The Military Utility Assessment Method for Future Technologies

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Abstract

The purpose of this report is to describe the Swedish Defence University (SEDU) Military Utility Assessment Method for Future Technologies (MUAFT). The report describes the actions taken in each step of the process and ends with references and a template for the technology memos used as basis for assessment.

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1 Introduction

The purpose of this report is to describe the Swedish Defence University (SEDU) Military Utility Assessment Method for Future Technologies (MUAFT).

In 2011 the Swedish procurement agency (FMV) requested SEDU to contribute to the annual Technology Forecast (TF). Technology Forecast has traditionally been used in Swedish defence context to label activities in the literature often referred to as technology watch, i.e. exploring development within technology areas of importance for defence research activities (Kindvall *et al.*, 2017).

For the 2011 issue of the TF report part of the staff at SEDU, researchers and officers teaching the use of military technology, were asked to give their view on how some technologies reported in prior issues were likely to affect the officers´ profession in a 2030 perspective (Andersson, 2011). The work was performed in a series of seminars discussing each technology's relation to the Elements of Combat Power[1] and determining whether the technologies were likely to become disruptive. The most important conclusions were drawn from discussions contrasting mechanisms reported by Hundley (1999), for how to bring about a successful revolution in military affairs, to those reported by Lorber (2002). In summary, the identification of fertile technologies in the TF is a necessary, but only, a first step on a long, uncertain, often expensive, path to increase the military utility of materiel (SEDU, 2011). Before taking that path it therefore seemed rational to recommend first exploring the potential consequences to the military capability of interest seen as a whole – and not to make assessments based purely on potential technical performance. The following year FMV consequently asked SEDU to assess the military utility of a set of technologies that had been reviewed by research agencies (Andersson, 2012). These assessments were included in the final TF report and corresponding assessments have been part of the process since then.

However, the demands to be met by MUAFT has evolved over time. The initial inspiration came from Disruptive Technology Assessment Games, DTAG, developed by NATO and later by NORDEFCO (Kindvall, 2013; Kindvall *et al.*, 2017, chap. 6.1.6). From the outset the concept of military utility has been central. Since 2015 the working group conducting the assessments at SEDU has used the following definition:

> "Military Utility is a function of three situational variables: the Element of Interest (EoI), the Military Actor and the Context. The concept has three dimensions. The *Military Effectiveness* dimension is a measure of the overall ability to accomplish a mission when the EoI is used by representative personnel in the environment planned or expected for operational employment of the military force. The *Military Suitability* dimension is the degree to which an EoI can be satisfactorily placed in military use in a specified context with consideration to interaction with other elements of the capability system. The *Affordability* dimension is a measure of compliance to the maximum resources a military

[1] Intelligence, Mobility, Effect, Protection, Sustainability, Command and Control (in Swedish doctrine).

actor has allocated to the EoI in a time frame defined by the context." (Andersson *et al.*, 2014, p. 31)

This report describes the actions taken in each step of the process and ends with references and a template for the technology memos used as basis for assessment.

2 The method

2.1 The context and constraints

The Swedish Technology Forecast process starts one year before the assessment of military utility of future technologies is to be performed. An expert group from the Swedish Armed Forces (SwAF) R&D department and the Swedish procurement agency (FMV) R&D management select interesting technologies to be further investigated. From a comprehensive catalogue of scientific reports from the Fraunhofer Institute in Germany, a number of scientific reports are selected and English translations of these reports are ordered. At the same time, reports from ongoing Horizon scanning activities at the Swedish Defence Research Agency (FOI) are ordered. The following year, the year for assessment, reports from selected research institutes are distributed by FMV to the assessment group at SEDU. An assessment of the military utility of the technologies described in the scientific reports is ordered.

Given the background, the context and a limited budget two major requirements on the MUAFT method emerge. It has to:

1. include assessments of consequences to the military capability of interest seen as a whole, and
2. perform cost-efficient assessments.

Consequently, the assessment group has to be large enough to represent necessary perspectives to assess a spectrum of military capabilities, and small enough to fit the budget. Since technology is the force for change in focus, and, since it is underpinning military capabilities, it is especially important that the members together represent both a broad scientific, technological and military competence base.

