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DIGITIZATION IN MARITIME INDUSTRY: COPING WITH A VESSEL'S ENGINE FAILURE

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Research paper

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Abstract

Digitization in the maritime industry is expected to transform businesses. The recently introduced mobile technologies in inter-organizational processes is an example of digitization in an industry which moves very slowly towards digital transformation. We focus on the influence of mobile technologies on control practices in inter-organizational processes related to coping with an engine failure. We collected qualitative data from in depth interviews with representatives of the involved parties. We identify organizational and behavioural challenges hindering information sharing during problem solving of an engine failure, as well as how mobile technologies are currently used. We conclude by reflecting on how introduction of mobile technologies influences control in the inter-organizational processes by addressing some of the identified organizational and behavioural challenges. Mobile technologies increase information sharing and thus the efficiency of inter-organizational processes when coping with an engine failure.

Keywords: Maritime Informatics, Engine failure, Inter-organizational processes, Control

1 Introduction

The proliferation of digital platforms as means of interacting with suppliers challenge the linear logic of supply chains (Parker et al., 2016) and is expected to change the market dynamics. Despite maritime industry being in a laggard position of IT adoption (Watson and Lind, 2015), the digital transformation is expected to lead to large efficiency gains (Brand, 2016).

In the maritime industry, unexpected events in the form of engine failure are very costly for the owner or the shipping management company operating the vessel. IT solutions may increase information sharing and thus improve coordination among the different organizations involved, i.e. the crew members, the shipping management company and the engine manufacturer, when coping with an engine failure. For example, the use of mobile technologies could enable involved parties to diagnose, assist or solve the problem even though it might occur halfway around the world.

Decision making while coping with an unexpected event is especially difficult when the involved parties do not share information efficiently. Ignoring warning signs or acquiring unreliable data, hinders foresight (Tamuz and Lewis, 2008). In this context, human bounds of rationality (Simon 1955) and awareness (Chugh and Bazerman, 2007) during an unexpected event further aggravate decision processes. Temporary disruptions in organizational processes are part of unexpected events which are temporarily unpredictable and their extent is also impossible to foresee. The related literature focuses on two main areas; collecting and interpreting the warning signals as well as decision making when coping with the unexpected event (Tamuz and Lewis, 2008). The use of IT solutions supports data collection and monitoring of the environment, humans reporting and analysing the data as well as interpreting the signals.

The study investigates control in inter-organizational processes when coping with an engine failure. We focus on how coordination and information acquisition; interpretation and use take place among the members of the different parties when an engine fails. The focus is placed on mobile technology effects on diagnosing the problem, the chosen course of therapy and consequently the relationship of the service provider with the customer. Our empirical context involves condition based maintenance activities and engine failures in vessels, and the study revolves around the relationship between the engine manufacturer, the crew onboard and the ship management company.

The paper is structured as follows. Section 2 offers a description of the empirical context. This is followed by an account of theoretical background in section 3 and subsequently the research method is described in section 4. The main findings are then presented in section 5 and discussed in section 6, by highlighting the contribution. Concluding and the future research directions are presented in section 7.

2 Empirical Context

Diesel engines are a continuous improving product evolving along with the experiences accumulated by R&D engineers of the engine manufacturer. In addition, the engine is part of a vessel with numerous systems working in concert for the vessel to function. Thus, each engine co-exists in a unique environment, the vessel, with several other systems. This implies differences in the conditions of the engine, e.g., replacement time for spare parts, maintenance requirements, filtering and use of oil for the engine etc. There are no two identical diesel engines placed in two different vessels.

Service engineers from the engine manufacturer should solve an engine failure problem promptly in collaboration with the chief engineer on board. The service engineers communicate with chief engineers by email or phone, and if necessary, travel and board the vessel to cope with the situation. The work of the service engineers is based on a small amount of contextual information because of lack of day-to-day contact with the specific engine, and thus, each situation requires fast updating about the problem-solving context (Augier et al., 2001; Shariq and Vendelø, 2011). Service engineers report that the technical assistance process is suffering and this causes an increase in the need to travel to vessels to repair engines. This involves costs in transportation and time, which may be substantial for the customer, if the vessel delays to arrive in the next port in time. Timing is highly important for vessels due to tight scheduling of cargos transportation and the increasing demands of customers for faster transportation of their cargos. Changes to the schedule, involves high costs for the ship management company as the cargo market is working in a dynamic mode of booking vessels on the move, while closer to cargos location, to reduce costs and time of delivery.

