Inter-professional simulator training for reliable ship-helicopter interactions

Thomas Lübcke
German Maritime Search and Rescue Service – DGzRS
luebcke@seenotretter.de

Hendrik Wilhelm
Witten/Herdecke University
hendrik.wilhelm@uni-wh.de

Oda Schliebusch-Jacob
German Maritime Search and Rescue Service – DGzRS
schliebusch-jacob@seenotretter.de

Tim Kreter
Witten/Herdecke University
tim.kreter@uni-wh.de

Tanja Martini
German Aerospace Center – DLR
tanja.martini@dlr.de

Torsten Gerlach
German Aerospace Center – DLR
torsten.gerlach@dlr.de

ABSTRACT

This work-in-progress paper presents the preliminary results of an exploratory study on the effectiveness of a simulator training for ad hoc collaboration between sea- and airborne professionals in the field of maritime search and rescue. To enable this training, two different types of simulators were coupled. This coupled simulation environment provided the 49 (preliminary) study participants—seafaring and helicopter professionals—with authentic simulator training conditions. Our training was developed and tested using a two-phase approach. In the first phase, we used qualitative methods to identify requirements and design a training using insights from domain experts. In the second phase—the preliminary results of which are presented here—we tested the impact of the training on the acquisition and transfer of competencies as rated by the participants. To uncover contingencies of these training effects, we explore demographic predictors. We show which set of participants perceived that they benefited most from the training.

Keywords

ad hoc teams, learning, maritime search and rescue, simulation, training

INTRODUCTION

In the event of major incidents, such as natural disasters or major accidents, cross-organizational cooperation—involving, e.g., fire departments, police, rescue services or military—is an effective way to mobilize the necessary resources in a short period of time to save human lives (Hällgren, Rouleau, & de Rond, 2018; Steigenberger, 2016). This requires people from different professions and backgrounds (full-employed rescue workers and volunteers) to solve tasks as an ad hoc team—that is, individuals who collaborate to accomplish a task but do not know each other, and have no prospect of further collaboration (Hollenbeck, Beersma, & Schouten, 2012; Salas, DiazGranados, Klein, Burke, Stagl, Goodwin, & Halpin, 2008)—often under critical conditions (Flin, O'Connor, & Crichton, 2007; Weick & Sutcliffe, 2015; Weick, Sutcliffe, & Obstfeld, 1999; Weick & Roberts, 1993). The organizations that commission these individuals strive for reliability in fulfilling their (sovereign) mission, and thus train these individuals in a standardized manner (International Maritime Organization [IMO], 2014; IMO 2015). Therefore, clearly defined hierarchies, training programs, and internal career paths are characteristic of these organizations. In addition, regular internal training and live exercises ensure that each individual and the organization as a whole are always able to act. In these settings, learning takes place primarily through practical action by systematically reflecting on operations, e.g., in debriefings or by means of after-action reviews (Klein, 2015; Kolb, 2014). These trainings are known to benefit individual's expertise. However, these trainings rarely cover cross-organizational work in ad hoc teams—where different professions from more than one organization are required to collaborate in a critical situation. In consequence, we know little about how rescue workers can be prepared for such incidents. This presents a problem, because large-scale incidents are projected to become more likely as a consequence of climate change (Birkmann, Liwenga, Pandey, Boyd, Djalante, Gemenne, Leal Filho, Pinho, Stringer, & Wrathall, 2022).

This article addresses this relevant shortcoming in previous research. We provide a preview of an ongoing—soon-to-be-completed—study, which analyzes data from a new cross-professional simulator training course (AMARIS[1] training) linking professionals from the shipping industry (shipmasters, nautical officers, and coxswains) and helicopter emergency medical service (HEMS) personnel, i.e. helicopter crews including pilots, medical crew members, and hoist operators. In this study, we seek to explain the AMARIS-induced competence acquisition—i.e., the improvement of professionals' ability to successfully perform cross-organizational work in ad hoc teams—and competence transfer—i.e., the ability to appropriately apply the acquired knowledge in the workplace—of training participants (Blanchard & Thacker, 2023; Shippmann et al. 2000; Thielsch & Hadzihalilovic, 2020). We do this in order to gain an understanding of whether joint simulator training for members of different professions has the potential to prepare them for future ad hoc team collaboration. To maximize practical relevance and impact, we conducted our study in the field of maritime search and rescue (SAR), a setting where cross-professional collaboration is both common in practice but non-existent in training programs. Our study covers three elements: two data collection phases (qualitative and quantitative) and the development of a technical simulator innovation allowing us to train and test inter-professional ad hoc teamwork. Specifically, we coupled[2] the SAR simulator center of the German Maritime Search and Rescue Service (DGzRS) in Bremen with the Air Vehicle Simulator (AVES) of the German Aerospace Center (DLR) in Braunschweig—two fundamentally different types of simulators that serve as a networked training and laboratory environment for the subsequent data collection. AVES consists of three simulators with a Roll-on/Roll-off (RO-RO) cockpit exchange concept and is in operation since 2013. A full motion and two fixed based simulators with large projection systems can carry cockpit modules and interchange them within a few hours. Currently four cockpit infrastructures are available: an Airbus A320, Airbus Helicopter EC135, Advanced Future Cabin (windowless cabin) and Falcon 2000 ISTAR (DLR, 2024). The SAR simulator is based on the networking of five ship handling simulators, two of which can be used multifunctionally: either as a ship, helicopter (tactical) or rescue control center workstations. The system is completed by a Maritime Rescue Coordination Centre (MRCC) cubicle with four workstations including a coastal radio station workstation and two Mobile Operation Stations (MOS), which can be integrated into simulations via Virtual Private Network (VPN) and are also designed to be multifunctional. All simulator cabins are equipped with communication media (e.g., radios, telephone, and e-mail). A central instructor center operates the SAR simulations. While the SAR simulator is used exclusively for training emergency personnel, the AVES is used purely as a research simulator for the development of information and control systems.

