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DEVELOPING A BENEFITS ASSESSMENT FRAMEWORK FOR SEA TRAFFIC MANAGEMENT SYSTEMS

Research

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Abstract

The maritime shipping industry is deeply rooted in history and tradition. Although it is one of the most important industries in today's global world, digital transformation has so far not penetrated the entire industry but merely commenced in a few individual companies. The heavy reliance on manual information retrieval and the collaboration willingness of other actors pose great challenges to more efficient, safe, and sustainable operations. As nobody seems to see the 'whole picture', the industry is characterized by individual (sub-) optimization neglecting completely the significance of the optimization of the entire ecosystem as a whole. Conducting an empirical pilot study using triangulation and in-depth, semi-structured interviews, we carried out an analysis addressing the research question: How can potential benefits of the implementation of a sea traffic management system be evaluated? Based on a thorough review of the academic literature on IS benefits assessment and a profound understanding of the maritime transportation-ecosystem and the design of a sea traffic management, a framework for assessing IS benefits is developed. The pilot interviews revealed the robustness of the framework confirming and refining the dimensions of the framework.

Keywords: IS benefits assessment, benefits hierarchy, sea traffic management, maritime transportationecosystem

1 Introduction

Today's world is composed of an increasingly more global and interconnected network of goods, people, as well as physical and non-physical objects relying heavily on information technology and effective trade infrastructures. Maritime transport has been increasing conjointly with growing global trade leading to increased negative environmental impact and larger operational inefficiencies. More than 90% of global trade is transported by sea (IMO, 2015); the most efficient and cost-effective mode of transportation as several warehouses can be carried on a single journey, labor costs are relatively low, and the journey is relatively fast (Kocak, 2015). For instance, transporting a kilogram of coffee from the Americas to Europe costs merely 15 cents (World Shipping Council, 2015). Such low transportation costs facilitate outsourcing and off-shoring and trigger a great need for global transportation. However, the societal and environmental costs implied by increased vessel traffic are enormous. Despite the cost and efficiency advantages, maritime shipping produces significant air pollution contributing heavily to climate change. Ocean shipping pollution, such as hull coating toxics release, oil spills, and ocean dumping represent major environmental issues regarding maritime shipping (Corbett and Winebrake, 2008). Better sustainability through a reduction of sea pollution and more optimized business processes are hence imperative.

1.1 The veritable cost revolution of the shipping industry

Within the territorial waters of the EU alone, there are around 29,000 port calls per year—more or less 580,000 individual vessel movements (EMSA, 2011). It is estimated that an average reduction of 1% in

the sailed distance per ship within the Baltic Sea region would translate into annual savings of approximately €100 million (Andersson and Ivehammar, 2014). Most of these savings are due to less fuel and other costs for the ship owner but also stem from less emission costs for society.

Throughout the shipping industry's history, the single most important expense in seaborne transportation has been the capital cost related to building a ship. In 2005, for example, it still made sense to sail faster because it was possible to save 1 USD per ton of cargo by arriving at the destination earlier. In 2008, the financial crisis meant a dramatic drop in the demand for transportation and sharply falling costs of capital (Stopford, 2013a). Accordingly, vessel costs went into a sharp decline, while oil prices kept skyrocketing. This shifted the discussion to revolve primarily around fuel costs and bunker consumption. In that year, fuel costs represented up to 60% of total vessel operating costs depending on the type of vessel and service (World Shipping Council, 2008). This development continued, and by 2012, vessel costs represented only half the costs of fuel. Accordingly, slow steaming to optimize bunker consumption became the standard. However, since 2011, the rapid decline in fuel prices has shifted the focus once again towards putting a greater emphasis on the costs of fixed assets—the vessel—and port expenses. Optimizing operational costs in order to reduce the turnaround time as much as possible has become top priority of many shipping companies today (Stopford, 2013b).

Throughout the last years, the maritime transportation industry has been experiencing various problems which derive mainly from issues related to communication problems and port congestions (Kocak, 2015). Moreover, the high complexity in information exchange and collaboration due to the interaction and interdependence of the numerous actors within the maritime transportation-ecosystem poses a big challenge for more efficient management. The EU currently supports various projects that address a more environmental friendly, efficient, and safer sea transport. For example, the Trans-European Transport Network focusing on innovation and technology in the maritime transportation sector (European Union, 2015), the European Blue Belt project creating a single transport area for shipping within the EU (European Union, 2013), or Portopia looking into a more sustainable port transport system (Portopia, 2015).

