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Estonia's Defence Research & Development

Lessons from the past, outlook for the future

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Abbreviations

AVT – Applied Vehicle Technology

BSC – Balanced Scorecard

C2 – Command and Control

CBRN – Chemical, Biological, Radiological and Nuclear

CCDCOE – Cooperative Cyber Defence Centre of Excellence

CD&E – Concept Development and Experimentation

CHOD – Chief of Defence

COE – Centre of Excellence

CSDP – Common Security and Defence Policy

EDA – European Defence Agency

EDF – Estonian Defence Forces

ENDC – Estonian National Defence College

ETF – *Eesti Teadusfond* (Estonian Science Foundation)

EU – European Union

HCSS – The Hague Centre for Strategic Studies

HFM – Human Factors and Medicine

HQ EDF – Headquarters of the Estonian Defence Forces

ICDS – International Centre for Defence Studies

ICT – Information and Communication Technology

IPR – Intellectual Property Right

IST – Information Systems Technology

IED – Improvised Explosive Device

JIP – Joint Investment Programme

MER – Ministry of Education and Research

MOD – Ministry of Defence

M&S – Modelling and Simulation

NATO – North Atlantic Treaty Organisation

NASA – National Aeronautical and Space Agency

NEC – Network Enabled Capabilities

NMSG – NATO Modelling and Simulation Group

NSE – Natural Sciences and Engineering

NURC – NATO Undersea Research Centre

OECD – Organisation for Economic Cooperation and Development

RC – Research Council

RE – Research Establishment

R&D – Research and Development

RD&I – Research, Development and Innovation

RDT&E – Research, Development, Testing and Evaluation

R&T – Research and Technology

RTO – Research and Technology Organisation

SAS – Systems Analysis and Study

SCI – System Concepts and Integration

SET – Sensors and Electronics Technology

SME – Subject Matter Expert

SSH – Social Sciences and Humanities

S&T – Science and Technology

TAI – *Tervise Arengu Instituut* (National Institute for Health Development)

TAKT – *Teadus- ja arendustegevuse koordinatsiooni töögrupp* (Research and Development Coordination Working Group)

T&E – Testing and Evaluation

TNO – Netherlands Organisation for Applied Scientific Research

TRL – Technology Readiness Level

TUT – Tallinn University of Technology

UAV – Unmanned Aerial Vehicle

UT – University of Tartu

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Executive summary

This report forms part of an ICDS project titled ‘Security, Strategy, Science and Technology’ (S3T) and aims to identify the conceptual and organisational challenges in Estonia’s defence R&D programme. It seeks to ascertain Estonia’s defence R&D achievements so far, thus testing the widespread perception that most of Estonia’s investments in this field have been ineffectual. The report also discusses the positive and negative aspects of ongoing reforms in defence R&D pursued by the defence organisation – the Ministry of Defence and the Estonian Defence Forces – and the prerequisites for and possible obstacles to their success.

The report uses data supplied by the MOD about Estonia’s Defence R&D Strategy and the respective decision-making structures and processes, budget allocations, project portfolio and the management thereof, plus international cooperation activities. It also draws upon a series of semi-structured interviews with civilian and military representatives of the defence organisation and members of the Estonian science and technology sector who are involved in R&D projects commissioned by the defence organisation or who serve on the MOD Research Council. These interviews made it possible to develop a thorough understanding of the situation and of stakeholder views, expectations and experiences.

A key finding of the report is that most of the outcomes of the defence R&D projects conducted until about 2009 have indeed made little or no impact on the capabilities or the performance of the defence organisation. The organisation did not have a proper strategy in this field and did not envisage how it could benefit from R&D investments. Its dominant approach was to accept most of the ‘supply push’ and to steadily increase the funding without linking it properly with defence requirements and ‘core processes’ in defence. This approach resulted in the creation of a rather random, incoherent and poorly managed project portfolio and the alienation of the main end-user – the military.

Another key finding is that the ongoing reforms, which started in 2008 with the institution of a formal Defence R&D Strategy, are placing defence interests and requirements at the centre of decision-making about R&D investments and make an attempt to connect them with capability development processes. Combined with budget pressures, this led to a reduction in the number of projects and refusals to fund them further, which alienated many members of the S&T community unwilling to accept the defence organisation’s new approach.

The Defence R&D Strategy is widely seen as a viable framework on which future efforts can be based. The new governance system that is emerging in the course of reforms is also considered to be a step in the right direction, especially in improving internal coordination in the defence organisation. However, the strategy itself does not define a clear level of ambition, expected outcomes, competence ‘niches’, criteria for R&D investments or preferences for bilateral cooperation partners. This complicates expectations management among the stakeholders. The strategy already needs to undergo a consultative and inclusive review to align it with the objectives of new national security and defence

strategies and to capture the progress made in re-thinking the central purpose of defence R&D and in identifying knowledge areas of key interest to defence.

The report identifies the following chief obstacles to the successful implementation of reforms and to ensuring a viable defence R&D programme in the future: divergent perspectives between various stakeholders on what R&D is and what its outcomes should be; a disconnect between the national R&D context and defence R&D, together with poor progress made in the development of an inter-agency approach in this field; the senior defence leadership's apparent reluctance to accept R&D investments as being of strategic importance; the absence of an effective framework for interaction and knowledge brokering between the defence organisation and the S&T community.

The end-user also suffers from a number of weaknesses, which make it difficult to implement a military requirement-centred approach: short-termism and the lack of 'business continuity'; some ill-defined 'core processes' with which R&D should be closely connected; a weak ability to define and manage its long-term knowledge and technology requirements and to derive R&D requirements from them; poor management of subject matter experts; the absence of centres of competence in its structure; an insufficient administrative capacity for running the R&D function. All this raises doubts about whether the new approach to defence R&D does not over-emphasise the need for a specific military requirement as the basis for undertaking R&D and whether the medium-term focus should rather be on strengthening the end-user's S&T awareness and competence.

The report ends with recommendations on how to improve the strategic management of defence R&D in Estonia (e.g. by introducing a Balanced Scorecard tool), how to advance the understanding of added value which R&D can create, how to better promote mutual awareness, dialogue and consensus between stakeholders, how to enhance the end-user's competence and how to improve the management of the project portfolio and individual projects.