There are several previous examples of simulators being networked for research and training purposes. These include the coupling of a ship handling simulator and an engine room simulator at nautical universities or the transnational linking of ship handling simulators in the European Maritime Simulator Network (EMSN) to research safe vessel traffic management (e.g. STM, 2024). Coupling the AVES with the SAR simulator is innovative in its approach, as it is the first to connect simulation environments across organizational boundaries

[1] AMARIS is an acronym for the German project title "Aeronautische und maritime Innovationsumgebung für interorganisationale Simulationen". Information on the project is available from the authors upon request.

[2] AMARIS required a distributed simulation setup across the internet, because the simulators are located in different facilities. While the AVES uses a software environment developed entirely by the DLR, the industrial standard "Distributed Interactive Simulation (DIS)" was used to interconnect both simulators. The SAR simulator works as a host and is capable of reading and writing the DIS-protocol standard. To ensure safety and security during data exchange, a VPN tunnel was used.

and different domains (Figure 1).

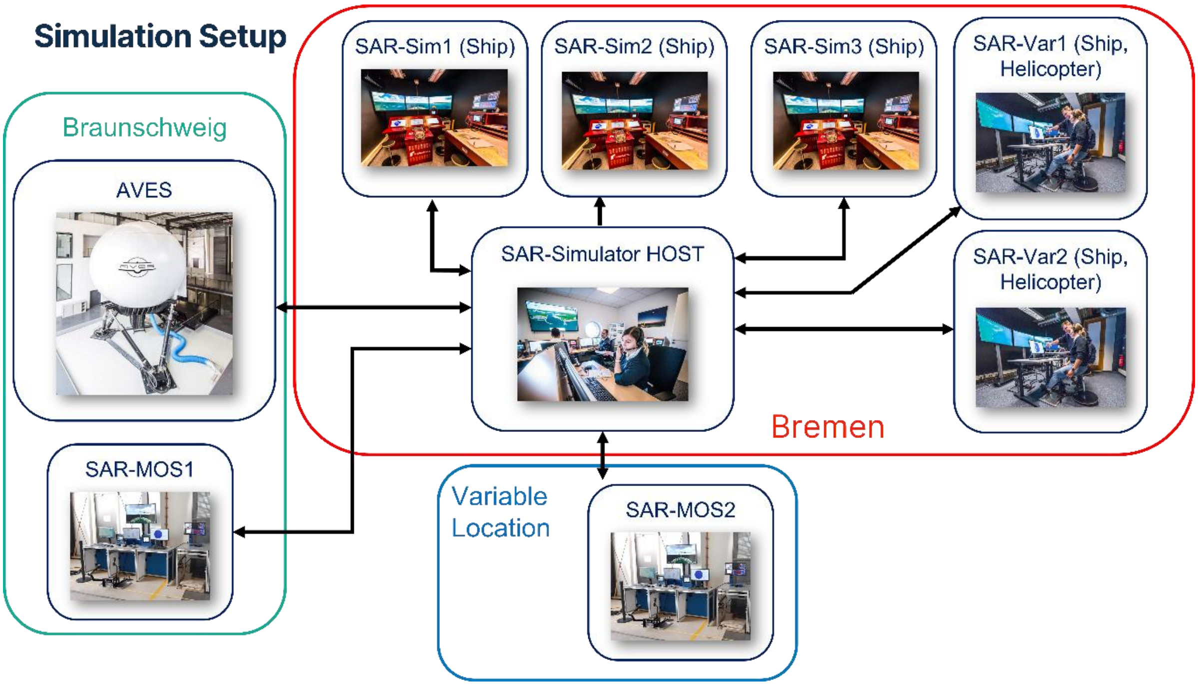

Figure 1. Simulation Setup

With the realization of this innovation, ship crews can train together with helicopter crews in joint scenarios—they can see the other units and have all the means of communication available to them on their real rescue units. In our quantitative study, we evaluate the effectiveness of our training in this innovative simulation environment, by collecting survey data on participants' perceived training success using the Feedback Instrument for Rescue Forces Education (Thielsch & Hadzihalilovic, 2020). This data shows that our training has a positive effect on the acquisition and transfer of competencies as rated by the participants. Additional analysis shows that the extent to which individuals benefit from the training varies based on professional background, age, and tenure. This provides criteria for selecting future training participants to maximize the potential future benefits of the training.

