Proceedings of the 33rd European Safety and Reliability Conference (ESREL 2023)
Edited by Mário P. Brito, Terje Aven, Piero Baraldi, Marko Čepin and Enrico Zio

doi: 10.3850/978-981-18-8071-1_P211-cd

Safety and Human Dependability in seaborne autonomous vessels

Christoph Alexander Thieme, Stig Ole Johnsen, Thor Myklebust

Software Engineering, Safety and Security, SINTEF Digital, Norway, {Christoph.thieme; stig.johnsen; thor.myklebust}@sintef.no

Highly automated and autonomous seaborne vessels (ASV) are developed to improve environmental impact and transport of goods and people. ASV are expected to be remotely supervised, to fulfil legal requirements and assure safe handling in cases of emergencies. The AutoSafe project is developing solutions for the safe operation of ASV. For emergencies, the human safety supervisors need to handle the vessel, supported by fallbacks, procedures, and technology. Passengers need to feel safe and know what to do in all situations, to avoid injuries or loss of life. International standards are a starting point to build safe, reliable and trust. The aim of this paper is to assess applicability and potential benefit of IEC62508:2010: *Guidance on Human Aspects of Dependability* to the AutoSafe cases, based on the identified project needs. IEC62508:2010 deals with the human aspect of dependability, where dependability is the combination of reliability, availability, maintainability, safety, etc. Methods and approaches exist to set requirements, assess, and evaluate human performance. However, they are most applicable to trained operators. Passengers' and especially emergency services' interaction with the ferry during emergency situations are only covered to a certain degree by the standard. These create human factor challenges, which should be referenced appropriately. IEC 62508:2010 should be updated with respect to highly automated and autonomous systems or refer to other relevant standards.

Keywords: Autonomy, Safety, Dependability, Human Factors, Seaborne vessels

1. Introduction

Automated and autonomous seaborne vessels (ASV) are expected to promote waterways as an alternative to land-based transport in dense urban areas. Several technical challenges need to be solved for ASV to be successful (Reddy et al. 2019). ASV will still rely on humans, such as, operators in a remote supervision centre (RSC) or remote operation centre (ROC), first responders in an emergency, and passengers using the ferry as intended.

The AutoSafe project (Holte 2021) aims to develop new concepts for the safe operation of ASV, in particular ferries. As part of the project, hazards were identified together with key stakeholders in several workshops (Johnsen et al. 2022). Hazards and risks related to emergency situations when several stakeholders need to interact dependably.

This paper uses the standard IEC 62508:2010: *Guidance on Human Aspects of Dependability,* to identify suitable human factors (HF) methods to assess and optimize human dependability of different stakeholders interacting with automated passenger ferries (APF) during emergency situations. The goal is to identify HF activities that will support the design of the system and facilitate safety demonstration, which is highly relevant for the economical and legal feasibility of APF. Suitable HF activities will allow for addressing the human contribution to the risk level and help to assure safety. Another objective of this paper is to identify shortcomings of IEC62508:2010, which could be addressed in future versions.

2. Background

2.1. *The AutoSafe project and initial findings*

The AutoSafe project has two goals, identifying new safety solutions for APF, which may be technical, technological, or operational, and providing the industry with knowledge and tools to assess the safety of proposed solutions. Previous project related publications form the basis for this article and will be briefly summarized.

Safety is closely linked to risk, where safe conditions are assumed when risks have been reduced to an acceptable level. Hazards are conditions or situations that may cause harm, i.e., an accident (Rausand and Haugen 2020). Johnsen et al. (2022) present the results from three group-based hazard identification workshops for APF with key stakeholders. The identified hazards were used to prioritize scenarios and identify proactive frequency reduction barriers and barriers to reduce the consequences if an accidental event should occur. The prioritized accident scenarios are:

(i) Fire in the engine room, passenger salon, or battery room;
(ii) Collision with other vessels or floating objects or grounding;
(iii) A passenger falling overboard, or a person floating in the water (MOB);
(iv) Evacuation due to fire, loss of stability, collision, grounding, or engine failure;
(v) Ferry loses stability or capsizes, due to overload or loss of watertightness;
(vi) Passenger emergencies caused by injuries, medical conditions, or vandalism.

