Grant Agreement number: 314286
Project acronym: MUNIN
Project title: Maritime Unmanned Navigation through Intelligence in Networks
Funding Scheme: SST.2012.5.2-5: E-guided vessels: the 'autonomous' ship

7.2: Legal and Liability Analysis for Remote Controlled Vessels

Due date of deliverable: 2013-08-31 (M12)
Actual submission date:

Start date of project: 2012-09-01 Project Duration: 36 months

Lead partner for deliverable: UCC
Distribution date: 2013-09-04 Document revision: 1.0

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	**Public**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Document summary information

Deliverable	**D7.2 Legal and Liability Analysis for Remote Controlled Vessels**
Classification	PU (Public)

Initials	Author	Organisation	Role
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Rev.	Who	Date	Comment
01.	FS	2013/07/31	First draft for comments by CML, MKA and MRTK
02.	FS	2013/08/14	Second draft for comments by CML, MKA and MRTK
03.	FS	2013/09/04	Final draft after Consortium Meeting, Trondheim, August 2013

Internal review needed: **[X] yes** **[ ] no**

Initials	Reviewer	Approved	Not approved
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Executive Summary

This document analyzes national and international laws and regulations relating to the duties, responsibilities and liabilities, as far as the autonomous navigation is concerned. The Deliverable 5.1 focused much on the description of three different international standards, i.e. safety, CDEM and pollution prevention. It established a legal and liability framework for the operation of autonomous or unmanned shipping. Making a link between legal analysis with other analysis, i.e. D.5.2 (process map for autonomous navigation), D.4.5 (architecture specification) and D7.1 (error and human intervention), as well as statements and presentations made during the meetings, especially Consortium Meeting in Trondheim, this document makes a difference between the operation on board a ship and ashore, focusing on duties, tasks and responsibilities of the SCC and ASC in more details. This document contains an analytical study of the basic legal obligations and responsibilities relating to collision, maintenance, visibility, lookout and watchkeeping. It establishes a foundation for a further deep and detailed consideration and elaboration of different scenarios of liability issues, in which an autonomous vessel is involved.

List of Abbreviations

ABS	Autonomous Bridge System
AEMC	Autonomous Engine Monitoring and Control
AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
ASC	Autonomous Ship Controller
AVs	Autonomous Vessels
CDEM	Construction, Design, Equipment, and Manning
Bunker Convention	Convention on Civil Liability for Bunker Oil Pollution
CLC Convention	International Convention on Civil Liability for Oil Pollution Damage
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
Dumping Convention	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
ECDIS	Electronic Chart Display and Information System
EEZ	Exclusive Economic Zone
Fund Convention	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage
GNSS	Global Navigation Satellite System
HNS Convention	Convention on Liability and Compensation for Damage in Connection with Hazardous and Noxious Substances by Sea
IMDG Code	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
INMARSAT	Convention on the International Maritime Satellite Organization
ISM Code	International Safety Management Code
Intervention Convention	International Convention relating to the Intervention on the High Seas in Cases of Oil Pollution Casualties

MSC	IMO Maritime Safety Committee
LLMC	Convention on Limitation of Liability for Maritime Claims
MARPOL	International Convention for the Prevention of Pollution from Ships
MiTS	Maritime Intelligent Transport System
MOUs	Memorandum of Understandings
MUNIN	Maritime Unmanned Navigation through Intelligence in Networks
OECD	Organisation for Economic Co-operation and Development
SAR	Search and Rescue
SBC	Shore Bridge Control
SCC	Shore Control Center
SEC	Shore Engine Control
SOLAS	International Convention for the Safety of Life at Sea
STCW Convention	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
UNCLOS	United Nations Convention on the Law of the Sea
UVs	Unmanned Vessels
VTS	Vessel Traffic Service

Table of Contents

1. Introduction: Purposes and Interconnections

This document analyzes the legal and liability perspectives of autonomous navigation, based on global rules and standards, the legal framework for which have also been discussed in Deliverable 5.2,[1] as well as the UK laws and regulations as an example of a national maritime legislation, including the 1977 UK Merchant Shipping (Safety Convention) Act,[2] the 2002 UK Merchant Shipping (Safety of Navigation) Regulations[3] and the 1998 UK Merchant Shipping (International Safety Management (ISM) Code) Regulations,[4] which are connected to other deliverables as the figure 1 shows. Basically the following figure origins from Deliverable 4.5 (Architecture specification). The purpose of using that figure and making a link between global instruments[5] is to illuminate that, indeed, every part and stage of the operation of an autonomous vessel is closely related to the regulations of international instruments. The Maritime Intelligent Transport System (MiTS) architecture itself is 'a set of rules to define the structure of a system and the interrelationships between its parts. The architecture is to varying degrees composed of published protocols, profiles and other standards'. [6] Such standards in general are applied globally. This is based on the fact that shipping mostly is considered as an international activity. The following figure describes how different parts of the operation are linked with international standards. It should be noted that there is a need in future to further consideration of the nexus between international standards and the MUNIN Project. For further technical and operational analysis of the

[1] D5.2: Process Map for Autonomous Navigation

[2] The UK Merchant Shipping (Safety Convention) Act 1977, c 24, (repealed 1.5.1994).

[3] The UK Merchant Shipping (Safety of Navigation) Regulations 2002 No. 1473.

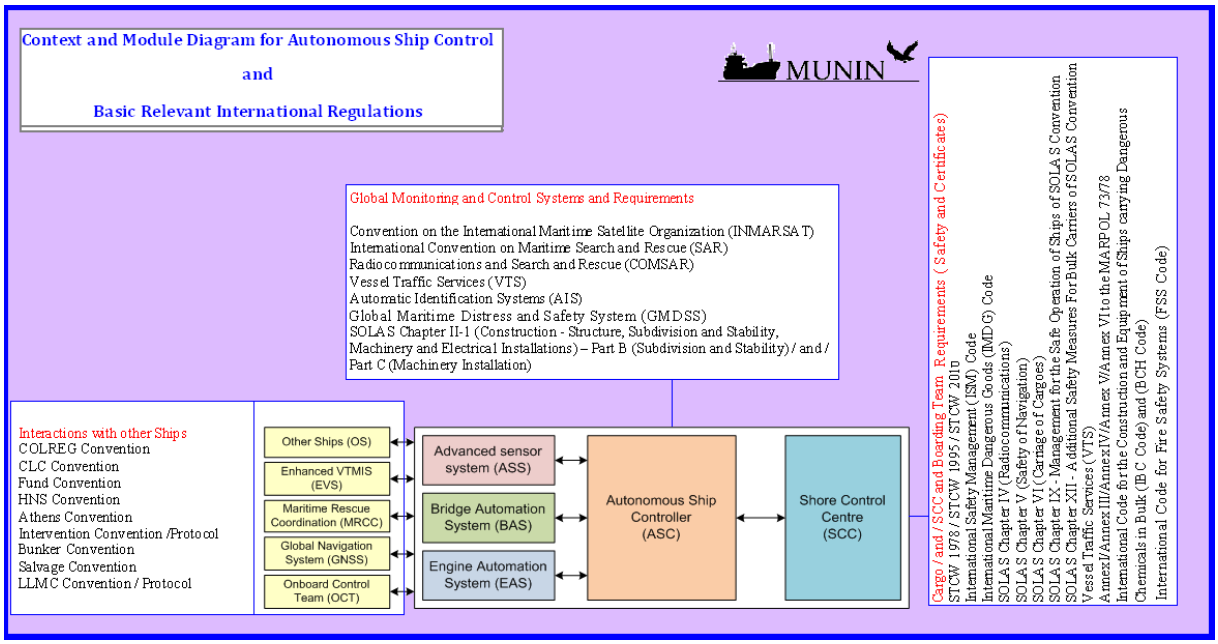
[4] The UK Merchant Shipping (International Safety Management (ISM) Code) Regulations 1998 (S.I. 1998 No. 1561).