OPERATIONAL BACKGROUND

The close practical relevance of our research has its origins in the operational practice of the maritime search and rescue service in Germany. The authority for this was transferred from the Federal Ministry of Transport to the non-profit organization DGzRS. This organization not only coordinates the rescue operations but also provides the necessary ships (IMO, 2006). In Germany, air support at sea is regulated by a mutual support agreement with the Ministry of Defense, which is responsible for the aeronautical search and rescue service. This means that SAR helicopters from the German Navy are also available on request of the DGzRS for rescuing people in distress at sea. Furthermore—and because international conventions oblige anyone in the vicinity of a maritime emergency to provide assistance—private offshore aviation represent a potential additional resource for DGzRS maritime rescue operations. With the ongoing expansion of offshore wind farms in the German Bight and the western Baltic Sea, these companies are now also present in the German Exclusive Economic Zone. The helicopters of these companies transport people and material to the wind farms or back to shore, and usually have medical personnel on board. The increasing economic use of maritime space for the production of renewable energies therefore generates an increase in the number of ships and helicopters that could assist in rescue operations. Formally, the tactical interaction between these resources in a rescue situation is regulated by an international set of rules. Specifically, International Aeronautical and Maritime Search and Rescue Manual (IAMSAR) published by the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) describes all essential procedures for the search and rescue of human life and is the common action framework for SAR organizations in an international context (IMO & ICAO, 2022). The organizations with a SAR mission—in Germany, the DGzRS and the Naval Air Wing 5—use the IAMSAR Manual as a legally binding tactical interaction framework. In addition, the officers of every merchant ship are required to have a current edition of the IAMSAR Manual at hand, in case their ship finds itself in distress at sea or has to carry out search and rescue operations on site. The situation is somewhat different in aviation. In civil aviation, the IAMSAR Manual does not have to be carried on board, and it is largely unknown to pilots. In the past, this has been repeatedly observed in the operational integration of offshore helicopters in rescue missions and real live exercises: Although offshore helicopters demonstrate continuously excellent skill at rescuing people in distress from ships or from the water, we found deficits in carrying out search operations because the necessary know-how is not mandatory for helicopter pilots. Taken together, these circumstances provide an excellent setting to advance our understanding of training for inter-professional ad hoc teamwork.

Our training is implemented by the DGzRS simulator training crew. For more than 20 years, the DGzRS simulator crew has been training nautical officers and captains of government vessels, in addition to its own emergency crews, to be able to take on leadership roles during maritime SAR operations (e.g., on-scene coordinators [OSC]). Our study draws on this extensive experience. Specifically, the AMARIS multi-day training course mainly takes place at the DGzRS SAR simulator center with participants from different organizations/authorities, with the HEMS professionals joining the training from the DLR facility in Braunschweig. To operationalize ad hoc teams, we randomly allocate seafaring professionals to trainings teams of three. These participants each occupy a simulator cubicle and apply the course content in scenarios of varying complexity. The HEMS professionals in Braunschweig were not subject to this randomization in team allocation, because there is only one cubicle in Braunschweig.

METHODS

In order to develop and test our training concept for inter-professional (seafarer and HEMS professionals) ad hoc teams, we conducted a two-phase study. First, to identify requirements both for such a training concept and a coupled simulator environment, we conducted an exploratory qualitative data collection using 25 semi-structured, guided interviews. Second, to test the effectiveness of our training concept, we enrolled a preliminary number of 49 unique participants (40 seafaring professionals, 9 HEMS professionals) and subjected them to the training protocol using the linked DGzRS and DLR simulators. In this phase of our data collection, we asked the participants to complete a survey after completing the training. The following paragraphs provide a detailed account of both phases of data collection and analysis.

