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CONTENTS

List of symbols and abbreviations

ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
AIS	Automatic Identification System
ASM	Application Specific Messages
BIMCO	Baltic and International Maritime Council
BV	Bureau Veritas
BU	University of Belgrade
CCNR	Central Commission for the Navigation of the Rhine
CDNI	Convention on the Collection, Deposit and reception of waste generated during navigation on the Rhine and other waterways
CEMT	European Conference of transportation Ministry
CFT	Compagnie Fluviale de Transport
CLNI	Convention on the Limitation of Liability in Inland Navigation
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
DoA	Description of Action
DST	Development Center for Ship Technology and Transport Systems
ECDIS	Electronic Chart Display and information system
ESTRIN	European Standard laying down Technical Requirements for Inland Navigation vessels
FMEA	Failure Modes and Effects Analysis
FV	Follower Vessel
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HAZID	Hazard Identification analysis
HMI	Human Machine Interface
IBC	International Bulk Chemical Code
IGC	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
ILO	International Labour Organization
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organisation
ISM	International Safety Management Code
ISPS	International Ship and Port Facility Security
IT	Information technology
IWT	Inland Waterway Transport
LLMC	Convention on Limitation of Liability for Maritime Claims
LV	Lead Vessel
MARIN	Stichting Maritiem Research Instituut Nederland
MARPOL	IMO's International Convention for the Prevention of Pollution from Ships
MLC	ILO's Maritime Labour Convention
NMTF	Stichting Netherlands Maritime Technology Foundation
OT	Operational Technology
RIS	River Information Services
SAR	International Convention on Maritime Search and Rescue

SOLAS	IMO's International Convention for the Safety of Life at Sea
SPB	Stichting Projecten Binnenvaart
SSS	Short Sea Shipping
STCW	International Convention on Standards of Training, Certification and Watchkeeping
UNECE	United Nations Economic Commission for Europe
VHF	Very High Frequency
VT	Vessel Train
VTS	Vessel Traffic Service

Definitions

Terms used in this report are defined here after:

- Active monitoring on bridge: a crew member is at watch on the bridge, providing a reduced response time in case of abnormal / emergency situation and an additional set of eyes.
- Control: controlling a vessel consists in regulating its trajectory, speed and orientation. LV is controlled by the onboard operators. FV is remotely controlled by operators on board of the LV.
- Conventional vessel: vessel not being part of a vessel train.
- Operators: crew members qualified to operate a VT (VT operator).
- Cybersecurity: preservation of confidentiality, integrity and availability of information in the Cyberspace (ISO/IEC 27032). It includes all cybersecurity class notation requirements in accordance with Bureau Veritas Rule Note NR 659 [10].
- Ergonomics: applied science that studies, designs and adapts equipment, work and the environment to meet human capabilities and limitations and to enhance safety and comfort (ISO 14105).
- Operating mode: Defines the navigation time allowed according to the Regulation for Rhine Navigation Personnel (RPN). A distinction shall be made between the following operating modes:
    - A1 navigation for a maximum of 14 hours,
    - A2 navigation for a maximum of 18 hours,
    - B navigation for a maximum of 24 hours,

  in a 24-hour period.
- Situation awareness: perception of environmental elements and events with respect to time and space, the comprehension of their meaning and the projection of their future status.
- Recommendation: guidance allowing to meet safety and security conditions.
- Reliability: property of a system and its parts to perform its mission accurately and without failure or significant degradation (ISO/IEC 27036-3).

1 EXECUTIVE SUMMARY

1.1 Problem definition

First applications of novel concepts such as the vessel train often encounter (regulatory) barriers and challenges that need to be overcome to smoothen the large-scale exploitation of the concept. Navigational safety and cyber safety and security as well as related human factors have a special attention for the vessel train's implementation. Interaction with other waterborne traffic of individual vessels and/or other vessel trains in busy waterways, unexpected situations onboard and outside vessels and severe weather conditions are some examples of such challenges.

The main problem to be addressed by work package 5 – Safety issues and human skills is the way to account for the VT related navigational and functional safety and security issues and the VT impact on human working conditions and skills. The overall objectives are to develop methods to assess the safety level of a VT operation and to derive recommendations for the VT designers, operators and regulatory bodies. In this context, the main objective of Task 5.4 is to develop recommendations to regulatory bodies and waterborne transportation operators defining modification needs for the current Regulations and operational principles for a feasible VT concept and its future ruling.

1.2 Technical approach and work plan

The activities in Task 5.4 are organised around three sub-tasks:

- Provide recommendations to regulatory bodies (CCNR, IACS, IMO, UNECE) addressing VT-related technological developments such as the command and control system, and on the VT operations based on the conducted safety assessment. Possibilities to propose a short-term procedure based on a case-by-case approval for (commercial) pilot projects will also be considered
- Communicate with authorities, inland water operators and other stakeholders in particular through the project Stakeholder Group, to influence the policy development that may affect the envisaged VT operation and define orientations for further developments of the vessel train concept
- Prepare the task deliverable (D5.4), this report.

1.3 Results

Current applicable Rules and Regulations have been analysed regarding their relevance for the VT concept. They were challenged from a view regarding concept of a train of vessels remotely controlled & monitored by a lead vessel, vessel remotely controlled with no crew in the wheelhouse for monitoring during normal operations, and reduced crew on follower vessels.

For vessel design and equipment it was identified that most of the modifications to be proposed affect "information acquisition" and "action" phases of human involvement. This means that the Regulations should make more provisions for mandatory sensing devices (thus facilitating the information acquisition) and for safety systems which are less reliant on human involvement and allow for execution of safety function from remote positions (thus facilitating the action phase). Identified requirements affect machinery and related systems, bilge, water ingress detection, fire detection and protection, anchor. Further, as vessel trains highly rely on critical systems, related in particular to geolocalisation of the vessels, data transmission, onboard control systems as well as global monitoring and supervision, technical and organisational cyber measures need to be dealt with.

For VT navigation current navigation rules raise the questions whether the lead vessel and its crew is allowed to represent all participating vessels. The existing Regulations are not adapted for vessels at

CCNR level 2 of automation and higher. They explicitly assign navigation operations to the human operator in the wheelhouse and thus precludes these operations to be carried out from other remote positions. Further aspects identified are: VT identification, safe distance and VT sailing rules.

For VT operation-related human element the following Regulations areas challenging the VT concept can be noticed: manning and working conditions as a result of reduced crew, skills and personnel qualification as a result of new technology enabling remote control of FVs in a VT and operating modes and organization of the working time. For navigation tasks, the latter focused on the situation that FV operators are "off duty" during normal VT operations, where their vessel is remotely operated.

For VT operation legal aspect the following areas of the legal framework are not addressed in the existing regulations: VT operation actors, their responsibilities and their roles, at different phases of the VT operation, consideration of the responsibility of the designer of the smart systems intended for essential service (VT control system) and consideration of the cyber risks.

In order to identify the VT in the Rules and Regulations, new definitions are needed. Suggestion for these definitions have been defined and it is shown that they can be added to the existing structure of these Regulations e.g. ESTRIN.

For both the VT vessels design and equipment and especially the VT control system, existing main technical compliance frameworks (ESTRIN and SOLAS) need to be modified/adapted according to the recommendations set out in the relevant chapter. These recommendations are the result of expert opinion during safety and cyber security sessions and simulations/real-life test of the NOVIMAR VT control system. It is shown that they can be added to the existing structure of these Regulations e.g. ESTRIN.

Ensuring the safety and ease of traffic on waterways is also the determining factor for the VT and the necessary extensions of the existing Rules and Regulations. For this, recommendations are formulated and structured in accordance with CEVNI Code. They concern specifics on VT operation procedures, special marking, sound signals, rules of the road and emergency procedures.
In addition to the adaptation of the existing police Regulations, internal guidelines must also be drawn up, which shall contain the following VT-specific topics: voyage information and voyage preparation, VT operating limits, VT forming by coupling/decoupling, and navigational procedures in emergency situations. These contents are essential for the operation of a VT but are not to be included in the Regulations.
The regulatory framework defining the crew member minimum number, qualification, training, and organisation of the working time, needs to be modified/adapted to facilitate the introduction of the VT. The operation of LV and FV need additional skills, training and qualification in reference to single vessel operation.

In business models where all VT vessels are owned by the same actor, the maximum liability for the vessel train as a whole could become so high that it is uninsurable. However, it is observed that in present day business models "a whole fleet" is often accommodated in a structure of several private companies in a holding. For this reason the ownership structure is an important parameter for insuring this business model.

Business models where multiple vessels from different owners take part in the VT are more complex to insure, however no "no-go" obstacles are foreseen.

For the insurance companies, it must be very clear which actors are involved in the Business Model at hand. Roles and responsibilities need to be very precisely and clearly defined in order to assess the situation and to come up with a suitable insurance offer per actor.

With regard to the VT control and monitoring system, manufacturers are usually very clear about where the responsibility of the manufacturer ends. In most cases, a duty to repair the system would be included, but the costs of any accidents/failures flowing from a product failure will be explicitly excluded. Insurance solutions need to be found for these gaps in liability, but this is unthreaded ground for most insurers so an off the shelf product should not be expected.

For the actual VT operation, it is vital that a clear division of responsibility has been agreed on beforehand. In addition, there is the need for hierarchy when multiple actors should act on the same time (e.g. during an emergency). For this, it is advised that the VT contract should make absolutely clear who is responsible for what. There should be a responsibility for the LV and a due diligence requirement for the FV.

In addition, from an insurance point of view, it needs to be very clear at what moment a vessel is within a VT (connected) or when it is outside the VT (disconnected). Having this insight, insurance issues can be pinpointed at the actual mode of operation of the vessel and thus where liabilities lay. To support this, a Voyage Data Recorder able to identify the moment of coupling and decoupling is highly recommended.

It remains the question how far insurance companies can go in insuring vessels that operate as FV in a VT, and thus give up part of their responsibilities.

The virtual platform brings cyber security risks. Currently, all damage flowing from a cyber-attack is excluded for vessel insurance. To insure this, cyber security measures put in place by the various actors need to be discussed with insurers to prevent insurance costs to rise sky high.

For insuring the actual VT operation, two methods have been identified:

- Fault-Based versus Contractual Liability, meaning that parties take on responsibilities and if something goes wrong, surveyors determine who is at fault. The party at fault will receive claims.
- A system of ‘contractual liability’, meaning that parties agree beforehand who is responsible for what, regardless of being at fault or not. This could then mean that someone damages an owners vessel, and (even though that someone was at fault) the owners has to cover the bill.

Introduction of new Rules and Regulations adapted to the VT concept should be accompanied by an appropriate procedure for the VT operation approval. The procedure for VT operation approval defined in this deliverable is to be implemented at two levels: approval of the VT operation by the competent Authority/Administration and check & verification to be performed by the VT company whenever a VT is formed.

Preparing Regulations adapted to the vessel train could be a complex and long process. An alternative way to authorize VT concept could be to prepare a request for a derogation with a pilot project.

2 INTRODUCTION

2.1 Background

2.1.1 Context

The European Commission Topic MG2.3-2016, dealing with new and improved transport concepts in waterborne transport, addresses the following challenges to waterborne transportation:

- Expansion of the waterborne transport chain from sea to river/canal up to the urban environment
- Optimisation of the waterborne transport chain, possibly by introducing automation in all waterborne operations
- Bringing the waterborne transport much deeper into multi-modal transport concepts, in particular to the benefit of domestic shipping and inland navigation in the European Union.
- Removal of the traditional barriers between transport modes.

In order to respond to these challenges, Novel Inland water transport and Maritime transport concepts (NOVIMAR) will develop the vessel train concept, waterborne version of the road platooning. The vessel train is a totally new element that will bring about a significant change in the existing waterborne transport and logistics systems. NOVIMAR is a 4-year EU funded project counting 22 partners.

First applications of novel concepts such as the vessel train often encounter (regulatory) barriers and challenges that need to be overcome to smoothen the large-scale exploitation of the concept. Navigational safety and cyber safety & security as well as related human factors have a special attention for the vessel train's implementation. Interaction with other waterborne traffic of individual vessels and/or other vessel trains in busy waterways, unexpected situations onboard and outside vessels and severe weather conditions are some examples of such challenges. This necessitates researches on navigational safety and cyber security issues, the impact on human working conditions & skills and contributions to regulatory developments for joint operations of conventional vessels and vessel trains. These researches are assigned to the work package 5 dealing with safety issues and human skills.

2.1.2 Work package 5 objectives

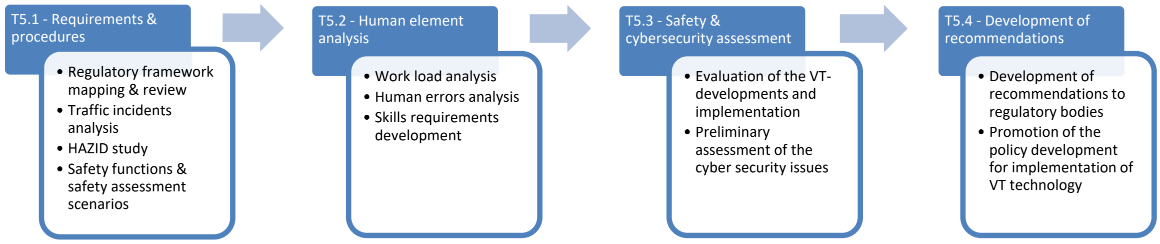
The work package 5 mission is to provide a first account on vessel train (VT)-related navigational and functional safety and security barriers, and on the VT impact on human working conditions and skills.
The main objectives of the work package 5 are:

- To define and apply an approach for the safety evaluation of VT's and to address cyber security issues.
- To analyze the task of human operators, to optimize their performance and define appropriate training.
- To communicate with regulatory bodies and other interested stakeholders to influence the policy development and overall trends of the inland water and short sea transportation cluster. This is the subject of this document.

The work package 5 is organized in four tasks as shown in Figure 1. Detailed outcomes of tasks T5.1, T.52 and T5.3 researches can be found in the following deliverables:

- D5.1 – Requirements on regulatory challenges, safety functions and safety assessment scenarios [1]
- D5.2 – Human impact assessment [2]
- D5.3 – Safety and cybersecurity assessment [3].

Figure 1: Work package 5 activities



2.2 Task T5.4 – Development of recommendations

2.2.1 Task objective

The main objective of Task 5.4 is to develop recommendations to regulatory bodies and waterborne transportation operators on how to remove the (regulatory) barriers for a feasible VT concept and its future ruling.

2.2.2 Task activities

Task 5.4 is composed of 3 sub-tasks, with associated activities as described hereafter:

- Sub-task T5.4.1: Provide recommendations to regulatory bodies (CCNR, IACS, IMO, UNECE) addressing VT related technological developments such as the command and control system, and on the VT operations based on the conducted safety assessment. Possibilities to propose a short-term procedure based on a case by case approval for (commercial) pilot projects will also be considered.
- Sub-task T5.4.2: Communicate with authorities, inland water operators and other stakeholders in particular through the project Stakeholder Group, to influence the policy development that may affect the envisaged VT operation and define orientations for further developments of the vessel train concept.
- Sub-task T5.4.3: Prepare the task deliverable (D5.4), being this report.

3 PLAN

3.1 Planned activities

The activities to be performed within the scope of task T5.4 include:

- Development of guidelines for existing Rules and Regulations modification
- Development of recommendations for Rules and Regulations modification addressing:
    - VT vessels design and equipment
    - VT systems design and installation
    - VT navigation
    - VT operation procedures
    - VT operation related human factors
    - VT operation insurance and liability
- Development of recommendations for VT operation approval
- Dissemination of the outcomes of WP5 to water borne transportation operators and communication with the relevant authorities
- Development of deliverable D5.4.

