Success factors for navigational assistance: a complementary ship-shore perspective

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Abstract
The maritime domain is under pressure from changing economic, political and environmental factors. Technological advancements facilitate increased monitoring and control from land. By viewing the maritime domain as a complex socio-technical system, the importance of understanding the role of the on board and shore-side operator in maintaining safety and efficiency of navigation becomes apparent, particularly when introducing new technology. This paper looks at the success factors for navigational assistance, as currently performed by maritime pilots and Vessel Traffic Service (VTS) operators, aiming to identify issues worth consideration in future navigational assistance services. One focus group and one combined workshop/focus group were held with three pilots and two VTS operators respectively. The first looked at the prerequisites for successful navigational assistance from the perspective of the pilot. Using a grounded theory-style approach, a proposition was created that the main indicator of success is “no incidents”, that success depends on the integration of local knowledge, preparation and foresight into the ship-shore system and that good communication is vital to achieving this. Testing this, the second study considered the role of communication in enabling the VTS operator to support the pilot; it confirmed the results of the first study, emphasising the importance of communication when working both with on board and shore-based pilots.

Introduction
The maritime domain is under pressure from changing economic, political and environmental factors. Modern shipping must deal with an increasing volume and diversity of waterborne transport operating within an ever decreasing navigational space, while simultaneously attempting to curb emissions. Larger vessels are being operated by smaller crews. Shipping routes are being integrated into inter-modal logistics networks. The move towards shipping as part of an integrated transport system brings with it increased demands for information exchange between the vessel and land-based stakeholders and authorities. Various initiatives on a national, European and international level are being put in place to address these challenges, which are pushing the boundaries (Rasmussen, 1997) of the International Maritime Organisation’s (IMO) guiding principles of safety and efficiency.
Advancements in communication and navigation technologies have paved the way for a technical infrastructure in which this information exchange is rapidly becoming reality, allowing for increased centralised monitoring and guidance of vessels. The IMO (2014) have recently finalised a draft Strategic Implementation Plan for e-navigation with the objective to “facilitate a holistic approach to the interaction between shipboard and shore-based users, under an overarching e-navigation architecture” by 2019. The ability to share information between ship and shore also opens up the possibility to introduce new forms of navigational assistance. However, before doing so, it is necessary to understand which services exist today to assist in the navigation of seagoing vessels, how they complement each other, and most importantly, what makes them work (Rochlin, 1999; Johansson & Persson, 2009).

Recent developments in organisational safety such as Resilience Engineering (Hollnagel, 2006) and Safety-II (Hollnagel, 2014) emphasise this same focus on everyday operations, a systemic view in which a successful outcome is created by adapting to the dynamic environment, and safety is often indicated by the absence of incidents (Woods, 2006). Indeed, perspectives from systems engineering dominate the literature on the maritime domain. It is often viewed as a complex socio-technical system (Perrow, 1984; Koester et al., 2007) or a Joint Cognitive System (JCS) (Hollnagel & Woods, 2005), in which the operator interacts with the organisation, technology, physical environment and many other factors, working together to keep the system operating within acceptable parameters and achieve a common goal, in this case the safety and efficiency of navigation. Much of the discourse revolves around control and the link between loss of control and unexpected events. Issues raised are whether safety is improved by centralised (shore-side) or decentralised (on board) control (Perrow, 1984; Weick, 1987; van Westrenen & Praetorius, 2012); the role of both feedback, i.e. input from the environment, and feedforward control, the ability to pre-empt deviations, driven by local knowledge (Hollnagel, 2002; Johansson, 2005; van Westrenen, 1999; Bruno & Lützhöft, 2009); and the importance of achieving tactical (short-term, localised) and strategical (longer term, system-wide) control (Praetorius, 2014; Praetorius & Hollnagel, 2014), although this is often not achieved in practice (Hollnagel & Woods, 2005). This paper, however, attempts to step back and describe some preliminary investigative studies into the success factors for various forms of existing navigational assistance from the perspective of the operator, with a starting point in practice, rather than theory.

