Stockholm Contributions in Military-Technology 2010

Editor: Åke Sivertun

NATIONAL DEFENCE COLLEGE

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Cover: Väddö 2008–01–22; TD01's preparations for missions in Tchad. Photo by Johan Lundahl/Swedish Armed Forces/Combat Camera.

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Foreword

Transformation in the military arena regarding national and international security calls for a deeper understanding of how to make use of the civilian proficiency in most relevant technological fields and how to create new military capabilities. Hence a better understanding of technologies and their applications in future defence and security systems is needed. One minor contribution in this respect is the ongoing development of a new academic subject:

Military-Technology is the science which describes and explains how technology influences military activity at all levels and how the profession of an officer affects and is affected by technology. Military-Technology is based on several different subject areas from different disciplines and combines understanding of the military profession deriving from social science with the foundations of natural science and with a superstructure and dynamics supplied by engineering.

When developing a new subject, not being a derivative of an "established" subject, natural publication sources are lacking. *Stockholm Contributions in Military-Technology* aims at, within suitable time, filling this gap to some extent.

Stockholm in June 2011

Martin Norsell, series editor
Associate professor in Military-Technology

Introduction: Contemporary Contributions in Military-Technology

Åke Sivertun

This compilation of recent Military-Technology papers is based on nine selected, peer-reviewed papers from the Military-Technology track at the International Society of Military Sciences 2010 Conference (Stockholm, 10–11 November 2010).

These contributions are examples on the broad scope of research and development that the organisations and researchers are involved in. However, the research field of Military-Technology not only deals with the use of technology, but also how the use of these technological artefacts and methods are interrelated and impact on the use and users. This theoretical concept is further developed in several contributions where the necessity of having a Military-Technology perspective to increase quality and relevance in officers' education is clearly illustrated.

As additional information about topics and interest in the field of Military-Technology, five exam essays from the officers' education presented at the division for Military-Technology at the Swedish National Defence College (SNDC) in Stockholm are described briefly at the end of this introduction.

The essays, being at research preparation level (level D or Masters level according the Swedish academic system), could also be used as an example of the military students' contribution to the development of the academic subject of Military-Technology.

However, let us start by introducing the main articles.

The Mutual Coupling Between War Fighting Capabilities and Military-Technology

In the article, the conditions for modern warfare and the internationally undisputed dependence on and interaction with technology is discussed. The authors begin with the presently used definition of the academic subject of Military-Technology in Sweden and Finland and this interaction is analyzed with reference to Swedish and Finnish doctrine. An elaborate discussion is given about how progression in the subject of Military-Technology is achieved compared to other military sciences.

Military-Technology is a relatively new academic subject and defined at SNDC as '*the interdisciplinary field that deals with military specific technology as well as with the impact of technology on tactics and operations*' (Axberg, 2003). This definition is used throughout the paper, meaning that the subject of Military-Technology describes and explains how technology influences military activity at all levels and how the profession of an officer affects and is affected by technology. Furthermore, it will be assumed that achieving military effects by using technology without considering the context is unlikely to be successful in modern warfare (Smith, 2007).

The paper focus on showing the interaction between capabilities needed in war and the definition of the subject of Military-Technology. If this interaction can be shown using the major doctrines it implies that officers with a Military-Technology perspective will be more versatile compared to their colleagues lacking this knowledge. This is because officers with knowledge in Military-Technology have yet another perspective to add to their 'tool-box' when solving problems in complex settings. Military-Technology is not to be mistaken for 'technology for military purposes' in the following.

The paper aims to highlight that the current focus on command levels might not necessarily be suitable for strengthening the war fighting capabilities. Finally, the Military-Technology connection and contribution to the war fighting capabilities are discussed. The shortcomings and pitfalls of the currently used methods to analyze such supposed interaction is also discussed.

The usefulness of learning Military-Technology is sometimes disputed from officers at different levels, pre-dominantly coming from a traditional background with a strong focus on War Studies. The argument is that you need no, or very limited, knowledge of the physical factors to be a good officer. War studies is defined as *'The study of war, warfare and conflict management where military resources are used, and how military resources are created and employed at all conflict levels. Focus is on the use of military force and the role of the military profession.'*

Furthermore, the necessity of having a Military-Technology perspective to increase quality and relevance in officers' education is advocated by the authors.

