Emerging technology calls for a systemic view on military capability

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Abstract
Many nations are developing their military towards so-called Multi-Domain Operations with artificial intelligence (AI) as a pivotal component, despite identified challenges. Modern-day military operations underscore the need for updated battle management and cross-domain communication, central to the principles of Joint All-Domain Command and Control (JADC2). AI's potential is obvious, and while autonomous platforms revolutionize warfare, they introduce complexities in command and control (C2), which is also reflected in capability development. This study identifies suitable concepts for systemic analysis of military capability and is the starting point in forming a framework for C2 capability development in the context depicted. A number of concepts are identified; Combat Power, Fighting Power, Joint functions, Warfighting functions, Elements of combat power, Warfighting Capability, DOTMLPF(I), TEPIDOIL, Fundamental inputs to capability, Defence lines of Development, and Military Power. The study also highlights their systemic character and guides the reader briefly in matching issues with suitable concepts.

Keywords
Capability, defence, socio-technical system

1. Introduction

Numerous nations are currently advancing their military capability towards mastering Multi-Domain Operations. Conducting military operations across multiple military domains, like air, sea, ground and cyber domains, is extremely complex and highlights the need for an updated approach to battle management and its associated command-and-control (C2) framework. The design of such a C2 framework enables commanders to synchronize and coordinate operations against a vast number of moving enemy targets in all domains. Accomplishing such operations with speed and acceptable risk for losses or collateral damage is currently challenging, due to outdated command and control-systems. In this context, Artificial Intelligence (AI) is an emerging technology with great potential - while also presenting substantial challenges and associated risks [1]. The development of autonomous weapon systems, supported by AI, pose new challenges to executing command and control. Research emphasizes that there are major risks with commanders not fully understanding the actions of AI-empowered systems [2]. We believe that benefiting from the potential in emerging technology, while shaping military capabilities that are acceptable to society from ethical, cultural, and legal perspectives, calls for a holistic approach to C2 development. Forming a suitable understanding of the concept of military capability is an important first step.

Though capability is central to assessments and decision-making in the defence and security sector the understanding of the term seems to differ a lot, thus hampering fruitful communication between

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scholars or professionals. Lindbom et al. made a thorough review of definitions in scientific literature related to risk management [3]. They found that the word capability is frequently used but rarely defined. Still, they managed to list thirteen definitions related to their area of research. They concluded that there are definitions that seem to equate capability with resources. Other definitions focus on the ability to solve a task or to obtain an objective. In the area of information systems, capability has been included in many enterprise architecture frameworks. The common purpose of the use of the concept of capability in that domain is modeling organization's ability to achieve an intension, sometimes combined with capacity and situational specifics. C.f. [4] for more details on the use of capability in those frameworks.

But, how does technology relate to military concepts of capability? When making assessments or decisions on what to do about a military threat we recognize that technology is an important aspect. However, it is evident that technology alone will not be enough. The integration of technology requires a framework encompassing doctrines, strategies, leadership structures, methodologies, and other elements. Having a systems approach, we can view a problem situation as a socio-technical system, including a potential military opponent with personnel equipped, trained, and organized to enforce the will of their leadership on us. Correspondingly, we can view our own military force as a respondent system made up of our own interacting social and technical components. See Lawson [5] for details on the systems model presented. Having this view, decisions can be made in relation to the anticipated effect of the entire respondent system if engaging the situation system – and risks of serious sub-optimizations are reduced. This is equivalent to making decisions based on how these are anticipated to affect the overall ability to solve a military task. Hence, if having a socio- technical systems view on matters in the military domain it is wise to start with a definition of military capability associated with the overall ability to solve a task or to achieve a goal. Such definitions will also be in harmony with lexical definitions like "the quality or state of being capable" [6], or "the ability or qualities necessary to do something" [7]. A few useful definitions are discussed below.

Assume we can agree assessments of a military force is ultimately about assessing its capability in some situation. The next step is then to analyze the problem at hand. This might involve questions like: if we choose this course of action how will that affect capability? Or, if we develop and acquire this equipment how will that affect capability? Or, if we organize in this way how will that affect capability? Depending on the nature of the question, the analysis will require a relevant concept of what elements constitutes capability and a valid theory for how the elements relate. Having a socio-technical view on capability means acknowledging that capability constitutes both social and technical components. From this view follows that, to properly understand capability, we must involve researchers and perspectives from both social science and from engineering disciplines, such as information system engineering. Though, any lack of understanding for others' viewpoints risk hampering a fruitful dialogue which leads to poorly designed systems and solutions to capabilities.