3.2 Research process

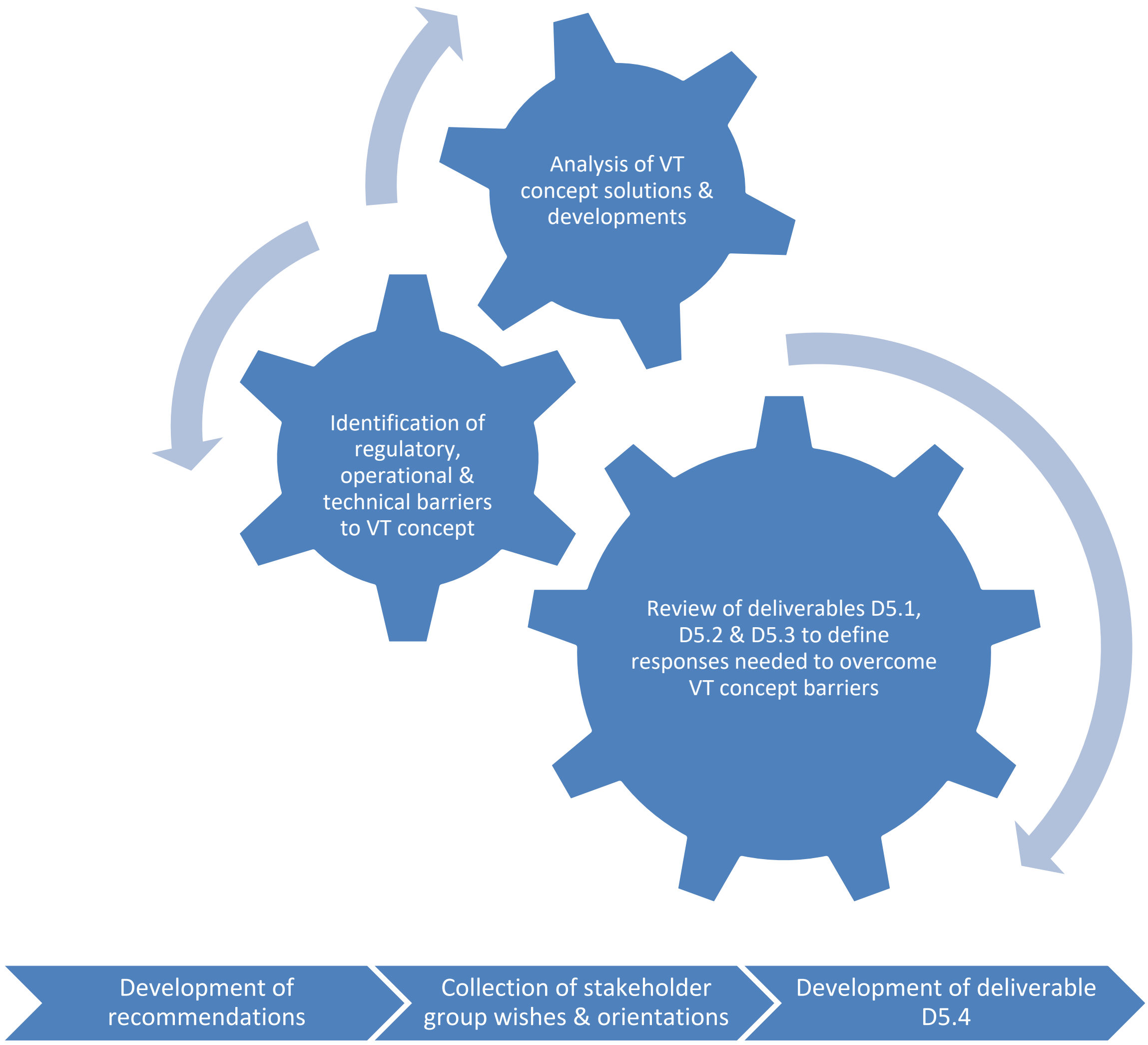
The activities of task T5.4 have been performed according to the global process set out in Figure 2.

3.3 Involved partners and assigned activities

The distribution of the activities among partners in Task 5.4 is summarised as follows:

- BV (task leader) develops guidelines and recommendations for Rules and Regulations adaptation. Develops recommendations on VT operation approval methods and procedures. Prepares the task deliverable
- BU contributes to the development of recommendations for VT vessels design and equipment and contribution to the development of recommendations on VT operation approval methods and procedures
- NMTF develops recommendations for insurance and liability
- SPB contributes to the development of recommendations for insurance and liability. Disseminates the outcomes of the task activities to stakeholders and communicates with the relevant authorities
- DST contributes to the development of recommendations for VT navigation and operation procedures Contributes to the dissemination of the outcomes of the task activities to stakeholders and communication with the relevant authorities
- CFT contributes to the development of recommendations for VT navigation and operation procedures
- MARIN develops the recommendations related to human element in the VT operation.

Figure 2: Recommendations development process



4 GUIDELINES FOR EXISTING RULES & REGULATIONS MODIFICATION/ADAPTATION

4.1 NOVIMAR vessel train concept

4.1.1 General

Regulatory, technological and operational barriers and challenges that need to be overcome to allow for a successful implementation of the VT concept in the waterborne transportation system are identified in section 4.2. Then in section 4.3 six research topics are introduced. These topics are detailed in the chapters 5 – 10. Finally, a conclusion is given.

4.1.2 VT configuration

Depending on the navigation area, the vessel train can consist of inland navigation vessels, sea-river vessels or short-sea ships.

The vessel train can consist of a different number of motorvessels that can be identical, similar or very different in types and sizes. The vessel train can include refits or newbuild vessels that are optimized to sail with full crew or reduced crew.

The LV can be a modified cargo vessel or a dedicated vessel without a cargo hold. FVs can be dedicated follower vessels, vessels that can also sail as conventional vessels outside the train or vessels that can also perform the role of LV if required.

The maximum allowable VT length is technically determined by the capability of the VT control and communication systems and the actual navigational situation on the waterway.

4.1.3 VT operational aspects

The VT concept can be applied to all cargo types, including hazardous cargo, unitised or in bulk. Given the fact that the project aims to overcome traditional barriers in intermodal transport and wants to penetrate urban areas, the logical primary cargo types are containers and RoRo cargo.

The roles of the vessels in the train are defined as follows:

- The LV sets out a sail plan and provides the FV's with the necessary data to follow its "tracks". It is responsible for the communication with outside parties and for the overall VT behaviour within the waterways' infrastructures and traffic. The LV takes preventive and/or curative action within the limits of its authority and technological ability, for example reducing speed, stopping, or adjusting the course. The LV has a limited and well defined authority over the FV's onboard systems, e.g. cannot restart engines and generators, activate fire-fighting systems or ballast pumps.
- The FV follows the sail plan set out by the LV by means of the NOVIMAR control system. The control system sets the parameters for track- and distance-keeping.
  The FV is responsible for keeping all own vessel systems up and running, solving emerging problems and taking appropriate action following LV instructions or based on own decisions. The FV is manned by at least one crew member. Its task is to take manual control in foreseeable situations as defined in the sail plan, to solve problems that arise on board and to act in emergency situations (water ingress, fire). Finally, the crew navigates the FV to connect with the VT and navigates the FV out of the VT towards the final destination.

The control centre could be a service centre for vessel owners/VT company or a facility established by a large owner/VT company, helping to assembling or voyage optimisation of the VT. This role has not been investigated in NOVIMAR.

The following degrees of control (see definition in 5.2.9) are provided for VT vessels:

- Full direct control for LV
  The LV is actively monitored and controlled at any time by the crew from the control station on board (bridge).
- Available direct control for FV.
  The crew is available on board, ready to take control as defined in the voyage plan, in case of warning or alert from the VT or as a result of emergency situation on board. Two cases can be distinguished:
  - permanently manned control station/bridge (active monitoring on bridge)
  - periodically unmanned control station/bridge (no continuous active monitoring on bridge).
- Full remote control for FV
  The vessel is actively monitored and controlled at any time by operators from the LV, within the limits of defined authority.

4.1.4 VT control

According to CCNR [6] definition of levels of automation in IWW, the required level of automated navigation on board of the follower vessel shall be level 3 i.e., “Conditional automation: the sustained context-specific performance by a navigation automation system of all dynamic navigation tasks, including collision avoidance, with the expectation that the human helmsman will be receptive to requests to intervene and to system failures and will respond appropriate navigation tasks, including collision avoidance”. The NOVIMAR control system has been defined to meet these requirements.

The VT navigation requires FVs to be equipped with control and monitoring systems which:

- communicate with the lead vessel
- command the manoeuvring systems (rudder and throttle) of the vessel
- maintain an ordered distance from the vessel in front.

During normal operation, the implemented standard procedures allow to perform continuously and without human intervention the following tasks:

- Avoiding traffic: encountering, overtaking or crossing
- Passing bridges
- Navigating narrow, shallow and/or bendy waterways
- Self-check of the VT system, supervision by leader vessel.

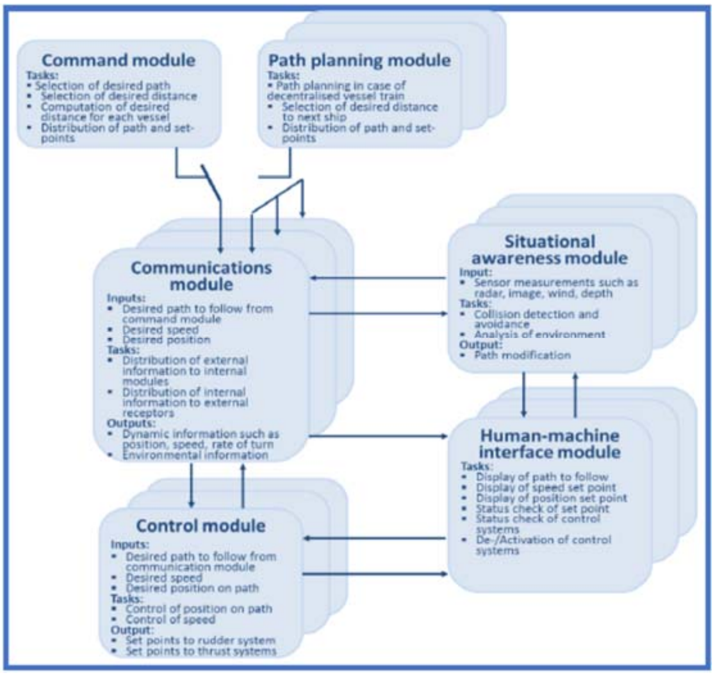
The standard procedures are handled according to the modular architecture as outlined in Figure 3. Concerning special operations, i.e. uncommon navigation tasks, only “joining/leaving (coupling/decoupling) a train” is covered by the research. The following special operations will not be included in the research because they are not done as a train, but by individual vessels:

- Docking/undocking at terminal
- Loading/unloading cargo
- Passing locks
- Embarking/disembarking vessels during joining/leaving.

Countering calamities underway, including emergency maneuvers, are not included in the automatic decisions of the VT control system.

The minimum distance (safe distance) between vessels within a VT shall be such as to minimise the risk of collision within the VT in the event of an emergency manoeuvre by any vessel within the VT.

Figure 3**:** NOVIMAR VT command and control system



4.2 Identification of potential barriers and challenges to VT concept implementation

4.2.1 General

This section aims to identify regulatory, technological and operational barriers and challenges that need to be overcome to allow for a successful implementation of the VT concept in the waterborne transportation system. Analysis of the outcomes of the research carried out in the project show that these barriers and challenges belong to three categories:

- Those inherent to the suitability of the existing regulatory framework (see 4.2.2)
- Those related to the VT operation impact on human factors (see 4.2.3)
- Those derived from the VT operation safety and security conditions (see 4.2.4).

In the following these three aspects are further discussed.

4.2.2 Regulatory framework

4.2.2.1 General

Current applicable Rules and Regulations in Table 1 (on page 23) have been analysed regarding their relevance for the VT concept as described in section 4.1. The analyzed framework has been challenged from a VT point of view regarding:

- concept of a train of vessels remotely controlled & monitored from a lead vessel
- vessel remotely controlled with no crew in the wheelhouse for monitoring during normal operations

- reduced crew on follower vessels.

4.2.2.2 VT vessels design and equipment

This section addresses the technical standards for cargo vessels contained in:

- The European Directive 2016/1629/EC [11], referring to European Standard laying down Technical Requirements for Inland Navigation vessels (ESTRIN)
- The International Convention for the Safety of Life at Sea, 1974, dealing with requirements about safety of life at sea (SOLAS) [14]
- Directive 2008/68/EC [12], referring to European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN),

with emphasis on those provisions which either explicitly require the presence of a human operator, or implicitly assume that a safety function would be carried out by a human operator, without explicitly requiring his/her presence.

The NOVIMAR VT concept solutions rely on the development of smart systems entailing implementation of three aspects of automation.

- Automated navigation, e.g, CCNR automation levels [6]
- Automated machinery systems e.g., Bureau Veritas additional class notation AUT-UMS [8]
- Automated operations, e.g., automated coupling/uncoupling or mooring systems.

The level of automation represents the degree of decision making (authority) deferred from the human to the system [9]. Four phases of human participation in vessel operation may be distinguished: (1) information acquisition, (2) information analysis, (3) decision-making, and (4) action. It may be demonstrated that most of the modifications to be brought to the regulatory framework affect “information acquisition” and “action” phases of human involvement. This means that the regulations should make more provisions for mandatory sensing devices (thus facilitating the information acquisition) and for safety systems which are less reliant on human involvement and allow for execution of safety function from remote positions (thus facilitating the action phase).

The wheelhouse is an essential part of the described safety concept. As noticed in [33], the wheelhouse may be regarded as a global safety centre of the vessel. Many safety regulations require the information necessary for safe vessel operations to be sent to the wheelhouse, where this information is to be analysed and from where the safety functions should be directed and/or executed, after the decision is made by human operators present in the wheelhouse. In context of the VT concept (and strictly from the point of the regulations), the absence of the human operators from the wheelhouse on follower vessels could be detrimental for the safety of the VT, unless the Regulations make clear provisions for redirection of the relevant information to the wheelhouse/control centre of the lead vessel.

Examples of regulations areas which ought to be amended and the reasons for the amendments are given hereafter:

- Machinery and related systems

  The Regulations explicitly assign remote monitoring and remote control of the machinery for essential services to the human operator in the wheelhouse and thus preclude these operations to be carried out from other remote positions.

- Bilge system

  The rule explicitly assigns remote monitoring of safety parameters to the human operator in the wheelhouse and thus precludes these operations to be carried out from other, remote positions.

- Water ingress detection system

The regulations do not make provisions for water ingress detection systems in e.g. cargo holds. In conditions of reduced crew, monitoring of cargo spaces and a timely detection of flooding should be assigned to systems.

- Fire protection and detection systems
    - Safety regulations for inland cargo vessels do not require permanently installed firefighting systems in accommodation spaces, wheelhouses, engine rooms, boiler rooms and pump rooms (i.e. in spaces occupied by crew) unless the vessel is intended to carry dangerous cargo. In addition, passive fire safety measures (requiring bulkheads and decks to be thermal boundaries of certain characteristics) are not a part of the rules for inland cargo vessels. Therefore, fire safety relies to a considerable extent on human presence and involvement.
    - The rules do not require a possibility to close the openings from a remote position. Hence, the absence of a human operator on-board would imply an increased risk of fire in the machinery space.
    - Human operators are responsible for extinguishing of fire. Insufficient number of human operators (as in partially unmanned sailing regimes) would increase the risk of fires.
- Anchor equipment

  Regulations do not make provisions for automated anchoring.

In addition to the above, to achieve a safe operation of vessel trains which relies highly on critical systems, related in particular to geolocalisation of the vessels, data transmission, onboard control systems as well as global monitoring and supervision, technical and organisational cyber measures shall be deployed. This requirement can be met through compliance of the VT with the requirements for the assignment of the additional class notation “Cyber secure”, according to Bureau Veritas Rule Note NR 659- Rules on Cyber Security for the Classification of Marine Units [10].

4.2.2.3 VT navigation

This section addresses the following Regulations, setting out the main navigation rule requirements:
- Police Regulations for the navigation of the Rhine (RPNR) [32]
- European Code for Inland Waterways (CEVNI), drawn up by the UNECE and covering police Regulations for the navigation of European inland waterway network [28].
- IMO Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972, as amended [13].

These Regulations apply to conventional vessels, i.e., to vessels operated alone or integrated in a convoy or side-by-side formation considered as a single nautical unit. The following main gaps with respect to the VT concept can be noticed:
- VT identification
- Safe distance

  According to section 5.2.7, the VT length depends on the distance between vessels in the train. The maximum allowable VT length is technically determined by the situational awareness and the capability of the VT control and communication systems. The permissible stopping distance prescribed is high compared to the probable distance between VT vessels.
- Sailing rules

  Current navigation Regulations raise the question whether the lead vessel and its crew is allowed to represent all participating vessels and if so, is the lead vessel operator able to judge that the sailing operations process such as overtaking, evasive actions are safe for all involved vessels.