The paper highlights the need for qualified and rapid emergency response. A key challenge is the reduced or non-existing crew on board the APF, challenging the dependable handling of passengers in emergency situations.

Fjørtoft and Holte (2022) present operational envelopes for ASV to make the operations more resilient and risk informed regarding operational risks. The envelopes are based on environmental and operational conditions, respecting human operational limitations (reaction time) and operational needs (deadlines for action completion to avert an accident). Environmental conditions are for example traffic density, visibility, and sea state. Operational conditions include operation modus (human operation, human supervision, fully autonomous, etc.) and status of communication or sensor systems.

Thieme et al. (2023) proposed an approach for identifying gaps of an APF design with respect to the regulations. Based on identified gaps a process is demonstrated to develop procedures addressing these gaps with meaningful information for human operators employing these procedures.

2.2. *Demonstrating dependability of humans in automated passenger ferry systems.*

The NMA developed guidelines for the approval of ASV, based on the IMO Circ. 1455 (IMO 2013). Circular RSV 12-2020 (NMA 2020) specifies necessary documentation for the approval of autonomous ships or alternatively designed systems operating in Norwegian waters (NMA 2020). Two principles are critical for approval: 1) the level of safety shall be equivalent or higher – compared to conventional solutions, and 2) a vessel that is built and planned to operate automatic or autonomously must comply with existing rules and regulations that apply to conventional ships of the same type. Solutions that do not meet requirements need to be risk assessed and accepted by the NMA.

For APF, this means that any reduction of the crew onboard must be compensated, documented, and approved according to existing rules and regulations. This implies that new safety-oriented solutions must be dependable, including an equivalent safety level and with verifiable performance. New solutions may include, i.e., locating ship operators on land in an ROC or RSC, thereby shifting responsibilities, with increased reliance on passengers and first responders during emergency situations.

2.3. *Dependability and human factors.*

Dependability is *the ability [of a system] to perform as and when required* (IEC 62508: 2010), including properties, such as, availability, reliability, safety, fault tolerance, recoverability, security, maintainability, maintenance support, and durability. The standard IEC 62508:2010 gives guidance on aspects of human dependability. Human dependability refers to the human being able to perform as and when required, meaning that the human takes the correct action, in the correct way at the right time. Incorrect actions can be classified as *human error* or *human failure*. Many definition exists, in short, human error can be defined as the discrepancy between the human action taken (or omitted), and the action intended(IEC 62508: 2010). Human failure are described as a deviation from the human action required to achieve the objective, regardless of the cause of that deviation (IEC 62508:2010). Human error has been a focus in many accident investigations, since the ability to perform intended actions is dependent on the operational design domain (ODD), usability and design of the system, human abilities, responsibilities, procedures, and training. Thus, in accident investigations, human error is seen as a symptom of underlying problems within the system (Dekker 2014).

The field of HF and ergonomics research is […] *concerned with the understanding of the interactions among humans and other elements of a system that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance* (IEC 62508:2010). Human-centred design aims at making systems more useable applying the principles of HF and ergonomics.

2.4. *Challenges and bias in automated systems*

ASV will make use of advanced algorithms incorporating some form of machine learning (ML) or Artificial intelligence (AI). AI and ML algorithms may have biases. This relates directly to aspects of design and usability of a system. ISO/IEC-TR 24027:2021 *Bias in AI systems and AI aided decision making* specifies three types of bias: (1) Human cognitive bias, influencing both the selection of data used as training sets for ML and the engineering decisions made throughout the ML development process. (2) Data bias, which will influence the ML system since the data used to train and test the will define the system model and the ML system's behaviour. This bias may stem from design decisions and constraints imposed by developers, management, or existing human cognitive bias. (3) Bias introduced by engineering decisions is caused by decisions related to requirements, design, choice of parameters, etc. ISO/IEC-CD-TR4569 (currently under development): *Functional safety and AI systems* provides guidelines for assuring the functional safety of AI-based systems, among others processes and best practices when developing AI-based systems.

