28th ICCRTS

Submission #32

Topic 3

RESEARCH PAPER

Endeavor complexity across command levels:

Defining and communicating attributes of an endeavor

Sigmund Valaker[#]

Else Helene Feet[#]

Rune Stensrud[#]

#-Department of Defence Systems
Norwegian Defence Research Establishment (FFI)
Kjeller, Norway

POST ADDRESS: FFI, Postboks 25, 2027 Kjeller, Norway

VISITOR ADDRESS: Instituttvn 20, 2007 Kjeller

Point of Contact: Rune Stensrud, rune.stensrud@ffi.no

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Sigmund Valaker
The Norwegian Defence Research Establishment
Sigmund.Valaker@ffi.no

Else Helene Feet
The Norwegian Defence Research Establishment
Else-Helene.Feet@ffi.no

Rune Stensrud
The Norwegian Defence Research Establishment
Rune.Stensrud@ffi.no

Abstract

What are the essential elements in the threat environment? In addition: How can they be communicated across strategic, operational and tactical levels? These two related questions are of importance practically, theoretically and methodically.

The development of novel military capabilities, e.g. effectors, should ideally answer needs identified in strategic scenario construction. In practice, however, a drift may occur between the command levels if the link is lost between strategic, operational and tactical levels i.e. "disconnect" that may leads to dysfunction in applying resources on a military problem. For example, the necessary resources, e.g. expertise put into developing certain capabilities, may not be provided if there are different understanding of scenarios across levels.

A long tradition of C2 research have focused on leading and coordinating military activities (e.g. operations and missions) and described in detail the control dilemma that a higher level (e.g. strategic) may have in adapting to feedback from lower levels (e.g. operational and tactical) (Johansson, Carlerby & Alberts, 2018). However, the C2 research to date have little to contribute to the specific needs that long-term and mid-term military capability development is facing in horizons beyond operations and missions (McKelvey, B., & Boisot, M., 2009). In this paper, we suggest that the control dilemma may be reduced in military capability development by defining common environmental attributes across levels. We draw on the elements of endeavor complexity as suggested by Johansson et al. (2018): who proposed Dynamics, Dependencies, Interactions for the Endeavor Space dimensions. These attributes create a set of dependencies that need to be successfully managed to achieve the objectives of a Complex Endeavor established by participating entities (SAS-143, 2023, p.44). To further increase relevance, we add the attributes related to enemy capabilities, intent, courses of action as well as the elements of our (blue side) intent, desired effects could be valuable as common attributes, more specifically availability and composition of forces (blue side, red side), update times, technology level, need for tactical coordination, and geography. We argue that the higher granularity of our suggested attributes is needed to be able to communicate relevant scenario and vignette information, and deviations, across command levels. Essentially care should be taken of the boundaries between environment and the organization, boundaries that are complex due to the hierarchical structure of most military organizations.

We illustrate our reasoning through a capability development case. We sketch some trajectories such development may take given discrepancies in understanding of the crucial scenarios and vignettes between levels. We suggest ways such discrepancies may be reduced with certain scenario and vignette attributes. Finally, some directions for further research is suggested as well as practical implications and advice.

1 Introduction

Classic and contemporary research on command and control (C2) have primarily focused on how an external environment is understood and task complexity influences how commanders cognitively bounded decisions are made for the use of existing military capabilities (Brehmer & Allard,1991; Bakken & Gilljam, 2003;). It is important to stress that one C2 approach is not appropriate in every situation (Granåsen, Barius, et al., 2018; Valaker et al, 2020). Prior C2 research have indeed used notions such as environment and started to define more detailed concept of the external environment such as through the concept of endeavour complexity (Johansson et al., 2018). Variety of the external environment are further specified in Valaker et al. (2020). An environment describes the system surrounding an activity. There are multiple types of environment, both physical and non-physical. Examples include: information, urban, political, and human. Operating environments define the surroundings of a mission and combine all the elements, conditions, circumstances and influences that affect a commander's decision making in accomplishing their mission. (NATO AJP-01(F) V1, para 4.35-4.36, dated Dec 22)

“The question is broader and deeper than it first appears. Gady’s critique of MDO rests upon two longstanding and intertwined debates: the utility of manoeuvre doctrine as an overarching approach to warfighting, and whether modern technology provides an intrinsic defensive advantage in military operations. Manoeuvre warfare arguably has an inherent offensive bias, particularly as implemented within a “Western way of war”. A mismatch between an offense oriented operational concept and an operating environment that incentivizes defensive actions could result in ineffectual military operations or even defeat. The essential question addressed in Mayer (2021) is whether emerging military technologies will undermine offensive-minded manoeuverist approach to warfare embodied in the MDO concept. The answer has wide-ranging implications for acquisition policies, force structure decisions, operational concept development, training regimes, and professional military education. ” (Gady, 2021, ‘Constraints on manoeuvre’-p.136, ‘Cyber and Space attack options’-p.137-138;Mayer, 2021 p. PAPER NBR – 2).

Moreover, Multi-domain operations (MDO) pose complex challenges that demand approaches beyond what traditional C2 theory suggests (SAS-143,2023, p6). MDO defined as: “Orchestration of military activities, across all domains and environments, synchronised with non-military activities, to enable the Alliance to create converging effects at the speed of relevance.(NATO MDO Concept, 2022, p. 6)” SAS-143 has explored how entities participating in these collective enterprises need to think beyond their traditional approaches to command and control to succeed in increasingly complex endeavors. Specifically, SAS-143 focuses on how multi-domain operations (MDO) can be better managed or governed by drawing upon C2 theory as well as the concept of harmonization.

Still, when the complexity of an environment is low we argue that there is less need to pool resources and to engage in close collaboration with other entities (Schneider et al., 2017). However, when there is a higher amount of elements in the environment that need to be tackled, and there is a higher number of interrelations among elements, it is more likely that resources from additional organizations are needed to solve the mission. It should therefore be seen as more relevant to collaborate with other organizations when environmental complexity is high versus when the environmental complexity is low. (Valaker et al.,2020) A classic cybernetic and contingency approach are thus often used to construct theories of how endeavour complexity and C2 are related and how that relation may affect decisions and outcomes addressing Ashby's “Requisite Variety” or, as paraphrased in Alberts' concept of "Requisite Agility"[Alberts et al. (2011) cited in Ivari et al. (2023)]. Boisote et al.(2011) recasts Ashby’s law as the Law of Requisite Complexity (McKelvey and Boisot, 2009) where a system, to be efficaciously adaptive, the internal complexity of system must match the external complexity it confronts.

However, the external environment and C2 not only influences the use of existing capabilities but also form the way future military capabilities and systems are developed (Granåsen, 2020). “A military “system” may be described as a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process.” Moreover according to Backlund (2002) definition of complexity of the external environment is discussed in litterature, both in general and, mostly, in relation to organisations and information systems: “Considering the subjective nature of complexity, complexity is defined as the effort (as it is perceived) that is required to understand and cope with something, but several other definitions and characterisations are also considered. Complexity is related to variety and information.”(Backlund, 2002, p.30). We argue in the article that the issue is whether the C2 organization has a set of C2 approaches that can match the effective variety of the environment – indirectly when building situational awareness and processing information about the environment, and respond to the range of situations represented by the environment i.e. bounce back. Essentially care should be taken of the boundaries between environment and the organization, boundaries that are complex due to the hierarchical structure of most military organizations.

Possessing an adequate military capability is a key-enabler for states to defend their interests, and this has accelerated the procurement of military equipment (Stoltenberg, 2016 cited in Granåsen et al., 2018). A more agile approach to C2 is needed to respond to the more varied, novel, complex and ambiguous threats of the future (Granåsen et al., 2020; UK MoD JCN 2/17). However, a changing security environment challenge our traditional definition and characterization of a "threat" and how this will affect our idea of capability development. A crisis response and management organization may be faced by a variety of blurring lines between what we seek to identify and consider, and what characterize the root causes of a potential complex endeavor. This is complicated further by the different understanding of endeavor complexity across command levels. We add to defining and communicating attributes of an endeavor deliberate actions and hostile environment. Then the "threat" and environment may be composed of a complex and ambiguous set of attributes that may not be traditionally handled by military capabilities alone. The

scope of what determines a national threat, may as well be caused by climate change, outbreak of diseases, and degradation of global food-chains or deliberate shortages (e.g. energy), that are causing conflicts and may need extensive military and civil-military cooperation.(Olsén et al.,2022)

The changing security environment requires that the development of novel military capabilities are an answer of the needs identified in strategic scenario constructions bounded by the decision-making process that leads to the chosen strategy. Thoughts about the future external environment by people in a C2 structure may be crucial in influencing what capabilities one see as needed. In other words, the capabilities are to a less degree given, but rather one foresee the capability needed. Moreover, each level in a C2 structure must do the same type of imagination of the future. As suggested by Brehmer (2013) every type of work group, such as every type of level of C2, are confined to particular tasks after contact with the adversary. (Brehmer & Thunholm,2011). Given that, different levels have different tasks (e.g. planning for the whole versus for particular parts of the organization); it is reason to believe that the futures imagined may at least have different emphasis.The strategic, operational and tactical levels may be appropriate to traditional military organizations but may not be applicable to some less traditional military organizations and certainly not applicable to many civilian organizations. One may ask if there is being a limited degree of change observed in C2 practice lately. This is despite the many accepted future drivers for substantial change to C2, and the numerous initiatives undertaken (investments made, strong political support form the highest levels of national defence organizations) (Granåsen et al., 2020; Houghton et al.,2022). Our method proposed in sub-chapter 4.7 handling a military problem, concern how we are evaluating C2 capabilities, socio-technically and functionally to evaluate success. Van Lamoen (2023) focus on collaborative innovation, implying internal actors' cooperation and the exploitation of their knowledge to preserve international safety and create public value. And found that the acquisition of knowledge is mostly done through the Knowledge Sharing process. Moreover, van Lamoen (2023) found that the development of knowledge mostly emerges from Learning from failure defined as: "the extent to which a team reflects upon the problems and errors it experiences, interprets and makes sense of why they occurred, and discusses what actions are needed to produce improved outcomes." Most importantly, result of the work of van Lamoen (2023) is that transactive memory was one of the key drivers of knowledge acquisition and development in a collaborative way. Transactive memory can be defined as: knowing who knows what. «Teams pursuing innovation must be adept at coordinating different learning activities over time, but existing theory provides little guidance to understand how learning activities should occur within and across episodes» (e.g. in this article learning across scenarios and vignetts). (Harvey et al., 2023)

In this article, we sketch this problematic, address this cost of meeting future requirements, and shape capability development. We also discuss whether endeavour complexity is suited as a concept to describe environmental complexity, in particular with regard to capability development, and to be a concept that can be used at all the C2 command levels. Summarized, based on the extant research on external environment we identified uncertainty and ambiguity as to overarching dimensions (for a detailed summary see: Valaker et al., 2020; Renn &Schweizer; 2009; 2020) other dimensions such as number of elements of an environment are thus added to the dimensions by Johansson et al., 2018). In addition, we discuss some more specific dimensions that are crucial to the defining of the "military problem".