The existing Regulations are not adapted for vessels at CCNR level 2 of automation and higher. They explicitly assign navigation operations to the human operator in the wheelhouse and thus preclude these operations to be carried out from other remote positions.

4.2.2.4 VT operation human element

This section addresses the following regulatory framework defining the crew member minimum number, qualification, training, and organisation of the working time:

- Regulations for the Rhine navigation personnel (RPN) [31], defining the crew member minimum number, qualification, training, and resting time
- European Directive 2014/112/EC [25], implementing the European Agreement concerning certain aspects of the organisation of working time in inland waterway transport
- European Directive 1996/50/EC [24], harmonising the conditions for obtaining national boat masters' certificates for the carriage of goods and passengers by inland waterway in the Community
- Seafarers' Training, Certification and Watchkeeping (STCW) Code [17].

As identified above, NOVIMAR VT concept is totally new. The following Regulations areas challenging the VT concept can be noticed:

- Manning and working conditions (reduced crew)
- Skills and personnel qualification (new technology)
- Operating modes and organization of the working time

The main parameter that impacts the working conditions and the crewing level is the operating mode of the vessel. On the river Rhine there are the operating modes A1, A2 and B. In combination with the equipment standard (S1/S2) and the type and size of the vessel, they define the crewing requirements. These Regulations are not adapted for vessels at CCNR level 2 of automation and higher.

4.2.2.5 VT operation legal aspect

The following areas of the legal framework are not addressed in the existing regulations:

- VT operation actors, their responsibilities and their roles, at different phases of the VT operation
- Consideration of the responsibility of the designer of the smart systems intended for essential service (VT control system)
- Consideration of the cyber risks.

4.2.3 VT operation human factors

The outcomes of the research related to the VT operation impact on the human element performed in the project contain recommendations for optimized working conditions, human reliability and training needs [2]. The research performed includes the analysis of the human element in VT operations, both in terms of potential source of failure and in terms of working conditions and required skills in order to produce design and operational recommendations.

The results indicate that it is technically feasible to sail the VT without navigation tasks on board follower vessels, subject to the implementation of appropriate measures related to the VT operational concept, control system design and human-machine interface design.

The LV operator tasks become more complex due to the monitoring of the FVs. The maximum duration of a shift is estimated, by experienced skippers to be four hours with two follower vessels in dense traffic scenarios. Above two follower vessels, the majority of the skippers hold the view that an extra LV operator is required because the task demand would become too high. However, context matters: less traffic and more space to manoeuvre would positively impact the maximum number of working hours.

The same result applies to how many FV operators are needed. The operational context strongly influences the requirement for active monitoring on FV bridge. Based on the used inland scenarios, it is estimated that active monitoring on the FV bridge is a necessity, at least for inland navigation on busy waterways. Other navigation areas, such as short sea – with more space and less traffic - might be more suitable to allow the FV operator to do other things other than being actively involved in navigational tasks.

The VT concept entails new human competences, working environment and adapted training specifications and procedures for VT operators as well as appropriate working conditions and work organisation to be addressed by:

- The regulatory bodies for the adaptation of existing regulatory framework
- The VT company and other operators of the waterborne transportation for the adaptation of operational principle protocol and procedures.

4.2.4 VT operation safety and security

The safety and security conditions are defined by the recommendations aiming to ensure that the suitable level of functionality and reliability of systems associated with essential services involved in the operation of vessel trains is achieved. These recommendations cover different aspects of the VT operation as well as the VT objects design, equipment and arrangements to be addressed by:

- The regulatory bodies for the adaptation of existing regulatory framework and/or
- The VT company and other operators of the waterborne transportation for the adaptation of operational principle protocol and procedures.

4.3 Overcoming barriers and challenges to the VT concept implementation

As outlined above, the implementation of the VT concept in waterborne transportation system entails the development of VT-adapted regulatory framework and operational principles. In the chapters 5 – 10 this is further explored and defined.

In addition, regarding SSS VTs, MSC.1-Circ.1638 - Outcome of the regulatory scoping exercise for the use of maritime autonomous surface ships (MASS) contains the analysis of regulatory modifications necessary for introduction of MASS. This analysis may be applied to seagoing VTs which could be classified as “Degree two” level of autonomy.

Table 1 shows the framework for IWT and SSS categorised to vessel design, construction and equipment, operational and human element.

Table 1: Regulatory framework

Category	Inland waterway transportation	Short sea shipping
Vessel design, construction & equipment	Directive 2016/1629/EC Technical requirements for inland vessels	SOLAS Convention
		Load Line Convention
		Directive 96/98/EC on marine equipment
		Directive 2009/16/EC on port state control
	Directive 2008/68/EC Transport of dangerous goods (A.D.N)	IMDG Code
		IBC Code
		IGC Code
		MARPOL
	Class Rules	Class Rules
Operational	Police Regulations for the navigation of the Rhine (RPNR)	COLREG
	Police Regulations for the navigation of European inland waterway network (CEVNI)	
	CDNI Strasbourg Convention (3)	
	CLNI Strasbourg Convention (4)	LLMC Convention
		ISM Code
		ISPS Code
	Tonnage Convention 1966	TMC Convention
		SAR Convention
		Directive 2010/65/EC (5)
		Directive 2002/59/EC (6)
		Regulation (EC) n° 725/2004 (7)

Category	Inland waterway transportation	Short sea shipping
Human element	Regulations for the Rhine navigation personnel (RPN)	MLC – Maritime Labor Convention
	Directive 2014/112/EC (1)	
	Directive 1996/50/EC (2)	STCW Convention and Code

(1) Directive 2014/112/EC implementing the European Agreement concerning certain aspects of the organisation of working time in inland waterway transport
(2) Directive 1996/50/EC on the harmonization of the conditions for obtaining national boatmasters' certificates for the carriage of goods and passengers by inland waterway in the Community
(3) CDNI Strasbourg Convention of 1996 on collection, deposit and reception of waste generated during navigation of the Rhine and other inland waterways
(4) CLNI – Strasbourg Convention of 2012 on limitation of liability in inland navigation
(5) Directive 2010/65/EC on reporting formalities for ships arriving in and/or departing from ports of the Member States
(6) Directive 2002/59/EC establishing a community vessel traffic monitoring and information system
(7) Regulation (EC) N° 725/2004 on enhancing ship and port facility security

4.4 Conclusion

Current applicable Rules and Regulations have been analysed regarding their relevance for the VT concept. They were challenged from a view regarding concept of a train of vessels remotely controlled & monitored from a lead vessel, vessel remotely controlled with no crew in the wheelhouse for monitoring during normal operations, and reduced crew on follower vessels.

For vessels design and equipment, it was identified that most of the proposed modifications affect “information acquisition” and “action” phases of human involvement. This means that the regulations should make more provisions for mandatory sensing devices (thus facilitating the information acquisition) and for safety systems which are less reliant on human involvement and allow for execution of safety function from remote positions (thus facilitating the action phase). Identified requirements affect machinery and related systems, bilge, water ingress detection, fire detection and protection, anchor. Further, as vessel trains highly rely on critical systems, related in particular to geolocalisation of the vessels, data transmission, onboard control systems as well as global monitoring and supervision, technical and organisational cyber measures need to be dealt with.

For VT navigation, current navigation rules raise the questions, whether the lead vessel and its crew is allowed to represent all participating vessels. The existing Regulations are not adapted for vessels at CCNR level 2 of automation and higher. They explicitly assign navigation operations to the human operator in the wheelhouse and thus preclude these operations to be carried out from other remote positions. Further aspects identified are: VT identification, safe distance and VT sailing rules.

For VT operation-related human element, the following Regulations areas challenging the VT concept can be noticed: manning and working conditions as a result of reduced crew, skills and personnel qualification as a result of new technology enabling remote control of FVs in a VT and operating modes and organization of the working time. The latter focused on the situation that FV crew are “off duty” during normal VT operations, where their vessel is remotely operated.

For VT operation legal aspect, the following areas of the legal framework are not addressed in the existing regulations: VT operation actors, their responsibilities and their roles, at different phases of the VT operation. Consideration of the responsibility of the designer of the smart systems intended for essential service (VT control system) and consideration of the cyber risks.

5 Vessel train definitions

5.1 General

In this chapter vessel train specific terms are defined. They can be added to the existing structure of the current Regulations e.g. ESTRIN, as follows:

Chapter 1 General

Article 01 Definitions

1 Types of craft
1-31 Lead vessel
1-32 Follower vessel
2 Assemblies of craft
2-7 Vessel train
4 Marine engineering terms
4-27 Vessel train configuration
4-28 Vessel train control system
4-29 Vessel degree of control
4-30 Vessel train length
4-31 Safe distance
etc., …

5.2 Definitions

5.2.1 Vessel train

A vessel train is a waterborne transport unit consisting of two or more electronically linked vessels communicating with each other and forming a platoon. The vessel train is composed by a lead vessel and one or more follower vessels controlled by a control system from the lead vessel.

5.2.2 Vessel train configuration

The vessel train configuration is the number and type of motor vessels forming the VT.

5.2.3 Lead vessel

Lead vessel is (LV) is the forward motorvessel of the VT specially equipped, manned and responsible for the control and monitoring of the VT.

5.2.4 Follower vessel

Follower vessel (FV) is a motorvessel participating in a VT, remotely controlled and monitored from a lead vessel.

5.2.5 Safe distance

Safe distance is the minimum allowable distance between VT vessels.

5.2.6 VT length

The VT length is defined by the number n of FVs in the train and the length measured along the VT axis line between the LV stern and the stern of the last FV, considering distances between VT vessels equal to their respective safe distances. The VT length, in meters, is to be determined using the following formula:

$$L = \sum_{i=1}^{n} (\mathrm{Li} + \mathrm{dsi})$$

Where:

- L: VT length, in meters
- Li: Length of FV number i, in meters
- dsi: Safe distance between FV number i and VT vessel in front, in meters
- n: Number of FVs.

5.2.7 Vessel train operator

The vessel train operator (LV operator or FV operator) is a crew member qualified to control and monitor a VT on board a LV or to operate a FV participating in a VT.

5.2.8 VT control system

The VT control system is the technical system used for remote control and monitoring of the FV's in the VT.

5.2.9 Vessel degree of control

The degree of control represents the degree of availability of human operating VT vessels on board or remotely outside the vessel from the LV [9].

5.2.10 Essential service

Essential service is a service necessary for a vessel to proceed at sea/river, be steered or maneuvered, or undertake activities connected with its operation, and for the safety of life [7].

5.3 Conclusion

In order to identify the VT in the Rules and Regulations, new definitions are needed. Suggestion for these definitions have been defined and it is shown that they can be added to the existing structure of these Regulations e.g. ESTRIN.

6 VT vessels design and equipment

6.1 General

To overcome the technical barriers to the implementation of the VT concept in the waterborne transportation system identified in section 4.2, existing main technical compliance framework (ESTRIN and SOLAS) needs to be modified/adapted according to the relevant recommendations set out in the following sections of this chapter:

- Section 6.2, for VT vessels design and equipment
- Section 6.3, for VT control system.

The modification/adaptation needed for the main technical compliance framework can be implemented as a new chapter or section dedicated to the VT concept, e.g. as follows, for the ESTRIN Regulations:

Chapter 32 Special provisions applicable to vessel trains

Article 01 General

1. *Application*
2. *VT operation approval*

Article 02 Vessel design, construction and equipment

1. *Stability assessment tool*
2. *Cargo system*
3. *Propulsion system*
4. *Steering system*
5. *Bilge system*
6. *Water ingress detection system*
7. *Fire protection and detection system*
8. *Anchor equipment*
9. *Automated machinery*

Article 03 VT control system

1. *General requirements*
2. *Certification*
3. *Control system equipment*
4. *Human-machine interface*
5. *Inter vessel communication system*
6. *Monitoring, detection and alarming systems*
7. *Cyber safety and security.*

6.2 VT vessels equipment

The existing Rules & Regulations need to be modified/adapted according to the recommendations given in Table 2 to integrate the requirements related to the VT vessels design and equipment.

Table 2: VT vessels design and equipment

Recommendations	Comments
Stability assessment tool All VT vessels shall be equipped with a certified loading instrument allowing to support stability assessment in all operating conditions.	To be addressed by ESTRIN
Cargo monitoring system FVs shall be equipped with a cargo monitoring system.	To be addressed by ESTRIN and SOLAS In conditions of reduced crew, cargo monitoring shall be assigned to systems. The correct stowage of cargo on board should rely on port operators, since VT vessels (FVs) have few means (reduced crew) for ensuring a proper cargo securing during navigation.
Propulsion system In addition to the main propulsion system, LV shall be equipped with a secondary means of propulsion. The secondary means of propulsion may be a bow thruster that is controlled from the wheelhouse with its own power supply and which is also effective in lightship condition. In vessels with a single main propulsion system, fitted bow thruster shall make it possible for the vessel to proceed under its own power in the event of a breakdown of the main propulsion system.	To be addressed by ESTRIN and SOLAS
Steering system VT vessels shall be equipped with a secondary means of steering. The secondary means of steering may be a bow thruster that is controlled from the wheelhouse with its own power supply and which is also effective in lightship condition. The recommendation may be waived if the safe distance to the vessel in front is taken at least equal to the stopping distance.	To be addressed by ESTRIN and SOLAS

Recommendations	Comments
Bilge system Automatic draining system shall be fitted.	ESTRIN and SOLAS Regulations do not make provisions for bilge automatic draining system. In conditions of reduced crew, bilge draining shall be assigned to systems.
Water ingress detection system A water ingress detection system triggering an alarm on board the own vessel and the LV shall be provided in machinery spaces located below the load line.	ESTRIN and SOLAS Regulations do not make provisions for water ingress detection systems. In conditions of reduced crew, monitoring of machinery spaces and a timely detection of flooding shall be assigned to systems.
Fire protection and detection system A fire detection system triggering an alarm on board the own vessel and the LV shall be provided in VT vessels' compartments presenting a high fire risk. Fixed fire extinguishing systems shall be provided in all VT vessels' spaces presenting a high fire risk, and trunks to such spaces, e.g., spaces containing: - internal combustion machinery used for main propulsion, or - internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or - any oil-fired boiler or fuel oil unit, or - gas generators, incinerators, waste disposal units, etc., which use oil fired equipment, or - batteries. Minimum requirements for the fixed fire extinguishing systems need to be defined.	To be addressed by ESTRIN and SOLAS In conditions of reduced crew, fire extinction in spaces presenting high fire risk shall be assigned to systems.
Attention allocation and fatigue monitoring system Means shall be provided to monitor the attention allocation and fatigue of the LV operator and activate the operator attention allocation during the voyage.	To be addressed by ESTRIN and SOLAS
Automated machinery for FVs The required level of automated machinery systems for FVs shall correspond to Bureau Veritas additional class notation AUT-UMS or equivalent, assigned to vessels which are fitted with automated	To be addressed by ESTRIN and SOLAS

Recommendations	Comments
installations enabling machinery spaces to remain periodically unattended in all sailing conditions, including manoeuvring.	
Automated operations for FVs The following may be required, depending on the crew level on FVs: - Automatic topping up of service fuel tank - Remote operation of openings in walls, ceilings, and doors of spaces with high fire risk - Remote anchor dropping from LV.	To be addressed by ESTRIN and SOLAS

6.3 VT control system

The existing Rules & Regulations need to be modified/adapted according to the recommendations given in Table 3 to integrate the VT smart systems-related requirements.

Table 3: VT control system design and installation

Recommendations	Comments
General requirements VT vessels are to be fitted with, at least, the following standard navigation equipment: - Navigation radar - Turning rate indicator - Autopilot connected to the rudder and the turning rate indicator - AIS transponder - ECDIS system providing the capability to display AIS information - At least two GNSS receivers - At least two VHF voice communication equipment. The VT control system shall be considered as a system providing essential service. Where an emergency electric power source is fitted, the control system shall be connected to the emergency switchboard. A partial or full redundancy shall be ensured for all VT control system components. An interruption of the command communication between LV and FVs shall not affect the local control of the FV's actuators. Besides AIS, each FV local situational awareness system shall be able to use local sensory information (e.g. tracking results from radar images) to define the objects in the surroundings, including the vessel to follow.	To be addressed by ESTRIN and SOLAS

<table>
<tr><th>Recommendations</th><th>Comments</th></tr>
<tr><td>Certification

The standard navigation equipment is subject to mandatory type approval.

Certification requirements need to be defined.</td><td>To be addressed by ESTRIN and SOLAS</td></tr>
<tr><td>Control system equipment

1. Radar

The radar output shall provide reliable information for the task of situational awareness in all operating weather conditions.