[5] At the global level: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW), (1984) UKTS 50 (Cmd. 9266), 1361 UNTS 190. (Adoption: 7 July 1978, Entry into force: 28 April 1984, Major revisions in 1995 and 2010). Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 20 October 1972, in force 15 July 1977; 1050 UNTS 16. International Convention for the Prevention of Pollution from Ships (MARPOL) (1973) 12 *ILM* 1319, and 1978 Protocol Relating to the 1973 International Convention for the Prevention of Pollution from Ships, of 2 November 1973 as amended (MARPOL Protocol) (1978) 17 *ILM* 546.

[6] ISO 10746-2:1996 "Information technology – Open Distributed Processing – Reference Model: Foundations". Deliverable 4.5. (Architecture Specification) which contains the description of an information architecture framework for the autonomous ship, based on the Maritime Intelligent Transport System (MiTS) architecture for general ship operations.

Figure 1 see Deliverable 4.5. In fact, Figure 1 shows the mutual and interrelatedness between international regulations elaborating global standards on the one hand, and the context and module diagram for autonomous ship control on the other hand which includes Autonomous Ship Controller (ASC), the Shore Control Centre (SCC) and other special software modules.[7]

Figure 1: Interrelationship: International Rules Establishing Global Standards and Module Diagram for Autonomous Ship Control (D.7.2 and D.4.5)



[7] Deliverable D4.5. (Architecture Specification) which contains the description of an information architecture framework for the autonomous ship, based on the Maritime Intelligent Transport System (MiTS) architecture for general ship operations.

2. Methodology

This document uses a method of qualitative research, analyzing rules, provisions, principles and procedures of inquiry in a particular discipline. Based on a participatory perspective, it examines numerous relevant maritime rules and principles contained in international and national laws and regulations taking into account obligations, responsibilities and liabilities of the operators of unmanned autonomous vessels. It starts with an introduction describing interrelationships between this document and other deliverables or tasks. Following a brief overview of the objectives of current standards and regulations, it outlines particular documents applicable to ashore and aboard ships. After describing SCC and ASC documentation legal system, it begins to analyze particular issues relating to legal duties and liability matters within the context of the MUNIN Project. They include legal and liability issues on maintenance of the ship, collision avoidance rules, the necessary communication systems and navigational aids including radar for the purposes of maintenance and collision avoidance, the basic and fundamental duties and factors relevant to lookout, routing and visibility. Finally it provides a set of conclusion remarks concerning future legal and liability rules, regulations and standards, coping with changes and greatest challenges.

3. Objectives of Current Standards and Regulations

The fundamental objectives of the existing rules and standards which are mostly adopted by the International Maritime Organization (IMO)[8] focus on safety-related issues, collision avoidance, environmental considerations, legal matters, technical co-operation,[9] and matters that affect the overall efficiency of shipping.[10] With this in mind, the main goals or objectives of international treaties establishing global rules and standards which must be applied by the State parties are as follows. The objectives of regulations will be highlighted so far as they are relevant to the operation of autonomous shipping.

3.1 SOLAS Convention 1974 as amended

The 1974 International Convention for the Safety of Life at Sea (SOLAS)[11] contains a number of amendments and was modified by several protocols. It is the most important of all global instruments for the following purposes:

1. Safety at Sea,
2. Establishing Construction, Design, Equipment and Manning (CDEM) Standards,
3. Establishing navigational standards.

[8] IMO's main task has been to develop and maintain a comprehensive regulatory framework for international shipping. There are a lot of shipping-related matters that fall under the auspices of the IMO. However, the IMO is not "operational" in the sense that it does not follow incidents and accidents at sea, such as groundings, collisions, explosions etc. It is also not a court. The relevant issues are considered by the International Tribunal for the Law of the Sea established under the United Nations Convention on the Law of the Sea (UNCLOS). The IMO does not get involved with issues such as fishing rights, territorial waters or EEZs. Such issues are regulated by UNCLOS and fall within the remit of other international organizations. See: IMO Library Services, External Relations Office, International shipping and world trade, Facts and figures, London, updated: October 2007, at 26-27; see also: United Nations, General Assembly, Sixty-second session, Agenda item 79 (a) of the provisional agenda, Oceans and the law of the sea, 12 March 2007, at 8-20, (Doc: A/62/66/Add.2); United Nations, General Assembly Fifty-third session, Agenda item 38(a), Oceans and the law of the sea, 20 March 1998, (Doc. A/53/456); LEG/MISC.5, 31 January 2007, at 3; see also IMO Website, available at http://www.imo.org/Legal/mainframe.asp?topic_id=706; and www.oceansatlas.com/unatlas/uses/transportation_telecomm/maritime_trans/shipping_world_trade/shipping_safe_and_friendly.htm

[9] Further issues are concerned with, mainly, piracy and armed robbery against ships and maritime security.

[10] Such as how a cargo manifest should be transmitted to the authorities ashore.

[11] International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS).

3.2 INMARSAT Convention 1976 as amended

In 1966, IMO's Maritime Safety Committee (MSC), following a preliminary consideration in the IMO, decided to study the requirements for a satellite communications system devoted to maritime purposes. In 1976 the IMO adopted the Convention on the International Maritime Satellite Organization (INMARSAT)[12] which was amended several times. In 1998, INMARSAT's Assembly agreed to privatize INMARSAT from April 1999, which comprises two entities:

1. INMARSAT Ltd - a public limited company which will form the commercial arm of INMARSAT.
2. International Mobile Satellite Organization (IMSO) - an intergovernmental body established to ensure that INMARSAT continues to meet their obligations.

The main goals of Inmarsat as an international maritime satellite system are to improve:

1. Maritime communications,
2. Distress and safety of life at sea communications,
3. Efficiency and management of ships,
4. Maritime public correspondence services,
5. Radiodetermination capabilities.

3.3 COLREG Convention 1972 as amended

The 1972 Convention on the International Regulations for Preventing Collisions at Sea (COLREG) was designed to update and replace the Collision Regulations of 1960. One of the most key innovations in the 1972 COLREG Convention was the recognition given to traffic separation schemes (TSS) contained in Rule 10. This Rule provides guidance in determining safe speed, the risk of collision and the conduct of vessels operating in or near TSS. In this respect, it should be noted that all vessels are required to comply with Rule 10 which is mandatory for all vessels when operating in or near TSS. The fundamental objectives of the COLREG Convention are as follows:

1. Establishing collision avoidance standards as will be discussed further in this deliverable,
2. Safety of life and property at sea,
3. Establishing navigational standards,

[12] The INMARSAT Convention was adopted on 3 September 1976 and entered into force on 16 July 1979.

4. Actions to avoid collisions or the risk thereof.

3.4 MARPOL Convention 1973/78

The 1973 International Convention for the Prevention of Pollution from Ships (MARPOL) and its 1978 revision are called collectively the 73/78 MARPOL Convention. In 1969 the IMO decided to convene an international conference in 1973 to prepare an international agreement for the control of the contamination of the sea by ships. The main objectives of MARPOL 73/78 are:

1. Preservation of the marine environment
2. Establishing pollution prevention standards,
3. Prevention and control of pollution by ships,
4. Protection of the marine environment.

3.5 STCW 1978, STCW 1995, STCW 2010

The 1978 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW Convention) was amended in 1995 and 2010.[13] It applies to seafarers serving on board seagoing ships entitled to fly the flag of a Party except to those serving on board ships owned or operated by a State and engaged only on governmental non-commercial service. One of the basic objectives of the Convention is to ensure that all seafarers serving on board a ship hold appropriate certificates. Further goals of the STCW Convention are:

1. Establishing mandatory and the minimum standards of competence required for seagoing personnel,
2. Safety at sea and property,
3. Establishing standards of training, certification and watchkeeping for seafarers,

3.6 Load Lines Convention 1966/1988

In 1966 the IMO adopted the Load Lines Convention,[14] which was amended by the 1988 Protocol,[15] containing provisions determining the freeboard of ships, conditions of

13 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW), (1984) *UKTS* 50 *(Cmd.* 9266*);* 1361 *UNTS* 190. (Adoption: 7 July 1978; Entry into force: 28 April 1984; Major revisions in 1995 and 2010).