In study phase one—our interview study—we approached individuals knowledgeable about the phenomenon we intended to study: We interviewed SAR stakeholders, such as helicopter pilots (13) and coxswains of rescue cruisers (8), but also safety officers (2), trainers (1), and training representatives from the participating organizations (1). We decided to use the data collection method of semi-structured interviews, because they offer the advantage of providing comparable responses across cases but can also be adapted to the background and experiences of the interviewees, thus allowing for additional exploration if needed. This is because semi-structured interviews allow for follow-up questions on individual aspects and any ambiguities can be clarified immediately (King, Horrocks, & Brooks, 2019). The interviews were conducted virtually[3] and were recorded and transcribed in accordance with both methodological (Miles, Huberman, & Saldaña, 2020) and data protection guidelines. The interview guideline was developed interdisciplinary, taking into account aeronautical, maritime SAR, and behavioral science perspectives at the same time. It covered items such as description of a recent and demanding incident concerning procedure, key aspects of ship – helicopter teamwork in SAR operations, and assessment of occurring challenges and how they were solved. To provide specific instances where inter-professional ad hoc teamwork is needed, special emphasis was placed on the consideration and description of various hoisting procedures and typical challenges and possible misunderstandings between helicopter pilots and coxswains when carrying out a hoisting maneuver. Another key focus was put on the technical set up of a joint simulation environment. Helicopter pilots as well as coxswains were asked to describe key features which they would like to see in a shared simulation environment. This information was essential to our technical development of a linked simulator environment. Overall, we collected 33 hours of interview data. On average, each interview lasted 78 minutes (min: 48; max: 113). We processed our interview data using content analysis. Our analysis of the qualitative data revealed that although the IAMSAR Manual Vol. III (IMO & ICAO, 2022)—as international SAR standard—regulates the cooperation between seafaring and flying units during missions, relevant regulations were not always sufficiently well known by interviewees, especially among commercial offshore pilots. Flying and seafaring units partly show significant differences in standard operation procedures and in communication routines. We found that this can have a negative impact on the quality of cooperation when carrying out both standard search procedures and hoisting maneuvers. For example, interviewees reported that when conducting

[3] We conducted the interviews virtually due to the COVID pandemic. To ensure interoperability and good data quality, we used the Microsoft Teams platform and its recording capabilities.

hoisting maneuvers, they found it essential that the processes run smoothly and that everyone involved can rely on each other. We also found that although these operations were often practiced under real conditions, the interviews expressed low confidence in their knowledge of the working conditions of the other unit (helicopter or rescue cruiser). Thus, the main result of study phase one was the identification of specific challenges and needs for improvement of joint SAR operations involving helicopters and rescue cruisers. The interview data also provided requirements for realizing a linked simulation environment for aeronautical and maritime SAR training, which informed our technical implementation of the simulator coupling.

We used the findings from study phase one, as well as additional expert workshops, to derive the training concept ("AMARIS Training"). Two workshops involving various SAR experts with either maritime or aeronautical background were conducted to identify and refine both training objectives and corresponding learning objectives. The first expert workshop started with defining the *key objective* of the AMARIS training ("Coordination of multiple [air and sea] units to manage a maritime SAR situation on the basis of IAMSAR III"). On this basis, the learning objectives and the training content to be derived from them were developed gradually and with an increasing level of detail. Using the example of the training objective ”Raising awareness of the capabilities and characteristics of seagoing and flying units“, the training content includes, for example, "imparting knowledge about the definition of operational limits", "recognizing dangerous situations in practice", and "reacting appropriately to the use of an emergency procedure by the other unit". All learning objectives and training content have to be considered both from an intra-profession and a cross-profession perspective. This means though the AMARIS training aims to improve ship-helicopter interaction, training effects in intra professional cooperation can also be expected.

The second workshop was centered on developing the AMARIS simulator scenarios. These were designed with a focus on the AMARIS learning objectives as well as the knowledge and skills previously identified. We collaborated with groups of aeronautical and maritime SAR experts, with the assistance support of the SAR simulator trainer team, to develop three scenarios. These scenarios varied in task complexity, starting from a less-complex ”starter scenario“ to a highly-complex major incident. We conducted multiple check-ups to ensure that all previously identified training objectives, knowledge, and skills were incorporated and trained in these scenarios. Once the training scenarios were finalized, we created written training materials. These training materials covered basic and advanced SAR knowledge (e.g., search patterns) as well as information on the special objectives of the AMARIS training.

Finally, an extensive testing and programming work took place in parallel with the content design of the training program to ensure the technical framework conditions (Szczygielski, Gerten, & Wilhelm, 2021).

Procedures and Participants

In study phase two—the testing of the effectiveness of the AMARIS training—we implement the AMARIS training using seafaring and HEMS professionals. We first provide information on the course of the training before describing our study sample. The AMARIS training contains two elements: First, an initial online information session with participants and representatives of the AMARIS project. This session was organized to ensure that both groups of participants (seafaring and HEMS professionals) were well-informed about the theoretical SAR basics, the specific objectives of the AMARIS training, and the research data collection. The session also provided details on data protection and allowed future participants to clarify related questions to ensure informed consent. Second, the AMARIS training in the two linked simulators (DGzRS in Bremen, DLR AVES in Braunschweig). Each training starts with signing the data protection agreement, followed by blocks of theoretical and practical instructions in data collection and simulator handling. Hybrid sections via a virtual communication platform alternate with separate instructions in Bremen and Braunschweig. All scenarios start with a joint virtual briefing and conclude with a virtual debriefing session connecting all teams in Bremen and Braunschweig. In the default mode, each training sessions covers three ship cubicles with teams of three seafaring professionals each in the SAR simulator in Bremen and three HEMS professionals (pilot, co-pilot, hoist operator) in the AVES simulator in Braunschweig, thus matching our theoretical interest inter-professional work. To ensure that (most of) our study participants operated in ad hoc teams, participants in the ship cubicles switched crew compositions for every scenario. As there is only one helicopter crew in the AVES simulator, this crew composition remained constant. Please note however that the inter-professional collaboration between ships—due to their changing crew composition—and the helicopter also operationalizes ad hoc teamwork. The simulator was operated by a team of 3-4 instructors with the support of 1-2 representatives of the Aeronautical Rescue Coordination Centre Glücksburg, Germany (ARCC). These individuals oversaw the training from the instructor room in Bremen, simulating foreign ships, the MRCC, and the ARCC. Data collection, storage, and analysis were performed exclusively by the university research team in accordance with the study's data protection protocol. We pretested the AMARIS training and data collection three times using instructors from sailing and water sports schools. These pretests resulted in minor modifications of the study protocol.