1.2 Sea Traffic Management as a Solution

The MONALISA 2.0 project exemplifies an initiative, which addresses the challenges the maritime shipping industry is facing today. It integrates much of the work of various other EU projects (e.g. National Single Window (EMSA, 2015) or the before mentioned projects) addressing the key areas of sustainability, efficiency, and safety. The focus of the projects lies in the establishment of a Sea Traffic Management (STM) system and a more effective information collaboration inspired by the aviation industry (cf. Eurocontrol, 2015). The implementation of such a sea traffic management information system not only creates efficiency and raises safety but also reduces the environmental impact of increased maritime traffic. Yet, for such a system to be successful, an alignment with the goals of the key actors within the maritime transportation-ecosystem is essential (Kocak, 2015).



Figure 1: Actors involved in maritime transportation-chain

Figure 1 illustrates the various independent but interacting actors of the maritime transportation-ecosystem—ports, port authorities, shipping companies, terminal operators, freight forwarder, agents—who are independently managed but are dependent on each other and connected on a daily basis (Caschili and Medda, 2012). Since all parts of the ecosystem co-evolve as well as strive for optimal efficiency in their own operations, the system is even more complicated and complex than it appears at first glance.

An "ideal" STM integrates different sub-concepts and provides a perfect bundling of all information to

be immediately and ubiquitously available as well as a level playing field for information exchange and better cooperation and collaboration between the different actors. STM provides a common format and architecture for a seamless exchange of route information and voyage plans. The Swedish Maritime Association (SMA) coordinates the STM, including its operation and tools. STM will improve the efficiency of the sea voyage as well as the operational efficiency of seaports. For instance, STM enables a route exchange between ships and shore-based traffic coordination centers as well as time slot allocation in congested waters. In ports, the different operations can optimize their operations through a better reliance on ETA information. Standard operating procedures ensure a safe and efficient deployment of the system. Various decision support tools, such as Maritime Spatial Planning, for both route exchange and route optimization are introduced. For testing and verification of the project, a European Maritime Simulator Network (EMSN), which consists of several European maritime simulation centers, will be established in order to conduct interconnected macro-simulation with a large number of ships. Additionally, Sea Traffic Coordination Centers (STCC) will be introduced to offer better ship to ship and ship to shore communication and improve the exchange of information and collaboration between the different actors (MONALISA2.0, 2015).

Implementing a system that is about to radically change an industry not only implies benefits but also entails costs. It is therefore important to thoroughly assess the potential benefits and risks that derive from the implementation of such a socio-technical system. With our study, we will address the research question: *How can potential benefits of the implementation of a sea traffic management system be eval-uated*? The aim of this study is to develop a framework for such an IS benefits assessment.

On the following pages, we will first address the methodology used for the literature review and the empirical setting. Then, we will give an overview of the literature on benefits assessment focusing on representational benefits measures and of the literature on voyage and seaport efficiency. Based on the literature review, we will then develop a framework to assess the potential benefits of STM systems. We will review the applicability of the framework through an empirical pilot study interviewing various actors of the maritime transportation-chain. Finally, we will analyze the relevance of the framework and provide a brief conclusion of our research.

2 Methodology

2.1 Literature Review

Due to the multidisciplinary nature of the assessment of benefits from IS implementation, different electronic databases were used for the literature research. Using a range of terms that included terms such as assessment of IT benefits; IS success factors; cost/benefit analysis in IS; IS success/failure; IS effectiveness; IS project evaluation; IS/IT-enabled benefits measurement; benefits assessment of IS in their keywords, titles, or abstracts, we searched for English language peer-reviewed journal articles without delimitating a specific time frame. This search yielded numerous articles, which were then briefly assessed based on the content of the abstract. Concentrating on IS effectiveness, performance evaluation, and assessment, 60 papers were classified as relevant and 30 of them were then studied in more depth. Of these, around 10 articles were used as foundation for the conduct of the literature review.

2.2 Empirical Setting

The purpose of the study is to develop a framework for assessing potential benefits stemming from the implementation of a sea traffic management system. As the implementation of such a system is a very complex and dynamic process over time involving numerous different actors and embracing events that happen unexpectedly, we found case study research (Yin 1994) to be the most suitable methodology for a benefits evaluation. Considering that an actual sea traffic management system is not yet in place and can therefore only be assessed on a conceptual level, we find it most adequate to focus on the perceptual perspective using qualitative research interviews.

