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# Military organisations and emerging technologies – How do unmanned systems find a role in future navies?

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**Abstract:** Fewer qualified platforms and reduced personnel within the navy are the reality for many nations, although operational requirements might have remained the same or increased over time. At the same time, research is advancing in unmanned and autonomous systems, which have also found application in military use. Therefore, navies need to develop approaches for effective technological transformation. To fulfil this need, this study aims to identify and describe the relevant research from different disciplines and their respective relation to the design of future navies. The study commences with a literature review related to knowledge support for understanding how emerging technologies, such as maritime autonomous systems (MAS), find their place in a military organisation. The findings suggest that the armed forces should be categorised as a sociotechnical system, built of systems-of-systems that together enable capability, and that it is as a capability enforcer that the overall system should be developed. This highlights the importance of structural and organisational changes in making the best use of the technology, as well as in making the sociotechnical system as efficient as possible. Therefore, the armed forces need to be learning organisations, exercising joint planning, where there is room for knowledge sharing and flexibility within the organisation despite different hierarchical layers.

**Keywords:** autonomous systems, concept development, sociotechnical systems, capability development, capability lifecycle

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## 1 Introduction

The reality is that in many nations, the navy is comprised of smaller organisations with fewer advanced platforms and fewer personnel, who are entrusted with the task of performing the same or even more advanced operations than earlier. At the same time, autonomous and unmanned systems are examples of technologies that are investigated and explored within the civil as well as the military realms, not only in a technical aspect but also operationally. Till (2018, p. 171) asserts that 'Navies evidently needs to develop a strategy for dealing with technological transformation', emphasising the need for making the best use of the systems and implementing them into existing organisations and operational concepts. This is also identified to be a problem in general for the development of defence capability (Hannay and Gjørven 2021; Liwång 2022). Unmanned systems could complement the existing platforms in tasks that are deemed as 'dull, dirty and dangerous' and by that creating more effective systems working together, not as add-ons to qualified platforms but to transfer the focus from today's platform centric approach to system of platform centric (Department of the Navy 2021).

To fulfil the need to develop contemporary strategies for implementing emerging technologies, this study aims to identify and describe the relevant research from different disciplines. The identified research should be described in relation to the design of future navies, exemplified by the introduction of maritime autonomous systems (MAS). MAS is selected as an example because effective implementation may demand changes in the social and organisational structures of a navy's organisation. MAS is here seen as a collective term for several different unmanned and autonomous systems in the maritime domain. These systems could be used in all conflict levels, both in offensive and defensive modes, giving rise to a wide range of aspects to consider, including ethical and legal.

This study comprises three steps. The first step is a literature review aiming at identifying areas that are useful when exploring how military organisations can meet new challenges, implement technical systems and at the same time make appropriate organisational changes and develop concepts. The second step identifies and describes research areas of interest and their respective roles in relation to implementing emerging technologies. The third step presents a synthesis on the findings that is especially focussed on the role of the existing research and approaches in the interplay between technical and organisational changes.

## 2 Method

To understand the role of technology within an organisation, there is a need to understand its context in the surrounding environment. In a military context, this may involve examining the operational concept of the organisation where the system is to be implemented and used. With that in mind, the first step of this study was a literature review concerning the areas of autonomous and unmanned development, concept development and innovation. The literature review also considered research on autonomous systems in general and MAS in particular. The systematic literature review was performed according to Denscombe (2010) to obtain a quantitative view on the research areas connected to MAS and concept development.

Based on the findings of the literature review, the second step qualitatively identified research areas of interest. The description of the identified research areas of interest and the qualitative discussion on their respective contribution was also supported by a wider search for publications and documentation not covered by the initial searches. This additional search, performed on scholar.google.com, library search engines and the internet, was directed specifically to the fields where the results of the initial literature review were identified to be limited. This search was conducted to identify relevant documents that contribute to creating an overall picture of the areas requiring attention, such as military and state doctrines and reports.