14 Adoption: 5 April 1966 and entry into force: 21 July 1968.

15 Adoption: 11 November 1988 and entry into force: 3 February 2000.

assignment of freeboard, stability and damage assumptions. The main objectives of the 1966 Load Lines Convention and its 1988 Protocol are:

1. Improving the safety of ships by outlining minimum standards for the safe loading of ships,
2. Establishing the relevant CDEM standards.

4. Analysis of Particular Documents Applicable to Ashore and Aboard Ships

In the context of the MUNIN project bulk carriers have been taken as an example to demonstrate the concept. With this in mind, it is necessary to consider whether an autonomous bulk carrier as an instance for the operation of an autonomous vessel can be defined as a vessel consistent with the definition incorporated in the provisions of the 1974 SOLAS Convention or in the UK laws and regulations.[16] The purpose of this section is to know whether or not the regulations on safety at sea as described in the 1974 SOLAS Convention are applicable to the operation of autonomous vessels in the context of the MUNIN Project. The importance and implications of this consideration to the MUNIN project is that if an autonomous ship within the context of MUNIN is considered as a vessel, then according to international treaties such ships are required to implement the relevant provisions. For example, under the provisions of Regulation 2, Chapter XII SOLAS Convention, all bulk carriers must comply with the requirements of this chapter. In addition, there are other provisions which must be taken into consideration in relation to autonomous shipping, e.g., minimum safe manning document (SOLAS 1974 (2000 amendments), Regulation V/14.2), and Paragraph 1 of Annex 2, which is related to documents required to be carried on board ships. According to this Annex, every ship to which the requirements of SOLAS Convention applies must be provided with an appropriate safe manning document or equivalent issued by the State as evidence of the minimum safe manning.

For the purpose of the examination of the possible applicability of SOLAS Convention, as the basic and fundamental treaty on safety at seas, the following factors should be taken into account:

First, at the global level, under the provisions of SOLAS Convention, a bulk carrier is defined as a vessel which 'is constructed generally with single deck, top-side tanks and hopper side tanks in cargo spaces, and is intended primarily to carry dry cargo in bulk, and includes such types as ore carriers and combination carriers'. Further, the SOLAS Convention provides that the present regulations, unless expressly provided otherwise, do not apply to:

(i) Ships of war and troopships,

(ii) Cargo ships of less than 500 gross tonnage,

[16] Most notably, the UK Merchant Shipping (Safety Convention) Act 1977, c.24, (repealed 1.5.1994), and the UK Merchant Shipping (Safety of Navigation) Regulations 2002 No. 1473.

(iii) Ships not propelled by mechanical means,

(iv) Wooden ships of primitive build,

(v) Pleasure yachts not engaged in trade,

(vi) Fishing vessels.[17]

Second, at the national level, the UK Merchant Shipping (Safety Convention) Act 1977 gives effect to the provisions of the SOLAS Convention and the 2002 UK Merchant Shipping Act deal with safety of navigation, implementing SOLAS Chapter V, 2002. Subject to the provisions of the 2002 UK Merchant Shipping Act, these Regulations apply to all UK ships wherever they may be and to all other ships while they are within UK waters. These Regulations do not apply to:

(a) warships or naval auxiliaries;

(b) ships, other than UK ships, which are owned or operated by a Contracting Government and used only on government non-commercial service; or

(c) ships navigating solely the Great Lakes of North America and their connecting and tributary waters as far east as the lower exit of the St. Lambert Lock at Montreal in the Province of Quebec, Canada.[18]

Third, the important point is that the requirements of the SOLAS Convention, which apply to ships, based on a certain level of tonnage,[19] as mentioned above, the general definition of bulk carriers does not qualify a bulk carrier to have a master onboard the ship. Hence, it could be said that an autonomous vessel or an unmanned vessel can be defined as a ship under the provisions of the SOLAS Convention.[20]

Fourth, in the light of the foregoing, the operation of an autonomous vessel, which can be described as a ship in accordance with the SOLAS requirements, must be carried out under

[17] International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988.

[18] The UK Merchant Shipping (Safety of Navigation) Regulations 2002 No. 1473.

[19] According to the 2002 of the UK Merchant Shipping Regulations, "tons" means gross tonnage and a reference to tons:

(a) in relation to a ship having alternative gross tonnages under paragraph 13 of Schedule 5 of the Merchant Shipping (Tonnages) Regulations 1982(c), permitted to be used pursuant to regulation 12(1) of the Merchant Shipping (Tonnages) Regulations 1997(d), is a reference to the larger of those tonnages, and

(b) (b) in relation to a ship having its tonnage determined both under Part II and regulation 12(1) of those 1997 Regulations is a reference to its gross tonnage as determined under regulation 12(1).

[20] International Convention for the Safety of Life at Sea, 1184 UNTS 2 (1974 SOLAS).

the provisions of the SOLAS Convention or other relevant international regulations in general. An autonomous vessel like other vessels is required to observe the international regulations, not only the requirements of the 1972 SOLAS Convention, but also other international rules and standards established by the international bodies, mainly the International Maritime Organization. Such requirements can be contained in a treaty or in other legal instruments, including protocols, amendments and resolutions. Every merchant ship based on its size is required to observe the pertinent global rules and principles, embracing manned vessels, autonomous or unmanned vessels. The definition of the SOLAS is comprehensive in character and includes many ships, including what is considered under the MUNIN Project. It is impossible to operate a vessel without taking into consideration the applicable rules and principles, the non-compliance with which endangers navigation and creates risks of accidents.

5. Shore Control Center (SCC) and Autonomous Ship Controller (ASC) Documentation Legal System

Generally speaking, in accordance with paragraph 1 of Article X of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW Convention)[21] those ships which are not excluded from the STCW Convention, are subject to control by port state control in order to verify that all seafarers serving on board who are required to be certificated by the Convention are so certificated or hold an appropriate dispensation.[22] Apart from these general provisions concerning seafarers on board the ship adopted by the STCW Convention, there are regulations which make a distinction between duties and responsibilities of operators on board a ship and ashore. With this in mind, in this section, it is necessary to refer to the relevant national and international laws and regulations and to clarify and distinguish between the role and responsibilities of SCC and ASC. It is evident that the operators or in other words personnel in the SCC take the roles of the master and chief engineer and also, according to the following regulations, of the company. The questions relating to the lookout and watchkeeping will be discussed further in the following chapters. In accordance with the SOLAS Convention[23] as well as the UK laws and regulations, i.e., the Merchant Shipping (Safety Convention) Act 1977,[24] the 2002 UK

[21] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (STCW), (1984) UKTS 50 (Cmd. 9266); 1361 UNTS 190. (Adoption: 7 July 1978; Entry into force: 28 April 1984; Major revisions in 1995 and 2010).

[22] Such certificates shall be accepted unless there are clear grounds for believing that a certificate has been fraudulently obtained or that the holder of a certificate is not the person to whom that certificate was originally issued (Article X(1)). Moreover, under paragraph 2 of Article X, "In the event that any deficiencies are found under paragraph (1) or under the procedures specified in regulation I/4- "Control Procedures", the officer carrying out the control shall forthwith inform, in writing, the master of the ship and the Consul or, in his absence, the nearest diplomatic representative or the maritime authority of the State whose flag the ship is entitled to fly, so that appropriate action may be taken. Such notification shall specify the details of the deficiencies found and the grounds on which the Party determines that these deficiencies pose a danger to persons, property or the environment".

[23] International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988.

[24] The UK Merchant Shipping (Safety Convention) Act 1977, c.24. These provisions of the Merchant Shipping Act have effect for the Modifications purpose of enabling effect to be given to the International Convention for the Safety of Life at Sea signed in London, November 1974 (in this Act referred to as the 1974 Convention). According to the provisions of this Act, the SOLAS Convention means the International Convention for the Safety of Life at Sea, 1974(a) as amended in accordance with its Protocol of 1988(b)

Merchant Shipping (Safety of Navigation) Regulations[25] and the 1998 UK Merchant Shipping (International Safety Management (ISM) Code) Regulations,[26] a ship must be operated by a company holding a document of compliance issued in accordance with the regulations of the Convention.[27] Such company in the context of the MUNIN project is the Shore Control Center (SCC) operating remote control of an autonomous ship. Accordingly, the operators in the SCC should observe the relevant regulations. It should be kept in mind that the international and national laws and regulations govern the whole parts of the MUNIN process as shown in the Figure 2 below.