Developing an OODA-based Operational Process Model for the Netherlands Armed Forces C4I Architecture

Since 2008, the Netherlands Defence Academy (NLDA) has been involved in the development of a C4I architecture (Command, Control, Communications, Computer systems and Information) for the Netherlands Armed Forces, in close cooperation with the Netherlands Organisation for Applied Scientific Research (TNO), as requested by the Netherlands Defence Staff. They reported on the research approach and the first results of the architecture work at the 14th ICCRTS (Ooms & Grant, 2009). According to that report the C4I architecture should provide a picture of both where they are and where they should be going, with respect to their Command & Control (C2) processes, the operational information support (requirements, services, systems) and the underpinning Information & Communication Technology (ICT) infrastructure. In this way the C4I architecture should provide a coherence and guidance for the evolution of their C2 processes and the required C4I support.

In the article, a service-oriented approach for the development of the C4I architecture is presented as suggested to have some potential benefits. It should allow rationalisation of software development efforts: services developed for naval C4I systems could be used for army C4I systems and vice versa. In addition, Netherlands service-oriented C4I systems could make use of services developed by NATO. Taking this concept one step further, in an international Service-Oriented C4I Architecture, Netherlands C4I systems could also make use of services from partner C4I systems in an international coalition. While assessment of the feasibility of this concept in an operational, bandwidth-limited environment is not part of this research, the adoption of a service-oriented approach supports an evolution in this direction.

Experimentations in Pre-Product Development

The major shortcoming of computer science is the belief that various "living labs", "proof-of-concept demonstrations" and other illustrations of the idea are a sufficient proof of its worth. The only way to fully exploit research results in product development is to be able to explain the meaning and consequences of the results. Therefore, a pre-product development phase is needed to ensure that the results are reliable and justified. The ultimate goal is to minimize the risks in product development.

This paper presents experimentations as a part of the pre-product development methodology called Innovation prototyping. Experimentations in it are focused, systematic and require a sound methodology. The key is avoiding quick and dirty hacks that do not allow analysis, do not prove anything and do not allow reuse. The result is a coherent rationale for product development, not a set of random ideas. Military applications are challenging enough for pre-product development cases.

Minimizing Risk from Armed Attacks: The Effects of the Nato Naval Ship Code

In this article, the NATO Standardization Agency (NSA) proposed Naval Ship Code (NSC) is discussed. NSC can be applied to surface naval vessels and other vessels operated by the armed forces or agencies of a state. The NSC is optional and based on, and benchmarked against, conventions and resolutions of the International Maritime Organisation.

The NSC covers areas such as ship controllability, engineering systems, fire safety, evacuation, communications and navigation. The code does, however, not include measures specifically designed to address the effects of armed attack.

The covered areas in NSC are further very important when the effects from an armed attack are to be minimised. This work investigates how the NSC will effect, and interact with, measures to ensure survivability under attack. Survivability is here seen as a function of the ships susceptibility, vulnerability and recoverability. Based on two case studies, this paper exemplifies the effect of the NSC on the vessels total safety. The case studies presented are ballistic protection on smaller naval vessels and bridge configuration to minimize effects of attacks.

As stated in the Maritime Strategy of the United States of America (DoD, 2007) the economy of the world is tightly interconnected and 90% of the world trade are transported by sea. The sea-lanes and supporting shore infrastructure are therefore very important to the global economy. The conflicts of today are increasingly characterized by a blend of traditional and irregular tactics, decentralized planning and execution, and non-state actors using both simple and sophisticated technologies in innovative ways. Naval operations of today are more focused on the littoral and the number mission types as well as threats are increasing (NSA, 2010). The Maritime Strategy therefore conclude that these conditions combine to create an uncertain future and sets also new demands on naval security as well as on naval ships to counter these threats. The need for further development of maritime security is also recognised by non-military authorities such as the International Maritime Organisations (IMO) and the

European Union. In the wake of the terrorist events on September 11, 2001, new civilian maritime regulations, such as the International Ship and Port Facilities Security Code (IMO, 2002) has been developed and implemented (Hesse, 2003).

Total safety or security can never be achieved (Grimvall, 2003 and Hughes, 2000) and safety, as well as security, efforts focus on reducing risk. How risk is assessed is therefore crucial when designing analysis methods, this especially as measures to reduce risk often are interconnected with each other and not possible to change without affecting other safety or security areas. It is a matter of compromises. How to systematically enhance survivability is an important question for both defence executives involved in technology development and field commanders in tactical deployment.

