



# Autonomous Vessel Skills Mapping Framework

**Entry-Level Operator & Technician**  
**Unmanned Surface Vessels (USVs) Under 7 Meters**

*Defining the essential knowledge, skills, and competencies required to support safe, efficient, and reliable autonomous vessel operations.*

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WORKSHOPS  
CONDUCTED:

- December 2, 2025
- March 25, 2026

PREPARED BY

**WaveWorks Alliance**

*A National 501(c)(3) Nonprofit Organization*

**[www.waveworksalliance.org](http://www.waveworksalliance.org)**

# Autonomous Vessel Skills Mapping Framework

## Entry-Level Operator & Technician (USVs Under 7 Meters)

### Executive Summary

This document builds on the December 2025 Autonomous Technologies workshop and synthesizes the March 25, 2026, WaveWorks Alliance workshop into a streamlined workforce framework for small autonomous surface vessels (USVs). It identifies core competency domains, defines operator and technician pathways, highlights workforce gaps, and recommends a modular training and credentialing model supporting credit, non-credit, and incumbent worker education.

#### Purpose

The workshop convened industry subject matter experts to identify the knowledge, skills, and abilities required for entry-level operators and technicians supporting autonomous vessels under seven meters. The resulting framework is intended to guide curriculum development, stackable credentials, workforce upskilling, and future certification alignment.

#### Industry Context

Small unmanned surface vessels represent an emerging segment of the maritime industry where traditional maritime knowledge intersects with robotics, software, marine electronics, communications, and data systems. Building this workforce will require two complementary approaches: preparing new technicians and operators with the full range of foundational maritime and technical competencies, while providing existing mariners, technicians, and vessel operators with targeted opportunities to expand and apply their experience in autonomous vessel operations. Together, these pathways can create a workforce that combines new technical capabilities with the operational judgment, safety awareness, and practical knowledge already present across the maritime industry.

#### Guiding Principles

- Build upon existing maritime competencies.
- Deliver training through modular, stackable credentials.
- Separate operator and technician pathways while sharing a common foundation.
- Emphasize competency-based assessment and work-based learning.
- Allow mission-specific specialization after core competencies.

Core Competency Domains

- 1. Maritime Operations (COLREGS, navigation, voyage planning, launch/recovery, weather)
- 2. Autonomous Systems (levels of autonomy, mission planning, remote operations, transfer of control)
- 3. Marine Electronics & Communications (AIS, GPS, radar, sensors, networks, RF, satellite)
- 4. Electrical & Mechanical Systems (power, batteries, propulsion, controls)
- 5. Software, Data & Cybersecurity (telemetry, diagnostics, firmware, cloud systems)
- 6. Maintenance & Diagnostics (preventive maintenance, troubleshooting, calibration)
- 7. Professional Skills (documentation, communication, risk management, teamwork)

| Operator Pathway                                                                                                                                                                                                                                                                                                                                                                                                      | Technician Pathway                                                                                                                                                                                                                                                                       | Workforce Gaps                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Primary responsibilities:                                                                                                                                                                                                                                                                                                                                                                                             | Primary responsibilities:                                                                                                                                                                                                                                                                | Priority gaps identified:                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"><li>• Mission planning</li><li>• Remote vessel operations</li><li>• Monitoring autonomous systems</li><li>• Payload management</li><li>• Situational awareness</li><li>• Emergency response</li><li>• Manual takeover when required</li><li>• CONOPS (Concept of Operations: a high-level document that explains how a fleet, port, or autonomous vessel system will run)</li></ul> | <ul style="list-style-type: none"><li>• Installation and integration</li><li>• Diagnostics and troubleshooting</li><li>• Marine electronics</li><li>• Software/firmware updates</li><li>• Calibration</li><li>• Communications infrastructure</li><li>• Preventive maintenance</li></ul> | <ul style="list-style-type: none"><li>• USV-specific training pathways</li><li>• COLREGS applied to autonomous operations</li><li>• Communications and networking</li><li>• Cybersecurity</li><li>• Deployment logistics and recovery</li><li>• Mission-specific specialization</li></ul> |