Introduction

Since 2009, the International Centre for Defence Studies (ICDS) has been conducting research in a field where security and defence strategy intersects with science and technology (S&T). In the Estonian public policy debate, it is certainly an undeservedly overlooked and, consequently, under-researched and poorly understood area, which is rather surprising given the importance of fast developments and breakthroughs in S&T to state and society in general. It is also a dimension of strategy which, if constantly neglected, does not lend itself so easily to exploitation by fast-track policy initiatives or offer quick solutions immediately applicable to urgent operational or tactical problems in ongoing operations. This, in turn, reinforces the benign conceptual, political and practical disregard, creating a paradox, as a result of which S&T plays a marginal, if any, role in the overall security and defence strategy of a nation fashioning itself as a knowledge-based high-tech state and society.

Through our sustained research interest in S&T issues pertaining to security and defence, we hope to partially remedy the situation by incrementally increasing awareness and conceptual understanding in Estonia of the role played by S&T in national security and defence. So far, we have produced a study on the experiences of small NATO Allies in defence research and development (R&D),[1] published in November 2009. In addition, we have contributed to the EU-funded 'Crescendo' research consortium with a study on S&T implications of Estonia's national security policy in April 2010.[2] In cooperation with the Estonian Ministry of Defence (MOD) and the Estonian Academy of Sciences, we have also conducted a seminar on inter-agency approach to research and technology (R&T) strategy for defence, security and safety, which was held in September 2010 in the margins of the NATO Research and Technology Organisation's (RTO) meeting in Tallinn.[3]

These projects have helped to raise further interest of our stakeholders in better understanding the ways in which policy, strategy and organisational arrangements in the field of security and defence interact with S&T – an area of ever-growing importance to the maintenance of the security of the Alliance and the European Union. To satisfy this interest, we brought our research projects planned for 2011–2012 under a broad heading 'Security, Strategy, Science and Technology' (S3T) and we will continue building our competence in this field. Our plans include the investigation of the defence R&D collaboration potential between the Baltic states and the need for investments in dual-use technologies to support Estonia's security, safety and defence policies.

Since autumn 2010, we have been undertaking a study on Estonia's defence R&D, the results of which are presented in this paper. The purpose of the study was to critically examine Estonia's policy, organisational mechanisms, experience and achievements in defence R&D in order to provide a set of recommendations for future efforts in this field. This is the first time that such a substantive study

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[1] See Jermalavičius, T. (2009a).

[2] See www.crescendo-project.org for more information about the Crescendo Project. The ICDS study about Estonia is part of the overall project report to the European Commission, which has not been made available to the general public by the research consortium.

[3] The summary of the seminar and its presentations are available from http://www.icds.ee/index.php?id=73&L=1&tx_ttnews[tt_news]=742&tx_ttnews[backPid]=92&cHash=3cd66ef74f.

focused on defence R&D strategy and its implementation has been undertaken in Estonia. Thus it filled a certain void in the public policy debate on the issue which is far from being uncontroversial. One expert said in an interview conducted for this paper: "Defence R&D is just a tiny portion of the overall defence investments portfolio of Estonia, but it causes perhaps the most headaches to decision-makers."[4] We hope that by registering and tackling some of those underlying controversies and causes of 'headaches', we will help to re-assess Estonia's past experiences and clarify future opportunities for its defence R&D policy. Thus we expect the study to be of interest to policymakers, military practitioners, the S&T community and the general public concerned with defence issues. Hopefully, it will also serve as a useful source of knowledge for NATO and EU partners who might consider the engagement of Estonia in collaborative programmes.

In terms of sources and methodology, this is a qualitative exploratory study which relies on publicly available information about Estonia's defence R&D (e.g. published strategy, budget information, presentations of defence officials) and on the data supplied by the Estonian MOD and the Headquarters of the Estonian Defence Forces (HQ EDF) about Estonia's defence R&D governance structure and various R&D projects conducted in the period of 2001–2010. The main effort, however, was directed at soliciting the experiences and perspectives from various stakeholders at the MOD, the EDF and the S&T community by means of semi-structured interviews in order to tap into a complex layer of attitudes, opinions, grievances, ideas, interests and aspirations which often serve as powerful determinants of strategy and which shape its execution.

In total, 18 interviews lasting between 1 and 1 ½ hours were conducted: seven interviews with the representatives of the R&D user side (the MOD and the EDF, collectively referred to in this paper as the 'defence organisation'[5]) and eleven interviews with the representatives of the supply side (scientists from research establishments – universities, research institutes and centres – who were, or still are, involved in defence R&D activities related both to technological and non-technological research, collectively referred to as the 'S&T community'). In order to encourage a candid sharing of knowledge and perspectives, all interviewees were assured of non-attribution in the paper. Whenever it is appropriate and helpful for understanding or explaining the identified issues, the analysis of the results of the interviews is supplemented by more theoretical points from the literature on S&T, defence strategy and policy, organisational culture and management.

There are important limitations to the scope of the study that have to be mentioned here. The study does not encompass enterprise-financed defence R&D and the views and perspectives of private sector (industry) representatives. Industry plays an important role in the strategic success of R&D, if one defines it as the making of products based on R&D outcomes available to the end-user in a timely and cost-efficient manner. Thus the omission of this perspective from the

[4] Recently, Estonia's media has also stirred some controversy by alleging that the MOD's investments in R&D have largely been a waste of money and, with few exceptions, have failed to produce outcomes that could be employed by Estonian soldiers in operations. See Vahter (2010) and Niitra (2010).

[5] It is important to underline, however, that the MOD and the EDF do not form a single legal entity (an 'organisation' in a legal sense) and that they have a past record of complicated relations, which have aggravated the problems and complexities of managing defence R&D.

study might be conceived as having a debilitating effect on the results. However, in the course of doing research for this paper, it was discovered that the situation within and the relationship between public stakeholders – governmental and public sector R&D – were complicated enough to warrant a separate focused investigation before attempting to venture into an even more complex world of interaction between the public and private sectors. Still, we hope that the study's findings and conclusions will serve us as a basis for further research into the 'value chain' of supplying national defence with knowledge and capabilities.

