Defence Technologies Forecast ("Wehrtechnische Vorausschau")

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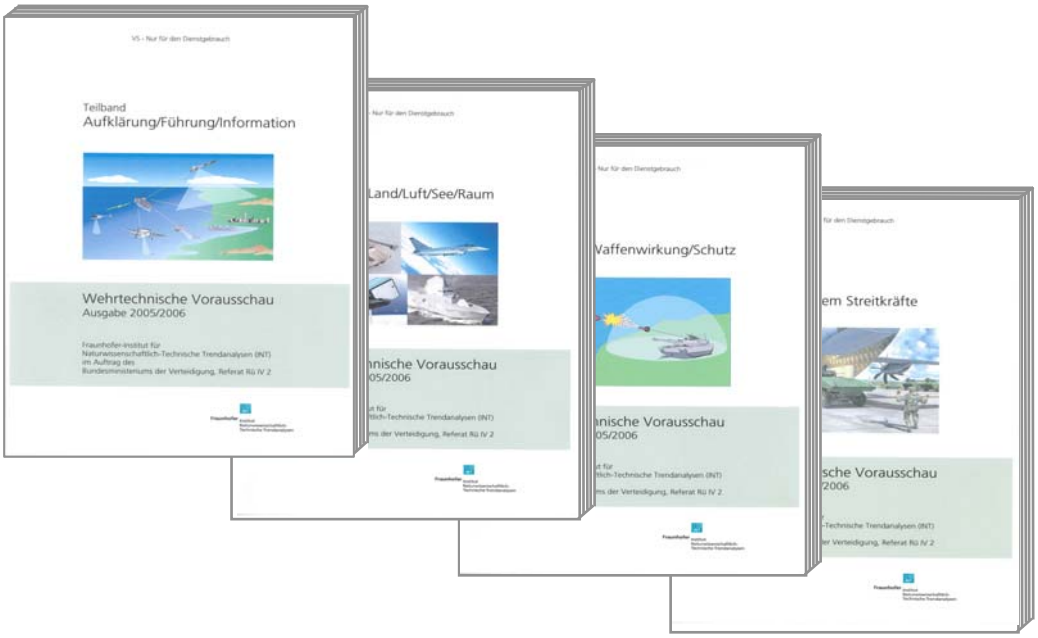
The Directorate General of Armaments of the German Federal Ministry of Defence regularly releases a document in the form of a general survey giving an overview of long-term technological developments with relevance for defence engineering. The Fraunhofer Institute for Technological Trend Analysis (INT) elaborates this "Wehrtechnische Vorausschau" (WTV; Defence Technologies Forecast) by evaluating a large number of national and international sources. The WTV is dedicated for planners in defence technology, the armed forces, and security politics.

The current issue of the WTV report consists of four volumes, each of them dealing with a certain aspect of defence engineering:

I) Reconnaissance / Command & Control / Information ("C4ISR")
II) Land/Air/Sea/Space Systems
III) Weapons / Effects / Protection
IV) Joint System of Armed Forces



In the following, we give some information both about the general conditions for our work and about our results, represented by the main technological trends in defence engineering.

1. Introduction

The past two decades have seen profound changes in the coordinates of security politics. Since the breakdown of the communist block, requirements to the military have altered drastically and can be worse and worse foreseen. This rapid change, the beginning of which has been coined "revolution in military affairs" but which is now an ongoing but rapid evolution, has forced western forces towards a paradigm shift from long-term planning to a continuous adaption process called transformation. Persistent transformation of military processes and equipment is not only demanded by the framework of security politics but just as much by the rapid development of modern technology, esp. in the civilian sector. Therefore a continuous monitoring and analysis of science and technology is essential to a modern R&T planning process.

To support such an R&T planning process, the Defence Technologies Forecast document has to meet the following requirements: It must give a comprehensive overview to ensure an early warning about novel emerging technologies. And it must be as readable and compact as is possible to retain the necessary information depth.

There are two principle motors of progress in defence engineering. On the one hand there is the "pull" of capability demands set up by the military, on the other hand the technological dynamics in general "pushes" new and novel applications.

2. The Fraunhofer INT Approach

To account for the "technology push" Fraunhofer-INT conducts synoptic as well as in-depth technology analyses, based on systematic scanning and monitoring process and exploiting a wide information base. Technology of the future usually starts in the basic-research laboratory. That is why we monitor both basic research and technology development, including current developments in defence engineering. For many years we have systematically and continually evaluated the most important sources of relevant information:

