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_P498-cd

Adopt or adapt? Seafaring communities of practices faced with increased automation

Asbjørn L. Aalberg

Industrial Economics and Technology Management, NTNU, Norway. E-mail: asbjorn.l.aalberg@ntnu.no

Aud M. Wahl

Industrial Economics and Technology Management, NTNU, Norway. E-mail: aud.wahl@ntnu.no

Gunnar M. Lamvik

Industrial Management, SINTEF Digital, Norway. E-mail: gunnar.lamvik@sintef.no

This study explores how we can understand seafarers' continuous development of local work practice in the face of new technology and discusses potential safety implications. Maritime transportation is undergoing rapid developments within maritime autonomous surface vessels (MASS), remote-control, and resulting in increasingly "smart ships". Maritime professionals and communities will remain crucial in the safe operation of these systems; however, the seafarers must learn new roles and work practices simultaneously with major changes in the sociotechnical systems. It is necessary to consider the impact of new technology from a social perspective, as emerging safe work practice is a collective accomplishment rooted in the context of interaction, situated in a system of ongoing practices, and adapted or adopted through participation in a community. The paper is based on a qualitative study that includes interviews with crew and participant observation on six car ferries using state-of-the-art automated systems and battery-electric propulsion. The findings show that seafarers adapt their work and learning practices through their physical and virtual community of practices. The automated technology was applied in ways that were discrepant to "imagined" and can be seen as practical drift. We discuss how these adaptations were developed and the potential safety effects, as well how we can understand seafarers' social system considering the increasing technological development in maritime transportation.

Keywords: maritime autonomous surface vessels, automation, safety, maritime, work as imagined, work as done, practical drift, community of practice.

1. Introduction

Seafarers face radical changes to their work environment and work tasks in the years to come due to the development of maritime autonomous surface vessels (MASS) and remote-control centres. This is leading to increased digitalisation and automatization of ships. Maritime professionals will remain crucial in the safe operation of autonomous ships; however, the seafarers must learn new roles and work practices simultaneously with these major changes to the sociotechnical systems within their lifeworld.

Seafarers have been regarded as a relatively self-driven communities sharing identities, practice and engaging in mutual learning (Lamvik 2012, Lamvik et al. 2009, Pareliussen, 2021). It is therefore necessary to consider the impact of new technology from a social perspective. There is a need for more research on how these changes to the technology, work and organizational context impact safe work practice. In this qualitative study, we address how seafarers adapt their practices when faced with the implementation of digitalised and automated technology found in auto-crossing and auto-docking systems onboard Norwegian car ferries. This is done by exploring the following research question: *How can we understand seafarer's continuous development of local work practice in the face of new technology?*

1.2. *Technological context: automated ferries*

Car and passenger ferries constitute a critical part of Norwegian infrastructure connecting remote geographical areas, such as islands, to the mainland. Ferries are a special type of maritime transportation, considering their repetitive sailing routes close to the inland, that for example influences the possibility of seafarers to sleep at home if they live close by. This is in contrast with e.g. deep sea shipping, however, many seafarers working on ferries have a background from other vessel types. The closeness to onshore also involves a better technological connectivity and possibility of support from other professions or vessels.

The ferries in this study are equipped with automatic crossing (auto-crossing) and automatic docking (autodocking). These shipboard systems ensure that a ferry stays on the pre-planned route with fixed waypoints, arriving at set timestamps by controlling acceleration, retardation, speed, and route, and thus reducing the need for manual steering. The ferries also have a new form of propulsion, with battery-electric energy instead of diesel, although still using diesel as backup. As part of the battery-electric technology, an automated vacuum mooring technology is installed at each dock on the connection, which the bridge officer initiates from the bridge during docking.

2. Theoretical background

The introduction of MASS means that the seafarers must learn new ways of working that implies a change in their communities of practice. Learning within a maritime professional community traditionally relates to the development of seafarers identify as crew members assimilate certain depositions, attitudes, and beliefs as part of belonging to the crew community. In the following we describe the social systems of seafarers; local work practice as continuous adaption and how new technology relates to these adaptions.