Ubiquitous Computing Has a Potential Use in Military Context

Even though ubicomp (ubiquitous computing) is nowadays usually linked with entertainment and experience industry, the original ideas on calm technology, that does not hinder performing the task at hand by making users to divide their attention, allow utilizing the paradigm in serious professional context. If time is a critical factor for success, as in military applications, ubicomp can provide solutions for accessing, filtering and managing the lifecycle of critical information.

The four key features of ubiquitous computing are:

1. *Availability and utilization*
2. *Dynamic contexts*
3. *Invisible computing*
4. *Concentrating on the task*

The key advantage of ubicomp is that it allows, with careful designing, preparing and indeed taking advantage of situations when the terminals (or users) are isolated. The paradigm aims to answer a fact of real life: the services must be provided in some form even though everything changes dynamically all the time when the service is being used, and the conditions are often everything but optimal.

Ubiquitous computing (ubicomp) as defined by Mark Weiser in early 90's is a promising paradigm that presents both great opportunities and great challenges. Weiser's idea was founded on simple sentences: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." (Weiser, 1991) The

major consequence of ubiquitous computing paradigm is that it allows users to easily learn and use complex computation information services without even being aware that they actually are using a computing system.

Ubicomp era is expected to realize after current Internet and distributed computing era. Common misunderstanding is that ubicomp would replace all the earlier paradigms. However, this is not the case. Mainframes and computing clusters will still be around for a long time for e.g. scientific computing, word processing will still be done on a desktop computer, and web pages will not certainly disappear. Ubicomp just adds one more possibility – the possibility to perform everyday tasks without the hustle and bustle usually linked with using a computer.

Ubiquitous computing does not refer to one single technology. It is a paradigm. Using WLAN, RFID, LAN, distributed computing, cloud computing, etc. will not make a system an ubicomp system. Also, ubicomp is almost exact opposite of virtual reality. It aims to hide computers in the user's world, not to bring users into the world of the computers.

Currently, ubicomp comes in many flavors, in addition to the Weiser's definition. They are not contradictory, but emphasize different areas. Pervasive computing emphasizes more the hardware and low-lever networking, e.g., sensor networks. Ambient intelligence approach presents view that everything is connected with everything, and puts heavy emphasis on networking research. Finally, chip-rich environment approach tries to embed a small processor into anything and everything, even the food packages, cardboard boxes and such.

This paper presents the key features and common denominators of ubiquitous computing.

An Experimental Approach to Improve on the Situational Awareness of Soldiers Transported in an Armored Vehicle

Inside armored vehicles the possibilities for looking out are rather limited. That is especially true for the soldiers being transported inside the personnel compartment. Because of this, the soldiers normally have very limited knowledge of what is happening outside the vehicle. One possible way to improve the situational awareness inside an armored vehicle is to have screens showing live images of the outside environment. This paper report from a current investigation utilizing a set of carefully placed cameras connected to screens streaming live images inside the vehicle. It was found that this will significantly improve the situational awareness of the soldiers inside the armored vehicle. Field trials conducted in a realistic environment show that a careful placement of the cameras and the screens will increase the safety, and the efficiency, of the soldiers when they dismount the vehicle.

AUV Localisation Using Floating Smart Dust

In this paper, the authors are investigating some alternative to GPS positioning when using under water AUVs. Navigation of submarines is a complex problem. GPS does not work below sea level, since water blocks the radio signals used for GPS triangulation. It is difficult to recognize objects on the sea bottom; usually no clear objects are available as a basis for landmark. Currently sonar is the preferred technology as sound can propagate over large distances. Beacons, such as buoys attached to the sea bottom, are used to broadcast sound signals. Some navigation technology is based on the magnetic field. Recently stereo vision cameras with onboard light source have been applied. All these technologies have their advantages and disadvantages. Beacons have to be installed in advance and are not very flexible. Sometimes in hostile environments only local sound sources can be used. The use of magnetic field is not recommended in case many interfering (e.g. iron) objects are in the environment. In this paper, the authors study the possibility to use "smart dust" to automatically navigate AUVs. We'll discuss possible models of smart dust and present our research results of computer simulations as well as some discussion and findings.

