Construction and Practical Research on the Maneuvering Training System for High-Speed Craft

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Abstract: Aiming at the deficiencies of the traditional training mode for high-speed craft, a hierarchical and progressive maneuvering training system integrating virtual and real training is constructed. Systematic research is carried out from five dimensions, which are capability stratification, subject design, implementation mode, evaluation mechanism and support conditions, forming an integrated training path of theoretical teaching, simulation and actual ship operation. This research provides a theoretical basis and practical support for the professional and standardized training of high-speed craft drivers.

***Keywords*:** high-speed craft maneuvering; training system; virtual-real integration; emergency disposal

1. Introduction

High-speed craft undertake maritime law enforcement, emergency rescue and maritime supervision tasks, featuring high speed, sensitive maneuverability and poor high-speed stability, which places extremely high demands on the maneuvering skills of drivers. At present, the training of high-speed craft is still dominated by actual ship training, which has such shortcomings as high risk, high cost, limited scenarios, inconsistent standards and subjective evaluation, making it difficult to meet the needs of actual combat. Combined with the maneuvering characteristics and task requirements of high-speed craft, this paper constructs a scientific, standardized, safe and efficient training method system, which is of great practical significance for improving the navigation safety and mission execution capability of high-speed craft.

2. Main Problems in the Maneuvering Training of High-Speed Craft

In the actual organization of training, the traditional mode is difficult to adapt to the maneuvering characteristics and task requirements of high-speed craft, with five prominent problems. First, the actual ship training has high safety risks. High-difficulty subjects such as high-speed marker circling, extreme steering, emergency ship stopping and fault disposal are prone to cause dangerous situations such as collision, grounding and capsizing, making it difficult to carry out normalized training. Second, the training cost is high and the efficiency is low. Actual ship training consumes a lot of fuel and equipment resources, and is significantly restricted by meteorological, sea condition and water area conditions, resulting in complex training organization and a long cycle. Third, the training system lacks systematicness, with no unified outline and hierarchical design, the content is biased towards basic operations, and the coverage of training in complex environments and emergency disposal is insufficient□1-3□. Fourth, it is difficult to reproduce actual combat scenarios. Scenarios such as night, heavy fog, strong winds and waves, equipment failures and multi-craft confrontation are difficult to organize stably, leading to a disconnect between training and actual combat. Fifth, the assessment and evaluation are highly subjective, mainly based on the instructor's experience judgment, lacking quantitative indicators and data support, and unable to accurately evaluate the capability level and weaknesses.

3. Overall Design of the Maneuvering Training System for High-Speed Craft

A complete training system of "three-level capability stratification, three-level implementation mode, four-dimensional subject system, multi-dimensional evaluation mechanism and five support conditions" is constructed. The three-level capability stratification includes the introductory level, the advanced level and the proficient level to realize the gradual improvement of capabilities; the three-level implementation mode consists of theoretical teaching, simulation and actual ship operation to build a virtual-real integrated training path; the four-dimensional subject system covers basic maneuvering, complex environment, emergency disposal and actual combat application to meet the training needs of all scenarios; the multi-dimensional evaluation mechanism takes quantitative indicators, automatic evaluation, comprehensive assessment and grade certification as the core to achieve scientific evaluation; the five support conditions are teaching staff, equipment, safety, system and data to provide comprehensive support for the implementation of the system. The overall structure has

clear logic, reasonable levels and strong operability, and is suitable for the systematic training of various high-speed craft drivers.

4. Construction of the Training System Involving Capability Stratification, Subject Design, Implementation Mode, Evaluation Mechanism and Support Conditions

4.1 Design of the Three-Level Capability Stratification for High-Speed Craft Maneuvering Training

4.1.1 Introductory Level of Basic Maneuvering

The introductory level is for new trainee drivers, aiming at mastering basic theories, establishing safety awareness and forming basic maneuvering capabilities. The main contents include the overall structure, power system, rudder and control devices of high-speed craft; International Regulations for Preventing Collisions at Sea; basic operation of life-saving, fire-fighting, mooring and other equipment; basic maneuvering subjects such as start-up and shutdown, idle speed control, straight-line navigation, small-angle steering, and berthing and unberthing. Through the training at this stage, drivers can independently complete basic navigation and berthing operations.

