



AutoMated Vessels and Supply Chain Optimisation for Sustainable Short SEa Shipping

D.4.1: Architecture for Autonomous tugboat operation

Document Identification			
Status	Final	Due Date	31 August 2021
Version	1.0	Submission Date	31/12/2021
Related WP	WP4	Document Reference	D.4.1
Related Deliverable(s)	D2.2, D2.4, D4.2	Dissemination Level	CO
Lead Participant	TUCO	Document Type:	R
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Document History			
Version	Date	Change editors	Changes
0.1	03/09/2021	C. V. Clausen	Table of Contents, Input in Sections 1.1, 1.2, 1.3.
0.2	07/10/2021	E. Kotsidis, N. Monios, N. Themelis, H. Oikonomidou	Input in Sections 2.1, 2.2, 2.3, 3.3, 3.5, 3.6, 4.2.1
0.3	20/10/2021	E. Kotsidis, N. Themelis, H. Oikonomidou	Input in Sections 3.1, 3.2, 3.5, 3.7, 3.9, Refinement of Section 2.1
0.4	19/11/2021	N. Monios	Corrections, Input in Sections 2.2, 4.1.2, 4.1.3, Appendix 1
0.5	17/12/2021	G. Kanellopoulos, M. Kostovasili, C. V. Clausen, J. Pedersen	Input in Sections 5.1, 5.2, Appendix 1
0.6	21/12/2021	K. Louzis, N. Themelis, H. Oikonomidou, N. Monios, E. Kotsidis, S.F. Pedersen, J. Vlavianos	Corrections and restructuring, Refinement of Sections 2.1, 2.2, Input in Section 5.3, Update of the Sections numbering
0.9	29/12/2021	K. Louzis, N. Themelis, H. Oikonomidou	Document ready for internal review.
1.0	31/12/2021	K. Louzis, N. Themelis, H. Oikonomidou	Reviewer comments addressed Final version to be submitted

Quality Control		
Role	Who (Partner short name)	Approval Date
Deliverable leader	TUCO	29/12/2021
Quality manager	NTUA	31/12/2021
Project Coordinator	NTUA	31/12/2021

Table of Contents

Executive Summary.....	7
1. Introduction	8
1.1 Purpose of the document	8
1.2 Intended readership.....	8
1.3 Document Structure.....	9
2. Architecture concept design.....	10
2.1 Operational states and level of autonomy	11
2.2 Requirements.....	14
2.3 Architecture schematic overview	22
3. Auto Pilot and Data Acquisition units	26
4. Sensors and monitoring devices	29
4.1 Requirements.....	29
4.2 AIS	31
4.3 RADAR	34
4.4 IMU.....	34
4.5 Camera system w/ 360 FOV.....	36
4.6 SWATH Sonar	37
4.7 GPS	39
4.8 LIDAR	41
4.9 Engine and rudder monitoring system	43
5. Software and interfaces	45
5.1 Network Layer Architecture.....	45
5.1.1 AI component	46
5.1.2 Data Processing & Database components	47
5.2 CAN Bus Interface	47
5.3 Expansions.....	50
6. Conclusions	51
References.....	54
Annex 1: TUCO's demo workboats	55

List of Tables

Table 1 Phases of conventional tugboat operations	11
Table 2 Autonomy levels as defined by DNV Class guidelines DNV-CG-0264 [1]	11
Table 3 Description of operational states for the MOSES autonomous tugboat swarm	12
Table 4 SysML relationships used in the requirements diagrams for the AutoPilot and STCS [2]	14
Table 5 Functional requirements and specifications related to autonomous navigation and swarm operation (Auto Pilot).....	19
Table 6 Functional requirements and specifications related to the interaction with the Tugboat Captain(s)	20
Table 7 Functional requirements and specifications related to the interaction with the Shore Tugboat Control Station (STCS)	20
Table 8 Technical specifications comparison for various candidates for the Auto Pilot and Data Acquisition units	28
Table 9 Monitoring Devices-Minimum required technical specifications	29
Table 10 Utility of sensors for a single tugboat and allocation to functional requirements ..	30
Table 11 Technical specification comparison for the candidate models for typical AIS systems	33
Table 12 Technical specification comparison for typical marine radar systems.....	33
Table 13 Specifications of the Ellipse 2-A AHRS sensor	35
Table 14 Sensors Specifications of the Ellipse 2-A AHRS.....	36
Table 15 Basic characteristics of camera sensors	36
Table 16 Specifications of DFF-3D multi-beam sonar	39
Table 17 Technical specification comparison for candidate Lidar systems	42
Table 18 Technical specification for typical rpm and Shaft Torque Meters.....	43
Table 19 Technical specification for typical Rudder/ azimuth angle transmitters.....	44
Table 20 Cellular modem technical details	46
Table 21 Existing navigation and communication equipment on TUCO demo workboats.....	56

List of Figures

Figure 1 State machine diagram for the autonomous tugboat swarm operation during Phase 3 of tugboat operations.....	16
Figure 2 Requirements and specification for the Auto Pilot, as described in D2.4.....	17
Figure 3 Requirements and specification for the STCS, as described in D2.4	18
Figure 4 MOSES tugboat architecture for enabling autonomous operations.....	22
Figure 5 Allocation of functional requirements to system components and architecture modules (Auto Pilot).....	24
Figure 6 Allocation of functional requirements to system components and architecture modules (STCS)	25
Figure 7 Nvidia Jetson AGX Xavier with its enclosure box. Source: Nvidia website ¹	27

Figure 8 MOSES tugboat architecture data flow diagram	31
Figure 9 Ellipse 2-A sensor.....	35
Figure 10 DFF-3D signal processing unit (left), multi beam transducer B54 (center) and SCX-20 satellite compass (right), by Furuno	38
Figure 11 Seafloor mapping with textured terrain and color scaling (TZ Professional v.4 software with DFF3D module enabled).....	38
Figure 12 Multi beam swath (coverage area that is being mapped) is displayed in 2D (left) and 3D (right) when the PBG module is enabled	38
Figure 13 DGPS illustration. Source: Website	41
Figure 14 Components' interface in MOSES architecture.....	45
Figure 15 ISO-11898:2003 CAN communication protocol	48
Figure 16 ISO-11898:2003 OSI model	49
Figure 17 CAN network implementation.....	50
Figure 18 MOSES TUCO demo workboat 1 architecture for enabling autonomous operation	55
Figure 19 MOSES TUCO demo workboat 2 architecture for enabling autonomous operation	55

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).