The reader should not expect this paper to cover all Estonia's defence R&D projects or seek a detailed overview of the projects that were included in the research. The study concentrates on generic lessons, experiences and issues – strategic and organisational – rather than detailed accounts of how the projects progressed or what they achieved. Certainly, idiosyncrasies of some high-profile individual projects can be quite illuminating. Furthermore, in a small portfolio of projects such as that of Estonia's defence R&D, the impact of those idiosyncrasies on the overall performance of the portfolio can be much greater than in large R&D programmes composed of hundreds or thousands of projects. However, the study sought to zoom out from the particular peculiarities of the projects and to keep the focus on the bigger picture by identifying issues that cut across many projects and thus lead to deeper underlying conceptual, structural or cultural problems which demand the most serious attention from all stakeholders. The paper focuses mostly on the following key questions:

- What has Estonia's defence R&D achieved so far? Has this indeed been a wasted effort?
- What are the positive and negative aspects of Estonia's ongoing reform efforts in this field? What are the possible obstacles to success in the future?

The paper is divided into five parts. In Part 1, various terms such as R&D and R&T are clarified. Part 2 describes Estonia's defence R&D policy, governance, resources and portfolio, together with the nation's international participation in the field and the evolution of all these factors. In Part 3, results of the interviews are outlined, which are then discussed in Part 4. The closing part summarises the findings, draws broader conclusions and articulates a number of recommendations for the future.

1. Setting the scene: terminology issues

Before delving into Estonia's defence R&D, it is first necessary to clarify some categories and terms used in this discourse. One of the first issues to tackle is the definition of R&D. Standard international practice is contained in the Frascati Manual, which defined R&D as 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications' (OECD, 2002: 30). Defence R&D is thus 'all R&D programmes undertaken primarily for defence reasons, regardless of their content or whether they have secondary civil applications' (ibid.: 86). The same standard distinguishes between basic research, applied research and experimental development (see Table 1). Authors of this standard, however, acknowledge that this is a neat theoretical point of distinction which, in practice, it might be quite difficult to find in particular projects.

Table 1: Frascati definitions – basic and applied research, experimental development

Basic research	Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
Applied research	Original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
Experimental development	Systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

Source: OECD (2002: 30).

The Frascati Manual also elaborates on several important considerations that stem from the above R&D definition and that are of significance to the examination of Estonia's R&D later in this paper:

- When determining whether an activity is R&D or not, the main criteria of novelty and resolving some scientific and/or technological uncertainty should be applied;
- The term 'R&D' applies not only to natural sciences and engineering (NSE), but also to social sciences and humanities (SSH);
- Consequently, the outcome of an R&D process can be a new piece of equipment, but also a novel methodology, a process (policy/procedure), an organisation or a service.

The latter two points are also echoed in the ways that technology – another critical term for this study – can be understood. Arthur (2009) defined technology in general as 'a collection of phenomena captured and put to use' (or a 'purposed system') and contended that as the phenomena in question could be physical, behavioural or organisational, technologies could also be different in nature:

- Device technologies or 'hardware' (equipment, gadgets, etc.);
- Method technologies or 'software' (industrial processes, algorithms, etc.);

- 'Nontechnology-like' or unconventional technologies (e.g. monetary systems, legal codes, etc.).

The last point could be seen as somewhat controversial, as it stretches the definition of technology to the limit: it would be reasonable to ask what is not technology if so much of human activity qualifies as 'unconventional technology'. On the other hand, such broad interpretation of what technology is provides ample space for incorporating social sciences and humanities into the technology discourse.

Two aspects have to be highlighted at this juncture. First, according to conventional wisdom, R&D is seen all too often as the realm of only NSE and its output is viewed as device technologies ('hardware') and method technologies ('software'). The OECD standard embracing SSH within R&D and Arthur's definition of technology, which includes 'nontechnology-like' (or unconventional) technology, are very valuable in moving the R&D policy discourse away from an NSE-centric (or 'hardware/software'-obsessed) narrative. Second, bearing in mind the Frascati definition of basic and applied research and experimental development, it is necessary to underline that the sought outcome of a particular R&D project need not necessarily be new technology (of whatever sort in Arthur's terms), but rather new knowledge – general knowledge (about the nature of some phenomena), as in the case of basic research projects, or knowledge tailored to a specific problem, as in the case of applied research projects. It is crucial to register all this from the very beginning because certain serious obstacles to defence R&D in Estonia are related to very different perceptions of various stakeholders of what technology represents and what R&D means.

Another terminological issue, which deserves attention, is that the term 'R&D' is often used interchangeably or in conjunction with such terms as Science & Technology (S&T) or Research & Technology (R&T). The Hague Centre for Strategic Studies (HCSS) compared these terms by using the Frascati typology (basic and applied research and experimental development), but they also added such terms as education, training and services. The outcome of their analysis is presented in Table 2, which demonstrates that R&D stops with experimental development (just as the definition in the Frascati Manual), but R&T goes further and includes the preparation of technological procedures and methods, while S&T encompasses such essential elements for the actual use of technology as education, training and service provision.

Table 2: Elements of different definitions

	Basic research	Applied research	(Experimental) Development	Technological Procedures and Methods	Education	Training	Services
R&D	x	x	x				
R&T	x	x	x	x			
S&T	x	x	x		x	x	x

Source: Rademaker et al. (2009: 8).

Chatham House, also employing the Frascati Categories, presents R&D as a capstone term spanning the entire process, while R&T or S&T represents just small portions of it, which is the opposite of what the HCSS concluded, but which is how many defence organisations often treat it (see Figure 1).

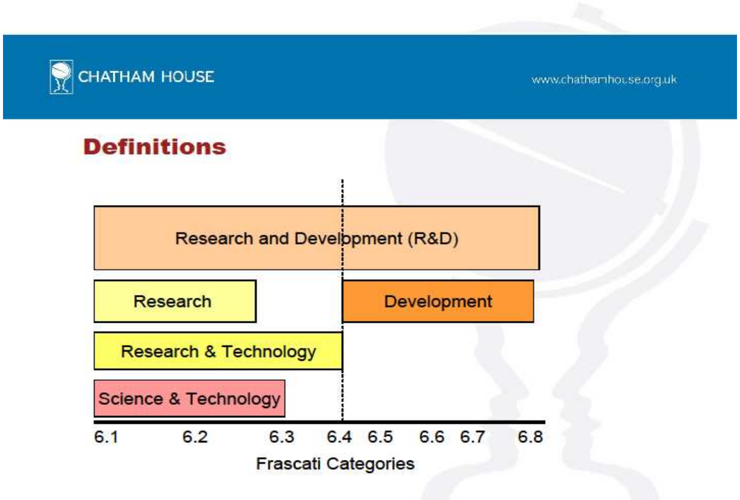
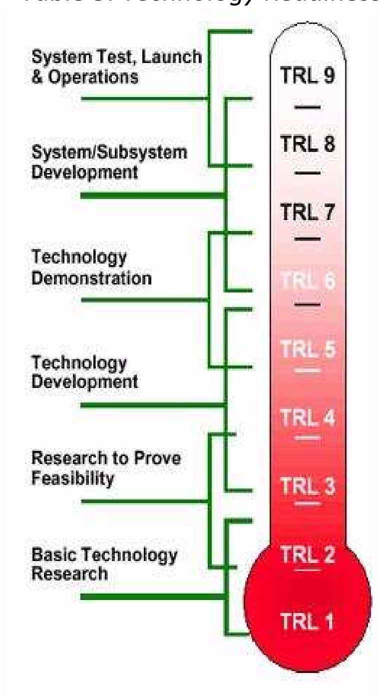


Figure 1: Relationship between terms. Source: RIIA (2011).