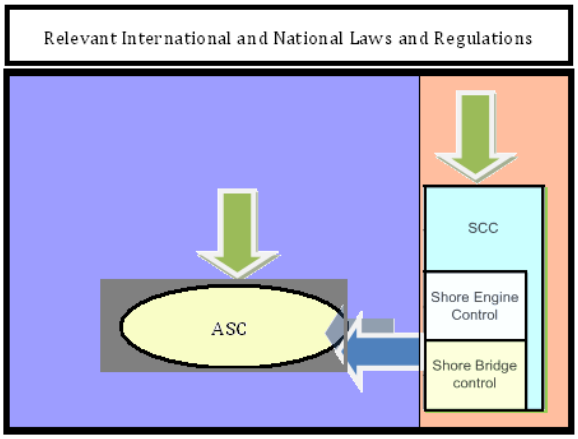


Figure 2: Relevant Maritime International and National Laws and Regulations Governing Shore Control Center and the Ship (Autonomous Ship Controller)

and the resolution of the Maritime Safety Committee of the IMO published by the IMO as Resolution MSC.99(73) of December 2000.

[25] The UK Merchant Shipping (Safety of Navigation) Regulations 2002 No. 1473.

[26] The UK 1998 Merchant Shipping (ISM Code) Regulations (S.I. 1998/1561). The 1998 ISM Code Regulations provide for the application of SOLAS Chapter IX on all ships to which the SOLAS Convention applies, other than those vessels for which legislation has been provided under The Merchant Shipping (ISM Code) (Ro-Ro Passenger Ferries) Regulations 1997 (S.I. 1997 No. 3022) .

[27] The UK Merchant Shipping (Safety of Navigation) Regulations, 2002, 1473.

6. Collision at Sea: Duties and Liabilities

6.1 The General Principle

Whenever a maritime accident occurs to a ship or a defect is discovered, either of which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment, the master is required to report at the earliest opportunity to the State or States concerned. It should be noted that in cases of accidents at sea, there are several instruments applicable to the operation of an autonomous ship. Apart from collision avoidance rules established by the COLREG Convention, in cases where an autonomous vessel is involved, the provisions of other treaties related to safety and pollution prevention, such as SOLAS[28] and MARPOL[29] Conventions, should also be applied. In different chapters of this document and Deliverable 5.1, the relevant regulations on safety as well as liability issues have been discussed. In this respect, it is worth remembering that, as discussed in D.5.1, the regulations relating to liability and compensation for damage cover different areas of the sea including the territory, territorial sea[30] or exclusive economic zone (EEZ)[31] or equivalent area of a State party to the treaties.[32]

[28] International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988.

[29] International Convention for the Prevention of Pollution from Ships (MARPOL) (1973) 12 ILM 1319, and 1978 Protocol Relating to the 1973 International Convention for the Prevention of Pollution from Ships, of 2 November 1973 as amended (MARPOL Protocol) (1978) 17 ILM 546.

[30] Article 2 of the 1982 UNCLOS establishes the legal status of the territorial sea, of the air space over the territorial sea and of its bed and subsoil. Paragraph 1 of this Article provides that
The sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea.
Under paragraph 2: "This sovereignty extends to the air space over the territorial sea as well as to its bed and subsoil". Moreover, paragraph 3 of Article 2 provides that
The sovereignty over the territorial sea is exercised subject to this Convention and to other rules of international law.

[31] In terms of damage, it is necessary to note that the following conventions are the main instruments: International Convention on Liability and Compensation for Damage in connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), (1996) 35 ILM 1406; International Convention on Civil Liability for Oil Pollution Damage (CLC 1969), (1970) 9 ILM 45, as amended in 1976 (1977) 16 ILM 617; and Protocol to amend the International Convention on Civil Liability for Oil Pollution Damage of 29 November 1969 (CLC 1992), 27 November 1992, 1996 UKTS 86 (Cmnd 3432). International Convention on the Establishment of an International Fund for Compensation for Oil Pollution (Fund 1971), (1972) 11 ILM 284; International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, (Fund 1992), (1996) UKTS 87; and International Convention on Civil Liability and Compensation for Bunker Oil Spills (Bunker), (2001) 40 ILM 1493. Subject to the Article II of the 1969 CLC Convention this Convention shall apply exclusively to pollution damage caused on the territory including

In the context of the MUNIN project, due to the fact that the SCC bears the pertinent duties, responsibilities and liabilities imposed by the international agreements on the master and chief engineer, therefore the obligations of the master and chief engineer must, as far as possible and according to the available technologies, be implemented by the SCC.

6.2 Collision avoidance COLREG Rules

In compliance with the applicable COLREG rules,[33] the provisions of SOLAS Convention[34] and other international regulations that are mostly adopted under the auspices of the IMO, the officer in charge of the navigational watch is required to take frequent and accurate compass bearings of approaching ships as a means of early detection of risk of collision. In accordance with the 1972 COLREG Rules, which revised and brought up to date the 1960 International Regulations for Preventing Collisions at Sea annexed to the Final Act of the International Conference on Safety of Life at Sea, a ship includes every description of water craft used or capable of being used as a means of transportation on water. The important point is that when approaching a ship or other water craft at close range or other objects in the vicinity when the risk of collision exists, in such situations the officer in charge of the navigational watch must take early and positive action and check that such action is having the effect of collision abatement. Under Rule 2 of the COLREG Convention, nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case. In the context of the

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the territorial sea of a Contracting State and to preventive measures taken to prevent or minimize such damage. The 1969 CLC doesn't cover EEZ.

[32] Under Article II of the 1992 CLC Convention, this Convention shall apply exclusively:
(a) to pollution damage caused:
(i) in the territory, including the territorial sea, of a Contracting State, and
(ii) in the exclusive economic zone of a Contracting State, established in accordance with international law, or, if a Contracting State has not established such a zone, in an area beyond and adjacent to the territorial sea of that State determined by that State in accordance with international law and extending not more than 200 nautical miles from the baselines from which the breadth of its territorial sea is measured;
(b) to preventive measures, wherever taken, to prevent or minimize such damage.

[33] Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 20 October 1972, in force 15 July 1977; 1050 UNTS 16.

[34] International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988, Safety of navigation Chapter V.

MUNIN project, the operator in the SCC who is responsible for the operation of an autonomous ship is required to take such necessary actions.

6.3 All Fundamental Factors Relevant to Collision Avoidance and COLREG Rules

6.3.1 First Category of Factors

For the purposes of avoiding any collision at sea, according to COLREG Rules, an important group of factors that should be taken into consideration is contained in the notion of safe speed. Within this concept many essential factors for the safety at seas and collision avoidance measures can be incorporated. With this in mind, every ship is required at all times to proceed at a safe speed so that it can take proper and effective action to avoid collision and to be stopped within a distance appropriate to the prevailing circumstances and conditions. This obligation is imposed upon the SCC operators playing the role of the master and monitoring the autonomous ship. The SCC in determining a safe speed, among other technical issues or matters, must take into account two basic groups of factors. The first group must be observed by all vessels, as follows:

(i) the state of visibility,

(ii) the traffic density including concentrations of fishing vessels or any other vessels,

(iii) the maneuverability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions,[35]

(iv) at night the presence of background light such as from shore lights or from back scatter of her own lights,

(v) the state of wind, sea and current, and the proximity of navigational hazards, and

(vi) the draft in relation to the available depth of water.[36]

[35] The following vessels shall be regarded as vessels restricted in their ability to maneuver: (i) a vessel engaged in laying, servicing or picking up a navigation mark, submarine cable or pipeline; (ii) a vessel engaged in dredging, surveying or underwater operations; (iii) a vessel engaged in replenishment or transferring persons, provisions or cargo while underway; (iv) a vessel engaged in the launching or recovery of aircraft; (v) a vessel engaged in minesweeping operations; (vi) a vessel engaged in a towing operation such as renders her unable to deviate from her course.