This study forms the starting point of our journey towards a socio-technical systems framework for developing military command and control capability. Next section, Section 2, describes our method. Section 3 presents our review of concepts identified in the military domain and Section 4 presents a concluding discussion.

2. Method

The aim of this study, as described above, is to find concepts suitable for socio-technical systems analysis of military capability. The research approach is non-systematic literature review in the military domain based on the experience of the authors. Two of the authors of this study are active officers, together representing more than forty years of experience in developing C2 capability, gained from various positions in the Swedish Armed Forces. One is also a senior lecturer at the

Swedish Defence University with more than ten years of experience in teaching military capability development to first and second cycle students.

First, concepts related to assessments of capability were identified. Then these were reviewed through the systems lens described in the introduction. The result is an assessment of each concept's usefulness to analysis of military problems.

3. Review of concepts related to military capability

3.1. Definitions of capability in military context

In the 2013 issue of *Textbook in military-technology, volume 9: theory and methods*, the authors make a slight modification of the lexical definitions and define capability as "to be able to do something successfully" [8]. They explain that in military contexts the term is often used with attributes relating the capability to missions at different levels of conflict, like having the capability to stop a military invasion, to do surveillance of own territory, or to perform ceremonial tasks. With this description it follows that a military actor is expected to incorporate many different capabilities. Some of them are in continuous use while others might never be tested. Whether a military actor can do something successfully or not also implies that it depends on the circumstances of the operation in question, and on potential adversaries.

The authors of the *Subject Description of Systems Science for Defence and Security [9]* instead refers the term to "a potential in a society, organization, group or individual to achieve a specific goal given the right resources". They also state that characteristic to capabilities in military units is that they are shaped under requirements from "uncertainty and large potential risks, both for society and for the individuals charged with protecting it" [9]. Thus, this definition highlights that capability is something abstract, an inherent potential in people, and that it exists in organizations on different levels. The referred text also justifies speaking of *military* capabilities, to distinguish them from others.

NATO defines capability as "the ability to create an effect through employment of an integrated set of aspects categorized as Doctrine, Organization, Training, Materiel, Leadership development, Personnel, Facilities, and Interoperability" [10], referred to as DOTMLPFI. NAF (NATO Architecture Framework) defines capability as "the ability to achieve a desired effect under specified standards and conditions" and highlights the use of scenarios, to describe a context, and a holistic engineering approach [11]. Each definition is easily associated with a systemic view on capability and is also very specific about its constituent elements.

Common to these definitions of the capability concept is that they associate capability with doing something or achieving an objective. This is similar to how capability is treated in enterprise architecture frameworks. The current view on capabilities also suggests separating one capability from another. We can say that a given resource contributes to a specific capability but not to another, or we can say that we lack a specific capability. There are many other definitions. See for example Henshaw et al. [12] or Lindbom et al. [3]. In addition, there are concepts easily associated with military capability, and sometimes used synonymously. *Combat power* is one example.

3.2. Combat power

"The total means of destructive and/or disruptive force which a military unit/formation can apply against the opponent at a given time." [13]

Power is frequently used in our context of interest. According to the Merriam-Webster dictionary there are several lexical meanings. Two of them are interesting in this text. First, the "ability to act or produce an effect" and, second," the possession of control, authority, or influence over others" [6]

The quote above is how NATO and the US Department of the Army defines the concept called *Combat power*. Note that the concept seems to be associated with the *means* to fight available to a specific military formation, of any size. Furthermore, it is related to the formation's ability to destroy or disrupt an opponent – not to perform any specific military task.

This concept might primarily be useful in political or strategic power discussions, perhaps for comparisons of combat power between two opponents, e.g., if it is greater or lesser, or for discussing whether a resource of interest contributes or not. From a systemic viewpoint on capability, the utility of this concept seems limited. Though, there are other concepts with similar labels that do contribute, like *Fighting power*.