Adding complexity to the picture crew members, i.e. chief engineers and the captain, are not permanent employees. Usually the crew members belong to another organization which is in charge of crew management. Their contracts with the vessel vary from 3 to 12 months. The vessel is an organization with temporal membership (Daciulyte and Aranauskaite, 2012) which makes the people on board a vessel less concerned with the incurred costs due to an engine failure and the maintenance services.

The third party in the picture is the shipping management company representing the interests of the owner. The technical superintendent from the shipping management company is responsible for the economy of the vessel and any unplanned technical budget changes (new spare parts, technical service required from the engine manufacturer). When an engine failure occurs, the chief engineer contacts the technical superintendent from the shipping management company. The technical superintendent decides if technical service is required in each situation and contacts the engine manufacturer to arrange for assistance. Figure 1 illustrates the relationship between actors. The chief engineer onboard is on daily communications with the superintendent responsible for the vessel while they both communicate sporadically with the engine manufacturer for maintenance activities when an unexpected event occurs.

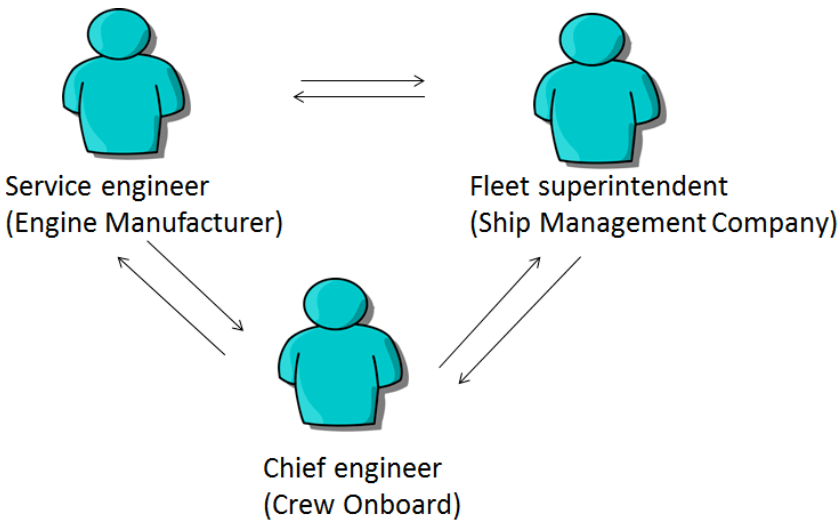

Figure 1. The actors participating in problem solving during an engine failure.

This study investigates how mobile technologies influence control practices in the inter-organizational processes while coping with engine failure. We described the organizational and behavioural conditions surrounding these unexpected events; the uniqueness of each engine, the temporal organizational membership in the vessel as well as the task interdependencies. Under these conditions cues about engine problem are likely to become weak and make problem solving a difficult task (Vendelø and Rerup, 2009).

3 Theoretical background

The theoretical background builds on Orr (1996) who describes mobile service engineers' work on photocopy machines. Orr (2000) suggests that it is the maintenance of a triangular relationship between the users of the machine (who are also customers of the parent company), the machine itself, and the technicians who are responsible for this relationship. The technician, who is viewed as a therapist, considers all aspects of the situation including the machine, the users, the location, and the environment. According to Orr (1996) "the principal issues for the technicians in this triangular interaction are control and understanding, and one reward for achieving the two is their own identity as competent technicians" (p.6). We instigate how mobile technologies influence control and inter-organizational processes when one organization has temporal organizational membership, a topic which is yet to be studied in the field.

So far, research on the use of mobile technologies has focused on organisational issues (Bellotti and Bly, 1996; Luff and Heath, 1998; Bellotti and Smith, 2000) such as coordination, communication, learning rather than on inter-organizational issues. Earlier studies on inter-organizational relationships have shown that management control techniques can be used in inter-organizational settings (Mouritsen et al, 2001; Carr and Ng, 1995; Dekker, 2004) and according to Dekker (2003) management control contributes to improved supply chain performance.

