Assessment of Potentially Disruptive Technologies for Defence and Security

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Technological developments are a key driver in NATO's future force planning. Technology watch, assessment and foresight are therefore activities that are vital to all NATO partners. NATO partners undertake research and share knowledge on a multitude of system applications, systems technologies and enabling technologies What is not so commonly performed is the integration of applications and technologies at an early stage to construct a view across the whole spectrum of technology developments relevant for defence, including the impact they may have on the military as a whole. This step requires cooperation and common understanding between scientists and military staff to get both good insights into technological possibilities and into military requirements.

The NATO-RTO SAS panel soubgroup 062 was therefore established to develop a methodology to assess technologies that might have a disruptive effect on defence and security. This foresight methodology combines elements of creativity, evidence, interaction, prognosis, and evaluation. The level of detail is above simple intuition and below war gaming. It has proved to be a cost-effective approach to aid decision-makers with respect to the systems and to the underpinning technologies worth investing in the time frame of 2020 and beyond.

Introduction

The term "Disruptive Technology" was introduced in the context of innovations in the business world based upon technological developments. It was meant to sharpen the view for new technologies which can disrupt the economic context of a business, ultimately leading to the breakdown of major companies. An example is the digital capture of pictures, which has drastically changed the situation for the camera and photo-finishing industry. The term "Disruptive Technologies" has also inspired other communities. One of these is the domain of international Research & Technology (R&T) cooperation and technological forecasting for public defence and security planning where it has gained a somewhat different meaning.

In this context, a “Disruptive Technology” stands for a technological development which changes the conduct of operations (including the rules of engagement) significantly within a short period of time and thus alters the long-term goals for concepts, strategy, and planning. Disruptive military technologies of the past are for example the nuclear weapon, radar-stealth technology or precision-guided munitions. Even early nuclear weapons had a yield that was about four orders of magnitude higher than the yield of bombs with chemical explosives. This technology enabled mutual destruction of opponents, made war highly irrational and resulted in the “Cold War” state of politics. Low radar observability, so-called stealth, has offered significantly better survivability for aircraft in hostile air defence, and has enabled air campaigns like in the Iraq wars. Precision-guided munitions with their significantly lower CEP (circular error probable) have reduced the number of munitions to destroy a target and the probability of collateral damage at the same time.

Approach

The question of how to identify the possible disruptiveness of technologies for defence and security is challenging. The standard bottom-up approach is intuitive “hunting and gathering”, based on the monitoring of technological developments. The second option is a top-down approach, where possibly disruptive capabilities are identified and analysed for their corresponding enabling (and therefore possibly disruptive) technologies. These pathways are typically chosen for national foresight activities. But they can at best identify “candidates” and a content-oriented analysis of disruptiveness has to be conducted to come to helpful conclusions and recommendations for decision makers.

Over a period of 3 years the NATO-SAS soubgroup 062 team has developed a promising methodology that has been tested several times. The first step as mentioned above was the identification of interesting technologies, performed by the participating nations, mainly based on evidence (e.g. literature scanning) and expertise methods (using skill and knowledge of experts). The relevant information about these technologies was then brought together, consolidated and given a common two-page format, known as the Technology Card or T-Card. These T-Cards contain information about the technology, its possible applications, readiness, drivers/actors and relevance for defence (see Fig. 1).

In a second, creative step a number of higher level “Ideas of System” were generated based on the identified technologies. The rationale behind this was that it is impossible to directly assess the impact of technologies but rather of the systems and capabilities that they enable. Although several of these systems were merely theoretical, they were considered feasible within the timeframe being considered. The “Ideas of System” were also put into a common three-page format. The second and third page of these so-called IoS-Cards contain detailed information about operational interest, performance, capabilities, underlying technologies, affordability and training requirements. The first page gives a brief description of the system, which is sufficient for the gaming step (see Fig. 2).

SAS TG-062 "Assessment of Technologies with a disruptive effect on Defence and Security" — **T- 021**

Technology Name: Walking Machines

Land	*X*	*Urban*	*X*
Navy		*Asymmetric*	
Air			

1. Which capability does the technology enable?

This technology could enable a significantly better mission performance esp. in urban terrain for ground troops. Systems based on it could carry mission equipment for the soldier or perform acquisition but also fighting missions. As it cannot be excluded that the human capability to move in all kinds of environment can be realized by an (in this sense autonomous) accompanying walking robot a significant disruptive effect seems possible. New application scenarios seem possible in the military and security (police) domains like riot control (psychological aspects), guard missions, swarm missions (a person accompanied by many robots) etc.