2.5. *The AutoSafe application cases*

To assess the needs for HF methods, this article builds on the application cases of the AutoSafe project. The first case the *Florø community ferry* is an APF commuting between the Norwegian city Florø and the Fjord offshore supply base approximately 2.6 km apart. The *Florø community ferry* is projected to operate close to shore with a speed of approximately 5 knots, taking about 20 minutes for the journey. The route is planned through sheltered waters, carrying up to 25 passengers on each trip. During initial trials a safety supervisor (SaSu) is expected to be on board, who will be relocated to a ROC after an initial trial period, leaving the APF uncrewed, yet not unsupervised. The case and role distribution is described in more detail in Thieme et al. (2023).

The second case, the *Trondheimsfjord APF* is based on the existing ferry route Trondheim – Vanvikan in Norway. The current ferry is a high-speed ferry sailing at 23 knots, approximately 16 km across the fjord. The fjord can be subject to strong currents and waves, with few obstacles (rocks, islands, etc.) on the route. The terminal areas are small, and some traffic (leisure craft and kayaks) are expected. On the current *Trondheimsfjord ferry* three people form the crew: the captain, the engineer, and the mate. The *Trondheim fjord APF* concept being explored in the AutoSafe project consists of one captain on board and an RSC to support the captain on board.

3. Assessment

3.1. *Approach to assessing HF methods*

IEC 62508:2010 provides mainly guidance for designing for the user and operator, i.e., user and operator are the same person. However, this is not the case for ASV, where these are different entities. Guidance on methods and activities in order to design a safe ASV with good interaction in all situations is needed. This paper uses the following approach to identify HF methods suitable for different design stages, for normal operation and emergency situations.

(i) Identify relevant stakeholders that will interact with the system during normal operation or emergency operation;
(ii) Identify roles and tasks for the stakeholders during normal operation or emergency operation;
(iii) Assign expected competency levels, training opportunities, and challenges regarding these tasks;
(iv) Review IEC 62508:2010, chapter 6 Human-oriented design at each life cycle stage and identify suitable methods for the stakeholders from Annex C Best practices for human-centred design;
(v) Summarize recommendations for HF activities for designers.

3.2. *Assessed need for human factors activities*

IEC 62508:2010 provides general guidelines for human-centred design that optimize human and system dependability, if applied correctly. These are:

- Fitness for use – design for the intended use, with the right function allocated to human and system. Consider the users characteristics and let them test the system.
- Simplicity – Attempt a design that is as simple as possible, with obvious functions and minimal need for training.
- Error tolerant and resistant – design that minimizes the opportunities for mistakes, is tolerant to erroneous input and fails in a safe manner in case of failure.
- Consistency – design that is familiar to users, such that they experience it in a similar fashion as with similar systems.
- Standardization – use standardized hardware and software when possible. Maintain interfaces for identical functions. Provide the same user experience by consistent controls, displays, markings, coding, labelling, and arrangement.
- User-centred perspective – Design with user roles, responsibilities, abilities, diversity, decisions, and goals in mind. This includes using familiar terms and images, providing timely and informative feedback, minimizing training requirements, and facilitation of transferring skills.
- Maintainability and maintenance support – Design for the ease of maintaining and repairing, and dis-/assembly the system, using common tools where possible, providing specialized tools where needed and providing needed logistics support.