**Overview of existing navigational assistance services**

“Navigational assistance” is an overarching term encompassing several forms of service which aim to assist the ship’s captain, known as the “master”, with the safe navigation of their vessel in areas where this is deemed necessary. It will be used in this paper to include pilotage services, both on board and shore-based, and navigational assistance as performed by Vessel Traffic Services (VTS). It should be noted that although this inclusive term is utilised by the author, it is not necessarily used by the practitioners.
**Pilotage**

Pilotage has a long and well-established history, stretching back at least 4,000 years (IMPA, 2014). Pilotage can be defined as “to guide vessels into or out of port safely - or wherever navigation may be considered hazardous, particularly when a shipmaster is unfamiliar with the area” (IMO, 2014), comprising “activities related to navigation and ship handling in which the pilot acts as an advisor to the master of the ship” (IALA, 2012a). Pilotage is generally conducted on board the vessel (Hadley, 1999; van Westrenen, 1999; Grundvik & Wilske, 2007) but, in some areas and in certain, often weather-related, circumstances, remote pilotage i.e. from “a position other than aboard the vessel concerned” (Hadley, 1999; EMPA, 2014) may also be conducted.

**Vessel Traffic Services**

Vessel Traffic Services (VTS) is a shore-based service, established to “improve the safety and efficiency of vessel traffic and to protect the environment”, offering one or more of three levels of service: information service (INS), navigational assistance service (NAS) or traffic organisation service (TOS) (IMO, 1967). NAS, a service “to assist on-board navigational decision-making and to monitor its effects”, is usually requested by the vessel (van Westrenen & Praetorius, 2012) or given when observed to be necessary by the VTS (IALA, 2012b). The vessel is recommended, but not obligated, to follow this advice (IMO, 1967). In practice, there is no sharp distinction between INS, NAS and TOS (Praetorius, 2014), and all may be seen as, directly or indirectly, assisting in the safety of navigation.

**Responsibility for safety of navigation**

Although both pilots and VTS operators may provide advice on navigational matters, responsibility for safety of navigation remains at all times with the master of the vessel (STCW, 1995/2010; COLREGS, 1972). The VTS operator or pilot do not relieve the master of this responsibility (IMO, 1967; IALA, 2012a).

**Method**

The general approach can be described as grounded theory-inspired, taking elements of grounded theory as developed by Glaser and Strauss (1967) (also Charmaz, 2000). A variety of methods and data sources were used in order to create and develop a general “proposition” concerning the success factors for navigational assistance. This was treated as a substantive theory (Denscombe, 2010), a localised, empirical theory, or a general statement about the phenomenon to be subsequently confirmed, refuted or amended, and was indeed used in this way throughout the remainder of the studies.

The process did not strictly follow the step-by-step procedure as originally described (Glaser & Strauss, 1967; Czarniawska, 2014), being more opportunistic and pragmatic in nature. As one aim of the studies was to feed the results back into the maritime community, it was considered important that the outcome be recognisable and relevant to practitioners. Therefore an approach with links to pragmatist thinking was used (Locke, 2001). Data collection was mainly done through a focus group (Corbin & Strauss, 2008; Stanton et al., 2006) and a workshop with expert practitioners. Field observations and informal conversations with various
stakeholders were also used to complement the data, utilizing a series of “double-back steps” (Glaser, 1978) to continuously refine the emerging results. The diversity of methods, data sources and materials was considered useful in highlighting different aspects of the topic (Glaser, 1978; Strauss, 1987). As the method and the results are very much intertwined in this approach, a description of how the studies were conducted, progression was made throughout and results were developed iteratively will be shown in this section; the actual results will be included in the following section.

*Focus group with deep sea pilots*

The studies commenced with a focus group looking at the success factors for navigational assistance from the perspective of the maritime pilot, more specifically, the deep sea pilot. The focus group consisted of three deep sea pilots operating in the Baltic Sea and Kattegatt/Skagerack areas. The pilots had similar backgrounds but varying levels of professional experience and length of service. The participants were given one open-ended question which was then discussed in detail with very little intervention from the moderators. They themselves described in very clear terms what they considered the success factors, and in particular how success is measured (see results). As they were emphatic on this point, their phrasing was retained and, by using constant comparison throughout the analysis, its centrality was confirmed. Likewise, the participants themselves identified the relationships between various types of information, which would become the categories and themes of the analysis, already during the focus group, and the importance of communication of this information between ship and shore. Thus, much of the analysis took the form of a cross-check on the data, rather than an analysis per se; it merely confirmed the relationships between the factors already identified by the participants.

