



Research and Practice on Autonomous Navigation for RV Zhuhaiyun



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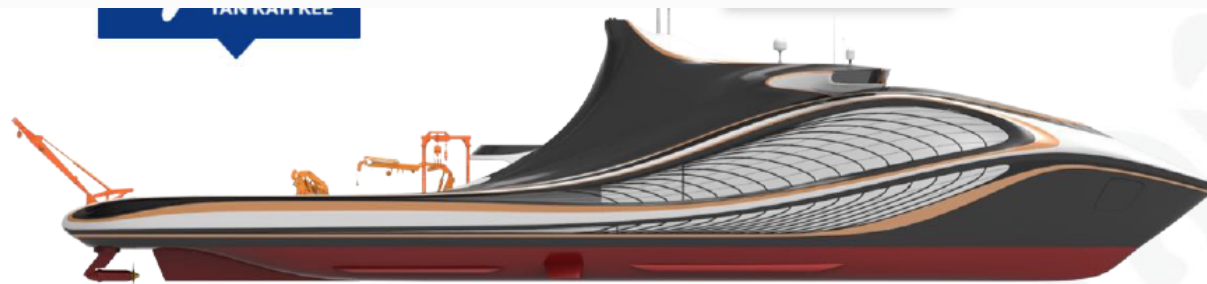
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Zhu Hai Yun

Launch: May 8 2022
Delivery: by end of 2022



General Specifications

Overall length (m)	88.5	Operational speed (kn)	13
Beam (m)	14.0	Range	6000 n. miles
Designed draft (m)	3.7	Endurance	32 days
Designed displacement (t)	~2100	Capacity	30 (15 crew, 15 scientists)
Dynamic positioning :	DP-1	Working deck (m ²)	430

**Owner: Southern Marine Science and Engineering,
Guangdong Laboratory (Zhuhai)**



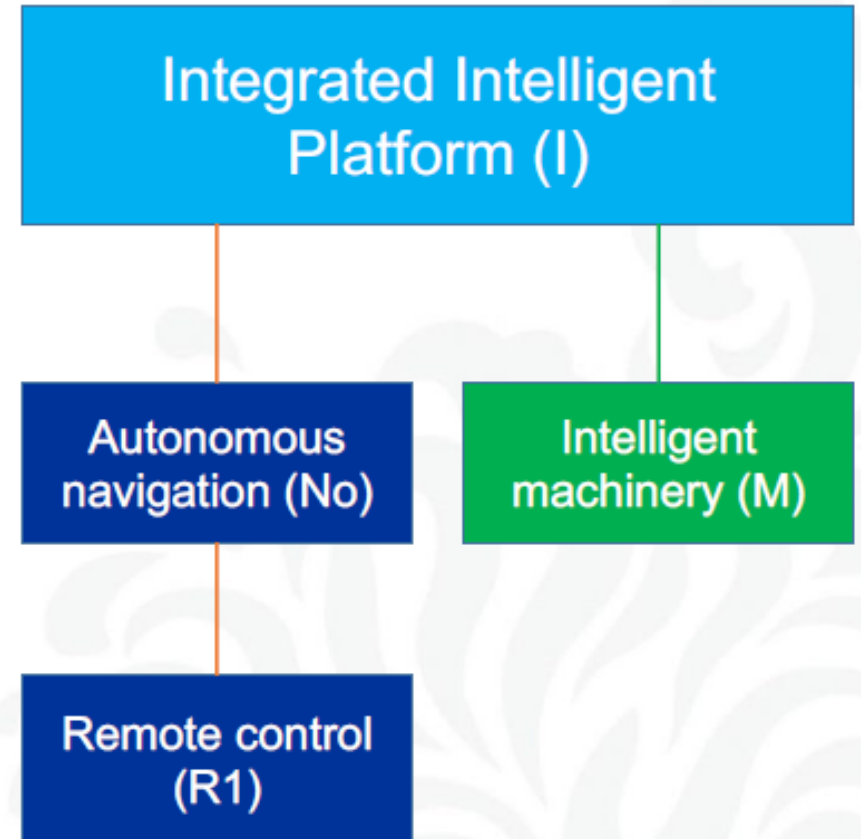
“Zhu Hai Yun” research vessel

The word first Research vessel to obtain China Classification Society(CCS) certification with R1 and No additional marks

Intelligent Ship Systems

CCS class notations: i-ship (R1, No, M, I)

- No: Autonomous navigation in **open waters**;
- R1: **Remote control** provided with crew members;
- M: Intelligent machinery system to support decision-making, operation, maintenance, and management;
- I: Intelligent navigation and intelligent machinery to form unified integration platform of **data acquisition, storage, integration, interaction, sharing and visualization**.





