

Original Research Article

The research on beidou satellite navigation technology for marine personal rescue system*Daihao Zhou¹, Jianxin Chen², Ruihan Zhang³**1 Jieyang Qianzhan Wind Power co., LTD, Jieyang, Guangdong, 522000, China**2 China Mobile Communications Group Guangdong co.,LTD.Jieyang branch , Jieyang, Guangdong, 522000, China**3 School of Advanced Manufacturing, Guangdong University of Technology, Jieyang, Guangdong, 522000, China*

Abstract: The marine environment is complex and dynamic, and maritime operations and related offshore projects face numerous safety risks. During offshore operations or the boarding and disembarking process, man-overboard incidents frequently occur. Rapid and timely emergency response and rescue measures are crucial to ensuring the safety of maritime operations. The maritime personal search and rescue system based on the Beidou Satellite Navigation System provides precise positioning and alarm services, enabling efficient distress alerts, self-rescue, and mutual rescue capabilities. Moreover, this system can serve as a vital complement to the global maritime distress and safety system, offering technological support to enhance maritime safety.

Keywords: Beidou satellite navigation system; Maritime operations; Maritime personal search and rescue system; Emergency rescue

1. Introduction

Offshore wind farm projects are often accompanied by high waves, strong winds, and rapid surges, putting construction personnel at significant risk of falling overboard. Moreover, many of these projects are located in regions prone to typhoons, exacerbating the safety risks during construction. Early offshore emergency rescue efforts primarily relied on visual and acoustic physical devices; however, these systems suffered from significant delays, limited effectiveness, and were highly influenced by weather conditions. Traditional models for predicting navigation routes and personnel drift have been inadequate in terms of both accuracy and real-time performance. To address these challenges, the maritime personal search and rescue system based on the Beidou Satellite Navigation System employs real-time regional broadcasting and mobile command technologies. By fully utilizing the unique short-message feature of the Beidou RDSS, the system transmits Beidou navigation and positioning information to the maritime rescue center in a timely and accurate manner. This system ensures precise location tracking of overboard personnel, providing a reliable guarantee for rapid rescue and significantly enhancing the efficiency and safety of offshore emergency response operations.

2. Research on maritime personal search and rescue**2.1. Challenges in personal maritime distress and rescue**

In offshore operations, individuals and small vessels that are not equipped with the globally standardized Global Maritime Distress and Safety System (GMDSS) alarm devices often lack efficient means of distress signaling. As a result, they may fail to send effective distress alerts in a timely manner, leading to missed

opportunities for rescue and making it difficult to receive prompt and effective assistance. Even when some vessels are equipped with alarm devices, traditional rescue methods, which lack precise vessel positioning technology, make it difficult for rescuers to locate the distressed vessel, causing delays in the rescue operation. Furthermore, traditional rescue methods are also hindered by poor communication quality. Due to distance and signal strength limitations, low-quality communications significantly impair the effective communication and guidance between rescuers and the distressed target, thereby further complicating rescue efforts.

2.2. Disadvantages of traditional maritime search and rescue

Compared to other satellite navigation systems, the Beidou Satellite Navigation System, with its unique RDSS communication function, offers an active position reporting mechanism that greatly improves the real-time accuracy and reliability of both positioning and communication. Since the official operation of the Beidou-3 global satellite navigation system, its stable performance and positioning accuracy, which is measured to be better than 4.4 meters globally, have provided high-quality and reliable positioning, navigation, and timing services to users. With the continuous advancement of mobile communication technologies, the real-time interconnection capabilities of maritime distress alerts have been significantly enhanced. The Beidou Satellite Navigation System plays a crucial role in ensuring the safety of vessel navigation, improving precise personal maritime positioning, and accelerating rescue response times, thus offering essential technical support and practical evidence for modern maritime emergency rescue operations.

3. Maritime personal search and rescue system based on the beidou satellite navigation system

3.1. T system model research

The maritime personal search and rescue system based on the Beidou Satellite Navigation System consists of three core components: the Beidou search and rescue command center, the Beidou onboard search and rescue terminal, and the Beidou personal search and rescue terminal. Figure 1 illustrates the system's structural diagram. The search and rescue command center is responsible for functions such as information processing, search and rescue information management, mission planning and command, routine duty alerts, and statistical analysis. The search and rescue terminal is equipped with features including early warning information reception, emergency alerts, position tracking, navigation, and short-message communication.

