MARITIME TECHNICAL WORKING GROUP

CASE STUDY: SEA MACHINES ROBOTICS – SM300 AUTONOMOUS COMMAND AND CONTROL SYSTEM

MAY 5, 2025

TABLE OF CONTENTS

wsp

DOCUMENT CONTROLS

RECORD OF APPROVAL

VERSION	CHANGE DESCRIPTION	DATE
01	First Draft	04/9/25
02	Final Draft	05/05/25

CHANGE MANAGEMENT

VERSION	CHANGE DESCRIPTION	DATE

LIST OF ABBREVIATIONS

ABS	American Bureau of Shipping
AI	Artificial Intelligence
AIS	Automatic Identification System
AUV	Autonomous Underwater Vehicle
BOEM	Bureau of Ocean Energy Management
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
CTV	Crew Transfer Vessel
IMO	International Maritime Organization
Jones Act	Merchant Marine Act of 1920
LiDAR	Light Detection and Ranging
MASS	Maritime Autonomous Surface Ship
MBES	Multibeam Echo Sounder
MSRC	Marine Spill Response Corporation
NOAA	National Oceanic and Atmospheric Administration
OWF	Offshore Wind Farm
OPEX	Operational Expenditures
ROV	Remotely Operated Vehicle
SOV	Service Operation Vessel
SM300	Sea Machines 300 Autonomous System
USCG	United States Coast Guard
USV	Uncrewed Surface Vessel

Overview of Autonomous Vessel Technology

Autonomous vessels incorporate varying levels of automation, from crewed ships with automated decision support to fully autonomous vessels capable of independent operation. Using advanced sensors, machine learning, and remote-control systems, these vessels can navigate, avoid collisions, and communicate with other vessels without human intervention. Their adoption is growing across industries such as commercial shipping, offshore energy, environmental monitoring, defense, and hydrographic surveying, offering improved efficiency, reduced operational costs, and enhanced safety by minimizing human exposure to hazardous conditions.

In recent years, advancements in AI and machine learning have become increasingly prevalent, enabling autonomous vessels to operate with greater precision, adaptability, and efficiency by enhancing real-time navigation, obstacle avoidance, and monitoring capabilities.

Autonomous Unmanned Vessels (AUVs) are a specialized class of autonomous vessels designed to operate without onboard crew, relying on advanced control systems to execute missions remotely or autonomously either on the surface or underwater.

Key capabilities of AUVs include:

- Autonomous navigation and collision avoidance using radar, LiDAR, and AI-powered situational awareness to safely operate in complex maritime environments.
- Remote operation from shore-based control centers, enabling real-time oversight and coordination of multiple vessels.
- Seabed mapping and offshore resource exploration, where AUVs equipped with advanced sonar and bathymetric sensors collect high-resolution data for research, infrastructure planning, and energy exploration.
- Deep-sea surveying for hydrocarbon reserves, allowing for the detection and assessment of underwater oil and gas deposits.
- Maritime security and defense operations, where AUVs conduct surveillance, reconnaissance, and border patrol missions to enhance situational awareness while reducing risks to human personnel.

Autonomous Vessel Challenges and Barriers

Autonomous vessel technology has made significant improvements over the past decade, but several factors still limit its broader adoption. An overview of key challenges and barriers in the AUV industry:

- Regulatory complexity - Different national and international bodies impose varying standards for safety, liability, and operations, creating a patchwork of requirements. Even as the global and federal agencies work toward consistent guidelines, the absence of a global framework complicates deployment.
- Safety and perception - A single incident can erode public trust in autonomous systems, especially in an industry that prioritizes risk management. Stakeholders demand

transparent incident reporting and solid evidence that autonomous vessels meet or exceed the safety performance of crewed operations.