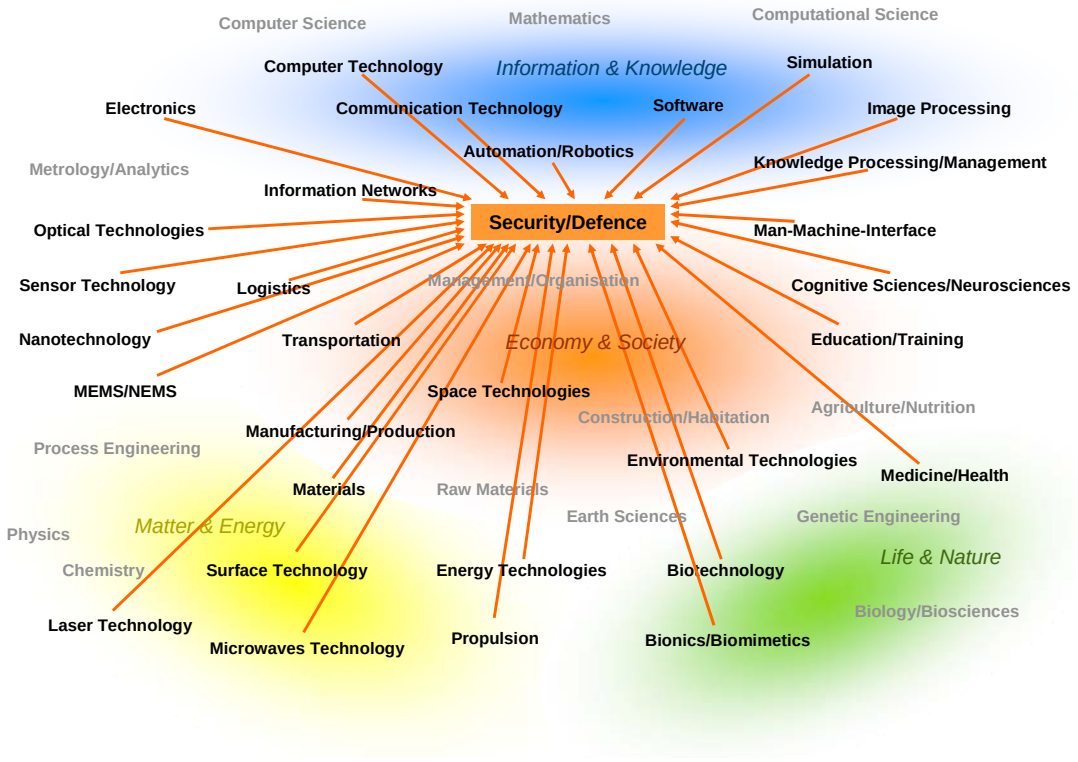
- Publications in technological and scientific review journals
- Reports of state-run and state-aided research institutions at home and abroad

- Periodicals and annual reports of companies and institutions with a high research and development profile
- Structured surveys of experts from industry and research
- Short reports of professionals completed on our account
- Retrieval in national and international data bases and in the internet
- Private communication at selected conferences

Moreover, a network of external experts has been established over the last few years, people on whom we might refer to, if very specific questions have to be answered.

To incorporate the "capability requirements pull" view into the study, the basic developments of the transformation of the Bundeswehr have to be taken note of. This is done by analysing basic documents like the Bundeswehr conception (Konzeption der Bundeswehr, KdB), maintaining permanent discussions with military planners, active participation at workshops of the Bundeswehr Transformation Centre (ZTransfBw), and by participation in the NATO disruptive-technologies assessment process (see poster "Assessment of Potentially Disruptive Technologies for Defence and Security"). All this helps us to develop a deeper understanding of the requirements on military technology. It is reflected e.g. in an explicit chapter on the technological aspects of transformation.

To elaborate the Defence Technologies Forecast report ("Wehrtechnische Vorausschau") all the information gathered about trends in militarily significant technological areas is analysed to form a comprehensive picture of the technological future. This knowledge is then pro-



jected onto the field of Security and Defence as a whole (cf. figure).

3. Results – Main Trends in Defence Technology

After the end of the Cold War, the basic security environment has changed, and so have the demands on the capabilities of armed forces. Nowadays, the so-called peacemaking and peacekeeping operations, some of which are carried out far away from the respective home country, are an essential task of armed forces. As a result, large mass military forces, which are equipped mainly with heavy battle tanks, are less in demand today than highly protected special units, which can move quickly even across major distances. That is reflected by the development in the field of weapons and military systems.

In addition, there are many technological developments that will change the equipment of our forces in terms of a "technology push". This development is accompanied by an increasing intertwining of technologies that can be used in the civilian and military sectors. In this context, the civilian sector is increasingly taking the lead. This is mainly due to the economic importance of information and communication technologies.

Our Defence Technologies Forecast WTV deals with all observable technological trends in the whole area of defence engineering. Taking all the special aspects into account, the following general trends can be identified:

- Informational dominance increasingly important

The information factor and related technologies to collect, transmit and process data is becoming more and more dominant, also in the military sector. This leads to new threats and types of conflict that are referred to as information operations. Technological development in this area is very much characterized by civil information and communication technology and by the area directly tied to it, namely digitalisation of all information.

The development in the field of communications media ultimately results in any information being available at any place and any time. At last this will allow for an overall networking of sensors, command and control, and weapon systems. This concept intended to increase the performance of armed forces is referred to as network-centric warfare.

- Increasingly smart and automatic procedures

The increasing availability of smart systems as well as substantial increases in the performance of sensors and navigation systems facilitate a far more efficient use of weapons.