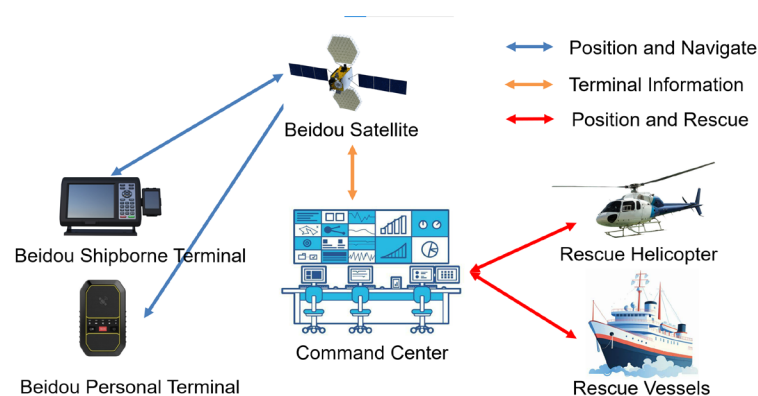


Figure 1. Structural diagram of the beidou satellite navigation system maritime personal search and rescue system.

The Beidou Satellite Navigation System maritime personal search and rescue system leverages the Beidou

satellite network. The personal search and rescue terminal calculates user location and provides one-way time synchronization using Beidou RNSS signals. The terminal employs Beidou RDSS short-message functionality for bidirectional communication, transmitting location and distress alert information to the Beidou search and rescue command center. Upon receiving this information, the command center coordinates and dispatches resources to initiate the rescue operation.

3.2. System testing

Under normal operating conditions, the Beidou Satellite Navigation System maritime personal search and rescue system records the operational trajectory through the device terminal and uploads data to the command center in real time. This data is used to map the trajectory and record system status. Figure 2 shows the navigational trajectory recorded during testing, while Figure 3 presents the operational status data. As shown, the Beidou Satellite Navigation System maritime personal search and rescue system offers high positioning accuracy and strong real-time performance, providing reliable safety assurance for rescue operations.



Figure 2. Test trajectory.

32°1.74'N	118°48.92'E
32°1.74'N	118°48.92'E
32°1.73'N	118°48.9'E
32°1.72'N	118°48.9'E

Figure 3. Operational status.

The device terminal is designed with a Beidou navigation chip, closely integrated with the Beidou satellite navigation system. It features strong anti-jamming capabilities and is capable of operating in harsh marine environments, ensuring stable system performance even under adverse weather conditions. Additionally, the terminal supports both manual and automatic water-triggered activation, is compact, energy-efficient, and easy

to install, making it suitable for long-term, reliable operation in marine environments. In the event of a distress situation, the command center can quickly locate the distressed personnel or vessel via the alarm system and terminal data, dispatching rescue teams for rapid response. This significantly improves rescue efficiency and enhances the success rate of personnel recovery.

4. Conclusion

This paper proposes and examines the maritime personal search and rescue system based on the Beidou Satellite Navigation System. By integrating Beidou's precise positioning and real-time communication capabilities, the system effectively addresses the shortcomings of traditional maritime search and rescue systems in terms of positioning accuracy, alarm timeliness, and communication quality. The system's comprehensive design and stability testing further validate its applicability in complex marine environments, demonstrating exceptional stability and reliability, particularly under extreme weather conditions. This system ensures high reliability in harsh marine environments, providing solid technical support for the timely rescue of overboard personnel and significantly improving rescue efficiency and success rates. With the continuous advancement of Beidou Satellite Navigation System technology, the system is expected to further expand its application scope, upgrade its facilities and equipment, contribute to the establishment of maritime operational standards, and enhance the overall level of maritime safety. Furthermore, it will play an active role in advancing the international application and integration of Beidou Satellite Navigation Technology.

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