| Recommended 180-Hour Curriculum                   | Credentialing Framework                                   | Implementation Roadmap                                                                    |
|---------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------|
| <b>Module 1:</b> Maritime Foundations             | <b>Level 1:</b> Maritime & Safety Foundation              | <b>Phase 1:</b> Validate competencies with industry.                                      |
| <b>Module 2:</b> USV Systems Fundamentals         | <b>Level 2A:</b> USV Operator                             | <b>Phase 2:</b> Develop modular curriculum and assessments.                               |
| <b>Module 3:</b> Operator Skills                  | <b>Level 2B:</b> USV Technician                           | <b>Phase 3:</b> Pilot delivery through community and technical colleges.                  |
| <b>Module 4:</b> Technician Skills                | <b>Level 3:</b> Mission Specialization                    | <b>Phase 4:</b> Align with USCG, IMO MASS Code, NMEA, and future industry certifications. |
| <b>Module 5:</b> Mission Specialization           | <b>Level 4:</b> Advanced Leadership & Systems Integration | <b>Phase 5:</b> Expand nationally through WaveWorks Alliance and partner institutions.    |
| <b>Module 6:</b> Simulation & Work-Based Learning |                                                           |                                                                                           |

Conclusion

Small autonomous vessels do not require smaller skill sets, they require broader, more integrated competencies. The current and future maritime workforce must combine traditional seamanship with expertise in digital systems, marine electronics, software, communications, autonomy, and mission management. Success in this emerging sector will depend on professionals who can operate confidently at the intersection of maritime operations and advanced technology.

The rapid growth of defense, commercial, and scientific applications for small autonomous vessels presents an opportunity to rethink how workforce preparation is designed. Because many platforms under seven meters operate with lower operational risk and different regulatory considerations than conventionally crewed vessels, education and training systems have greater flexibility to develop competency-based pathways that respond quickly to technological innovation while maintaining appropriate safety and operational standards.

Rather than preparing technicians and operators for a single occupation, education and training systems should develop adaptable maritime professionals who build expertise over time through stackable credentials, modular learning, industry-recognized competencies, and continuous professional development. This approach creates a workforce capable of evolving alongside rapidly advancing autonomous technologies while preserving the human judgment, decision-making, and operational expertise that remain fundamental to safe, resilient, and effective maritime operations. As autonomous vessel technologies continue to mature, the organizations that invest in flexible workforce models today will be best positioned to meet future operational demands and sustain America's maritime competitiveness.

# Autonomous Vessel Skills Mapping – Entry Level Operator/Technician

## March 25, 2026

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                              |
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| <b>March 25, 2026, Workshop Members/Subject Matter Experts</b> <ul style="list-style-type: none"> <li>Aditya Nawab, CEO &amp; Founder, Robosys Automation</li> <li>Chad Furhmann, Vice President, Core Group Consulting</li> <li>Kyle Warren, Technical Sales Manager, Sonardyne</li> <li>Mark Oslund, Director of Standards, National Marine Electronics Association</li> </ul>                                                                                                                                                                                                                             | <b>WaveWorks Project Managers / Board Members</b> <ul style="list-style-type: none"> <li>Denielle Christensen, Executive Director &amp; CEO, WaveWorks Alliance</li> <li>Dustin Varnell, Director, Spirit Advisory</li> <li>Ann Avary, Director NW Center of Excellence for Marine Manufacturing &amp; Technology</li> </ul> |
| <b>December 2025, Workshop Members/Subject Matter Experts</b> <ul style="list-style-type: none"> <li>Chad Furhmann, Vice President, Core Group Consulting</li> <li>Kyle Warren, Technical Sales Manager, Sonardyne</li> <li>Mark Oslund, Director of Standards, National Marine Electronics Association</li> <li>Craig Reid, Vice President, Engineering and New Energies, DNV</li> <li>Aditya Nawab, CEO &amp; Founder, Robosys Automation</li> <li>Nathan Krohn, USV Engineering Lead, Triton Systems, Inc.</li> <li>Liesl Hotaling, Director of Program Development, Marine Technology Society</li> </ul> | <b>WaveWorks Project Managers / Board Members</b> <ul style="list-style-type: none"> <li>Denielle Christensen, Executive Director &amp; CEO, WaveWorks Alliance</li> <li>Dustin Varnell, Director, Spirit Advisory</li> </ul>                                                                                                |

### Acknowledgements

The development of the **Autonomous Surface Vessel (ASV) Operator and Technician Occupational Knowledge and Technical Competency Framework** was made possible through the generous contributions of industry subject matter experts who volunteered their time, knowledge, and practical experience. Their expertise ensured that the occupational knowledge, technical competencies, and workforce requirements identified in this framework accurately reflect current industry practice, emerging technologies, and the evolving needs of the autonomous maritime sector. We extend our sincere appreciation to each participant for their commitment to advancing maritime workforce development and helping create a framework that will guide education, training, and career pathway development for this rapidly evolving occupation.