As all the participants and researchers present were either native speakers, with the exception of the author who has a good working knowledge of the language, the focus group was held in Swedish. Transcriptions were made in the original language and loosely translated by the author. The transcriptions were coded and analysed iteratively using an inductive approach. Comparison was conducted throughout with photographs of the participants’ brainstorming on the whiteboard and the authors’ own notes. As codes and categories emerged, the wording was kept as close to the original as possible. In most cases, a direct translation into English was considered sufficiently accurate. Open coding produced a large number of categories which were then, by a process of axial coding, interlinked and consolidated into themes and related to a central concept (Strauss & Corbin, 1990) from which the proposition was developed. A table and corresponding diagram showing the relationships between categories, topics and main concept was generated and from this the proposition was formulated (Figure 1).

A very preliminary version of the proposition was presented in text and diagram form to pilots and VTS operators at a project meeting and received positive feedback. Informal conversations revealed support for the proposition from the point of harbour and coastal pilots (“difference minimisation”, Glaser & Strauss, 1967) as
well as deep sea pilots. One of the participants in the focus group also confirmed that this was a true representation of their discussion.

**Workshop with Vessel Traffic Service (VTS) Operators**

Having considered the success factors from the perspective of the on board pilot, and having received confirmation, albeit on a limited scale, from a wider community of pilots and VTS operators, the phenomenon was investigated further by looking into how communication between ship and shore contributes to successful operations from the point of view of the shore-side operator, the VTS operator ("difference maximisation", Glaser & Strauss, 1967). Initially the second data collection was intended to be another focus group mirroring the first but from the shore-side perspective. It was to form part of a larger expert workshop looking at everyday operations in the VTS domain. However, due to availability of participants, only two were able to remain for the part of the workshop which is described in this study and the format was thus revised.

The participants, experienced VTS operators working in two large European ports, were first asked individually to describe their VTS areas by drawing a map on the whiteboard, and then describe the process of communication between the VTS and pilots by annotating on the map. They were then asked, in a group interview style, to discuss what makes for successful communication between the VTS and the pilots, what can be improved. Since both on board and shore-based pilotage are available in their areas, they were asked how the communication changes in the case of the pilot being shore-based as opposed to on board the vessel. Photographs of the maps and diagrams drawn by the participants were taken and the discussions were voice recorded. The language used was English. Once again, transcriptions were made of the recordings and a loose open coding conducted. However, instead of developing categories from the wording of the discussions, the categories developed in the analysis of the first focus group were used to sort the data. These were deemed to be mainly sufficient, though a couple of new categories were added. Throughout this sorting process, the participants’ maps and drawings were continuously referred to, as were the table and diagram of results and the proposition from the previous study. The table and diagram were then annotated to show how the findings from the second study confirmed or refuted those of the first, and to show any new data which had emerged. As certain aspects were identified as being of greater importance during the second study, these were also highlighted.

**Field observations and further informal conversations with practitioners**

Following the workshop with the VTS operators, further low key data collection was conducted over a period of several months to observe how the factors identified by the respondents manifest themselves in practice. This included the shadowing of a harbour pilot in their daily work: receiving the pilot booking from the VTS, transfer with the pilot boat to the vessel, boarding the vessel at the pilot boarding point, connecting the tugs and berthing the vessel in the harbour. Several informal conversations and observations have also been held with pilots and VTS operators, both in their operational environment and in training situations, such as the pilot station, VTS centre, classroom and VTS simulators.
Results

Focus group with deep sea pilots

The main findings of the first focus group with the deep sea pilots were that:

The main indicator of successful navigational assistance is “no incidents”. This is dependent on (i) the pilot as the link in the chain of communication between the vessel and the VTS and (ii) the integration of information based on local knowledge, preparation and foresight.

