AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

D.4.1: Architecture for Autonomous tugboat operation

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List of Acronyms

Abbreviation / acronym	Description
AB	Advisory Board
ACK	Acknowledgement Signal
AHRS	Attitude and Heading Reference System
AI	Artificial Intelligence
AIS	Automatic Identification System
CAN	Controller Area Network
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
D2.1	Deliverable number 1 belonging to WP 2
D2.4	Deliverable number 4 belonging to WP 2
D4.1	Deliverable number 1 belonging to WP 4
DAQ	Data Acquisition unit
DGPS	Differential GPS
DLC	Data Length Code

Abbreviation / acronym	Description
DSS	Deep Sea Shipping
EC	European Commission
EOF	End of Frame
FOV	Field of View
GPIO	General Purpose I/O
GPS	Global Positioning System
GPU	Graphics Processing Unit
HW	Hardware
IDE	Identifier Extension
IFS	Inter-frame Space
IMO	International Maritime Organization
IMU	Inertial Measurement Unit
LAN	Local Area Network
Lidar	Light Detection and Ranging
NVR	Network Video Recorder
OSI	Open Systems Interconnection
PoE	Power over Ethernet
Radar	Radio Detection and Ranging
RQ	Requirement
RTK	Real-Time Kinematic
RTR	Remote Transmission Request
SOF	Start of Frame
SOLAS	Safety of Life at Sea
STCS	Shore Tugboat Control Station
SW	Software
SysML	Systems Modelling Language
TRL	Technology Readiness Level
VHF	Very High Frequency
VPN	Virtual Private Network
WP	Work Package

Executive Summary

The present document is a deliverable of the MOSES project WP4, referring to autonomous tugboats used for the manoeuvring and docking of large containerships. Based on the functional requirements and specifications identified in D2.4, this report is connected with Task 4.1 and aims to describe the functional and operational architecture for enabling autonomous tugboat operation, either for a single tugboat or a swarm of tugboats. This architecture will also be implemented in the related MOSES Pilot Demonstration to be conducted in WP7 or transforming existing vessels with remote-control capabilities to autonomous agents (supporting both a single unit and a swarm formation).

In order to fulfil this goal, the control architecture is designed to be modular. It consists of the following components: i) detection module, which is responsible for sensor data-processing ii) path planning module, which is responsible for autonomous navigation and manoeuvring and includes all the motion control operations and iii) control module, which translates the high-level decisions from the navigation algorithms into actionable steering and propulsion commands. For the implementation of the autonomous tugboat swarm architecture in the MOSES Pilot Demonstrations (WP7) existing technology will be exploited for the control module. Therefore, the present document focuses on the configuration of the detection (Data Acquisition unit and sensors) and path planning (Auto Pilot) modules along with the description of the communication interfaces between the different components of the system. The implemented methodology includes the following steps: 1) identifying operational states in terms of autonomy level for the autonomous swarm, 2) refinement of the requirements and specifications described in D2.4, 3) definition of the architecture, 4) allocation of the requirements to different components of the architecture, 5) identification of candidate models for the different components and description of their basic technical characteristics.

This deliverable will inform the design of the training environment in T4.2, which is used for the development of the swarm intelligence algorithms carried out in T4.3. Finally, the evaluation of the architecture in terms of aspects such as performance, redundancy, operability, scalability, and controllability will be performed in the Pilot Demonstrations (Task 7.2).