The key actors were identified by meticulously examining the various internal and external documents provided by the ML project members focusing on the optimization of the voyage and the optimization of the port operations. For our data collection we focused on the Baltic Sea area—specifically Denmark and Sweden as test countries—as pilot region since the ML trials and "test beds" are conducted in this area. The intention is to extend this research to other European countries in order to obtain a broader picture across borders and cultures. The data collection took then part in two rounds. Before conducting the first round of interviews, two 'pilot' interviews were set up with a small shipping company in Copenhagen in order to obtain a more solid understanding of the possible research problems and to highlight potential gaps and opportunities (Sampson, 2004) as well as to gain a general overview of how the shipping industry operates, what common problems and areas for improvement exist, and how the ML project influences the business model of the company and can provide value.

As it is very important to obtain a thorough picture of what exactly is happening during the voyage and in the port, gaining insight into the operations of all these actors along the maritime transportation-chain is essential. Each of the actors represents a key actor in the maritime transportation-ecosystem. The interviews were conducted with cargo owners, shipping companies, shipping agents, and port operators—port, terminal, tugboat operator, pilot, port authority, port control. In total 19 interviews were conducted and all key actors were represented at least once. The first round of interviews was used to gain a deeper insight into the complexity of the maritime transportation-ecosystem and a better feeling of the current situation, the major problems and areas for improvements as well as for the potential benefits of the ML project and the impact on the business model of the different companies. The second round of interviews was based on the knowledge gained in the first round and took a closer look at port operations and efficiency gains through better port effectiveness.

The conduct of the interviews in both the set-up of the different rounds of interviews and the composition of the interview questions followed a Tracer approach. As Tracers clarify a particular process by focusing on the context rather than the connection between the people interviewed, these studies are very valuable, especially due to their real-time nature, which allows the researcher to identify and respond directly and immediately to emergent issues and to undertake a follow-up straight away (Chau and Witcher, 2005). In our case study approach, this method is especially valuable in the conduct of the individual interviews as these are intended to identify 'stories' to populate our benefits framework rather than provide concrete answers to predefined standard questions. Conducting the interview, key elements were identified before—port and voyage optimization potential; elements from the business model, such as key partners, key processes and resources, and revenue/cost streams—as well as common problems and areas for improvement. The questions were divided into general topics, such as *responsibilities and daily routine, current problems, potential areas for efficiency gains, impact of ML on the business model*. Nevertheless, the majority of the questions, and above all the story line, evolved throughout the different interviews and knowledge gained in one interview was then applied in the subsequent interviews in order to gain a more profound insight into specific matters.

For the data analysis, the interviews were partly transcribed with the aim to capture essential statements in form of insightful quotes. Together with the notes that were taken during the in-person interviews, the transcripts were used to filter out the most important themes in the interview. As the main objectives of the ML 2.0 project are efficiency, safety, and sustainability, we categorized the themes in accordance with these three dimensions applying a type of thematic analysis approach (Boyatzis 1998) inspired by Braun and Clarke (2006) in order to pinpoint sub-categories and metrics for our framework. For instance, statements about bunker savings were collected under *lower costs*, statements regarding information sharing/communication under *accurate real-time information*, and ideas for additional income under *higher revenue*. The responses then provided metrics such as *higher delivery precision* for the accurate real-time information sub-dimension. All transcripts of the 19 interviews were thus structured in this way and the most important quotes and special comments were highlighted separately in order to make sure to integrate them into the final analysis.

3 Theoretical Foundations

3.1 Approaches to IS Benefits Assessment

Coombs et al. (2013) raise the question about the ability of companies to measure benefits realized through IT investments as well as the ability to effectively manage them. They emphasize that there are substantial deficiencies in the current practices. Even though literature proposes many techniques for benefits assessments, hardly any of them is being used (Ballantine and Stray, 1998; Hu et al., 2007). Uncertainty of future business activities as well as the dynamic nature of projects and the constant management learning during the development pose major challenges for a thorough and reliable benefits analysis (Farbey, Land, and Targett, 1993; Serafeimidis, 1997; Smithson and Hirschheim, 1987). Specific projects are often only identified and initiated when IT problems arise. It is thus essential for organizations to gain a profound comprehension of the issues involved in the costs and benefits of IS development and implementation.

Various studies compare benefits, such as tangible vs. intangible (Sanchez and Robert, 2001), or classify them into certain categories like strategic, management, operational, functional, and support benefits (Farbey, Land, and Targett, 1999; Shang and Seddon, 2004). However, these classifications are only useful to a certain degree as they merely unfold and prevail a comprehensive understanding of potential benefits deriving from IT realizations. This is primarily due to the fact that it is very challenging to apply these categorizations in practice as the boundaries between categories are rather indistinct (Coombs *et al.*, 2013). To overcome this dilemma, other scholars suggested to provide clear definitions of benefits, such as "an outcome whose nature and value is considered advantageous by an organization" (Thorp, 1998).