Based on our dimensions in the external environment we develop a threat model to link means-ends-ways causal links needed for organically exploiting information from a current to a future situation supported by methods and process-handling in terms of scenarios exposing C2 for input insecurity (e.g. Endeavour Complexity (cross domain)).

As a theoretical basis we draw on the extant research on military C2 theory, cybernetics, human factors (human-in-the-loop) and organization science (Daft, R. L., & Weick, K. E.;1984; Dess, G. G., & Beard, D. W.,1984; Daft, R. L., &. ,., & Lengel, R. H. ,1986; Seidl, D., & Werle, F.,2018; Dooley, K. J.,2021; Westbury, 2021).

Furthermore, we illustrate our theory by a case study of capability development in the Scandinavian context. To develop the notion of external environment, its interpretation across levels and its influence on capability development.

We outline theoretical implications, and suggestions for future research, e.g. notional system norms (including modelling of uncertain systems) to formulate boundaries of the control dilemmas (and control design rules of thumb) supported by codifying the dimensions of uncertainty (i.e. Unstructured Uncertainties, Parametric Uncertainty, Structured Uncertainties). We propose extending the uncertainty modelling of the environment based on investigation and review of work done recently in SAS-143 research group on C2. Moreover, we propose practical implications and method guidelines as a follow

up on increased C2 Harmonization variety discussion (SAS-143,2023, p101).

2 Status of C2 research on C2 and external environment

Recent research have indicated that the influence of harmonization levels on Multi-domain operations (MDO) effectiveness and the moderating roles of organizational environment pose complex challenges that demand approaches beyond what the traditional C2 theory suggests (Johansson et al,2018; Valaker et al., 2020).

A military harmonization approach we define as "the systems approach attempts to view the world in terms of irreducibly integrated systems. It focuses attention on the whole, as well as on the complexity of interrelationships among its constituent parts." Given the fact of emergent behavior - these relationships need not be complex at all if technology and interrelationships are fully integrated. However, environment may limit use of standard operational procedures and limit collaboration. Coordination of modern warfare typically relies on obtaining sufficient data by surveillance and orientation, followed by subsequent reporting of the results. The operations are, if conducted in the atmosphere, entirely by means of radio wave technology. Shortage of radio spectrum available for use in an area will increase the delay in observing, locating and sharing information between operators. Other fundamental limiting factors are the number of users (and enemy jammers), weather conditions and local terrain obstructions. These make some coordination forms more unfavorable, in particular if the geographic distances between coordinating parties have links of insufficient capacity. The workaround for this problem may be to establish elevated nodes for connecting different teams, for instance using airborne or satellite relays. However, such solutions may have their weaknesses regarding availability and risk of interception, as well as risk of saturation by enemy jamming.

In systems theory, the term 'environment' is defined as the set of all objects a change in whose attributes effects the system as well as those objects whose attributes are changed by the behavior of the system. (Hall & Fagen, 1956.) "The line that separates the aspects of a system from those of its environment tends to blur as the unit of observation moves from natural and designed physical systems to human and conceptual social systems. While the former are easier to define and have relatively clear-cut aims or purposes, the latter are more difficult to define; most often they do not have clear-cut and agreed upon aims or purposes, and even when agreed upon, these may change over time." (Laszlo and Krippner, 1998, p.47)

Harmonization varies and we call this variation harmonization levels. Today's mission environments often require collaboration we could conceptualize as harmonization that are transforming a set of entities into an effective enterprise. Recent command and control (C2) theorizing in the NATO research group SAS-143 have suggested, that "by using harmonization arrangements to achieve interactions across both military and other non-military organizations, chosen C2 approach should be bespoken."(Alberts, 2019) SAS-143 advice so far, are refuting the idea of centralized, or even coordinated, command, which SAS-143 claim is unfit to deal with the variety of challenges found in modern conflict." This 'challenge space' is referred to as the Endeavour space (E-space). This means that different approaches to C2 must be applied depending on the problem at hand. (SAS-143,2023, p.17-18)

Endeavour complexity is thought to influence C2 and harmonization levels chosen. In Valaker et al. (2020) variety of the external environment is further specified as composed of both 1) uncertainty and 2) ambiguity. "We define uncertainty as the complexity and dynamism of the environment. It includes complexity referring to number of elements in the environment and number of interrelations among them (Luhman, 1975; Schneider et al., 2017) "The greater the number of elements and their interrelations, the higher the degree of complexity "(Luhman, 1975 cited in Schneider et al., 2017). It also includes dynamism, which we see as the rate and volume of change in the environment in other words, the volatility of the environment (Dess and Beard, 1984). As for 2) ambiguity, we see as the degree to which there are different interpretations of an environment (Daft and Lengel, 1986). These notions of organizational environment is somewhat similar to Johansson et al. (2018) concept of endeavor complexity, which delineate three aspects: dependencies (between components of entities of a system), dynamics (rate of change within a system) and tractability (degree to which a system is understandable (including surprising events). However, in addition to Johansson et al. (2018) we add number of elements to our definition of environment. "

Yet, these dimensions may not have enough fidelity to aid the development of capabilities across military command levels. We exemplify some aditional dimensions that could be needed as more high-resolution notions of an external environment that may be derived from the more generic dimensions. The composition of the force (blue or red), their technological maturity as well as their coordination needs, we see as a subset of the more generic term complexity referring to number of elements and the complexity of their interrelations. Update time on critical information (e.g. how early do you get a warning of a

specific threat) we see as a subset of dynamism, i.e. the rate of change (in a high or low dynamic setting in endeavor space) due to the requirement of " time slots" for humans to make decision. By definition, dynamic decision making (DDM) dictates that multiple and interrelated decisions be made in a continuously changing environment. (Gonzalez, 2005) A series of actions must be taken over time to achieve some overall goal; the actions are interdependent so that later decisions depend on earlier actions; and the environment changes both spontaneously and as a consequence of earlier actions (Edwards, 1962). Another dimension we see as not easily subsuming to prior dimensions and that is the geography and its influence, and we name this a spatial dimension.

Complex endeavors (SAS-143, 2023, p.43) further indicate a wide set of attributes of endevour complexity (or external environment attributes):

- A mission challenge that requires a variety of operations to create a variety of effects
- An enterprise consisting of a heterogeneous set of partners with different organizational forms and approaches to C2, management and/or governance
- No single enterprise chain of command; rather multiple entity chains of command operating in parallel
- Potential for conflicts among the operations that individual entities undertake
- Potential for conflicts among the effects that entity operations are trying to create
- A lack of familiarity among participating entities with each other's areas of expertise, values, culture, concepts of operation, processes
- Need to share information to develop appropriate levels of shared awareness among subset of participating entities
- Different degrees of technical, semantic, and social interoperability, technology sophistication and capabilities
- Potential for conflicting interests and/or priorities
- Missing definitions and standard operation procedures (of levels map) to the way decision rights are delegated

The question arises as to whether these terms are understood in similar ways, i.e. "harmoniously" across military command levels. Moreover how do they influence not only C2 approach, but also the development (problem definition, option generating, and selection among options) for capability development in a long term defence planning (LDTP) - setting.

3 Long-Term Planning of Military Capabilities in MDO

Long term defence planning (LDTP) is a complex, multi-stage, iterative process. In this article we are looking into the stages of capability requirements determination and capability assessment to assess fulfilment of the previously identified capability requirements. Using the identified requirements and current capabilities as primary inputs. Our use case will look closely into the capability assessment to produce a list of capability gaps that require solutions and indicates the time frame in which those solutions are needed according to a military problem. Capability assessment will then help us leading LDTP process to capability options development and solution selection. (Stojkovic et al., 2007).

The changing security environment requires that the development of novel military capabilities are an answer of the needs identified in strategic scenario constructions bounded by the decision-making process that leads to the chosen strategy. This is largely about the balance between what you want to use the armed forces for versus what it is possible to achieve, given various limitations identified in an external environment (e.g. modelled as an endeavor space).