- Technical - High bandwidth connectivity (e.g., LTE, satellite) is essential for real-time vessel control and sensor data, and remote offshore environments can prove to be difficult. Also, retrofitting older vessels with AI based systems, sensors, and communication platforms can also be costly and technically challenging.
- Onshore Infrastructure - Widespread adoption of autonomous vessels requires significant investment in shore-based infrastructure, including port automation systems, control and data centers, high-bandwidth communication networks (antennas, satellites), and reliable power supply systems. Without these components, managing and monitoring autonomous vessels efficiently becomes difficult.
- Cost - Installing and integrating autonomous technologies often requires significant up-front investment in equipment, software, and training. While these systems can reduce long term labor and operational costs, returns may be unclear, especially in immature markets like the US.
- Workforce - Moving from onboard crews to shore-based control centers, hybrid operations or monitoring calls for new skill sets and training. Vessel operators will need specialized training in remote supervision and data analytics. In markets like New York, where workforce unionization is common, there may be political resistance if autonomous technologies appear to reduce job opportunities, particularly given the government incentives aimed at expanding jobs in the offshore wind industry.
- Scope and limitations - Autonomous operations excel at repetitive or specialized tasks such as surveying, patrolling, or set transport but still rely on human oversight for complex decision-making or emergency situations. Marine environments are unpredictable and the systems still rely on human oversight to manage mechanical failures, weather conditions, or decision-making that goes beyond standard algorithms.

Sea Machines Robotics

Sea Machines Robotics, a Boston-based company in marine autonomy and advanced perception systems, specializes in the development of autonomous command and control solutions for commercial and industrial maritime applications. Founded in 2017, the company has positioned itself as one of the leaders of maritime automation.

Sea Machines' most prevalent technology is the SM300 Autonomous Command and Control System, a modular autonomy solution designed to convert conventional crewed vessels into remotely operated or fully autonomous platforms. The SM300 system provides real-time situational awareness, autonomous navigation, and collision avoidance, allowing vessels to perform complex operations with minimal human intervention. The system integrates with radar, LiDAR, AIS, optical cameras, and remote communications (LTE, Iridium, Starlink) to ensure safe and efficient uncrewed operations.

Below in Figure 1 is an overview of the system and its specifications for achieving retrofit-ready technology of the SM300.

SEA MACHINES 300

ONBOARD CABINET

Intelligent Control Hub with Flexible Sensor Integration

Primary Hardware	Description
Cabinet Enclosure	IP65 Rated Industrial-Grade, Stainless Steel
Processors	Siemens S7 PLC, Industrial Linux Computer
Dimensions	20 x 20 x 8.80 inches (50.8 x 50.8 x 22.35 cm.)
Weight	65 lbs. (29.48 kg)
User Interface (Local)	Siemens 9 inch Touch Screen HMI
Components	100% Solid State, Ruggedized
Certifications	By most recognized authorities (ABS, DNV)
Temperature Rating	0–60° C
Integrated Machinery	**Compatibility**
Engines	Electronic or Mechanical
Steering	Electronic or Hydraulic
Transmission	Clutch & Gear Control
Auxiliaries	Per Operator Requirements
Integrated Sensors	**Sensor Input**
Differential GPS	Position, Heading, COG & SOG
AIS	Ship Traffic Sensor
Radar	ARPA Targets
Image/Video	Multiple Cameras
Depth Sounder	Sounder Feed
Payload Control	**Applications**
Sonar	Survey
Winches / Loading	Tugs / Aquaculture
Davit / Crane	Equipment Deployment
ROV	Research, Mining, Recovery
Moonpool	Equipment Deployment

REMOTE USER INTERFACE

Rugged Intuitive Interface & Control Devices

User Interfaces	Component Type
Graphical Remote User Control	Ruggedized Laptop with Aux Screens
Autonomous Modes	**Capabilties**
Planned Route	Grids, Patrol, Dynamic
Collaborative	Escort / Synchronized Ops
Waypoints	Planned Routing or Dynamic
Safe Routing	ECDIS Integrated
Obstacle Avoidance	Multi Sensor Detection
Communications	**Type**
Inshore / Nearshore	IP Radio, 4G/LTE
Ship-to-Ship	IP Radio
Long Range (>5nm)	Satellite (L-band, VSAT KU, KA)
Machinery Parameters	**Commands & Alarms**
Engine Start/Stop	Remote Start / Stop
RPM	Throttle Command
Engine Temp / Engine Oil Pressure	Engine Alarms / Faults
Gear Oil Pressure	Pressure Alarms
Fuel Oil	Tank Levels
Angle Indicator	Degrees PRT/STBD
Interruptions	**Safety Devices**
Loss of Communications	All stop, Hold Station, Other
Manual Emergency Stop	ALL STOP on all interfaces
Failure Modes	Pre-programmed or customized