The third step of the study is a synthesis where the identified research and knowledge areas were addressed across the identified areas and disciplines. The synthesis describes the findings in relation to the systems engineering process, the sociotechnical systems engineering and the organisational change process.

## 3 Initial literature review

The initial search was conducted using the research database Scopus to obtain a general picture of the research areas, where a broad search consisting of the terms related to unmanned or autonomous systems in the maritime arena altogether resulted in around 30,000 publications, as can be seen in Table 1. When adding the term military or defence to the search the total number amounted to 1,700 publications. Table 1 also shows that the initial search in relation to concept development resulted in almost 4,000 publications, whereas the ones related to military or defence were only 127.

The literature search identified that the amount of research and development in relation to autonomous and unmanned maritime systems or vehicles has been far-stretching and thorough, especially when it comes to engineering and computer science research and results. These results presented a good overall picture of the technical forefront in autonomy and unmanned systems in areas such as navigation, communication, propulsion, endurance and range, and as examples we may mention Maguer et al. (2018), Batalden et al. (2019) and Teeneti et al. (2019). Out of these publications, only a small portion represents the areas of social science, management and multidisciplinary research, and it is this component that presents specific insight into the interplay between technology and social system aspects, i.e. constitutes the principal interest for this study. The percentage ratio between the areas of engineering and social science, management and multidisciplinary research was similar for the searches, with or without considering the military arena.

There are limited, but important, scholarly works available in the areas of interest dealt with in this study. There is, for example, an ongoing discussion of accountability, dealing with the responsibility in different levels of any action performed by the autonomous system. The wide area of international law and the use of unmanned or autonomous underwater systems is also something that is not fully explored and needs further research as the technology advances and the capabilities of the systems become enhanced (Rogers 2012; Schmitt and Goddard 2016). However, this research often has a weak link to the actual technology development performed and is often spread-out over several different fields.

Important information was found within the area of War Studies, covering both historical and contemporary aspects of the specific concerns arising within the armed forces when dealing with innovative technology and organisational change. As can be seen from Table 1,

**Tab. 1:** Result of initial literature search in the research publication database Scopus.com, performed March 2020

| Search string | Total | Engineering | Social science | Management | Multi-disciplinary |
|---|---|---|---|---|---|
| (Autonomous OR unmanned) AND (surface OR underwater OR maritime) AND (system OR vehicle) | 30,167 | 20,960 (69%) | 1,163 (4%) | 292 (1%) | 239 (1%) |
| (Autonomous OR unmanned) AND (surface OR underwater OR maritime) AND (system OR vehicle) AND (military OR defence OR defence) | 1,700 | 1,309 (77%) | 69 (4%) | 124 (1%) | 11 (0.1%) |
| (concept development) | 3,763 | 1,574 (42%) | 746 (20%) | 282 (7%) | 13 (<0.01%) |
| (concept development) AND (military OR defence OR defence) | 127 | 81 (35%) | 18 (8%) | 12 (5%) | |
| Innovation AND military | 3,263 | 1,226 (23%) | 844 (16%) | 389 (7%) | 22 (<0.01%) |

War Study publications are found in the column for Social Science and most often in publications with a specific military or defence focus (Grissom 2006; Adamsky 2008; Andersson et al. 2015; Andersson 2020).

Based on the findings in the literature review, this study identified four research areas of specific interest where scholarly work contributes to an understanding of issues that could arise within organisations, in this case the armed forces, with advanced technology as well as complex structure and tasks. These identified research areas are summarised as Technology and Armed Forces, MAS, System perspectives and Concept and Capability Development. The areas of interest in many cases address, and sometimes in an overlapping manner, similar difficulties presented using different vocabularies and approaches. These areas present a multitude of different perspectives to consider when aiming to understand the interactions between technology and its surrounding organisation.

In relation to the areas Technology and Armed Forces and Concept and Capability Development, the qualitative review of the texts indicated that the initial literature review results did not result in a description adequate for inculcating a comprehensive understanding. Therefore, complementary searches were performed on scholar.google.com, library search engines and the internet, especially for social science publications related to Technology and Armed Forces and for publications and documentation related to military practice, such as doctrines, handbooks, reports and policies, especially in relation to the area Concept and Capability Development. The aim of these searches was to provide additional documents to deliver a more complete description of the four identified research areas of interest.