Table 1 summarizes the stakeholders and associated considerations for the *Florø community ferry* and the *Trondheimsfjord APF*. In addition to SaSu, RSC and ferry passengers, emergency services, and other vessels and boats were identified as relevant stakeholders. The stakeholders are mainly system internal (SaSu, RSC crew and users) but especially for emergency situations other traffic participants and emergency services become important actors. Where emergency services will assist if they have the right resources, the active participation of other vessels and boat is subject to each individual vessel. Other vessels and boats may be called in to help through radio or through signalling.

The main challenges identified for almost all stakeholders are situation awareness and communication of information in a network of actors, i.e., Distributed Situational Awareness (DSA, Stanton 2016). Especially SaSu/captain and RSC may communicate with several actors at the same time while carrying out additional tasks. This may lead to delayed responses or actions.

Passengers will need guidance in emergency situations. Whereas many situations can be trained by the SaSu, RSC crew and to some extent emergency services, the opportunity for training and development of competences of passengers, and other vessels and boats is limited. These are heterogenous groups with different needs, competencies, and backgrounds.

The identification of HF activities is summarized in Table 2. The proposed methods found in IEC 62508:2010 are grouped by life cycle stage. The most relevant for this paper are:

- Concept/definition stage – clarify and understand the objectives of stakeholders interacting with the system. Risks are identified and requirements are documented, including dependability of the system and human stakeholders. This stage includes human-centred planning, need analysis, and human-centred design requirement elicitation.
- Design/development – apply human centred analysis to ensure that system requirements reflect human capabilities and limitations, design alternatives are sufficiently explored, and human related risks are identified and accounted for.
- Realization and implementation – make decision regarding purchase/manufacturing of components and integration of these.
- Enhancement– monitor and improve system performance through upgrades, additions, or additional training. HF should be evaluated, and changes should consider the impact on human performance.

Several activities and methods mentioned in the concept/definition and the design/ development stages are mentioned in later stages. These are only listed once. Table 2 indicates that the recommended methods are mainly applicable to end users that are also operators. For large user groups (passengers) and sporadic users, i.e., emergency services, other vessels, and boats, less methods and activities are available due to lack of data or the uncertainty around these stakeholders.

Table 1. Summary of stakeholders and their high-level tasks, their competency level, training opportunities and challenges for both AutoSafe cases.

Stake-holders	**Remote SaSu – *Florø case***	**Captain – *Trondheim case***	**RSC**	**Passengers**	**Other vessels and boats**	**Emergency services**
Tasks during normal operation	Monitoring the ferry, the ferry environment (i.e., traffic, weather, etc.) and passengers. Communicate with passengers if needed.	Monitoring traffic and ferry behaviour. Assisting passengers boarding and disembarking. Assist passenger with questions and requests.	Monitor technical condition of the ferry. Raise attention of SaSu in case of detected deviations.	Board and disembark the ferry. Comprehend safety instructions provided before/ during departure. Enjoy the ferry ride.	Observe the ferry as part of the normal traffic.	No role.
Tasks during emergency operation	Assessing status and severity of the emergency. Remotely controlling ferry. Alert emergency services if necessary. Guiding and instructing passengers through public announcement system. Go to the ferry's location and assist passengers and MOB physically.	Assessing status and severity of the emergency. Controlling ferry manually. Alert emergency services if necessary. Guiding and instructing passengers.	Support SaSu with information on ferry status and coordination of emergency services and other parties assisting in the emergency. Trouble-shooting of problems and root causes.	Follow and assist SaSu, if required. Warn if MOB is detected. Safely evacuate and assisting personal medical emergencies by following SaSu's guidance.	If called on radio, assist the ferry and passengers, i.e., evacuation required or MOB.	Assist the SaSu in resolving emergency situations, i.e., firefighting, evacuation, MOB rescue.
Competency levels	High	High	High	Mixed, unknown demographics	Mixed, unknown demographics	High
Opportunity for training	High before and during ferry is in operation.	High before and during ferry is in operation.	High before and during ferry is in operation.	Limited to information provided before and during voyage.	Very limited through advertising or information campaigns.	Limited through common exercises before or during the ferry is in operation.
Challenges	Situation awareness during remote monitoring. Switching between monitoring and controlling the ferry. Multiple roles in case SaSu needs to physically aid the ferry. Communication with several different actors.	Handling of passengers while controlling the ferry and communicating with several stakeholders. Switching from monitoring to taking control.	Situation awareness. Transition from passive monitoring to communicating information and status to SaSu or emergency services.	Obtaining situation awareness and necessary information in an emergency. Follow instructions with limited guidance by humans. Keeping calm and assisting other passengers if necessary.	Understanding the need to help. Obtaining information on what help is needed.	May have other emergency cases at the same point of time. Situation awareness of what help is needed.