At the time of writing, 50 participants from various organizations participated in five AMARIS training sessions. Because one participant had to leave the AMARIS training early due to professional commitments, our preliminary sample consists of 49 individuals. Seafaring professionals came from the DGzRS (permanent [17] and volunteer [7] sea rescuers), further participants were also professional seafarers with theoretical and practical expertise in participating in sea rescue operations (16). Helicopter pilots came from the Navy (6), from (commercial) offshore helicopter service companies (2), and from general air rescue service providers (2). The heterogeneity in participants' organizational backgrounds provides an ideal match with our interest to study inter-professional ad hoc teams. On average, participants had worked for their organizations for 9 years (SD = 9.26) and in their jobs for 6 years (SD = 8.07). The mean age was 44 years (SD = 11.22). The gender distribution of 45 (91.84%) males is consistent with the gender distribution in the seafaring profession.[4]

Measures

We collected data on study participants' demographics, professional background, and—after completing the AMARIS training—perceived training effectiveness. These data were collected using a survey. Prior to the data collection, we discussed the survey with representatives of the professional groups involved in the AMARIS study, and we pretested scales with individuals who did not participate in the main study. This pretest consisted of a think aloud protocol to receive structured feedback on the validity and comprehensibility of the scales (Sudman, Bradburn, & Schwarz, 2010).

Outcome. To measure the perceived effectiveness of the AMARIS training, we asked participants to complete the Feedback Instrument for Rescue Forces Education, which we provided as a validated German translation (Thielsch & Hadzihalilovic, 2020). This instrument allows participants to subjectively assess their perceived training success, providing important information on the effectiveness of the AMARIS training. To ensure valid responses, the wording of the items was slightly adapted from the instrument's original firefighting context to our SAR context. Overall, the instrument covers six subscales—Trainer Behavior, Overextension, Structure, Group Behavior, Competence Acquisition, and Transfer—relevant to the AMARIS training evaluation. Answers ranged from 1 ("strongly disagree") to 7 ("strongly agree"). For each subscale, the corresponding items formed a single scale (Trainer Behavior: Cronbach's $\alpha = 0.71$, Overextension: Cronbach's $\alpha = 0.92$, Structure: Cronbach's $\alpha = 0.90$, Group Behavior: Cronbach's $\alpha = 0.83$, Competence Acquisition: Cronbach's $\alpha = 0.96$, Transfer: Cronbach's $\alpha = 0.75$). For this preliminary report, we focus on the two outcome subscales, i.e., self-rated Competence Acquisition and Transfer (Blanchard & Thacker, 2023).

Independent Variables. To identify which individuals perceived to benefit more—and which ones less—from the AMARIS training, we focused on established demographic and job predictors of training outcomes (Nazir, Jungefeldt, & Sharma, 2019; Sellberg, 2017; Colquitt, LePine, & Noe, 2000). Specifically, we tested for differences in the outcome for the following grouping variables: Age, Tenure (Organization), Tenure (Job). To create grouping variables for these variables, we conducted median splits. This procedure resulted in the following independent grouping variables: Age (younger: 25 years – 42 years, older: 43 – 69 years), Tenure Organization (low tenure: 0 – 5 years, high tenure: 6 – 32 years), Tenure Job (low tenure: 0 – 3 years, high tenure: 4 -32 years), and trainees' formal Education (1 = Secondary School, 2 = Intermediate Maturity, 3 = University Entrance Qualification, 4 = Graduate). We do not examine trainee gender due to the limited variance in this demographic in our current sample. However, we tested whether DGzRS Status (0 = non-DGzRS, 1 = DGzRS Volunteer, 2 = DGzRS Employee) explains differences in the outcome variables.

RESULTS

All analyses presented below were performed in Stata 16.1. Table 1 displays descriptive statistics and correlations among our study variables. The directions of the significant correlations are in the expected directions. In addition, as expected, we observe strong correlations between tenure organization and tenure job ($r = 0.72$). Since we do not present a multivariate analysis in this preliminary report, this unsurprising correlation is not a cause for concern.

[4] According to the Baltic and International Maritime Council & the International Chamber of Shipping (2021), women worker represents 1.28% of the global workforce in the shipping industry. The International Transport Workers' Federation (2024) states, the global proportion of female workers in the maritime sector is 2%.