# 4 Identified research areas of interest

The identified four areas are described with the intention of structuring different aspects of problematic areas in general and linking them to areas where military organisations struggle to include and utilise new technology within existing organisational boundaries.

## 4.1 Armed forces and technology

'Peacetime innovation involves placing bets on the kinds of technology, training and force structures that will be needed for a world that has yet to emerge' (Kollars 2017, p. 125). The development of the means of war is and has been an important aspect of the development of the armed forces. Every step along the technological path has changed the operational behaviour, the order of battle or the power balance between parties. This makes military innovation two-fold; military innovation is carried out both to protect against other nations' systems and to develop own new abilities (Weiss 2018). However, this is problematic for a nation that is not often challenged in a conflict situation, making military innovation more top-down, excluding the experienced warfighter from the process (Kollars 2017).

Military innovation is an area sometimes addressed within the field of War Studies. The relationship between armed forces and technology has been a focus of academic research. However, War Studies is typically theoretical or conceptual, presenting an approach for understanding and describing a nation's military power and capability. The research does not typically provide solutions for

development of tools for system development, such as systems engineering. More problem-oriented research, especially in relation to military development, can usually be found in the area of Military Operations Research (Scala and Howard 2020).

The question of how exactly to characterise War Studies constitutes an ongoing discussion and there are several different parallel traditions. Possible contributions from War Studies therefore include war and strategy as an art or science, critical studies of possibilities as well as limitations, a pragmatic dialogue between disciplines and a focus either on theory or practice (Jakobsen 2017).

For a military organisation, the terms power and capability are central concepts and typically used in doctrines to describe the potential of an armed force, and these terms are sometimes used as synonyms (Biddle 2004). Power is more often discussed in War Studies and capability is a related term more often used in connection with technology development, armed forces development and organisational praxis.

A common theme when discussing military organisations is the hierarchy. The military hierarchy can come in different layers, not only in relation to rank but also age, gender and whether a given individual happens to be of military or civilian status within the organisation (Wilcox 2009; Friesl et al. 2011; Wibben 2018). This hierarchical mind-set could impose a negative impact on the ability to communicate new technologies within the organisation, manifesting in the form of tensions and conflicts in priority-allocation between projects set out to handle new systems and technologies and the organisational aspects that encompass handling of the more day-to-day concerns of military work (Friesl et al. 2011). The organisational aspect of concept development therefore needs to address how knowledge sharing is performed in relation to new organisational entities.

Military innovations need to be considered as a multidisciplinary research area related to areas such as management and organisational theory (Griffin 2017). Multidisciplinary perspectives are needed because 'culture sets the context for military innovation, fundamentally shaping organizations' reactions to technological and strategic opportunities' (Grissom 2006, p. 916).

The development process also needs to be understood in the light of the military as a learning organisation. In this perspective, knowledge is transformed into operational skills and will affect how ideas and technology can be implemented. Therefore, it is important to establish an organisational culture of experimentation and creativity (Dyson 2019). Kollars (2017) mentions the difference between genius and mastery and a need for both in the process of developing and implementing new technology in the armed forces. Without the genius, meaning the scholarly community, there is no innovation. At the same time, the master, here presented as the warfighter, plays an important role in understanding how this new technology fits into the operational needs. This is also emphasised by Till (2018), who points out the importance of strategic thinking keeping up with technological change, emphasising that otherwise the field would be dominated by technocrats.

## 4.2 Military MAS

Research on MAS highlight issues that arise when introducing new technology into the armed forces. MAS is here seen as a collective term for several autonomous and unmanned systems in the maritime domain and can be used in all conflicts levels, both in offensive and defensive tasks. The research area presents a wide range of scholarly work, from the deep understanding in functionality of the technology, through operational use, to ethical and legal aspects of using products that are supposed to perform without constant human supervision (Williams 2015; Johansson 2018; Maguer et al. 2018; Till 2018; Larsbrink 2020; Werin and Wedin 2020). As mentioned, the research concerning technical aspects of the products are still by far outnumbering the areas handling the more multidisciplinary and social aspects of the same, even if there has been an increased number of publications handling the latter in recent years.