[36] In accordance with the 1972 COLREG Convention, 1050 UNTS 16, a vessel constrained by her draft means a power-driven vessel which because of her draft in relation to the available depth of water is severely restricted in her ability to deviate from the course she is following.

6.3.2 Second Category of Factors

The second group of factors is dedicated, specifically, to ships with operational radar systems, which in the operation of an autonomous vessel by the SCC must be taken into consideration. They include:

(i) the characteristics, efficiency and limitations of the radar equipment;

(ii) any constraints imposed by the radar range scale in use;

(iii) the effect on radar detection of the sea state, weather and other sources of interference;

(iv) the possibility that small vessels, ice and other floating objects may not be detected by radar at an adequate range;

(v) the number, location and movement of vessels detected by radar;

(vi) the more exact assessment of the visibility that may be possible when radar is used to determine the range of vessels or other objects in the vicinity.[37]

6.4 The SCC: Duties, Responsibilities and Liabilities

In relation to the operation of autonomous or unmanned ship in the context of the MUNIN project, the SCC has the main obligations and responsibilities for the operation of the vessel and to take all appropriate measures necessary to prevent a collision. This obligation is accompanied with the obligation to take the best practicable steps using several electronic navigational aids and appliances, or in other words, anti-collision radars, including Automatic Radar Plotting Aid (ARPA) and Electronic Chart Display and Information System (ECDIS), Automatic Identification System (AIS), and Global Maritime Distress and Safety System (GMDSS).[38] It is the duty of the SCC to take all necessary measures, as far as is possible, to prevent collision at sea if a risk of collision exists. In practice, proper use must be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.

[37] Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 20 October 1972, in force 15 July 1977; 1050 UNTS 16.

[38] Chapter IV of SOLAS 1974, and the instruments adopted by IMO relating to the Global Maritime Distress and Safety System (GMDSS).

6.5 Positive Actions to Prevent Accidents: Liabilities of the SCC

In order to avoid collision at sea, based on the circumstances of the case and prevailing situations, the SCC must take in sufficient time any positive action. Taking into account all circumstances, any alteration of speed and/or course to avoid collision must be large enough to be readily apparent to another vessel observing visually or by radar. The effectiveness of the collision avoidance action must be carefully checked by the available systems until the other vessel is finally past and clear.[39] These collision avoidance actions must, in practice, be such as to result in passing at a safe distance. As far as the time factor is concerned, to allow more time to assess the situation, if it is necessary for the prevention of collision, a vessel must reduce its speed or take all way off by stopping or reversing its means of propulsion.

[39] It should be noted that a ship proceeding along the course of a narrow channel or fairway shall keep as near to the outer limit of the channel or fairway which lies on her starboard side as is safe and practicable.

7. Obligations Relating to Maintenance of the Ship

7.1 Shore Control Center (SCC) and Autonomous Ship Controller (ASC): Tasks and Responsibilities

The condition of the vessel and its equipment shall be maintained to conform with the provisions of the existing regulations to ensure that the vessel in all respects will remain fit to proceed to sea without danger to the vessel, other vessels or persons on board or to the marine environment.[40]

Maintenance can be divided into two main types: First, shore-based maintenance, which must be monitored and controlled by SCC, and second, at-sea maintenance capability, which is the task of both SCC and ASC. As mentioned above, the SCC plays the central role in the operation of an autonomous vessel. Meanwhile, it bears the main responsibility and liabilities for the operation and the consequences of the operation. The basic obligations of the master and chief engineer will be imposed on the SCC. With this in mind, in the case of a remote operation of an autonomous vessel, the SCC operating remote control should establish procedures to ensure that the autonomous ship is maintained in conformity with the provisions of the relevant rules and regulations and with any additional requirements which may be established by national countries. In meeting the established rules and procedures, the SCC should ensure that all requirements are implemented. Furthermore, as far as the technical tasks of ASC are concerned, it must report to the SCC any deficiencies which require corrective actions.

7.2 Maintenance Procedures

The maintenance procedures and programs, which may be computer-based in the context of the MUNIN Project, include testing and inspections. The maintenance procedures must be carried out by the SCC or on board control team based on the guidelines developed by the IMO and in a manner having due regard to ensuring the reliability of all systems including fire-fighting systems and appliances. Maintenance procedures also include cargo loading

[40] International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988. See also The UK Merchant Shipping (International Safety Management (ISM) Code) Regulations 1998 (S.I. 1998 No. 1561).

and discharge equipment, fire detecting systems and tank venting, as well as anti-pollution equipment.[41]

7.3 Arrangements for Inspections

The arrangement for inspection of autonomous vessels can be inferred from the requirements of the 1972 SOLAS Convention. According to the SOLAS Convention, the SCC is liable to arrange for inspections of autonomous vessels which must be carried out at regular intervals. The inspection requirements, which include main propulsion and auxiliary machinery including boilers and pressure vessels and equipment essential to the safe operation of the ships shall be made by qualified personnel.[42]

7.4 Critical Systems and Equipments: Pertinent Responsibilities

The SCC operating remote control should establish procedures to identify critical equipment and technical systems whose sudden operational failure might result in hazardous situations. Such equipment and systems, especially in the context of the operation of autonomous navigation include fire-fighting systems and appliances and navigational aids including radar. For this purpose, the IMO requirements relating to ship-borne radio equipment forming part of the global maritime distress and safety system and for electronic navigational aids, as will be discussed in the following chapter, must be respected.

[41] The duties of the SCC to arrange for inspections of the vessels and the inspection requirements, can be inferred from International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988, Safety of navigation Chapter V.

[42] For further requirements on inspection, see the 1974 International SOLAS Convention 1184 UNTS 2, Consolidated edition 2004, Chapter V: safety of navigation.

8. Legal Duties Relating to the Necessary Communication Systems and Navigational Aids for the Purposes of Maintenance and Collision Avoidance

8.1 Introduction

The 1974 SOLAS Chapter IV elaborates the provisions relating to radio communication services by Contracting States and provides for the keeping of equipment on board ships for safety and also for distress purposes as well as for general radio communications. After the adoption of amendments to Chapter IV in 1988, the Global Maritime Distress and Safety System (GMDSS) became effective in 1999. GMDSS is a worldwide satellite-based network of automated emergency communications for ships at sea. Additionally, it should be mentioned that the SOLAS Convention also establishes the global requirements in relation to Vessel Traffic Services (VTS).[43] In this regard, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) makes recommendations with regard to VTS in addition to the SOLAS provisions Chapter V with the purposes of developing common standards and ensuring uniformity of effect.[44] One factor that should be noted is that for the purpose of the operation of an autonomous ship, the shore-based users of such systems, for example, VTS operators, need to be appropriately trained in order to efficiently use such systems.
In addition to the foregoing, several other communication systems and navigational aids including radar have been developed and enhanced in recent years necessary for the purposes of maintenance and collision avoidance, the relevant aspects of which will be highlighted below. In so doing, it is important to note that the operational and technical issues and aspects are beyond the scope of this task and legal analysis of the operation of autonomous shipping. However, in order to establish a foundation upon which legal obligations and responsibility of the operators are examined a brief explanation of each system seems to be necessary as follows.

[43] The 1974 International Convention for the Safety of Life at Sea, 1184 UNTS 2, Chapter V.
[44] The work of the committees is aimed at developing common standards workshops through publications of IALA Recommendations and Guidelines. Among IALA's committees, it is the IALA's VTS Committee that periodically publishes hardware standards, policy and training standards.

8.2 Automatic Radar Plotting Aid (ARPA)

Automatic Radar Plotting Aid (ARPA) is a navigational aid. According to the international regulations the personnel operating this navigational aid must be familiar with and have technical knowledge of its limitations, including those of its sensors, and risks of over-reliance on ARPA. Moreover, they must be aware of the fact that there is a need to observe at all times the standards and principles to be observed in keeping a navigational watch. They are required to gain knowledge of:

1. the criteria for the selection of targets by automatic acquisition;
2. the factors leading to the correct choice of targets for manual acquisition;
3. the effects on tracking of "lost" targets and target fading; and
4. the circumstances causing "target swap" and its effects on displayed data.[45]

As noted above, the SCC takes the role of the master and the operator in the SCC monitors the ship and the ship itself will have automatic lookout. From a legal point of view, the requirements of STCW Convention should be adjusted and developed through the adoption of new qualifications so as to capable to cover and apply to the operators of the SCC who are practically need to gain the relevant knowledge before taking the responsibility for the operation.