2. AIS

Every effort shall be done to minimise the risks of misconfiguration or faulty installations.

3. GNSS

The required precision of the GNSS shall be:
- Position less than or equal to 5 m
- Heading less than or equal to 1°
The fitted GNSS shall ensure the required accuracy for the following components:
- Radarpilot VT
- Situational awareness module
- Trackpilot.

The minimum required GNSS position and heading accuracy level shall be ensured in all operating conditions.
To make the track control more robust against faulty GNSS measurements, a second GNSS receiver shall be installed at the opposite end of the vessel.

GNSS redundancy shall be ensured by installation of:
- Either two GNSS receivers
- Or one GNSS receiver combined with a GNSS compass

4. Turning rate indicator

The required resolution of the turning rate indicator is 0,1°/min or better.

5. Control interfaces
Where a permanent active human monitoring is not provided on the FV bridge, the key alarms shall be interfaced with the VT control system to be able to make the LV aware of problems with the autopilot of a FV and to caution the crew on the FV. This alarm must</td><td>To be addressed by ESTRIN and SOLAS</td></tr>
</table>

Recommendations	Comments
be heard on several places on the FV or on a remote monitoring device, e.g.: • Control interface to the rudder: rudder hydraulics failure, failure to reach the desired rate of turn, failure of rate of turn sensor • Control interface to the throttle providing appropriate signals. The interface of the propulsion control system shall be able to handle invalid commands (like a jump from full ahead to full astern) without the danger of damaging the propulsion unit.	
Human-Machine Interface (HMI) The HMI shall provide the following functionalities: 1. Control access providing HMI controls to trigger the VT specific command means: - to trigger coupling actions - to control operation modes - to select guiding line and safety contours. 2. Control feedback providing measures to monitor the control state: - Visualize the VT coupling state - Display the VT operation mode - Visualize the guiding line offset - Show the guiding line for the followers. 3. Status providing measures to quickly recognize the overall status of the system: - Display deviations from the setpoint of the FV - Define and display core parameters for the FV - Display all system warnings and alarms in a central alarms system - Display safety related functions of the FVs. 4. Traffic situation and awareness providing means to: - Display ECDIS chart - Display own VT positions - Display radar video - Display unified surrounding traffic based on AIS and radar targets (1) - Display and visualize collision avoidance functionality.	To be addressed by ESTRIN and SOLAS (1) This is a requirement to the VT ECDIS system to display a unified surrounding traffic scene that is a fusioned track scene spanning over the complete vessel train like known from VTS systems. This scene is built from local sensory information like radar and AIS.

<table>
<tr><th>Recommendations</th><th>Comments</th></tr>
<tr><td>Inter vessel communication system
- Inter vessel communication system shall ensure an optimal communication between vessels in all operating conditions. The frequency attenuation induced by the weather shall be anticipated in the definition of the VT configuration.
The needed bandwidth strongly depends on the data transferred and the number of vessels. If only tracks and status info is transmitted (which is enough for a vessel train) 100-200kBit/s should be sufficient per vessel. If web-views and radar video are added, at least 500kBit/s-1MBit/s per vessel will be required.
- Inter vessel communication technologies shall be selected considering regulatory as well as other constraints in the intended operation areas, e.g.:
• Limitation of the radiated power in inland applications
• Adaptation to both inland vessels and seagoing vessels where the VT operating area includes both IWT and SSS.</td><td>To be addressed by ESTRIN and SOLAS</td></tr>
<tr><td>Monitoring, detection and alarming systems
Automatic failure detection and alarming systems are to be provided for:
- All VT control system equipment
- Detection systems
- Power supply system.
- Command communication between LV and FVs.
The source system and source vessel of the alarm shall be appended so that the operator always recognises from which system and vessel an alarm has been issued.</td><td>To be addressed by ESTRIN and SOLAS</td></tr>
<tr><td>Cyber safety and security
Appropriate technical and management cyber measures are to be deployed to allow a safe operation of the VT in all operating conditions. This requirement can be met through compliance of the VT with the requirements for the assignment of the additional class notation “Cyber secure”, according to Bureau Veritas Rule Note NR 659- Rules on Cyber Security for the Classification of Marine Units.
Technical and organizational recommendations related e.g. to equipment protection, cyber Security Policy, etc, in accordance with the Rule Note NR 659 [10] are:
• When preparing the installation of a VT control system on a newly built or retrofitted vessel, the architecture should include cyber security equipment and servers. (Firewall – DMZ – DIODE – gateway, Bastion, etc…).</td><td>To be addressed by ESTRIN and SOLAS</td></tr>
</table>

Recommendations	Comments
• Networks switches hosting systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment shall not be directly connected to network switches hosting remotely connected systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment, without network protocols disruption mechanisms (e.g. network diodes). • Remote access (e.g. 3G/4G) packets transport should rely on layer 3 protocols ensuring both identification, authentication and encryption (e.g. IPsec). The implementation of the relevant security mechanisms should be done accordingly. • GNSS receivers should be protected against spoofing by relying either on satellite navigation data authentication (e.g. OS-NMA (Open Service Navigation Message Authentication)) or signal-level GNSS authentication (e.g. Galileo Commercial Authentication Service (CAS)) • Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment, should ensure both the integrity of the data managed, sent or received. • Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment, should permanently monitor their permeability against any vulnerability exploitation, privilege escalation and malicious code execution. • Networks switches hosting systems, failure of which could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment shall not be directly connected to network switches hosting remotely connected systems, failure of which will not lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment, without network protocols disruption mechanisms (e.g. network diodes). • For more security, it is recommended to set up a Demilitarised Zone (DMZ), enabling communication between the protected and unprotected network without establishing a direct connection between them. • It is advised to establish a DMZ and cyber watch team to control the flows of the net to the ships (DMZ) as an example.	

Recommendations	Comments
Companies providing the VT Control system should manage the DMZ solution. • An Event Log Recorder (ELR) should be deployed, with a managing policy implemented. Remote access (e.g. 3G/4G) packets transport should rely on layer 3 protocols ensuring both identification, authentication and encryption (e.g. IPsec). All remote access events should be recorded for review in case of a disruption to an IT or OT system. Systems should be clearly defined, monitored and reviewed periodically. • All security equipment and physical equipment accesses should be properly configured and managed. Remote access (e.g. 3G/4G) packets transport should rely on layer 3 protocols ensuring both identification, authentication and encryption (e.g. IPsec). • A Cyber security policy should be deployed and implemented by the crew. Maintenance policy, third party management policy, training program and related procedures would be described in this policy. • A partial or full redundancy shall be ensured for all VT control system components. • The network flow should be properly managed. • Account and administration right should be properly managed (password policy, less privilege), in accordance with the deployed cyber security policy • A global architecture and network data flow should be presented to understand the network interconnections. • Ensure that the FV is always cyber compliant before and after coupling: decoupling operation. • The policy and security mechanisms used to manage the data quality shall be described focusing on the accuracy, completeness, reliability, relevance and timeliness.	

6.4 Conclusion

For both the VT vessels design and equipment and especially the VT control system, existing main technical compliance frameworks (ESTRIN and SOLAS) need to be modified/adapted according to the recommendations set out in this chapter. These recommendations are the result of expert opinion during safety and cyber security sessions and simulations/real-life test of the NOVIMAR VT control system. It is shown that they can be added to the existing structure of these regulations e.g. ESTRIN.

7 VT operation and navigation

7.1 General

Ensuring the safety and ease of traffic on waterways is also the determining factor for the VT and the necessary extensions of the existing Rules and Regulations.
In addition to the adaptation of the existing police Regulations, internal guidelines must also be drawn up, which shall contain the following VT-specific topics:

- Voyage information and voyage preparation
- VT operating limits
- VT forming by coupling/decoupling
- Navigational procedures in emergency situations

These contents are essential for the operation of a VT but are not to be included in the Regulations. Within the next sections, the proposals for the implementation/amendment of the Regulations and guidelines are explained in detail in:

- Section 7.2: VT navigation
- Section 7.3: Voyage information, voyage preparation and VT operating limits
- Section 7.4: VT forming by coupling/decoupling.

The modification/adaptation needed for the main technical compliance framework can be implemented e.g. as follows for the ESTRIN Regulations:

Chapter 32 Special provisions applicable to vessel train

Article 04 VT operation procedures

1. *General requirement*
2. *Voyage preparation*
3. *VT forming and coupling/decoupling.*

The modification/adaptation to VT navigation rules and emergency procedures can be implemented, e.g. as follows, for the **CEVNI Code** and thus forms the necessary template for implementation in national and international police Regulations:

Chapter 1 General provisions

Article 1.01 Meaning of certain terms

I Types of vessels

13 Lead vessel

14 Follower vessel

II Convoys

5 Vessel train

III Other terms

19 Vessel train length

20 Safe distance.

Chapter 3 Visual signals (marking) on vessel

III Special marking

Article 3.39 Additional marking for vessel trains.

Chapter 4 Sound signals; radiotelephony and navigation devices

Article 4.08 Additional provisions for vessel trains.

Chapter 6 Rules of the road

I General

Article 6.03 Vessel train: General rules

II Meeting, crossing and overtaking

Article 6.03bis Crossing vessel train

Article 6.06bis Meeting vessel train

Article 6.010bis Overtaking vessel train.

Annex 12 EMERGENCY PROCEDURES

I General

II IT infrastructure and VT systems failure

III Problem on one or several vessels of the vessel train.

7.2 VT navigation

The main police regulations shall be modified/adapted according to the recommendations set out in Table 5.

Table 5: Regulatory aspects of VT navigation

Recommendations	Comments
VT identification 1. VT vessels shall be marked by explicit distinguishing marks (day and night) in order to be easily identified as vessels being part of a train. Extension/length of the VT shall be emphasized by special marks to be adopted for LV and last FV. 2. VT vessels shall be equipped with AIS according to the local Regulations of the waters in which they are intended to operate and providing, at least, the following information: - Vessels belonging to the VT, VT length and speed - Type of vessels, loading conditions (draught), vessel speed and distance between vessels - Direction of travel - Leader of the VT (for communication). 3. VT shall be equipped with a horn producing a dedicated sound signal to inform the other vessels about its presence, e.g., in case of low visibility.	To be addressed by all relevant Police Regulations.
VT vessels safe distance 1. As a rule, the safe distance to be considered for any VT vessel shall be taken not less than the stopping distance determined according to the Regulation in force in the operating area.	To be addressed by all relevant Police Regulations.

<table>
<tr><th>Recommendations</th><th>Comments</th></tr>
<tr><td>This provision may be waived for vessels fitted with a bow thruster equipped with an interface for external control. In this case, a shorter distance can be adopted, depending on the vessel size, loading conditions and operating area, e.g, a safe distance of at least one vessel length shall be adopted for inland navigation vessels.
2. It shall be ensured that the VT control system keeps the safe distance between the vessels in VT in case of failure of Trackpilot VT on one FV.
3. High difference in manoeuvrability of VT vessels is to be avoided. Pushed convoys and side-by-side formation were not considered in the research.</td><td></td></tr>
<tr><td>Navigation rules
In principle, the VT should - at least in the initial phase of practical implementation - only perform the necessary navigational manoeuvres. An anticipatory and defensive behaviour of all vessels in the area of the VT contributes significantly to safety.
It is expected that other vessels in the area of the VT will show increased vigilance and take all opportunities to assist (course and/or speed changes) when encountering and overtaking. Clear communication with the Leader of the VT is mandatory.
1. FV bridge shall be manned at critical locations of voyage plan where gusty winds or strong currents can be expected, based on local climate or local situations.
2. FV bridge shall be manned in case of low visibility or heavy traffic.
3. In case of permanent deterioration of the GNSS reception, e.g., in the areas with steep slopes at the bank of the river, the VT shall be decoupled, and each vessel shall be sailed manually.
4. Overtaking other vessels with the VT - at low relative speed difference - is currently not recommended. Nevertheless, this decision, especially when overtaking slow vessels, is the responsibility of the LV operator, taking into account the boundary conditions (distance, etc.) and paying particular attention to the motion behaviour of the entire VT.
5. The following provisions shall be observed by vessels outside the train:
- Give right of way to VT and keep safe distance from the train, while encountering traffic.
- Call VT via VHF, describe planned manoeuvre and ask for right of way, if traffic cannot give right of way.
- While overtaking a VT, the vessel is responsible for overtaking procedure, the vessel keeps safe distance to train.
- Crossing between vessels in VT is clearly not recommended. However, a general prohibition of crossing is also not recommended, as especially for VTs with a large number of</td><td>To be addressed by all relevant Police Regulations.

(1)
The existing rules for ferries are still good. However, it</td></tr>
</table>

Recommendations	Comments
followers, crossing must remain permitted for ferries. However, the crossing procedure must then be safely possible, taking into account the ambient conditions, and must be announced in advance by radio. The responsibility for this lies with the skipper of the crossing vessel. (1)	remains to be seen whether crossing a VT is feasible in practice. At first glance, crossing a VT by a ferry should be prohibited as loss of control either in the VT or by the ferry could lead to unavoidable collision danger. There is a role for traffic management systems to regulate traffic flows and avoid ferries crossing VTs.

7.3 Voyage information, voyage preparation and VT operating limits

Table 6 contains central points for the operational running of a VT, of which voyage planning and the necessary information updates in particular should be regulated in internal guidelines. In the rest of the IWT, voyage planning is also not part of the Regulations. Other aspects, such as responsibilities and operational limits, are already part of the police Regulations and can be adapted and extended.

During active and fully coupled operation of the VT, the LV operator shall always be responsible for the entire VT. For example, paragraph 1.02 of the Rhine Police Regulations already regulates this in detail. It may be sufficient here to mention the specific case of the VT once.

Chapter 10 of the Rhine Police Regulations defines restrictions on navigation during high and low water. These Regulations continue to apply and should be defined in more detail for the VT within the framework of an internal guideline. However, specific Regulations depend on many factors (see Table 6) and empirical values from real operations are needed. Continuous recordings with a voyage data recorder can be helpful here.

Table 7 shows a draft checklist for information update, which could be used in vessel operations to make the necessary information and its temporal and local changes known on the VT's vessels.

Table 6: Regulatory aspects of voyage information, voyage preparation and VT operating limits

Recommendations	Comments
Operating limits The vessel train operating limits and capabilities shall be defined and considered when defining the voyage plan. The operating limits shall, at least, refer to the following parameters:	To be addressed by Police Regulations

<table>
<tr><th>Recommendations</th><th>Comments</th></tr>
<tr><td>- Level of automation of VT vessels
- Degree of control of VT vessels
- Applicable Rules and Regulations
- Traffic conditions
- VT length
- Maximum/nominal service speed
- Controllability of VT vessels
- Operating mode
- Situational awareness system characteristics
- Navigation system characteristics
- Communication system characteristics
- Control system characteristics

All operations for which a VT vessel has to be directly controlled or may be remotely operated shall be clearly defined.