2.1. *The social "system" of seafarers*

Anteby, Chan and DiBenigno (2016) proposes three analytical lenses to better understand different aspects of a professions and distinguish between *becoming* av a member of a community, practicing professions as in *doing* and understanding the relationship between a profession at its surroundings as in *relating*. Lave and Wenger (1991) coined the term communities of practice (CoP) to describe how meaning is negotiated and reflected in the practices of groups of professionals. They describe learning as a social process taking place in a participation framework and structured by the tools available in specific situations. The concept can be used to explore both professional and organizational behavior and learning. Following Gherardi (2017), safe work practice among sharp end operators can be understood as an emerging collective accomplishment rooted in the context of interaction, situated in a system of ongoing practices, and adapted or adopted through participation in a community.

According to Koliba and Gajda (2009) a community of practice can be said to exist when three criteria are met; the members of a group share a common set of characteristics such as roles, goals or expertise; the members can interact directly with each other in a physical or virtual space; the members possess a common domain, practice or set of practices. A central concept following the CoP perspective is 'situated learning' and the relationship between experienced and inexperienced members of a community such as in apprenticeship and mentoring relationships or peer-to peer learning. Dialogue is a central aspect of cultivating an effective community of practice, whether it is face- to-face or via electronic tools, this includes storytelling and narrative development and adoption of a common language (Koliba and Gajda 2009).

According to Wenger (2011:1) CoP are 'groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly'. In this line of thought, most seafarers participate in numerous CoP's. Some of them might share some common features such as a geographical proximity, shared artifacts, members or related enterprises and configurations of CoP's can be considered constellations of CoP's (Clarkin-Phillips, 2011).

Noordegraaf (2020) claim we will see an increase in heterogeneity and fragmentation within professional fields such as navigators or engine room engineers caused by interweaving of professional fields and dependencies of other professional in daily work. This will lead to a 'connected professionalism' that exist between and among connected actors rather than within a profession. This shift requires more knowledge of how professional fields are changing and how professional actions, authority and expertise become more relational. Pareliussen et.al. (2021) discusses how new technology in the maritime sector impact connectiveness between professionals. He argues that technology can lead to more connectivity and input from other professionals in other sectors, such as equipment manufacturers.

Supporting this notion, Lamvik, Wahl and Buvik (2009) investigated good operation practices among deck and engine room officers and argued that a strong community of professionals at a ship may explain why onboard work practices is different from what is specified in the company's standard operating procedures.

4.2. *Local work practice as continuous adaption*

Snook (2000) coined the term 'practical drift' to describe a slow, but steady, uncoupling of local practice from written procedures where locally efficient behaviour becomes accepted practice. He claimed that 'over time, globally designed but locally impractical procedures lose out to practical action when no one complains' (Snook 2000:185). This can be compared to what Reason (1997) described as 'necessary violations' where sharp-end operators optimize their workload by finding a balance between procedures and experience-based problem solving. This may lead to a gap between preferred and actual work practice and eventually a difference in how work is imagined or thought of and how work is actually done onboard a ship. This can be referred to as WAI (*work as imagined*) and WAD (*work as done*) (Dekker 2006: Hollnagel, 2014).

According to Hollnagel, this dichotomy often wrongly implies than one is right and the other is wrong. WAD is often seen as a less effective way of doing things while WAI is expected to be the safe and efficient procedure. This suggests that the difference between WAI and WAD is a problem that need to be eliminated and that the best solution is to force WAD to comply with WAI. He explains that a perfect match between WAI and WAD is not the solution in order to maintain safety, rather the aim is to understand what determines how work is carried out and to find effective ways of managing the variability of WAD within acceptable limits.

4.3. *New technology and local adaption*

Considering the context of adaptations to work, we will now turn to theory that might help explain how technology is adopted or adapted into organizations and practitioners.

In a so-called constructive approach, also known as the SCOT perspective (Social Construction of Technology), one can describe the adoption of technology as relying upon relevant social groups (Bijker et.al. 1989). All new innovations need a group of people who actual take the new tools and techniques into use, and at the same time though this activity these people indirectly decides the design and specification of the new innovation.