8.3 Electronic Chart Display and Information System (ECDIS)

As the safe use of ECDIS requires knowledge and understanding of the basic principles governing ECDIS data and their presentation rules as well as potential errors in displayed data and ECDIS-related limitations and potential dangers**,** a structure of activities should be defined by the SCC. A detailed specification of activities must be developed for this structure. Information obtained from ECDIS must be correctly interpreted and analyzed, taking into

[45] International Convention on Standards of Training, Certification and Watchkeeping for Sea Farers 1978 (STCW), (1984) UKTS 50 (Cmd. 9266); 1361 UNTS 190. One of the major features of the revision of 1978 STCW Convention by the 1995 Amendments was the division of the technical annex into regulations, divided into Chapters as before, and a new STCW Code, to which many technical regulations were transferred. Part A of the Code is mandatory and the minimum standards of competence required for seagoing personnel are given in detail in a series of tables. Part B of the Code is recommended. It contains recommended guidance which is intended to help Parties implement the Convention.

account the limitations of the equipment and all connected sensors as well as prevailing circumstances and conditions.[46]

8.4 Automatic Identification System (AIS)

In addition to anti-collision radar (ARPA) and ECDIS, vessels have been equipped with an Automatic Identification System (AIS), which became mandatory on most ships in 2002 and have provided additional functionality to support collision avoidance. In fact, for the purpose of collision avoidance, in order to operate autonomous navigation by shore based remote monitoring, in so far as information models and protocols for specific ship to ship and ship to shore services, such as AIS and GMDSS are concerned, the development of an enhancement of the Automatic Identification System seems to be necessary. It is worth mentioning that in the 59th Session of the IMO NAV Sub-Committee (NAV 59), taking place between September 2-6, 2013, the NAV 59 is going, according to its provisional agenda, to revise the guidelines for the onboard operational use of AIS, which might be of interest to the MUNIN project. With the development of this project, it would be possible to prepare some operational suggestions for the purpose of adaptation or revisions.

An important factor to be noted is the right of sovereign coastal States in relation to cooperative measures to complement the littoral AIS. From an operational and technical point of view, it is necessary to consider whether how much the shore-based AIS can contribute to the activities of a coastal State. Then in turn, it is essential to analyze the implications of such contributions and interferences upon the rights, obligations and responsibilities of the coastal State.

8.5 Global Navigational Satellite System (GNSS)

GNSS is both a positioning and an accurate navigation service for the different modes of transportation, including shipping. It provides a level of accuracy, integrity and continuity appropriate to safety of navigation. The technical and operational aspects of GNSS and its uses are beyond the realm of this deliverable. From a legal point of view, using such spatial systems has some implications on the operation of autonomous

[46] International Convention on Standards of Training, Certification and Watchkeeping for Sea Farers 1978 (STCW), 1361 UNTS 190.

vessels by the SCC. The fundamental legal issues in relation to GNSS are legal obligations and liabilities. Generally, such systems are intended to support the decision-making process in order to avoid dangerous situations and collisions. When the SCC uses GNSS, it is required to take all appropriate measures and every technical action that are necessary to prevent collision at sea. Here it is necessary to make a distinction between ASC (automatic unit on board) and SCC operators. If an accident arises from the SCC operators' failure in using such systems, the given SCC operators are liable for the damage. Moreover, if the ASC causes an accident and the operator contributed to the cause of the accident in any way, the given operator is responsible for the damage.

9. Lookout

9.1 The Principle of Proper Lookout

Every vessel, including autonomous vessels, must be operated at all times maintaining a proper lookout by all available means appropriate with the prevailing circumstances and conditions, in order to make a full appraisal of the situation and of the risk of collision.[47] For the purposes of collision avoidance and pollution prevention, it is necessary to have a lookout by means of all appropriate means available to shore based personnel. From a technical point of view, lookout may/must basically be an automatic function with support from SCC only in exceptional circumstances. The details of the contribution of the SCC will be examined further during the future development of the MUNIN project. In any case, generally, one of the factors that should be noted is that, as mentioned above, the advanced technologies and developments such as ARPA, ECDIS, AIS and GNSS serve to help to take collision avoidance actions and to increase safety and the great efficiency of constant watch-keeping safer than today's manned vessels.

9.2 The Duties of Lookout

The lookout must be able to give full attention to maintaining a proper lookout and no other duties shall be undertaken or assigned which could interfere with duties of the lookout. The situation of many factors must carefully be assessed and full account must be taken of all relevant factors which will be highlighted as follows. It should be noted that the operator in the Shore Bridge Control (SBC) operates as the master, the operator in the Shore Engine Control (SEC) operates as the chief engineer and the ASC has the role of a lookout. As the following consideration shows, there are some factors, according to which the whole tasks relating to lookout is not upon to ASC. In fact, the SCC is also must contributes to the duties of lookout.

9.3 The Basic and Fundamental Factors Relevant to Lookout

In order to ensure that a proper lookout can continuously be maintained, the personnel responsible for the lookout are required to take into consideration all fundamental applicable factors, including the following factors:

[47] Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 20 October 1972, in force 15 July 1977; 1050 UNTS 16.

9.3.1 State of Weather and Sea

One of the main factors is state of weather and sea. The likely weather conditions predicted for a given period of time are based on all available information. The basic task of SCC and ASC is management and handling of ships in heavy weather.

9.3.2 Traffic Density

The second factor in relation to lookout is traffic density and the operational and technical activities, which must be considered by the SCC and ASC. In areas of high traffic density, strict control of the ship's steering is necessary.

9.3.3 Traffic Separation Schemes

One of the main factors relevant to lookout is that when an autonomous vessel is in or near Traffic Separation Schemes (TSS), much more attention is necessary for the operation of a vessel. In accordance with the 1972 COLREG Convention concerning traffic separation schemes,[48] the rules of COLREG apply to traffic separation schemes adopted by the IMO. A vessel using a traffic separation scheme is required to

> (i) proceed in the appropriate traffic lane in the general direction of traffic flow for that lane,
>
> (ii) so far as practicable keep clear of a traffic separation line or separation zone,
>
> (iii) normally join or leave a traffic lane at the termination of the lane, but when joining or leaving from either side shall do so at as small an angle to the general direction of traffic flow as practicable.[49]

[48] A Traffic Separation Scheme (TSS) is a traffic-management route-system ruled by the IMO. The TSS rules are incorporated in the International Regulations for Preventing Collisions at Sea.

[49] In accordance with the COLREG Rules 1972, a vessel shall, so far as practicable, avoid crossing traffic lanes but if obliged to do so shall cross on a heading as nearly as practicable at right angles to the general direction of traffic flow. A vessel shall not use an inshore traffic zone when she can safely use the appropriate traffic lane within the adjacent traffic separation scheme. However, vessels of less than 20 meters in length, sailing vessels and vessels engaged in fishing may use the inshore traffic zone. Moreover, a vessel may use an inshore traffic zone when en route to or from a port, offshore installation or structure, pilot station or any other place situated within the inshore traffic zone, or to avoid immediate danger. A vessel other than a crossing vessel or a vessel joining or leaving a lane shall not normally enter a separation zone or cross a separation line except: (i) in cases of emergency to avoid immediate danger; (ii) to engage in fishing within a separation zone.