Defence acquisition managers within NATO and its individual member states often use the term 'Research, Development, Test & Evaluation' (RDT&E), which is embodied in the so-called Technology Readiness Levels, TRLs (nine of them in total – see Table 3). First conceived by NASA, then adopted by the U.S. Department of Defense and, consequently, by NATO, TRLs elaborately split the entire process into thoroughly described (and measured) constituent elements (note, however, that activities on different TRLs overlap). In accordance with the Frascati model, R&D in its pure form should end somewhere on TRL5 or TRL6.

Table 3: Technology Readiness Levels (TRLs)



TRL9	Actual system proven through successful mission operations
TRL8	Actual system completed and qualified through test and demonstration
TRL7	System prototype demonstration in a relevant environment
TRL6	System/subsystem model or prototype demonstration in a relevant environment
TRL5	Component and/or breadboard validation in a relevant environment
TRL4	Component and/or breadboard validation in a laboratory environment
TRL3	Analytical and experimental critical function and/or characteristic proof of concept
TRL2	Technology concept and/or application formulated
TRL1	Basic principles observed and reported

Sources: Mankins (1995) and U.S. Department of Defense (2009).

These divergences might seem to be quite insignificant. However, different perceptions of what constitutes R&D and how it relates to other terms or processes often create different expectations about the scope of R&D strategies and the outcomes of specific programmes, particularly in countries which have little experience with using R&D, e.g., for the acquisition of military capabilities. Without attempting to resolve the terminology conundrum, but seeking to avoid unnecessary cluttering and obfuscation, the present study employs only the term R&D as per the Frascati categorisation. It also employs S&T only as an abstract reference to a broad sphere of activities, in which new scientific knowledge and novel technologies are generated and made available for use.

2. Estonia's defence R&D and its evolution

This part of the study describes Estonia's defence R&D and its evolution. It briefly lays out the national context, in which defence R&D is set; presents the main points of the Estonian defence R&D strategy; outlines the characteristics of the nation's defence R&D governance and portfolio; and presents the dynamics of the defence R&D budget and international collaboration efforts. The provision of this overview was useful for spotting certain problematic issues, which were further pursued during the interviews. It also provided a necessary backdrop for the interpretation of the results of the interviews.

2.1 National context

The Estonian government places a strong emphasis on building a knowledge-based society, on the stimulation of R&D activities and on the promotion of innovation in both the public and private sectors. The capstone strategy is contained in a document approved by the Parliament (*Riigikogu*), entitled 'Knowledge-based Estonia: Estonian Research and Development and Innovation Strategy 2007–2013' (henceforth the 'RD&I Strategy'), which is periodically reviewed and updated, following the inputs and the interests of various governmental, public and private stakeholders. The RD&I Strategy asserts that 'national research and development programmes will be launched on the basis of the strategy […] for solving socio-economic problems and achieving the objectives in socio-economic sectors that are important to every resident of Estonia, as for instance energy, national defence and security, health care and welfare services, environmental protection, and information society' (Government of Estonia, 2007: 6).

The RD&I Strategy sets out specific R&D fields, in which major investments would be concentrated for the next five-year period. For instance, for the period of 2007–2013, the Estonian government regards three fields of R&D investments as strategic priorities – information and communication technologies (ICT), biotechnology and materials technology (ibid.). Without expanding too much on the ways in which the above priorities can be pursued, it is useful to highlight two principal avenues. One is an inter-agency mechanism in which national R&D programmes can be set up with a particular ministry in the lead, but including other ministries and their subordinate agencies on their steering committees.[6] Another approach would be to reflect – to the highest degree possible – the priorities of the national RD&I Strategy in the institutional R&D programmes of individual ministries.

Estonia's public universities (the University of Tartu, Tallinn University of Technology, the Estonian University of Life Sciences, Tallinn University, etc.) and independent public research institutes sit on the supply side of the RD&I Strategy. In addition, business enterprises, particularly in high-tech sectors, sometimes have their own R&D capabilities. They can act as suppliers in government-funded R&D contracts, but sometimes they also act as customers

[6] To date, national R&D programmes in biotechnology, health, energy technology, environmental protection and environmental technology have been set up, while programmes in ICT and materials technology are being prepared (MER, 2011).

who commission and fund R&D projects at public universities or institutes with the purpose of using their results for the development of new or for the improvement of the existing products or services. The government's principle organisational instruments for the administration of public financing for RD&I are:

- The Estonian Science Foundation (*Eesti Teadusfond* – ETF) and the Archimedes Foundation, both of which fall under the area of governance of the Ministry of Education and Research (MER). In accordance with the amendments to the Organisation of Research and Development Act, a new body – the Estonian Research Agency – will be established in March 2012, while the mandate of the ETF will have expired by then (*Riigikogu*, 2011);
- Enterprise Estonia, an organisation which is governed by the Ministry of Economic Affairs and Communications and is dedicated to the promotion of innovation in the national economy. It provides funds for R&D projects with a high potential for commercialisation and facilitates the formation of so-called 'competence centres' focused on industry-led R&D.[7]

In terms of financing, Estonia's RD&I Strategy stipulates that Estonia should spend 3% of GDP on R&D by 2014, approximately half of which would come from public sources (Government of Estonia, 2007: 34). In 2009 (so far the latest year for which financial data is available), the actual R&D expenditure comprised 1.42% of GDP (or 197 million euros), half of which was public spending, including EU funds (Heinlo, 2011: 378). Although this fell short of the RD&I Strategy target of 1.9% of GDP for 2009, it still represented an increase compared to 1.29% of GDP in 2008 (see Figure 2). The government claims that on the basis of most R&D indicators, Estonia is one of the most successful new EU member states and that the growth in R&D funding was the fastest in the entire EU during the period of 2000–2006, even though the EU average has still not been reached (MER, 2011).