However, in spite of providing useful academic insights, the conceptualization of IS-enabled benefits delivers little contribution to the actual assessment of benefits. To dive deeper into this topic, Coombs et al. (2013) identified the most common approaches to IS benefits assessment from a representational perspective: objective and perceptual measures.

3.1.1 Objective Measures

The underlying assumption of the objective perspective is ontological and epistemological in nature perceiving IS failure/success as discrete and determinant and ascribing it the ability to be objectively measured (Introna and Whittaker, 2003). Moreover, system success/failure can be attributed to the system's properties or factors; e.g., information, system, and service quality as well as satisfaction with the system, realization of expectations, performance and functionality, or other predefined objectives (Doherty, Ashurst, and Peppard, 2011). Many studies have tried to assess the potential benefits using economic measures. These studies follow in the footsteps of Thorp (1998) who postulates 'if you can't measure it, you can't manage it'—highlighting the critical importance of the assessment of IS-enabled benefits. Such measures are instinctively objective and include measures such as profitability, productivity, costs, quality, operative efficiency, and consumer surplus (Lin, 2009). Objective measurements can be perceived from a process-oriented perspective focusing on models of value creation, which assess IS investment benefits at the intermediate process level (Ray, Barney, and Muhanna, 2004). Thus, IS projects are usually declared to be successful if a working system is delivered "on time, on budget, and to specifications" (Doherty *et al.*, 2011).

The adoption of objective measures, which are predominately accounting oriented, is heavily debated due to their significant weaknesses. Researchers argue that these measurements are not suitable as they fail to capture intangible aspects of firm performance. Moreover, due to the isolation of IS investment contribution, second-order effects cannot be seized; for example, assessing the benefits in terms of return on investment or return on management or profits (Smith and McKeen, 1993). Additionally, factors such as the unavoidable uncertainties in determining or predicting the time and budget required to develop such a sophisticated system are completely ignored.

In spite of their serious weaknesses, businesses still rely heavily on objective measurements neglecting to a large extend completely the potential intangible benefits that could be secured using different assessment approaches (Petter, DeLone, and McLean, 2012). Such measures are most significant when assessing systems that focus on transaction processing and thus deliver tangible benefits (Coombs *et al.*, 2013). Remus and Wiener (2010) point out that objective measures are indeed significant "as the identification of factors and properties that are critical to achieving project and system success enables managers and IS professionals to focus their attention on managing and controlling a limited number of factors in notoriously complex IS projects" (Cecez-Kecmanovic, Kautz, and Abrahall, 2014).

3.1.2 Perceptual Measures

Many studies conclude that it is not possible to approach the account of success/failure in an objective way as the evaluation results cannot exist independently of the actors with diverging views and probably conflicting interests. Success/failure of IS implementation does not just exist but rather emerges through specific organizational, socio-cultural, and political processes and thus demonstrate an interpretivist point of view (ibid.).

In contrast to objective measures, perceptual measures rely essentially on the quality of the respondent's recall. By concocting IS success/failure in a subjective apprehension—narratives, social constructs, and political processes within a specific organizational context—very diverse theoretical approaches can be conducted (Bartis and Mitev, 2008). Such assessments used to be done mainly by using a Likert scale and measure the benefits on different organizational dimensions; for example, strategic, informational, and transactional (Mirani and Lederer, 1998). Recently, practitioners approached the assessment of IS impact through experts' self-reported data (Jeffers, Muhanna, and Nault, 2008; Nevo and Wade, 2010). As this approach depends highly on the competence of executives' perception of the information technology impact, Tallon and Kraemer (2007) conducted a study of 196 executives' views on firm performance and IT investment correlation in order to validate these research methods. Although the perceptions are not a precise proxy, they are "sufficiently accurate, credible, and unbiased as to constitute a viable approach to IT impact assessment" (ibid., p. 45). Moreover, they are especially viable in situations where the collection of primary data on IT impact is hard to collect. Therefore, "perceptual measures have the ability to provide new and useful insights into a wide variety of IT impacts across the firm" (ibid.).

Hedman and Borell (2004) point out that perceptual measures, for example narratives, might advance evaluation practice as they provide a richer evaluation picture revealing additional meaning not included in traditional evaluations. In addition, Coombs et al. (2013) argue that these alternative non-accounting methods of IS-enabled benefits are very valuable when analyzing intangible benefit levels but they need to be agreed with business managers to ensure their consistency and variability throughout the business. They follow the line of argument of Klein et al. (1997) who propose that the technical functionality also needs to be taken into consideration when selecting the most appropriate measures.