When a VT is intended to contain vessels with significant difference in manoeuvring capabilities, it is the responsibility of the LV operator to sail the own vessel as if it was the slowest vessel in terms of manoeuvrability in the train. The following manoeuvring capabilities shall be provided when a vessel requests for coupling:
- Maximum rate of course change: This value describes the ability of a vessel to turn around bends
- Maximum acceleration
- Maximum speed
- Minimum power at which lateral control is still possible
- Maximum deceleration at minimum power
- Maximum deceleration at reversed power.
The values concerning longitudinal control shall then be used to adjust the settings of the speed control loop of the LV. In this way, the dynamics of the slowest vessel could be taken into account when accelerating or decelerating the VT.</td><td></td></tr>
<tr><td>Responsibilities
There shall be a responsible party defined at all times and in all circumstances for all operations of the vessel train. The following distributions of roles and responsibilities should be clearly defined and described in the operating limits:
- On board FVs, between automation systems and the FV operator
- On board LV, between automation systems and the operators
- Between the FV operator and the LV operators
- Task of LV operator to be included in operational procedure.</td><td>To be addressed by Police Regulations</td></tr>
</table>

Recommendations	Comments
Procedure for voyage information update 1. All voyage information (nautical publications, weather forecasts, etc...) shall be updated before each voyage planning and during the voyage. 2. All VT vessels shall be fitted with a connection to the corresponding information portals of the individual countries (internet link to RIS). 3. The implementation and regular updating of the voyage plan shall be carried out by the persons involved in the preparation of the voyage plan. The ultimate responsibility during the voyage in the VT lies with the LV operator. The preparatory work may be carried out by other responsible persons. 4. The checklist for the availability and status of sources that are used to monitor the meteorological and nautical status along the VT planned voyage is given in Tab 7. This checklist shall be used before departure and during the voyage on relevant parts. For instance, when a FV joins or leaves the VT, or just before (and sometimes after) critical parts of the voyage like locks, ports or any obstacles.	To be addressed by internal guidelines, ESTRIN and SOLAS There is no fundamental difference to today's practice. However, experience has shown quite clearly that many accidents or near-accidents are due to inadequate preparations when planning the journey. In the internal guidelines, voyage planning, its responsibility and, if necessary, the transfer of responsibility between several persons should play a prominent role. This contributes significantly to safety.
Voyage plan 1. The individual vessels characteristics shall be taken into account when defining the voyage plan. 2. Mixing vessels with very different manoeuvring capabilities and speeds in one vessel train shall be avoided, unless the effectiveness of the VT control system is proven. 3. The voyage plan shall be initially drawn up by the VT company, taking into account the current daily and hourly environmental conditions on the relevant stretches of water. After loading, the voyage plan shall be checked and validated on board by VT operators, taking into account the actual draught and the environmental conditions during the voyage (draught restrictions and bridge clearance heights). This voyage plan, verified for the individual vessel, is input for the coordination within the VT. Even before the final coordination in the VT, target values for draught and clearance height can be defined for all FVs, which shall not be exceeded under any circumstances. An exceeding of the target values would then already be noticeable. 4. Where the VT is intended to be operated on bendy waterways or through narrow passages, the accuracy of the track control system on each vessel shall be analysed to determine the upper limit of the track control accuracy for the waterway considered. Vessels fitted with a track control showing poor accuracy shall not be permitted to join the	To be addressed by internal guidelines ESTRIN and SOLAS

Recommendations	Comments
train. The required accuracy level for a river or river stretch shall be proved by a certificate.	
Voyage Data Recorder (VDR) It is recommended to install a VDR on vessels participating in a vessel train both for insurance in case of an accident and for data analysis of VT operation. This VDR could be combined with data monitoring on critical shipboard systems for predictive maintenance purposes to increase system reliability and to reduce the workload for a reduced manned FV. The data recorder should be used to record at least the necessary parameters for the VT system (propeller rotation rate, rudder angle, distance to the vessel in front, etc.), as these are necessary for the control anyway and are therefore available. Any additional data (GPS, engine(s), etc.) can and should usefully supplement the data set.	To be addressed by ESTRIN and Police Regulations. For sea-going vessels VDRs are mandatory according to SOLAS for all passenger vessels and for all other vessels above 3000 gross tonnage, if constructed after 01-07-2002.

Table 7: Checklist for information update

Checklist for the availability and status of sources that are used to monitor the meteorological and nautical status along the Vessel Train planned voyage.				
Lead Vessel		**Following Vessels**		
Name		1	Name	
Number			Skipper	
Skipper			Place of joinging VT	
2nd Skipper			Place of leaving VT	
Other vital staff		2	Name	
Voyage Start Time & Date			Skipper	
Time & date reaching critical location			Place of joinging VT	
Time & date reaching critical location			Place of leaving VT	
Time & date reaching critical location		3	Name	
Time & date reaching critical location			Skipper	
Time & date reaching critical location			Place of joinging VT	
Time & date reaching critical location			Place of leaving VT	
Voyage End Time & Date		4	Name	
Voyage Start Location			Skipper	
Critical location			Place of joinging VT	
Critical location			Place of leaving VT	
Critical location		5	Name	
Critical location			Skipper	
Critical location			Place of joinging VT	
Critical location			Place of leaving VT	
Critical location		6	Name	
Critical location			Skipper	
Critical location			Place of joinging VT	
Voyage End Location			Place of leaving VT	
Weather Situation		**Now**	**When Reached**	
Weather at Start	Status			
	Source used			
	Source updated?			
Weather at Critical location	Status			
	Source used			
	Source updated?			
Weather at Critical location	Status			
	Source used			
	Source updated?			
Weather at Endpoint	Status			
	Source used			
	Source updated?			
Nautical Situation		**Now**	**When Reached**	
Situation at Start	Water depth			
	Current			
	Source used			
	Source updated?			
Situation at Critical location	Water depth			
	Current			
	Source used			
	Source updated?			
Situation at Critical location	Water depth			
	Current			
	Source used			
	Source updated?			
Situation at Endpoint	Water depth			
	Current			
	Source used			
	Source updated?			

7.4 VT forming by coupling/decoupling

The VT forming procedure includes:

- Preparation of the LV for its task
- Preparation of the FV for joining the VT
- Positioning the FV for joining the VT formation and activation of the VT control system
- Electronically coupling with transferring command and monitoring to LV.

VT operation procedures and relevant regulatory framework need to be modified/adapted according to the recommendations set out in this section. The formal procedures related to coupling/decoupling (joining/leaving), defined in Annex A (section 13.1), shall be implemented.

Before taking control of an FV, LV operators shall first ensure that they have an accurate situational awareness and that all devices to control and monitor the vessel remotely are available and operational. During coupling, operators on the LV and on the FVs, are involved and follow the procedure defined in Annex A (section 13.1). The end of the coupling procedure defines the responsibility transfer for navigating the FV to the LV operator.
The operators shall be supported by the system during coupling by transmitting VT-specific AIS ASM messages.
To ensure a safe coupling manoeuvre, the VT control system shall define a window of speed and distance inside of which coupling is possible. This window shall be displayed on the FV's HMI. The coupling can be initiated only if the FV is inside this window.

7.5 Navigational procedures in emergency situations

The emergency procedures set out in Tab 8 shall be implemented as internal guidelines.

The behaviour in emergency situations is already sufficiently documented by the Police Regulations in general form (for example in paragraphs 1.04 to 1.06 of the Rhine Police Regulations).

Table 8: Emergency procedures

Recommendations	Comments
IT infrastructure and VT systems failure In case of IT infrastructure or VT systems failure, the following emergency procedures apply. 1. Emergency alarm is triggered from LV The emergency alarm state is transferred to all FVs. On the FVs an alarming system triggers and the FV operators are called on the bridge. 2. Emergency alarm is triggered from FV In case a local system triggers an emergency alarm (e.g. fire or local manual trigger) the alarm is transferred to all vessels in the train. On all FVs and the LV an alarming system triggers and the VT operators are called on the bridge. 3. Connectivity between the vessels is broken or disturbed All vessels supervise watchdog signals from other partners and trigger the local emergency alarm if the watchdog triggers. This results in an	

Recommendations	Comments
alarm on all vessels even though the vessels cannot communicate with each other anymore. 4. Urgency call The LV operator can use the urgency call to request a FV operator on the bridge. The urgency call does not trigger a VT wide emergency and has no influence on the control of the vessel.	
VT specific alerting system VT specific alerting system shall be available. - An alert function shall be provided to allow a FV or LV operator to wake up the crew on the other vessels in case of hazardous situation. The display module shall provide means to acknowledge alerts by human interaction. - Automatic alerting system shall be available to allow warning the crew of the own vessel in case of, e.g.: • Failure of the communication link to the other vessels • Error in system status of one of the predecessor vessels or error in the own system status • For the LV when an imminent collision of one of the FVs is detected.	
Problem on one or several vessels of the vessel train 1. General philosophy The philosophy in case of problems on one or more vessels in the VT (i.e. how to address the problem and how to proceed with the journey) should be risk-based. The hazards which imply higher risks may require stopping of the complete vessel train (e.g. man overboard, fire or flooding of vessels). Conversely, in case of the hazards with lower risks (e.g. a malfunction of a system or a device on one of the followers which would not progress to a serious accident), it would be possible to reconfigure the vessel train, so that the VT may continue the journey while the follower is being fixed. In some cases, however, it may be possible to fix the problem on one of the units while the VT is en route. The possibility of repairing malfunctions on board depends heavily on the number of the remaining crew. A crew transfer from another vessel using the ship's boat should only be an exception. 2. Procedure applicable in port	

<table>
<tr><th>Recommendations</th><th>Comments</th></tr>
<tr><td>In the event of malfunctions on one or more vessels, conditional waiting times may be expected. Regardless of the vessel on which the problem exists, if all planned VT vessels are still in port, a distinction shall be made between whether a short-term solution/repair of the problem is expected or a longer-term shutdown is anticipated. In case of a short-term problem solution, the VT can start with a corresponding delay, otherwise as planned.
- Serious problems on the LV, which cannot be solved in the short-term. In this case, the planned FVs have to start the voyage themselves with corresponding availability of the crew and possibly resulting delay. If a replacement LV is available, the journey can be started with a delay in the VT.
- Serious problems on a FV, which cannot be solved in the short-term. In this case, the VT may continue its voyage without the vessel concerned. The respective vessel can later continue the voyage alone with the appropriate crew or, if necessary, join another VT.

3. Procedure applicable during navigation
Irrespective of the solution, the responsible district control center (VTS) and the traffic in the vicinity is always informed in this case. Furthermore, a quick agreement of the procedure (which vessel receives which task) among the involved vessels is advantageous. Especially in case of several FVs, an independent continuation of the voyage is preferable to stopping and anchoring. In addition, external vessels can also be included if they have a better starting position for assistance.
- Problem on the LV, vessel is stopped and anchored. One of the FVs is selected to go alongside and tow the LV to the next port. The crew of the LV must organise the handling of the lines.
- Problem on one of the FVs, vessel is stopped and anchored. The LV goes alongside and tow the FV to the next port. The crew of the LV must organize the handling of the lines.
If it is justifiable to secure the damaged vessel without the use of anchors, this should be done as a matter of course. Especially the release of the stern anchor is not easy and requires assistance from a second vessel anyway.
It shall be possible to decouple a FV from VT in case of specific emergency situations, to regain the vessel control.</td><td></td></tr>
</table>

7.6 Conclusion

Ensuring the safety and ease of traffic on waterways is also the determining factor for the VT and the necessary extensions of the existing Rules and Regulations. For this, recommendations are formulated and structured in accordance with CEVNI Code. They concern specifics on VT operation procedures, special marking, sound signals, rules of the road and emergency procedures.

In addition to the adaptation of the existing Police Regulations, internal guidelines must also be drawn up, which shall contain the following VT-specific topics: voyage information and voyage preparation, VT operating limits, VT forming by coupling/decoupling, and navigational procedures in emergency situations. These contents are essential for the operation of a VT but are not to be included in the Regulations.

8 VT-related human element

8.1 General

To overcome the barriers to the implementation of the VT concept in the waterborne transportation system identified in section 4.2, the regulatory framework defining the crew member minimum number, qualification, training, and organisation of the working time, needs to be modified/adapted.
The modification/adaptation to VT-related human element regulatory framework can be implemented, e.g. as follows, for *the Regulations for the Rhine Navigation Personnel (**RPN**):*

Part I General provisions

Chapter 1 General provisions Applicable to …….

Article 1.01 Definitions

Types of vessels

Lead vessel

Follower vessel

Assemblies of craft

Vessel train

Personnel

Lead vessel operator

Follower vessel operator

Other terms

Vessel train length.

Part II Crew-related requirements

Chapter 3 Provisions applicable to all types of vessels

Section1 Crew member qualification Special marking

Article 3.02 Requirements

9 Vessel train operators

Section3 Minimum crew onboard

Article 3.14 Vessels' equipment

1.3 Standard S3

Article 3.24 Minimum crew for VT vessels

Part IV Requirements regarding VT operator' certificates

Chapter 10 General provisions applicable to Part IV

Article 10.01 Scope of application

Article 10.02 Mandatory VT operator's certificate

Article 10.03 VT control system certificate

Article 10.04 Types of VT operator's certificates

Chapter 11 Provisions regarding VT operator's certificate

Section 1 Conditions for obtaining a Rhine VT operator's certificate

Section 2 Admission and examination procedures

Section 3 Examination for physical and mental fitness

Section 4 Suspension and withdrawal

Chapter 12 VT operator's certificate

Chapter 13 Transitional provisions

Table 9 defines recommendations with respect to human element.

Table 9: VT-related human element

Recommendations	Comments
Competence and skills The following recommendations shall be considered when defining the required VT operator competence and skills: - The VT operation entails more and complex tasks compared with a conventional vessel. Instead of controlling one vessel, the LV operator gains navigational responsibility for multiple vessels and needs to control and monitor the VT via the VT control system. - Achieving a high level of situational awareness and a better understanding of the VT control system under different operational conditions, are critical to the ability of the operator to supervise the VT effectively and taking decisions adequately. - Understanding of the control system also includes understanding when the performance is degraded and learning the limitations of the system. The operator needs to know the complexities of the intended operating areas and be able to estimate the sailing behaviour of different vessels correctly. Following skills shall be required for the VT operator - VT control system handling competences - VTS competences - competence to prepare a voyage plan and to perform tasks as prescribed in "checklists" - Minimum initial skipper experience	To be addressed by all relevant human element-related Regulations listed in Table 1
Crew number 1. Navigation task consists of: - Vessel command, including steering, adjusting speed and other related wheelhouse activities - Monitoring and responding to emergencies, maneuvers, etc... 2. Navigation task - At least one LV operator shall be on board the LV - At least one FV operator shall be on board each FV - The number of crew members depends on the VT length as well as on the waterway traffic and physical characteristics (bends, width, etc.) - Required crew number for LV per shift • One LV operator if the number of FVs does not exceed 2 • Two LV operators if the number of FVs exceeds 2. - Required crew number for FVs per shift (1) One FV operator shall be on board each FV. Provisions shall be made to have the FV wheelhouse attended when required, in accordance with the voyage plan.	To be addressed by all relevant human element-related Regulations listed in Table 1 (1) Provided that all requirements and procedures for VT safe operation are implemented, there is no need for continuous human attendance in the FV’s wheelhouse for

Recommendations	Comments
3. Required crew number for other tasks The number of required minimum crew members depends on implemented technical and/or organisational solutions, e.g. automated operations such as those related to mooring / unmooring, anchoring.	monitoring functions during normal operations. In urgent conditions human attendance is needed in the FV's wheelhouse for monitoring functions to reduce the probability of certain hazards to occur. Most of these situations can be predicted and should be part of the voyage plan, identifying beforehand the need for human attendance.
Organisation of working time - VT dedicated equipment standard S3 shall be defined. S3 equipment standard shall correspond to: • Navigation level of automation: CCNR level 3 • Machinery automation level: Bureau Veritas additional class notation AUT-UMS or equivalent - The number of crew members also depends on the organisation of working hours and shift operations. In particular, the maximum possible shift length for LV operators needs to be defined. - The number of crew members shall be defined depending on the operating mode and the equipment standard. - The handling of stand-by times and their recognition as rest periods shall be specially considered.	To be addressed by all relevant human element-related Regulations listed in Table 1
Working environment/conditions - The ergonomics of monitoring systems (HMI design) shall take into account the human vigilance that could be reduced during extended periods of remote control or complexity of the interface when several vessels / FVs which are in different situations are managed by only one operator. - The human-machine interaction shall fit to the needs, abilities and constraints of the human operator, to create an optimal collaboration between the machine and human operator, which in return will create a better system performance. - Attention allocation and fatigue of the crew LV operator shall be monitored and the operator attention allocation activated during the voyage.	To be addressed by all relevant human element-related Regulations listed in Table 1
Training specifications The simulation tests showed that special focus needs to be put on the training of VT operators as the operation of a VT differs significantly	To be addressed by all relevant human element-

<table>
<tr><th>Recommendations</th><th>Comments</th></tr>
<tr><td>from the operation of a single nautical unit.
Implementation of the VT concept entails availability of training and quality procedure to ensure that the operators are aware of:
- The operating limits of the VT
- The purpose and the different phases of the planned operations
- The level of automation and the degree of control of each phase
- The effect of automation and the working of the different control options in each phase of the operation
- The main risks of the VT systems
- The means of control and alert in case of failure or damage
- The available fail-safe sequences.

The VT operator shall be able to use and, depending on the organisational solution implemented for maintenance, to maintain the different VT systems and support tools.