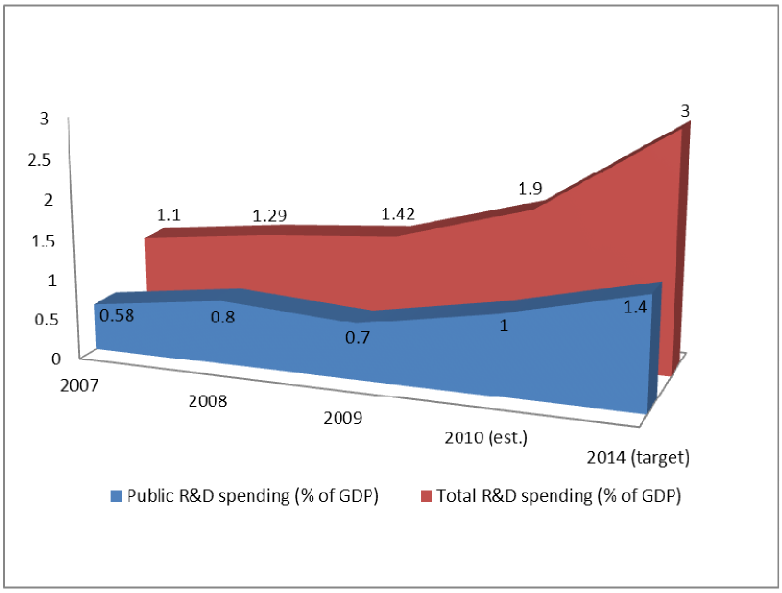


Figure 2: Estonia's R&D expenditure. Source: MER (2011).

[7] Currently, there are eight such centres: three in IT and electronics, two in food-related research, two in biomedicine and one in nanotechnology (Pralla, 2010).

It is clear from this that even in the throes of the deepest recession in 2009, when Estonia’s GDP contracted by 16%, its R&D expenditure in real terms did not drop so dramatically: compared to 2008, public spending on R&D decreased by 7% (down to 96 million euros) and funding by enterprises by 8% (down to 76 million euros) (Heinlo, 2011: 378). This could partly be explained by the continuing inflow of EU funds and a need to put up co-financing from national sources. However, a clear understanding that R&D is of strategic importance to future economic competitiveness and national welfare might also have played its part in maintaining the same level of funding in real terms, even though the fall in GDP was rather significant. It is also obvious that the public sector is, and in the foreseeable future will remain, the largest source of R&D investments in Estonia.

2.2 Defence R&D strategy

The MOD is one of the few ministries in Estonia that has its own R&D programme. Prior to 2008, the MOD had no formal R&D strategy in one piece. It was mainly crafted on the basis of the MOD’s and the HQ EDF’s correspondence with each other; memos on *ad hoc* issues and problems; and the minutes of various meetings. Since 2008, a formal Defence R&D Strategy has been in place (although it is still without any approved implementation plan), which articulates three main aims of R&D in defence:

- To support Estonia’s defence capabilities through the development of competence in military science and through the development of practical solutions for use in defence;
- To contribute to the projects of NATO and the EU, thus positioning Estonia as a valuable partner and Ally;
- To develop and sustain the potential of the Estonian S&T community – universities and research establishments – in areas of relevance and importance to security and defence.

The aims are pursued along five strategic directions:

1. The delivery of practical applied S&T solutions to support the mission of the MOD and the EDF. These R&D activities are undertaken following ‘top-down’ requirements, essentially reflecting the end-user’s ‘technology pull’, which cannot be satisfied by simply procuring products and services available on the market. Within this strand of strategy, R&D project grants tailored to a specific set of requirements are provided.
2. The creation and the development of competence in civilian research establishments and universities, which are of importance to defence, but which should not necessarily reside within the defence organisation (the MOD or the EDF). This direction includes, for instance, the provision of scholarships to PhD students at universities as a means to encourage the study of subjects that pertain to defence; the provision of grants to researchers to study defence-related subjects, etc. Within this

strand of strategy, expectations focus on competence and knowledge (and corresponding deliverables) rather than the deployment of new technology to the field.

3. International collaboration and participation in EU and NATO projects. The strategy seeks to establish Estonia as an active contributor to the projects of NATO RTO and the European Defence Agency (EDA) and to enable Estonia to bring home new collaborative knowledge and technological solutions relevant to its defence needs.
4. The sponsoring of R&D ideas that are proposed by the S&T community and that correspond to the needs of the MOD and the EDF. This is the mechanism through which 'bottom-up' initiatives and the 'technology push' are handled by the defence organisation. Still, the decisions to provide grants for 'bottom-up' projects are based on whether demand from the end-user, i.e. the EDF, can be identified. (Thus this is essentially a variation of the first direction.)
5. The development of research competence and capacities of the EDF, focusing mainly on those areas where in-house organisational competence is essential (such as tactics, military psychology, modelling and simulation, etc.). Although the strategy does not define any specific areas or means, this refers mainly to the development and retention of military specialists and researchers in the fields that are important to the EDF.

It is quite noteworthy that the Estonian Defence R&D Strategy does not include the enabling of the defence organisation to be a 'smart customer' and a 'smart user' of technologies as one of the objectives. In many other NATO nations, this is considered to be of paramount importance: the R&D function serves as a tool to develop a better understanding of where technology is moving, what is being offered in civilian and military markets, what civilian innovations could be adapted for military uses, what problems and challenges the procurement of certain technologies may entail, and so forth (Jermalavičius, 2009a). It might be a tacit goal in Estonia's defence R&D activities, but it is not properly spelt out, let alone established as having a pivotal role in R&D investments.

The Estonian Defence R&D Strategy does not stipulate that the aim of defence R&D investments should be to support the growth of a defence-related industry in Estonia or innovation in the national economy. It is primarily focused on the needs of national defence, leaving economic or scientific needs to be fulfilled by other strategies, mechanisms and organisations (e.g. Enterprise Estonia) or by a positive ripple effect of defence R&D investments. This does not preclude the defence organisation from contributing to the projects aimed at achieving the highest TRLs if necessary, but this is mostly seen as the subject of industrial and business policies – a remit of the Ministry of Economic Affairs and Communications – rather than a Defence R&D Strategy.