The general thought is to use autonomous and unmanned systems as integrated solutions, as a complement to other manned platforms, instead of as add-ons to existing advanced platforms (Department of the Navy 2021). According to Till (2018), the introduction of unmanned systems in naval operations can be transformational if introduced together with changes in doctrines and operational changes.

There are differences between surface and underwater systems in some areas, such as navigation, docking, information transfer and endurance, which arise from the inherent properties of a system acting beneath the surface of the ocean.[1] This could lead to underwater systems generally requiring more autonomy than systems on the

**1** This is a result of the very different conditions for transmission of electromagnetic waves in air versus water; it needs to be noted that transmission is very limited in water. This leads to substantially reduced communication rates and distance, as well as diminished sensor performance.

surface or in the air (Johansson 2018). Furthermore, legal issues and maritime rules could differ between the two systems (Sparrow and Lucas 2016). Specific laws and regulations for the operation of MAS are currently missing or incomplete. Examples include the legal aspect for operating without a commanding officer, and if the MAS is an extension of the launching or controlling warship or can be considered as a standalone system (Johansson 2018). There are, however, important experiences that can be drawn from Unmanned Aerial Vehicles and Unmanned Ground Vehicles, when it comes to operational thinking, legal aspects, moral, ethics and organisational thinking (Ho et al. 2011).

There are also concerns about whether the introduction of these systems could lower the threshold to start a war due to the illusion that war has no cost in the terms of lives (Johansson 2018). This raises the question of trust in unmanned and autonomous systems, both for commanders and operators, which is a challenge when it comes to implementing such systems in the armed forces and operating the existing ones (Ho et al. 2011; Johansson 2018; Mansfield et al. 2019; Schaefer et al. 2019). To build trust in a technical system, the system needs to be considered as being effective, reliable and safe, especially in a military application where a variety of additional concerns are introduced and the knowledge in connecting technical issues to ethical challenges is weak in general and especially weak in relation to military organisations.

## 4.3 System perspectives

A sociotechnical system can be seen as a hybrid system that includes elements of technical and social natures, with a clear interaction between people, organisation and technology. These systems have a multitude of heterogeneous users whose contribution to the system could vary substantially (Franssen and Kroes 2009). In the literature, several parallel definitions of sociotechnical systems exist. Baxter and Sommerville (2011) mention five key characteristics for the sociotechnical system:

- They should have interdependent parts.
- They should adapt to and pursue goals in external environments.
- They have an internal environment comprising separate but interdependent technical and social subsystems.
- The systems goals can be achieved by more than one means.
- The performance of the system relies on the joint optimisation of the technical and social subsystems. Focussing on one of these systems to the exclusion of the other is likely to lead to degraded system performance.

The number of specific military studies with a sociotechnical perspective were very limited in the results of the literature review. However, several of the civilian studies have potentially important results also for military system design.

When developing and working with sociotechnical systems, there could be several parallel system boundaries (Kelly 1978; Trist 1981; Walker et al. 2008; Baxter and Sommerville 2011; Vermaas et al. 2011). Therefore, when developing military sociotechnical systems, different system boundaries need to be considered. The system not only includes the military organisation but could also possibly contain organisations such as acquisition agencies, authorities and the defence industries surrounding the technical systems.

Designing a sociotechnical system involves designing roles and tasks for people to fulfil, as well as rules and regulations to handle the same (Franssen and Kroes 2009). Human, social, organisational and technical factors need to be considered in the design of sociotechnical systems, and it is not generally the technical integration is the complex part (Kelly 1978; Trist 1981; Walker et al. 2008; Baxter and Sommerville 2011; Vermaas et al. 2011). Baxter and Sommerville (2011) summarise the design of sociotechnical systems in three parallel and interacting activities: the Systems engineering process, Sociotechnical systems engineering and the Organisational change process, all of which need to be present to create an effective sociotechnical system. These activities will be used for the synthesis of this study.