In a nutshell, in order to assess systems that are designed to improve the decision-making and to provide intangible organizational benefits, researchers should apply both perceptual-based/proxy measures and economic quantitative measures to effectively evaluate the potential benefits. Employing such a mix of objective and perceptual data will provide a more thorough picture of the IS impact (Tallon and Kra-emer, 2007).

3.2 Voyage and Seaport Efficiency

A major challenge of establishing efficient port operations is the fact that the different activities within the port ecosystem do not constitute a homogenous group and differ greatly in regards to the services, level of skills, or regulation required. The many different actors constituting the port ecosystem share the responsibility for superior service delivery (Trujillo and Tovar, 2007). Therefore, when analyzing port efficiency, each component needs to be look at from a different angle and also deserves a differentiated approach taking the specific peculiarities into account. Additionally, the multi-country perspective as well as private information make the assessment of port efficiency even more complicated (Trujillo and Tovar, 2007). Along these lines, in accordance with Friedrichsen (1999), an assessment of a port's performance needs to address the efficiency of the overall port ecosystem.

Today, nearly 90% of all goods traded globally depend on maritime transport somewhere along the supply chain. Terminals account for 80% of handling business and thus often drive the choice of port by a shipper (Trujillo and Tovar, 2007). It is noteworthy that in 2002 the average port efficiency reached merely 60%. That is, 40% more traffic could have been handled with the exact same resources (ibid.). Clark et al. (2004, p. 424) argue that "the (in)efficiency, even timing, of many port operations is strongly influenced (if not dictated) by customs" and vary (greatly) from country to country. They put forward that a port's efficiency is a principal determinant of shipping costs. They argue that if port efficiency was improved from the 25th to the 75th percentile, shipping costs could be reduced by more than 12%, since inefficient ports heavily increase the handling costs.

Since different seaport stakeholders hold different goals with respect to efficiency and profitability, seaport effectiveness becomes a matter of perspectives (Dooms et al. 2004). Verhoeff (1981) emphasizes that the competition between different seaports is set by regional factors, such as geographical location, local infrastructure, level of industrialization, government policies, and operational performance. Low et al. (2009) add that seaport connectivity is another key determinant for reaching competitive advantage. Da Cruz et al. (2013) set forth that different port stakeholders internalize numerous factors that interfere with a seaport's striving for competitiveness. That derives from the fact that different port users and providers have a quite different understanding of the key factors of seaport competitiveness.

In a nutshell, in order to optimize internal seaport processes and to boost a port's level of efficiency, a collaboration between all stakeholders of the seaport ecosystem is essential (Da Cruz *et al.*, 2013). Within this ecosystem, the shipping company represents the key actor in studying seaport competitiveness (Tongzon and Sawant, 2007). Service providers need to have a thorough understanding of the users' port experiences in order to be able to improve a port's competitiveness (Tongzon, 2009). Therefore, it is crucial to determine antecedents of competitiveness, identify performance gaps, and ascertain where exactly the port may optimize its operational efficiency. Moreover, efficient door-to-door cargo transport from departure to destination of the goods needs to be enabled through the integration of the seaport into intermodal links (Da Cruz *et al.*, 2013).

4 Development of Benefits Framework

Based on these two perspective, we established a 'benefits hierarchy' (Table 1) grounded in the key objectives—*efficiency*, *safety*, *sustainability*—and potential benefits proposed in the ML project.

These dimensions will be further broken down in sub-dimensions and then refined with the insights gained in the research interviews, which will provide metrics to evaluate these key benefits in more depth.

The **efficiency benefits** dimension can be grouped into the sub-dimensions: lower costs, accurate realtime information, higher utilization of resources, and higher revenue.

Safety benefits derive from both less accidents and higher security.

Sustainability benefits can be achieved through less negative environmental impact and a better CSR profile.

Using objective and perceptual measures, lower costs, for example, can be evaluated by using measures from the objective perspective obtaining quantitative figures to compare the costs over time tracking a percentage change. A better CSR profile, on the other hand, can be more adequately analyzed using measures from the perceptual perspective, such as conducting interviews with both stakeholders and

end-consumers about their perception of the CSR profile of a specific company and/or the maritime transportation-ecosystem in general.