3.3. Fighting power

"The ability of any actor to use, or threaten to use, force to achieve a desired outcome is dependent on their will to act, their understanding and their capability to act decisively. Together these determine an actor's effectiveness – their fighting power – and represent respectively its three interrelated components: morale, conceptual and physical. No component is more important than any other; for instance, it does not matter how advanced the platforms, weapons, and sensors if the people operating them lack legitimacy, morality, motivation, doctrine and training, or adequate leadership. Likewise, the three components are not independent; each overlap with, and rely on, the others." [14]

So far, the presented concepts can only be used for accounting or managing a portfolio of capabilities. They say very little about how various phenomena affects military capability. However, in many Western doctrines, the ability to fight has for a long time been captured using a concept labelled the *Fighting power* of a military actor. The quote above is from the British doctrine. The Fighting power as defined there comprises three interdependent components: the conceptual component, (the thought process), the morale component (the ability to get people to fight); and the physical component (the means to fight). Hence, what the actor wants to do is a product of the conceptual component. The manpower and equipment required to do it constitute the physical component, and the resolve to do it is a product of the morale component.

Having a systems' view on capability it is especially interesting to note that *Fighting power* is viewed as the effect of three interacting and interdependent components, thus, it can be regarded a system's effect. The concept is, for example, applicable in the study of cases where the morale component seems to compensate for an adversary's superior physical forces, or, in the study of cases where an innovation in physical forces does not seem to have the foreseen effect on the battlefield, perhaps due to underdeveloped doctrine.

3.4. Joint functions, warfighting functions or the elements of combat power

"Joint functions — Related capabilities and activities placed into seven basic groups of command and control, information, intelligence, fires, movement and maneuver, protection, and sustainment to help joint force commanders synchronize, integrate, and direct joint operations." [15]

"To execute combined arms operations, commanders conceptualize capabilities," and "[when achieved, it] is the total means of destructive, constructive, and information capabilities that a military unit or formation can apply at a given time." [13]

Another systemic conceptual framework is used by military actors in the design of their forces. Its main purpose is to facilitate the planning, or study, of dynamics in the application of capabilities in military operations. It is called *Joint functions* on joint level in the US and in NATO, or *Warfighting functions*, or *Elements of combat power*, on component level. There is a difference in the exact number or clustering of functions or elements, but the use of the concept is similar. It is described in the NATO allied joint operations doctrine: "The joint functions are a framework that provides the commander

and staff a means to visualize the activities of the force and to ensure all aspects of the operation are addressed. They are a point of reference, as well as a description of the capabilities of the force. Several subordinate tasks and related capabilities help define each of the joint functions and some of them could apply to more than one function. In any joint operation, the commander joint task force (JTF) may choose from a wide variety of joint and service specific capabilities and combine them in various ways to perform joint functions and accomplish the mission" [16]. For example, an artillery battalion with the capability to deliver indirect fire might in some phase of the operation support a mechanized battalion and in some phase of the operation produce fires to neutralize the target – thereby contributing to the task force's collective functions maneuver and fires respectively. The NATO allied joint operations doctrine also points out that "forces and assets are not characterized by the functions for which the commander is employing them. A single force or asset can perform multiple functions simultaneously or sequentially while executing a single task" [16]. How the subordinate capabilities are applied to contribute to the joint functions is determined in the operations plan.

The Swedish strategic doctrine uses the equivalent of six joint functions for the purpose described above: intelligence, movement and maneuver, fires, command and control, sustainment, and protection [17]. In the handbook on management in the development of military units' availability has been added. The concept is used in the handbook to make sure that a military unit under development is designed with all essential capabilities in mind. [18]

Another way to describe the concept is using a technique known as design logic. When designing a military force, the joint functions/warfighting functions/elements-of-combat-power can be viewed as the *functions* necessary to fulfil the system's *purpose*. The subunits realizing the physical *form* of the force support the functions necessary to solve the mission. Figure 1 shows the use of the design logic pattern to illustrate the role of joint functions/warfighting functions/elements-of-combat-power in the design of a military force. The pattern to the left is generic and the pattern to the right is specific to the design (force generation in the planning of an operation) of a military force.

