Input paper: [[1]](#footnote-1) ARM18-7.3.2

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

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

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

Agenda item [[2]](#footnote-2) 7.3

Author(s) / Submitter(s) CHINA MSA

Proposals for revision of Guideline G1078

# Summary

The 78th Council of IALA reviewed and approved the 2023-2027 work programme, which includes work on updating the G1078 planned by the ARM Committee. In accordance with the requirements of the plan, China MSA submits some suggestions on the revision to G1078 on The Use of AtoN in the Design of Fairways (ed2.0).

* 1. **Purpose of the document**

To update G1078 on The Use of AtoN in the Design of Fairways (ed2.0).

* 1. **Related documents**

1. IALA G1063 The Use of AtoN in the Design of Fairways and channels (ed2.0)
2. IALA-committee-work-programme-2023-2027
3. IALA G1081 Provision of Virtual Aids to Navigation-Ed2.0, June 2021
4. IALA R0143 Provision of Virtual Aids to Navigation (O-143)-Ed2.0, June 2021

# Background

The IALA G1078 on The Use of AtoN in the Design of Fairways (edition 2.0) was published in October 2021. The purpose of this guideline is to give guidance for Marine Aids to Navigation (AtoN) providers and competent Authorities on the use of AtoN in the design of fairways and channels, and review of existing AtoN for fairways and channels. In the guideline, factors that should be considered when designing or reviewing AtoN for fairways/channels approach to and exiting from a Port or Harbour, through an area with specific features, fairway/channel cutting across a fishing, environmental and / or protected area (including dynamic marine mammal protected areas), and two-way traffic are provided. Relevant cases are also provided in the appendix.

Recent years has witnessed the rapid development of shipping industry. In order to make the most of the available water depth, projects including dredging channels and setting multiple-channel have been increasingly utilized in major ports across China. The demand for using different water depths of the channel is different, and there are various factors in the AtoN design or review of the channel route, which also involves the application of virtual AIS AtoN. China has carried out useful practices in these areas and formulated corresponding standards, which could provide a reference for other countries.

A comprehensive review of G1078 has been conducted and its amendments have been incorporated into the 2023-2027 IALA Committee work plan.

# Discussion

## Add the design or review of AtoN for dredged channels In Chapter 3 and Chapter 5

In Chapter 3, to add the content that should be considered in the design or review of AtoN for dredged channels: buoys should be continuously positioned along the channel boundary. The location of the buoy should be determined based on the channel's wind, wave, and tide current conditions, as well as the dimensions and navigation requirements of the channel, the maintenance and dredging requirements of the channel, the water depth outside the channel trough, and the characteristics of the buoy. It is recommended that the buoy position should have a proper distance with the bottom edge of the channel.

Inclusion of a provision in 5.2: Under standard meteorological visibility conditions, the placement of buoys on the straight section of a dredged channel should meet the visual requirements that next sequential mark can be seen from the mark during the day, and the next two mark can be seen at night.

## Add the design of or review of AtoN for multiple-channel In Chapter 3 and Chapter 5

In Chapter 3, to add the content that should be considered in the design or review of AtoN for multiple-channel: The multiple-channel should be marked with AtoN to the navigation requirements and setting conditions.

Inclusion of a provision in 5.2: A multiple-channel system in which the middle is designated for larger vessels and the sides for smaller boats can be marked by lateral marks indicating the outer boundary for smaller boats, and virtual AtoN can be used to mark the boundaries for larger vessels. For multiple-channel systems where the larger and smaller boat lanes are separate, lateral marks can be placed outside the two lanes, and virtual AtoN can be used to define the boundary between them.

## Add the appendix of the case "Design of AtoN for Dredged channels - AtoN for the Yangtze Estuary Deepwater Channel (China)"

The Yangtze Estuary Deepwater Channel Regulation Project is a world-class estuary management initiative, representing the largest, most investment-intensive, and most challenging project in China's maritime history. The project's navigation channel spans approximately 92.2 kilometers (approximately 50 nautical miles) with a channel bottom width ranging from 350 to 400 meters. To ensure the achievement of the desired water depth, not only was the channel dredged, but also a series of underwater structures, totaling approximately 120 kilometers in length and comprising of diverging outlets, guide jetties, and spur dikes, were constructed. The implementation of this project has significantly improved the environmental water conditions: vessel traffic increases in volume and size, channels intersect, and numerous underwater structures are constructed. Consequently, the establishment of AtoN faces unprecedented challenges. Therefore, to add an appendix to G1078: Design of AtoN for Dredged channels - AtoN for the Yangtze Estuary Deepwater Channel (China), which could provide a good case study for the design of AtoN for dredged waterways.