Studies of technical service work (Orr, 1996; 1998) and call centers (Frenkel et al., 1995; Korczynski et al., 2000) provide evidence of the changes in organizational control practices. Organizational control has been conceptualized in different ways. The most dominant view is that of Tannenbaum (1963) where control is the sum of interpersonal influence relations in an organization. This view relates control to power. Others have viewed control as a problem in information flows (Ouchi, 1979; Ouchi and Maguire, 1975) and as a problem in creating and monitoring rules in a bureaucratic structure (Weber, 1947; Perrow, 1975). Grounded in rationality, the cybernetic control theory depicts organizational control based on a process of measuring, comparing and providing feedback (Zweig et al., 2008). However, little is known about mobile technology influences of the control practices in the inter-organizational processes and relationships among the actors in the maritime industry, among the service engineers, the shipping management company and the crew members.

According to Decker (2004) the primary purpose of control in inter-organizational setting is coordination of interdependent tasks between the different actors. When tasks become more interdependent and more uncertain, the need for coordination and joint decision making increases. There are various levels of interdependence from very low when one actor can perform the work with a little coordination to very high where continuous communication and joint decision making is required (Shollo et al., 2015). In particular Thompson (1967) categorizes interdependence in pooled, sequential and reciprocal, where pooled is low interdependence between partners and reciprocal is high interdependence i.e. one actor's activities serve as input to the other actor's activities.

Control in inter-organizational processes is exercised by coordination and monitoring mechanisms among organizations that discourage opportunistic behaviour (Williamson, 1975). Activities like taking shortcuts, breaking promises, masking inadequate or poor quality work and generally being dishonest in order to gain advantage are examples of opportunism. Although opportunism at the organizational level was not readily monitored (Provan et al., 1989) the emergence of inter-organizational systems as well as mobile technologies information sharing has increased considerably monitoring in inter-organizational processes.

Our study contributes to the understanding of how the introduction of mobile technologies influence control in inter-organizational processes by focusing on information sharing and support coping with an engine failure.

4 Methodology

Our research aims at investigating control in inter-organizational processes where service engineers cope with unexpected events in the form of engine failures. Given this purpose, we adopted an interpretive approach, which allows us to give voice to the informants' experiences and practices. We conduct a qualitative case study in a Diesel engine manufacturer, which provides the technical services. We concentrated on understanding the troubleshooting, decision making processes that take place both from a distance and when service engineers decide to go on board either to further investigate or solve the problem.

We chose the specific case because it constitutes a typical intensity case, which illustrates what is typical when coping with unexpected events. In addition, engines from the specific manufacturer are installed roughly 50% of the vessel population of the world. This makes the case very rich in information because the technical service department gets calls from all over the world.

To obtain a solid understanding of both the problem-solving context, and decision making during unexpected events, we combine a set of data collection techniques, including; semi-structured interviews with service engineers from the engine manufacturer manufacturer, superintendents from the ship management company and crew members, email and recorded telephone communication between service engineers, crew members and superintendents when handling cases of engine failure, and the service engineers' reports about previous cases of engine failures.

The richest source of empirical data for investigating our research question stems from semi-structured interviews with service engineers. Over a 12-month period, we carried out 23 interviews service engineers the engine manufacturer's premises. We also interviewed 6 fleet superintendents from shipping management companies operating in Denmark, Norway and Singapore who as well as 2 crew members. Most of the service engineers interviewed had served as chief-engineers onboard and thus could provide information from this perspective as well. An interview guide was developed prior to the interviews containing open-ended questions about the technical assistance provided during the occurrence of an engine failure. Each interview lasted on average 50 minutes. The interviews provided insight into the current practices of technical assistance and the decision making when coping with engine failures. During interviews, we applied the layering technique to examine the topic from every angle (Lee, 1999; Schultze and Avital, 2011; Van Maanen, 1983). The interviews were transcribed verbatim amounting to approximately 400 pages.

In addition to the interviews, we collected company documents as well as emails and service technical reports (approximately 50 pages) about specific instances, which were brought up during the interviews. When interviewees would refer to specific events, we would ask for the email exchange and the file that the company had about the instance mentioned. In this way, we could triangulate the data through different sources.

For getting a detailed overview of the empirical setting and identifying indicators of how the troubleshooting and maintenance processes unfolded, we carefully read all transcripts of the interviews as well as the background material (email exchanges and technical reports). We employed constant comparative techniques (Strauss, & Corbin, 2008; Suddaby, 2006) to analyze the data in a systematic and iterative manner.