Table 2. Evaluation of example methods mentioned in IEC 62508:2010 usefulness for the different stakeholders. Methods mentioned in several lifecycle stages are only listed once. Fields marked with (x) are limited applicable, due to lack of data or uncertainty of the usefulness.

Activities in the lifecycle phases	**SaSu *Florø case***	**Captain *Trondheim case***	**RSC**	**Passengers**	**Other vessels and boats**	**Emergency services**
			Concept/definition stage			
Future workshops	x	x	x			x
Focus groups	x	x	x	x	x	x
In depth analysis of work and lifestyle	x	x	x			x
Participatory workshops	x	x	x	(x)	(x)	x
Consult stakeholders	x	x	x	x		x
HF analysis	x	x	x	x		x
Context of use analysis	x	x	x	x		x
Task analysis	x	x	x	x		x
Cognitive task analysis	x	x	x	x		x
Work context analysis	x	x	x	x		x
Operational sequence diagrams	x	x	x	x	(x)	x
Action/information requirements	x	x	x	x	x	x
Timeline	x	x	x	x	x	x
Situation awareness analysis	x	x	x	x		x
Workload analysis	x	x	x	x		
Human performance reliability analysis	x	x	x	(x)		(x)
Heuristic/expert evaluation of usability	x	x	x	x		x
Usability benchmarking	x	x	x	(x)		x
Predetermined time standards	x	x	x	(x)		
Prototyping and usability evaluation	x	x	x	(x)		(x)
Develop simulations	x	x	x	x	x	(x)
Scenarios	x	x	x	x	(x)	x
Personas	x	x	x	x	(x)	(x)
Storyboards	x	x	x	x	(x)	(x)
			Design/development			
Physical ergonomics	x	x	x	x		
Participatory design	x	x	x	(x)		(x)
User interface standards and guidelines	x	x	x	x		x
Use of HF engineering data for evaluation	x	x	x	(x)		(x)
Mock-ups	x	x	x	(x)		(x)
Work domain analysis	x	x	x	(x)		(x)
Workload assessment	x	x	x			(x)
Human performance model	x	x	x	x	(x)	x
Design for alertness	x	x	x		(x)	
Staff planning	x	x	x			
			Realization/Implementation			
Risk analysis (process and product)	x	x	x	x	x	x
User feedback on usability and experience	x	x	x	(x)		(x)
Design criteria checklist	x	x	x	x		x
Performance measurements	x	x	x	(x)		(x)
Guidelines on common industry format for usability reports	x	x	x	(x)		(x)
			Enhancement			
Organizational/environmental context analysis	x	x	x	(x)		x
Continuous direct observations	x	x	x	x	(x)	(x)
Sampled direct observations	x	x	x	x	(x)	(x)
Interviews and questionnaires	x	x	x	x	x	x

3.3. *Recommended methods and activities*

Stakeholders need to be engaged early in the design process to identify and address HF challenges. This is also necessary to assess the risk level to establish the HF contribution to risk and accordingly design for safe operation. IEC 62508:2010 mentions many available methods for addressing HF needs and finding solutions that enhance the performance of operators and supervisors. However, reference to best practices regarding ROC, as mentioned in the ISO11064 series are missing. Application of HF methods need to be balancing cost, time, and the expected gain in human dependability.