*The occupational knowledge and technical competencies presented in this framework represent the collective judgment of the participating industry subject matter experts at the time of the analysis. As autonomous surface vessel technologies, regulations, and operational practices continue to evolve, this framework should be reviewed and updated periodically to ensure continued relevance and alignment with industry needs.*

## Goal

Define and map high-priority technical competencies for small autonomous vessels, up to seven meters, to support development of a modular training framework.

## Purpose

This group of subject matter experts was convened as a targeted and facilitated follow-up to the December 2025 workshop. The focus was intentionally narrowed to **autonomous unmanned surface vessels under seven meters in length** - a rapidly emerging segment with distinct operational, technical, and regulatory considerations.

The objective of this convening was to **define and map high-priority roles and technical competencies** required to design, operate, maintain, and support small autonomous vessel systems. These competencies will directly inform the development of a **modular, stackable training framework** aligned with industry needs and future certification pathways.

This work is designed to move beyond concept and into application, providing a **clear, competency-driven foundation** that can be deployed across credit and non-credit postsecondary programs, and adapted for workforce upskilling and cross-sector use. The competencies identified will inform K12 pathway development and programming in later phases of development.

## Context

The International Maritime Organization (IMO) recently published the first International Code of Safety for Maritime Autonomous Surface Ships (MASS Code). The newly adopted code will support the safe integration of AI-enabled and remotely operated commercial ships into global shipping. More about the MASS Code can be found at [Autonomous Shipping](#). In a December 2025 U.S. Government Accountability Office (GAO) report, the Coast Guard regulates autonomous ships within existing legal frameworks. The report can be accessed via the following link: [Coast Guard Approaches to Autonomous Ship Regulation](#).

An autonomous vessel is generally defined as a boat or ship that can operate independently of direct human interaction, ranging from automated decision-support systems to fully autonomous, crewless operations.

The under-7-meter USV class represents the most accessible entry point for autonomous maritime operations. These vessels operate in environments where COLREGS provisions are simplified and the barrier to operational deployment is lower than larger commercial vessels.

This creates a clear opportunity: existing mariners holding USCG small tonnage licenses, as well as unlicensed operators, vessel crew members, and maritime technicians, already possess many of the foundational competencies needed to support, operate, monitor, and maintain autonomous and remotely operated vessels. The gap between current maritime credentials, workforce experience, and emerging USV operational requirements can be identified and addressed through a targeted training framework that builds upon existing knowledge while introducing the additional skills required for autonomous systems, remote operations, sensor integration, communications, troubleshooting, maintenance, and mission management.

This approach recognizes that the future USV workforce will extend beyond licensed mariners alone. It will require a combination of licensed operators, unlicensed vessel personnel, shoreside operators, maintenance technicians, electronics specialists, and other maritime professionals who can safely and effectively support autonomous vessel operations. By leveraging existing maritime competencies and creating clear upskilling pathways, the industry can accelerate workforce development while reducing barriers to entry for both incumbent workers and new entrants.

### **Modular Training Framework**

A modular training framework is a flexible education and workforce development model that breaks comprehensive programs into smaller, independent, and stackable learning modules. Each module is designed to develop a specific competency, technical skill, or body of knowledge while also serving as part of a larger credential or career pathway.

This approach supports both entry-level learners preparing to enter the maritime workforce and current maritime professionals seeking to upskill or reskill as technologies, regulations, and industry needs evolve. Rather than requiring participation in lengthy traditional programs, learners can access targeted instruction that is directly aligned with their immediate workforce needs and career goals.

For the maritime industry, a modular framework provides a practical, cost-effective, and responsive training strategy. It enables education providers and employers to deliver relevant instruction more efficiently, supports just-in-time workforce development, reduces time away from the job for incumbent workers, and creates flexible pathways for lifelong learning. As the maritime sector continues to integrate advanced technologies, autonomous systems, digital tools, and new operational requirements, modular training offers a scalable approach for keeping the workforce current while expanding access to high-quality maritime education.

### **Autonomous Vessel (USV) Framework Overview**

This framework establishes a modular, stackable training and credentialing system for autonomous vessel (USV) operators and technicians. It aligns with USCG and STCW foundational concepts while preparing for future USV-specific certifications.