As a first step in the data analysis we developed an overview of the technical assistance process. This overview facilitated our understanding of the way the service engineers practiced troubleshooting and maintenance. In the next step, we read all documents/emails and technical reports to identify components of raw data across the different sources. We especially searched for passages that captured expressions of control issues in the inter-organizational process of troubleshooting and maintenance. We organized the first-order codes into tables that supported a single theme across the various data sources inspired by the in-vivo coding technique (Strauss, & Corbin, 2008). We then developed the second-order themes and continued in several iterations until we agreed on the final themes presented in the next sections.

5 Findings

In this section, we present the inter-organizational relationships when coping with an engine failure as depicted by the informants. We describe the organizational and behavioural conditions, which create a unique setting and influence coping with the engine failure. Engine failures are slowly incubating events, and thus, several actions can be taken to prevent them while observing warning signals. The maintenance activities have profound impact on the decisions and actions taken while coping with an engine failure. Besides, the crews' activities as well as historical data about the engine performance and other information about the engine are also important. However, during the interviews we learned that on an everyday basis the crew responsible for the engines seldom follow the prescribed standards and routines for maintenance of the engines. Also, information about the engine is rarely collected in a systematic manner. Thus, conditions that could reduce the probabilities of an engine failure as well as support service engineers when addressing such an event, are not in place and oftentimes the conditions in place work in the opposite direction. To offset the adverse effects of the abovementioned conditions the informants described how they use mobile technologies aiming at sharing information and improving communication and coordination among them.

5.1 The division of the task

The inter-organizational processes in the common task of solving an engine failure involve three representatives of large and complicated networks of interests and concerns: the chief engineer onboard the vessel, the fleet superintendent representing the commercial interests of the shipping management company, and the service engineer representing the engine manufacturer. In a general sense, they share an interest in the engines running reliably and smoothly. However, when it comes to enacting such general interest, the concerns for the engine are framed differently.

First, there is the crew onboard the vessel, a social organization with trained officers and relatively unskilled seamen. Among the officers, there is a least one trained chief engineer. Both officers and seamen have weak ties to any vessel. At any point in time, the crew represents a random draw from a large pool of officers and seamen. The average duration of a call of duty is around three months. When reporting back, the crewmembers are assigned to vessels wherever there is a vacancy. In the present context, the crew is represented by the chief engineer. For the chief engineer onboard the vessel, the care for the engine is considered in the context of a wide range of tasks under the influence of a systematic reduction of the size of crews. There is an implicit or explicit priority decision behind the chief engineers' behaviour, influenced also by personal traits such as experience, sense of accountability, and future career prospects.

While the relationship between crew and vessel is temporary and transient, the relationship between the vessel and a ship management company is more stable and of longer duration. This is also true of the crew members' relationship with the ship management company. The ship management company operates a fleet of vessels but may not own them. Still, the fleet of vessels is operated at the ship management company's expense, allowing it to service customers and generating a profit from such service provision. In the current context, a fleet superintendent who authorizes the payments in relation to engine maintenance and repair represents the ship management company and its business interests. The fleet superintendents reframe the engine concerns within a more general commercial agenda. Saving costs on engine maintenance is rational as long as it does not impinge negatively on the revenue stream. An engine failure is always a loss in a double sense: the direct costs of repairs, and the opportunity costs of not charging customers for shipping services provided, or paying penalties because of delay. Since these costs are difficult to calculate ahead of time, the behaviour of the fleet superintendents has a certain element of strategizing against an uncertain and unpredictable future.

The third party is the engine manufacturer who is responsible for servicing the engines after they have been installed in the ships. They are participating in a double capacity. First, they are designers and manufacturers of the engines, and as such, they have an interest in gaining experience to improve future engine designs. They are also carrying a product responsibility for the efficacy and reliability of the current engines. Besides, they are technical service providers and are paid for ensuring that any engine problem is solved expediently so that the ship may return to the fleet as fast as possible. In the present context, the service engineer represents the engine manufacturer. The service engineers face a similarly delicate agenda. In general terms and as already indicated, they have an interest in learning from failure, but in order to protect their reputation as engine manufacturers, and in respect for the welfare of their customers and the ship crews, their prime interest lies in avoiding engine failures. However, when failures occur they have potentially conflicting interests in wanting to solve the problem competently without delay, on the one hand, and not wanting to be held financially accountable for the failure, on the other hand. If the failure is tracked to the design of the engine, there is much to learn for the manufacturer, but also a legitimate reason for the ship management company not wanting to cover the costs of repair. Thus, in the decisions of the service engineer, there might be an interest in finding remedies for the failure in ways that put the blame on the use of the engine, not the design of the engine.