Table 1. Means, Standard Deviations, and Correlations

	Mean	SD	1	2	3	4	5	6
1. Age*	1.47	0.50						
2. Tenure Organization*	1.49	0.51	0.39					
3. Tenure Job*	1.43	0.50	0.34	0.72				
4. Education	3.35	0.80	-0.26	0.03	0.19			
5. DGzRS Status	0.84	0.92	0.35	0.40	0.34	-0.29		
6. Competence Acquisition	4.38	1.58	0.29	-0.31	-0.05	-0.10	0.12	
7. Competence Transfer	4.95	1.32	0.16	0.15	0.41	-0.01	0.28	0.38

n = 49, correlations larger than |0.29| are significant at p < 0.05.

* Dummy variables based on median-split (1 = low, 2 = high).

To show the extent to which trainees perceived the AMARIS training to benefit their competence acquisition and transfer, Table 1 provides corresponding descriptive statistics. Table 1 shows an average Competence Acquisition of 4.38 (out of 7). The standard deviation for Competence Acquisition is 1.58, suggesting relevant variance in the participants' perception. The participant's average Competence Transfer (4.95) exceeds average Competence Acquisition, and a slightly smaller standard deviation (1.32), suggesting that the training offers relevant insights for advanced professionals with practical expertise. To better understand which trainees perceive that they benefit more (or less) from the AMARIS training, we performed the non-parametric Wilcoxon rank-sum tests for all binary independent variables. For the two categorical independent variables (Education, DGzRS Status), we conducted Kruskal-Wallis tests.

For Competence Acquisition, we found that trainees with higher Age had a significantly higher level than trainees with lower Age (p = 0.05). Figure 2 provides a strip plot illustrating this result. In contrast, trainees with low Tenure in their Organization had a marginally significant higher level of perceived Competence Acquisition than trainees with high Tenure in their Organization (p = 0.06). Figure 3 provides a strip plot illustrating this result. Surprisingly, we observe that trainee Tenure in the Job does not appear to explain any of the variance in this outcome (p = 0.83). We also do not observe significant differences in perceived Competence Acquisition for different levels of Education (p = 0.81) or DGzRS Status (p = 0.82).

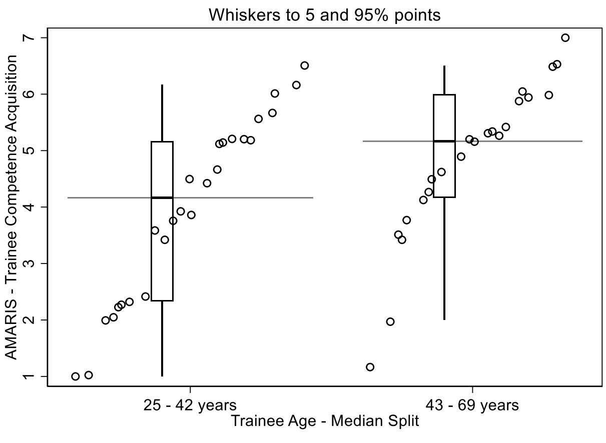

Figure 2. Competence Acquisition and Age

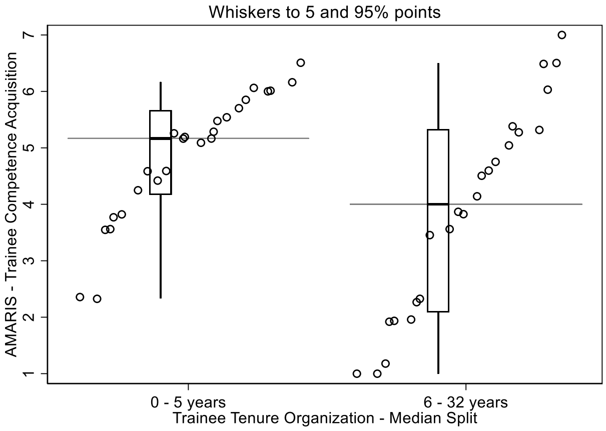

Figure 3. Competence Acquisition and Tenure Organization

For Competence Transfer, we found no significant difference between trainees with higher and lower Age (p = 0.32) and Tenure in their Organization (p = 0.21). However, our results show that trainees with high Job Tenure had significantly higher levels of perceived Competence Transfer than trainees with low Job Tenure (p = 0.01). Figure 4 provides a strip plot illustrating this result. We do not observe significant differences in perceived Competence Transfer for different levels of Education (p = 0.45) or DGzRS Status (p = 0.11).