The VT operator shall be able to effectively operate the VT and ensuring safe navigation for the whole VT. A VT operator dedicated training program shall include, at least, the following competences.
1. Ability to effectively couple and decouple vessels using the VT control system by adequately assessing the ability to couple safely, taking into account variables such as speed, distances between vessels, current speed and direction, expected manoeuvring behaviour of the vessel and environmental conditions.
2. Active and clear communication with vessels within the VT and outside the train about the VT status and all navigational intentions, especially for evading manoeuvres.
3. Adequate keeping track of internal VT systems status to:
- Sustain situational awareness of the status of the system, such as the system settings as distance setpoint and selected control mode
- Detect any system (mode) changes
- Understand the consequences of the system (mode) changes for the VT and the navigational environment.
4. Adequate keeping track of the navigational status of the VT, in particular any offset of a FV to the distance setpoint, engine use capacity and active prediction and assessment of the track for each FV.
5. Monitoring of environment, including detection and anticipation of environmental changes and surrounding traffic such as targets, waterway characteristics or weather conditions:
- Adequate detection and identification of forthcoming situations that may require FVs attention</td><td>related Regulations listed in Table 1</td></tr>
</table>

Recommendations	Comments
- Detection and monitoring of all targets and obstacles that could pose a navigational threat to the VT - Detection of waterway characteristics, such as water depth, current, bridges, allowing to assess whether adjustments to the VT track are required or attention from the FV's is appropriate. 6. Control and maneuver of the VT: - Adequate set of the speed and track that can be achieved by every FV - Communication with FV's operator in time, for operational conditions that may require intervention - Adequate response to identified targets or obstacles by maneuvering the VT safely without creating or enlarging navigational risks - Provision of clear instructions to FV's in emergencies. 7. LV operators shall be trained to understand: - Differences in FV characteristics (vessel class, maneuvering capability, speed, length, breadth, draught, loading conditions...) - Influence of VT operation on the crew of vessels outside the train. 8. Training of VT operators shall include cyber security and safety aspects, namely: - Understanding and strict respect of cyber policy - Securing information and protecting privacy - Recognising and avoiding cyber threats. A high level of reliability of control systems is required to ensure, at least, a VT operation safety level equal to that of a conventional vessel. Persons in charge of VT control system maintenance should be trained to aquire skills and knowledge enabling them to diagnose and repair the control system faults. The training will include, e.g.: - Monitors and displays - Power supplies: ratings, energy saving function, typical faults, etc… - Electro-static discharge and safety precautions - Fault diagnosis - Component and module substitution and testing techniques.	

8.2 Conclusion

The regulatory framework defining the crew member minimum number, qualification, training, and organisation of the working time, needs to be modified/adapted to facilitate the introduction of the VT. The operation of LV and FV need additional skills, training and qualification in reference to single vessel operation.

9 INSURANCE AND LIABILITY

9.1 General

In this chapter the Vessel Train concept is looked at from a liability point of view and the needs for insurance. Firstly, focus is put on two NOVIMAR business models and the actors in these models. Then the focus is shifted towards the actual operation of a VT. Having this insight an overview is given of foreseen types of insurances. Finally, conclusions and recommendations are formulated. For this chapter a Dutch insurance company was consulted.

9.2 Vessel train concept

9.2.1 Business model for VT operations

Within NOVIMAR two business models (BM) are exploited:

- In BM3, one shipping company owns the whole fleet. Both the LV and the FV's are property of one and the same vessel owner.
- BM4 is a virtual service provider (digital platform) bringing together an LV and FV's, most probably each having a different owner.

For BM3, where all VT vessels are owned by the same actor, the maximum liability for the vessel train as a whole could become so high that it is uninsurable. This is caused by the mechanism of totalising the individual limits of liability. However, it is observed that in present day business models "a whole fleet" is often accommodated in a structure of several private companies in a holding. For this reason, the ownership structure is an important parameter for insuring BM3.

Business Models where multiple vessels from different owners take part in the VT (BM4) are considered to be complex to insure, however no "no-go" obstacles are foreseen. The aspect of cyber security was identified as a point of concern.

> *Here it should be noted that BM4 is "unexplored territory " for an insurer. Insurance is namely based on law and jurisdiction combined with risk analyses based on probability. Since both are lacking, we believe that much more water will have to flow through the Rhine before an insurance solution can be put in place for BM4. Regardless, the liabilities with regards to people, properties and the environment are the same, so it should not be rocket science"*
> *(From interview a Dutch insurance company, 2020).*

Based on a chosen Business Model, insurance companies need to know which actors are involved in order to define the needed insurance type. This is discussed in the following.

9.2.2 Actors, responsibilities and roles

To insure a Business Model actors, their responsibilities and their roles need to be very precisely and clearly defined.

For a better understanding of this requirement NOVIMAR's actors (WP2) were presented and discussed to understand how an insurance company would interpret these. This led to suggestions for adjustments for the actor Cargo Owner (CO) and Freight Forwarder (FF). Further it was suggested to add the actor

Stevedore. For the purpose of this investigation the roles were adjusted accordingly forming the base for the identification of insurance types per actor in section 9.4.

- Vessel Train Organiser (VTO) is either a physical person (third-party logistics service provider, shipping company) or a virtual service provider (VSP) (i.e. a platform). The VTO is responsible for the composition and management of a Vessel Train:
    - Defining and advertising/announcing VT transport schedules including assembly points.
    - Assigning LV's to the transport schedules.
    - Identifying FV's that will make use of a certain transport schedule.
    - Organising the (dis)assembling of the VT during its voyage.
- Leader Vessel Owner (LVO) is a shipping company owning and operating a LV. This LV is either a dedicated LV or a cargo ship equipped and manned to act as a LV. The LVO is responsible for:
    - Providing one or more LV's that are equipped with certified and well maintained systems needed to lead a VT.
    - Providing a qualified and well trained LV crew responsible to lead the VT.
    - Executing the transport of the VT in accordance with the transport schedule.
- Follower Vessel Owner (FVO) is a shipping company owning and operating a FV. A FV can either be a specially designed vessel or an existing vessel retrofitted to meet the requirements for remote control from a LV. The FVO is responsible for:
    - Providing a FV that is equipped with certified and well maintained systems needed to operate as FV in a VT.
    - Providing a qualified and well trained FV crew.
    - Signing up for a VT based on VTO advertised/announced VT transport schedules.
    - Ensuring the timely arrival at the VT assembly point in accordance with the transport schedule.
- Cargo owner (CO) is a customer needing a waterborne transport service to ship cargo from a departure point to an arrival point. Originally, the CO was intended to be responsible for the chartering of a following vessel for its cargo. However the insurance company suggests to move this responsibility since it was deemed risky to place it with the CO. The CO is deemed to opt for the most economical option, and this might not always be a ship & crew that are on a standard of safety and skill needed for VT operations. When following this suggestion the CO would be responsible for paying the FF for the service of chartering vessels to transport the cargo.
- Freight Forwarder (FF) is an agent handling requests for transportation from cargo owners. This role might also be part of the Vessel Train Organiser (VTO), but is meant to take the responsibility of contracting an FVO away from the CO. Since the CO is often preoccupied with costs, time and operational smoothness, he might overlook the important aspect of safety. LVO's and FVO's need specially trained crew, an ensured high level of maintenance, certificates etcetera to operate in a VT. This will come at a high cost, and the CO will always try to get his cargo moved at the lowest cost. This conflict, especially since a CO has no specific knowledge of vessels (let alone a VT), must be avoided. Therefore, the FF would be in charge of chartering a suitable (safety approved) vessel for the freight transportation. The FFs responsibilities will be laid down in a charter party or booking contract, which can range from 0% to 100% regarding liability (free form of contract). If this role is taken up by the VTO, this changes the VTO role significantly. It was suggested to make the FF responsible for contracting (a part of) an LVO/FVO for the transport of his customer's cargo.
- Cargo Consolidation provider is the function at a seaport or inland-port responsible for the pre-sorting of cargo ensuring that cargo intended for the same destination will be loaded into one vessel. In that way there is no need for this vessel to stop at multiple ports. This will reduce waiting

time and as a result the whole transportation time. It is important to keep in mind that some cargo is hazardous, and possibly not suitable to be consolidated. The CCp's services are not limited to vessels in a Vessel Train.

- Stevedore is the party responsible for the correct physical loading of cargo on board of the vessel. Stevedores are chartered, and the charterer is responsible for damage flowing from actions or failures by the stevedore. The stevedoring role and responsibility can be taken on by specialists, a terminal or in some cases even the respective vessel. Something to keep in mind is the need for a strict division of responsibilities and the agreement on 'if this, then that' cases for what to do when damage occurs. In current IWT practises, this is not always strictly agreed upon.
- LV/FV operator is a person responsible for:
    - The loading/offloading of cargo, the planning and transit from port to port, and the execution of standard/emergency procedures.
    - Maintenance condition of the vessel. This consists of periodic routine maintenance performed by the vessel's crew where needed supported by the owner's maintenance organisation and/or contracted suppliers.
    - Stability. The vessel must be in accordance with stability requirements.
    - Stowing of cargo. Cargo must be stowed in accordance with stability and safety requirements.
    - Certificates. All required certificates are available and valid.
    - Crew. Crew is certified and trained for VT operations.
    - Emergency procedures trained. Individual vessels have prepared procedures in place for emergency situations.
- Public sector is the part of the economy composed of both public services and public enterprises. Relevant for VT operations are port authorities, waterway authorities, regulators and policy makers.
- Society are the people and their representatives living and working in the areas where the Vessel Train is expected to operate. Societies opinion is important, but in most cases society is represented by the public sector.

In addition to above identified roles it was identified that the manufacturer of the VT control and monitoring system is an important enabler of Vessel Train operations. For this reason the liability position of this actor was discussed.

9.2.3 Manufacturer of VT control system

The VT control and monitoring system is integrated with the vessel's navigation-, communication-, propulsion- and steering system. It forms the technical backbone for the VT operations. Captains of LV and FV's thus have to rely on this system during the transit on the waterways as the technology is there to reduce human intervention, especially on the FV's. This aspect was discussed and it was observed that most producers of similar products (and the control system is a product in that sense), have guarantees and/or terms & conditions.

Usually, these are very clear about where the responsibility of the manufacturer ends. In most cases, a duty to repair the system would be included, but the costs of any accidents/failures flowing from a product failure will be explicitly excluded. Insurance solutions need to be found for these gaps in liability, but this is unthreaded ground for most insurers so an off the shelves product should not be expected.

Where above discussion focusses on the organisation in support of VT operations, in the following the operational activities within the VT are discussed and viewed from an insurance point of view.

9.3 Hierarchy of responsibilities during Vessel Train Operations

The Vessel Train must be seen as a system consisting of a lead vessel and one or more follower vessels. The composition of the VT and its mission is pre-planned by the VT organiser. The captain of the LV is then tasked to perform this mission. For this he will prepare a voyage plan, for which he receives latest status updates from the participating FV's. After sharing the voyage plan between VT participants, the LV will start the joining (coupling) procedure. This procedure will lead to the forming of the VT, a row of vessels following each other with a mutual safe spacing. The LV will be the most forward vessel.

When the VT is formed the VT will get underway heading towards its destination. During this transit the FV's are remotely operated from the LV. No navigational tasks are performed on the FV's, thus no human attendance is required in the wheelhouse. Under normal circumstances this situation remains until arrival at destination, where the VT is disconnected during the leaving procedure. For this the wheelhouse of each FV is manned.

An important aspect of the voyage planning is the identification of locations along the route where manoeuvring the VT is expected to be difficult as a result of e.g. heavy current, wind effects or heavy traffic. The captain of the LV will instruct the FV's for these locations to ensure human attendance in the wheelhouse for safety purpose.

Unforeseen situations need to be handled as they come. In general situations that do not affect the VT operation should be handled on the vessel where the situation occurs. Strictly speaking there is no need to inform the LV.

Situations that do affect the operation of the vessel train need a joined response, where combined actions from multiple actors are needed. The LV will initiate emergency procedures for the VT as a whole, whilst the FV in distress will try to deal with the situation e.g. by performing an emergency decoupling procedure steering the FV to a safe situation.

When zooming into these responsibilities the picture used for discussion with the insurance company is as follows:

- Preconditional responsibilities. In order to safely participate in a Vessel Train each captain (LV, FV) is responsible for the status and organisation on board of his vessel. This concerns aspects like:
    - Maintenance status of vessel and equipment.
    - vessel's stability.
    - Stowing of cargo.
    - Certificates valid and available on board.
    - Crew certified and trained for VT operations.
    - Definition of emergency responses to shipboard deviations from normal.
- VT responsibilities LV
    - Voyage planning (update based on actual situation on track and FV's input).
    - In charge of joining procedure (coupling).
    - Executing the voyage plan i.e. leading the VT from A to B.
    - In charge of departing procedure (decoupling).
    - In charge of VT response to emergencies or needed deviations from plan.

    - Emergency response to shipboard deviations not affecting the VT operation.
- VT responsibilities FV
    - Providing accurate input for voyage plan.
    - Performing joining procedure under supervision of LV (coupling).
    - Checking correct functioning of VT control system after coupling.
    - Attending wheelhouse in accordance with voyage plan or on instruction of LV.
    - Performing the departing procedure (decoupling).
    - Executing emergency response to situations affecting the VT operation
    - Emergency response to shipboard deviations from normal not affecting the VT operation.

Overviewing these operations from an insurance point of view, it is vital that a clear division of responsibility as shown in above example has been agreed on beforehand. In addition the need for hierarchy when multiple actors should act on the same time (e.g. during an emergency) during the actual VT operation is paramount. For this it is advised that the VT contract should make absolutely clear who is responsible for what. There should be a responsibility for the LV and a due diligence requirement for the FV.

In addition from an insurance point of view it needs to be very clear at what moment a vessel is within a VT (connected) or when it is outside the VT (disconnected). Having this insight insurance issues can be pinpointed at the actual mode of operation of the vessel and thus where liabilities lay. To support this a Voyage Data Recorder is highly recommended. Obviously this recorder needs to identify the moment of coupling and decoupling. It is thereby advised to explore the possibility to insure any vessel meant to join/leave the VT to be part of this system, ensuring that the coupling/decoupling procedure is also covered.

As shown above many actors play a role in the preparation and execution of the VT operation. As incidents/accidents often are a result of a chain of events each actor could be its cause. E.g. an error made by the VTO may not be noticed by the LV captain when updating the voyage plan and may lead to an incident during the VT transit from A to B.

However assuming that actors, roles, responsibilities etc. are well defined and outcomes of risk analyses to counter identified hazards have been put in place, there is a need to insure the residual risks. This must be done for individual actors and for the actual VT operation. This is discussed in the following.

9.4 Insuring actors and the actual VT operation

Focussing on the actors, Table 10 shows the required insurance type. It is thereby noted that all actors need an Error & Omission cover (E&O). The identified insurance types are:

- Error & Omission cover (E&O).
- Cargo Insurance.
- Charterer's Liability (CL), which is based on the liabilities that the hirer of a vessel may have towards the owners of the vessel. This depends on the contract between owners and Charterers (VTO).
- Protection & Indemnity (P&I), covering the legal liabilities that owners have towards people, properties and the environment.
- Hull and Machinery (H&M), covering any damage or loss to the owners' vessel or equipment.

Table 10: Insurance overview

Actor	Insurance type	Remark
Vessel Train Organizer – physical person	E&O	In the event this actor also becomes the actor who hires a vessel, he also needs charterers liability.
Vessel Train Organiser – virtual service provider	E&O	In the event this actor also becomes the actor who hires a vessel, he also needs charterers liability.
Leader Vessel Owner	P&I, H&M	
Follower Vessel Owner	P&I, H&M	
Cargo Owner	Cargo insurance	
Freight Forwarder		
Cargo consolidation provider	E&O, professional liability insurance, or product liability	Depending on exact role and responsibility
Stevedore	-	Stevedore faults are usually covered by the insurance of the actor hiring the stevedore.
Captain leader vessel	P&I	Already taken care of under P&I for negligence
Captain Follower vessel	P&I	Already taken care of under P&I for negligence

Actor	Insurance type	Remark
Public sector	-	
Manufacturer of VT Control system	Product liability will probably cover very little so additional insurance recommended	

For insuring the actual VT operation two methods have been identified: Fault-Based versus Contractual Liability.

Normally, most shipping contracts are 'fault based', meaning that parties take on responsibilities and if something goes wrong, surveyors determine who is at fault. The party at fault will receive claims.

In a VT, which has many different acting parties, this might be very hard to work with. Therefore, a solution in use at wind farms at sea can be an example. Here, a system of 'contractual liability' has been developed, meaning that parties agree beforehand who is responsible for what, regardless of being at fault or not. This could then mean that actor one damages a vessel belonging to actor two, and (even though actor one was at fault) actor two has to cover the bill since this was agreed upon beforehand. This principle could be further explored taking into account present day experiences with a so called TOWCON contract.