Figure 1 SM300 Technology Overview

SM300 System Deployment & Applications

The SM300 system has been deployed in multiple operational environments, demonstrating its capabilities in various offshore settings.

Key deployments include:

- CT & NY – First Harvest Navigation: Integrated with the cargo vessel Captain Ben Moore (63ft. x 21.3 ft. aluminum catamaran), where the SM300 system enabled autonomous and remote-helm operation. The first hybrid cargo vessel to feature remote crew-assist technology in the U.S. The vessel operates between Norwalk, Connecticut, and Huntington, New York, transporting palletized produce and food across Long Island Sound. See Figure 2.

- Galveston Bay: Used aboard DEA Marine Services' survey vessel Sigsbee, where it enabled a hybrid crewed/uncrewed hydrographic survey for NOAA, covering over 600 autonomous nautical miles (By 2021).
- SELKIE 7 (Sea Machines Robotics, USA): A 7-meter (m) uncrewed surface vessel (USV) designed for hydrographic surveys, offshore asset inspections, and environmental monitoring. Equipped with an under-keel sonar mount, CTD winch, and a cargo bay.
- North Sea & Dutch Wadden Sea: Integrated with Deep BV's survey vessel, Loeve (8 m/26.2 ft.), where it enabled fully autonomous and remote-helm hydrographic surveys. This allowed for continuous operation in shallow waters and tidal environments, optimizing data collection accuracy while minimizing risk to personnel.
- Netherlands/Denmark: Nellie Bly (Machine Odyssey): An autonomous tug that completed a 129-hour voyage over 13 days (over 1000 nautical miles), remotely commanded by U.S. Coast Guard (USCG)-licensed mariners stationed 3,000 miles away in Boston. This demonstrated the SM300's capabilities in long-distance autonomous operations and successfully executed 31 collision avoidance and traffic separation maneuvers. See Figure 3.
- California – Foss Maritime: Integrated with the tug Rachael Allen, where the SM300 system enabled autonomous transit and station-keeping for tanker escort and ship assist operations. The system interfaces with Kongsberg-MTU propulsion controls, allowing for remote piloting trials from a shore-based command center.
- Hawaii – USCG Research & Development Center: Integrated with a Sharktech 29 Defiant autonomous vessel, developed in partnership with Metal Shark Boats. The SM300 system was tested in USCG-designated waters to evaluate autonomous surveillance, interdiction, and patrol capabilities.
- Portland, Maine – Marine Spill Response Corporation (MSRC): Integrated with a Kvichak Marco skimmer boat, where the SM300 system enabled autonomous spill-response operations. Conducted in August 2019 for the U.S. Department of Transportation Maritime Administration (MARAD), this deployment showcased the world's first autonomous oil spill response vessel.

As noted, the SM300 system has been deployed in multiple locations and settings, including the east coast of the United States as shown in Figure 4.