Moreover, there is an ongoing debate as to carry out Multi-Domain Operations and how to best prepare your force for it and implement the concept in NATO. However, neither the domain term itself, nor MDO as a resulting construct is unitarily understood among the participants in the debate. Based on this apparently fractured understanding of both the domain term and MDO as a concept, navigating the security environment becomes challenging for small states such as Norway. Example of varying points of view and perspectives involved, "are the UK approach to MDO that differs somewhat from the one found in either the US or in NATO. Primarily the difference between the NATO and US concept(s) and the one described in Joint Concept Note 1/20 (UK MoD, 2020), lies in the level of command the concept appears to be addressed to. Where the US and NATO concepts primarily concern themselves exclusively with military actions, the UK concept, termed "Multi Domain Integration (MDI)" to a larger extent considers a

whole of government approach," (p.32, Nedrevåg,2023). "This is primarily because the various interpretations lead to significantly different adaptations of one's posture and policy, with several of the adaptations having the potential of being mutually exclusive. In total this shows that the apparent lack of a common understanding of the terms and concepts discussed in this debate contributes to potential misunderstandings in aligning both force structure, doctrine, and general security policy." (Nedrevåge,2023, p.IV). Given the potential cost associated with investing in the "wrong" structure or approach, this ambiguity is especially troubling for smaller states such as Norway with relatively limited capacity to pursue multiple tracks of developments and force structures. However, given the varying points of view and perspectives involved, a unitary understanding of the term and the MDO concept is unlikely (NATO, 2022; Nedrevåge,2023, p.V). It is therefore imperative that one is mindful of the perspectives of the various participants when trying to make sense of the debate.(Nedrevåge,2023, p.IV-V ,p.32).

However, starting with the development of novel military capabilities, e.g. effectors, development should ideally answer needs identified in strategic scenario construction. (Greenley et al., 2006). In particular, the attributes related to enemy capabilities, intent, courses of action as well as the elements of our (blue side) intent, desired effects could be valuable as common attributes. First, a clarification of the terms defined and discussed central to the understanding of the cognitive system engingeering approach taken in this article is done. The terms *capability*, *effect*, and *long-term planning of military capabilities*. We choose to take as a starting point the definitions NATO has made in ACT directive 80-7, "Managing Transformation", which is NATO's most important directive to describe these terms.

3.1 How to manage transformation describing the terms of Capability Based Planning

The overall method is called Capability Based Planning (CPB) and is a standard method for long-term defense planning in the Western world after the Cold War (Walker, S., 2005; TTCP, 2006).

3.1.1 Capability Based Planning

Capability Based Planning (TTCP, 2004) is the overarching process by which the main structure of the Armed Forces is determined. Military long-term planning can be defined as follows based on (Vatne et al., 2020; Stensrud et al., 2008): «Long-term planning is a process where possible future operational environments are explored, long-term objectives are defined for the development of the armed forces and a strategy is established for how the objectives are to be achieved."

However, the most important aspect of long-term planning is the decision-making process that leads to the chosen strategy. This is largely about the balance between what you want to use the armed forces for versus what it is possible to achieve, given various limitations in an endeavor space. The most obvious example of such restrictions and boundaries is economics, but what is legally or morally acceptable will always come into play.

3.1.2 Capability

Our definition: "A capability is the ability to achieve a desired effect." is based on the NATO definition: "A Capability can be defined as the ability to produce an effect that users of assets or services need to achieve."

In a capability-based planning context, two factors are important to note in this context:

The definition introduces the concept of effect and relates capability unambiguously to this. The following appears in the elaboration of the definition: A Capability will consist of one or more functional components: Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities and Interoperability (DOTMPLFI)."

3.1.3 Effect

Our definition: "Effect = change to one or more parts of system, a system or systems in an environment by our own action(s)". Which we base on the NATO definition: "Cumulative consequence across the environment caused by one or more actions. An objective will be achieved through the creation of a number of effects."

3.2 The connection between scenarios and vignettes

In structural planning, the scenarios are used as a starting point for capability requirements, which are again compared with a structural plan (strategic guideline) and are a starting point for further structural development. The scenario analysis normally consists of determining

objectives (e.g. Norwegian and allied objectives) at strategic and operational level, and then developing methods of action and task decomposition (Vatne et al., 2020) illustrated in Figure 1.

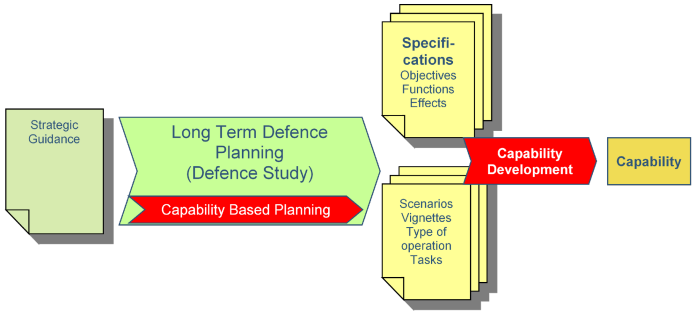

Figure 1: *Illustration of a possible context: Scenarios - functions - types of operations when assessing a new capability within the Strategic Planning process (Stensrud et al., 2008).*

The tasks are developed, analyzed and capability requirements determined based on military judgement, simulations, models, rules of thumb from doctrine and concepts. The task breakdown is a good starting point for vignette development at a tactical level or for functional analyses.

3.3 Functional Analysis

Functional analysis involves the use of some form of procedure, that is, a formal procedure, for collecting and organizing data about an empirical phenomenon modeled into an appropriate model with a known format, in order to systematically handle complex, grouped and connected system elements.

The model approach in functional analysis is based on simplifying the representation of real systems for predicting the consequences of an event (a scenario). (Wikberg, P., Designing Case Studies, p31-48, 2014, “Chapter in Bergren, P., Assessing C2 Effectiveness”)

In this article, a use case study is defined as "an empirical investigation that maps a phenomenon in a real context where the demarcation between the phenomenon and the context is not clear and clarified" (Yin, 2003). Compared to laboratory experiments, use case studies are because phenomena can be explained by logic, and generalized rationality through experiments and studies. Use case studies are the opposite of statistical generalization supported by many controlled trials in a controlled environment (so-called controlled randomization). For these reasons it has sometimes been criticized (Bromley, 1986), and (Cook and Campbell, 1979). E.g., it can be difficult to reproduce observations made in a use case study. The consequences are that the use case study does not intend to uncover general laws, as in scientific research. However, its strength is to provide analysis that are heuristic. It is about testing whether a certain method is "good enough", given the room for action, and restrictions in technology, resources, time, laws and regulations, political will and beyond. Conclusions that can be drawn from a case study are valid for a given context, and the ambition is not that conclusions from a use case study are valid for all conceivable settings. Correspondingly, testing solution alternatives for Interaction Design patterns, based on Operational Demands identified in trials and experiments with different organizational solutions are some examples of issues that require an approach that is targeted, open, and involving so that the use case study and the empirical evidence can be evaluated afterwards.

To guide the functional analysis, we suggest following a method that help us to evaluate the needed capability requirements according to a schema illustrated in Figure 2. In a capability requirements context illustrated in Figure 2 (i.e. the main boxes labelled *Foundation*, *Specifications* and *Evaluation*) we use a Situated Cognitive Engineering (sCE) method (Neerincx & Lindenberg, 2008 cited in Vught et al.,2020) where we expand the term Use Case with Scenario and Vignettes (e.g. defined as a set of episodic Use Cases that include context i.e. Endeavor complexity) and a simplified Evaluation (Figure 5).

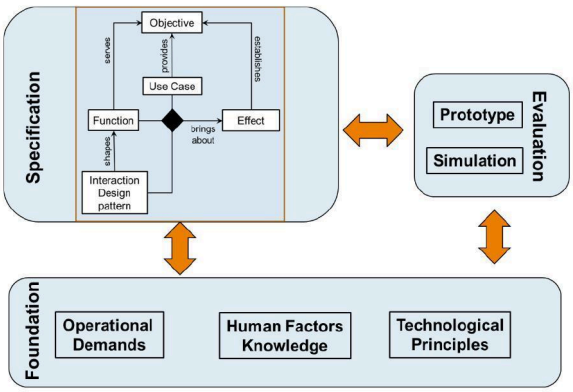

Figure 2: *Functional Analysis - Evaluation method are based on the Situated Cognitive Engineering (sCE) method (Neerincx & Lindenberg, 2008 cited in Vught et al., 2020).*

3.4 Cognitive Systems Engineering

(CSE) guiding CBP development of a military joint cognitive system

The above functional analysis we augment by the Cognitive System Engineering (CSE) also called Joint Cognitive Systems (JCS) methods and techniques derived from systems theory (cybernetics, information theory, communication networks, and socio-technical systems) where you combine systems theory and analysis (decomposition strategies). Historically, a recognition emerged that mental processes where one acquires knowledge and understanding through thought, experience and sensation, known as cognition, are "situated", and i.e. located in a specific context. (Doyle et al., 1982;Simon, 1996; Mumford, E., 2006; Novikov D.A 2016;)

Capabilities to achieve effects, linking ends-ways-means, C2 approach is just one, but essential part, to achieve effect. Specifically, building upon the RAND report Defence of Europe's Northern flank (Black, J. et al. (2020)), we focuses on how multi-domain operations can be better managed or governed by drawing upon the concept of harmonization as well as C2 theory. However, the theme discussed in the article, Optimization of Joint Cognitive Systems when under pressure and threatened needs guidance when handling complexity of an Endeavour. *Complex Endeavors* stem from one or more of a set attributes of these endeavors (SAS-143, 2023, p.43). These attributes create a set of dependencies that need to be successfully managed to achieve the objectives of a Complex Endeavor established by participating entities[1] measured against various threats.

