Prior to ARM13, it was suggested that Recommendation O-113 The Marking of Fixed Bridges and Other Structures Over Navigable Waterways was brought in to the revised R0139 Recommendation and associated guidelines. However, it was discussed at ARM13 but not advanced due to time limitation. China MSA therefore share some experience of utilizing advanced electronic technology regarding this issue, and hope this would be useful in relevant issues’ consideration.

# Discussion

## Hong Kong-Zhuhai-Macao Bridge

### **Overview of the HZM Bridge**

*figure 1 Layout Plan of Main Bridge*

The Hong Kong–Zhuhai–Macau Bridge is a 55-kilometre bridge–tunnel system consisting of a series of three cable-stayed bridges, an undersea tunnel, and four artificial islands. It is both the longest sea crossing and the longest open-sea fixed link in the world. The HZMB spans the Lingding Bay and Jiuzhou channels, connecting Hong Kong, Macau, and Zhuhai—three major cities on the Pearl River Delta.

### **Navigation circumstance**

Four navigable channels were designed for ships crossing the Bridge: Jiuzhou Port Channel, Jianghai Channel, Qingzhou Channel and the channel between east and west artificial islands.

Jiuzhou Bridge is a 5-span continuous cable-stayed bridge with double towers and single cable surface steel and concrete composite beams. Two navigable holes was set, with a clearance height of 24.5 meters and a horizontal clearance of 173 meters, and a designed navigable tonnage of 5,000 tons.

*figure 2 the bridge over Jiuzhou Port Channel*

Jianghai Bridge is a cable-stayed bridge with a central single cable surface and three towers of steel box girder. The bridge is equipped with one navigable hole with a clearance height of 40 meters, a horizontal clearance of 210 meters, and a designed navigable tonnage of 10,000 tons.

*figure 3 the bridge over Jianghai Channel*



Qingzhou Bridge is a cable-stayed bridge of steel box girder with two towers and two cable faces. It is the largest span bridge in the HZMB. The bridge is equipped with one navigable hole with a clearance height of 42 meters and a horizontal clearance of 318 meters, and a designed navigable tonnage of 10,000 tons.  
Between those two artificial islands, an immersed tunnel with a length of 6.7 km was built in order to reserve the main navigational channel for 300 thousand tons oil tankers and avoid affecting the normal take-off and landing of aircrafts at the Hongkong airport.

*figure 4 the bridge over Qingzhou Channel*

## Traditional Aton Planning

Traditional Atons still remain an important foundation for ensuring the safety of navigation, an Aton network which consist of 53 special marks, 16 lateral marks and 50 fixed beacons was deployed near the main Bridge area to mark prohibited zones, channels and structures.



*figure 5 Layout Plan of buoys in the Bridge area*

## Bridge Collision Prevention Warning System

### **Collision prevention requirement of the Bridge**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bridge Name | Main Span(m) | Amount of Navigable Hole | Navigable Clearance(m) | | Designed Navigable Tonnage(t) | Collision Prevention Requirement |
| Vertical | Horizontal |
| Jiuzhou Bridge | 768 | 2 | 24.5 | 173 | 5000 | Height limitation |
| Jianghai Bridge | 994 | 1 | 40 | 210 | 10000 |
| Qingzhou Bridge | 1150 | 1 | 42 | 318 | 10000 |

### **System working principle**

A Bridge Collision Prevention Warning System(BCPWS) aims to provide a wider range and more informative collision warning, which consist of front terminal system, analysis system and warning system.

The front terminal system is composed of radar data acquisition unit, hydrometeorological detection unit, video monitoring unit, ship air draft detection unit and intelligent warning display and notification unit. These units are to be installed in different parts of the bridge as per its function, to collect navigable clearance data, water level data, video/image data, passing ship’s air draft data and water flow speed data, etc.

The collected data will be sent back to the analysis system through the mobile network or optical fibre, and the cloud centre of the collision warning system for major facilities will receive the above data, and simultaneously process to analyse. In the case of the violation of height limitation and off-course events, early warning notification will be sent timely through SMS, email and mobile APPs. At the same time, sound and light alarm signal as well as automatic call through VHF radio station and AIS short message will be sent to warn the client ships. The video capture unit will also be activated simultaneously to take images of the ships in violation of navigation rule.