A parallel perspective to the sociotechnical system understanding is the system-of-system perspective. Systems-of-systems can be described as a composition of underlying systems that together increase in complexity and functionality. When addressing system-of-systems, Maier (1998) identifies two criteria:

- Operational Independence of the components: each component in the system must be capable of being used independently.
- Managerial Independence of the components: the component systems can and do operate independently.

According to this definition it is possible to understand the different military capabilities as system-of-systems that are able to fall back to less integrated configurations, as units or technical functions (Maier 1998). One example is underwater capability with its components consisting

of command, control and communication, ships and possibly autonomous and unmanned vehicles. The functionality of the autonomous system can be understood as a part of a system-of-systems since they are meant to be used independently and not as add-ons to more advanced systems.

System-of-systems typically highlight the importance of interfaces. Since the military could have human training and indoctrination as part of their architecture, the interface mentioned here is not shaped merely by technology (Maier 1998). Maier (1998) also highlights that military technical systems could have a long lifecycle, making these systems-of-systems eclectic with old and new systems working side-by-side.

Both the sociotechnical system and system-of-system perspectives highlight that it is not the individual capability of either human or machine that is of importance but the interaction and interfaces between the two that creates a reliable system.

## 4.4 Concept and capability development

The area that is least researched with a military focus is the design process and its relation to concept and capability development. The definitions of military capability, and its relation to military power, vary with the different nations, but the core is an ability to perform in a desired way. The Australian Defence Capability Development Handbook 2014 defines Military capability as 'the capacity or ability to achieve an operational effect.' (Department of Defence 2014, p. 2). The British Ministry of Defence defines Military Capability as 'development of the ability, both now and in the future, to have military influence and project force' (Ministry of Defence 2020, p. 5) while NATO defines capability as 'The ability to create an effect through employment of an integrated set of aspects categorized as doctrine, organization, training, materiel, leadership development, personnel, facilities, and interoperability' (DOTMLPFI) (NATO Standarization Office 2021, p. 23). The NATO definition includes the parts of the organisation that enables the capability, which in the UK is called Defence Lines of Development (DLoD): Training, Equipment, Personnel, Information, Concepts and Doctrine, Organisation, Infrastructure, Logistics (and Interoperability) – TEPID-OIL (British Ministry of Defence 2020). In Australia it is referred to as *fundamental inputs to capability* and consists of: Organisation, Command and management, Personnel, Collective training, Major systems, Facilities and training areas, Supplies, Support and industry (Department of Defence 2020). The examples above show that a military organisation needs to consider more than just the technical systems to create capability.

Another approach for understanding capability and concept development is to describe the military operational environment in terms of three landscapes: the physical, such as the terrain, technical systems and infrastructure; information, which is the combination of media, social media and other data in cyberspace; and the human landscape, which is the aggregate of cultures, ideologies and institutions (Veldhuis et al. 2018). All these aspects are essential when planning an operation, and not merely the knowledge of how to use the technology against an opponent.

One concrete example of a specific approach for capability development is the Concept development and experimentation (CD&E) process. This process supports development and experimentation by providing a common framework, decision support and practical guidelines for capability development (Pikner 2015). The CD&E process is a NATO product used to identify new solutions that improve military capability (NATO ACT 2021). The CD&E method could be used to link a national strategy to actual capabilities, thereby helping armed forces evolve concomitant with the rise of new technologies, approaches to warfare and roles (Van Antwerpen and Bowley 2012).