The entire field of protection is also increasingly characterized by automated or intelligent procedures. The increasing use of so-called standoff weapons, in particular of guided missiles, is important for the protection of one's own soldiers as well. They reduce one's own risk by avoiding direct force-on-force situations, because they allow engaging point targets from a distance.

- More and more unmanned systems deployed

There are a lot of technological developments that will increase the performance of unmanned military systems. Such systems will more and more bring forth better mission performance, effectiveness in combat, and, last but not least, personnel safety. Especially the last-mentioned aspect is the main motivation for their use in the new mission scenarios.

The most important overall trend in the field of unmanned systems is their increasing autonomy. In future they will be more and more able to perform without a human operator and manage even extensive tasks in complicated environments for quite a long time. The special problems of locomotion of unmanned ground systems might be solved by the development of proper walking machines.

- The soldier as a system

This approach, which had at first been developed in the United States, assumes that the individual soldier can also be regarded as a system that can be equipped with all the technical components needed. Initial international developments in that field focus on the infantryman's equipment. The German Bundeswehr has introduced a first system comprising an adapted radio set and satellite navigation system GPS (Global Positioning System), a PDA (Personal Digital Assistant) with a digital map as well as a digital camera. Thus, card and compass have served their time. Exchanging or adding modules can achieve future technological progress.

In this regard, supporting soldiers by mechanically operating auxiliary systems is extensively considered. So-called exoskeletons, which are meant to be put on like a suit and increase the strength in order to support mechanical bodily functions, are an example of such systems. Other considerations pertain to partly autonomous robots, which operate near the soldiers and carry heavy weights for them or may even independently transport them back to the base in case of an injury.

- Directed-energy weapons supplement conventional means of warfare

Conventional weapons have immediate mechanical or thermal effects. Directed-energy weapons like lasers or high-power microwaves are based on electromagnetic radiation, which is transformed into thermal or electric energy in the target.

Depending on the intended use of laser weapons, a distinction is made between different power classes. So-called low-energy lasers (medium output below 1 kW) can be used to cause in-band damage to sensors (e.g. to attacking guided missiles), i.e. to interfere with them within the respective sensitive wavelength range. Medium-energy lasers (medium output up to some 100 kW) are suited to destroy optical and electro-optical devices (so-called out-of-band damage). High-energy lasers feature far higher outputs in the megawatt range, and can be used to destroy (relatively light) structures, for example, on missiles. The major disadvantage of laser weapons is that the atmosphere interferes with their effectiveness. Hence, the use of lasers to destroy structures will play a role mainly in scenarios to defend against missiles within upper layers of the atmosphere or in space.

High-power microwave (HPM) weapons radiate above a wavelength of 1 mm, and so the atmosphere does not absorb their radiation. In principle, they are also ready for use today. Their microwave field couples into electric circuits, where it generates voltages and currents high enough to interfere with or destroy electronic components. There is a wide range of possible targets for high-power microwave weapons today, and it will continue to grow. It ranges from "turning off" electronically initiated mines or booby traps, which are hidden at the side of the road, to stopping enemy vehicles.

- Non-lethal weapons in favour of the principle of proportionality

Non-lethal weapons are supposed to keep in view the proportionality of means used against enemies, who are, in principle, inferior. They are meant to incapacitate persons without causing them permanent harm, if possible, or to render their equipment useless, for example by "deactivating" electronic functions with HPM weapons. Pistol-like electro-shock devices, which transmit electric pulses by firing hook-like electrodes, are an example of non-lethal weapons used already against human beings in a non-military context.

The main problem with non-lethal weapons, besides their operability, is to maintain their non-lethality in practical use. A lot of work is being carried out in this field of international research and development.

- Military outer-space operations

To date, satellites have exclusively been used for combat support, i.e. especially for reconnaissance and surveillance, communication and command, as well as for navigation and weather observation. In these functions, they are still increasing considerably in significance. Owing to this fact, outer space could on the medium to long term turn into a battlefield.

This would have strong effects on the type of technology that has to be employed for support systems in space operations. In addition to that, satellites will on the long term be applied as weapon carriers for space-to-space operations, but also e.g. for the engagement of hostile ballistic missiles.

- Increasing threat by CBRN weapons

The threat from chemical, biological, and nuclear weapons remains to be existent. New political developments but also new or easier-to-produce versions of the named weapons may even lead to an increase in threat. Radiological weapons and, due to recent developments in biotechnology and genetic engineering, novel chemical and biological weapons add to the imminence.

The development of classical nuclear weapons nowadays focuses less on pure nuclear fission and fusion weapons but rather on the so-called third- and fourth-generation weapons. Third-generation weapons are able to selectively enhance or suppress any of the destructive effects combined in a nuclear weapon's explosion, i.e. they can, for example, generate neutron radiation far above the average. Concerning their explosive power, fourth-generation nuclear weapons lie between conventional bombs and traditional nuclear weapons. Bunker busters (earth-penetrating weapons), which are said to be able to destroy bunkers buried deep underground (some 10 m, for example), are an example of that type. Because in their case the blast effect is maximised and any radioactive fallout is expected to remain buried underground, they are supposed to have a net effect much the same as a conventional bomb but with a considerably stronger blast wave.

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