Efficiency		Safety		Sustainability	
Lower costs	0	Less accidents	0	Less negative environmental impact	O/P
Accurate real-time information	0	Higher security	P/O	Better CSR profile	Р
Higher utilization of resources	0				
Higher revenue	0				

O: objective perspective | P: perceptual perspective

Table 1: ML objectives grouped according to objective/perceptual perspective

Overall, using both the objective and the perceptual perspective will provide a more detailed picture of the key drivers and root causes. Often, the ability to actually quantify the measures is the goal in many evaluation processes as quantifiable measures help to set more specific goals and milestones; in addition, they can also be used for benchmarking within and across organizations.

In general, categorizing and organizing benefits in such a hierarchical way provides a good foundation for determining the best way to measure the potential benefits of the implementation of an information system. It is very important to have a very thorough understanding of the common objectives and how they are built up from the bottom; i.e., which factors actually drive them. These sub-dimension-benefits are also good keywords for the research interviews as the interview questions can be tailored to fit these keywords exactly and thus provide a more profound understanding of how these dimensions drive the key benefits. This approach allows the researcher to direct the interview questions more accurately in order to achieve the desired outcome—e.g. a quantifiable number or a 'story'/quote.

5 Empirical Pilot Study

In order to test our initial benefits framework, we conducted an empirical pilot study in the Baltic Sea Area interviewing all actors within the maritime transportation-ecosystem as described in detail above in section 2. Based on the analysis of these qualitative research interviews highlighting the current challenges and key areas for improvements as well as the potential opportunities and risks, we compose a benefits assessment framework that can be used to evaluate the implementation of sea traffic management systems.

As the stakeholder perspective plays a crucial part in a thorough analysis of the potential benefits of a STM system, we decided to evaluate the interviews under two headings: (1) optimization of the sea voyage and (2) optimization of port operations.

5.1 Optimization of Sea Voyage

The optimization of the sea voyage focuses on route optimization between the port of departure and port of arrival. Here, the introduction of the AIS and ECDIS systems has already provided a substantial improvement regarding safety and efficiency. Nevertheless, national requirements, which can differ greatly between countries and between ports, pose a big challenge to the assessment of the effects of STM as well as to standardization/optimization within the entire ecosystem. Furthermore, some shipping lines and some ports already have very advanced systems, which are not very different from what is proposed in STM. Finally, even though some companies own more or less the whole value chain, estimates of key data like the ETA are often very imprecise until rather late. It was a Preem voyage loading on a Preem berth, it's Preem planning - Preem people all the way. [...] Everything Preem and still the [estimates of ETA] were off by 2 days. This sort of proves the challenges (Gustavsson, Tärntank).

Already today, some shipping lines have integrated systems for their own processes all the way from berth to berth. Energy-saving projects are also on top of the agenda for Stena Line. Subsequently, they feel that the potential benefits from STM will be rather small for them, as they have excellent systems and the capability to dedicate some of their staff to work solemnly on energy saving projects. In other cases, the actors were very excited about the potential value of a fully implemented STM and they agreed on the potential high bunker savings they could achieve.

I think, to cut 10-15% on bunker over the year is possible - more than possible. And also if you can have a system in ports, [it could] cut 1-2 hours, which is around 10-15%. Of course you can do it (Möller, Tärntank).

Every ton we can save due to reliable information is worth something. [By slowing] down to 10 knots and then being there [just-in-time] for berthing, we can save 6-7 tons in 20 hours. That is fantastic. There is a value ... for the environment as well (Gustavsson, Tärntank).

Just one knot is a lot of money already (Lewerentz, Stena Line).

Efficient voyage planning starts very early in the process. This obviously requires good internal information systems and really effective networks to potential suppliers. Planning takes place on a basis of limited transparency and many uncertain elements.

A good operator ... can earn his/her salary in one week or a couple of days. That's what good operators are doing today already (Möller, Tärntank).

Optimized sea voyages will lead to reduced turnaround time due to less time spent on sea. This saved time translates into savings on fixed assets, such as vessel, crew, and provisions. Moreover, real-time and bundled information offers the possibility to decrease the leeway in the planning of the voyage capitalizing on capacity utilization. An optimized sea voyage will thus lead to more transparency and less variability. Shipping lines will be able to handle unexpected events in a more effective manner.

Sometimes, there are hiccups during the voyages. If you can't foresee [these unexpected events], it could be beneficial [to be connected to such a STM system]. If we knew five hours ahead that there will be congestion in Gothenburg Harbor, then we could slow down all the way. If that were possible to foresee [with STM], that would be perfect for us. (Lewerentz, Stena Line)

5.2 Optimization of the Port Operations

The optimization of the port operations focuses essentially on the collaboration effectiveness within the ports. As the numerous different activities within the port do not constitute a homogenous group and differ greatly in regards to, for instance, regulations, services offered, or level of skills. Only a collaboration between all actors of the ecosystem can push the optimization of the internal port processes and boost the port's level of efficiency as one actor by himself/herself is not able to provide all services required (Da Cruz *et al.*, 2013). A global STM system will provide added value especially through coordination efficiency and reduced turnaround time, reduced workload, elimination of work, and less mistakes.