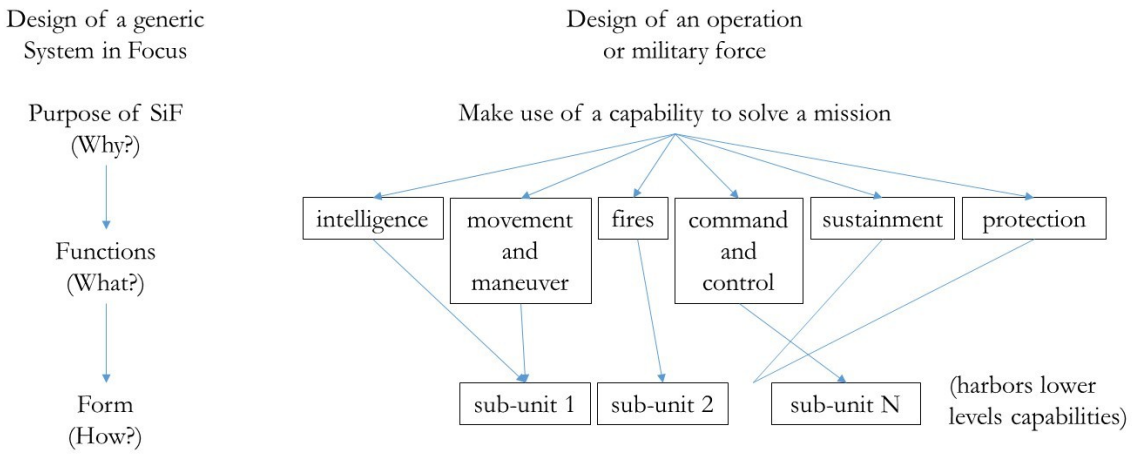

Figure 1: The use of the design logic pattern to illustrate the role of joint functions/warfighting functions/elements-of-combat-power in the design of a military force.

The pattern is recursive and consequently we can use it to find a balanced design in any size of military force – even in a single platform unit like for example a main battle tank (MBT). The design logic pattern helps us to distinguish between a function and a capability. There is a difference, but one that can be difficult to perceive at times. What is a capability and what is a function is a matter of which mission designer or analyst has in focus. Note that when using the concept to improve a technical system one has already decided on the general design, but it can be used to balance subsystems for

overall performance. In the MBT example the framework can be used to support a decision on whether to rely on passive protection or whether to invest in active protection measures. The latter must be weighed against increased signature within the protection function, and it might have unwanted secondary effects on other functions, like possibly on movement and maneuver.

3.5. Capability-Based-Planning and Warfighting capability

At the end of the Cold war western states found themselves faced with great uncertainty to what end their armed forces should be developed and trained. To many states there were no longer an evident threat and a concept called *Capability-Based Planning* was born [19]. Using Capability-Based-Planning, fighting power is viewed as a portfolio (a collection) of so-called *Warfighting capabilities*.

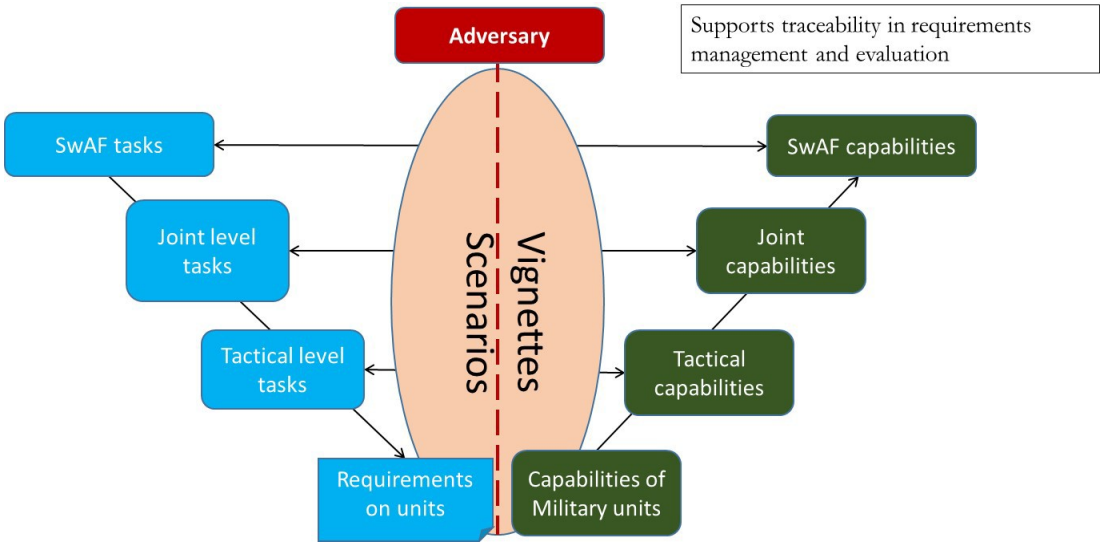

Figure 2: The Traceability model that the Swedish Armed Forces use for their version of capability-based planning.