3.5 Joint Optimization

The UK MOD Development, Concepts & Doctrine Centre, proposed an alternative definition of Command and Control (C2)(UK MOD (2017) cited in Niven (2023)): *A dynamic and adaptive socio-technical system configured to design and execute joint action.*

A key question that can be addressed using this definition of Command and Control is: How does one achieve the process of optimization, and more specifically a capability that answers complex demands created across several levels of C2 systems? We argue that this is reasonable to achieve if Foundation and Specification are balancing performance and robustness (i.e. balancing agility and resilience) that answers complex demands. Within the confines of defined parameters, this does not mean that optimization in general can be achieved, but rather for specific contexts. Limitations and challenges emerge when striking this balance between resilience and agility. Some will argue that this is also unsatisfactory as it includes the *execution* of action which makes it closer to a definition of an operation. Inspired by the UK MOD DCDC proposal for C2 definition, we assume that "if using such a definition to assess C2 system effectiveness, one would necessarily include the performance of force elements in delivering effects" (Niven,2023, p.2). The connection of this with *C2 effectiveness* is uncertain in any given situation. Nevertheless, Optimization require a level of integration of effects that is feasible across several levels of a C2 system. The complexity of decision-making tasks, the context in which decisions are made, and the need for explainability and transparency can pose challenges to achieving an optimal integration of humans and autonomy (Endsely, 2015). Decision-making scenarios that require nuanced judgment, intuition, or ethical considerations may require a higher level of human involvement and oversight (e.g. integration of C2 Systems with Unmanned Aircraft in combat). Additionally, unforeseen or novel situations may push the limits of autonomy systems, highlighting the need for human adaptability and decision-making capacity. (Bakken & Hærem, 2020; Bakken, 2020). Socio-technically, one answer is to inform capability development by the interaction of social and technical factors and conditions for successful (or unsuccessful) system and human performance (Wickens et al., 1992). Another response to this friction of understanding among levels of command are Joint Optimization theory. (Houghton et al., 2006; Walker et al., 2008)

Together general system theory may help us to appreciate goal orientation within cognitive systems (teleological view) and closed-loop nature of perception and action handling system degradation.

3.6 Environment

Handling an external environment we assume is a key to strategic scenario construction and generation of alternative solution through a concept-led capability development methodology. The boundary of an external environment is fluctuating i.e. the essential elements in the threat environment are dynamic and we need defining boundaries when testing the set of objects to be analyzed (i.e. the analysis object to handle threats). A threat is an adversary's ability and willingness to use the physical

[1] Endeavor Objectives may not be formally established by participating entities and entity objectives and priorities may differ. It can be expected, however, that to some degree there are common objectives or objectives that are complementary.

domain to monitor, disrupt or attack its targets in the air, on the ground and at sea. There are countless threats and these are challenging to protect against, especially when contested and congested. In the air domain, this can be combat aircraft, attack helicopters, large and small drones, missiles or similar. The threats can have different characteristics.

In an environment with threats we need defining Fluctuating Boundaries[2] and communicating attributes of an endeavor. We are using Asencio et al (2019) development of a theoretically grounded framework of boundary transitions and their effect on individuals working in dynamic teamwork settings.

In the sub-chapter, we see fluctuating boundaries and communicating attributes of an endeavor as a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process. The line that separates the aspects of a system from those of its environment tends to blur as the unit of observation moves from natural and designed physical systems to human and conceptual social systems. (Laszlo and Krippner, 1998)

Objects that can be / cannot be controlled by a Joint Cognitive System (JCS) dependencies and requirements to objects whose functions are important for the ability of the JCS to maintain control (Le Coze, J. C. (2015);Hollnagel et al.,2005).

Military Joint Cognitive System (JCS) capabilities whose functions are important (or not important) for the ability of survivability is to be investigated in Table 1 template. We consider box one.) in Table 1, as the needed Organic capabilities (i.e. an ambition of high Harmonization Levels) to solve a given MDO problem. We include box two.) in Table 1, as non-Organic capabilities (i.e. reachable, still not in use for JCS). Box three.) in Table 1, cannot be effectively controlled by the JCS. In addition, box four.) are excluded from the JCS.

We argue that specification of capability requirements are shaped by the Boundaries for the JCS we are supposed to design. Foundational factors for the JCS to be designed are operational demands and resources that brings about effects. To evaluate the effects we will allow simplifying the sCE-method (previously illustrated in Figure 2) by introducing a simple evaluation method in support of the capability based-planning phase assessing and prioritizing capabilities (described in sub-section 4.7).

Table 1: Military Joint Cognitive System capabilities (Inspired by Johansson BJE, 2019)

	Capabilities whose functions are important for the ability of the JCS to survive	**Capabilities whose functions are of no consequence for the ability of the JCS to survive**
Analysis Objects (in mil structure) that can be effectively controlled by the JCS	1. Objects are included in the JCS Description of Analysis Object	2. Objects may be included in the JCS
Analysis Objects (in mil structure) that cannot be effectively controlled by the JCS	3. Objects are not included in the JCS	4. Objects are excluded from the description as a whole

4 The Military problem

We now illustrate various assignments that require coordination, integration of activities (Rico, R., et al., 2018), in a joint operations setting the organizational environment and their attributes and the different interpretations could jointly affect where Land, Air, and Navy are collaborating on a joint major task across C2 levels. This again provide input to a capability development, or more precisely capabilities development.

In the sub-chapter we describe the Threat Environment and to handle a contested and congested Threat Environment. Previously, we have proposed a C2 Primary Alternate Contingency Emergency (PACE) concept for coordination and switching between forms of coordination adapted to changes in the E-space (Stensrud et al., 2023).

4.1 The Threat Environment

[2] Published in Safety Science, 2015, p.123-141 Reflecting on Jens Rasmussen's legacy A strong program for a hard problem - Jean-Christophe Le Coze. Asencio et al (2019) develop a theoretically grounded framework of boundary transitions and their effect on individuals working in dynamic teamwork settings.

In order to counter maritime surface and air threats, we need capabilities to detect, track and neutralize threats. The research cited in this sub-chapter was prepared for a report written for the Norwegian Ministry of Defense and conducted by RAND Europe (Black et al, 2020). Black et al. (2020) are presenting Strategic options for Norway. These options implicate supporting actions like developing more robust ISR coverage to ensure situational awareness, considering steps to increase the deterrence posture in Northern Norway, enhancing the protection of bases and forces against air and missile threats, maximising the F-35's potential as an enabler for joint operations, and preparing for operations in contested cyber, space and electromagnetic environments.

4.2 To Handle the Treat System

How do Norway's and allies capabilities discover, follow and defuse a threat system potentially affecting Europe's Northern Flank?

According to Black et al. (2020), we need to expand capacity and explore concepts to secure reinforcement and solidify our contributions. Conceptually, to handle the treat system and combating MDO threats e.g. Detect, Track and Neutralize, our analysis we will need to develop capabilities and concepts (e.g. tactical concepts) In sub-chapter 4.6 below, we will generate an example of needed generic capabilities (Table 2) and functions required with the help of the proposed set of methods.

4.3 Capability modeling

Command and control between the C2 nodes on Europe's Northern Flank has at the same time become more complex and challenging to manage. Work is being done continually to have an overview of all potential threats domain-wise and overall without unnecessary interfering civil air, sea and cross-border traffic on the European Northern flank. This is the military sensor and monitoring infrastructure secured by comprehensive and supra-national cooperation, which is also linked to NATO. All operations that are potentially launched will affect cooperating entities, and procedurally all ongoing control and notification throughout this region on Europe's Northern flank.

In general, the threat system potentially affecting Europe's Northern Flank has become more complex and challenging. Cruise missiles and tactical ballistic missiles are among the most serious Land, Sea and Air threats that can hit the Northern flank, including the Baltics. Today's security situation is very tense and defensive capabilities do not provide a sufficient defense (deterrence) against the serious missile threat on High Value Targets and civilian infrastructure. There is a need to modernize and increase the amount of current defensive capabilities (air defenses, bases, support structure). Without a sufficient quantity and mix of different defensive capabilities, the possible reception of allied forces will be difficult. Likewise, the vulnerability of Nordic F-35 fighter jet, their bases and associated support structure will be critical.

To handle these effects in a contested environment we are suggesting a model of coordinated action (illustrated in Figure 3), i.e. a specific way of ensuring agile C2, as one out of several capabilities needed. In addition to the proposed C2 capability there will be need to develop sensor and strike capabilities amongst others. However our suggested C2 capability includes leveraging specific technologies e.g. artificial intelligence (AI).

4.4 A Model of coordinated action in multiteam systems

Designing an organization template for coordinating responses in a "multi-team" setting, we will need to develop a flexible C2 approach. We build a model where inputs to shift and consequences of shifts in coordination forms are delineated (Figure 3) based on consideration of system dynamics typically found in integration entities. To ground a dynamic perspective we combine insights from cybernetic theory and Organization and Management Theory (OMT).

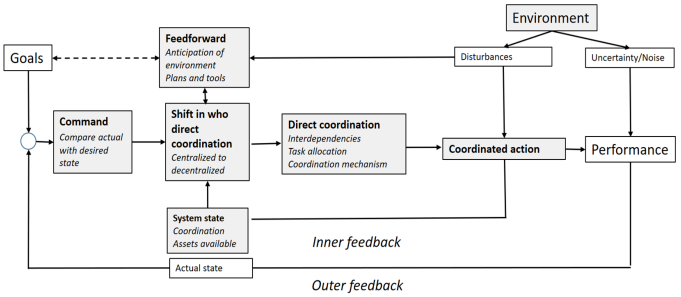

Figure 3: *A Model of Coordinated Action in Multiteam Systems.* (Stensrud, Valaker, Mikkelsen & Haugen, 2021)

To illustrate prior research and our own theory and framework for shifts between coordination forms we continue using a stylized military example of air, land and navy teams, entities, with a mission of jointly striking a target. Effector and sensor entities from the different services in combination are regarded as being able to strike the target, but the enemy A2AD capability suggest that the mission is facing a fleeting congested and contested environment. During the execution of the mission the various entities may experience restrictions to their communication with each other, and they may need to use stealthy modes of operation to succeed (Stensrud, Valaker, Mikkelsen & Haugen, 2021). At the same time, it is of utmost importance to be able to jointly striking the target. The air entities are able to use their sensors to detect a target, land entities may provide more detailed information about the target and naval entities can be used to strike the target, or sensors and effectors may be distributed in various other ways. Such a mission may evolve from a planning phase, to execution of the mission and then back to assessment and planning of future missions. What do prior theory and research regarding multiteam systems suggest about C2 approaches?

