International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 14, Issue 11 [November 2025] PP: 102-104

A Fundamental Analytical Study of the NI Annex J Curriculum: Structuring Competence for Remote DP Operations

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ABSTRACT: *The rapid development of remote–operation technologies and Maritime Autonomous Surface Ships (MASS) is reshaping the operational structure of the maritime industry. Dynamic Positioning (DP) operations, once carried out exclusively onboard, are now shifting toward shore-based Remote Operation Centres (ROCs). This transformation requires a new set of competencies and a training system that reflects the distinct characteristics of remote operations. In response, the Nautical Institute (NI) introduced Annex J as the first structured framework for training and certifying Remote DP Operators. Although Annex J marks an important step, its educational design, integration of human factors, and coherence with existing DP programs have not been fully examined.*

This study analyzes Annex J from educational, operational, and regulatory perspectives. The curriculum is evaluated using principles of competency-based education, human–machine interaction, and the emerging requirements of the MASS Code. The results show that Annex J adopts several essential features of competency-based training, including performance-oriented learning outcomes and scenario-based assessments. At the same time, the curriculum still lacks clear quantitative evaluation tools and does not fully incorporate key human-factor considerations such as cognitive workload, automation trust, and ROC-specific situational awareness. These limitations are significant in safety-critical contexts like remote DP operations.

The study concludes that Annex J serves as an early but meaningful foundation for remote DP competence. To ensure effective alignment with MASS operations, further development is needed in simulation design, human-factor integration, and assessment standardization. The findings provide guidance for maritime training institutions preparing for the transition to remote and autonomous vessel operations.

Date of Submission: 04-11-2025 Date of acceptance: 14-11-2025

I. INTRODUCTION

The rapid development of remote operation technologies and Maritime Autonomous Surface Ships (MASS) is reshaping the operational structure of the maritime industry. Dynamic Positioning (DP) operations, once carried out exclusively onboard, are now shifting toward shore-based Remote Operation Centres (ROCs). This transformation requires a new set of competencies and a training system that reflects the distinct characteristics of remote operations. In response, the Nautical Institute (NI) introduced Annex J as the first structured framework for training and certifying Remote DP Operators [1]. Although Annex J marks an important step, its educational design, integration of human factors, and coherence with existing DP programs have not been fully examined.

This study analyzes Annex J from educational, operational, and regulatory perspectives. The curriculum is evaluated using principles of competency-based education, human–machine interaction, and the emerging requirements of the MASS Code [2]. The results show that Annex J adopts several essential features of competency-based training, including performance-oriented learning outcomes and scenario-based assessments [1]. At the same time, the curriculum still lacks clear quantitative evaluation tools and does not fully incorporate key human-factor considerations such as cognitive workload, automation trust, and ROC-specific situational awareness [4-6]. These limitations are significant in safety-critical contexts like remote DP operations.

The study concludes that Annex J serves as an early but meaningful foundation for remote DP competence. To ensure effective alignment with MASS operations, further development is needed in simulation design, human-factor integration, and assessment standardization. The findings provide guidance for maritime training institutions preparing for the transition to remote and autonomous vessel operations.

II. STRUCTURAL ANALYSIS OF ANNEX J

2.1 Competency-Based Training in Maritime Training

Competency-Based Training (CBT) places emphasis on measurable performance rather than time-based progression. It is widely used in aviation, nuclear power, and medical simulation training—sectors where human error may lead to high-risk outcomes. The core principles of CBT include clearly defined learning outcomes, scenario-based training, objective evaluation methods, and structured feedback [3].

DP training has long incorporated simulation-based methods, but the shift toward remote operations introduces new cognitive and operational demands. Annex J adopts CBT in its general structure [1], yet it remains necessary to assess whether its competency definitions sufficiently reflect the complexity of remote operations, where operators must perform high-level interpretation of indirect and sometimes uncertain information [4][6].

2.2 Human Factors in Remote Operations

Remote operations differ substantially from onboard environments in terms of human factors. Operators cannot rely on direct sensory input such as vessel motion, vibration, or environmental cues. Instead, they depend on camera feeds, numerical displays, alarms, and visual indicators. This change affects the structure of situational awareness, particularly in the perception and comprehension stages [4].