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IMO – the *International Maritime Organization* – is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. IMO's work supports the UN sustainable development goals.

Maritime Autonomous Surface Ships Code (MASS Code) is a comprehensive set of autonomous navigation rules for ships, aimed at guiding ships to navigate on the water surface, ensuring safe navigation, and protecting the environment. MASS Code is not just a set of rules, but also a responsibility and requirement for travelers.

MASS Code Road Map At IMO

the roadmap for the MASS Code has been revised at the 109th session of the Maritime Safety Committee (MSC) of the International Maritime Organization (IMO), with the specific content as follows:

Dec. 2024: Finalize and adopt non-mandatory MASS Code.

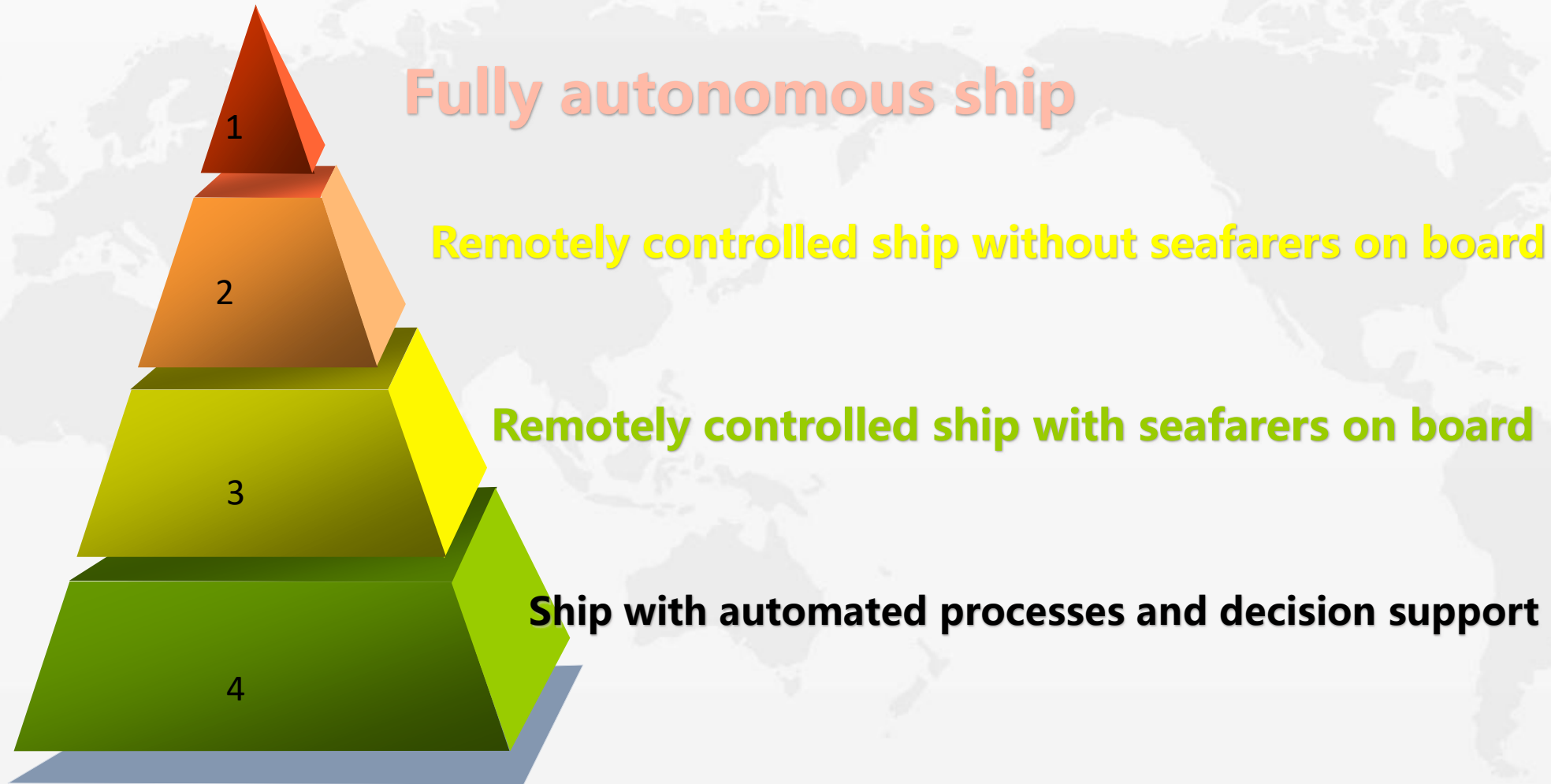
May 2026: Complete and adopt the non-mandatory MASS Code.