Multiple early warning and notification means enable the incoming ship to make preparation in advance when she is relatively still a long way to the bridge, so that she could manoeuvre within a safety and adequate water when there is a possibility of collision with the bridge, so as to prevent accident from occurring.

### **Overall system structure and subsystems**

The Bridge Collision Prevention Warning System(BCPWS) was supported by a Maritime Traffic Safety Warning System Platform, the structure diagram was showed in Appendix 1. And all the required functions were achieved by the following 7 subsystems’ organic integration:

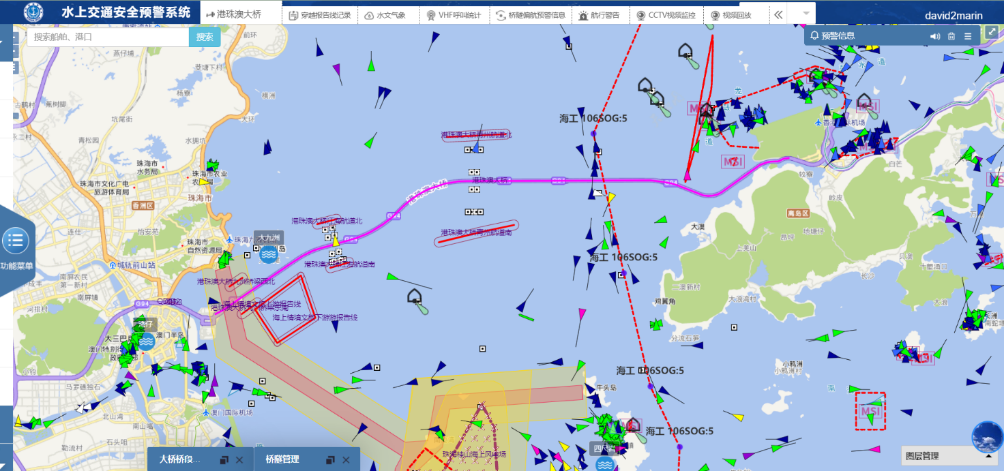
1. Height limitation warning subsystem(structure diagram was showed in Appendix 2), which aims to detect, analyse ship’s air draft as well as send sound/light warning if necessary;
2. Off-course warning subsystem, of which radar and CCTV were applied to monitoring vessels within a range of 2 km so that a off course incident could be found in time.
3. AIS/VHF intelligent warning subsystem, of which a virtual fence based on AIS technology was established within a range of 2 km so that a VHF warning call or AIS short message could be activated if any off course occurs. And all the vessels’ track within the range as well as alarm records will be automatically recorded.
4. Traffic and violation capture subsystem, which aims to collect vessel traffic data and to capture illegal anchorage, fishing and operation as well as unconventional ship manoeuvring.
5. Hydrometeorological warning subsystem, which aims to monitoring the wind speed, visibility, tide, etc. A warning via VHF will be send to the vessels in vicinity if there is any extreme weather such as visibility less than 1km or wind speed over Beaufort scale 9.
6. Operation data collection centre, which aims to process all the acquired data accordingly.
7. Device self-checking subsystem, which aims to regularly self automatically check and test all the device and sensors.

### **Network Topological Diagram**

Same working principle can also be used in off shore windfarms. A Network Topological Diagram which including the application in off shore windfarm was showed in Appendix 3.

### **System performance**

The system went into operation on 26th July 2021, and as of the first half of August, a traffic flow of more than 4,000 vessels of all kinds had been monitored, with more than 400 AIS warnings issued.