The Process of Situational Awareness Support for Information Sharing

The interest for Situational Awareness in sharing information is discussed by Anne Koskinen-Kannisto from the Navy Command in Finland. In her contribution, the PSAS (Process of SA Support for Information Sharing) that supports the individual in a team gaining Situational Awareness (SA) and sharing information is investigated. The author refers to a project supporting individuals as to improve their ability to gain Shared Situational Awareness (SSA) as a team. Cooperations require all participants to share relevant information in order to collaborate in a challenging environment. Information requirements are key elements when we are trying to achieve Situational Awareness. In the MNE5 MSA (Multinational Experimentation 5, Maritime Situational Awareness Experimentation) she discovered issues affecting information sharing. Based on the Experimentation, she was able to see that by giving the operator's guidance and support for their work with a formalized Process, the researchers were able to support operators in this task.

Interactive Teaching of Military-Technology: A Pilot Study of Implementation

In this article, the experiences from use of the interactive learning platform CompEdu, that has been developed and used since 1997 at the Division of Heat and Power Technology at the Royal Institute of Technology, are presented. CompEdu has recently been introduced as a new tool for teaching Military-Technology at the Swedish National Defence College (SNDC). In this pilot study, interactive teaching has been tested at the initial training of junior officers at SNDC. Results from a student evaluation of the tool are presented. These results will be incorporated in future implementations of this interactive teaching method on a broader scale in Military-Technology. The students appreciated the freedom of being able to choose when and where to study the pensum and found CompEdu being an excellent tool for facilitating reviewing the chapter before an exam. An outline for future work is presented.

Examples of the Military Students' D-Level Essays in Military-Technology*

The Military Benefit with Introduction of a Digital Fire Management Support System for Precision Targeting

In the report by Major Lars Göran Rutgersson, an officer at the Artillery unit A 9 in Boden (Northern Sweden), the Military benefit in introduction of a digital (GIS based) fire management support system for precision targeting is studied. The argument is that today's conflicts often takes place among civilian populations and that combatants can range from militias to criminal gangs and that the need for precision targeting has raised. These conditions further put new demand on the military capabilities to operate in these complex environments like built up and urban areas with dense population. Rutgersson claims that there is a general trend of today's artillery units that they also must be able to act against smaller targets, represented of groups of two to four persons. Experiences from conflicts like those in Iraq and Afghanistan have demonstrated the need for the abilities of precision fire in order to avoid casualties among the civilians and to reduce the risk of collateral damage. A prerequisite for the implementation of precision fire is that the target position can be determined with a very high accuracy.

With help of a digital fire management support systems containing a three-dimensional digital map linked to the FOI (Fire Observation Instrument), the

* The essays can be found and downloaded from DiVA (the Digital Scientific Archive) at <http://fhs.diva-portal.org/smash/search.jsf> (in Swedish, with a summary in English).

target location error for the target in an urban environment can be reduced significantly. He also shows through two experiments that it is possible to get precision coordinates for a target with help of the GIS and the 3D map regardless availability of GPS signal and support! If the 3D map is provided in advance, it is possible to pick up the coordinates for these positions directly in the map database with a precision of less than few meters.

It was also shown that the target could be examined with much higher accuracy as it was possible to move around in the map and look at the surrounding area identifying both pros and cones in deciding if the target was possible to defeat or not.

The time aspect was also stressed, as experiences shows that the time window from detection to possibility to combat a target only is about 5–10 minutes. If you are not able to act within this time frame, you will be in the risk situation of being a target yourself. The possibility to update blue forces in almost real time in the Information System was also mentioned as a benefit for avoiding fratricide.

LPI-Radar – Gain or Pain?

In this report, Lieutenant Commander Torbjörn Lundströmer from the 4th Naval Warfare Flotilla brings up the questions about implementation and use of LPI (Low Probability of Intercept) Radar. The study has as its goal to investigate the Military Benefits when using LPI-radar compared to other technologies like FMCW (Frequency Modulated Continuous-wave) radar, Radar Electronic Support Measures (ESM) systems and taking counter measures as Stealth technology etc. All these are also compared with different tactical behaviour that can support or work counter to the technology in itself. A short historical background is given, pointing to the present situation where the technology is developed in a way that contemporary Radar systems are very hard to detect by an opponent's electronic support measurement systems. Through some scenarios in the naval domain, is shown some tactical benefits a user of low probability intercept radar may have. The analysis indicates that until electronic support measurement systems with the ability to detect radar systems using low output power are available, it is still possible to gain tactical advantages with present systems.

Fuel Cells in Military Units

Major Jan Ohlson from Air Defence unit 6 have studied the use of different technologies for production of electric power. As electricity is a central utility

for all modern activities, including defence, the methods for provision of this service is crucial for the possibility to act and sustain.