- December 2026: After the adoption of the non-mandatory MASS Code, develop a framework for an Experience Building Phase (EBP).
- 2028: Based on the non-mandatory Code, the results of the Experience Building Phase and the review by relevant sub-committees, start developing the mandatory MASS Code and consider amendments to the International Convention for the Safety of Life at Sea (SOLAS) (new chapter) for its adoption.
- Before 1 July 2030: Adopt the mandatory Code, which will enter into force on 1 January 2032.

Mass Code Roadmap at CCS(China Classification Society)

- Rules & Guidelines for Intelligent Ship in 2015,presented concept, path and main architecture of intelligent ships.
- Update and issued Rules for Intelligent Ships(2020), based on application experience ,industry feedback, research results, international legislation etc.
- Since 2022,the Rule is updated regularly every year based on experiences and outcome of research projects. The newest version is Rules for Intelligent Ship(2024), it came into force on 1st April 2024.

Operability for Autonomous level





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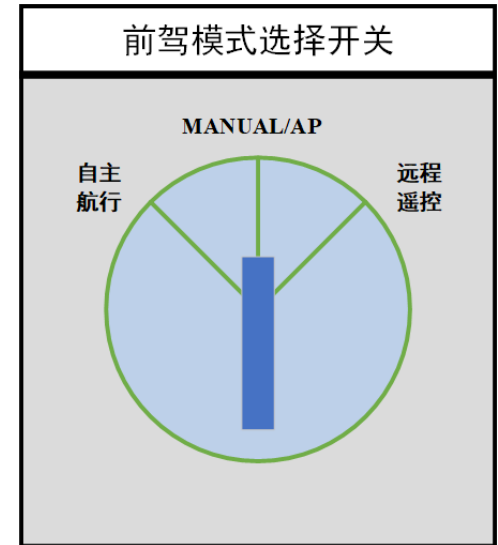
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System Development of Zhuhaiyun

The system has three working modes:

- 1、 **Manual/AP Mode:** The ship is manned and can use AP(AUTO PILOT).
- 2、 **Autonomous Mode:** planning routes, autonomous navigation, and autonomous collision avoidance.
- 3、 **Remote Mode:** Controlled by remote control station with seafarers on board



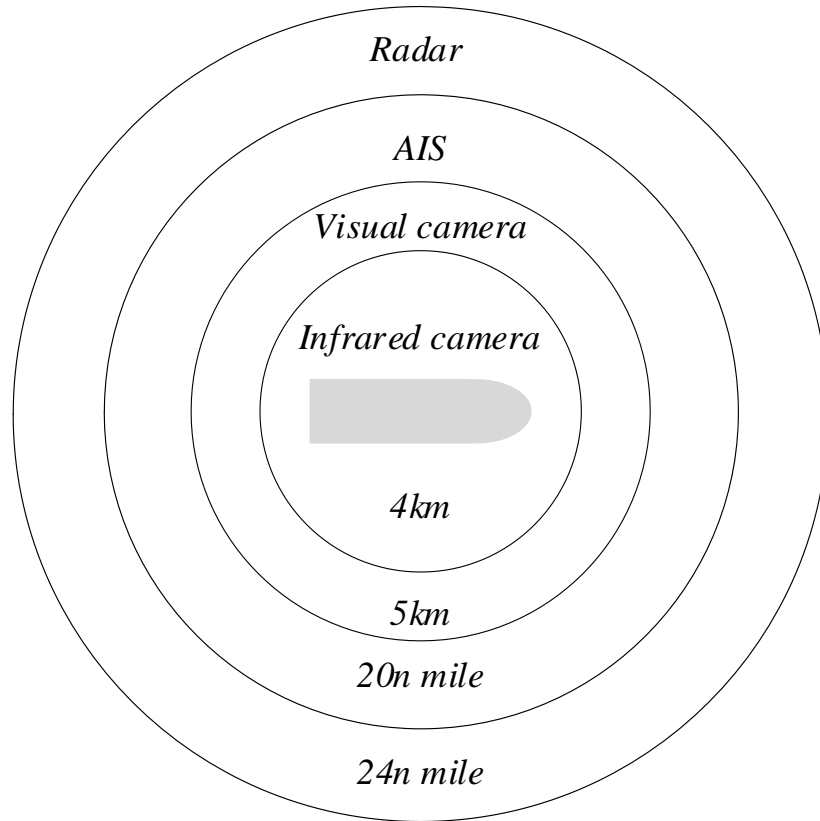
3、 Progress in core technology

自主航行系统的核心技术

The three core subsystems of autonomous navigation :