Lützhoft (2004) labelled seafarers' efforts in making technology function as *integration work*. She argued that mariners create a co-operational system by re-building the systems to become understandable. Moreover, seafarers often want control – and seeks to find ways that technology could provide it. However, automated systems are more complex and therefore, knowing how to make a system work, especially in case of malfunction, is harder.

Cook & Woods (1996) highlight in their studies that such integration work consists of two intertwined adaptations: *the system tailoring* (technology) and *the task tailoring* (practice). They argue that professionals are active agents and not passive technology users. By configuring the technology, they reduce may cognitive workload on themselves, and by changing their practice they might ensure a smooth interaction while obliging to the invariable features of the technology. The altering of systems might however pose a safety risk, especially if automated systems are intertwined with others.

3. Method

This work is based on a qualitative study that includes nine days of field work on six domestic car ferries in Norway using state-of-the-art automated systems (automatic crossing and docking) and battery-electric propulsion. We typically spent 1,5 days on each of the six ferries on three different connections, operated by two shipping companies.

Primary data consisted of open and semi-structured interviews with 33 maritime crew members, including 19 bridge crew officers, 9 engine crew and 5 deck crew. In the analysis, we primarily used the interviews with bridge crew officers. We conducted observation using participatory transects and shadowing (Czarniawska, 2018), observing normal operation, troubleshooting work, coffee breaks, hand-over situations among other work situations. Informed consents were obtained and approximately 1/3 of the interviews were audio recorded and transcribed. Data was analysed by means of inductive coding through adapted guidelines of thematic analysis (Braun & Clarke, 2006). The study was approved by the appropriate data ethics institution in Norway.

4. Findings

In this section we highlight how the seafarers adapted and shared practices within their communities using illustrative examples from observed practice and the interviews.

4.1. *Findings new ways to use the technology*

For the bridge crew, auto-crossing and auto-docking, vacuum mooring and charging of batteries were the most important elements to learn how to use and apply in practice. Typically, from the outset some procedures with key points were set by the shipping company, indicating how to use the system. Then, the 10-15 navigators on a connection experimented towards finding the best way to sail during operation. Such adaptations to practice seemed to be independent of company or system developers' advice, intentions or design. The seafarers adapted the technology by optimizing when to apply it and moved beyond the initial guidelines.

When sailing with auto-crossing, alarms will go off when approaching the docking area, telling the navigator to take over manual control or engage the auto-dock system if available. Without intervention, new alarms go off. In case of no human intervention after a certain number of alarms, the system would put the ferry in a "fail-safe" stand-still mode. The seafarers found out that they could have a more convenient and energy-saving approach to quay by overlooking some alarms, as illustrated by the following quote from a captain:

"*If I take over [manual control] at the first alarm, I have to remember to accelerate a bit so it does not go into maneuver mode instead of transit. Therefore, I like to intervene at 3 to 4 alarms so I get a better transition and can glide into the dock.*"

Thus, through such fine-tuned adaptations crew optimized when they would take over manual control, by trial and error, and discussions with peers. The navigators on different boats, but on same connection, talked with each other to learn and find best practices; "*This is something we [the navigators on the connection] have talked about. I believe everyone does it like this.*"

Even the stand-still mode was explored in their new practices. For example, in case of queue for docking at the quay, the captain normally needed to micro-maneuver the ferry to stand-still, which demanded constant attention and control. By themselves, they figured out that they could apply the stand-still mode in such situations, which enabled them to leave this task to the automated system and consequently relieve cognitive resources towards outlook or other tasks. This use of the system was not prescribed in procedure or manuals from the system provider or shipping company. They tested the stand-still mode somewhat impulsive on a "calm evening", both in terms passengers and weather simply refusing to attend to alarms. This story was told to us from several shifts, indicating that it was something that had been shared among the crews.

4.2. *Sharing insights through dialogue*

To create new work practices and share the knowledge to enable safe work with the technologies, the seafarers engaged with each other.

Seafarers often talked to each other about work. Exchanges of information and knowledge could also happen via e-mail or, more often, through informal telephone calls between navigators on watch on two ferries going in parallel. Informants told us that they often spoke to other navigators for instrumental purposes (for example giving information about planned maintenance for the vessels), as well as just to have a chat if they were bored. We observed how the telephone calls included both the aspect of helping each other finding a good practice and serving the interpersonal relationship between colleagues. In the following example, a troubleshooting situation occurred at one of the connections where several ferries were sailing.