In the Armed Forces many units are provided with electricity from generators. It is now technically possible to replace noisy and vibrating generators that are presently used with more quiet fuel cells. As a bonus, we obtain better ergonomics for those working in units powered by generators. This report describes the function of different types of fuel cells, what fuels they use and how they can be transported. Furthermore it shows how two generators are used, what improvements can be achieved and what negative effects that could be the result when switching to fuel cells. Important factors are to what extent existing fuels systems can be used or if an additions supply chain of for example hydrogen is necessary to operate the fuel cells. On the other hand can a lot of the present water supply to the military units be replaced as the process in the fuel cell results in quite a lot of water that can be used for different purposes! Finally the military benefit of retrofitting is analyzed as we also can gain less noisy and less easily detected units and several logistical advantages. Some of those extra benefits are related to the climate where the fuel cells are supposed to work so the analysis must be extended to the tasks and conditions involved.

A Warship Is Not an Armed Merchant Ship

In this study, Lieutenant Commander Jon Wikingsson from the 3th Naval Warfare Flotilla deal with the development of requirements within the process of production of naval vessels, exemplified by a configuration solution of the bridge. Today many civilian rules are applied that not fully take the military use and situations into account. The aim in the report was to suggest new demands to the process of production in order to create the best conditions on configuration solutions of naval vessels in order to ensure the combat at sea, deal with damage caused by the combat and at the same time satisfy the safety demands of the crew.

From acquired knowledge of the process of production, human factors, the combat at sea, the safety of the crew and a standard of combat survivability, an analysis is conducted of a configuration solution of an existing bridge, before the damage occurs and after received damage caused by combat.

Thereafter the configuration solution of the bridge is developed and a renewed analysis is conducted in a corresponding way. The result is presented as a number of demands that ought to be added to the requirement list related to the process of production in accordance with the given aim of the thesis.

Surface Vessels Protection Against Penetration from Small Arm Fire

Lieutenant Commander Jonas Westin from the 3th Naval Warfare Flotilla studied the protection against penetration from small arm fires on surface vessels. In the report, it is discussed to what extent simplified penetration calculations of small-calibre projectiles is a useful tool for assessing the physical protection capability. The work should be seen as an attempt to create an accessible tool in the form of a simplified equation that allows for a better and safer use of the naval vessels. The tool will also be used at different levels so that decisions and instructions could be clearer.

Performed calculations show a very limited capacity of a ship's basic design in terms of physical protection against the use of small-calibre projectiles. How do we know that the calculations are correct? By verifying the calculations with practical shooting tests, a substantial condition to answer the question will be created. To shoot against a material with two different thicknesses estimated to produce perforation and non-perforation is a good approximation of the equation's usability in the context.

Summary

Military-Technology is both natural and social sciences. This dichotomy can be seen as problematic or strength, but it is necessary to cover the research questions in the research field, i.e. technology for military purposes. When it comes to military technology, studies are often based on engineering and science. When we, however, approach the interaction between technology and military operations, social science and other disciplines should be important elements in the studies, including knowledge of people and organizations. Scientific knowledge is never the "truth" but depending on our present knowledge, the focus and the theoretical framework in which the studies are made.

As Military-Technology can be regarded as both natural and social science, the same phenomena must be viewed from different perspectives. For example, a command and control management system and its functions can be studied from an engineering perspective, but also from a social science point of view. The scientific perspective (or paradigm to use) will then control the language, study methodology and results.

The theoretical framework also affects the choice of method to study the subject. In operation research, it is crucial for example to determine what factors should be studied and how to collect empirical data on these factors. This can be done through own experiments or tests, or by studies of documents relating to various systems' performance. Should we add questions about usability, ease of use and perception of a system, a survey can be appropriate (which is a

common social science method). Then you as an author have to be able to handle the responses correctly and draw the relevant conclusions of these.

In these last presented essays, literature studies on secondary sources are predominant. This is not strange as military equipment is not only expensive but it might also be dangerous to experiment with it. Often real data about performance are classified and impossible to present. In spite of these conditions, these reports are a contribution to the knowledge within the discipline in a significantly way. Many of the topics were furthermore given by representatives from the different services at the military HQ and other duties. This shows the relevance of the studied questions. The results have also been presented to prospective users to test the relevance of the suggested solutions. The results will further contribute to the training at the Swedish Defence University College by giving examples of well performed studies.

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