# proposal

It is recommended that the ARM Committee adopt the aforementioned content, which including the appendices listed in the attachment, as base document for updating G1078.

# Action requested of the Committee

The Committee is invited to consider the proposal, and take action as appropriate.

# Annex 1 "Design of AtoN for Dredged channels - AtoN for the Yangtze Estuary Deepwater Channel (China)"

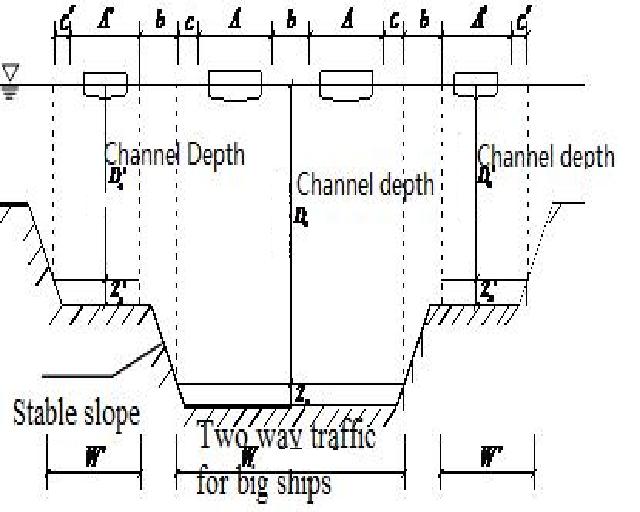
At the water area of Yangtze River Estuary, there are 511 AtoN marks, including visual AtoNs such as light vessels, light-buoys, light beacon & lighthouses, and radio AtoN, such as racon & AIS AtoNs, and virtual AIS AtoN and warning sign dayboards according to the characteristics and demands for the control project of deep-water navigation channel at Yangtze River Estuary. For details, see table 1.

**Table 1: Number AtoN to be established at Yangtze River Estuary**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Location  Type | North Passage | South Passage | South Port Waterway | South Waterway | North Port Waterway | North Waterway | Subtotal |
| Light-boats | 2 | 3 |  | 2 |  |  | 7 |
| Light-buoy | 58 | 73 | 29 | 58 | 54 | 30 | 302 |
| Light beacon | 52 | 6 | 13 | 28 | 9 | 2 | 110 |
| Lighthouse | 1 |  |  |  | 1 |  | 2 |
| Warning sign |  |  |  | 4 |  |  | 4 |
| Virtual AIS AtoN | 3 | 4 | 8 | 16 | 2 |  | 33 |
| AIS AtoNs | 9 | 9 | 1 | 9 | 4 | 4 | 36 |
| Racon | 8 | 4 | 1 | 3 | 1 |  | 17 |
| Total |  |  |  |  |  |  | 511 |  |