4.1.2 Advanced Level of Precise Maneuvering in Complex Environments

The advanced level is for drivers who have mastered basic skills, focusing on improving environmental adaptability and precise maneuvering level. The training contents include high-speed navigation control, S-shaped marker circling, small-radius steering and course keeping; maneuvering methods in environments such as wind waves, strong currents and shallow waters; obstacle avoidance and meeting in narrow channels, fishing areas and dense navigation areas; equipment use and lookout methods for night navigation and low visibility navigation; basic communication, command and coordination of craft teams. Through systematic training, drivers can stably maneuver craft in common complex environments and complete precise position control and navigation tasks.

4.1.3 Proficient Level of Emergency Disposal and Actual Combat Application

The proficient level is for backbone drivers and commanders, focusing on extreme working condition disposal and actual combat mission execution. The core contents include emergency disposal of equipment failures such as main engine flameout, rudder failure and propeller entanglement; emergency maneuvering for dangerous situations such as rapid rescue for man overboard, collision, grounding, instability and capsizing; law enforcement maneuvering such as high-speed pursuit, target interception and alongside boarding; tactical coordinated maneuvering such as multi-craft formation navigation,coordinated law enforcement and joint search and rescue. The training at this stage highlights actual combat, confrontation and extremeness, and comprehensively improves the decision-making and maneuvering capabilities of drivers in high-risk scenarios.

4.2 Design of Training Subjects for High-Speed Craft

4.2.1 Basic maneuvering subjects

Basic maneuvering is the core skill of high-speed craft driving, focusing on training drivers' ability to stably control the hull attitude, speed and course. The main subjects include cold (hot) start-up and standardized shutdown; idle and low-speed navigation control; straight-line navigation and course keeping; berthing and unberthing against or with the current; small-angle steering and marker circling navigation; high-speed acceleration and smooth gliding control. Through repeated practice,standardized operation procedures and muscle memory are formed, laying a foundation for advanced training.

4.2.2 Complex environment maneuvering subjects

Complex environment subjects aim to improve drivers' adaptability to hydrometeorology and restricted waters. The main subjects include navigation maneuvering methods in different wave directions such as following seas, beam seas and quartering seas; speed and course correction in strong current areas; obstacle avoidance navigation in shallow waters and reef areas; fishing net evasion and safe navigation in fishing areas; use of navigation lights and lookout duty at night; auxiliary navigation with equipment such as radar, Beidou and electronic charts. The training focuses on improving environmental perception, risk prediction and dynamic correction capabilities.

4.2.3 Emergency disposal subjects

Emergency disposal is a key capability to ensure navigation safety, focusing on training the ability of rapid response and correct disposal in sudden situations. The main subjects include emergency ship stopping for main engine failure during high-speed navigation; emergency maneuvering and safe anchoring for rudder failure; emergency steering and approach rescue for man overboard; early warning of hull instability and anti-capsizing maneuvering; damage control and personnel

evacuation disposal after collision and grounding.

4.2.4 Actual combat application subjects

Actual combat application subjects are closely combined with task scenarios to realize a seamless connection between training and actual combat. The main subjects include target overtaking and safe interception; controlled approach and transverse berthing; formation keeping and tactical coordination of multi-craft formations; water area control and maneuvering at the scene of emergency search and rescue. Through the construction of actual combat scenarios, drivers' tactical awareness, coordination ability and mission execution ability are strengthened.

4.3 Construction of the Three-Level Virtual-Real Integrated Training Implementation Mode

4.3.1 Consolidating the Cognitive Foundation through Theoretical Teaching

Theoretical teaching adopts a combination of classroom lectures, case analysis, video teaching and online courses, covering the basic dynamics of high-speed craft, navigation rules, equipment principles, emergency procedures, actual combat tactics and other contents. Through the review of typical accident cases, risk awareness and the concept of standardized operation are strengthened, providing theoretical support for simulation training and actual ship operation.

4.3.2 Improving Skill Proficiency through Simulation Teaching

Simulation is the core means to solve the problems of high-risk, high-difficulty and high-repeatability training, with prominent advantages of safety, high efficiency, repeatability and traceability. In the basic training stage, it helps drivers familiarize themselves with the control console, master the coordination of engine and rudder, and basic maneuvers such as berthing and unberthing; in the environmental training stage, it reproduces scenarios such as strong winds and waves, night, heavy fog and narrow channels to improve environmental adaptability; in the emergency training stage, it sets dangerous situations such as equipment failures, man overboard, collision and grounding to strengthen the rapid disposal capability; in the confrontation training stage, it constructs scenarios such as multi-craft coordination and law enforcement interception to improve the tactical maneuvering level [4]. The simulator can record data such as rudder angle, rotational speed, track, course and collision avoidance parameters in real time, automatically generate evaluation reports, and accurately locate skill weaknesses.