10. Visibility and Congested Waters

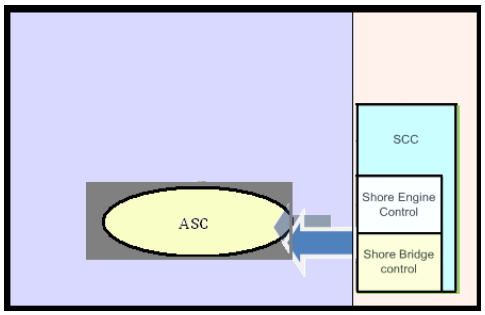
10.1 Clear Weather and Visibility

Watchkeeping is conducted under different conditions and in different areas. One of them is clear weather. In such situations, on board a manned ship, the officer in charge of the navigational watch is required to take all necessary measures in compliance with the applicable international rules and regulations. In clear weather, whenever possible, it is the officer in charge of the navigational watch that must carry out radar practice.[50] In the operation of autonomous vessels, while the Autonomous Bridge System (ABS) detects areas of limited visibility, the SCC using radar systems is required to conduct exact assessment of the data relating to visibility. The data may make possible to determine the range of vessels or other objects in the vicinity. It is the SCC that, for the purposes of collision avoidance, must implement the obligations imposed by international regulations and take the necessary measures and use the appropriate means available.

10.2 Limited and Restricted Visibility

Often adverse weather can increase the possibility of a collision or an incident. The restricted visibility is referred to any condition in which visibility is restricted by fog, mist, falling snow, heavy rainstorms, sandstorms or any other similar causes. When restricted visibility is encountered, it is the responsibility of the officer in charge of the navigational watch on board a manned vessel to comply with the relevant rules of the international regulations. In terms of autonomous vessels, it is the task of the SCC and/or ASC to take necessary measures for the prevention of accidents at sea. In relation to the operation of an unmanned ship, the SCC is responsible to adopt all appropriate measures. Any autonomous ship must be operated at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. The SCC operators who are in charge of operating and monitoring the engine room must get engines ready for immediate maneuver.

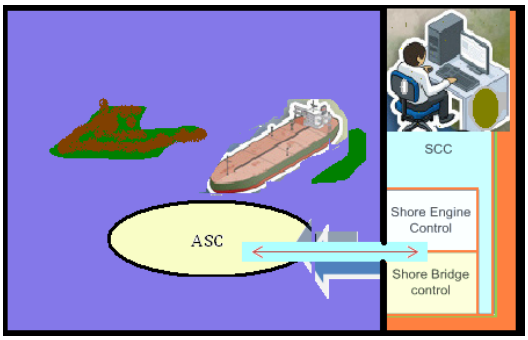
[50] Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 20 October 1972, in force 15 July 1977; 1050 UNTS 16.



Briefly, every section in the SCC, either Shore Bridge Control (SBC) or Shore Engine Control (SEC) must have due regard to the prevailing circumstances and conditions of restricted visibility when complying with the COLREG Rules.

10.3 Congested Waters

Having due regard to the limitations of the radar and other systems, such as ARPA, ECDIS and AIS, on board a manned vessel, the officer in charge of the navigational watch is required to use such navigational aid systems whenever restricted visibility is encountered and at all times in congested waters.[51] Based on the foregoing, it becomes clear that the obligations relating to the operation of an autonomous vessel is generally imposed upon the SCC, both SBC and SEC. Despite this, it should be kept in mind that it is intended in the context of the MUNIN project to use manned vessels during most congested waters and probably also where TSS is in operation. In any case, the important point is that the relevant spatial analysis of data received from navigational aid systems, such as AIS, in relation to ports and ashore facilities or nearest vessels must be used to keep "eyes on the target".



[51] International Convention on Standards of Training, Certification and Watchkeeping for Sea Farers 1978 (STCW), (1984) UKTS 50 (Cmd. 9266); 1361 UNTS 190.

11. Duties Relating to Routing

11.1 The Routing Systems

The International Maritime Organization (IMO) is recognized as the only international body for developing regulations and criteria at the international level for vessels' routing systems.

Under SOLAS Convention,[52] ships' routing systems contribute to safety of life at sea, safety and efficiency of navigation and/or protection of the marine environment. Such systems are recommended for use by, and may be made mandatory for, all ships, certain categories of ships or ships carrying certain cargoes, when adopted and implemented in accordance with the guidelines and criteria developed by the IMO, which will collate and disseminate to Contracting States all relevant information with regard to any adopted ships routing systems.

11.2 Principal Objectives of Routing Systems

The main purposes of the routing systems as described above are as follows:

1. Contribution to safety of life at sea,
2. Safety and efficiency of navigation,
3. Protection of the marine environment.

11.3 Duties Relevant to the Routing Systems

It should be noted that despite the fact that IMO is the only international body for the development of routing systems, taking initiative steps for establishing a ships' routing system is the duty of the given State or States. The State or States concerned in establishing and developing such systems for adoption by the IMO should take into consideration the necessary regulations developed by the IMO.[53] In practice, routing systems should be submitted to the IMO for the adoption. However, a State implementing such systems not

[52] International Convention for the Safety of Life at Sea, 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), Chapter V, safety of navigation.

[53] Under the provisions of the International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), vessels' routing systems should be submitted to the IMO for adoption. However, as far as is possible, the State or States concerned implementing the ships' routeing system not intended to be submitted to the IMO for the adoption or which have not been adopted by the IMO are recommended to take into consideration the established or adopted guidelines and criteria developed by the IMO.

intended to be submitted to the IMO for adoption or which have not been adopted by the IMO are encouraged to take into account, wherever possible, the IMO guidelines and criteria.

While some routing systems are recommended, some of them are made mandatory. Therefore, any vessel, including an autonomous dry bulk carrier or an unmanned ship in the context of the MUNIN Project, within a mandatory routing system adopted by the IMO is required to use this mandatory routing system. This can be inferred from the above-mentioned general provisions of the 1972 SOLAS Convention.

In order to operate vessels, when States are intended to prescribe the necessary routing systems, standards and regulations, it is necessary to ensure that such rules and standards[54] are capable of respecting current navigational requirements under the relevant international instruments. In terms of MUNIN, routing practically will be done by SCC, giving consideration to systems, but this information must also be made available to the ASC so that routing systems are not violated during automatic operation.

[54] The technical necessary routeing systems, standards and regulations are contained mainly in COLREG, SOLAS and IMO resolutions.

12. MUNIN Future Necessary Developments and Greatest Challenges

12.1 International Standards and Liability Rules and Regulations

The assessment of international rules and regulations made in deliverables 5.1 and 7.2 shows although the legal obligations and liability issues may vary from country to country, most ships engaged in global trade must be operated under the governing standards laid down by IMO. The analysis of legal and liability rules and regulations also shows that some components of the international regulations and standards are general in character likely to produce interpretable results applicable to the MUNIN project, especially in relation to the tasks of SCC as described in the Figures 1 and 2, making a relationship between international standards and liability rules on the one hand, and the context and module diagram for autonomous ship control on the other.

12.2 Coping with Change

In order to achieve the basic goals of international regulations, ships are designed with suitable safety margins and have safety equipment and sufficient strength in special damaged conditions such as collision. In this regard, the existence of the Global Maritime Distress and Safety System (GMDSS), Automatic Radar Plotting Aid (ARPA), Electronic Chart Display and Information System (ECDIS), Automatic Identification System (AIS), and Global Navigational Satellite System (GNSS), as well as further technological developments help to the safety and collision avoidance measures of the autonomous shipping as defined in this project.

12.3 The MUNIN Project's Greatest Challenges: The Necessary Modifications

In the context of the MUNIN project, enforcement of global rules, regulations and standards concerning ships' routing systems and communications, prevention of collisions entails the adaptation to new laws and rules and modification of a number of regulations, taking into account the above-mentioned developments and standards. In this respect it should be noted that there are no sufficient rules, principles or standards that require coastal States to maintain awareness. As far as information exchange between e.g. national Vessel Traffic Services (VTS) is concerned, one of the basic gaps is

lack of maritime standardized structure for data and data exchange that enables SCC or shore-based authorities to exchange information with other SCC or authorized shore-based users.

12.4 The Further Analysis

The future examination of international regulations and standards is necessary, taking into consideration the current and future development of the global rules and standards at the IMO or other international organizations as well as of the MUNIN project. During conducting the analysis of the relevant regulations in these deliverables, it became clear that there are fundamental linkages in some areas, and this is the basic point for further analysis of international standards and liability rules and regulations.