The linkages of the Defence R&D Strategy with the national RD&I Strategy are also rather indirect: defence is one of the functions mentioned by the RD&I

Strategy in support of which national programmes could be launched, but so far a national programme dedicated to defence objectives does not exist (the Defence R&D Strategy does not have such a status). Moreover, the defence organisation does not participate in any of the four national R&D programmes as a stakeholder, even though the objectives of some of them might correlate with national defence interests (see section 2.5 and Table 5).

By extension, the inter-agency aspect of defence R&D is quite underdeveloped. This might get rectified if the inter-agency working group on dual-use technology, which was set up in 2010 as a result of an MOD initiative to explore possible synergies of R&D investments in the domain of security, safety and defence, produces positive results and if they are then fed back into the RD&I Strategy's process led by the MER. This may even lead to the formulation of a national R&D programme in security and defence. Broader conceptual and policy prerequisites for such an inter-agency approach (in the form of a comprehensive approach to security and defence, set out in the National Security Concept of 2010 and the National Defence Strategy of 2011) are already in place. However, the working group has met only once since its establishment and has not yet made much progress towards its objectives.

2.3 Governance

Estonia does not have a dedicated defence R&D entity – either inside the defence organisation or outside of it – for running its entire defence R&D programme or parts of it (see Figure 3). The Estonian MOD, which bears the overall responsibility for R&D strategy and the oversight of its implementation in defence, relies on the following arrangements in performing this function:[8]

- A system of boards under the auspices of the MOD to bring together relevant internal and external expertise and decision-making authority to develop consensus and awareness, to coordinate plans and activities, to generate advice or to make strategic and operational decisions.
- A system of MOD contracts with R&D suppliers – universities, research establishments, business enterprises or even individual researchers. Contracts are usually concluded for up to four years and they are subject to annual performance reviews.
- A small staff inside the MOD (one civil servant at the Procurement Department, which is in the area of responsibility of the Undersecretary for Defence Investments) and the HQ EDF (one staff officer in the J5/9 branch and a part-time civilian advisor) to administer the entire system and to provide day-to-day support to key decision-makers.[9]

[8] The governance framework of Estonia's defence R&D is laid out in the Defence R&D Strategy, but ongoing reforms have already rendered it obsolete. In this section, the study relies on the description and the presentation of the reformed system by the MOD.

[9] Since 2001, the tasks related to R&D policy and the attendant position of an R&D coordinator at the MOD have migrated from one functional unit to another: initially, the position was in the area of responsibility of the Undersecretary for Defence Policy and Planning; later, it was moved under the Undersecretary for Defence Planning and, in 2005, under the Undersecretary for Defence Investments (where the R&D coordinator also had temporary support in administrative matters from an additional staff member for one year – an arrangement, which will expire in 2012). When setting up its coordinator's position (which happened only in 2009), the EDF, however, chose to incorporate R&D management and administration tasks into the HQ J5/9 section (Defence Planning) rather than the J4 section, which has the most to do with procurement activities. The distribution of R&D policy, coordination and administration tasks in the defence organisation is again becoming a topical issue in the context of the recent plans to set up a separate agency in the MOD in charge of defence procurements, resources and investments.

In addition, the defence organisation has a very small in-house capacity for R&D confined mainly to the Estonian National Defence College (ENDC) with the Centre for Applied Studies and the Modelling & Simulation Centre.

The system of boards might sound as an over-statement, since it has only two entities within it – the MOD Research Council (RC) and the R&D Coordination Group (better known by its Estonian abbreviation, TAKT). This element of governance underwent a significant reform in 2009–2010 in order to improve the quality of S&T advice given to the MOD, the oversight of the defence R&D programme and internal coordination in the defence organisation.

The RC, which serves under the sole authority of the Minister of Defence, existed before the reform. Its original role was to assess research grant applications submitted to the MOD by scientists and to decide which proposals should be accepted and financed. Initially, it was composed of scientists only, but later senior MOD and EDF officials (e.g. chiefs of services) were also included. This attempt to mix scientific advice with decision-making eventually proved ineffective for connecting S&T with defence needs and for developing a meaningful science-military dialogue, which necessitated the governance reform.

During the reform, the composition and functions of the RC were reviewed to re-emphasise its analytical role and the importance of expert advice. The current RC is tasked with providing the MOD with advice on Estonia's S&T potential and the Defence R&D Strategy in general; on the implementation of the directions set out in the strategy; and on specific requirements and projects. This is where military requirements are translated into scientific language understandable to the S&T community. The RC is composed of scientists (e.g. representatives of the University of Tartu and Tallinn University of Technology) and military experts (leaders of capability working groups, tasked with the implementation of the capabilities laid out in the Long-Term Defence Development Plan 2009–2018[10]). Estonia's representatives – scientists and military experts – at NATO RTO panels and NATO research establishments (REs) are also included as *ex officio* members of the council. Due to this composition, the RC is now the focal point where military and scientific expertise meet and interact to produce advice for MOD decision-makers on how R&D can contribute to the fulfilment of defence priorities and capability requirements.

The TAKT is a completely new board tasked with the coordination of R&D requirements, plans, regulations and procedures in the defence organisation and with the preparation of the decisions of the MOD leadership – the Minister, the Permanent Secretary and Undersecretaries – regarding the Defence R&D Strategy, its implementation, its budget and the funding of specific projects or initiatives. The TAKT is chaired by the head of the MOD Procurement Department and composed of the representatives of the MOD Policy Planning, Defence Planning and Procurement Departments, the HQ EDF and the ENDC.

[10] The job of these leaders is the closest thing that Estonia has to 'capability directors', which are fairly commonplace, but still very important positions in advanced defence organisations.

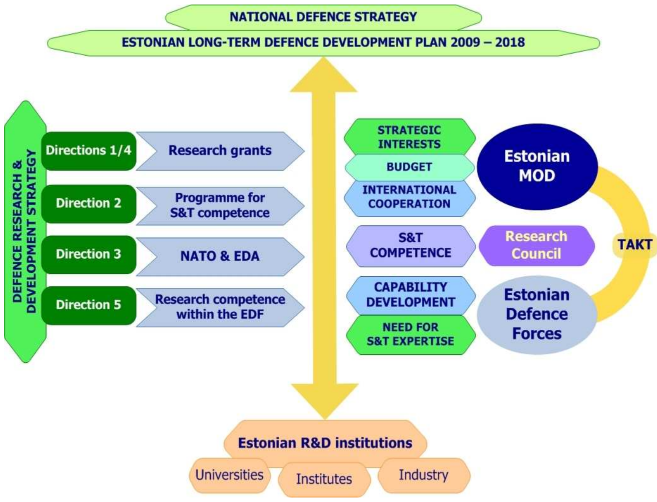


Figure 3: Estonia's defence R&D governance. Source: Estonian MOD.