Figure 2 Captain Ben Moore Vessel

Figure 3 Nellie Bly

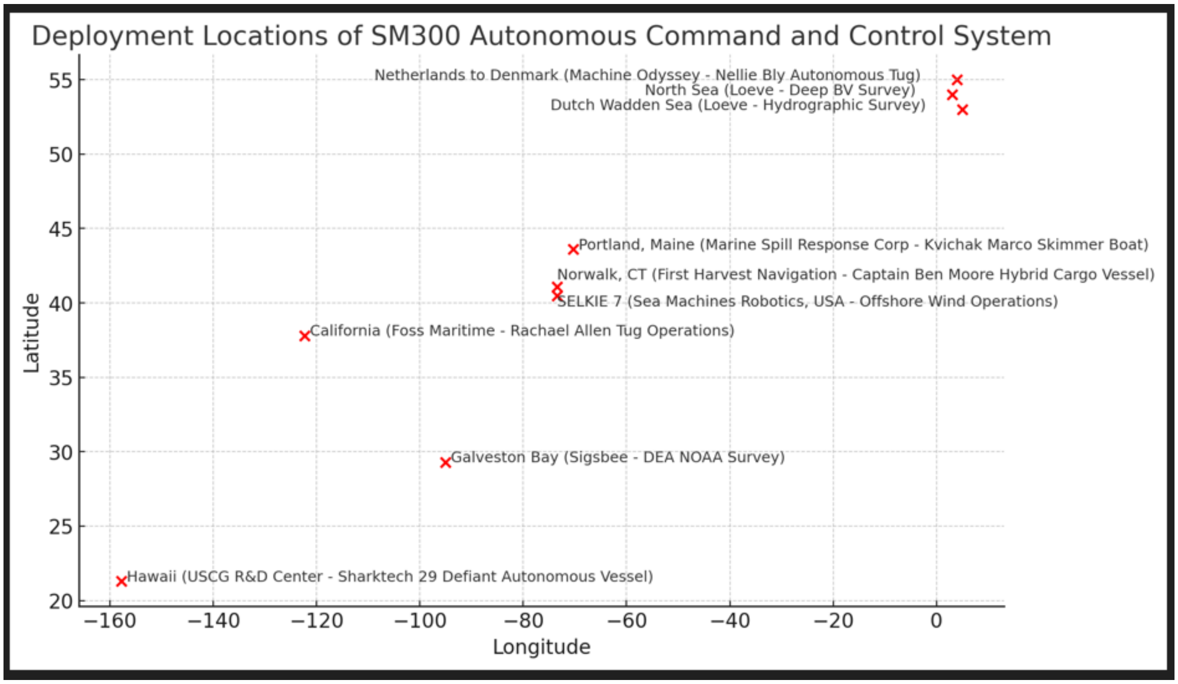

Figure 4 SM300 Deployment Locations

Challenges in Offshore Wind Vessel Operations

The offshore wind industry relies on a fleet of specialized vessels for offshore operations and face significant challenges that impact project timelines, costs, and overall efficiency. These challenges stem from harsh environmental conditions, logistical complexities, high operational expenses, and increasing sustainability requirements. Addressing these issues is critical for improving offshore wind farm development and optimizing long-term operations.

CHALLENGE	DESCRIPTION	IMPACT ON INDUSTRY
Crew Safety & Fatigue	Offshore wind operations require vessels to operate in harsh environments with long shifts, extreme weather, and physically demanding tasks.	Increased risk of accidents, fatigue-related errors, and crew injuries. Adverse weather can reduce workability windows, delaying projects.
High Operational Costs	Vessel operations require large crews, high fuel consumption, and frequent maintenance. The need for specialized vessels (SOVs, CTVs, and survey ships) further drives up expenses.	Increases CAPEX and OPEX, making offshore wind projects more expensive and dependent on vessel availability.
Survey Efficiency	Traditional survey vessels rely on human crews, are limited by shift durations, and may be prone to	Slower, costlier, and less precise seabed mapping and infrastructure

	inconsistencies in data collection. Asset inspections often require divers or ROVs deployed from crewed vessels.	monitoring, leading to longer permitting and maintenance cycles.
Environmental Sustainability	Maritime operators face pressure to reduce carbon emissions and fuel consumption.	Requires investment in low-emission technologies and hybrid/electric solutions.
Distance from Shore	As OWFs move further offshore, vessel transit times increase, and traditional crewed operations become more challenging.	Longer travel distances reduce effective working hours, increase fuel consumption, and raise logistical challenges for maintenance, inspections, and crew rotations.