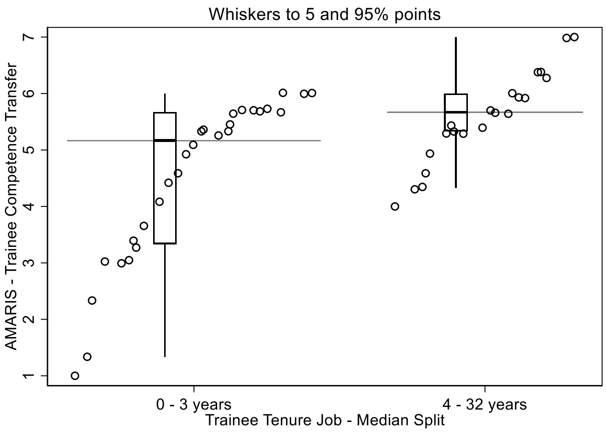

Figure 4. Competence Transfer and Tenure Job

Taken together, the results for Competence Acquisition are consistent with the notion that older trainees with limited exposure to their current organization perceive themselves as particularly benefiting from the AMARIS training. The results for Competence Transfer are consistent with the argument that trainees with more extensive work experience in the maritime or aviation environment have more extensive mental representations of situations to which they can relate the AMARIS training material and experiences. In addition, as suggested by the non-significant results for both outcomes and Education and DGzRS Status, the AMARIS training does not appear to be exclusive in terms of formal education or professional SAR affiliation, suggesting that the training is inclusive in nature.

DISCUSSION AND CONCLUSION

The data available to us so far shows that the AMARIS training tested in our study is perceived as effective as a cross-professional qualification program. This is a promising initial result, suggesting that the previously identified training needs and critical mission situations cover relevant issues, and that the AMARIS training effectively addresses those issues. We were able to demonstrate that participants perceived that they gained skills from the simulator training, regardless of their age and professional experience. However, the results need to be scrutinized closely, as we found that older participants, in particular, gained more competencies overall than younger training participants.

This is significant as older professionals are often difficult to reach with simulator training courses (Gully & Chen, 2010) as these professionals often do not consider such courses to be ”real live” or “hands-on“. Two conclusions can be drawn from this, although additional data and analyses are required: First, our simulators may have created a level of immersion that allowed all participants to perceive the situations created in the scenarios as authentic and to engage with them. This would be positive a training-inherent effect, as it could provide effective starting points for inclusive simulator training.

Second, the older participants may have a deeper understanding of the factual necessity of specifically training the topic of cross-professional collaboration (e.g., “effective ship-helicopter interaction”), so that potential concerns or reservations about simulator training may have simply faded. We therefore find a greater awareness of the importance of knowledge among the older study participants, which indicates an increasing level of professionalization over the course of their professional lives.

A surprising result for us was the significant correlation between the length of time spent in the organization—i.e., Tenure: Organization—and Competence Acquisition: participants who have been with their current organization for longer showed a lower level of competence acquisition than people who have only recently started working for their organization. The question of whether this could be due to motivational- or competency-related causes affected by the organizational tenure would have to be investigated using a larger sample, multivariate methods, and potentially additional data sources.

PRACTICAL IMPLICATIONS

The cross-domain networking of two different simulators implemented in the AMARIS project offers the possibility of linking the SAR Simulator Center with other flight simulators. This will allow the implementation of joint training content and new transdisciplinary training formats in the future, but it will also open up new research and development opportunities: The cross-disciplinary simulation of complex rescue missions suggests to be a promising laboratory environment for testing communication paths, operational procedures, and information systems with emergency personnel and obtaining well-founded end-user feedback. the possibility of operating prototypes of newly developed assistance systems during the simulation show great potential for researchers to bring innovation and end users together at an early stage.

LIMITATIONS

Our study does have limitations. Some will be addressed in our full manuscript, while others may inspire future research. First, this preliminary study analyzes a relatively small data set. To provide a robust analysis with our current number of observations, we rely on simple statistical tests. We are aware that we are currently using binary predictors (by means of median splits), and we cannot use control variables to account for potential omitted variable bias. While seafarers were randomly allocated to teams, our study is not an experiment, as it does not have control and experimental conditions. Thus, using multivariate methods once our data set is sufficiently large is our next step to rule out such issues. Second, due to limitations in both the simulator setup and the availability of helicopter pilots, we could not randomize team allocations among helicopter staff within each experiment. Future research should attempt to overcome this shortcoming by operating in settings with sufficiently large populations to ensure full randomization of participants.

ACKNOWLEDGMENTS

The joint research and development project AMARIS is part of the Security Research Program of the German Government and funded by the German Federal Ministry of Education and Research (BMBF), grant no. 13N15500, 13N15501, and 13N15502.

REFERENCES

Baltic and International Maritime Council & International Chamber of Shipping (2021). *Seafarer workforce report 2021*. July 2021.

Birkmann, J., E. Liwenga, R. Pandey, E. Boyd, R. Djalante, F. Gemenne, W. Leal Filho, P.F. Pinho, L. Stringer, & Wrathall, D. (2022): *Poverty, livelihoods and sustainable development*. In: *Climate Change 2022: Impacts, adaptation and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1171–1274. https://doi.org/10.1017/9781009325844.010

Blanchard, P.N., & J.W. Thacker (2023). *Effective training: Systems, strategies, and practices*. (7th ed.) Thousand Oaks: SAGE.