**1.1 AtoN Layout for multiple-channel**

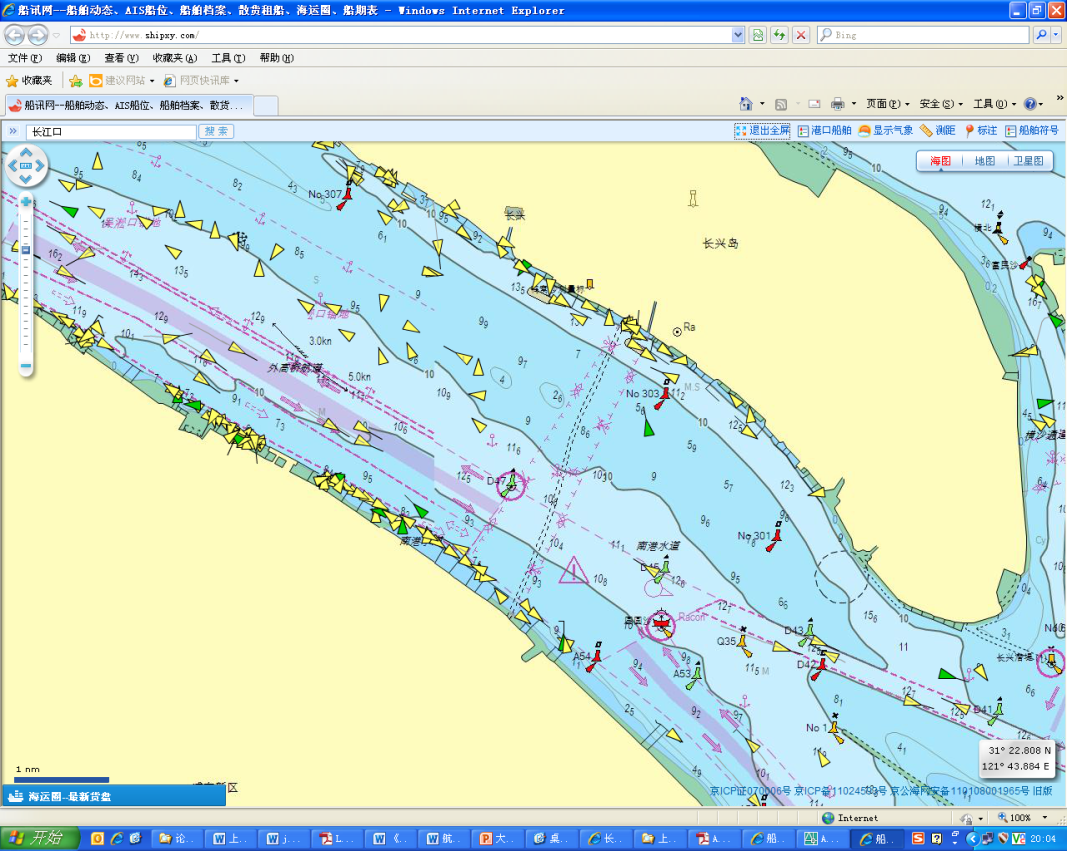
In order to meet the navigation demands in the deep water channels and ensure the safe navigation of ships while reducing the project investment, the AtoN is mostly placed in the middle of the deep water channels for two-way navigation (main channel) and the multiple-channel for one-way navigation of small ships (auxiliary channels), with the cross-section shown in Fig. 1.

****

**Fig. 1 The cross-section of multiple-channel**

In the South Port waters, i.e., from Yuanyuansha -- the main channel at Yangtze River Estuary upstream to its crossing with Huangpu River,the water depth was desirable before the project, with large ship traffic volume. By virtue of the anchorage to the north and Waigaoqiao Terminal to the south, ships here may turn round, get berthed, go in and out of the anchorage and maneuver to avoid collision. With the project, the deployment of AtoNs became a hard nut, for the ships will be larger, the channels will be dredged locally with the ship traffic continuing to increase and the big and small ships must be separated.If the Light-buoy is used to mark each channel of multiple-channel, they will become an obstacle to navigation in narrow waterways, making it inconvenient for ships to navigate.

Currently, the shore-based AIS system along China’s coastal areas has been basically completed, forming a continuous coverage at the waters along the Yangtze River Estuary. According to the 2002 revised edition of SOLOS, ships of and over 500DWT should be equipped with AIS before 2008. This means it was possible to deploy virtual AIS AtoN. Therefore, the virtual AIS AtoN is designed to mark the limits of multiple-channel, and AIS AtoN is designed to mark the limits of the main channel and light-buoys to mark the limits of auxiliary channels. In this way, as for small ships, visual observation is adequate to identify the limits of auxiliary channel; while bigger ships can sail in the main channel along the ECDIS so as to meet the requirement of marking the limits of the main channel. Fig 2 shows the application of this solution in South Port Waters.



**Fig.2 Deployment of AtoN at South Port Waters**

**1.2 A Number of Warning Modes adopted for newly built guiding dikes under Special Navigation Conditions**

The regulating structures for XinLiuhe sand bar and Nanshatou Channel submerged dikes at the diverge of South Port and North Port deep water channels at the Yangtze River Estuary is composed of XinLiuhe sand bar works and Nanshatou submerged dike works. The Xin Liuhe sand beach protection project consists of a southern beach protection embankment, a northern beach protection embankment, a beachhead protection embankment, and a submerged beach protection embankment, with a total length of 8610m, of which the total length for the first three dikes is 3,073m, with a top elevation of +2.0m; while the submerged dike is 537m in length and 2.0m in height. the Nanshatou Channel submerged dike is 2,390m in length, of which the transitory part connecting the Northern Dike is 500m in length, with a height of 2.0m and gradually reduced to -2.0 m. The main part of the submerged dike is 1,300m in length, with the top elevation of -2.0m. The transitory part connecting the Zhongyangsha Longitudinal Dike that runs along the channel for 590m, with the top elevation gradually rising from -2.0m at the main dike to +3.2m as high as that of the Zhongyangsha Longitudinal Dike.