It is inconceivable that such a divide of interests and concerns could be bridged in general and therefore to enable a rational process in problem solving. The bridging must be achieved in the specific situation by some form of negotiation, as we will show below. In addition to the divisions caused by different interests and concerns, the tasks are further complicated by people not knowing the things that might in fact be knowable. Ignorance is not a temporary complication, but a premise on which problem needs to be solved. If what we know determines what we see, problem solving may not happen in a shared reality across all participants. Some of the complications from this fact are illustrated below.

> “I think the language barriers are the most difficult, because often when we are talking to them it is very difficult to hear what they are saying and very difficult to understand.” (Interviewee 16).

> “The problem of the today shipping is that a huge majority of the crews are very inexperienced. I mean, the shipping companies are hiring from the absolute cheapest places...” (Interviewee 15).

> “Sometimes we should ask a lot of questions to get an answer because what they think and say it is not always the important stuff, and we know what to ask?” (Interviewee 12).

5.2 The uniqueness of the problems, the problems of uniqueness

As mentioned in the empirical setting every engine is unique. This uniqueness is a result of a mix of design and nurture factors. Each design is different from the other because design engineers introduce small modifications in new designs. At the same time, different engine builders might use different materials or slightly different measures making the engines different. Once an engine is built and placed in a vessel, its life begins and it is from this moment that the nurture factors come into the play. First, the way that the engine is installed might be a bit different every time which might have consequences later in the engine’s lifetime. For example, one of the service engineers’ reports:

> “We have a lot of different settings, all depending on which engine type, when it was produced and what parts are mounted in the engine. All these information gives to the engine a different setting.” (Interviewee 13).

During the lifetime of an engine, its maintenance level plays a very important role in the performance of the engine. By maintenance level things like the quality of the inputs like oil/water/amount of air used for the engine, as well as the frequency of repairs, the quality of spare parts, the hygiene of the engine and the conditions of the other machines it is connected to play an important role in the way the machine will evolve during its lifetime. These are all different factors that service engineers need to acquire knowledge about during problem solving. A service engineer explains the need to have an overview of the system and knowledge of the different inputs in order to detect the error and solve the problem.

> "So it is important to understand the engine and all the auxiliaries, because oil is being put in to the engine water, air and fuel, so it may not always be the engine which introduces the problem. Maybe it is coming from outside it could be the oil quality or the water in the system so that's why it is important to understand the engine but also surround auxiliaries" (Interviewee 7).

> "There was one of the superintendents many years ago who went out for a normal troubleshooting to a vessel regarding the electrical side of the engine. When he arrived there he saw that the state of the engine looked like 30 years old, even though they were operating it only 5 years. It was covered in oil and it was very difficult to find even trace where the wires were going." (Interviewee 16).

This information is crucial for the service engineers to understand the problem, find its cause and fix it. Since the service engineer have no way of knowing what goes on in the vessel it is very hard for them to perform troubleshooting.

5.3 Not knowing the truth, or not telling it

For the service engineers to perform their tasks of understanding (find the cause of the problem) and then solving the problem (repair the engine) either from a distance, or onboard they depend on the ability and the willingness of the crew members and the fleet superintendent to provide information about the engine. The service engineers usually prefer to talk to crew members because they operate the engine every day.

> "It helps if you could talk more to the people on the vessel, because they know what is happening and they can tell it. Maybe sometimes the fleet superintendents are also pressed regarding the money and what to do" (Interviewee 16).

When troubleshooting is done from distance, then the tasks are coordinated through the fleet superintendent. The fleet superintendent decides what information to share with the service engineer and with the crew members.

> "For example sometimes when the chief engineer makes a request for spare parts and the company [the fleet superintendent] will look and take all the expensive things out and send it to us, we will make the quotations back [to the fleet superintendent], then the company will send a PO [purchase number] and we will do the delivering. The chief engineer doesn't know anything before he receives the parts, then he will say I have requested this and that but I didn't get it. And it could be me there standing doing the job but I don't have the parts, because this guy sitting in the ship company office [fleet superintendent] is looking to reduce costs." (Interviewee 17).