Aligned Maritime Pathways Framework

| Maritime Pathway  | Core Focus                                            | Key Skills & Systems                                                                                                     | Alignment / Support Areas             |
|-------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Vessel Navigation | Safe vessel movement and navigation                   | Charting, RADAR, GPS, AIS, COLREGs                                                                                       | Safety, Operations, Electronics       |
| Vessel Operations | Shipboard and deck operations                         | Seamanship, cargo handling, maintenance - Pre-mission checks, payload integration, recovery operations, readiness cycles | Operations, Safety, Materials Science |
| Electronics       | Marine electronic systems                             | Navigation electronics, sensors, communications                                                                          | Vessel Navigation, Electrical, Safety |
| Electrical        | Power generation and distribution                     | Motors, generators, controls, electrical safety                                                                          | Electronics, Vessel Operations        |
| Operations        | Coordinated maritime activities                       | Logistics, port operations, compliance                                                                                   | Vessel Operations, Safety             |
| Logistics         | End-to-end support for USV deployment and sustainment | Transport, storage, staging, spare parts, consumables, timelines                                                         |                                       |
| Safety            | Personnel, vessel, and environmental protection       | Emergency response, firefighting, hazard control                                                                         | Embedded in all pathways              |
| Materials Science | Marine material performance                           | Corrosion control, metals, coatings, composites                                                                          | Welding, Vessel Operations            |
| Welding           | Fabrication and structural repair                     | SMAW, GMAW, FCAW, GTAW, inspection                                                                                       | Materials Science, Safety             |

SME Inputs & Discussion

Competency Mapping – Informed by the Subject Matter Experts

| USV Operator                                                                                                                                                |                                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operator Role (what does the operator do?)                                                                                                                  | Operator Technical Skills                                                                                                                                                                         |
| Voyage planning /Con-ops                                                                                                                                    | Rules of the road (COLREGS)                                                                                                                                                                       |
| Knowing the maritime space. People often have no idea of the maritime space. Understanding the maritime regulations and industry best practices.            | Trouble shoot an issue to hand off to a technician.<br>Troubleshoot and hand overs.                                                                                                               |
| Situational awareness.                                                                                                                                      | Situational awareness.                                                                                                                                                                            |
| Operating the sensors onboard.                                                                                                                              | Communications/Comms                                                                                                                                                                              |
| Understanding of vessels and specialized missions (i.e. search and recovery vs. mapping)<br><br>Mission specific skills will vary.                          | Basic IT skills.                                                                                                                                                                                  |
| Mission specific skills including operation modes (i.e. towing, restricted ability to maneuver vs underway)                                                 | Manufacturers best practices.                                                                                                                                                                     |
| Secondary training will be critical – depending on the mission of the USV.                                                                                  | Basic common actors when it comes to installation and checks of systems.                                                                                                                          |
| Understanding the sensors and onboard instruments.                                                                                                          | Commercial applications – generally geared to very specific skill sets.                                                                                                                           |
| Internal navigation systems – might be a higher-level piece – not entry level.                                                                              | Smaller vessels – off the shelf equipment is more common.                                                                                                                                         |
| Multiple types of operators – readiness, sea trial, communication skills – how the craft is built, it’s intended purpose and sensory information coming in. | Understanding of marine electronic and networks. Evolving into autonomous operations – the operator has to be able to see and interpret systems and notify through an alert of a problem or issue |

|                                                                                          |                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Understanding positioning/real time telemetry and system alerts.                         | Connectivity/Connected systems.                                                                                                                                                                                                  |
| Multi-vessel coordination (swarm-lite operations)                                        | Cyber security.                                                                                                                                                                                                                  |
|                                                                                          | Three stages – set to work (Commissioning) operational – broad spectrum (multi-disciplinary) – operation in different WX conditions.                                                                                             |
| Exception handling (loss of comms, GPS degradation)                                      | Transfer of control – knowing what the software is doing – someone who has a little of software experience along with vessel operations (i.e. GPS) – be able to take vessel from autonomous to manual system mode.               |
| NOTE: Operators are less ‘drivers’ and more air traffic controllers for robots on water. | Display control (HMI – human machine interface) – not actually operating the system – understanding the system is important – need to learn the entire system is important. Kyle shared his fire control experience in the navy. |
|                                                                                          | Understanding the OEM's – logistics – deployment/mobilization.                                                                                                                                                                   |
|                                                                                          | Remote piloting (manual override/teleportation)                                                                                                                                                                                  |
|                                                                                          | Supervisory control of autonomy (human-on-the-loop)                                                                                                                                                                              |
|                                                                                          | Mission planning software.                                                                                                                                                                                                       |
|                                                                                          | Geofencing & waypoint programming                                                                                                                                                                                                |
|                                                                                          | Payload operation (camera, sonar, sensors)                                                                                                                                                                                       |