2.2 Phase 1 Preparation

Each input report is expected to include an estimate of the present state and a prediction of the future state of the technology in focus, in the timeframe set by the TF-process. The technologies can then play the parts of forces for change acting on military capabilities.

Each report is assigned to the member of the assessment group having the best match in expertise and interest for the technology in focus. He or she reviews the report and takes on the role of being an advocate, promoting the use of that technology. The report is basically held for true, otherwise the task of the assessment team would slip into reviewing the work of the research institute.

On the basis of the report the advocate of the technology designs an idea of a technical system (or several) exploiting the new technology, and puts it in one or two credible future military scenarios. The systems and the scenarios are chosen in such a way that the benefits of the technology becomes evident. The scenario indirectly defines the military capabilities of interest. Inspiration to this approach was found in the DTAG use of *Ideas of Systems Cards* (IoS) and *Vignettes*, respectively (Kindvall, 2013; Kindvall *et al.*, 2017, chap. 6.1.6).

The advocate of the technology then prepares a memo as basis for discussion in an upcoming seminar. The memo (See the template in the appendix) should include:

1. A summary of the technology's present and predicted states, including its possibilities and constraints. A generally accepted way to present predictions on future technologies in a defined timeframe it is to use the Technology Readiness Level (TRL) concept (Mankins, 1995).
2. Assumptions made that support the future scenario. These usually centre on the development of the technology but can also include assumptions regarding other forces for change.
3. A presentation of the future scenario/-s, based on the assumptions above.
4. A first iteration for a SWOT analysis regarding the use of the technology in the assigned scenario(s).
5. A preliminary assessment regarding the technology's contribution to military effectiveness, or impact on capabilities, of the military actor in focus.
6. A preliminary assessment regarding the technology's impact on military suitability and on affordability. The assessment is structured using DOTPMFLI to cluster short statements about the footprint of the technology on military capabilities illustrated in the scenario (as compared to a non-specified extrapolated state).
7. A preliminary assessment regarding the aggregated future military utility of the technology in focus.

In the continued presentation of the assessment method we will use the *3-D printing technology* as an illustrative example. It was assessed as a supporting technology in *military mobile facilities for spare part production* (Silfverskiöld *et al.*, 2015).

2.3 Phase 2 The seminar

Each technology in focus is discussed in a seminar. In due time before the seminar the memo prepared by the advocate for the technology in focus is distributed to the assessment group so that all members are well prepared for the seminar.

At the seminar the underlying scientific report describing the technology is briefly introduced. The advocate for the technology presents the idea of a technical system, it's identified possibilities and constraints, and the assumptions that have been made. The suggested military use and the concept scenario are presented and then discussed in pleno. The advocate promotes the use of the new technology in the scenario. The other participants' roles are foremost to criticize based on the contents of the memo and on their individual knowledge and experience.

After an initial discussion the advocate and the critics together modify the technical system and the scenario to versions agreeable to the assessment group as a whole. The idea is to sculpt a credible forecast of a military scenario, exploiting the potential in the technology in focus, with efficient use of the knowledge and experience present in the seminar.

Next, the use of the technical system in the specified military scenario, including the use of the technology in focus, is analyzed in four steps.

Step 1 – SWOT-analysis

SWOT-analysis is a tool often used in business contexts (See for example (Blokdyk, 2019)). It was originally developed by Albert Humphrey. The purpose in this context is to identify *Strengths*, *Weaknesses*, *Opportunities* and *Threats* from using the technical system in the scenario, to be used as basis for continued assessment. Strengths and weaknesses are internal and inherent attributes of the technical system while opportunities and threats are external attributes of the operational environment. Strengths and opportunities are helpful to achieving the military objectives while weaknesses and threats are harmful to the mission accomplishment. As an example, these statements have been excerpted from the 3-D printing SWOT:

> *"(S): Spare parts can be manufactured locally on a national scale or in theatre within an international expeditionary task force… (W): Difficulties achieving consistent quality, testing procedures etc… (O): New concepts for reducing maintenance costs… (T): Low quality products finding their way into the supply chain…"* (Silfverskiöld *et al.*, 2015)

Step 2 – Assessment of capability impact

The purpose of the second step is in essence to create basis for assessing the military effectiveness dimension of military utility (Andersson *et al.*, 2014).