- **situational awareness system,**
- **autonomous navigation decision-making system,**
- **autonomous navigation control system**

situational awareness system

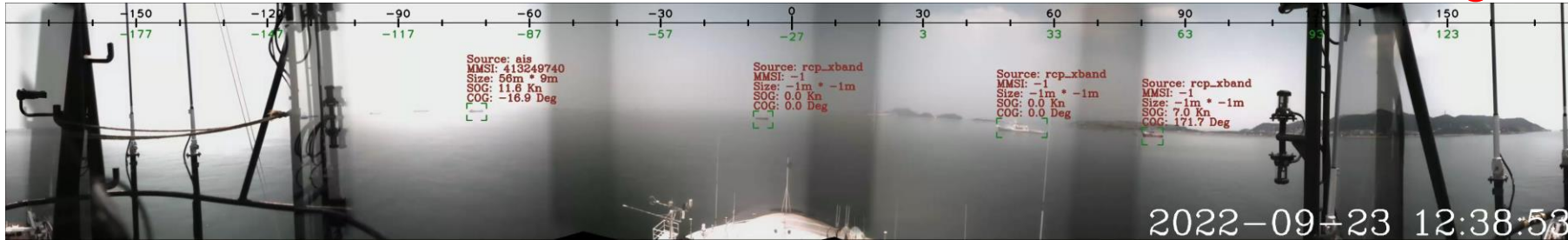


In the face of complex marine environments and navigation situations, a multi-sensor fusion external situation comprehensive perception system has been adopted, forming a perception circle with complementary capabilities from far to near.

3、 Progress in core technology

3.1 situational awareness system

visible light

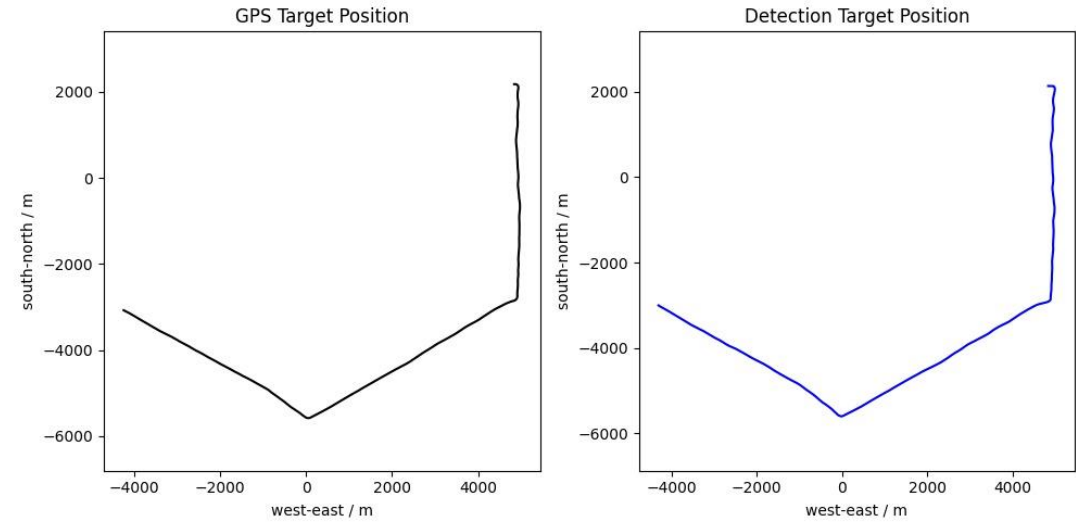


infrared light

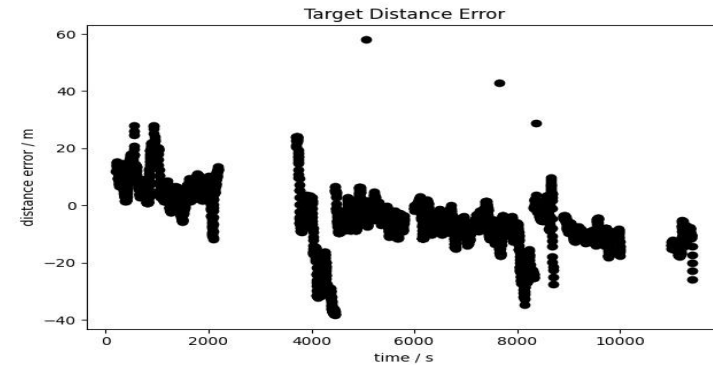


We have developed a 360 ° visual perception system with visible light and infrared sensing capabilities, as well as sea surface target recognition capabilities, which can efficiently integrate with radar data.