The changing security environment requires that the capabilities of a variety of entities are available, not only military ones. In the article, we explore how entities participating in a collective endeavour need to think beyond their traditional approaches to command and control to succeed in increasingly complex missions. Further work should be done on evaluating whether Endeavor Complexity is a sufficient and necessary concept / typology to orchestrate one's own resources to meet a threat (Johansson, Carlerby, Alberts (2018).

Our model for coordination shift could be one way in which future technologies are considered and could be used as an advantage in fostering integration between specialized entities. Novel technology is of course a very broad category, here we consider some possible implications of information technology, and related to this AI. AI refers to the ability of machines to match human problem solving, or at least mimic cognitive functions associated with the human mind, in terms of learning, reasoning, planning and acting in a complex cyber-physical environment, thus allowing autonomous robot or vehicle control, automated information fusion and anomaly detection and intelligent tutoring. Thus, the term AI in this setting is primarily concerned with the ability of a machine to perform an 'intelligent action' (Andås, 2020).

Consistently storing data is important as well, to exploit AI. Based on our evaluations lately on results from exercises among partners in NATO, a vision for the future of MDO is to allow entities in different domains share and store information. Basically, MDO way foreward should prioritize enablers securing a minimum connectivity supporting collaboration removing cross-branch and cross-agency barriers. "To day, this is enabled and coming true due to hard work, due to optimal provision of excellent technical backup from the supporting entities and support teams ad-hoc. In everyday operations, NATO has limited automated tools available to pick relevant information out of the trillions of bits of data routinely collected. There is only rudimentary, combined information sharing and task architecture to ensure that the right unit gets the right information at the right time. The vision for the future is one of constant connectivity and collaboration, removing cross-branch and cross-agency barriers that characterized the NATO in the past." (Stensrud, Valaker, & Haugen, 2020, p.5).

As suggested by our model, technological maturity and diversity, e.g. connecting to AI or other technological resources of the entities involved, is part of what goes into deciding what particular coordination form to use. "We assume that with higher technological maturity the potential for, if needed, shifts can be done to more distributed types of coordination forms. More mature technology may significantly reduce the costs of various coordination forms, so that entities both centrally and decentralized may be more available for observing, predicting and directing coordination," (Valaker, et al., 2020, p.19).

Further research is needed to design mechanisms for shifts between C2 Approaches illustrated in Figure 4 creating a workable approach space across C2 levels.

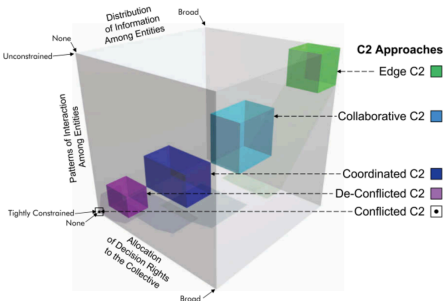

Figure 4: *C2 Approaches according to SAS-085*.

One of the significant challenges is congested, contested and denied environment such as in an A2AD context (e.g. cyber threats) which influences the complexity and dynamics of the missions. This should suggest a need to dynamically shift coordination form, yet few have examined *how* to make such shifts. We propose a model and C2 approach framework according to SAS-085 where: 1) entities hold updated information about the current coordination form (e.g. information about who is delegated/claiming the responsibility to coordinate), and

2) use known criteria for shifts in coordination form (e.g. shifts from centralized to decentralized or small world network) systematically and based on feedback and feedforward. Such a coordination concept could reduce coordination costs (e.g. due to communication overload in the organizational structure leading to delays of communicating coordinating decisions) as well as ensure reliable shifts between who is responsible for coordination. We propose that shifts in coordination form could be an example of requisite C2 agility i.e. shift options between C2 approach space boxes presented in Figure 4, may imply costs (e.g. communication costs) across C2 levels, and should be investigated further.

4.5 Main Interplay of Study

Main Interplay of Study are based on the following statement from the RAND Report, "Defense of Europe's Northern Flank" (Black et al., 2020), and as Norway contemplates the priorities for its next Long-Term Defense Plan (LTP), it finds itself in a Europe, a NATO, and a global environment that have all changed markedly since the last iteration of the Plan was released in 2020. How to navigate these stormy and uncertain waters is a pressing question not only for defense planners in Oslo, but also for international allies, who look to Norway to help bolster defense and deterrence on NATO's northern flank. (Black, J. & Thune, K., 2023) We suggest a Framework for functional analysis (Vught et al., 2020) based on Scenario-driven and empirical findings. Evaluation of Casual factors and Causal chains of effects.To guide the development of A High-level Concept e.g. Cap Stone concept for the Northern flank of NATO, we outline a set of tenets according to the following intentions:

- Secure that the need of development activities is identified
- Secure that relevant ideas are developed further to solve future missions and tasks
- To ensure the integrity of the framework, secure that the good ideas generated on lower level in the defense organization, is deeply top-down rooted
- Provide for sufficient resources to be allocated to the development of actual concepts
- Secure concept development is improving the military decision-making.

The proposed Norwegian a High-level Concept for the Northern flank of NATO should organizationally separate force generation and operations(training, exercises) and develop a flexible and resilient basic description of re-inforcement of capabilities. Constitute a policy instrument with a common interface to the Norwegian government and NATO. Cooperate closely with the science and technology (S&T) environment directing basis for identifying the relevant capabilities (joint or combined wise) for future military operations.

This provides however just a starting point for capability development. We suggest that the needs of novel capabilities must be communicated and interpreted across the C2 levels regardless of the options (e.g. specialization versus integration). A High-level Concept development will need a clear and uniform description of tasks, abilities and relationships, requiring a clear and realistic force structure template and it must be possible to describe in a simple and clear way comparisons between different structures and in different time perspectives (i.e. the balance of threat theory[3]). (Warden et al.,1995 "Target model"; WardenIIIs,1998,'Concentric Ring Theory'; Walt,2022,'UKR war accelerate U.S. expectation of greater European responsibility for own security')

4.6 Variables of Interest

Variables of interest characterizing the selected use cases are dependencies, dynamics and complexity. (Alberts, 2019; Schneider et al., 2017)

The **Dependencies (High) i.e.**

- Shared situation awareness required across dependent entities in the Northern Flank environment

- Significant amount of non-organic information required by entities to handle the wast areas High North

- Planning and/or operations undertaken by different entities in the same or different domains are constrained or sequenced due to the problem space in the High North

- The effects created by an operation in one-domain impacts the success of an operation in another domain (success dependencies). Coordinating Air, Land and Navy resources as examples of this dependency on the Northern flank.

Dynamics (High) i.e.

[3] S. Walt developed the balance of threat theory, which defined threats in terms of aggregate power, geographic proximity, offensive power, and aggressive intentions. It is a modification of the "balance of power" theory, whose framework was refined by neorealist Kenneth Waltz.

- Less time available to complete plan – operation (East-West axis on the Northern flank).

Complexity (High) i.e.

- Extra time required to plan and execute

- More situation awareness within entities are required to plan and execute

- Extra time required for 'think' – perform required cognitive tasks

- Small amount of non-organic information required

- Requires more effort to extract necessary information (a lot of noise)

Inspired by Scenario 8, in Alberts (2019) presentation slides based on 24thICCRTS paper: '*Is a Bespoke Design for Multi-Domain C2 Necessary?*'.

We suggest that the control dilemma may be reduced in military capability development by defining common environmental attributes for the strategic level scenario construction, the operational level scenarios, and the tactical level construction of vignettes. E.g. by matching missions against possible resources: support for concept-led capability development and planning processes. Matching missions against possible resources: support for capability development and planning processes by a simple assessment of resource objects (named analysis objects).

Table 2: Example of analysis objects

	Capabilities whose functions are important for the ability of the JCS to survive (Northern Flank)	**Capabilities whose functions are of no consequence for the ability of the JCS to survive**
Analysis Objects (in mil structure) that <u>can be</u> effectively <u>controlled</u> by the JCS	1. Organic Objects <u>included</u> in the JCS: A flexible set of capabilities that enable Norway to respond quickly to rapid changes in threat. Ability to support and operate alongside large-scale Allied land, air and naval forces, as well as deepening cooperation to enhance interoperability. Defensive capabilities to sustain and enhance national resilience.	2.Non-Organic Objects <u>may be included</u> in the JCS: Network Enabled Weapons (NEW), Surface-Attack systems, MALE, HALE drones, enhanced Space
	Explore concepts to disrupt adversary's tempo of operations Leading to: Capability development of C2, defensive counter-measures of bases, air ports, harbors, Investments in flexible counter-capabilities e.g. (Air Defenses, LRAD(80-500km) MRAD(10-80km) SHORAD(0-10km).)	capability. Support of NATO.
Analysis Objects (in mil structure) that <u>cannot be</u> effectively <u>controlled</u> by the JCS	3. Civil infrastructure	4. Objects <u>are excluded</u> from the description as a whole: Nuclear capabilities[4].