The service engineers report that the amount and willingness to share information depends on the urgency of the situation. The more urgent the situation appears to be, the more information sharing occurs and the more the fleet superintendents use service engineers from the manufacturer because they know that the job will be done.

> "When we have a specific case from a customer where something has failed and we asked them about their engine maintenance? They will always say it is according to our instruction book, so it is difficult to know what it is done prior to the problem on board. And I don't know how we can ever get this information from the customer. But often if it is a big issue then they are willing to give us a lot of information and go into open dialog to find the solution of the problem" (Interviewee 15).

There is a strong tension between the fleet superintendent, the crew members and the chief engineer in the vessel. The fleet superintendent and the crew members belong to different organizations. Sometimes the crew members may try to cover up mistakes or the poor maintenance jobs. The temporary membership intensifies this behaviour because of lack of care and continuity.

> "For example if you have an engine damaged where one of the bearings is damaged and they are telling us that the engine has in total 17.000 running hours, and they have just replaced the lube oil filter. Then we will come back and ask have you checked and found any signs of rackets. Because the problem is that they start to disassemble everything out and they don't know what to look for and then sometimes they destroy the evidence. If we are trying to find the reason to the problem, then, sometimes, they have also removed the actual cause of the damage …" (Interviewee 12).

The chief engineer or the fleet superintendent sometimes do not provide information which is decisive for the engine manufacturer or the insurance company paying for the repair.

> "But of course we discuss with the crew about the history and what happened, because the chief engineer and the superintendent do not always know the truth and then sometimes a third engineer on board pulls you aside and tells that it is not exactly what happened. So, you get a second story of the problem which might be the truth" (Interviewee 13).

When physical presence is warranted for dealing with an engine failure, high cost may incur and it is the role of service engineers to identify the actual cause of the engine failure and repair it. This process should be based on evidence and be transparent for the two parties to make their financial claims. For example, the service engineer should prove in an undisputable manner the source of the problem. If it was a product fault, then the cost falls to the diesel engine manufacturer while if it was a human error the cost falls to the customer. Service engineers also keep the fleet superintendent updated with the status of the task.

> "You know if I have received a case that I have to do a lot of background information then I will just inform the customer. I will write to him that I am looking into his case, but we need to find this information and it could take 1-2 days. But in this way, they know that there is someone working on that and that's usually what they want us to do. They want to see that someone is handling the case because when it gets personal they get a name or face on the mail they are much more secure than when they have send an e-mail and don't know anything about that for on two days or even one week" (Interviewee 16).

The way that the different parties coordinate the engine work (maintenance and repair) is based on a schema based mode where the manufacturer has written an instruction book about when should oil, water and consumed spare parts, be changed. However, for optimizing the engine performance and prolonging its lifetime the manufacturer recommends a condition-based approach to be followed by the crew members and the owners. The service engineers have no control over the maintenance activities or the decision making about changing spare parts.

> "You know the end goal should be to help them to prolong the TBO (time between overhaul), instead of just following the instructions. Because like this it is very strict and when it comes to 16.000 hours then they will say we should overhaul because this is on the book. Of course, it is stated in the book but you have also to do something when you see it. If you walk in the engine room and you hear something from the engine you should maybe stop it and check it, but this is not so common for many of the crew members who are working with the engines today. So, we want them to get more focus on condition based maintenance instead of just regular maintenance." (Interviewee 16).

5.4 Mobile technologies and information sharing

Accurate information about the vessels engine facilitates coping with an engine failure. Some cases a very simple communication via exchange of emails can solve the problem of the engine failure in good time (i.e., within 24 hours) and at no cost for the customer. The informants explained how the introduction of smartphones enable service engineers to collect more information of the engine's conditions before travelling to the vessel or consult other colleagues in the headquarters while on board and dealing with a problem.

> "Our service hubs they do a lot of calling when they are on site and then we try to help them especially now all have IPad, IPhones and so on. So it is quite easy for us to supply them with the correct work cards, procedures right away" (Interviewee 17).

Real time pictures of the broken or damaged parts, or performance data (photos of what are indicators currently showing) compensate for difficulty of the crew members to report accurately.