3、 Progress in core technology

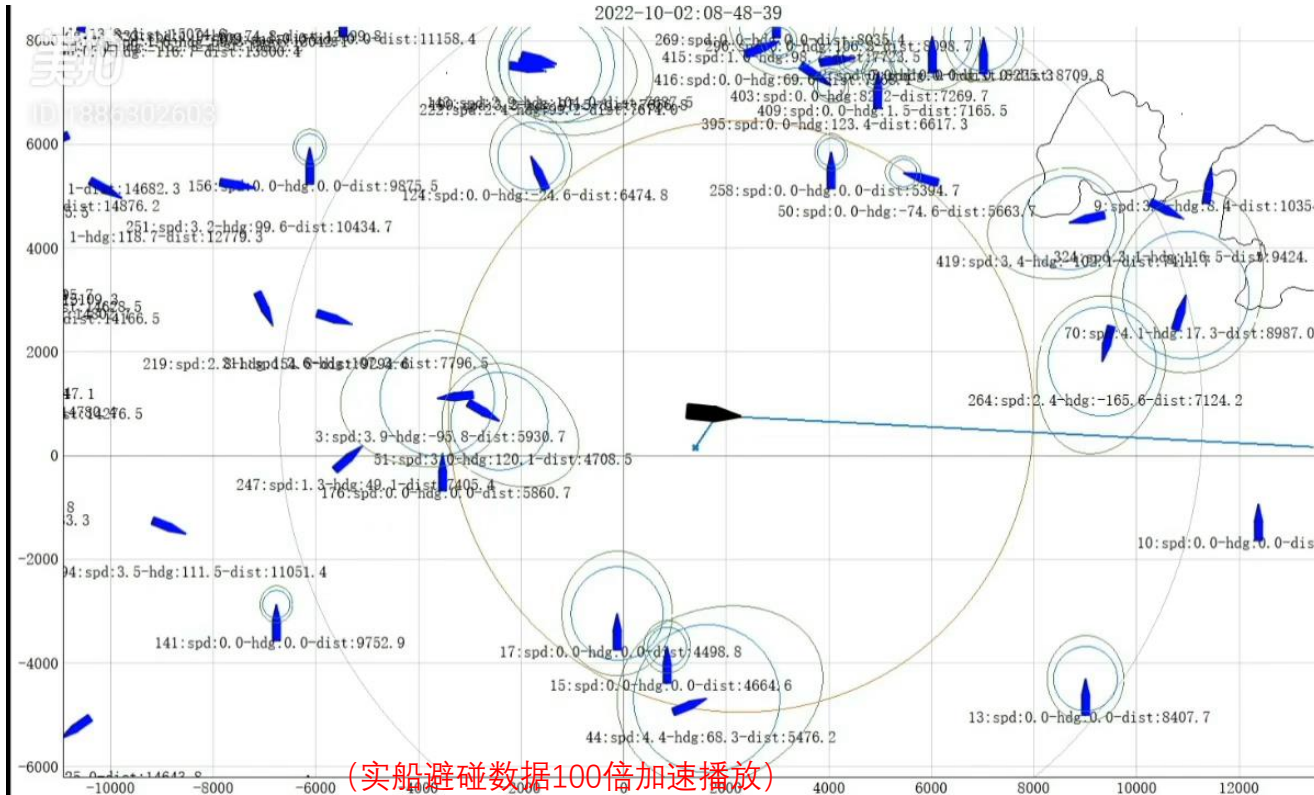


A large number of awareness experiments have been conducted at sea,
Analyzing over 30000 data with a perceptual accuracy of over 95%



3、 Progress in core technology

3.2 Autonomous collision algorithm



Autonomous collision avoidance decision-making:
Real time planning of collision avoidance paths during navigation to try to meet COLREGS
Since the actual use of the ship, hundreds of actual ship collision avoidance have been completed.