Table 1 Offshore Wind Vessel Operations Challenges

SM300 System Features

The SM300 System offers a scalable, adaptable solution for offshore vessel operations by enabling autonomous navigation, remote control, and fleet coordination. Unlike many emerging maritime technologies, the SM300 is commercially available and can be installed on existing vessels in under a week in some cases, making it a practical option for enhancing autonomous capabilities in offshore environments.

The table below outlines how the SM300 system could address key operational challenges:

CHALLENGE	CHALLENGE ADDRESSED BY	KEY FEATURES ENABLING THE SOLUTION
Crew Safety & Fatigue	Autonomous Navigation & Collision Avoidance – The SM300 integrates Ai powered radar, LiDAR, optical cameras, and AIS, allowing vessels to navigate without constant human intervention. This reduces crew exposure to offshore hazards and minimizes fatigue-related incidents.	Autonomous Navigation & Collision Avoidance – AI driven perception systems provide situational awareness, allowing vessels to detect and avoid obstacles with greater precision.
High Operational Costs	Remote-Helm Operation & Fleet Optimization – The SM300 enables vessels to be remotely commanded from a shore-based control center, reducing the need for large onboard crews.	Remote-Helm Control & Fleet Coordination – Wireless IP radio, LTE, Iridium, and Starlink connectivity enable centralized vessel command and fleet coordination, optimizing crew allocation.
Survey Efficiency	Continuous, High-Precision Surveying – SM300-powered vessels operate 24/7, enhancing seabed mapping, cable route planning, and	Survey-Ready Automation – Pre-programmed mission execution, waypoint tracking, and precision control ensure high-quality data

	infrastructure inspections with higher accuracy and efficiency.	collection while reducing human error.
Environmental Sustainability	Sustainability & Emissions Reduction – By supporting hybrid and fully electric vessel operations, SM300-powered vessels lower carbon emissions and reduce fuel dependency.	Seakeeping & Adaptive Motion Control – Regulates vessel speeds and movements to optimize fuel efficiency, reduce emissions, and improve safety in rough sea conditions.

Table 2 Address of Offshore Wind Vessel Operations Challenges

NAVIGATIONAL SAFETY AND SECURITY

Maritime navigation faces distinct challenges, including the presence of unregulated vessels, often referred to as “shadow fleets,” operating without proper oversight or communication. According to the International Maritime Organization (IMO), unregulated vessels operating without proper oversight or communication pose significant collision and environmental hazards, particularly in busy shipping lanes, such as those within New York harbor and the surrounding area. Additionally, integrating autonomous technology heightens vulnerability to cyber threats, requiring robust cybersecurity measures.

Autonomous vessels equipped with Sea Machines' SM300 system address these navigational hazards by substantially reducing reliance on human judgment, thus minimizing risks associated with fatigue, poor visibility, and situational misjudgment. By continuously integrating data from radar, AIS, GPS, and computer vision, autonomous vessels enhance real-time situational awareness and collision avoidance capabilities. The SM300 system can swiftly detect and respond to vessels operating without proper identification, further mitigating potential navigational threats. Sea Machines' technology also conforms to international maritime collision regulations (COLREGs), ensuring regulatory compliance and effective hazard mitigation. Comprehensive cybersecurity features and continuous system monitoring protect against digital vulnerabilities, reinforcing both physical and cyber safety. This integrated approach enhances the overall security, safety, and resilience of maritime autonomous operations.

INFRASTRUCTURE REQUIREMENTS

Sea Machines’ SM300 system integrates easily into existing vessels and port operations without specialized infrastructure. There are three main control configurations available for operating SM300-equipped vessels: shipboard control, shore-based control, and the portable beltpack.