Colquitt, J. A., LePine, J. A., & Noe, R. A. (2000). Toward an integrative theory of training motivation: A meta-analytic path analysis of 20 years of research. *The Journal of Applied Psychology*, *85*(5), 678–707. https://doi.org/10.1037//0021-9010.85.5.678

DLR – German Aerospace Center (2024). *AVES motion simulator.* https://www.dlr.de/de/forschung-und-transfer/forschungsinfrastruktur/grossforschungsanlagen/aves-motion-simulator, (2024-04-12).

Flin, R. H., O'Connor, P., & Crichton, M. (2007). *Safety at the sharp end: Training non-technical skills.* Aldershot: Ashgate.

Gully, S & Chen, G. (2010). Individual differences, attribute-treatment interactions, and training outcomes. In: Kozlowski, S. W. J., & Salas, E. (2010). *Learning, training, and development in organizations. The organizational frontiers series*. New York: Routledge, pp. 3–64.

Hällgren, M., Rouleau, L., & de Rond, M. (2018). A matter of life or death: How extreme context research matters for management and organization studies. *Academy of Management Annals*, *12*(1), 111–153. https://doi.org/10.5465/annals.2016.0017

Hollenbeck, J.R., Beersma, B., & Schouten, M.E. (2012). Beyond team types and taxonomies: A dimensional scaling conceptualization for team description. *Academy of Management Review* 37(1), 82-106.

International Maritime Organization & International Civil Aviation Organization (2022). *International aeronautical and maritime search and rescue manual: IAMSAR Manual Vol. III: Mobile facilities*. *IMO publication*. London: IMO.

International Maritime Organization (2015). *GMDSS Manual: Global maritime distress and safety system* (8th ed.). *IMO publication*. London: IMO.

International Maritime Organization (2014). *SAR on-scene coordinator (IAMSAR Manual, Volume III)* (2014 ed.). *Model course: Vol. 3.15*. London: IMO.

International Maritime Organization (2006). *SAR convention: International convention on maritime search and rescue, 1979; as amended by resolutions MSC.70(69) and MSC.155(78); 2006 edition* (3rd ed.). *IMO publication*. London: IMO.

International Transport Workers' Federation (2024). *Women seafarers*. https://www.itfseafarers.org/en/issues/women-seafarers, (2024-02-07).

King, N., Horrocks, C., & Brooks, J. M. (2019). *Interviews in qualitative research* (2nd ed.). Los Angeles: SAGE.

Klein, G. (2015). A naturalistic decision making perspective on studying intuitive decision making. *Journal of Applied Research in Memory and Cognition*, *4*(3), 164–168. https://doi.org/10.1016/j.jarmac.2015.07.001

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. Upper Saddle River, NJ: Pearson Education.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). Los Angeles: SAGE.

Nazir, S., Jungefeldt, S., & Sharma, A. (2019). Maritime simulator training across Europe: A comparative study. *WMU Journal of Maritime Affairs*, *18*(1), 197–224. https://doi.org/10.1007/s13437-018-0157-0

Salas, E., DiazGranados, D., Klein, C., Burke, C. S., Stagl, K. C., Goodwin, G. F., & Halpin, S. M. (2008). Does team training improve team performance? A meta-analysis. *Human factors, 50(6),* 903-933. https://doi.org/10.1518/001872008X375009

Shippmann, J. S., Ash, R. A., Batjtsta, M., Carr, L., Eyde, L. D., Hesketh, B., Kehoe, J., Pearlman, K., Prien, E. P., Sanchez, J. I. (2000). The practice of competency modeling. *Personnel Psychology, 53(3)*, 703-740.

STM – Sea Traffic Management (2024). https://www.seatrafficmanagement.info, (2024-04-12).

Sellberg, C. (2017). Simulators in bridge operations training and assessment: A systematic review and qualitative synthesis. *WMU Journal of Maritime Affairs, 16*(2), 247–263. https://doi.org/10.1007/s13437-016-0114-8

Steigenberger, N. (2016). Organizing for the big one: A review of case studies and a research agenda for multi-agency disaster response. Journal of Contingencies and Crisis Management, 24(2), 60–72. https://doi.org/10.1111/1468-5973.12106

Sudman, S., Bradburn, N.M., & Schwarz, N. (2010). *Thinking about answers*. San Francisco: John Wiley.

Szczygielski, T., Gerten, E., & Wilhelm, H. (2021*). AMARIS Schulungskonzept.* Universität Witten/Herdecke.

Thielsch, M. T., & Hadzihalilovic, D. (2020). Evaluation of fire service command unit trainings. *International Journal of Disaster Risk Science*, *11*(3), 300–315. https://doi.org/10.1007/s13753-020-00279-6

Weick, K. E. & Sutcliffe, K.M. (2015). *Managing the unexpected: Sustained performance in a complex world.* Hoboken: Wiley.

Weick, K. E., Sutcliffe, K.M., & Obstfeld, D. (1999). Organizing for high reliability: Processes of collective mindfulness. *Research in Organizational Behaviour, 21*, 81-123.

Weick, K. E., & Roberts, K. H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*(3), 357-381. https://doi.org/10.2307/2393372