At dock, the charging port would not open, and alarms rang on the bridge, and the captain called the on-board chief engineer to start troubleshooting. Then he concluded that they did not have time to wait for charging the batteries and would have to start the back-up diesel engines for the next crossing. When leaving the quay, he called the captain on one of the sister ships waiting in line, to let them know about the situation. While talking they turned the subject onto discussing which button to press to start the charging – there were two redundant buttons, one on the touchscreen and one physically on the bridge. The captain shared his insight on what he considered to be the best button to minimize technical problems or delays. The apparently close colleagues made fun of each other while discussing these specific operational issues. To illustrate, the captain laughingly implied that his colleague's problem was that he lacked the skill of pushing buttons: *"I'll show you. It's easy to push a button - my grandmother could've done it!*". This example illustrates that seafarers engage in dialogue with close colleagues virtually to develop and share new practices.

4.3. *Ensuring competent practice for newcomers*

Newcomers to the ship and connection, both young and more experienced, also needed to obtain competence and develop safe work practices with the new technology. Generally, a rule is that a new navigator needs 20-30 hours of familiarization training on board a new ferry, before getting formally certified by the captain for sailing on his/her own. Such familiarization training on a basic level involves learning the boats systems and features by accompanying someone experienced, and eventually sailing themselves under observation by a captain. When we spoke to navigators, we asked them if they had a checklist or a guideline for what to go through during such training, we got the response that it was primarily through the crews' or captain's own subjective, informal judgment. This is illustrated by a captain that noted: *"we basically put them in the chair and see how quick they get the hang of things*."

The introduction of auto-crossing systems had led the crew to include a new aspect in their formal familiarization routine at their own discretion. During our observations, a navigator was undergoing such familiarization training to obtain approval for sailing on the connection. During this training, the navigator was asked by the captain to sail with and without the new auto-crossing system. We asked the captain what they should learn during familiarization, and he told us the following:

"we say that there are 3 things one have to master on familiarization: autopilot, auto-crossing and manual sailing."

These three aspects were not specified given by the shipping company but rather based the crew's own judgment on what was important knowledge and skill, as the captain told us that "*we have decided it here on board"*. Several informants noted that they thought it was too little room for training on new technological systems on the bridge. A captain said*: "It is too little focus on system understanding [by the shipping company].*" He followed up by explaining that those who are present at development and testing with the supplier implicitly get extra learning effects. Regarding the rest of the navigators, the captain rhetorically asked, *"How should they learn?"* and indicated that learning is presumed to take care of itself either individually or by colleagues during operation: *"It's just being taken care of on the bridge, you know."*

Regarding auto-crossing and -docking, only one of the three connections in this study had a formal course and training requirement before being qualified to use the systems. Few of the informants on this connection emphasized the course as an important part in getting to know the system, even though they seemed satisfied with the information given. On the two other connections without formal training required, a voluntary course was offered, however it seemed few attended the course. There were also and in-house check with 20-30 hours practice required on one of connections, however, overall, it seemed that the continual use of the systems was seen as more important to get to know the systems

To summarize, seafarers, partly due to lack of formal training, developed their own mechanisms for ensuring that new practice was shared to new colleagues.

5. Discussion

In this study we explore how we can understand seafarer's continuous development of local work practice in the face of new technology. In this regard, we can summarize our findings as follows:

- Seafarers developed local practices using the technology in different ways than they were designed for.
- The seafarers engaged in mutual learning through dialogue and experimentation in their social environment, both physically and virtually, to obtain and share new practices
- Seafarers ensured mutual practice and competence to newcomers by adapting their informal training processes on board, through situated learning.

Local adaptations were prominent in the use of the systems; the seafarers found their own ways. These adaptations were de-attached from company or system developers, developed through experimenting combined with an ability to improvise. The purpose of the adaptations was increased efficiency and convenience. On a general level this finding supports that the notions of social construction of technology also regards for automated technology. It can specifically be seen as integration work (Lützhoft, 2014) both on task level and system level (Cook & Woods, 1996).