- Shipboard Control: This configuration refers to direct control from the onboard wheelhouse. The vessel’s captain or onboard crew operate the SM300 from familiar vessel consoles integrated with Sea Machines’ system. This setup is beneficial when immediate onboard oversight and control are desired, particularly during operations that require advanced vessel handling or rapid response in challenging conditions.
- Shore-Based Control: This remote operation approach allows operators at onshore command centers to manage vessel navigation and mission execution via reliable communication networks, typically cellular or satellite. Shore-based control centers provide enhanced flexibility, enabling centralized supervision of multiple autonomous or

semi autonomous vessels simultaneously. This configuration is preferable for users managing larger fleets, long-duration missions, or operations in high-risk or remote environments, reducing crew risk exposure and potentially lowering operating costs. (See Figure 5).

- Beltpack Remote-Helm Device: A portable, handheld wireless controller that enables short-range remote vessel operation. This option is useful for precision maneuvering during docking, cargo handling, or confined-water operations. It relies on short-range wireless communications similar to industrial wireless remote controls. The beltpack is preferable for mariners requiring greater mobility and direct visual oversight, making it ideal for harbor tugs, cargo transfer operations, or close-quarter maneuvers where precision and responsiveness are critical.

Overall, the choice between shipboard, shore-based, or beltpack control depends primarily on the end user's specific operational needs. Ports and vessel operators managing small-scale or precision-focused operations may prefer the beltpack or onboard control, whereas larger-scale commercial operations or fleets are more likely to utilize shore-based control for centralized fleet management and operational efficiency. Because of SM300's versatility, most ports can support autonomous vessels without significant infrastructure modifications beyond ensuring robust and reliable connectivity. In addition, use of shore-based or beltpack remote controls adds a layer of safety by reducing mariner exposure to potential collisions in high-risk situations.

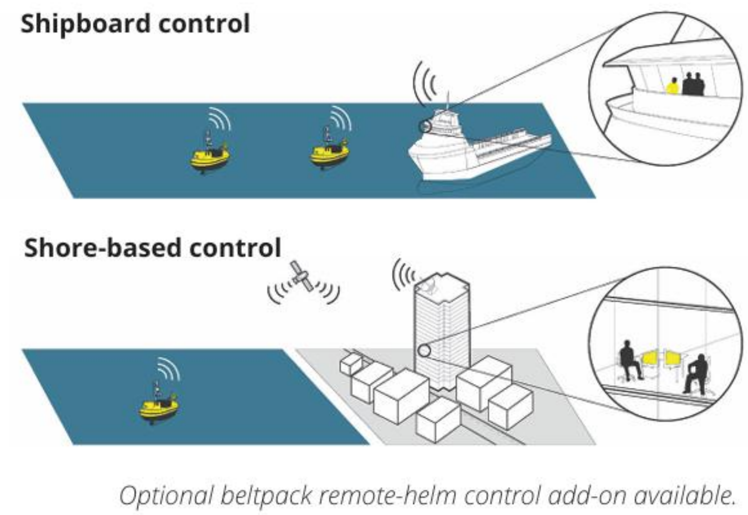

Figure 5 SM300 Control Interfaces

SM300 SYSTEM - TRAINING APPROACH AND SKILL DEVELOPMENT

Based on publicly available information, no specifc training applications or programs have been identified, as this technology has only been applied on a small amount of project specifc deployments; however, Sea Machines generally provides both formal and informal guidance on how to operate and maintain their autonomous control systems. While the SM300 system does not necessarily create entirely new maritime roles, Sea Machines does recommend specialized training for mariners transitioning to the use of autonomous systems, including system calibration, remote monitoring and control, and managing cybersecurity protocols. It is anticpated that existing crew or shoreside staff will take on additional responsibilities related to remote command and control, data interpretation, cyber security, and software troubleshooting. This could involve cross-training mariners to become proficient in the SM300's user interface and emergency override procedures. Rather than introducing wholly new job types, Sea Machines' approach generally augments traditional mariner skill sets with a focus on technology, situational awareness, and continuous system monitoring.

Potential OWF Support from the SM300 System

The SM300 Autonomous Command and Control System has the potential to enhance offshore wind operations by increasing efficiency, safety, and regulatory compliance. With its advanced autonomy, remote operation, and AI-powered situational awareness, the system could optimize key offshore wind activities by reducing costs, improving data accuracy, and minimizing human exposure to hazardous environments.