As previously mentioned, capability is a central concept for a military organisation to assess and communicate the abilities and performance of the organisation, and these are often associated with certain major systems, such as an air defence system or naval ship, representing the respective capability. A shift from addressing major systems and threat-based planning introduces the term Capability Based Planning (Smith and Oosthuizen 2012; Thaba 2020), stepping away from the platform/system centric focus (Fitzsimmons 2007, p. 103). This becomes clear when considering military capability as something that outlives the duration of an individual system. Such approach urges for a Capability Life Cycle mind-set as a complement to System Life Cycle, which could give a different way of viewing the technical system life cycle (Helfat and Peteraf 2003). When discussing the capability lifecycle, sometimes modularity and interoperability are presented as solutions (Webster et al. 2019), which is more a reference to the System Life Cycle-view. A Capability Life Cycle-view will instead enquire how the capability is anticipated to evolve through its lifecycle, depending on which parts comprise its sociotechnical structure (James 2016).

Concept and Capability development are emerging fields for method development; however, the

documentation and research are limited. A central theme of work in concept and capability development is the design of technology, organisations or processes to meet specific capability needs. There are typically more explicit approaches for the development and design of technology than social components, such as organisations or processes.

# 5 Synthesis

Here, the four identified areas are addressed together, even if they do not necessarily have a common research base. In this study, we use the three interacting processes (see Figure 1): the Systems engineering process, the Sociotechnical systems engineering and the organisational Change process, presented by Baxter and Sommerville (2011), to structure the synthesis.

## 5.1 The systems engineering process

The field of engineering today encompasses both technology and approaches for the design of technology in general, such as Systems Engineering. The literature review indicates that the research in autonomous underwater systems, especially the research on the technology and the possibilities it provides, is extensive.

The study also identifies that the Systems-of-systems perspectives and the Sociotechnical system perspectives provide specific input to the systems engineering process, additionally providing descriptions of how technology and technology-use interact with areas such as sociotechnical systems engineering and the organisational change process. However, the number of design approaches for managing such interactions between social and technical aspects is very limited in the material studied. The Capability Life Cycle and its different approaches, such as Capability Based Planning, could be seen as a development to approach design with a focus on capability rather than technology. However, these perspectives and approaches are not yet put under academic or scientific scrutiny to any sufficient extent.

Therefore, even though the design of technical artefacts is well researched, there is still a need for developing the interactions between technology and organisations. This also includes aspects such as how interactions and roles between different stakeholders should be considered. One example is the effect on development if the different entities within the defence sector were closer, instead of the process being 'more focused on acquisition than [on] collaboration' (Prives 2020, p. 4), implying that the political aspects on military procurement need to be reconsidered. A Swedish example of a step in this direction is the national research and innovation agenda for underwater technology in Sweden, NRIA-U 2019 (Project group SubTechSweden 2019). Such initiatives, if they include both technical and organisational aspects, could serve as a common foundation for development.

## 5.2 The sociotechnical systems engineering

The sociotechnical and the system-of-systems concepts can be seen as parallel perspectives that have several areas in common. Strengths from these two perspectives could be combined, followed by the addition of specific approaches for investigating analysis and design of future capabilities. They specifically contribute with an understanding of how an organisation can be viewed as the compound of the different realms of technology, people and organisation and that the organisation is a representation of how well the interfaces are defined and managed. However, the identified perspectives are directed more

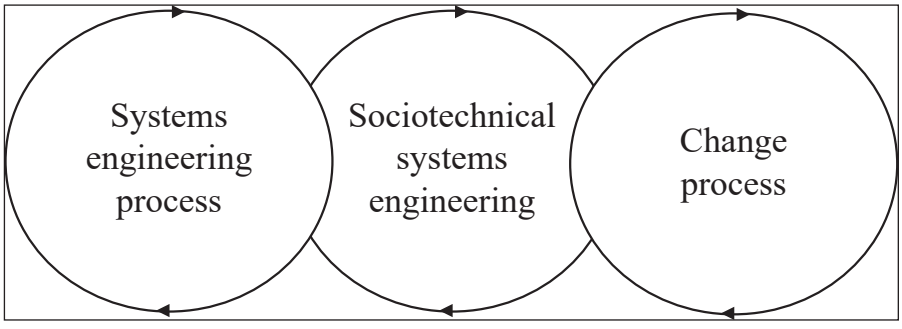


**Fig. 1:** The three interacting processes: the Systems engineering process, the Sociotechnical systems engineering and the (organisational) Change process, redrawn from Baxter and Sommerville (2011).

towards the interaction with the systems engineering concepts than towards the interactions with organisational change.