A surprising finding (at least for the author) was the respondents’ unanimous insistence on “no incidents” as the trademark of a successful assistance, rather than, as might have been expected, safety. Incidentally, when the moderator tried to categorise “no incidents” as “safety” during the discussion, the respondents interjected with a comment that “What is safety? We can’t measure it, but what we can see is that nothing went wrong.” The above formulation emerged from the grounded theory-style analysis of the data. This was then used as the proposition to be further investigated in the remaining studies. A visual representation is shown below.

![Diagram showing success factors from the perspective of the pilot]

**Figure 1. Success factors from the perspective of the pilot**

Local knowledge is made up of information about (a) the traffic intensity, such as the types, sizes, speeds and schedules of vessels operating in the area and which routes they tend to take; (b) environmental factors such as weather patterns, water depth, currents, water level etc.; (c) experience, not just in terms of training and time as a captain or pilot, but also regarding the interpretation of information from the environment, other vessels, technology, the vessel crew and the VTS.
Preparation is mainly concerned with (a) vessel and traffic information, both in terms of receiving the details of the vessel to be piloted, size, type, crew, shiphandling characteristics, destination and estimated time of arrival (ETA), but also the expected traffic situation and intensity; (b) weather forecasts, including predicted wind, visibility, waves, currents and water level; (c) organisation, including factors such as scheduling, possibilities for rest periods, travel, handovers between pilots, as well as the ability of the pilot to receive and assimilate weather and vessel information and create a plan for the voyage.

Foresight is built on a combination of (a) vessel and traffic movements, both the shiphandling of the vessel being piloted in the current traffic situation and weather conditions, and the interaction with other vessels and VTS in the area; (b) environmental conditions, the effect they are having on the vessel and traffic movements; (c) ability to adapt to the vessel and its crew, other traffic, weather etc. in order to avoid incidents and keep the appointed ETA.

The pilots perceived their role as integrating the aforementioned information and being the link in the chain of communication between the vessel crew, particularly the master, and the shore-side VTS operators. While they acknowledged that the level of communication and cooperation between parties may depend on culture, nationality and role of the different parties, and is not always optimal (see also TSBC, 1995), they emphasised that communication is usually successful because of the inherent trust in the role of the pilot (see Meyerson et al., 1996; Bruno & Lützhöft, 2010); they are welcomed on board and seen as part of the bridge team, bringing their local knowledge, preparation and foresight to the situation and bridging the language gap between the ship and shore (also noted in van Westrenen 1999, 2011; van Westrenen & Praetorius, 2012).

Workshop with Vessel Traffic Service (VTS) Operators

The second study, the workshop with VTS operators, confirmed the results of the first. Although the focus was on communication, all the categories identified as success factors in the first study were mentioned as being instrumental by the VTS operators, with a particular emphasis on preparation. The main findings were thus that:

*Success is dependent on good communication between the VTS, pilot and vessel, being especially critical in the preparation phase.*

Additionally, a number of new issues were highlighted: the importance of communication between the pilot and tugs and fishing vessels; the role of the pilot as the interpreter between the vessel, where English will usually be the language used with the crew, and the VTS and tugs, where the communication may often be in the local language; that changes in routine and particularly in the co-location of the VTS and pilot services may have major impact on the communication between the parties (see also Praetorius, 2014). This was considered true regardless of whether the pilot is on board or shore-based. The findings from the second study were used to annotate and modify the results diagram as shown in figure 2.
Field observations and further informal conversations with practitioners

During the field observations of the pilot at work and other informal conversations with pilots and VTS operators, the findings from both the studies with the deep sea pilots and the VTS operators were again confirmed. In particular, the inherent “status” of the pilot as the local navigation expert (as noted in van Westrenen, 1999; Darbra et al., 2007) as soon as they step on board the vessel, and the ability to quickly build a relationship of trust (see also Meyerson et al., 1996; Bruno & Lützhöft, 2010) with the master and crew using verbal and non-verbal communication (see Flin et al., 2004) were noted. The role of the pilot as interpreter between the tugs and vessel was also apparent. Also noticeable was the proactive nature of both the pilot and VTSO operator at work; continuously scanning the information available to them, weighing up options, planning the next steps and adapting the language and content of their communication to effect the required response from the vessel crew.