In the 2012 and 2013 forecasts the capability impact on all warfighting capabilities (DoD, 2008) in the SwAF Traceability model (SwAF, 2011) were assessed. In 2014 the work required to do assessments on several similar warfighting capabilities was found not to be effective use of resources. Since then the impact of the technology is instead assessed relative to the *Elements of Combat Power* in Swedish doctrine: Effect, Mobility, Sustainability, Command and Control, Protection, and, Intelligence and Information (Försvarsmakten, 2016, p. 61). This is also in agreement with the corresponding analysis in DTAG concerning the impact on "Combat Functions" (Kindvall, 2013, chap. 6). Thus, in the 3-D printing example the technology was simply assessed to have its greatest impact on sustainability.

> *"The impact is assessed to be great on maintenance and logistics, increasing the availability of platforms in all services."* (Silfverskiöld *et al.*, 2015)

In DTAG there are several grades to express the scale of impact (Kindvall, 2013, chap. 6).

Step 3 – Assessment of footprint

The purpose of the third step is instead to create basis for assessing the military suitability and affordability dimensions of military utility. "Footprint" should be understood in the wider sense established lately, when for example discussing the carbon dioxide footprint. Hence, here it denotes the influence on other components in the capability system.

The assessment results in a compilation of anticipated footprints, created by the use of the technology in the scenario, structured according to DOTPMLFI (NATO, 2019). See Table 1 for the 3D-printing example.

Table 1 Footprints from the 3D-printing technology assessed in the technology Forecast 2015.

Influencing factor	**Footprint**
Doctrine	An overview of logistic concepts will be necessary.
Organization	Could have great impact on logistic organization due to reduced transports and new manufacturing activities in theater.
Training	A new logistic concept and new organization might render new demands for education and training; especially for personnel in units potentially isolated and having other primary tasks.
Personnel	New professions, a new logistic concept and new organization might render new demands for education and training.
Materiel	3D-printers are new materiel systems for the military organization. Manufacturing could cause health risks.
Facilities	Facilities for maintenance of 3D-printers needed. Different needs for storage of spare parts. Limited variety of items needed. More build material required. Production facilities using 3D-printing have to be modified to reduce health hazards.
Leadership	-
Interoperability	Development of common standards for quality assessment and testing 3D-printed products required.

Step 4 Assessment of the need for military R&D

The purpose of the fourth step is to assess efforts needed from the armed force´s R&D - should they wish to facilitate the introduction of the technology into service. The assessment group typically suggests monitoring civilian technology development, or if they find that the development is militarily driven, to initiate R&D projects funded by the Armed Forces. In the 3D printing example the suggestion was:

> *Development is "mainly driven by civilian sector. Military R&D should focus on feasibility and logistic concept studies."* (Silfverskiöld *et al.*, 2015)

2.4 Phase 3 Conclusions on military utility and recommendations

The result of the seminars is documented and distributed to the members of the assessment group, in preparation for the final phase in the MUAFT.

In a final seminar the assessment group is gathered to formulate a conclusion on the assessment of the military utility of each future technology in focus. Consensus is sought using a variant of the Delphi method (Jaiswal, 1997, pp. 213–215). If consensus cannot be reached this is reflected in the uncertainty associated with the assessment.