War Studies offer knowledge on several aspects of the military sociotechnical systems under study, e.g. how the organisations of such systems affect military actions. However, the descriptive nature of War Studies means that the discipline does not provide any explicit support for the development (design or engineering) of future military organisations.

The results from the literature review also show that implementing new technology in an organisation, such as the armed forces, especially innovative technology, requires more than the actual technical system itself. An understanding of how this system works within its environment and organisation is vital. Therefore, it is important to consider the armed forces as the sociotechnical system it actually envisions, with its inherent elements that could be represented by the prerequisites for capability, which are either expressed as DOTMLPFI, DLoD or Fundamental Inputs to Capability, or using other similar definitions. The sociotechnical systems engineering approach proposed by Baxter and Sommerville (2011) and the NATO CD&E process are two approaches specifically for this purpose. However, they cannot be considered to be complete approaches for system design, and they have so far only come under limited academic attention.

## 5.3 The organisational change process

To use new technology efficiently, it needs to find its place in the armed forces, satisfying both organisational and capability needs. Otherwise, the implementation of new technology risks taking a 'technology shortcut' where new technology only replaces old, never reaching the stage of organisational change that is needed to change or improve the capability. This approach can be useful when one system replaces another due to obsolescence-related factors (e.g. end-of-life), but is not a model suitable for all new technology. The understanding of the organisational change needed to design the new system is often absent or very limited. Therefore, a technology-induced organisational change process is required if the technology is to present alternatives and additions to existing organisation and capabilities. Additional issues concerning innovative technology include how these systems will fit into each nation's defence strategy; how and to what degree they will be integrated into the naval forces; and what the legal, policy and diplomatic implications of this are (Berkowitz 2014).

The development process needs to be understood in the light of the military as a learning organisation (Dyson 2019). It is important to know the organisations' operational will and, through this means, to ascertain what the contribution of this technology could be. The need for new technology generally comes in two different ways: try new technology, then implement tactical or operational ways to use them – or observe deficits in the existing tactics, then search for and implement new technology. Either way, both genius and mastery are important for understanding and identifying opportunities and limitations with both existing systems and ways of working as well as for understanding and recognising new innovative technologies. Kollars (2017, p. 126) states that 'warfighters contribute to peacetime innovation by helping to establish a baseline understanding of the distance between current systems and future ones, thereby helping to develop training, leadership and education systems'.

There is not always one objective value lens for capability – the understanding will be subjective and dependent on perspective and the utility may not be noticeable or obvious to everyone. Therefore, joint planning is essential; otherwise, important knowledge of the possibilities of the organisation and its capabilities could be missed. To understand how the structure of the sociotechnical system can and needs to change with the introduction of innovative technology, it is important to consider that it involves not only the introduction of a new technology into the existing system but perhaps also rewriting of the sociotechnical map. It is important to remember that 'Ideas… are fundamentally meaningless without the much more complex process of implementation' (Kollars 2017, p. 137).

## 5.4 To summarise

The development in relation to MAS suggests that autonomous systems should, instead of being allowed to function merely as add-ons to existing advanced platforms, be implemented in a new organisational and command and control structure. However, the material found in this study does not provide a clear set of scientifically sound approaches for developing such a new structure. The knowledge and approaches offered by sociotechnical and system-of-system perspectives, as well as capability models, all highlight that the final capability, of for example a navy, is the combination of technical and social components. Theories of a clear military origin also highlight the need to view this capability in the context of the threat and other external factors.

It is important to see capability for what it is: not one system but collaborative systems that together solve a task where e.g., the capability to acquire information in the underwater domain is a capability that can be solved by a composition of systems. The large, manned platforms are not the only ones that should be recognised as independent systems; an independent system could also be a MAS that is able to independently operate from any platform and that possesses the ability to interact with others to achieve the desired capability.