At the moment, there are many different but no integrated systems in place. Unfortunately, they can neither deliver the necessary accuracy nor validity with regards to time estimates. Throughout the interviews the recurring theme was the importance of accurate and up-to-date information, which would make it possible for the actors to always trust the information displayed in the STM system and thus, planning could be optimized more efficiently and effectively. An integration of systems and ubiquitous availability of information would be a major improvement in the operation for all actors involved, since "chasing" desired information consumes resources equivalent to timesaving of more than 50% (e.g.

Kärnebro, Port of Gothenburg). By optimizing the port ecosystem as a whole and benefiting from resulting synergies, the turnaround time could be reduced significantly. In the ports, every minute counts and even the slightest improvement will make a huge difference in monetary terms.

We had the aim in Göteborg to reduce [the turnaround time by] 15min. Because you have a lot of money when you talk about 15min. Then everyone is more alert. We talk about minutes and then it results in hours (Möller, Tärntank).

Furthermore, a better information flow between the different actors could allow for a reduction in the notice time for ordering a pilot or tug in order for the actors to be able to react more quickly and flexibly to unexpected events. At the moment, the lack of common standards and requirements regarding the way business processes are handled is a big challenge.

Every port is different. For example, in Slagen (Norway) the cost for lying at the quay is quite expensive and the cost for pilot to anchorage is quite cheap [if you compare it to the cost of laying at the quay] (Karlsson, SMA).

Moreover, planning operations in ports can be seen as some kind of certainty funnel, where initial vague information, e.g. about ETA, becomes more and more certain the closer the vessel gets to the port. For many of the actors it is therefore impossible to optimize and realize efficient capacity planning.

[In the tug business] we don't have a day or two, [and we certainly] don't have two weeks. That means we can't actually plan our capacity way in advance. We only have experience and annual peaks ... to actually plan capacity. [...] The complexity means that the focus from our side becomes 'just getting things done' in order not to hamper the effectiveness of the port, instead of the bottom line of our company (Biangslev, Svitzer).

It is clear that more transparency in port operations, especially the crucial ETA/ATA, will contribute to a reduction of costs, since it becomes easier to optimize planning and operations. The earlier one gets the information, the better. Examples of that could be a notification about a container ship blocking the fairway. This kind of information would be very beneficial in order to slow steam and thus reduce bunker consumption.

If we know 5 hours ahead that there will be congestion in Gothenburg Harbor, of course, then we slow down all the way. If that were possible to foresee [with STM], that would be perfect for us (Lewerentz, Stena Line).

Respectively, a better information infrastructure and exchange will lead to a significant reduction of the workload for some of the actors in the port, e.g. agents, linesmen, or pilots, but also for the captain and his/her crew on the vessel. Especially the need for constant email and telephone communication would be reduced significantly.

If STM was reliable, that means, if you could really, really trust that the information is reliable, I think everybody within the whole nautical chain could make their own business better by planning their resources in a better way. For example, linesmen. Instead of having 35 employees, maybe they could [make due with] 30 or maybe they could decrease their prices. The same [applies to] tug companies. For us, yes, maybe we could make our organization up here in a better way. We can use our employees in a better way (Kärnebro, Port of Gothenburg).

Additionally, efficiency gains are possible through a better grouping of operations. For example, tug operators could reduce the commuting time for the crew by grouping different journeys together and thus also reduce the environmental impact significantly.

In Milford Haven (UK) there is a lot of tugs, because there is Terminal that takes in oil and gas. They are based quite far away from where the tug jobs are. That means that tugs steam back and forth to do their jobs. And if they had better knowledge [about] what was going to happen for the next 24 hours or something like that, they could kind of wait out there instead of going back and forth (Christensen, Svitzer).

Through collaborating more closely with each other, learning and spillover effects will complement and nourish the coordination effectiveness. Considering the fact that at the moment there are almost no

standardization processes in place, joint effort might change this in the future improving the port ecosystem beyond the goals of STM. Nevertheless,

Before you can launch a tool [like STK and initiate major changes], you need to know the processes and understand them very well (Kärnebro, Port of Gothenburg).

When they get the information from the agent that they will have to anchor, they are instructed to slow-steam immediately. That works actually very (Näsström, Preem).