Communication delays, varying sensor reliability, and the operator's interaction with automated systems can increase cognitive workload. These issues are recognized in MASS Code discussions, which highlight the need for human-centered ROC design and robust operator training [2]. Annex J mentions several of these elements but does not present a fully developed human-factor framework [1].

2.3 Regulatory Context: MASS Code and Remote Operation

The MASS Code outlines requirements for ROC certification, communication reliability, and remote operator qualifications [2]. It introduces expectations for continuous vessel monitoring, redundancy in communication systems, and structured emergency response procedures. These elements shape the operational environment that Annex J must support. As MASS-related standards evolve, Annex J may serve as a reference point for future revisions of STCW or related competence frameworks.

2.4 Structural Analysis of Annex J

Annex J is based on a task-centered understanding of remote DP operations. It retains the broad structure of the NI Model Course, including theoretical instruction, simulator-based training, and operational assessment, but adapts each component to reflect the distinct characteristics of remote operations [1].

Remote operators are required to interpret multiple streams of information simultaneously: AIS, radar, LIDAR, environmental sensors, CCTV images, and integrated vessel data. Annex J identifies these tasks as core learning objectives [1]. This emphasis reflects the fact that remote operators must compensate for the lack of physical cues through deliberate and systematic information processing [4][6].

The curriculum includes abnormal and degraded mode scenarios, such as communication loss, reduced bandwidth, video latency, sensor inconsistency, thruster malfunction, and possible cyber disruptions. These scenarios represent realistic events in remote operation settings, where rapid and reliable decision-making is essential [2][3].

Annex J also redefines traditional "sea time." In remote DP operations, operational experience is gained not through physical presence onboard but through accumulated time spent monitoring and controlling vessels from ROC facilities [1]. This shift reflects a deeper pedagogical interpretation of what "experience" means in remote contexts.

2.5 Comparison with Existing DP Training Program

The differences between Annex J and traditional DP training arise from the nature of remote operations themselves. Traditional DP Operators rely on direct visual and physical cues from the vessel and its environment. They interact with bridge teams and observe the vessel's motion in real time. Remote operators do not have access to these cues and must instead rely on visual displays and interpreted sensor data [4].

These fundamental differences lead to distinct learning needs. For remote operators, situational awareness must be developed through cognitive processes rather than direct perception [4][6]. This creates new challenges in simulation design, as the training environment must realistically replicate the uncertainty and delay inherent in remote systems [5].

The assessment methods also differ. While traditional DP evaluation relies on instructor observation of onboard performance, Annex J requires multi-layered assessment that considers communication quality, sensor reliability, team interaction within the ROC, and the operator's ability to manage automation [1][3].

Annex J aims to introduce a more structured framework, yet its current version does not include detailed quantitative criteria, which limits the consistency of evaluation across training centers.

III. CONCLUSION

Annex J is significant as the first internationally recognized curriculum for Remote DP Operators [1]. It anticipates the operational changes expected in the MASS era and provides a foundation for standardized competence development [2]. However, as an early model, it also contains limitations that require careful consideration.

The most critical gap is the limited integration of human-factor principles. Remote operations involve unique cognitive demands that do not arise in traditional DP environments [4-6]. The curriculum identifies several of these issues but does not provide a structured approach to developing or assessing them [1].

The second limitation concerns evaluation. Remote DP performance can be measured through objective indicators such as response time, interpretation accuracy, and error-handling behavior, yet Annex J provides only general evaluation guidelines [1]. A more mature system would require standardized rubrics, performance benchmarks, and multi-observer calibration [3].

A third issue is the gap between Annex J's assumed ROC environment and the actual technological diversity among existing ROCs. The curriculum presumes a relatively uniform operational environment, while real-world systems vary considerably in automation level, communication architecture, and sensor integration [2].

This study examined the NI Annex J curriculum through educational, operational, and regulatory perspectives. Annex J represents an important first step toward defining remote DP competence and provides a meaningful foundation for the transition to MASS-based operations. However, its current version requires further refinement, particularly in integrating human-factor research, enhancing ROC-based simulation design, and establishing quantitative assessment tools.

For maritime training institutions, Annex J provides a strategic direction for developing programs that meet the demands of future remote and autonomous vessel operations. Further research should explore real-world implementation of Annex J, empirical evaluation of training outcomes, and the development of advanced competence models suited to remote operational environments.

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