2.4 Budget

Just as there is an established consensus among NATO and EU member states that they should spend at least 2% of GDP on defence, there is an agreed benchmark that at least 2% of a nation's defence budget should be devoted to R&D. NATO Secretary General Anders Fogh Rasmussen, who advances the idea of 'smart defence' in an age of financial austerity, implores member states to spend more on R&D and stresses the significance of R&D investments, especially in multinational projects, to enhancing the performance and capabilities of defence organisations, while deriving more value for taxpayers' money (Rasmussen, 2011). In a similar vein, the EDA encourages all nations to spend at least 20% of defence R&D funds on collaborative projects (EDA, 2007).

In Estonia, defence R&D expenditure peaked in 2008, when approximately 1.85 million euros (or 0.62% of the entire defence budget) were spent on R&D projects. In 2009, during the financial crisis, defence R&D expenditure suffered a precipitous decline to less than 0.5 million euros (or about 0.16% of the defence budget) (see Figure 3).

Although financial difficulties of the state certainly serve as a good explanation for this, the fact that the reduction was rather drastic in defence R&D and went against the overall trend of maintaining the level of national R&D investments during the economic crisis suggests that this explanation might not be sufficient. Furthermore, the proportion of Estonia's defence R&D expenditure in its defence budget did not reach and, judging from the short-term budgetary perspective, is not likely to reach the NATO and EU benchmark of 2%.

However, the Estonian MOD does not absorb even the modest financial resources currently available to defence R&D. In 2010, according to the MOD sources, a portion of the planned R&D budget was left unused and had to be returned to the national budget at the end of the fiscal year. Again, this is indicative of deeper challenges and issues underlying defence R&D and the ongoing shift in R&D policy in Estonia, which were ascertained in the course of the interviews made for this study and are reported in Part 3.

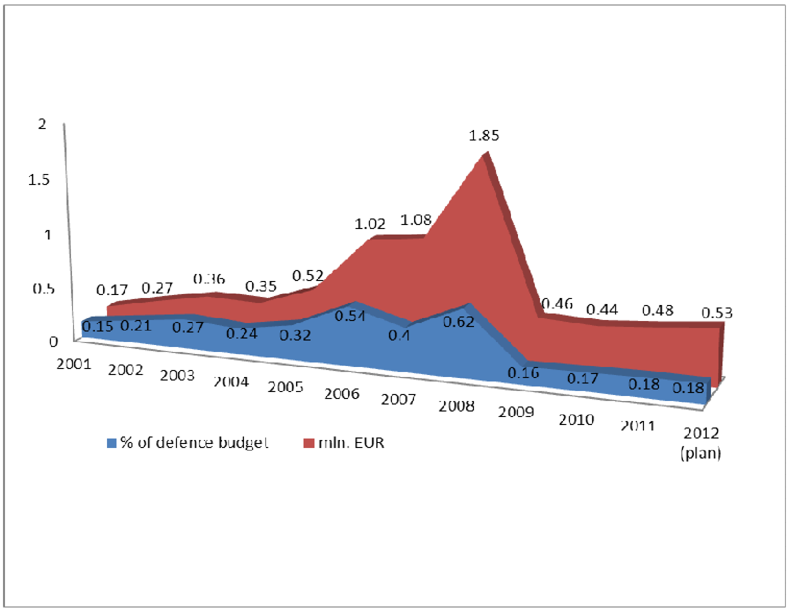


Figure 4: Estonia's defence R&D spending. Source: Estonian MOD.*

*This is only the spending administered by the MOD Procurement Department and reported to the international authorities as Estonian official defence R&D spending. Some other MOD departments and EDF structural units also finance projects or programmes that would qualify as R&D under the Frascati definition (e.g. in the areas of defence policy and planning, environmental management, logistics, military education, military history, etc.), but are not subject to the R&D governance framework described in this study and are therefore not consolidated as part of the overall defence R&D budget.

2.5 Portfolio and its management

From 2001 to 2010, the Estonian MOD provided funding (in total about 6.53 million euros over this period) to more than 50 R&D projects. In terms of desired outcomes, some of them had studies (publications) as deliverables, others sought to produce a demonstration prototype, while some pushed for fielded equipment. The portfolio included projects mostly from the NSE domain, although some could be assigned to the SSH domain (see Table 4). However, the portfolio's composition appears to be rather random: it is difficult to discern any particular pattern or strategic direction in it that would suggest a deliberate focus of R&D investments on any particular 'niches' or on a specific part of the R&D process, e.g. applied research or experimental development. (Indeed, some of the projects might not even qualify as R&D projects following the Frascati criteria. This would indicate that some initiatives were funded from the R&D budget as a matter of bureaucratic convenience.)

Furthermore, in the past, projects were endorsed mainly on the basis of their scientific merit, while they had only a tenuous link with the defence domain. It was common practice that the MOD first approved all project proposals endorsed by the RC and then afterwards ordered the EDF to formulate a corresponding military requirement to suit them. These criteria and the whole approach hardly guaranteed a clear focus on, and a high relevance to, defence needs. As a result, the R&D portfolio was based on the principle of sprinkling funds randomly across the national S&T base in response to a 'supply push'. In a similar vein, the cuts during the budgetary crisis were administered not in a highly strategic manner, but by simply ranking the ongoing projects in terms of their scientific achievements and performance (on the basis of an assessor's conclusions) and then by terminating the funding to lower ranking projects.

Today's outcome is a much smaller portfolio, which still contains a rather random mix of items.