13. MUNIN Future Development and Legal Implications on E-Navigation

13.1 The Concept of e-Navigation

The concept of e-Navigation is an IMO initiative to harmonize and enhance navigation systems. It is defined as:

> e-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment

Working groups in three sub-committee (NAV, COMSAR and STW), and a correspondence group, as well as the International Hydrographic Organization (IHO) and the International Association of Aids to Navigation and Lighthouse Authorities (IALA), are working on an e-Navigation strategy implementation plan.

13.2 Common Purposes

One of the basic common features of the MUNIN project and e-Navigation is taking appropriate measures to reduce collisions by means of using a number of ship- and shore-based technologies that promise to improve situational awareness and decision-making. As discussed earlier, these include the Automatic Identification System (AIS), Electronic Chart Display and Information System (ECDIS), Integrated Bridge Systems/Integrated Navigation Systems (IBS/INS), Automatic Radar Plotting Aid (ARPA), radio navigation, Long Range Identification and Tracking (LRIT) system, Vessel Traffic Services (VTS) and the Global Maritime Distress Safety System (GMDSS).

13.3 Future Legal Implications

The development of new technologies requires new rules, principles and standards. At the global level, there is no international legislation to regulate and identify responsibilities of appropriate parties. In the MUNIN project, further analysis of the responsibilities and liabilities of the SCC on the operation of vessels can have potential impacts on the responsibility and liability of parties as defined in the concept of e-Navigation. This requires further legal studies how the development of the MUNIN

Project could have positive implications on the research within the e-navigation initiative.

14. Final Remarks: Basic Achievements from Beginning to the Consortium Meeting in Trondheim

The final remarks is based on the whole analysis of the two deliverables, discussions, comments and opinions posed during the development of the project as well as those of posed during the Consortium Meeting with the presents of the representatives of the IALA, Germanischer Lloyd Ship Classification and other partners in Trondheim during 27th to 30th August 2013.[55]

14.1 Goal-based Assessments

The key objective of the MUNIN project is sustainable maritime shipping with its economic, social and environmental perspective. Having due regards to the objectives of international conventions, goal-based analysis of international rules and standards has been made with a view to the achievement of safe, secure, efficient and environmentally sound shipping, as described in this deliverable and D5.1. Taking into account the objectives of international rules and standards, the legal analysis has examine specific rights, duties and responsibilities of States (D5.1), as well as of the SCC and ASC (D.7.2) in relation to the operation of autonomous vessels and unmanned vessels.

14.2 The Basic Approach towards the Establishment of a Legal Framework

Taking into consideration the fact that issues relating to unmanned shipping have not been regulated yet, the goal-based analysis of the current safety, CDEM and pollution prevention standards inferred from the existing international treaties, in order to lay down a legal and liability framework for autonomous and unmanned vessels. The duty to implement safety standards is basically upon flag States. Construction and manning rules and standards are partly technical and partly goal-based standards, which must be observed by all ships, depending on the purpose and size of the vessel. Standards of pollution prevention are incorporated in the IMO Conventions, as discussed in these documents. As far as tasks and responsibilities of the SCC and ASC are concerned, the SCC plays the essential role in the operation of an autonomous vessel. The basic obligations of the master and chief engineer will be imposed on the SCC. In meeting the established rules

[55] For further discussions and comments made during the Consortium Meeting in Trondheim see the Consortium Meeting Reports.

and procedures, the SCC should ensure that all requirements are implemented. In this regard, the ASC must report to the SCC any deficiencies which require corrective actions.With this in mind, in the case of a remote operation of an autonomous vessel, the SCC operating remote control is required to adopt all necessary measures and establish all appropriate procedures to ensure that the autonomous ship is maintained in accordance with the objectives and provisions of the relevant international rules and regulations. Indeed, this legal framework makes a link between objectives of international rules and standards on the one hand, and obligations and responsibilities of the SCC and ASC on the other hand.

14.3 Liability and Responsibility Scenarios

As discussed above, the SCC has the main role to play in the operation of an autonomous vessel. Taking into consideration the roles of the SCC, it bears the main responsibility and liabilities for the operation and the consequences of the operation of the autonomous vessel. When the SCC takes the role of master, practically and legally, the obligations of the ship's master will be imposed upon the Shore Control Center, and the responsibility passes on to the current SCC operators in case of damage. However, this responsibility is not general and unlimited. There are a number of limitations. It depends on the system-based limitations, circumstances as well as processes, as discussed in D5.2 (process map) and also architecture, as discussed in D4.5. The responsibility of the SCC will not be based on a "one size fits all" approach. In every process, the duties and responsibilities are different. For example, according to the COLREG Rules, the necessary actions that must be taken to avoid a collision in a close quarter situation are different from other situations. Moreover, depending on whether the autonomous vessel is the stand-on vessel or the give way vessel, the obligations and responsibilities of the SCC and responsibility between vessels are different. The key point is the fulfilment of the obligation of compliance with international rules. This general obligation of compliance must be implemented by means of taking actions as established by the rules and according to the prevailing conditions, especial circumstances, including the limitations of the vessels involved, as well as all dangers of navigation and collision. It is necessary to consider different scenarios according to different situations. An important factor to be noted is that the D5.1 and D7.2 (legal analysis) make a link between legal foundations with other analysis, D.5.2 (process map for autonomous navigation), D.4.5 (architecture specification) and D7.1 (error and human intervention), as well as statements and

presentations made during the meetings, especially Consortium Meeting in Trondheim. In fact, the D5.1 and D7.2 have established a legal and liability framework for the operation of autonomous or unmanned shipping. This framework contains an analytical study of the main legal obligations and responsibilities relating to collision, maintenance, visibility, lookout and watchkeeping. Within this framework we will elaborate and consider profoundly and in more details the international standards, making a connection between law and other tasks of the MUNIN projects. This includes different scenarios of liability issues in which an autonomous vessel is involved. In order to contribute to the future development of shipping, the diverse settings of liability matters will be examined which entail responsibilities and liabilities arising out of accidents between an autonomous vessel with different types of vessels and installations within certain situations and circumstances, based on the provisions of a number of liability conventions. Such progress and advanced liability analysis in conjunction with the MUNIN processes and architectures will definitely contribute in fortifying the body and foundations of international maritime rules and standards which will be developed within the framework of the intergovernmental and non-governmental organizations, such as IMO, IALA, Germanischer Lloyd Ship Classification - Maritime Service, and other international and regional governmental and non-governmental organizations and societies.

15. References: International and UK Instruments Applicable to the MUNIN Project

The UK Merchant Shipping (Safety Convention) Act 1977, c.24, (repealed 1.5.1994).

The UK Merchant Shipping (Safety of Navigation) Regulations 2002 No. 1473.

The UK Merchant Shipping (International Safety Management (ISM) Code) Regulations 1998 (S.I. 1998 No. 1561).

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International Convention on Maritime Search and Rescue (SAR)

Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 20 October 1972, in force 15 July 1977; 1050 UNTS 16.

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International Convention for the Safety of Life at Sea (London) 1 November 1974, in force 25 May 1980, 1184 UNTS 2 (1974 SOLAS), as amended in accordance with its Protocol of 1988.

International Maritime Dangerous Goods (IMDG) Code.

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International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, (1996) UKTS 87.

Athens Convention Relating to the Carriage of Passengers and their Luggage by Sea

International Convention on Civil Liability and Compensation for Bunker Oil Spills (Bunker), (2001) 40 ILM 1493.

International Convention on Liability and Compensation for Damage in connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), (1996) 35 ILM 1406.

Radiocommunications and Search and Rescue (COMSAR)

Protocol of 1996 to amend the Convention on Limitation of Liability for Maritime Claims, (LLMC Protocol 1996), 35 ILM 1433.

Convention on the Control of Harmful Anti-Fouling Systems on Ships, (2001) IMO Doc AFS/CONF/26.

International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, (1970) 9 ILM 25.

Protocol to the 1969 International Convention on the High Seas in Cases of Marine Pollution by Substances other than Oil, 1973, (1974) 13 ILM 605.

International Convention on Salvage, 1996 UKTS 93.

Convention on the International Maritime Satellite Organization (INMARSAT), adopted on 3 September 1976 and entered into force on 16 July 1979.

Safe Loading and Unloading of Bulk Carriers (BLU Code) adopted by the IMO by Resolution A.862(20).