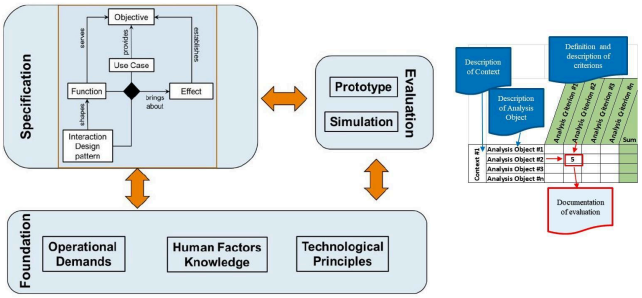

Figure 5: *Illustration of a possible evaluation: From left to right the process model, are based on the Situated Cognitive Engineering (sCE) method (Neerincx & Lindenberg, 2008 cited in Vught et al.,2020) when assessing a new capability within the Strategic Planning process.*

4.7 Example of Evaluation

[4] The risk of a protracted major power conflict escalating to a nuclear confrontation is not even addressed in the MDO approach, however, apart from simply noting an assumption that nuclear weapons will not be employed (TRADOC, p. A-1 cited in Mayer (2021) p. PAPER NBR – 7)

We may assume that based on our selected use case (the RAND Report, "Defense of Europe's Northern Flank," (Black et al.,2020)) the military organization of the Northern Flank has started a process of determining its capability requirements through the analysis of Strategic Guidance provided in the Nordic White Paper supported by the Capability Planning Guidance[5] of participating Nordic partners. This analysis can be likened to mission analysis during a military appreciation process. Methods for conducting this analysis may include:

- Environmental scanning
- Scenario planning
- Scenario validation
- Concept evaluation (such as using metrics and measures)
- Combat simulation
- Impact analysis
- Vulnerability analysis

Staff responsible for developing the concepts should also consider:

- **Templates**. A generic template should be developed for alignment to a common style and as a guide for content
- **Use of expert teams**. During initial definition and development expert teams should be assembled from across Defense to produce or reject initial concepts for further testing, experimentation and evaluation
- **Consultation**. In the early stages, consultation should be limited, but expand rapidly as the concept matures. Broad consultation is essential before any form of higher echelon endorsement is sought
- **Studies and experimentation**. The conduct of studies and experimentation, and evaluation within Nordic military organization, should be applied according to NATO development handbooks. Results from experimentation are one of the principal drivers for concept revision.

The capability-based planning process creates an evolutionary dynamic that identifies flaws, adapts concepts and ultimately generates consensus and unity of purpose. Ideally, this process takes an untested hypothesis and allows its evolution into a more assertive conclusion. The product of this evolutionary dynamic is capability based innovation and change that leads to progress.

Specifically, we are to use a soft problem structuration of environment ("boundaries") supplemented by organizational storytelling (Brady, Naikar & Treadwell, 2013) leading to requirements and needs of Joint Cognitive System (or parts of it) within a strategic analysis: using inputs of situation and environment onto case studies of military strategy narratives in a maritime air mission. Methodology similarities with HF methods: cognitive work analysis, task analysis, strategic analysis templates. E.g. mapping abilities of a set of capabilities with tasks (i.e. according to optimizing sub-goals (sequencing, and scheduling tasks) achieving an overall mission goal).

We indicate that a way ahead for capability development methodology is to match missions with resources and modus operandi (Granåsen, 2018; Van de Ven, 2005; Pentland, 2012) where we make use of existing strategic guidelines and policies as well as operational concepts used in the alliance. We methodically decompose means-ends and means-ends-ways based on investigations of central documents, systematic review of NATO capability codes which means that we are aligned with NATO's generic tasks in the missions. The requirements that emerge are matched against selected scenarios. The instrument apparatus, i.e. which future resources (capabilities (military and civil-military capabilities) as well as existing ones (sensors, effectors and decision-making nodes) will potentially match the threat environment due to the mission portfolio now and in the future. This will be an iterative review. Output from the methodology will, among other things, be an MQL (Master Question List), Capability traceability matrix, and a goal-setting hierarchy based on a list of "what we know about," and "what we need to clarify (investigate further)," and "what different strategic guidance and arrangements can be devised to match missions with resources in a future threat environment". As we have suggested, using the set of dimensions of the environment could aid in communicating across levels about the capabilities and what they may entail.

4.7.1 Organizing an evaluation

In the following, a brief description is given of the practical application of the assessment model. Initially, some considerations are stated in connection with the organization of the work. Then a description is given of the implementation of an assessment. Largely this model is based on prior work by the authors of this article, but adapted to the key problematics of capability development in a novel security situation.

An analysis group should carry out the assessment. The analysis group(s) should consist of people with competence in both the academic basis, i.e. analysis objects and contexts, as well as the methodological basis and the content of the assessment model (Figure 6).

[5] A Nordic structur development planning process emphasizing the Nordic dimension: "Nordic Strukturutviklingsplan" (SUP)

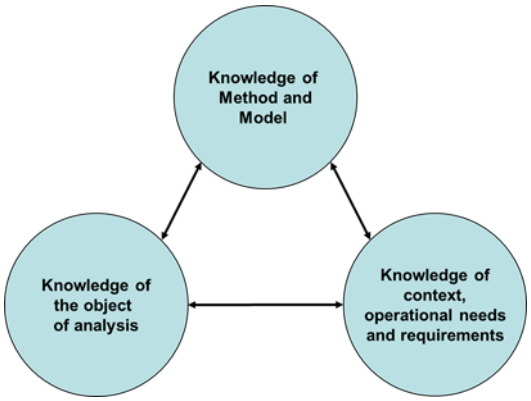

Figure 6: *Areas of competence*.

As previously stated, the group or groups must have members with solid knowledge of the objects of analysis. Their role is to contribute with knowledge of technical and practical possibilities and limitations of the analysis objects that are important for the assessments, and thereby contribute to the assessments being carried out within the framework of what is technically and practically feasible.

The group or groups must also have members with solid knowledge of the contexts and the operational requirements and needs that follow from them. Their role is threefold. They must first describe the contexts and thereby establish the external operational framework for and delimitations of the assessment (cf. chapter on context). Secondly, they must identify operational possibilities, roles and tasks for the analysis object within the context. Finally, they must carry out the qualitative assessments and estimate the analytical object's operational effect in the context.

The group or groups should have one member who takes responsibility for facilitating and leading the implementation of the assessment. The person in question must have solid knowledge of the methodological basis, the assessment model in general and the assessment criteria in particular. Their role is to ensure that the assessments are methodologically sound, that traceability is established by the assessments being documented in a satisfactory manner and that there is progress in the assessments.

The groups can interact (observe) several players/simulants and take care of events that happen at the same time. The basic procedure is to allow the elements analyzed in the analysis environment to facilitate the players' interaction without interruption. The synthesis of the result is done by reading the model elements and the observers presenting sub-results based on the performance in the analysis environment i.e. "Data Elicitation". "The group factor is a part of the design of the system analysis procedure. A highly social process and all the participants' objective levels of expertise, as well as on this interaction." (Bromme et al., 2001)

It is important to emphasize that there is nothing stopping a person from having multiple roles. What is important is that the respective roles are fulfilled and that the group as a whole has a sufficient supply of representative competence to ensure relevant and valid results.

For implementation, a path consisting of five main phases- is defined as shown in Figure 7.

4.7.2 Analysis Object

An analysis object is an object whose operational effect must be assessed within a defined context. An object of analysis can be a relatively concrete concept, which makes it relatively manageable without decomposing it further. However, many analysis objects are somewhat more complex and may require a decomposition to make it manageable. Which type of decomposition is appropriate varies in relation to what the object of analysis is.

4.7.3 Evaluation Criteria

The term operational effect is often used to express the extent to which our working methods, organization and resources contribute to goal achievement in a given context. In an operational context, effect is the same as impact. When developing military structures or operations, one wants the operational effect to influence. The purpose of the assessment criteria is to have a conceptual apparatus that gives the opportunity to discuss the extent to which an object of analysis produces an operational effect. Naturally enough, the set of evaluation or assessment criteria can be put together in many different ways, and there will usually be a need to adapt the set somewhat depending on the nature of the object of analysis. However, it seems reasonable that there is consistency between the criteria chosen in a given case and the decomposition made at the highest level.

- Examples of evaluation/analysis criteria (in Figure 8):
- Resource utilization: effective resource utilization, (Conservation Of Resources (CoR-theory)
- Speed and responsiveness: *presence of allies at t=0+x hours/days notification, mobility*
- Robustness (physical protection, resisting moral degeneration, information security)
- Applicability and flexibility: *availability of national forces*
- Technological Innovation and Maturity level (LoA, TRL)
- C2 and coordination (harmonization level, interoperability level, modes of operation): *need for tactical cooperation*

- Intelligence (JIPOE): *the geography of the scenario for own forces and for enemy forces, composition of enemy forces*
- Logistics, Generate and maintain structure elements: *maintain competence, generate and maintain a sufficient amount of personnel, material and technical systems*

4.7.4 Implementation Path

In the evaluation or assessment model, the score is set quantitatively based on a qualitative assessment that reflects both the significance of the assessment criterion in the context and the analysis object's impact on the existing structure. It is therefore important to document the qualitative assessments that form the basis for determining the score.

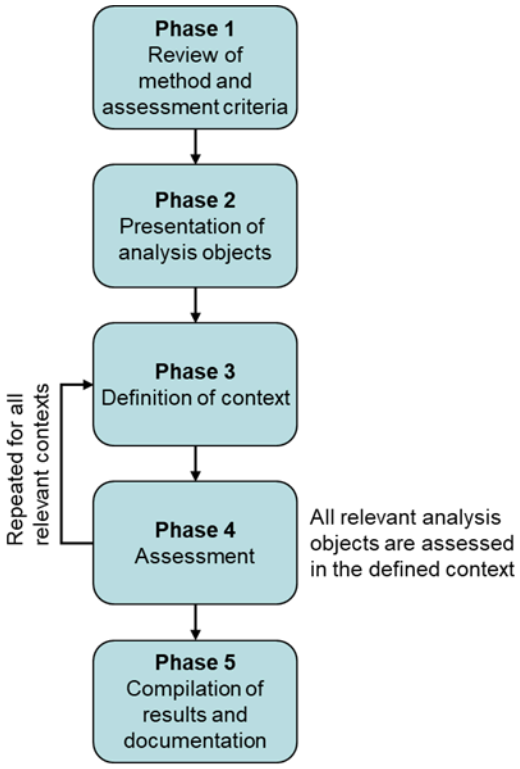

Figure 7: *Illustration of an Implementation Path consisting of five main phases - when assessing a new capability within the Strategic Planning process.*