While specific commercial deployments within offshore wind projects have not yet been publicly documented, Sea Machines highlights the SM300's potential suitability for offshore wind operations, citing use-cases such as inspection and maintenance, logistics and supply chain management, and data collection and mapping. Sea Machines online blog posts have noted "Offshore energy plays a vital role in meeting global energy demands, contributing significantly to the production of renewable energy, oil, and gas. With the expansion of offshore energy projects worldwide, ensuring the efficiency, safety, and sustainability of operations becomes paramount. Unmanned vessels have emerged as integral tools in offshore energy operations, offering innovative solutions to challenges such as inspection, maintenance, and logistical support." Many of these use cases, including logistics and supply chain management, navigational support (e.g., collision avoidance), and data collection and mapping are likely to be applicable to New York harbor and their associated OWF installations.

Seabed Surveys & Mapping

The SM300 could be integrated with survey vessels to enable the autonomous collection of high-resolution bathymetric data for cable route planning, site selection, and permitting requirements. Equipped with multibeam sonars, sub-bottom profilers, and magnetometers, SM300-powered vessels could operate continuously without crew fatigue, ensuring faster and more cost-effective survey campaigns.

- Hydrographic Surveys: Mapping seabed features for offshore wind farm placement of vessels, assets and navigation safety.
- Geophysical Surveys: Characterizing seafloor geology to support engineering design and installation.
- Unexploded Ordnance Surveys: Identifying potential hazards from historical munitions left on the seafloor.

Asset Inspection & Maintenance

The SM300 could enable real-time monitoring of subsea cables, turbine foundations, and offshore substations, ensuring early detection of structural wear, corrosion, or mechanical stress.

By integrating with autonomous ROVs and AUVs, SM300-powered vessels could conduct high-precision, automated inspections without divers or crewed vessels.

- Proactive Maintenance: Frequent inspections to prevent costly failures and reduce downtime.
- Cable Protection Monitoring: Detecting sand wave movement and evaluating the need for cable protection systems such as rock dumping and concrete mattresses.
- Extended Asset Lifespan: Continuous monitoring enables predictive maintenance strategies, minimizing emergency repairs.

Operations and Logistics

The SM300 could support autonomous offshore logistics, including material transport and crew transfer operations. By enabling uncrewed operations, it could reduce reliance on expensive crewed support vessels, cutting fuel costs and improving operational efficiency.

- CTV Support: Autonomous navigation for crew transport and small-scale cargo deliveries during installation and maintenance phases.
- Guard Vessels & Offshore Surveillance: Autonomous patrols of offshore wind construction zones to prevent unauthorized vessel entry and enhance site security.
- Buoy Deployment & Servicing: Automating offshore marker buoy placement and maintenance to aid navigation and environmental monitoring.

Environmental Monitoring

By equipping autonomous vessels with hydrophones, passive acoustic monitoring systems, and environmental sensors, SM300-powered vessels could support comprehensive impact assessments and ecosystem monitoring.

- Marine Mammal Observation: Autonomous data collection to assess the impact of wind farm construction on marine species and ensure endangered mammals are not within the defined area during installation.
- Fisheries Studies: Monitoring fish populations, seabed habitats, and benthic conditions to evaluate ecological effects.
- Artificial Reef Research: Evaluating turbine foundations' potential to support marine biodiversity.

The SM300 Control System presents an adaptable solution for offshore wind operations, with the potential to streamline surveying, maintenance, logistics, and environmental monitoring.

Regulatory Agencies for Autonomous Vessels

Autonomous vessels operating in U.S. waters are subject to regulation by the following agencies, regulatory bodies and laws.

US Coast Guard (USCG)

The Coast Guard is the federal agency responsible for regulating U.S. waterways to ensure that they are safe and secure. The Coast Guard acts as the lead agency within the U.S. delegation to the International Maritime Organization (IMO).