6 Analysis

Our pilot study documented in section 5 above turned out to be very beneficial. Firstly, it is clear that there is a huge potential for improvements in sea traffic management—regarding both the sea voyage optimization and the port optimization. With a global STM system, the actors within the maritime transportation-ecosystem will be able to adjust their capacities more appropriately and according to actual market demand. By optimizing the entire ecosystem as a whole, STM takes the interdependencies into consideration and prevents sub-optimization. This new socio-technical system will create a win-win situation for the entire ecosystem; i.e., if all actors get connected and collaborate, they will all benefit from a more efficient and effective collaboration and coordination.

Secondly, the pilot interviews convinced us that the overall framework and the specific dimensions we asked about made sense to the interviewees. It was possible to discuss challenging problems and barriers to improvement with the different actors. In other words, our initial framework is overall robust enough to encompass all views expressed. Furthermore, dividing the analysis into *sea voyage* and *port optimization* provides a more structured and clearer insight into the potential benefits. Moreover, in addition to a sole benefits assessment, the impact STM has on the business model of the individual actors can also be evaluated by using other tools, e.g., Osterwald and Pigneur's (2010) business model canvas. This tool can be used to analyze the current business operations of each actor in detail and then to refine the model with a STM scenario. As the whole ecosystem perspective is too complex to be illustrated meticulously on such a canvas, creating a canvas for each individual actor will provide a better overarching perspective of the entire ecosystem and the great optimization potential.

Thirdly, the pilot interviews revealed suggestions for sub-dimensions and metrics we had not included in our first version of the framework. We were thus able to reformulate some of the sub-dimensions even further developing specific metrics (based on the interviewees' quotes) to evaluate the sub-dimensions and thus the overall expected benefits of the implementation of a STM system. Figure 2 demonstrates the final version of the ESS (Efficiency-Safety-Sustainability) Framework.

It is also important to note that different actors are motivated and influenced by the same events in fairly different ways. Benefits of STM (especially reduction of extra costs) are reflected both in standard situations—the optimization of common routines and coordination—and in the situations of unexpected events, where the STM will reduce/eliminate the risk of occurrence of these events as well as allow for a quicker recovery from emergencies. Despite the fact that a lot of information is already available today, there is an abundance of different sources of information impeding the individuals to gain access to the benefits of different information sources and to form a coherent/accurate picture.

The information is there, it is just a question if it actually reaches us in the end (Sundvall, Preem).

7 Conclusion

Applying qualitative research in form of an empirical pilot study using triangulation and in-depth, semistructured interviews, we carried out an analysis addressing the research question *How can potential benefits of the implementation of a sea traffic management system be evaluated?* by developing a framework (the ESS framework—Figure 2) for such an IS benefits assessment. Our pilot study confirmed the validity of the framework allowing us to refine and tailor it to the specific needs of the actors involved in the maritime transportation-ecosystem. To obtain more robustness, a future study should include actors from other areas in Europe as well as a bigger sample size. Once the ML test beds are in place, it will also be easier to brief the interviewees on STM as they will be able to understand the bigger picture of STM better and thus relate it more effectively to their current operations. This will contribute to a firmer framework, too.

Nevertheless, we must not neglect the fact that a global STM system will only provide the previous mentioned benefits if all actors are 'on board' and willing to cooperate and collaborate. The success of this system depends completely on the willingness to change and modernize the maritime shipping industry and the acceptance of the system by all actors.

Obviously, if more people got connected to the same sort of system/platform, then this guy would also be canceled early and then there would be sort of a balance. Rather than him being smarter than me in being able to keep his ships on schedule, I think it would balance out. I don't think you want to be the first guy to be totally transparent (Gustafsson, Tärntank).

As many of the respondents weren't able to completely understand and picture this STM system, a successful implementation of a STM pilot project will make it possible for all stakeholders to understand how the STM concept works and to assess the direct implications for the overall ecosystem.

The day [Mona Lisa 2.0 STM] works, we will be part of it. The environmental aspects will be huge if its works the way it is supposed to do. And I think, sooner or later, we have to [...] optimize our routes and to be more efficient when it comes to emissions (Sundvall, Preem).

Increased global sea transport does not only lead to a better access to products from all over the world and the way shipping is handled in terms of efficiency and safety but also to greater negative impact on the environment. STM demonstrates a great solution to tackle the various problems the maritime shipping industry has been facing for many years. The implementation of a global STM system will create efficiency and raise safety while reducing the environmental impact of increased maritime traffic.



Figure 2: The ESS Framework

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