4.3.3 Consolidating Actual Combat Capabilities through Actual Ship Operation

Actual ship operation is carried out after passing the simulation assessment. Under the on-site guidance of experienced instructors, the focus is on strengthening the actual ship maneuvering feel, environmental perception, craft team coordination and on-the-spot decision-making capabilities, transforming the skills formed in simulation training into actual combat capabilities in real scenarios. Actual ship training pays attention to detail correction, experience transfer and disposal of sudden situations, realizing skill consolidation and capability improvement.

4.4 Construction of a Multi-Dimensional Quantitative Assessment and Evaluation System for High-Speed Craft Maneuvering Training

4.4.1 Construction of an Evaluation Index System for Maneuvering Training

To scientifically evaluate the effect of high-speed craft maneuvering training, a quantitative and measurable evaluation index system with five dimensions is established. First, grasp the standardization of operations, focusing on assessing the compliance of procedures such as start-up and shutdown, rudder control, and berthing and unberthing; second, control the maneuvering accuracy of high-speed craft with course keeping deviation, berthing position error and marker circling track accuracy as the core; third, improve emergency response capability, evaluating emergency response time, correctness of disposal procedures and effect of danger control; fourth, establish safety compliance, counting the number of irregular operations, correct rate of collision avoidance decisions and risk control level; fifth, strengthen coordination and cooperation, evaluating the efficiency of craft team communication, command, lookout and operation coordination. All indicators are quantitative and measurable to avoid subjective evaluation deviations.

4.4.2 Design of the Implementation Mode of Maneuvering Training Evaluation

The evaluation adopts a combination of multiple methods and comprehensive weighted assessment. The automatic simulator evaluation realizes objective scoring based on the data acquisition system, with accurate, fair and traceable results; the actual ship instructor evaluation relies on on-site observation to evaluate maneuvering feel, emergency disposal, environmental adaptability and team cooperation capabilities; the theoretical written test inspects the mastery of rules, cognitive understanding of principles and familiarity with emergency procedures. Finally, the weighted scoring is carried out according to 25% for theory, 35% for simulation and 40% for actual ship, ensuring a comprehensive, objective and credible evaluation.

4.5 Support Conditions for the Implementation of the High-Speed Craft Maneuvering Training System

Teaching staff support. A trinity teaching team of "theoretical instructors + simulation instructors + actual ship instructors" is established. Theoretical instructors have solid professional knowledge and are responsible for basic teaching; simulation instructors are proficient in the high-speed craft training simulation system and good at data analysis and precise error correction [5]; actual ship instructors have rich front-line maneuvering experience and can transfer actual combat skills and disposal experience. The three teams divide work and cooperate with complementary advantages to ensure the implementation of training effects.

Equipment support: Equip with high-performance high-speed craft maneuvering simulators with the functions of dynamic simulation, environmental simulation, fault setting, data acquisition and evaluation analysis; configurespecial training craft and supporting life-saving, fire-fighting, communication and monitoring equipment [6]; establish a regular calibration, maintenance and update mechanism for equipment to ensure that training equipment is stable, reliable and close to actual combat.

Safety support. Establish access standards for meteorological and sea conditions for actual ship training, and clarify the conditions for prohibiting training in severe sea conditions and complex waters; strictly implement safety measures such as craft team division of labor, wearing of life-saving equipment, on-site supervision and pre-positioning of rescue forces; formulate a complete emergency disposal plan, clarify the emergency response process and disposal authority, and realize the safety control of the whole training process.

System support: Formulate a unified training outline, safety management regulations and assessment and evaluation standards, and bring the whole training process into the track of standardized management. The training contents, processes and standards are solidified through systems to ensure the long-term stable operation and efficient implementation of the system.

5. Conclusion

The maneuvering training system for high-speed craft constructed in this paper takes three-level capability stratification as the core, four-dimensional subjects as the carrier, three-level virtual-real integrated training as the path, multi-dimensional quantitative evaluation as the means and all-round support as the backing. It effectively solves the prominent problems of the traditional training such as high risk, low efficiency, inconsistent standards and unscientific evaluation. After the implementation of the high-speed craft maneuvering training system, the maneuvering skills, emergency disposal capabilities and actual combat level of drivers can be significantly improved, the training cost and safety risks can be reduced, and the talent training cycle can be shortened, which has strong theoretical value and practical application value.

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