Discussion

The number of respondents in both the focus group and the workshop was unfortunately very low and not representative of the population as a whole. It was established that the participants of the first focus group also had considerable experience operating within harbour and coastal pilotage areas and so were qualified to represent not only deep sea pilots, but pilots in general. Still, anchoring in a wider population of pilots and VTS operators is needed. Also, when considering the interaction between the pilot, VTS and vessel, it is of course necessary to consider
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the perspective of the master and crew of the vessel being assisted. This remains to be done in the near future. The author believes that the results are nevertheless indicative and that further studies following this cumulative, flexible approach approach (Corbin & Strauss, 2008) will confirm this.

From both the ship and shore-side perspectives, two main points were emphasised throughout: that success is dependent on communication and integration of information. The proposition developed during the first study with the deep sea pilots was thus confirmed. This rather simplistic proposition, easily recognisable to practitioners, almost to the point of being too obvious (consider Czarniawska’s (2014) comment on grounded theory being “nothing more than the common sense of fieldwork”), nonetheless disguises the complexity of the services provided by pilots and VTS operators within the maritime domain. It focuses on the ability of the human operator within the system to integrate and communicate, without going in detail into the vast range of sources of information being integrated and communicated; the various means and timescales within which this is being realised; and the dynamic and unpredictable nature of many of the elements and the interaction between them. Only by observing them at work can this complexity truly be appreciated.

In addition to building on this empirical approach, a parallel examination of navigational assistance from a theoretical perspective may provide additional insight and give weight to the findings so far established. It became apparent during the analysis of the second study that, while the practitioners, particularly the pilots, identified and categorised their work as the integration of local knowledge, preparation and foresight, within each of these topics, another pattern may be identified; each is based upon information regarding (i) vessels and traffic, (ii) weather and physical environment and (iii) the skills and characteristics of the operator. In other words, the ship-shore interaction may be seen as the human, technical and environmental elements of a complex socio-technical system (Perrow, 1984) or joint cognitive system (Hollnagel & Woods, 2005).

Furthermore, the distinction made, consciously or unconsciously, by the operators can be regarded as relating to different but interrelated aspects of time: (i) local knowledge, about traffic, environment and other factors, is built over a long time period, but once established is fairly constant; (ii) preparation is concerned with the hours or day before the navigational assistance takes place; (iii) foresight deals with the present and near future. Integration and communication of information on all three time scales is necessary to ensure success, creating the preconditions for what may be described as strategic or tactical control in a resilient system (Praetorius & Hollnagel, 2014). Although the participants do not speak in terms of control, talking instead of communicating information between ship and shore, aspects of both centralised control, e.g. the VTS coordinating pilot boarding, and decentralised control, such as the pilot directing the tugs, may be seen.

More problematic is the apparent paradox that, while the official goal of both on board and shore-side navigational assistance is the safety and efficiency of navigation (IMO, 1967; 1969), in practice a successful outcome is “no incidents”. Safety is seen as a dynamic non-event (Weick, 1987). Indeed, according to the
practitioners in these studies, it is unmeasurable. While they can identify the necessary ingredients to create success, and observe these in their daily work, they cannot identify success itself other than as the absence of failure. They are also divided on the extent to which success is partially attributable to chance. This same paradox is discussed in some detail within the field of resilience engineering (Hollnagel, 2014), and appears to be one of the major challenges to be met in order for organisations concerned with safety in dynamic conditions to change their focus towards success in everyday operations. This also has implications for the design of future navigational assistance services, if they are to achieve a positive measure of safety, rather than be characterised by a lack of failure.

Conclusions

The main conclusions to be drawn from this simple preliminary study are that, from the perspective of the on board and shore-side operator:

The main indicator of successful navigational assistance is “no incidents”. This is dependent on (i) the pilot as the link in the chain of communication between the vessel and the VTS and (ii) the integration of information based on local knowledge, preparation and foresight.

It is hoped that further investigations, both in terms of additional empirical data collection and an examination of the phenomenon from a theoretical perspective, will contribute to a set of preconditions for successful navigational assistance which should be considered in the development of future maritime communication infrastructures and e-navigation services.

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