COLREGS:
International Regulations for Preventing Collisions at Sea

3、 Progress in core technology

3.3 自主航行控制算法

The core objectives of navigation control :

Based on the hydrodynamic performance and thruster performance of the ship.

Complete high-precision trajectory tracking control.



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4、 Long range testing



A special Cruise jointly organized and implemented by SML and SMERI . On October 30-Nov.18, 2023, the "Zhuha Yun" completed a long - duration scientific expedition cruise. It departed from Zhuhai, headed to Dalian, passed through Shanghai, and finally returned to Zhuhai.

4、 Long range testing



Zhuhai--Dalian

This Cruise lasted 124 hours and had a total voyage of 1500 nms.

Autonomous navigation of 1245 nautical miles, with a total duration of 103.8 hours, Completed over 80 autonomous collision avoidance tasks.

4、 Long range testing

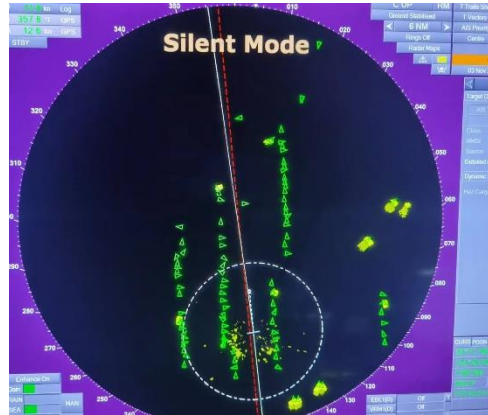


Dalian---Shanghai

This Cruise lasted 52 hours and had a total distance of 458 nautical miles, Autonomous navigation of 249 nautical miles, with a total duration of 20.7 hours,

Completed over 50 autonomous collision avoidance tasks.

4、 Long range testing



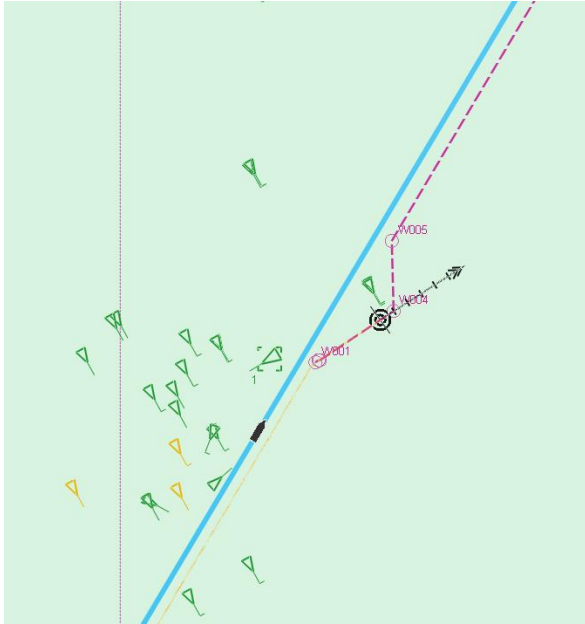
Having experienced multiple complex coastal waters such as Zhoushan, we have achieved autonomous collision avoidance in over 100 complex scenarios, with a total human intervention time of less than 2%.

Autonomous navigation through the 'fishing area'

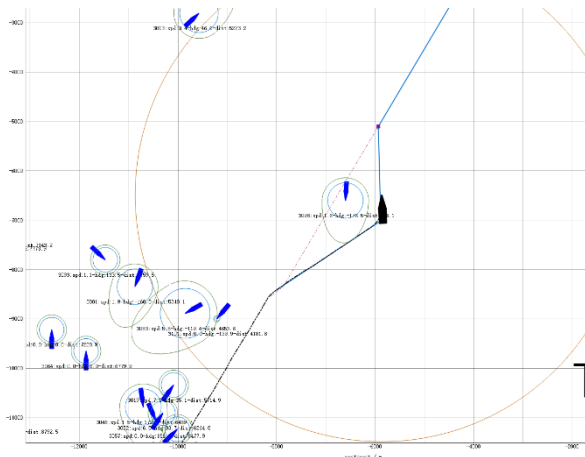


Autonomous navigation control in tough sea conditions

4、 Long range testing



Through this long-distance "pressure test", a rich sample of navigation scenarios from south to north in China was collected, accumulating a large amount of measured data and practical experience



The above PPT provided by Yin Fei, Shanghai Marine Equipment Research Institute

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自然资源部第二海洋研究所
SECOND INSTITUTE OF OCEANOGRAPHY, MNR

Thank you!