2. Operational limits of the enabled capability

It should be possible to realize a robot able to carry up to 50kg of payload for a reasonably long mission.

Source: TU München

3. Readiness of the technology

Actor systems in industrial robot applications are available with a very high degree of maturity (and a high price) for heavy duty systems. For systems building on these components the power supply for a mobile machine would be a major problem. There is a spectrum of options like artificial muscles but they are in an early stage and it is hard to assess the technological potential.

The "leg"-movement control has the "trivial" technical aspect of how to move it once one knows what movement (of the single leg) is needed. This in principle is solved. The more demanding aspect is the "artificial intelligence" problem of how to move the whole system autonomously in an unknown territory from A to B or to follow a soldier (a remote control of the basic leg movement would not make sense). This is in a status of dynamic, creative, playful and funny experimentation. The "final" challenge is autonomy to fulfil a task. This is basic research.

In 10 – 15 years a simple "beast of burden" function in moderately difficult terrain seems possible)

4. Hazards

The basic vulnerability would very much be the same of a soldier. On the other hand a great variety of systems may be possible ranging from very small and cheap (for acquisition missions) to rather big and heavily armored systems. Specialized varieties may also be possible to reduce vulnerability (very fast, very flat, …).

The typical scenario probably would be "asymmetric". A "professional" version is probably not a cheap solution. It seems not likely that an asymmetric enemy can make use of it. If "robot servants" and semi-professional toy systems become a reality in civilian applications the situation may change (e.g. for "suicide bombing" missions).

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5. Technology description

Two- or multi-leg walking machines have become an option since the industrial robots have "solved" the problem of realizing "legs or arms". The most important "first to solve" technological capability for all kinds of higher level "system/mission capabilities" is the problem of data/information processing for movement control in all kinds of terrain. There are several ways to realize "actor components" like legs but the critical technology is the intelligent software enabling "cross-country" or "urban" mobility. Another problem not yet solved is the power supply.

6. Drivers / actors

There is a very active civilian research community (RoboCup) and within the military and security scene there is a high interest for this technology's potential. Because of the high dynamics new and surprising developments are possible and may be expected.

7. Applications / Use

The technology is not yet in service (except some woodwork machines, controlled by driver but with some autonomous resp. semiautomatic functions), applications anticipated for:

- service robots
- rescue systems
- agriculture applications
- acquisition systems (?)
- security systems

8. Defence Relevance

In the long run no substantial obstacle seems to exist, to realize e.g. a dog-size (great dane) accompanying walking robot carrying a payload of perhaps 50 kg for several sortie hours, running on battery or (more likely) powered by some sort of fuel and able to move in the same terrain and with the same speed like a soldier on a mission. It is possible that it can perform with significantly higher speed than the soldier providing new options for action. Such a system could be a carrier in a broad spectrum of missions:

- simple "beast of burden" for infantry missions in difficult (including urban) terrain, "just" following the soldier and carrying mission equipment
- acquisition for the soldier e.g. in urban terrain
- "manipulation" mission in dangerous situation (opening doors, deactivation of bombs)
- "armed" remotely controlled mission
- "high speed" missions to be non-lethal e.g. in a riot control situation
- rescue mission for a person
- control of arrested persons

Fig. 1: Example for a Technology Card (Walking Machines)

SAS TG-062 "Assessment of Technologies with a disruptive effect on Defence and Security"

I - 011

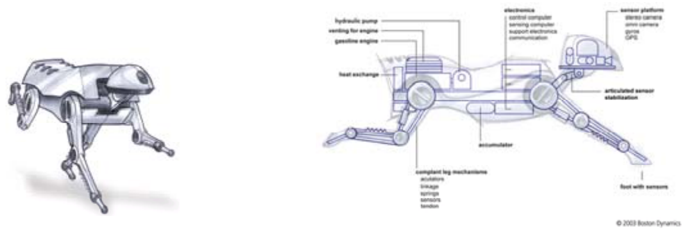
Idea of System: Personal Robot

Land	X	Urban	X
Navy		Asymmetric	X
Air			

Assumptions for the DTAG:

"Beast of burden" walking machine with four legs (big dog size)

- payload up to 50kg
- mission time before refueling several hours (with respective logistics longer)
- capable to autonomously follow the soldier through all kinds of terrain (incl. urban)
- speed: same as soldier
- autonomous actions possible (autonomous/remotely controlled acquisition or attack)



Source: Boston Dynamics

Fig. 2: Example for page one of an Idea-of-System-(IoS-)Card (Personal Robot)

The third step and core of the methodology is the so-called "Disruptive-Technology Assessment Game" (DTAG) where the potential use of the "Ideas of System" is explored in a military context, by interaction of military players, technologists and analysts. Three DTAGs were held that lasted for a week each.

Every DTAG consisted of a number of vignettes, each considering a different military task. The military tasks were set within the same NATO scenario in 2020, but were independent of each other. For the game, military players were split into two teams, Red and Blue, with each team supported by technologists, an analyst, and a military controller.

The game cycles started with a tactical situation briefing. In phase 1 the players generated their course of action (COA) using current capabilities und doctrine, enhanced with some capabilities expected to be standard in 2020. This was followed by a confrontation discussion, where all DTAG participants met and the Red and Blue teams briefed each other on their COAs. In phase two the same vignette was played but now IoS-Cards were present for the generation of the COAs. Afterwards, all DTAG participants met and the Red and Blue teams again briefed on their new COAs. Discussion was mediated and covered reasons why COA had changed (if it had), reactions to each others' plans, the main benefits (or issues) that the IoS gave over current capabilities, and any other implications (e.g. less manpower required), as well as any other new ideas of system that had arisen. This discussion was facilitated by the lead technologist and the information was captured by a scribe. Post-game information capture was achieved through structured interviews of the Red and Blue teams. This elicited more detailed information than has been discussed during the confrontation. Throughout the cycle, information was captured for later use. Each cycle took approximately one day to conduct.

The information captured from the three DTAGs was used to assess the relative disruptiveness of the technologies considered by the group. This information was collated and analysed for each IoS-Card, along with an analysis of the impact the IoS had had in the operational environments considered. Focus then moved back to the technologies which are essential to the realisation of the IoS and which may require support for R&D.

Conclusion

The different steps of this approach (identification of promising technologies, creation of Ideas of System, assessment game, and analysis with focus on planning support) represent the different characteristics by which foresight methods can be sorted (see Fig. 3). This is very desirable from a methodological point of view. The approach allowed for an element of unconstrained thinking, and the wargame-like areas created an open communication opportunity. On the other hand, by bringing technology and military experts together it could be avoided to deal with unrealistic technological or tactical conclusions.

Fig. 3: Representative foresight methods clustered according to their characteristics (Kreativitäts-Methoden = creativity, Diagnose-Methoden = evidence, Partizipative Methoden = interaction, Prognose-Methoden = prognosis, and Planend-evaluierende Methoden = evaluation), source: Birgit Weimert, priv. comm., 2009.

The Disruptive Technology Assessment Games have provided a fruitful discussion forum between technologists, analysts, and military commanders and a broad perspective due to nationality, job, experience, and background. It has indeed enhanced common understanding and has proven to be a challenging environment forcing people to think out-of-the-box. This structured assessment represents a cost-effective approach to aid decision-makers with respect to the systems and underpinning technologies worth investing in the time frame of 2020 and beyond.

Although the methodology has proven to be successful, the process has shown some limitations. The initial identification of possible technologies of interest was limited by the participating countries and their national work in the area. The security classification "NATO unclassified" limited the ability to consider more sensitive technologies. The outputs were constrained in validity to the range of situations considered by the vignettes, thus for broad applicability a broader range will have to be considered.

The first technology assessments have given us the impression that the methodology and the process stand for a robust approach that deserves extension. Therefore a follow-on activity to NATO-SAS subgroup 062 has started to continue this technology-assessment process and to further refine the methodology. While this activity has concentrated on military scenarios it is applicable to civilian security as well.

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