According to relevant specifications, AtoNs shall be placed to identify the position and orientation of regulating structures. Light beacons shall be placed on the Southern Dike, the Northern Dike and the Round-up Dike. Besides, the submerged dikes are marked by a combination of light beacons and traffic warning signs, as the downstream part of the Nanshatou Channel where submerged dikes are constructed was originally a habitual navigation channel for a large volume of traffic for passenger boats, fishing boats and other small ships. After the navigation is prohibited in this area , many small ships may still sail in this area out of habits. That is the reason that the submerged dikes are noted on the warning signs with two Chinese Characters “qiandi”, so as to increase the ships’ ability to identify the signs and to reinforce the warning effect. Fig.3 shows the boards and structure designs.



**Fig. 3 Installation of warning signs in guiding dikes**

**1.3 Solution for drifting buoy**

There are three turning points along the North Passage, and the maximum turning angle at one of them is 36°. The maximum pressure angle between the channel and the main tide current of the ebb and flow is 25°, far exceeding the requirement that the design pressure difference wind of ships in the channels shall be less than 10°-15° recommended by IALA in its Guide to AtoN.

Besides the difficulty in controlling the ships’ maneuvering, the setting, application, maintenance and management of light-buoys also increase the technical difficulties. As a result, we adopted a cross isometric deployment, i.e., deploying the light-buoys at equal distance on each side and symmetrically positioned on opposite sides, to mark the limits of the navigation passage, aid the ships to avoid buoys and facilitate the maintenance and management of light-buoys. However, after Phase 1 project was implemented, we found the some light-buoys had drifted. Analysis indicates that, on the one hand, the dikes in the project restrain the flow, increasing the flow volume of water returning to the North Passage, accelerating the flow dynamics, building up the natural brushing to the channel, so as to deepen the channel, lead the flow and reduce the back silting. Data shows that after the project completion, the flow rate in some channel segments sped up from the original 0.5m/s- 1.0m/s to 2.0m/s-3.0m/s and in particular, the rotating flow at the outer channel of North Passage has a greater angle; on the other hand, in the geological aspect, the project has silty sand and mucky silty clay. The increased rotating flow and the smaller friction between the buoy sinkers and the soils, causes insufficient buoy anchorage and drifting of light buoys.

Under certain conditions, the increase in anchoring force is the key to reduce the displacement of the buoy, which is mainly formed by vertical and horizontal stretching resistance. The horizontal tensile force is mainly formed by the friction force of seabed soil (sandy soil) and the difference between passive and active earth pressure, while the vertical tensile force is formed by weight of the sinker in water and the weight of the covering soil underwater. It is obvious that the anchorage of buoys, including the structure, shape, material, and installation mode of anchor chains and sinkers are factors to affect the anchorage.

We conducted much research and improvement to the anchorage system of light-buoys along the Yangtze River Estuary. Although lengthening the anchor chain was considered as one means, it should not be used as this would increase the swinging radius of the light-buoys and hence occupy more channels. It was once suggested that two sinkers are bound together with one of them in the shape of anchor fluke to improve the anchor holding capacity. However, the experiment showed that the improved capacity is not obvious and the difficulty in maintenance is increased. Therefore the only practical way is to use the single-point anchorage to increase the anchorage of the sinker by changing its structure, shape and material.

****According to its geometric shape, the sinker can be divided into: prismatic, rectangular, prismatic bow, semicircular, etc. The latter two have a low center of gravity and good stability. According to the placement of the sinker, it can be divided into flat and buried types. Since the flat type of sinker is not buried under the soil, there is no active and passive pressure difference, nor is there the weight of the overburden layer.Only the friction caused by the difference between the weight of the sinker in water and the upward pulling force of the anchor chain is present, resulting in poor anchoring ability. The use of buried type can greatly improve the anchoring ability, but due to the complexity of construction and maintenance and high cost, it is not suitable for use in the Yangtze River estuary channel with many light buoys. Therefore, based on the 5-ton cast iron sinker structural design recommended by the International Association for Lighthouse Authorities (IALA) in its "Recommendations on the Design of General Anchoring Appliances", the anchoring force of light buoys can meet the anchoring requirements in the Yangtze River estuary waters. And the cast iron sinker is easy to extract due to its small size, which facilitates engineering maintenance dredging and subsequent channel displacement during widening, as shown in Fig.4

.

**Fig. 4 Deployment of light-buoy**

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