The development of new practices was primarily through social learning among the crews. Learning took place in an environment where the persons belonged to each other through a social work environment with aligned values and purpose, thus aligning with the concept of communities of practice (Wenger, 2011). Social learning took place physically through doing and speaking with the onboard crew. However, the interactions did not only occur between officers on the same ship. For the navigators, telephone calls and e-mails between seafarers on sister ships were important to facilitate information exchange and mutual reflections, indicating features of a virtual CoP. Most sharing of information and insights were orally rather than documented through writings or data. This is in line with Koliba and Gajda (2009) emphasising dialogue.

Considering the intertwined relations of crew on sister ships, there is an open question how one should consider the boundaries and overlaps between CoP's in car ferry transportation and maritime transport in general, which is especially pertinent for the future, considering increasing connectivity with onshore functions. Perhaps the future social system of maritime professionals could be best understood as constellations of CoP's.

5.1. *Safe adaptations?*

It is interesting to discuss whether adaptations the seafarers manifested are positive in terms of safety. The local adaptations might be seen as practical drift (Snook 2000). Such drift may be both positive and negative in terms of ensuring safety.

Some of the adaptations are perhaps clear in terms of their effect on safety. On the one hand, when the captains ignore alarms for the purpose of convenient and efficient transmission towards dock, it is likely to be reducing safety margins, perhaps not by the lack of paying attention to designers' alarms, but primarily because the effect is higher speed during arrival. On the other hand, the crew's own adaptations of the crew familiarization training routines represent an adaptation that increases the safety margins. Here, they included sailing with and without the automated systems, in the absence of formal guidelines. The training assumingly contributes to a more correct and competent use of safety-critical automation.

Some adaptations are more challenging to discuss in terms of 'net' safety effect. In the situations where they deliberately forced the system into a stand-still mode (similar to a dynamic positioning stand-still) during fog or queue at dock, they are effectively reducing cognitive stress in a critical situation, thereby assumingly increasing safety margins. This decision-making could be seen as a form of professional bricolage, situational improvising with whatever it as hand, including artefacts that may have the very logical opposite in its design. It resembles a demonstration of adaptive capacity from the resilience perspective (Woods, 2015). Thus, their craftmanship rooted in their professional competence holds a safety potential if channeled in the right way.

Despite this apparent safety effect, there are some challenges here due to these systems getting more complex and interwoven in cyber-physical space. Whereas earlier, the professional was in more or less complete control over his or her mechanical equipment, in the complex technological environment, it will be impossible for the captain to fully understand the implications of altering technology such a way as in the example. This problem of increased automation was also argued by Cook & Woods (1996). In our case, hypothetically, the captain might had initiated cascading effects and errors on other parts of the sociotechnical system unknowingly. Moreover, the "drift" implies that perhaps the seafarers are taking system boundaries too lightly due to a high perceived control and trust in the systems' capabilities. The 'net' safety effect of such local adaptation is therefore debatable and need further inquiry in the years to come.

A loose coupling between ferry crew and the shipping company may be one of the reasons why seafarers are prone to local adaptations to work. This may lead to a gap between preferred (by designers or company) and actual work practice. This can be seen as representing WAI (work as imagined) and WAD (work as done) (Dekker 2006: Hollnagel, 2014). When the work connected with remote control centres become more inextricably linked, the culture of valuing own local adaptations will probably be challenged. It is yet to be investigated how one can retain the positive effects of the professional independence of these communities of practices, while developing new organisations and work processes with autonomy and remote control.

5. Conclusions

Seafarers adapted the technology in operation, and thereby adapting the artefact into something else than designed and integrated it to their work environment through a social learning process. In this way, one could argue that the social continuous development of work of seafarers is largely within the "status quo", as this is similar to previous research on maritime professional work. However, we think it will be necessary to widen our knowledge about these ways of adapting and learning as ships become more autonomous and the system expands and with less crew onboard. There is a need for new theory to understand social learning in this setting. As virtual connectivity and collaboration will be increased with remote control centres and higher levels of ship autonomy, future research should aim for a better understanding of social learning, for example virtual communities of practice in maritime transport.

