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AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

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List of Acronyms

Abbreviation / acronym	**Description**
EC	European Commission
D3.5	Deliverable number 5 belonging to WP 1.
WP	Work Package
IOSS	Intelligent Operator Support System
DTA	Dynamic Task Allocation
RCHS	Robotic Container Handling System
3DWI	Three Dimensional World Interpreter
SA	Situational Awareness
SAR	Situational Awareness Recovery
IDDFS	Iterative Deepening Depth-First Search
Ro-Ro Ferries	Roll-On-Roll-Off Ferries

Executive Summary

The work described in this report is directed towards developing and demonstrating a Robotic Container Handling System (RCHS) that, when mounted upon a hybrid electric feeder vessel, will stimulate and support the use of short sea container services for small ports that have no or limited terminal infrastructure. This innovation fits the MOSES-project aim to significantly enhance the Short Sea Shipping (SSS) component of the European container supply chain by implementing a constellation of innovations including innovative vessels and the optimization of logistics operations.

In most port terminals, moored container ships are loaded and unloaded with shore cranes. In that case it is a crane operator who controls the crane, who knows which container to move, who estimates the distance between the spreader and the container, who reduces speed if necessary, etc. The safety of the operation is ensured by a direct line of sight to the operation, relatively high degree of supervision by others and the creation of a safe and closed operational area. The RCHS research challenge is to bridge the large gap between the current manned way of working and the envisioned operational concept where the RCHS can perform all these tasks unmanned and on its own, i.e. autonomously.

The RCHS consists of a crane, software that drives it, a sensor suite that provides information about the operational area (e.g. the location of a container) to the crane, software enabling autonomous operation, and a shore control centre from which operators remotely monitor and supervise the crane’s operation. The innovation described in this report aims to develop an Intelligent Operator Support System (IOSS). This system aims to allow multiple operators to supervise multiple autonomous operations by exception to ensure their effectiveness and safety. This many-to-many concept assumes a stage in human-automation collaboration design where supervision of maritime autonomous surface ships is not permanently required anymore. For instance, in this operational context operators may need to intervene only in situations that are beyond container handling itself, e.g. to deal with a missing container, or people or vehicles that are in the way.

One of the challenges we addressed in this context is to balance the task assignments and support functions over the operators to ensure the cognitive task load matches the operator’s mental capacity. Also, human attention is limited and operators therefore must constantly shift attention resulting in moment-to-moment fluctuations in situation awareness. For this, we developed the concept of continuous risk assessment to initiate the process of operator situation awareness recovery. Furthermore, the many-to-many ratio between supervising operators and autonomous ships implies that operators will not be able to supervise all ships in parallel. For this reason we applied progressive disclosure technology for the IOSS

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interface design. It entails a three-layer interface that progressively discloses more information about the operations an operator supervises and enables increasingly more complex and involved control actions. The interface design provides an overview of the entire fleet, a localized overview of the status of a single ship, and a situational view providing an entirely immersive view using virtual reality on a single situational perspective of a ship.

For the latter, the immersive view, we build a digital twin as a virtual reality environment in which the operator can freely explore the sensor data the ship acquires. Given the fact that a virtual reality application in this context is new we additionally conducted an online experiment to determine what level of information richness is required for a remote operator to be able to understand the situation and to intervene in a container (off)loading operation. The main conclusion of the experiment supports the use of a digital twin in this context.

Based on an internal demonstration of the Intelligent Operator Support System architecture, we can conclude that we have succeeded in developing an operator support environment which is fully functional for shore control centres. It can be applied in centres in which multiple operators need support in guiding multiple autonomous processes, in ensuring safety within the local operational area, and to intervene if the situation calls for it. With this innovation, we have taken an important step towards a support concept that can be used generically for the supervisory control of other types of autonomous systems, such as autonomously sailing ships.

In order to the RCHS to function as a system-of-systems it is necessary that the components can exchange data. For this purpose, the IOSS is provided with a backend architecture that enables information exchange with other system software components. The integration of the subsystems will be realized in the pilot demonstration phase of the MOSES-project (WP7, task 4).