Therefore, the identified gap in relation to approaches for true sociotechnical design risks having substantial impact on the effective implementation of MAS with the aim of supporting military capability. Maybe, inspired by the CD&E approach, the use of experiments is, with an explorative purpose where practitioners and engineers meet, a way to short-circuit the process and force all parties to address each other's perspectives. At least until there are more rigorous approaches for sociotechnical design.

## 6 Discussion

The aim of this study is to present a picture of difficulties and issues encountered when implementing innovative technology in the armed forces, by presenting relevant work within different research areas, such as autonomous systems, concept development and War Studies, and then merge them into three processes to visualise their interconnection. These processes address the technical system, the sociotechnical system and the organisational changes. Noticeable in these processes is the tendency of what is here referred to as the technology shortcut, which the design and implementation of new technology that tend to connect to the technical and sociotechnical systems but exclude to some extent the organisational change.

In these processes, the initial focus should be on concept development, since it is at this initial step of system design that large changes can be introduced. The aim is to create conditions for balanced changes in e.g. doctrine, organisation and technology, which facilitates creation of the capabilities needed. Often the life cycle is considered on a system level, and not on a capability level. However, if the organisation instead implements a capability lifecycle perspective, the capability will evolve through its lifecycle depending on which parts go into constituting its sociotechnical structure. The question of how an existing capability can be enhanced or developed using this new technology can then be addressed and answered.

There is no one-to-one solution for replacing manned systems and functions with unmanned ones; however, a change in the organisational structure could present new opportunities with the new technology and enhance the capabilities. To address how an autonomous system ought to ideally fit into the sociotechnical system that a navy represents, several areas need to be considered. These areas might include the structure, competence and categories of the personnel and laws, as well as regulations and doctrines related to the autonomous systems. The autonomous systems will be able to complement the manned platforms as system-of-systems in new constellations and create capabilities in ways that have hitherto remained unexplored. However, this presupposes trust in the system – as an innovative technology, as a part of the sociotechnical system and as a capability enforcer. While all of these remain important challenges, these concerns cannot currently be effectively addressed due to the lack of approaches for sociotechnical systems engineering and the organisational change process.

Capabilities sometimes tend to be equated with actual systems, which are often referred to as the political aspects of system procurement. Large expensive systems require time-consuming and complex decisions for acquisition, which often render that once the decision is made, it is at system level, such as submarine and aircraft systems. This approach is easier to convey from a military perspective and easier for politicians to respond to, because the higher up in the hierarchies, the more abstract the concept of capability becomes.

There are areas not covered in this study that also have importance in the development of systems for defence and security. Such areas include e.g. human factors engineering and ethics. The role of such areas deserves attention and development; however, it has not been the focus here.

## 7 Conclusion

This study addresses concerns that arise when implementing innovative technology, such as MAS, into organisations such as the armed forces where it is possible and convenient to complement the traditional manned platforms. The study also addresses how concept and capability development can relate to War Studies. It is important to understand the complexity of the organisation and its tasks when implementing innovative technology; and also to categorise the armed forces as a sociotechnical system having organisation, personnel, units and boundaries as well as a system-of-systems that produce and enable

desired capabilities. The sociotechnical boundaries can also change depending on the stage of the lifecycle.

Military organisations also need to consider the capability lifecycle as a complement to the system life cycle when developing and implementing new technology. The capability lifecycle presents an overview of the desired capability when planning for future compositions of technology and units, instead of focussing on the individual systems. The approach highlights the importance of joint planning and making necessary organisational and structural changes to provide for effective use of innovative technology and avoid confining the scope of capability augmentation to merely replacing old technology with new.

Additionally, the organisation needs to trust the system and see the innovative technology as a part of the sociotechnical system and as a capability enforcer. This could impose additional challenges on those involved in assuming responsibility for autonomous systems, since there are parts of the implementation that involve relinquishing manned control and leaving certain decisions to the technology itself. Therefore, the armed forces need to be learning organisations where there is room for knowledge-sharing and flexibility within the organisation, despite the involvement of various hierarchical layers.

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