The conclusion regarding the future military utility of the technology is formulated using one of four statements: significant, moderate, uncertain or negligible. It is considered *uncertain* if the assessment group as a whole has difficulties to decide on any of the other value statements. It is *significant* if the technology is assessed to make significant contributions to enhancing the military actor´s in focus military capabilities, or if it is considered potentially disruptive. It is *negligible* if no increase in military effectiveness can be foreseen, or if either the cost or the mismatch in military suitability is anticipated too great. Finally, the military utility is considered *moderate* if it is neither significant nor negligible. The moderate statement was introduced in 2016 in order not to intermingle these technologies with those of uncertain military utility. Using these four statements the technologies will be sorted into three categories of recommendation. The military actor is typically recommended to exploit the technologies with significant contributions to its military capabilities, to monitor the development of technologies with moderate or uncertain impact, and finally not to invest in technologies with negligible impact. In the 3D printing example the final assessment stated:

> *"In summary, our overall assessment is that 3D printing has significant potential for military utility, possibly disruptive. Logistic concepts for both national and expeditionary missions will be affected in the 2040 time frame. This technology development will be driven by the civilian industry, however, a SwAF in-depth study is recommended as it could help to form potential logistic concepts, and determine what methods and systems are suitable for military adoption, as well as what kind of application-specific issues have to be addressed in order to fully exploit the new technology."* (Silfverskiöld *et al.*, 2015)

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<Technology in focus> (memo template)

Ref: [Reference to the reviewed report], Referee: <NN>
Interview: <NN, researcher, FOI>

Introduction

<A summary on the technology's in focus present and predicted states. The description should relate to TRL assessments. The assessments made in the reviewed report are held for true.>

Identified possibilities and constraints

<A summary on the technology's in focus possibilities and constraints. The assessments made in the reviewed report are held for true.>

Suggested military use

The following military use for <technology in focus> are suggested in the reviewed report:

- <A listing of suggestions from the reviewed report>

Assumptions

The concept scenarios are based on the following assumptions:

- <Assumption necessary to support the scenario described later, regarding maturity of underpinning technologies or other developments in society>
- <Next assumption>
- …

Concept systems and scenarios in 20<XX>

Concept system 1 <name of concept system>

<A suitable description of a concept system exploiting the technology in focus>

Scenario 1 <name of scenario 1>

<A suitable description of a scenario describing beneficial use of the technology in focus, either from your military actors perspective or from a potential adversary perspective. Ideally the scenario includes a description of a challenging military situation on suitable command level and an operational environment.>

Concept system 2 <name of concept system 2>

<A suitable description of a second concept system exploiting the technology in focus>

Scenario 2 <ZZ>

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SE-651 80 Karlstad
Visiting address: Våxnäsgatan 10, Karolinen
Phone +46 8 553 42 500, Fax +46 8 553 42 598

<Another scenario describing other aspects of the technology in focus>

SWOT-analysis

The following strengths, weaknesses, opportunities and threats with <the concept for a technical system in the YY> scenario were identified at the seminar:

Strengths: • …	Weaknesses: • …
Opportunities: • …	Threats: …

The following strengths, weaknesses, opportunities and threats with <the concept for a technical system in the ZZ> scenario were identified at the seminar:

Strengths: • …	Weaknesses: • …
Opportunities: • …	Threats: …

Assessment of capability impact

<Describe the impact the technology is likely to have on your military actor´s capabilities. Focus on the military effectiveness dimension, that is which capabilities will benefit and why. Use the Elements of Combat Power in Swedish doctrine as framework (*basförmågorna* in Swedish): Effect, Mobility, Sustainability, Command and Control, Protection, and, Intelligence and Information.>

Assessment of footprint

The following list is a compilation of anticipated footprints on capability development if the technology in focus is to be used as described.

Influencing factor	**Footprint**
Doctrine	<Ex. An overview of logistic concepts will be necessary…>
Organization	<Ex. Could have great impact on logistic organization due to …>
Training	<Ex. A new organization might render …>
Personnel	<Ex. …will render new demands for education and training. …>
Materiel	<Ex. ... manufacturing could cause health risks …>

Facilities	<Ex. …facilities … have to be modified to reduce health hazards.>
Leadership	<Ex. …will require change management to…>
Interoperability	<Ex. common standards for quality assessment and test required. …>

Assessment of the need for military R&D

< The assessment group´s view on actions needed from the Armed Force´s R&D - should they wish to facilitate the introduction of the technology into service. >

Conclusions on military utility and recommendations

<The final discussion of the assessment group is documented and the military utility of the future technology is assessed significant, moderate, negligible or uncertain. The discussion is followed by a recommendation to R&D policymakers>