		Analysis Criterion #1	Analysis Criterion #2	Analysis Criterion #3	Analysis Criterion #n	Sum
Context #1	Analysis Object #1	5	4	3	5	17
	Analysis Object #2	5	1	2	4	12
	Analysis Object #3	4	3	3	4	14
	Analysis Object #n	3	3	5	-2	9
Context #2	Analysis Object #1	3	-2	5	3	9
	Analysis Object #2	2	3	1	4	10
	Analysis Object #3	2	1	3	-3	3
	Analysis Object #n	4	4	5	2	15
Context #3	Analysis Object #1	-2	2	4	5	9
	Analysis Object #2	3	2	2	2	9
	Analysis Object #3	1	5	5	3	14
	Analysis Object #n	5	3	3	2	13
Sum	Analysis Object #1	6	4	12	13	35
	Analysis Object #2	10	6	5	10	31
	Analysis Object #3	7	9	11	4	31
	Analysis Object #n	12	10	13	2	37

Figure 8: *Illustration of a possible evaluation: Scenarios - functions - types of operations when assessing a new capability within the Strategic Planning process. Inputs: Context, Analysis Criterion and documentation of evaluation. Outputs: Sum of AO's per Criterion and Context.*

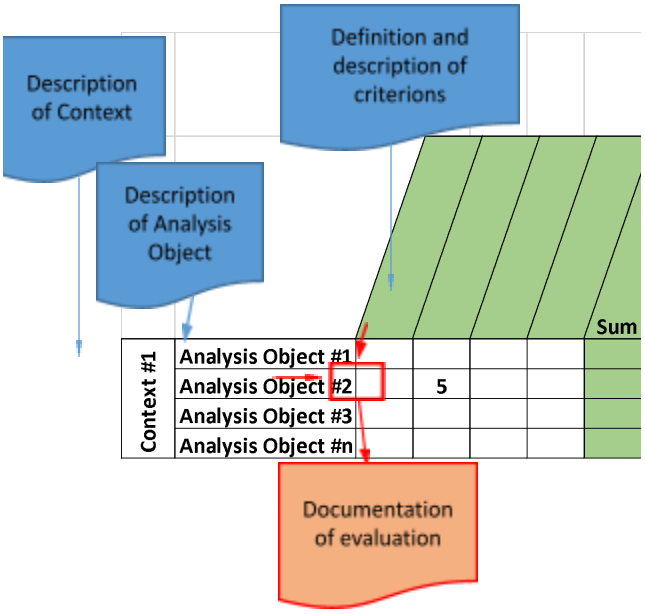

Figure 9: *Illustration of a possible Evaluation process: Connecting Context (Scenarios - functions - types of operations) and Analysis Objects when assessing a new capability within the Strategic Planning process.*

The framework can help ensure coordinated development "across" command levels. The framework use an Unweighted Factor Scores method in the example illustrated in Figure 8, by comparing the total score for each individual analysis object, it will be possible to get a picture of which analysis objects are assumed to produce the greatest operational effect within the individual context and across contexts and command levels.

Assume these should somehow be weighted then there exist multiple methods for the estimation of factor scores, and they vary in their complexity and application i.e. : regression-based or exact methods, sum scores and approximate methods, and expected posterior methods. Factor/component scores are given by F=XB, where X are the analyzed variables. B is the factor/component score coefficient (or weighted-likelihood) matrix. (Eastbrook et al., 2013)

5 Discussion

Is endeavor complexity a sufficient and necessary concept / typology to orchestrate one's own resources, e.g. through capability development, to meet a future potential threat? In addition, how do varying interpretations of the external environment (e.g. modelled as endeavor complexity) across C2 levels influence this development?

In this paper, we have discussed this taking into account whether specific aspects of the organizational environment (positioned in E- space) moderates a relationship between Multi Domain Operation (MDO) effectiveness and uncertainty when Endeavour Complexity is high respectively low, by introducing a boundary for uncertainty i.e. modelling uncertain systems (Asencio et al., 2019;Gu, D.-W., Petkov, P. H., & Konstantinov, M. M., 2013). Further, we have included the threat system as a part of endeavour complexity across command levels: Defining and communicating attributes of an endeavour, we suggest that the modelling effort are bounded by differing interpretations. Such interpretations may however be understood, to some extent, using case studies and systematically interpreted using operational research models which at subsequent steps include experts across and taken from the various command levels. E.g. using expert elicitation from not only the strategic and operational level, but also experts at lower operational and tactical and sub tactical levels. Crucially these different groups from different levels may need to meet and discuss jointly future capability needs. Systematically discussing the futures imagined is crucial in this respect and it may require considerable attention to specific attributes of the external environment. The method framework and detailing of environment dimensions as we suggest, may aid in such collaborative innovation by providing common references.

We are thus looking into elements in endeavour space and how to handle means-ends disconnect, and friction internally and among Allies investigating future approaches to C2 when the conflict space have fluctuating boundaries . Some other research are developing similar frameworks. Asencio et al (2019) develop a theoretically grounded framework of boundary transitions and their effect on individuals working in dynamic teamwork settings; Grant et al., 2014, “Libya” use case exemplify fluctuating boundaries; Tørrisplass, 2018, “Boundaries for use of F-35 as a deterrent Strategic Capability at the Northern flank” also exemplify an outlook that is informed by both strategic operational and tactical knowledge about the security situation.

According to SAS-143, research group on C2: "The E-space is a three-dimensional conceptual model that can be used to analyse the characteristics of a problem with the purpose of finding an appropriate approach to C2 for the problem. The E-space dimensions are dynamics, dependencies, and coupling. We are supplementing this model by an uncertainty model used as a tool for conceptualizing the operational context and analysis of how different problem types require different harmonization efforts." (SAS-143,2023,p.17) We thus follow up on this thread of research but with a focus on capability development, going beyond harmonizing existing organizations or organizational units.

1.1 Theoretical Implications

SAS-143 research group’s research report investigates how the challenge posed by different positions in the E-space creates demands for different approaches to C2 and harmonization of effort between different entities in a complex endeavour.

Our article nuances this research model by defining main interplay scenarios e.g. a story board of vignettes continuing the work of SAS-143 empirical research detailing "time-snakes" in E-Space by the help of use cases. Time-snakes graphic are used to support the readers understanding of the changes in complexity, a E-space “time-snake” representation has been added to each case, illustrating each entities movements in the E-space between each phase in the respective case. The time-snake graphic is presented for each domain to avoid cluttering. (SAS-143,2023, p.179)

We suggests that future work should be looking into how upper and lower bounds of uncertainties and ambiguities form these "time-snakes". Our proposal includes thoughts on how to connect the dots of tactics, operational art and strategic thinking in a main interplay of vignettes, long-term technological innovations, and short- and medium term conceptual development. Different methods may be appropriate for this analysis.

Short list of proposals follow from a short review of literature. These are ideas for future research:

Techniques of generating alternative stories (scenarios) by "creative combinations" method, described in The NATO Alternative Analysis Handbook, second Edition – December 2017, provides a good structure to ensure relevance and consistency.

Methods of analysing historical episodes labelled, Qualitative CHA method, is dependent upon using a process-tracing tool which use causal-process and structural observations identifying and characterizing historical analysis.

Another stream of methods are based on architectural frameworks labelled mission threads. Mission treads is an operationally driven structural quantitative method i.e. mission thread analysis (identifying interactions and causal factors) to identify mission steps (e.g. diagrams of need lines connecting nodes).

1.1.1 Variables of Interest

Specifically the following variables of interest could be important to inquire:

C2 approach, collaborative behaviours and exchange of information that are characterized as partly observable and partly controllable (Alberts et al.,2019) based on 24thICCRTS paper: '*Is a Bespoke Design for Multi-Domain C2 Necessary?*'..Attributes of interest for handling Cyber Domain specific variables of interests may also be included.

1.1.2 Uncertainty modelling

It could be argued that we are discussing the impact of *Input uncertainty* versus *Output uncertainty* and the mix of these two in an Uncertainty modelling effort (with help of robust control theory) below. Further work could be done to analyse this.

Bounded interactions of command and control in E-space are dependent upon handling (filtering) limitations of individuals, teams and organizations to create, pass, absorb and transmit data and information (Marvin L. "Lenard" Simpson, 2020). As well as limitations of C4IS. Future work should investigate notional system norms (including modelling of uncertainty bounds) that includes a need to formulate boundaries and basics for collective behaviour (and control design rules of thumb) supported by codifying the (mathematical) formulation of uncertainty (i.e. Unstructured Uncertainties, Parametric Uncertainty, Structured Uncertainties) extending the uncertainty bound modelling of the environment based on investigation and review of work done recently i.e. social network analysis of C2 experiments (ELICIT) continuing the work by SAS-143 research group lead by Dr. Marvin L. "Lenard" Simpson, Jr for his efforts to use social network analysis to characterize different C2-harmonization arrangements. (SAS-143,2023,p.8) Exploring the characteristics of dynamically changing networks (Covering) investigating in (inter)actions and cooperation. (Janssen et al., 2014 p.152-175, in Grant (eds) book on Network topology in command and control.)

1.2 Practical Implications

The practical implication of conducting studies where there are more variables than available data and/or measurement points is that conclusions cannot be drawn based on deductive logic. Even with a well-directed and well-prepared study, it is not always possible to represent all the factors that can influence the results. Therefore, it is important to provide a theoretical basis that is relevant for understanding case studies designed to investigate many simultaneous influencing factors. The results from a case study will often be indications, and not significant findings, consequently foundational studies will facilitate the analysis of the modelled systems that are the focus of this note. Source: (Wikberg, P., Designing Case Studies, p31-48, 2014, "Chapter in Bergren, P., Assessing C2 Effectiveness") (Wikberg, 2014)

Moreover, Long Term Defence Planning (LDTP) process development of defence is ideally an ongoing, evolutionary process, led by strategic guidance, pushed by technology advances, constrained by economics and politics, and to some extent, pulled by users' perceptions of the requirements. The aim is to maintain the necessary defence capability in an era of reducing public spending and increasing demands for efficiency, accountability and transparency in acquisition processes. (Stojkovic, et al. 2007)

Ideally, a MDO framework should include enablers that practically and theoretically solve the asymetricies between objectives, functions and effects. How should the military instrumentation adapt to a military problem regarding capabilites in use, and issues of capability interchange-ability? How to support this analysis – what types of attributes? We argue that the higher granularity of our suggested attributes is needed to be able to communicate relevant scenario and vignette information, and deviations, across command levels. Essentially care should be taken of the boundaries between environment and the organization, boundaries that are complex due to the hierarchical structure of most military organizations.