| USV Technician                                                            |                                                                                                      |
|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Technician Role (what does the technician do?)                            | Technician Technical Skills                                                                          |
| Troubleshooting and diagnostics                                           | Adaptability                                                                                         |
| Emergency procedures – loss of comms, etc.                                | Electronics troubleshooting                                                                          |
| Bridge resource management training                                       | Electronics expertise and electrical skills                                                          |
| Payload management – comms mast**, launch and recovery – sub systems      | Industry certification and best practices (i.e. ABS, NMEA, ABYC)                                     |
| Safety and emergency response.                                            | Vessel systems training and familiarity                                                              |
| Hardware and equipment – both installation and maintenance                | Specific training and certification for vessel COI (certificate of inspection) and level of autonomy |
| Knowledge of the data layer – what’s feeding the system                   | Training and familiarity with digital controls and sub-systems                                       |
| Include both software and hardware – multi-disciplinary facet             | Training and safety standards for batteries and battery systems                                      |
| Cross training – any system on a vessel is a target for the technician    |                                                                                                      |
| Understanding hardware and software interconnection                       |                                                                                                      |
| Understanding full system integration                                     |                                                                                                      |
| Use of electrical and mechanical diagnostic equipment                     |                                                                                                      |
| Critical Communications                                                   |                                                                                                      |
| Knowledge of equipment regulations, standards and industry best practices |                                                                                                      |
| Cross Skills for marine and tech                                          |                                                                                                      |
| Soft skills – documentation                                               |                                                                                                      |
| Configuration of autonomy software                                        |                                                                                                      |
| Sensor fusion basics (GPS, IMU, AIS, radar, LiDAR)                        |                                                                                                      |
| Calibration of navigation systems                                         |                                                                                                      |
| Firmware/software updates                                                 |                                                                                                      |

*NOTE: Both roles need these skillsets, but at different depths. This is where maritime meets robotics. The vessel is constantly “deciding,” and someone needs to understand that logic.*

**\*\*POINT OF CLARIFICATION**

**Vessel and Maritime Fundamentals for the Operator & Technician**

**Key Skills:**

- COLREGs interpretation (especially for remote/autonomous compliance)
- Basic seamanship (stability, buoyancy, small craft behavior)
- Weather interpretation (localized, nearshore effects)
- Situational awareness in congested waterways
- Launch & recovery (often the highest-risk phase)

**NOTE:** Unmanned doesn’t mean “un-marinered” in terms of knowledge. For sub-7m platforms, skillsets tend to be practical and scenario-based, not license-heavy like traditional STCW pathways.

*The development of this framework was supported by AI Large Language Models, which assisted with drafting and editing.*

### Acknowledgements

The Autonomous Vessel Skills Mapping Framework reflects the collective expertise and contributions of maritime industry leaders, autonomous technology professionals, educators, and workforce development practitioners who participated in the December 2025 and March 2026 workshops. Their insights helped identify the occupational knowledge, technical competencies, and workforce requirements necessary to support the emerging autonomous vessel sector.

WaveWorks Alliance extends its sincere appreciation to all subject matter experts, industry partners, and project contributors who dedicated their time and expertise to this effort. Their participation has helped establish a foundation for future education, training, credentialing, and workforce development initiatives supporting autonomous maritime technologies.

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| <b>Denielle Christensen</b> , <i>Executive Director &amp; CEO, WaveWorks Alliance</i>                                                         | <b>Nathan Krohn</b> , <i>USV Engineering Lead, Triton Systems, Inc.</i>                    |
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*Participation in the Work Group does not necessarily imply endorsement of every finding or recommendation contained in this report.*

## About WaveWorks Alliance

WaveWorks Alliance is a national nonprofit organization dedicated to expanding awareness of and access to careers within the ocean economy. Through partnerships with industry, education, government, and workforce organizations, WaveWorks Alliance develops workforce strategies, educational resources, career pathways, and industry-informed frameworks that support the growth of a skilled maritime workforce.

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For information about this framework or future workforce development initiatives, please contact WaveWorks Alliance.

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## Disclaimer

This framework was developed through industry collaboration and reflects the knowledge, experience, and perspectives of participating subject matter experts at the time of publication. The information presented is intended to support workforce development, education, credentialing, and training pathway discussions within the maritime and autonomous systems sectors.

Autonomous vessel technologies, regulations, standards, and operational practices continue to evolve. As such, this framework should be periodically reviewed and updated to maintain alignment with current industry needs and emerging best practices.

*Prepared by WaveWorks Alliance through industry-led workforce research and stakeholder engagement activities.*