Stakeholders need to be involved, for example through workshops, interviews, and surveys to assess how they will engage, use and interact with the system. However, passengers and other traffic participants, will have little experience with emergency situations and thus can give limited input to these topics. More guidance is needed on how to efficiently involve these groups. People are normally willing to help and they stay calm in emergency situations, given the right guidance (through people and design). Therefor it is important that emergency scenarios are tested with passengers representing the whole spectrum of potential users to demonstrate that dependability targets are met. Normal operation should also be tested in a trial period with adequate supervision and monitoring, where the SaSu or captain easily and quickly can take action to handle any unforeseen or difficult situation.

Several general challenges were identified for ASV and AI-based systems in Endsley et al. (2021). These need to be overcome. IEC 62508:2010 does not explicitly provide guidance for these challenges, nor do the referenced methods and approaches fully address these challenges. The challenges are:

- Automation confusion – Users and operators may not understand the working mechanisms of the AI system;
- Irony of automation – People get bored or inattentive when everything is going right. When an unexpected situation occurs, the AI may need help from the operator who then will experience high workload;
- Poor situation awareness and out of the loop – Operators or users may be slower to perceive information and it may take longer to respond to a problem, especially to problem that were not encountered before;
- Human decision bias – Operators and users will need to rely on the system's recommendations and may thus not detect if there are better suited solutions;
- Degradation of manual skills – Operators or users may lose the skill to operate the system adequately due to little use.

Human dependability must consider the ODD and DSA to ensure safety and rapid emergency response. The information systems need to be tailored to the stakeholders' needs. Supervisors will have different information needs than passengers or emergency services, regarding the type, presentation, and timeliness of information. Biases need to be removed from the AI-based system, and from the users and passengers towards the system to ensure efficient communication. There needs to be transparency and explainability of AI, that provide the possibility for an operator in ROC/RSC to understand why decisions were made (Endsley et al. 2021; Thieme et al. 2021).

4 Conclusion and further work

This paper aims at identifying suitable HF methods to asses risk contribution and optimize performance of different stakeholders in APF operations. IEC 62508 was used as a starting point for identification of such HF methods. For operators and operating users, methods and approaches are available. However, for emergency situations when emergency services, and *unknown* and untrained passengers need to interact with the APF, little guidance is available.

4.1. *Input to updating IEC 62508*

Applying IEC 62508:2010 to APF may be challenging. Firstly, the role of passengers as *users* is not explicitly covered. In the context of APF the passengers are highly relevant as they will need to become active in emergency situations, following instructions and potentially assisting the onboard/remote crew. Similarly, designing for system external humans, such as emergency services or other traffic participants is not covered explicitly. DSA is an important concept to be considered, since different people with thus different perceptions and competency levels may need to carry out the same tasks, which will influence the dependability.

With the introduction of automated functionality, new situational factors may become relevant that are not listed in the standard, such as, trust, situational awareness, and automation etiquette. Lastly, the standard recommends HF methods that are older and does not mention newer methods, such as the CRIOP method (Johnsen et al. 2011) or standards for ROC, such as, the ISO 11064 series.

4.2. *Further work*

Based on the findings described in this paper the AutoSafe project will apply suitable methods to develop and asses dependable design solutions for APF. Different methods will be applied in workshops to ensure safety in all phases of operation.

Acknowledgments

The authors wish to thank the partners in the AutoSafe project for their input and cooperation. The work was supported through the Research Council of Norway, grant nr. 320798 - AutoSafe.

References

Dekker, Sidney. 2014. *The Field Guide to Understanding "Human Error."* 3rd edition, Extended, Re-Organized, Simplified. Boca Raton, FL London New York: CRC Press.

Endsley, Mica R., Barrett S. Caldwell, Erin K. Chiou, Nancy J. Cooke, Mary L. Cummings, Cleotilde Gonzalez, John D. Lee, et al. 2021. *Human-AI Teaming*. *Human-AI Teaming*. National Academies Press. https://doi.org/10.17226/26355.