Based on the insights discussed before, the following conclusions and recommendations have been formulated.

9.5 Conclusions and recommendations

9.5.1 Conclusions

The conclusions are:

- In busines models where all VT vessels are owned by the same actor, the maximum liability for the Vessel Train as a whole could become so high that it is uninsurable. However, it is observed that in present day business models "a whole fleet" is often accommodated in a structure of several private companies in a holding. For this reason the ownership structure is an important parameter for insuring this business model.

- Business models where multiple vessels from different owners take part in the VT are more complex to insure, however no “no-go” obstacles are foreseen.
- For the insurance companies it must be very clear which actors are involved in the Business Model at hand. Roles and responsibilities need to be very precise and clear defined in order to assess the situation and to come up with a suitable insurance offer per actor.
- With regard to the VT control and monitoring system, manufacturers are usually very clear about where the responsibility of the manufacturer ends. In most cases, a duty to repair the system would be included, but the costs of any accidents/failures flowing from a product failure will be explicitly excluded. Insurance solutions need to be found for these gaps in liability, but this is unthreaded ground for most insurers so an off the shelves product should not be expected.
- For the actual VT operation it is vital that a clear division of responsibility has been agreed on beforehand. In addition there is the need for hierarchy when multiple actors should act on the same time (e.g. during an emergency). For this it is advised that the VT contract should make absolutely clear who is responsible for what. There should be a responsibility for the LV and a due diligence requirement for the FV.
- In addition from an insurance point of view it needs to be very clear at what moment a vessel is within a VT (connected) or when it is outside the VT (disconnected). Having this insight, insurance issues can be pinpointed at the actual mode of operation of the vessel and thus where liabilities lay. To support this a Voyage Data Recorder is highly recommended. This recorder needs to be able to identify the moment of coupling and decoupling.
- It remains the question how far insurance companies can go in insuring vessels that operate as FV in a VT, and thus give up part of their responsibilities.
- The virtual platform brings cyber security risks. Currently, all damage flowing from a cyber-attack is excluded for vessel insurance. To insure this cyber security measures put in place by the various actors need to be discussed with insurers to prevent insurance costs to rise sky high.
- For insuring the actual VT operation two methods have been identified:
    - Fault Based versus Contractual Liability, meaning that parties take on responsibilities and if something goes wrong, surveyors determine who is at fault. The party at fault will receive claims.
    - A system of ‘contractual liability’, meaning that parties agree beforehand who is responsible for what, regardless of being at fault or not. This could then mean that someone damages an owners vessel, and (even though that someone was at fault) the owners has to cover the bill.

9.5.2 Recommendations

Recommendations for the business developers are:

- Define the business model in such a way that actors, roles and responsibilities are unambiguous and have no overlap with each other. Ensure that during the actual VT operation a hierarchy is put in place in support of the LV captain ensuring clear command and control within the VT. By doing this for each actor, standard insurance types can be identified.
- Insure actual VT operations based on a system of ‘contractual liability’, meaning that parties agree beforehand who is responsible for what, regardless of being at fault or not.
- With regard to the VT control and monitoring system, discuss with insurance companies solutions for gaps in manufacturers liability.

- Ensure that cyber security measures are developed, put in place and proven in order to prevent sky high insurance fees or to face a situation that no one wants to insure this aspect.
- Equip vessels with a voyage data recorder to pinpoint the actual mode of operation of the vessel and to pinpoint where liabilities lay.

Recommendations for insurance companies are:

- Explore the system 'contractual liability', meaning that parties agree beforehand who is responsible for what, regardless of being at fault or not.
- Explore the requirements for cyber security measures needed to insure remote controlled vessels.
- Explore liability aspects of technical systems needed for remote controlled vessel operations.

10 RECOMMENDATION FOR VT OPERATION APPROVAL

10.1 General

From the safety assessment point of view, a VT represents a complex system which should attain a sufficient level of safety, while each of its components should conform with the appropriate safety requirements as well. Introduction of new Rules and Regulations adapted to the VT concept should be accompanied by an appropriate procedure for the VT operation approval.

The procedure for VT operation approval defined in this chapter is to be implemented at two levels.

- Approval of the VT operation by the competent Authority/Administration shall be carried out according to the procedure described in section 10.2.
- Check and verification to be performed by the VT company whenever a VT is formed, to be carried out according to 10.3.

10.2 Approval procedure to be implemented by Administration/Authority

10.2.1 Request for approval

The request for VT operation approval is to be submitted to the Administration/Authority by the VT company and/or the vessel owner, depending on the business model. The following business models are considered:

- The VT company is the owner of the whole VT fleet – BM3
- The VT company operates a VT made of multiple vessels from different owners – BM4.

The request should define at least the boundaries related to the VT configuration and operational aspects and the specification of the business model.

10.2.2 Documents to be submitted

The particulars and documents related to the following are to be submitted for approval:

- VT and VT objects: VT configuration, vessels characteristics, vessels design and equipment, VT systems
- operation environment
- manning and work organisation.

The particulars and documents to be submitted shall contain all details required to verify the compliance of the VT at both level of each system/vessel and level of the VT considered as a single nautical unit.

10.2.3 Examination of the suitability for VT operation

As a prerequisite, the VT vessels shall comply with all Regulations in force in the operating area.

The examination of the VT suitability for operation shall be carried out according to the process shown in Figure 4, using the checklist in Annex B (section13.2). The process includes:

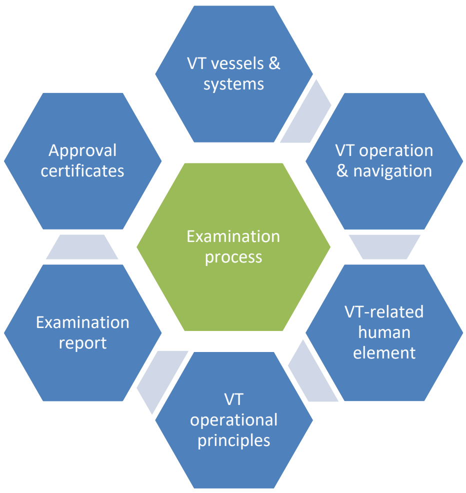
- Examination of VT vessels and systems design, with special consideration for cybersecurity
- Examination of VT-related operation and navigation
- Examination of VT-related human element
- Examination of VT-related operational principles:
    - Check of the implementation of required procedures
    - Audit to be carried out regularly to check effectiveness of the implementation of the operational principles.
- At each step, the implementation of the safety assessment outcomes should be checked, if relevant.

If the VT operational parameters are out of the range of the standard one, i.e., the number of FVs exceeds 4, or the distance between VT vessels is less than the safe distance prescribed according to section 7.2, or there is a significant difference in VT vessels manoeuvrability capabilities, the approval process described in this section shall be supplemented by a safety assessment to be carried out according to the guidelines given in section 10.2.4.
Upon satisfactory completion of the examination, certificates of approval will be issued by the competent Administration/Authority. Two types of certificates can be distinguished:

- Certificate of VT operation approval issued to VT company
- Certificate of vessel approval for operation in VT, issued to VT company and/or vessel owner, depending on the business model.

The period of validity shall not exceed five years.

Figure 4**:** VT suitability – Examination process



10.2.4 Risk assessment

Where the VT operational parameters are out of the range of the standard parameters, the general approval procedure (see 10.2.3) shall be supplemented by a VT operation safety assessment carried out according to the following guidelines.
The safety assessment may be carried out using the principle of equivalent safety with the conventional vessels or the principle of ALARP risks (As Low As Reasonably Practical risks).
The VT operation safety assessment shall be carried out considering two levels of assessment:

- VT as a single nautical unit
- VT objects, i.e., individual VT components (vessels and equipment).

The VT shall be considered as a single nautical unit for safety and cybersecurity assessment. Verification of compliance with the Rules and Regulations as well as the review of implemented different solutions shall be carried out at both assessment levels.
The effects of the VT operational parameters and the VT systems performance on the safe operation capabilities (controllability, situational awareness) and human factors (skills, workload, working conditions) shall be thoroughly investigated.
The VT model assumptions shall include different operational aspects:

- Navigation under normal conditions broken down into sequences to be investigated for different possible variability of the environment
- Coupling/decoupling (Joining/leaving) a train
- Emergency situations.

The VT functions shall be broken into different groups covering different operational aspects listed hereabove:

- Voyage, e.g functionality related to the voyage planning
- Navigation, including e.g, the data acquisition and analysis
- Detection of navigational and environmental conditions including e.g, retrieving of data for navigational & weather forecast and situational awareness systems
- Safety and emergency, including e.g, the necessary alarm systems
- Security
- Vessels integrity and stability-related functionality
- Cargo management with regard to the safety of the vessel and protection of the environment.

10.2.5 Derogation for pilot project

Preparing Regulations adapted to the vessel train could be a complex and long process. An alternative way to authorize VT concept could be to prepare a request for a derogation with a pilot project. This is possible, e.g., in the scope of article 25 of European Directive 2016/1629 in order to encourage innovation and the use of new technologies in inland navigation [11]. The procedure described in this chapter may be implemented by the competent Administration/Authority to permit the VT operation, using the recommendations set out in chapters 5 – 9 as provisional compliance requirements.

10.3 Check and verification procedure to be implemented by the VT company

The VT company shall ensure that the vessels joining the VT fulfil all safety and security conditions. This will be achieved by checking the status of the following:

- Implementation of the quality procedure for periodic routine maintenance
- Correctness of cargo stowing in accordance with stability and safety requirements
- Validity of all required certificates
- Crew certification and training for VT operations
- Preparation and implementation of operation and emergency procedures by individual vessels.

10.4 Conclusion

Introduction of new Rules and Regulations adapted to the VT concept should be accompanied by an appropriate procedure for the VT operation approval. The procedure for VT operation approval defined in this chapter is to be implemented at two levels: Approval of the VT operation by the competent Authority/Administration and check and verification to be performed by the VT company whenever a VT is formed.

Preparing Regulations adapted to the vessel train could be a complex and long process. An alternative way to authorize VT concept could be to prepare a request for a derogation with a pilot project.

11 CONCLUSION

Current applicable Rules and Regulations have been analysed regarding their relevance for the VT concept. They were challenged regarding potential reduction of the crew size, remote control and vessel platooning.

For vessel design and equipment it was identified that most of the modifications to be proposed affect “information acquisition” and “action” phases of human involvement. This means that the Regulations should make more provisions for mandatory sensing devices (thus facilitating the information acquisition) and for safety systems which are less reliant on human involvement and allow for execution of safety function from remote positions (thus facilitating the action phase). Identified are machinery and related systems, bilge, water ingress detection, fire detection and protection, anchor. Further, as vessel trains highly rely on critical systems, related in particular to geolocalisation of the vessels, data transmission, onboard control systems as well as global monitoring and supervision, technical and organisational cyber measures need to be dealt with.

For VT navigation, current navigation rules raise the question whether the lead vessel and its crew is allowed to represent all participating vessels. The existing Regulations are not adapted for vessels at CCNR level 2 of automation and higher. They explicitly assign navigation operations to the human operator in the wheelhouse and thus precludes these operations to be carried out from other remote positions. Further aspects identified are: VT identification, safe distance and VT sailing rules.

For VT operation-related human element the following Regulations areas challenging the VT concept can be noticed: manning and working conditions as a result of reduced crew, skills and personnel qualification as a result of new technology enabling remote control of FVs in a VT and operating modes and organization of the working time. For navigation tasks, the latter focused on the situation that FV operators are “off duty” during normal VT operations, where their ship is remotely operated.

For VT operation legal aspect, the following areas of the legal framework are not addressed in the existing Regulations: VT operation actors, their responsibilities and their roles, at different phases of the VT operation, consideration of the responsibility of the designer of the smart systems intended for essential service (VT control system) and consideration of the cyber risks.

In order to identify the VT in the Rules and Regulations new definitions are needed. Suggestion for these definitions have been defined and it is shown that they can be added to the existing structure of these Regulations e.g. ESTRIN.

For both the VT vessels design and equipment and especially the VT control system, existing main technical compliance frameworks (ESTRIN and SOLAS) need to be modified/adapted according to the recommendations set out in the relevant chapter. These recommendations are the result of expert opinion during safety and cyber security sessions and simulations/real-life test of the NOVIMAR VT control system. It is shown that they can be added to the existing structure of these Regulations e.g. ESTRIN.

Ensuring the safety and ease of traffic on waterways is also the determining factor for the VT and the necessary extensions of the existing Rules and Regulations. For this, recommendations are formulated and structured in accordance with CEVNI Code. They concern specifics on VT operation procedures, special marking, sound signals, rules of the road and emergency procedures.
In addition to the adaptation of the existing police Regulations, internal guidelines must also be drawn up, which shall contain the following VT-specific topics: Voyage information and voyage preparation, VT operating limits, VT forming by coupling/decoupling and navigational procedures in emergency

situations. These contents are essential for the operation of a VT but are not to be included in the Regulations.
The regulatory framework defining the crew member minimum number, qualification, training, and organisation of the working time, needs to be modified/adapted to facilitate the introduction of the VT. The operation of LV and FV need additional skills, training and qualification in reference to single vessel operation.

In busines models where all VT vessels are owned by the same actor, the maximum liability for the vessel train as a whole could become so high that it is uninsurable. However, it is observed that in present day business models "a whole fleet" is often accommodated in a structure of several private companies in a holding. For this reason, the ownership structure is an important parameter for insuring this business model. Business models where multiple vessels from different owners take part in the VT are more complex to insure, however no "no-go" obstacles are foreseen.

For the insurance companies it must be very clear which actors are involved in the Business Model at hand. Roles and responsibilities need to be very precisely and clearly defined in order to assess the situation and to come up with a suitable insurance offer per actor.
With regard to the VT control and monitoring system, manufacturers are usually very clear about where the responsibility of the manufacturer ends. In most cases, a duty to repair the system would be included, but the costs of any accidents/failures flowing from a product failure will be explicitly excluded. Insurance solutions need to be found for these gaps in liability, but this is unthreaded ground for most insurers so an off the shelf product should not be expected.
For the actual VT operation, it is vital that a clear division of responsibility has been agreed on beforehand. In addition, there is the need for hierarchy when multiple actors should act on the same time (e.g. during an emergency). For this, it is advised that the VT contract should make absolutely clear who is responsible for what. There should be a responsibility for the LV and a due diligence requirement for the FV.
In addition, from an insurance point of view it needs to be very clear at what moment a vessel is within a VT (connected) or when it is outside the VT (disconnected). Having this insight, insurance issues can be pinpointed at the actual mode of operation of the vessel and thus where liabilities lay. To support this, a Voyage Data Recorder (VDR) able to identify the moment of coupling and decoupling is highly recommended.
It remains the question how far insurance companies can go in insuring vessels that operate as FV in a VT, and thus give up part of their responsibilities.
The virtual platform brings cyber security risks. Currently, all damage flowing from a cyber-attack is excluded for vessel insurance. To insure this, cyber security measures put in place by the various actors need to be discussed with insurers to prevent insurance costs to rise sky high.
For insuring the actual VT operation, two methods have been identified:

- Fault-Based versus Contractual Liability, meaning that parties take on responsibilities and if something goes wrong, surveyors determine who is at fault. The party at fault will receive claims.
- A system of 'contractual liability', meaning that parties agree beforehand who is responsible for what, regardless of being at fault or not. This could then mean that someone damages an owners vessel, and (even though that someone was at fault) the owners has to cover the bill.

Introduction of new Rules and Regulations adapted to the VT concept should be accompanied by an appropriate procedure for the VT operation approval. The procedure for VT operation approval defined in this chapter is to be implemented at two levels: approval of the VT operation by the competent Authority/Administration and check & verification to be performed by the shipping company whenever a VT is formed.

Preparing Regulations adapted to the vessel train could be a complex and long process. An alternative way to authorize VT concept could be to prepare a request for a derogation with a pilot project. The general procedure defined for VT approval may be implemented by the competent Administration/Authority to permit the VT operation, using developed recommendations as a compliance reference.

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13 ANNEXES

13.1 Annex A - Coupling/decoupling procedure

The coupling process can be performed while the LV or VT is (electronically) anchored or while it is travelling. The coupling / decoupling is to be performed according to the following procedures.