> "We ask them to send either pictures of the broken parts and sometimes they are very limited in information in the first email so we ask them for more information from performance [data] to more pictures documentation, because many times I feel that pictures are showing more than the customers on board actually think they are" (Interviewee 13).

The service engineers onboard use pictures which enable them to acquire real time information from experts on how to deal with a problem and solve it. Using mobile devices like smartphones and tablets they can reach the broader support network i.e. other service engineers who are either specialized on a specific component or that have worked with the same vessel before as well as people from the design, operations or sales departments:

> "It is the small details. If you have a specific problem with something and you cannot find it, then the guy who designed it, can tell you 'it is because you have to do this'... I couldn't find what the problem was, so I called the guy who made it, because I know him I have been working with him a lot. So, he sent me a picture and support me over the telephone, I was able to locate the fold and the customer could see that was a minor error" (Interviewee 2).

The pictures/photos are also used as evidence from the service engineers to show to the owner the cause of the problem.

> "The problem is that on new engines you cannot use paper for gasket, you have to use a special material… We had a customer who had 5 engines on two vessels destroyed, due to a 10$ rubber gasket missing between lube oil filters. Each crankshaft for these engines was nearly 1.000.000 DKK and the frame was a little bit over 1.000.000 DKK. ... We had no problem with the customer when he saw that he accepted it, we had pictures and everything" (Interviewee 12).

The pictures that are taken are also used to document events or to demonstrate who is accountable for specific problems. The following quotes show how in an instance the photo was used to show that it was the crews fault and in another instance the actions of the service engineer were documented.

> "It is actually the tricky part, because they are trying to hide the human errors. Again, it is a simple investigation take a photo and you can see this part should had been mounted that way and even if you found it mounted correctly. Later, you can see some small imprints that actually it was mounted in a wrong way and then to hide the mistake they tried to switch it" (Interviewee 18).

6 Discussion

The study of inter-organizational processes in coping with an engine failure provided some interesting observations about control practices and how organizational and behavioural conditions hinder the flow of information from the crew members to the service engineers. The introduction of mobile technology is offsetting part of these problems and highlights the underlying opportunities. Maritime industry is a laggard in the digitization process (Watson and Lind, 2015). Yet, our study shows that even simple solutions such as the use of a smartphone may lead to efficiency gains. We identified four types of organizational and behavioural conditions influencing the current control practices in the inter-organizational processes of coping with an engine failure.

First, communication issues among the different actors restrain the ability of service engineers to understand and coordinate their work with the crew members and the fleet superintendent. Communication has been long acknowledged as the essence of organizational life (e.g., Reinsch, 2001; Yates and

Orlikowski, 1992). Inter-organizational communication has also been highlighted as an important factor in increased performance of the collaborating firms. Specifically, operations management researchers have documented how inter-organizational communication enhances buyer–supplier performance (e.g., Carr and Pearson, 1999; Prahinksi and Benton, 2004; Cousins and Menguc, 2006). The main reason behind communication problems when coping with an engine failure, is that the communication with the vessel, most of the time, is mediated by a third actor, i.e. the fleet superintendent. This in turn, might cause information loss, or information filtering by the fleet superintendent who controls the flow of communication. Moreover, the poor communication skills of the crew members create difficulties in communicating the problems with the engine.

Second, the temporal membership of the crew members performing service work has adverse effects in information sharing. It aggravates the communication challenge because of lack of continuance and learning from the crew members. In temporary organizations, the notion and importance of care is significantly reduced. Orr (2000) shows that the notion of care is important in introducing and embedding technology in society for the society's benefit. Lack of care it is not only linked to an opportunistic behaviour from the side of crew members because of the lack of work continuance but also from the lack of technical skills in doing engine maintenance jobs. Thus, we observe that the temporal membership creates both a lack of care from the crew members as well as it prevents learning about the machine maintenance job. Temporary organizations literature assumes that members are adequately skilled and thus can perform the tasks or develop new routines and adjust to a surprise as explained by Bechky and Okhuysen (2011). However, in this study we found that the hiring strategy of the ship management companies is cost based and does not take into consideration the required skills of the crew members. The temporary status of the crew and the chief engineer onboard may reinforce a mentality of time discounting (Daciulyte and Aranauskaite, 2012) since they do not feel responsibility for the vessel's long-term conditions and wish to push forward laborious tasks. This latter characteristic of the crew members relates to how short time affects the behavior of humans with temporary organizational membership, who tend to focus more on the task at hand rather than the long-term issues.