*figure 6 PC terminal screenshot*

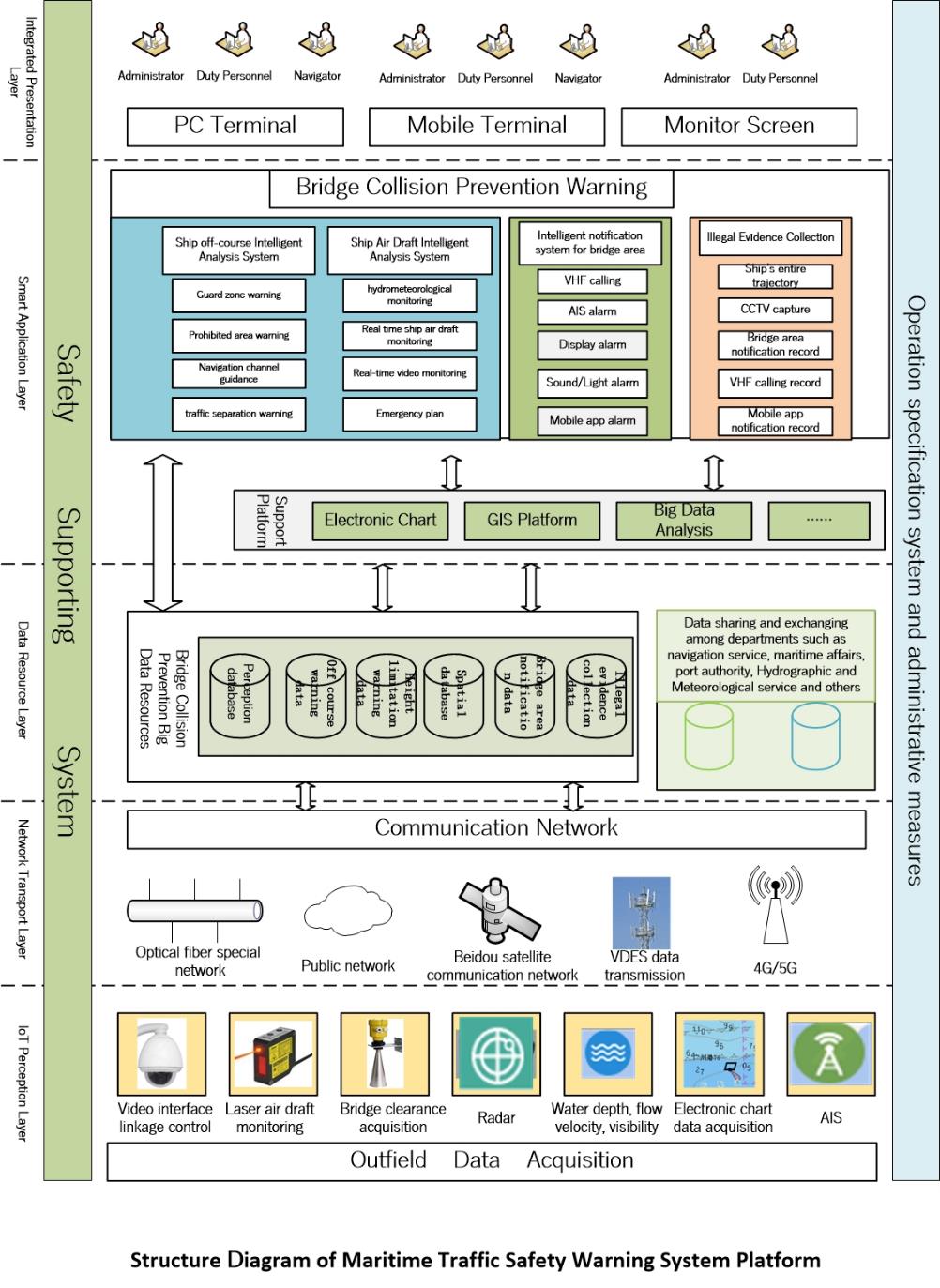
# References

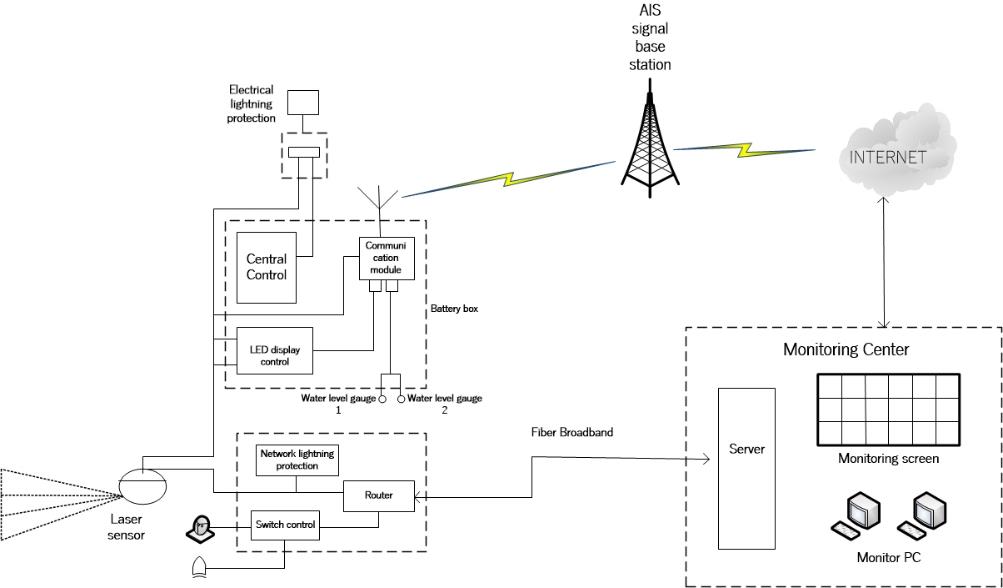
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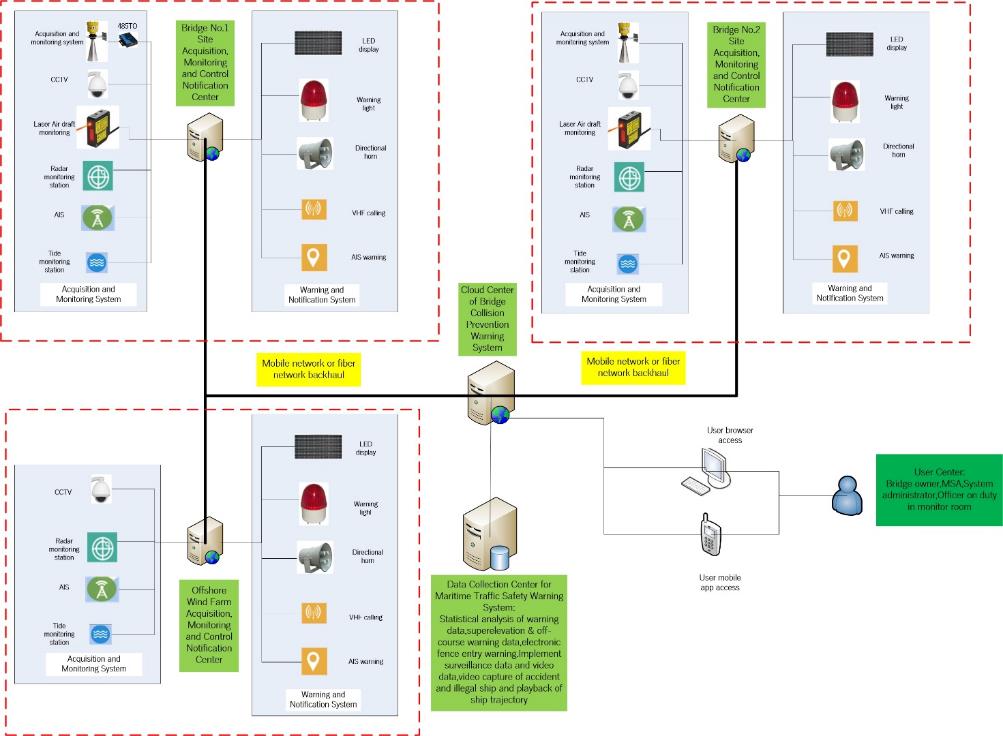
# Action requested of the Committee

The Committee is requested to note this information.

1. Structure diagram of Maritime Traffic Safety Warning System Platform



1. Structure diagram of Height limitation warning subsystem
2. Network Topological Diagram



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