Each Warfighting capability refers to an objective, a task that needs to be accomplished in support of the objective, or the task force necessary to conduct these tasks. They are seen as building blocks possible to combine to form new warfighting capabilities on successively higher command levels. The purpose is primarily to support military capabilities management in uncertainty [20]. One merit is that a military actor can "provide capabilities suitable for a wide range of challenges while working within an economic framework that necessitates choice" [21]. Another important result claimed by proponents is that it shifts the generation of requirements away from a platform centric focus [20]. The US portfolio called *Universal Joint Task List* is often used as a model for other states.

The Swedish Armed Forces started implementing Capability-Based-Planning, with a portfolio of Warfighting capabilities, the so-called *Traceability model* (translation from *Spårbarhetsmodellen* in Swedish), at the turn of the last decade [22]. A Warfighting capability was defined as "a specific activity, for which resources have been acquired and trained, in order to achieve a desired effect that varies depending on scenario and ambition" [23]. After 2015 the Swedish portfolio of warfighting capabilities is no longer public. However, the ambition to uphold traceability between tasks and capabilities on all command levels still applies. In a Swedish Armed Forces (SwAF) presentation [24] to the Swedish National Financial Management Authority (ESV) the traceability model was illustrated using the Vee-model [25]. See Figure 2. To the left in the Vee-model is shown how the task from the

government is recursively broken down into tasks at successively lower command levels, and on the right side how the capabilities of the armed forces are successively integrated to correspond to these tasks. The diagram has been adopted from an illustration of "*Spårbarhetsmodellen*" [24].

The model shows how a strategic task corresponds to *Strategic capabilities*, how joint tasks corresponds to *Joint capabilities*, how tasks on component level corresponds to *Tactical capabilities,* and lastly how all of these are integrated from the capabilities of the military units. The verification of capabilities on each level is performed against predefined vignettes and scenarios involving a potential adversary in focus.

The Capability-Based Planning and Warfighting capabilities concepts thus makes it possible to have a system management view on the forces and capabilities of a military actor. A Lego metaphor easily comes to mind. Having all kinds of pieces in your toy box sets you up to build a new and innovative construct if the need suddenly arises. The tools and processes of Systems Engineering seems to apply.

3.6. The DOTMLPF construct and similar acronyms

In parallel to the Capability-Based-Planning initiative, many nations have found it useful to think of and manage military capabilities as systems comprising similar abstract elements [21]. In the US the system elements comprise; Doctrine, Organization, Training, Materiel, Leadership and education, Personnel and Facilities (DOTMLPF) [26]. NATO adds an I for Interoperability [27]. The common aim is to obtain a holistic view of capability development, thereby shifting attention away from the traditional platform centric approaches and towards non-materiel aspects.

To scholars interested in understanding the value of technology in military capability this is useful. Regardless of the categorization of elements, we realize that any component in a system, like the Materiel/Equipment element, can deliver no effect by itself but has dependencies to the other elements. Thus, equipment must be operated by well-trained people, organized to support a fitting doctrine. Consequently, when assessing the military utility [28] of a new technology we should relate it to the predicted change in delivered military effect, which is indirectly a measure of the induced change in military capability.

3.7. Military power, the modern system view

The modern system is a tightly interrelated complex of cover, concealment, dispersion, suppression, small-unit independent maneuver, and combined arms at the tactical level, and depth, reserves, and differential concentration at the operational level of war. Taken together, these techniques sharply reduce vulnerability to even twenty-first century weapons and sensors. Where fully implemented, the modern system damps the effects of technological change and insulates its users from the full lethality of their opponents' weapons. [29]

The concepts presented so far are ontological and give no real evidence as to how the components of capability interact – especially if one is interested in the effects of technology change. That is why Stephen Biddle's Modern System theory is relevant. In his book *Military Power* [29] he views military capability as the military dimension of power and claims it can be understood as a function of the interaction between *Force employment, military technology*, and *Preponderance*. Force employment comprises tactics, doctrine, skill, morale and leadership, and Preponderance can be understood as mass, or force numbers. By using a mix of qualitative and quantitative methods in case studies of past military conflicts, Biddle finds that after World War I the outcome of military land battle is determined by Force employment. His study shows that an actor having a modern system view (see the quote above) on the application of its forces can exploit properties of military technology. But, he claims, these have changed little after WWI. Consequently, when engaged with a high-tech adversary, the capability to modify force utilization could suppress the impact of new technology.