Third, the mix of design and nurture factors results in unique engine problems every time. This requires a deep knowledge of the specific engine and its context in order to understand and solve the problems. Despite the obvious value of appropriate engine maintenance, the study revealed several conditions that do not allow for the use of the official guidelines and manuals. The lack of a formal procedure combined with the complexity and particularities of each engine in a specific vessel raise the probability of a failure. The problem may be aggravated to serious operation disruption since the information leading to the failure is not collected or monitored. Thus, finding the actual cause of the problem and addressing all the related consequences could be a laborious task that takes time. This in turn raises costs for the ship management company.

Fourth, the task interdependence appears to be very high during an engine failure. As such, it seems that the relationship between the actors is reciprocal where there is a need for more complex coordination mechanisms in order to communicate and adjust to each other's situation (Decker, 2004). Thus, the crew members are required to follow a scheme-based approach when it comes to coordinating interdependent tasks. However, we observed a high degree of opportunistic behavior (Provan et al., 1989) which makes the coordination of the tasks even more complicated. In this context, it would be very difficult if not impossible to discuss about developing a culture in the crew of observing cues indicating potential problems in the engines and reporting them.

The four organizational and behavioural challenges are offset by the introduction and use of mobile technologies. Table 1 provides examples of how the four challenges are addressed using mobile technologies which increase information sharing.

Organizational and Behavioural Challenges	Mobile Technologies and Information Sharing
Communications between involved parties	• *Increase information sharing* • *Real time information sharing* • *Richer information through photos and videos*
Temporal organizational membership	• *Documenting incidents* • *Accountability*
Knowing the engine and its context	• *Richer information through photos and videos* • *Faster support from the broader network of experts*
Coordination of interdependent tasks	• *Better decisions on ordering the right spare parts* • *Faster support from the broader network* • *Increased monitoring* • *Increased documentation of evidence*

Table 1. Organizational and behavioural challenges when coping with an engine failure and the role of mobile technologies in information sharing.

The informants describe how they use mobile technologies to reduce the adverse effects of the conditions described above. They use mobile technologies to send pictures of the broken parts or of different indicators. By using pictures, they offset communications issues as well as some opportunistic behaviour from the crew members. Also, sending pictures to headquarters enables less experienced service engineers to tap into the knowledge of senior colleagues who may improvise and suggest solutions which speed up problem solving. Besides, mobile technologies support bricolage by enabling the creation of a broader group of people (Garud and Karnoe, 2003), who coordinate their efforts from dispersed geographical locations (e.g., manufacturer's headquarters, service hub, ship management company premises and onboard the vessel) to swiftly solve the problem of the engine in the unknown environment of the vessel with several uncertainties.

We should note that service engineers cannot reverse the situation nor do they have control over engine failures they can only repair the engines. In this situation, service engineers use mobile technologies ex-post to determine the cause, ensure accountability and document the evidence. While control and monitoring mechanisms during normal maintenance activities do not exist and the relationship among the crew members, the fleet superintendent and the service engineer is very fragile during breakdowns, mobile technology is used both for problem diagnosis monitoring and documenting the evidence.

7 Conclusion

This study provides evidence on the importance of digitization in the maritime industry. Our findings show that the by simply introducing the use of smartphones as means of gathering and sharing information in digital formats can lead to significant efficiency gains due to improved information sharing among parties in inter-organizational processes. We investigated control practices in the inter-organizational processes when coping with an engine failure. We identified four organizational and behavioural conditions which impede service engineers in their troubleshooting and maintenance activities. We also show how the use of mobile technologies can counterbalance some problems in this inter-organizational process because of lack of contextual information and/or opportunistic behaviour of the actors when engine failure occurs.

Despite the interesting insights obtained in this study, the reader should note that our data mainly represent the view of service engineers working for the manufacturer. The informants experience as chief-engineers has offset part of potential bias in their answers. However, this affects the generalizability of our findings. Further investigation focusing on the views of the crew members is warranted. Besides, in-situ observations of the underlying processes during an engine failure would further increase our understanding of the inter-organizational processes.

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