2 Further Research

The main theme of this paper is the small nation perspective on Capability based Planning and how such planning could be related to the overall long-term defence planning process given the problematic of creating a workable and similar approach across C2 levels.

A fundamental issue in long-term defense planning is the ability to predict how the armed forces may operate in the future in a rational, analytical and systematic way. Such a problem structuring approach provides an opportunity for specialists of concept development to support decision makers by facilitating the creation, development and assessment of robust developmental concepts. Long-term defense planning addresses the process that investigates possible future operating environments, defines long-term objectives and develops a force structure (development) plan to best adapt the defense organization to those objectives (and environments) given. To achieve balance between the variables *ways*, *ends* and *means* is in other words the purpose of the long-term defense planning. Principally, a capability (e.g. Maritime Air operations) may be regarded as an initiative or outline influencing *means* and *ways* in such a way that the balance between the variables is optimal.

NATO Multi Domain Operation concept (2022) may be an example of overarching concept that creates the prerequisites for long-term planning in the context of our High North Use Case.

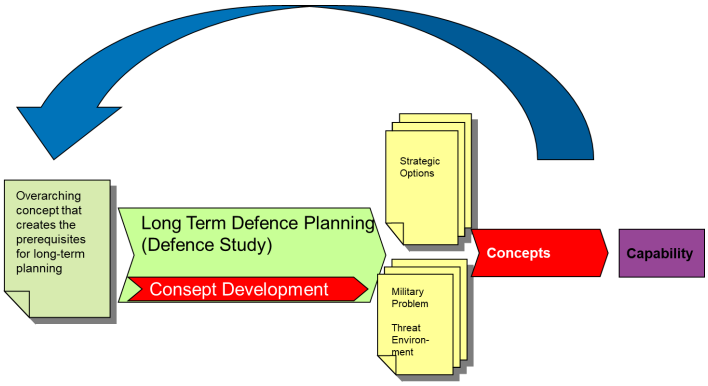

Figure 10: *Illustration of a possible context: Strategic Options - functions - types of operations when assessing use and interchange-ability of capability within the Strategic Planning process (Stensrud et al., 2008).*

The defense capability handling emergency adapted to the Northern Flank of NATO environment, Norway and its allies is aware of the threat we face at any time and it is therefore a continuous competition to have a credible defense capability as a deterrent. Norway and our allies should at all times be better equipped, be able to use resources better, be better prepared and hold out longer than an opponent. Capability development and R&D is a central tool in this interstate competition. Discussion points to the Capability Based Planning approach may include the following *Questions* mentioned and discussed during the evaluation of High North Use Case work:

- Q1: How-to initiate and speed up: Long-Term Planning of military capabilities? How-to keep track of the development of military capabilities e.g. as configuration items (CIs)?
- Q2: How-to manage transformation in a complex threat environment, down-selecting to the attributes of an endeavor?
- Q3: Use case extentions: adaption of modes of operations and leadership in command and control (C2) across domains in Multi Domain Operations.
- Q4: And, a combination of JCSE, Human Factors and Operational Analysis Research methods and use of functional analysis evaluating interchangeability in use of capabilities, is a way forward?

Military need to adapt to a contested and congested endeavor space with high dynamic i.e. a military problem with needs of capability interchange-ability. An illustration of a possible context for assessing use and interchange-ability of capability within the Strategic Planning process in Norway are sketched in Figure 10.

Norway is a small country with limited resources. It is important to get the most operational effect out of the resources and structure we have. Norway must contribute to the alliance and has vested interests in developing solutions that meet Norwegian needs. Norwegian industry must further develop and renew the product portfolio to give allies the operational capability they have invested in by buying Norwegian.

Technology and knowledge are international currency that must be protected. Norway gets access and can influence through contributions in allied cooperation, but we must still be able to utilize new technology for Norwegians operational needs, with our own data and in our own environment. The technological development means that moreover, that warfare is changing. We must therefore investigate other ways of responding to threats and tasks and find other ways to achieve ambitions and seize technological opportunities. We have to consider costs and the passage of time in new ways and make knowledge-based and long-term choices. We need to develop evaluation methods and evaluate the condition of it and our operational capability and take follow-up measures which is our main theme in this article.

Strengthening the Norwegian defense capability requires greater investment, both to replace outgoing systems and build new capacities. Along with conceptual and technological development, new needs will also arise. There are also demands for more sustainable solutions that do not reduce operational capability, and the systems and operations must be adapted to climate change.

We already know that Norway need a new maritime surface structure, air defense and long-range precision fire according to use case in this article. These are

considerable investments.

In addition, society must also strengthen preparedness and endurance. There will be a demand for shorter reaction times, and it is becoming increasingly important to have a good understanding of the situation through monitoring, intelligence and rapid operational processes. We must have enough personnel, material and supplies, and we must be able to train and rehabilitate personnel, maintain materiel, and receive additional supplies during a conflict. New technology such as digital education, surveillance from space and additive manufacturing will affect these areas.

Reasons for this are, among other things, that there is a chronic imbalance between the size and material of the armed forces and the resources needed to staff, train and maintain it. And that Norway's defense capability in particular has not changed its structure and operational concept after the Cold War, including with regard to economic and technological development, this is emphasized in the public discourse in Norway. An example is the dispute between the defense's top management and the Ministry of Defense over the acquisition of new tanks. Tanks in themselves are not outdated, claims the chief of defense of Norway, but are not suitable if you are to defend the Northern flank of NATO, such as in the mountains in the north. "It will be far more effective with missiles and other weapons that can hit a powerful enemy from a long distance," according to Diesen (2023), former head of defense in Norway.

The military power at the Northern Flank, is increasingly dependent on the resilience of civilians and society for endurance, and this cooperation must be further developed. Experimentation, concept development and innovation must build further on the existing knowledge base, in order to find solutions that get more out of the current systems.

Moreover, put more attention to the challenges in the lower parts of the conflict spectrum, so that this does not turn into a “blind spot” in the ability to maintain Norwegian security, and explore new concepts, and clarify the distinction between those who are responsible for its operational capability today, and those who shall design it for the future. (Skjelland et al., 2022, p.4)

Norwegian long-term Defense planning was previously founded on Defense Studies carried out every four years to provide military advice to the Norwegian MoD and the participating Governments of the Nordic states. This process is changing, and this paper recommends integrating concept development into the continuous long-term defence planning process.

In further research on the topic of endeavor complexity across command levels, we are to establish a sound capability-led development trajectory for new capabilities. E.g. defining and communicating attributes of an endeavor (investigate the potential benefits of new potentially disruptive technology, e.g. AI application) to defense systems e.g. that qualitatively and quantitatively imply how we assess and evaluate success in our examples to do so in real world cases. An example it would be interesting to see if this approach leads to a different set of capability requirements, is a framework that support future acquisition of Norwegian uncrewed system (UxS) (Stensrud et al., forthcoming). Moreover, this research should support a functional analysis that suggests that autonomy must be distributed to reduce vulnerability and be scalable to handle emergency adapted to the Northern Flank of NATO environment e.g. an autonomous system that interacts with its surroundings demonstrating a cooperative design approach with new opportunities (e.g. with and without AI support). We claim that a common future acquisition framework of Norwegian UxS applications (with AI) can reduce the burden on the operator based on results from future functional analysis (sCE-method) and empirical studies. Further research could be done along several lines:

1. Understand proposed Norwegian High-level Concept e.g. Cap Stone concept in the context of NATO doctrines and allied doctrines(Grant, T., 2021; NATO, 2022)
2. Understand Norwegian High-level Concept in a wider context of C2. (e.g. system-dynamic perspectives) (Nissen & Alberts, 2009;Alberts,2015;SAS-143, 2023)
3. Paying attention to and discussing 1 and 2 in light of the breadth of potential threat environment (e.g. along dimensions such as Johansson et al. (2018): Coupling/causality, dynamics, degree of complexity/tractability (Snowden (2007) see also Grant (2021)).
4. Our contribution: Examples of evaluation criteria: Land, Sea and Air threats, number of threat entities, size, range, speed, payload, sensors, effectors, autonomy and artificial intelligence capability, in a long and short-term perspective etc.
5. Chosing an application for Future research on uncrewed system (UxS) design solutions less dependent to operate with tightly coupled Command and Control systems, making it contribute to operating as an integrated capability. (Stensrud et al., forthcoming)

Summing up the article, the need for requsite agility and resilience is emergent when planning for future defence

handling emergency adapted to the Northern Flank of NATO environment, according to bullet points 1) to 5) above. The article sheds light on resource allocation for future military operations, sheding light on how different command levels perceive the environment and the development for the future battlefield. However, it can still vary how the environment and the development of capabilities is viewed by different command levels internally in a military organization. Such differences may result in limited resources and control dilemma that can arise when resourcing a specific mission in the Northern Flank of NATO environment. This can be perceived as a "wicked problem". The premise 'locked situational awareness' must change before learning can take place. At the same time, new understanding of the situation is conditioned by learning. The problem will probably not diminish when changing procedures, routines and practices is the recipe on how to form new locked situational understandings. Importantly, due to the nature of such decision-making, the process and methods described in the article provides insights that provide the basis for further test and evaluation, rather than "blind" re-circulation of prescriptive solutions.

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