Fjørtoft, Kay, and Even Ambros Holte. 2022. "Implementing Operational Envelopes for Improved Resilience." In *Proceedings of the International Conference on Applied Human Factors and Ergonomics 2022*. Applied Human Factors and Ergonomics International (AHFE International). https://doi.org/10.54941/ahfe1002507.

Holte, Even Ambros. 2021. "AutoSafe." 2021. https://www.sintef.no/projectweb/autosafe/.

IEC 62508. 2010. "IEC 62508: Guidance on Human Aspects of Dependability." International Electrotechnical Commission.

IMO. 2013. "MSC.1/Circ.1455: Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various Imo Instruments." *MSC.1/Circ.1455* 44 (0).

ISO/IEC CD TR 4569. Under development. "ISO/IEC CD TR 4569 Artificial Intelligence — Functional Safety and AI Systems." International Organization for Standardization, International Electrotechnical Commission.

ISO/IEC TR 24027. 2021. "ISO/IEC TR 24027:2021 Information Technology — Artificial Intelligence (AI) — Bias in AI Systems and AI Aided Decision Making." International Organization for Standardization, International Electrotechnical Commission.

Johnsen, Stig Ole, Cato Bjørkli, Trygve Steiro, Håkon Fartum, Hanne Haukenes, Jasmine Ramberg, and Jan Skriver. 2011. "CRIOP: A Scenario Method for Crisis Intervention and Operability Analysis." Trondheim Norway: SINTEF.

Johnsen, Stig Ole, Christoph Alexander Thieme, Thor Myklebust, Even Holte, Kay Fjørtoft, and Ørnulf J. Rødseth. 2022. "Hazards and Risks of Automated Passenger Ferry Operations in Norway." In *Proceedings of the 13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022)*. https://doi.org/10.54941/ahfe1002312.

Norwegian Maritime Authority. 2020. "Rundskriv 12-2020: Føringer i Forbindelse Med Bygging Eller Installering Av Automatisert Funksjonalitet, Med Hensikt å Kunne Utføre Ubemannet Eller Delvis Ubemannet Drift."

Rausand, Marvin, and Stein Haugen. 2020. *Risk Assessment*. Hoboken, N.J: Wiley. https://doi.org/10.1002/9781119377351.

Reddy, Namireddy Praveen, Mehdi Karbalaye Zadeh, Christoph Alexander Thieme, Roger Skjetne, Asgeir Johan Sorensen, Svein Aanond Aanondsen, Morten Breivik, and Egil Eide. 2019. "Zero-Emission Autonomous Ferries for Urban Water Transport: Cheaper, Cleaner Alternative to Bridges and Manned Vessels." *IEEE Electrification Magazine* 7 (4): 32–45. https://doi.org/10.1109/MELE.2019.2943954.

Stanton, Neville A. 2016. "Distributed Situation Awareness." *Theoretical Issues in Ergonomics Science* 17 (1): 1–7. https://doi.org/10.1080/1463922X.2015.1106615.

Thieme, Christoph Alexander, Marilia Abilio Ramos, Even Ambros Holte, Stig Ole Johnsen, and Thor Myklebust. 2023. "New Design Solutions and Procedures for Ensuring Meaningful Human Control and Interaction with Autonomy: Automated Ferries in Profile." In *Autonomous Vessels in Maritime Affairs - Law and Governance Implications*, 1. Edition. Vol. Vol. 1. Cham, Switzerland: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-24740-8_11.

Thieme, Christoph Alexander, Marilia Ramos, Ingrid Utne, and Ali Mosleh. 2021. "Proceedings of the International Workshop on Autonomous Systems Safety IWASS 2021." Los Angeles, CA, USA: The B. John Garrick Institute for the Risk Sciences. https://doi.org/10.34948/N33019.