On the other hand, in battle with a non-modern system army the effect of exploiting technology changes is often great due to an increase in the adversary's vulnerability. Increased superiority, Biddle claims, only matters in battle between modern system armies [29]. Warfighting is also a two-way street where an adversary undertaking similar activities, trying to degrade own forces capability. When engaging an adversary with similar capabilities the force that processes the targeting[5] process faster holds the advantage [30].

Last, the Modern system theory applies to land battle. One can't help to ask, are there similar relationships between force employment, technology change and preponderance in the airspace and maritime theatres?

4. Discussion

Capability is a core measure of what matters in the military domain. Therefore, military capability is often at the heart of public or scholarly discussions. Unfortunately, in practice misunderstandings occur. This is partly because there are many different interests in and views on the subject, but also partly since there is many related and similar concepts brought into the discourse by representatives of different professional and scientific disciplines. Some of the concepts commonly used in the military domain have therefore been described to increase awareness of their nuances. See Table 1 for a compilation.

Table 1
Presents the list of concepts and their respective features.

Concept	Analysis use	Design/Management use	Systemic character
Capability	limited, for relating to tasks	useful for accounting	none
Combat Power	limited, for overall comparisons	limited	none
Fighting Power	highlights non-material aspects	useful in strategic planning and in force production	as an effect from interaction between physical, conceptual and moral components
Joint Functions Also Warfighting Functions, or Elements of Combat Power.	highligts the need for balance in a force, or in a technical system, useful in identifying vulnerabilities	useful in force generation, in the dynamic design of an operation, and to support design choices in a technical system	constitute a generic first level in a hierarchical system view on capability
Warfighting Capability	highlights the variety of abilities in an actor´s armed forces, useful to focus assessments in the forecasting of the military utility of innovations	relates to a portfolio independent of potential adversary, useful in longterm force planning	constitutes the second and lower levels in a hierarchical system view on capability
DOTMLPF Also TEPIDOIL, or Defence Lines of Development, or Fundamental Inputs to Capability	highlights interdependence between material and non-material aspects in capability	serves to categorize warfighting capabilities, supports requirements management and evaluation in military capability development	constitutes an abstract conceptual system view on capability
Military Power – the Modern System view	provides a theory on the interaction between force employment, technology and preponderance in military capability, highlights non-material aspects and the effect of numbers	limited	as an effect from interaction between force employment and technology, under the influence of preponderance

Several of the concepts were evidently developed from a system thinking point of view, although this is implicit in the respective definitions. Still, they differ in how useful they are for analysis or design in different contexts. If the interest of analysis is in how requirements on weapon platforms have evolved within the capability of Combat Air Support since 1940, then perhaps one should choose the DOTPMLF(I) construct to study how the changes in operational context trace down to the interfaces

between Materiel (M) and Doctrine (D), between Materiel and Training (T) etc. If interest of analysis is in finding an explanation as to why Ukrainian soldiers were sitting on top of their armored personnel carriers (APC) instead of in them during the conflict with Russia-supported forces in 2014, then perhaps we should choose the Fighting-Power concept to study the interaction between physical and morale factors. A conclusion to draw is, if we always casually replace military capability with Warfighting functions then the analysis will only be interesting less than half of the time.

Of course, the true capability of military force could only be fully assessed when the force engages an adversary. Only then it is possible to know the opponent and his abilities and shortcomings. This makes assessing military capability exceptionally challenging, and therefore it is best conducted with a base of science combined with art. In the context of rapidly advancing technological progress and its ongoing integration in society, we claim designers of military capability benefit from adopting a holistic system perspective as they outline the specifications for various sub-systems, whether technical or socio technical. No doubt, assessments of such capabilities require parallel use of several of the capability concepts presented here. This implies that the current methods regarding capability development should evolve to become more holistic, flexible, and comprehensive [31].

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