Moreover, considering that the core features of continuous development and learning within the communities are rooted in their professional culture and identity, industry and research will need actual practical solutions to prevent loss of professional competence, identity and culture, so the maritime transportation industry still can attract competent professionals and maintain safety with inevitable changes caused by the rapid increase of automated systems and new work processes.

Acknowledgement

The authors thank the participants to the study. The study is funded by Research Council of Norway through grant number 324726.

References

Anteby, M. Chan, C. K., DiBenigno, J. (2016). Three lenses on occupations and professions in organizations: Becoming, doing, and relating. *Academy of Management Annals, 10*(1), 183-244.

Ardichvili, A. (2008), Learning and knowledge sharing in virtual communities of practice: Motivators, barriers and enablers. *Advances in Developing Human Resources* Vol. 10, No 4, August 2008, 541-554.

Bijker, W.E., Hughes, T.P. & Pinch, T. (eds) (1989). *The social construction og technological systems*. Cambridge: the MIT press

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology, *Qualitative Research in Psychology, 3,* 77-101. 10.1191/1478088706qp063oa

Cook, R. I. & Woods, D. D. (1996). Adapting to new technology in the operating room. *Human Factors*. Vol. 28(4), p. 593-613, 10.1518/001872096778827224

Clarkin-Phillips, J. (2011). Distributed leadership: Growing strong communities of practice in early childhood centres. *Journal of Educational Leadership, Policy and Practice, 26*(2), 14-25.

Czarniawska, B. (2018). *Fieldwork techniques for our times: shadowing*. Qualitative Methodologies in Organisation Studies. Palgrave Macmillan.

Dekker, S. (2006). *The Field Guide to Understanding Human Erro*r. Ashgate, Aldershot, London

Noordegraaf, M. (2020). Protective or connective professionalism? How connected professionals can (still) act as autonomous and authoritative experts. *Journal of Professions and Organization*, 2020, 7, 205-223.

Pareliussen, B., Æsøy, V. & Giskeødegård, M. (2021). Professions, work, and digitalization: Technology as means of connective professionalism. *Journal of Professions and Organizations,* 2021, 00, 1-15.

Gherardi, S. (2017). 'A practice-based approach to safety as an emergent competence. In Bieder, C., Gilbert, C., Journé, B., and Laroch, H. (eds.), Beyond safety training: Embedding safety in professional skills, Cham: Springer Open, pp. 11–22.

Hollnagel, E. (2015). Why is Work-as-Imagined Different from Work-as- Done? In *Resilient Health Care*, Vol. 2. CRC Press.

Koliba C. and Gajda R. (2009) "Communities of Practice" as an Analytical Construct: Implication for Theory and Practice. *Intl. Journal of Public Administratio*n, 32, 97-135.

Lamvik, G.M., Wahl, A.M. & Pettersen Buvik, M. (2009). Professional culture, work practice and reliable operations in shipping. Proceedings of the European Safety and Reliability Conference 2009 (ESREL 2009), p. 785-790, CRC Press. ISBN 978-0-415-55509-8

Lamvik, G.M. (2012) The Filipino seafarer. A life between sacrifice and shopping. *Anthropology in Action*, *19, 1, 22-31*. Berghahn Books.

Lave, H., and Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Lützhoft, M. (2004). "The technology is great when it works": Maritime technology and human integration on the ship's bridge. Dissertation. Linköping studies in science and technology.

Reason, J. (1997). Achieving a safe culture: theory and practice. *Work & Stress*, *12*(3), 293-306.

Snook, S. A. (2000). *Friendly fire: The accidental shootdown of US Black Hawks over northern Iraq*. Princeton University Press

Wahl, A. M. (2020). Expanding the concept of simulator fidelity: the use of technology and collaborative activities in training maritime officers. *Cognition, Technology & Work, 22*(1), 209-222. 10.1007/s10111-019-00549-4.

Wenger, E. (2011). 'Communities of practice: A brief introduction.' STEP Leadership Workshop, University of Oregon, October 2011. https://scholarsbank.uoregon.edu/xmlui/handle/1794/11736

Woods, D. D. (2015). Four concepts for resilience and the implications for the future of resilience engineering. *Reliability Engineering & System Safety*, *141*, 5–9.