Sea Machines have worked with the USCG to test and validate autonomous vessel operations, particularly in USCG-designated test zones such as Galveston Bay and Hawaii. The Sharktech 29 Defiant autonomous vessel, developed with Metal Shark Boats, underwent USCG-supervised trials to assess its performance in autonomous surveillance, patrol, and interdiction operations. These trials aimed to evaluate the viability of AUVs in maritime law enforcement and security applications.

International Maritime Organization (IMO)

The IMO is developing a regulatory framework for autonomous ships in commercial operation in international waters that addresses cross-cutting issues such as safety, training, and legal liabilities. It is generally expected to be adopted by member countries on a non-mandatory basis in 2025 and in force on a mandatory basis for member countries in 2032 by amending an existing IMO convention. Selected countries have approached regulation of autonomous ships in various ways, including regulating them within the framework of existing laws and regulations, modifying regulations, and creating new regulations and policies.

The IMO has introduced Maritime Autonomous Surface Ship (MASS) Guidelines, with which the SM300 system is fully compliant. These guidelines ensure that autonomous vessel operations adhere to existing safety and regulatory standards while paving the way for the gradual adoption of fully autonomous offshore wind logistics and maintenance vessels.

American Bureau of Shipping

The ABS is a U.S. regulatory body and classification society that establishes and enforces safety, design, and operational standards for commercial vessels, including autonomous ships.

ABS has verified the SM300 system aboard Foss Maritime’s tug Rachael Allen, marking a key regulatory milestone for autonomous vessel technology. The SM300 enables autonomous transit and station-keeping, interfacing with Kongsberg-MTU propulsion controls for enhanced crew safety and operational efficiency. The collaboration between Sea Machines, Foss, and ABS underscores industry-wide efforts to integrate autonomy into commercial operations. Rachael Allen is currently deployed in California for tanker escort and ship assist operations.

Jones Act

Sea Machines' SM300 deployments within the U.S. have consistently complied with Jones Act regulations, primarily because the system integrates seamlessly with domestically built and flagged vessels. As a retrofit solution designed to enhance autonomous capabilities of conventional vessels, the SM300 generally does not impact a vessel's compliance status with the Jones Act. All Sea Machines deployment examples were either built and flagged in the U.S., operated domestically, or engaged in activities exempt from Jones Act requirements, further demonstrating the system’s compatibility with existing U.S. maritime regulatory frameworks. Operators aiming to implement autonomous technologies within U.S. waters can leverage systems like the SM300 without requiring new builds or foreign vessel involvement, thereby simplifying regulatory compliance and enabling broader adoption in domestic maritime operations.

Lessons Learned

Through multiple deployments across different maritime environments, several lessons have been learned regarding the integration and operation of the SM300 system:

- Collaborative autonomy with manned motherships expanded survey coverage and minimized downtime. Coordinated deployment of multiple autonomous vessels maximized data collection and significantly shortened survey durations.
- Remote operation capabilities reduced human exposure to hazardous offshore environments. The SM300 mitigates risks associated with severe weather, vessel collisions, and crew fatigue, enhancing overall safety.
- Lower reliance on crewed vessels led to fuel savings and reduced carbon emissions. The SM300's ability to support uncrewed operations aligns with industry sustainability goals, decreasing environmental impact.
- While the SM300 meets key regulatory requirements, further standardization is needed. Full integration of autonomous vessels into commercial maritime operations requires continued development of industry-wide regulations.
- Autonomous operations remain reliable in challenging conditions. The SM300 enables vessels to continue working through poor visibility, extreme weather, and rough sea states.

Many of these lessons, including collaborative autonomy, remote operation safety benefits, reduced environmental impact, and regulatory standardization, apply broadly to autonomous maritime technologies beyond the SM300 system. Future efforts and industry recommendations should focus on standardizing protocols, ensuring operability between systems, and developing comprehensive training programs, thus supporting widespread adoption and integration of autonomous vessels into maritime operations.