1. Coupling of a vessel to a LV, while LV is anchored
   A potential FV approaching, communicates its arrival time via radio. The FV steers into the train position behind the LV with the desired distance to the LV and requests electronically to build a VT. If the LV operator accepts the FV, he acknowledges the request electronically.

Table 1: Procedure to couple a vessel to a LV, while LV is anchored

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
		Sails to the roadstead	LV electronically anchors at the roadstead	
1	Radio	Communicate arrival time and desired position in train to LV		LV, joining FV
2	Radio		LV waits for FV to arrive	LV
3			LV selects / checks appropriate fairway borders for joining FV	LV
4	WLAN	When the approaching vessel is close enough, the WLAN mesh gets active.	The joining vessel receives an IP address from the VT Leader	
5		FV is positioned in the VT		joining FV
6	AIS	FV requests building a train electronically by sending out an VT AIS ASM message: - Source ID of joining vessel - Convoy state = 1 (passive coupled and request for acknowledged coupling) - train formation with joining vessel added at desired position in the train		joining FV
7	AIS		LV acknowledges the request by sending out an VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	LV
8	WLAN	VT relevant data is exchanged and processed	VT relevant data is exchanged and processed	

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
9			VT anchors at the roadstead, waiting for departure	LV

2. Coupling of a vessel to a LV, while LV is travelling
A FV that is approaching communicates its arrival time and desired position in the train via radio. The train now prepares the joining of a new vessel, e.g. by setting a larger distance between two vessels from the LV. The FV steers into the train position with the desired distance to the LV and requests Deliverable D3.2 electronically to join the train. If the LV operator accepts the new FV, he acknowledges the request electronically.

Figure 1 Main steps during coupling

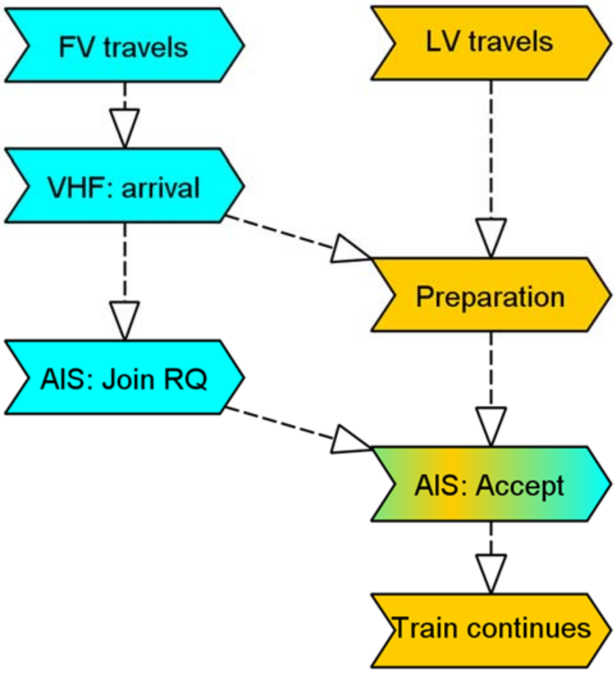

Table 2: Procedure to couple a vessel to a LV, while LV is travelling

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
		FV travelling	LV travelling	
1	Radio	Communicate arrival time and desired position in train to LV		LV, joining FV
2	Radio		LV waits for FV to arrive	LV
3			LV selects / checks appropriate fairway borders for joining FV	LV

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
4	WLAN	When the approaching vessel is close enough, the WLAN mesh gets active.	The joining vessel receives an IP address from the VT leader	
5		FV is positioned in the VT		joining FV
6	AIS	FV requests joining the train electronically by sending out a VT AIS ASM message: - Source ID of joining vessel - Convoy state = 1 (passively coupled and request for acknowledged coupling) - train formation with joining vessel added at desired position in the train		joining FV
7	AIS		LV acknowledges the request by sending out a VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	LV
8	WLAN	VT relevant data is exchanged and processed	VT relevant data is exchanged and processed	
9			LV corrects / checks convoy distances	LV
10			VT travelling	LV

3. Coupling of a vessel to a VT, while VT is anchored
   A FV that is approaching communicates via radio its arrival time and desired position in the train. The train now prepares the joining of a new vessel by possibly calling the crew of the FV on board to manually steer their vessels into the correct position. If the new FV intends to join at the end of the train, the other FV do not need to get involved. The FV steers into the train position with the desired distance to the LV and requests electronically to join the train. If the captain of the LV accepts the new FV, he acknowledges the request electronically.

Table 3: Procedure to couple a vessel to a VT, while VT is anchored

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
		Sails to the roadstead	VT anchors at the roadstead in VT formation	
			LV transmits the VT convoy by sending out an VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	
1	Radio	Communicate arrival time and desired position in train to LV		LV, joining FV
2	Radio		FV position in between: train prepares for adding new FV	LV, affected FV
			FV position at end of train: waits for FV to arrive	LV
3			LV selects / checks appropriate fairway borders for joining FV	LV
4	WLAN	When the approaching vessel is close enough, the WLAN mesh gets active.	The joining vessel receives an IP address from the VT Leader	
5		FV is positioned in the VT		joining FV
6	AIS	FV requests joining the train electronically by sending out an VT AIS ASM message: - Source ID of joining vessel - Convoy state = 1 (passive coupled and request for acknowledged coupling) - train formation with joining vessel added at desired position in the train		joining FV
7	AIS		LV acknowledges the request by sending out an VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	LV
8	WLAN	VT relevant data is exchanged and processed	VT relevant data is exchanged and processed	
9			VT anchors at the roadstead, waiting for departure	LV

4. Coupling of a vessel to a VT, while VT is travelling
   A FV approaching, communicates via radio its arrival time and desired position in the train. The train now prepares the joining of a new vessel, e.g. by setting a larger distance between two vessels from the LV. The FV steers into the train position with the desired distance to the LV and requests electronically to join the train. If the LV operator accepts the new FV he acknowledges the request electronically.
   Table 4: Procedure to couple a vessel to a VT, while VT is travelling

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
		FV travelling	VT travelling	
			LV transmits the VT convoy by sending out an VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	
1	Radio	Communicate arrival time and desired position in train to LV		LV, joining FV
2	Radio		FV position in-between: train prepares for adding new FV by setting a local distance gap	LV
			FV position at end of train: waits for FV to arrive	LV
3			LV selects / checks appropriate fairway borders for joining FV	LV
4	WLAN	When the approaching vessel is close enough, the WLAN mesh gets active.	The joining vessel receives an IP address from the VT Leader	
5		FV is positioned in the VT		joining FV
6	AIS	FV requests joining the train electronically by sending out an VT AIS ASM message: - Source ID of joining vessel - Convoy state = 1 (passive coupled and request for acknowledged coupling) - train formation with joining vessel added at desired position in the train		joining FV

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
7	AIS		LV acknowledges the request by sending out a VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	LV
8	WLAN	VT relevant data is exchanged and processed	VT relevant data is exchanged and processed	
9			LV corrects / checks convoy distances	LV
10			VT travelling	LV

5. Decoupling of last vessel while VT is travelling.

Table 5: Procedure to decouple last vessel while VT is travelling

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
			VT travelling	
			LV transmits the VT convoy by sending out a VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	
1	Radio	Communicate wish to leave LV	LV calls FV crew on board for initiation of decoupling procedure	LV, leaving FV
2	AIS	FV requests leaving the train electronically by sending out an VT AIS ASM message: - Source ID of leaving vessel - Convoy state = 3 (decoupled and decoupling request in case of acknowledged coupling) - train formation		leaving FV
3	AIS		LV acknowledges the request by sending out an VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - new train formation	LV
4		Left FV travelling	VT travelling	LV

6. Decoupling of vessel inside the train, while VT is travelling

Table 6: Procedure to decouple a vessel inside the train, while VT is travelling

Step	Comm.	Procedure of joining FV	Procedure of LV / VT	Crew
			VT travelling	
			LV transmits the VT convoy by sending out a VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - train formation	
1	Radio	Communicate wish to leave LV	LV calls FV crew on board for initiation of decoupling procedure	LV, leaving FV
2	AIS	FV requests leaving the train electronically by sending out an VT AIS ASM message: - Source ID of leaving vessel - Convoy state = 3 (decoupled and decoupling request in case of acknowledged coupling) - train formation		leaving FV
3		FV navigates to the side, so that the train can close the gap		
4	AIS		LV acknowledges the request by sending out an VT AIS ASM message: - Source ID of LV - Convoy state = 2 (active acknowledged coupling) - new train formation	LV
5			LV corrects / checks convoy distances	LV
6		Left FV travelling	VT travelling	LV

13.2 Annex B - VT operation approval - checklist

	VT OPERATION APPROVAL REPORT	VT informat
	VT COMPANY NAME	REGISTER NUMBER
	APPROVAL DATE	DATE 1ST CERTIFICATE

xx =xxxxx

OK = requirement is satisfied

NA = not appicable

R = remark

Approval Item	Description	NA	OK	R
	VT characteristics			
1	VT length:			
2	Number of follower vessels:			
3	VT nominal speed:			
4	Minimum distances between vessels:			
5	Operation limits			
	VT smart systems			
1	Control system			
2	Navigation system			
3	Communication system			
4	Monitoring and alarming system			
5	Situational awareness system			
6	IT and OT systems			
6.1	System overview			
6.2	System functionality (description of the system’s mission, boundaries, etc)			
6.3	Components and sub-systems			
6.4	Interfaces, information flows, etc			
6.5	Design of onboard and onshore systems			
6.6	Inventory of IT and OT equipment			
6.7	Design of shore to VT systems communications			
6.8	Design of vessel to vessel network communications			
	Vessels main characteristics (for each VT vessel)			
	New built			
	Retrofit			
1	Rule length (m):			
2	Breadth (m):			
3	Depth (m):			
4	Draugth (m):			
5	CEMT class:			
6	River-sea			
7	Short sea			
8	Cargo type and packing			

8.1	Bulk			
8.2	Container			
8.3	RoRo			
8.4	Hazardous			
	Vessels operation (for each VT vessel)			
1	Level of automated navigation (CCNR):			
2	Level of automated machinery:			
3	Degree of control			
3.1	Full direct control control			
3.2	Available direct control			
3.3	Full remote control control			
	Vessels design and equipment (for each VT vessel)			
1	Wheelhouse: Fixed / Movable			
2	Propulsion system			
2.1	Installed brake power			
2.2	Number of propellers			
2.3	Type of propellers			
2.4	Auxiliary propulsion			
3	Steering system			
3.1	Number of steering systems			
3.2	Type of steering systems			
3.3	Auxiliary steering system			
4	Electrical power supply system			
5	Bilge system			
6	Water ingress detection system			
7	Anchor equipment			
8	Fire protection and detection system			
9	Stability assessment tools			
10	Controllability - stopping distance			
11	Cargo system			
	Operation environment			
1	Operating areas (IWT, SSS, route, etc,)			
2	Waterway characteristics			
3	Waterway conditions (wave, tide, current, weather, etc.)			
4	Traffic characteristics			
	Manning (for each vessel)			
1	Number and qualification of operators			
2	Operator's tasks and responsibility			
3	Operating mode			
4	Human-machine interfaces description			
	Risk assessment report			
1	Assumptions			

2	Scenarios			
3	Outcomes			
4	Implementation of risk assessment outcomes			

	VT OPERATION APPROVAL REPORT	VT VESSEL
	VT COMPANY NAME	REGISTER NUMBER
	APPROVAL DATE	DATE 1ST CERTIFICATE
xx =xxxxx		VT VESSELS

OK = requirement is satisfied

NA = not applicable

R = remark

Approval Item	Description	NA	OK	R
	Certification			
1	General safety (ESTRIN, SOLAS)			
2	Carriage of dangerous goods			
3	Class			
4	Others			
	Stability assessment system			
1	Suitability			
	Propulsion system			
1	Suitability for VT operation			
2	Suitability of the secondary means of propulsion			
3	Failure detection and alarming system			
	Steering system			
1	Suitability for VT operation			
2	Suitability of the secondary means of steering			
3	Failure detection and alarming system			
	Power supply system			
1	Failure detection and alarming system			
	Bilge system			
1	Availability of automatic draining system			
2	Failure detection and alarming system			
	Water ingress detection system			
1	Availability of water ingress detection system			
2	Failure detection and alarming system			
	Fire protection and detection system			

1	Availability Fixed fire fighting system			
2	Availability of fire detection and alarming system			
3	Failure detection and alarming system			
	Anchor equipment			
1	Bow and stern anchors			
2	Fitted operation system			
	Machinery automation			
1	Notation UMS-UMS assigned			
2	Other features			

	VT OPERATION APPROVAL REPORT	**VT CONTROL SYS**
	VT COMPANY NAME	**REGISTER NUMBER**
	APPROVAL DATE	**DATE 1ST CERTIFICATE**
xx =xxxxx		**VT CONTROL SYSTEM**

OK = requirement is satisfied
NA = not appicable
R = remark

Approval Item	Description	NA	OK	R	NOTI
	Certification				
1	Type approval				
	Standard navigation equipment - General requirements				
1	Radar				
2	ROT indicator				
3	Autopilot				
4	AIS				
5	GNSS				
6	VHF voice communication				
	Control system equipment - Design, installation & arrangement				
1	Radar				
2	ROT indicator				
3	AIS				
4	GNSS				
5	Control interface to the rudder				
6	Control interface to the throttle				
	Human-machine interface - Design and arrangement				
1	Control access				
2	Control feedback				
3	Status				

4	Traffic situation and awareness			
	Intervessel communication system			
1	Design and arrangement			
2	Installation			
	Monitoring, detection and alarming system			
1	Design and arrangement			
2	Installation			
	Cyber safety and security			
1	Design measures			
2	Constructional and installation measures			
3	Management measures			

	VT OPERATION APPROVAL REPORT	**VT OPERATION**
	VT COMPANY NAME	**REGISTER NUMBER**
	APPROVAL DATE	**DATE 1ST CERTIFICATE**
xx =xxxxx		**VT OPERATION**

OK = requirement is satisfied

NA = not appicable

R = remark

Approval Item	Description	NA	OK	R	NOTES
	Voyage information and voyage preparation procedures				
1	Operating limits				
1.1	Definition				
1.2	Implementation in the operation procedures				
2	Responsibilities				
2.1	Definition				
2.2	Implementation in the definition of operating limits				
3	Voyage information update				
3.1	Procedure				
3.2	Procedure implementation				
4	Voyage plan				
4.1	Procedure				
4.2	Procedure implementation				
5	Voyage data recorder				
5.1	Data recording procedure				
5.2	Procedure implementation				
	VT forming - coupling/decoupling				
1	VT forming				

1.1	General procedure			
1.2	Procedure implementation			
2	Coupling			
2.1	Procedure for different VT operation phases			
2.2	Procedure implementation			
3	Decoupling			
3.1	Procedure for different VT operation phases			
3.2	Procedure implementation			
	VT navigation			
1	VT identification			
2	Safe distance between VT vessels			
3	Procedure implementation			
	Emergency situations			
1	IT infrastructure and VT systems failure			
1.1	Procedure			
1.2	implementation			
2	VT specific alerting system			
2.1	Procedure			
2.2	implementation			
3	Problem on one or several VT vessels			
3.1	Procedure			
3.2	implementation			

	VT OPERATION APPROVAL REPORT	**HUMAN ELEMENT**
	VT COMPANY NAME	**REGISTER NUMBER**
	APPROVAL DATE	**DATE 1ST CERTIFICATE**
xx =xxxxx		**HUMAN ELEMENT**

OK = requirement is satisfied

NA = not appicable

R = remark

Approval Item	Description	NA	OK	R	NOTES
	Competence and skills				
1	LV				
1.1	VT operator certificate				
1.2	LV operator skipper experience				
2	FV (for each FV)				
2.1	VT operator certificate				
2.2	FV operator skipper experience				
	Crew number				
1	Navigation task				

1.1	LV - VT operator			
1.2	FV - VT operator (for each FV)			
2	Other tasks			
2.1	LV			
2.2	FV (for each FV)			
	Organisation of working time			
1	Suitability			
2				
	Working environment/conditions			
1	Human-machine interface design			
2	Attention allocation monitorig			
3	Fatigue monitoring			
	Training			
1	Training plan			
2	Training procedure			

VT OPERATION APPROVAL REPORT		**REMARKS**		
VT COMPANY NAME		**REGISTER NUMBER**		
APPROVAL DATE		**DATE 1ST CERTIFICATE**		