Table 4: Portfolio of Estonian defence R&D projects, 2001–2011

Project	Duration	Domain	Project	Duration	Domain
Analysis of BALTCCIS interface and development opportunities	2008	NSE	Anti-tank warfare simulator development	2001	NSE
Acoustic target prototype development	2003	NSE	Analysis of load distribution and biomechanics, injury prevention and training in the cases of military personnel with flat foot syndrome	2008	NSE
Analysis “Russian Military Report”, “Russian File” and “Russian Political Elite”	2001–2004	SSH	Assessing the soil crossing ability of heavy military vehicles	2007–2008	NSE
Baltic air policing study	2009–2010	SSH	Coatings and composite materials based on organic conductors	2001–2004	NSE
Conductive textile prototype development	2005–2007	NSE	COST project “Metal ions with the crystalline structures of oxide matrices”	2001	NSE
Cyber attacks and defence simulation software	2007–2011	NSE	Development of a set of psychological tests for EDF personnel selection	2001–2002	SSH
Digital radar	2002–2005, 2008	NSE	Disruption of military radio communication services	2001	NSE
Electric activation of IEDs and suppression of its source	2004–2006	NSE	Health and work environment of military staff	2008	SSH
Helicopter targeting simulation system	2002–2003	NSE	IED neutraliser	2007–2008	NSE
Light armour panels – manufacturing technology	2008–2009	NSE	Mapping software for handling spatial data	2003	NSE
Military communication systems and equipment disruption analysis	2002	NSE	Monitoring, suppression and neutralisation of radio-based systems (IRIS)	2007–2010	NSE
Network Enabled Capabilities (NEC) and spontaneous networks	2008	NSE	Physical and cognitive performance capacity in the conditions of chronic heat stress	2007–2011	NSE
Preparation of the 3rd Annual National Plan of Estonia's integration into NATO	2001–2002	SSH	Prospective development model and its implementation for the Defence League	2006–2007	SSH
Portative analyser of chemical warfare agents	2005–2006, 2008–2012	NSE	Psycho-sociological autopsy of homicides and suicides in the cases of gambling dependence: implications to military environment and public perceptions	2008	SSH
Radio technical background study	2004	NSE	Shooting gallery simulator for national defence course classrooms in public schools	2003	NSE
Smoke screen prototype development	2003	NSE	Technical specifications for EDF uniforms	2008	NSE

Project	Duration	Domain	Project	Duration	Domain
Training landmine	2008	NSE	The use of GPS navigation systems in obtaining meteorological data	2005–2009	NSE
UAV data processing	2006–2008	NSE	Unmanned Aerial Vehicle (UAV)	2003–2008	NSE
Unmanned ground vehicle (UGV)	2005–2007	NSE			

Source: Estonian MOD.

Until about 2009, the 'supply push' was usually either reluctantly endorsed by or imposed upon the military. In some cases, such as the IRIS project, where a pressing and specific operational need indeed existed (in the case of IRIS – the suppression of the IED threat in the Afghanistan operation and the reduction of the risk of casualties among Estonian soldiers deployed there), the 'supply push' and the 'demand pull' met and produced those very few (although, by some accounts, conditional[11]) 'success stories' of Estonian defence R&D and industry programmes. In some other cases, although the demand and supply sides were in balance (e.g. the training landmine project), their funding was curtailed due to financial pressures, but without properly consulting with the end-user. In most cases, however, the delivered studies or prototypes – although satisfying their authors and the MOD as fulfilling the scholarly or technological ambitions set out for the projects and thus meeting their original objectives – made little or no impact on the organisational performance, competence or capabilities of the defence organisation. In technological and innovation-related parlance, they ended in the 'valley of death' of technology.

Since the adoption of the Defence R&D Strategy in 2008 and the reorganisation of the governance framework, there has been an ongoing shift in the MOD approach to constructing its R&D portfolio, reinforced by a change in the stance of the military who have started resolutely rejecting many ideas and existing projects as not corresponding to their requirements. The Defence R&D Strategy established that all new projects should meet to the highest degree possible two main established criteria: 1) projects must have a clear link with long-term development plans and capability priorities or with Estonian national security policy (have a strong 'demand pull'); 2) projects must reflect a high level of S&T competence available in Estonia (the 'cutting edge' on the supply side).

Initially, just after passing the Defence R&D Strategy in 2008, the MOD envisaged four directions, constituting the core of its R&D programme:

1. Counter-IED;
2. Situation awareness, information assurance (sensors, passive radars, multi-sensor tracking, cyber security, etc.);

[11] IRIS was the most expensive project in the portfolio, having received slightly over 1 million euros of funding over several stages. This underlines the fact that the commercial development of a product based on R&D requires substantial investments in order to bring the product to the market. Usually, the ratio of funding channelled into defence R&D and subsequent commercial development is 1:2 (i.e. every euro or dollar spent on R&D has to be supplemented by another two in order to turn an experimental prototype into a commercial product). If there are multiple competing defence priorities, there must be very compelling reasons for a programme to go beyond R&D necessary to enable a 'smart customer' posture (i.e. beyond its advisory role) and to provide funding for developing new technology to the highest TRL. Questions remain over whether technology similar to IRIS was not available for procurement off-the-shelf (thus also avoiding potential interoperability problems with the Allies), whether IRIS is competitive enough in international defence markets, how justified it was to put public funds from the defence budget into a commercial development project, etc.

3. CBRN: detection of chemical substances;

4. Network Enabled Capabilities (NEC).

Later, using the aforementioned criteria, the RC undertook a mapping and assessment exercise that yielded a list of 42 more specific technological competences, which were of interest to defence and which were informally grouped by the MOD into three broad thematic groups (see Table 5).[12] The intention is to periodically revise those competences and to re-assess their importance as defence and national security needs and S&T abilities evolve, although the MOD is reluctant to explicitly prioritise them according to the results of the RC assessments. Nonetheless, this indicates already a much more structured and rigorous approach to the construction and the revision of the defence R&D portfolio, which may eventually lead to very clear, specific and formally fixed 'niches' of specialisation in the future.

Table 5: Suggested future directions of Estonia's defence R&D

Areas	Technological competences
I. Situation awareness, systems, system integration and decision-making	• Sensor networks, cognitive signal processing and data fusion • Communication systems (including C2 compatibility) • Complex man-machine systems (including contingency awareness) • Agent-based software engineering (including modelling) • Radar technology • Sensor technologies (RF, optical sensors, sounders, pressure sensors, seismic, magnetic, electrical, chemical, and biological) (including materials) • Network enabled capability • The exchange of information between different types of radio, quality of service (QoS) • Narrowband and wideband radio communication systems interoperability, including interoperability with NATO • Interoperability in the semantic domain (ontology) • C4ISR and reliability of complex systems (including self-monitoring and self-improvement) • Energy-efficient systems (consumer optimisation) • Robotics, unmanned systems and artificial intelligence • Acoustic conditions in the Baltic Sea • Rapid Environmental Picture (REP) systems in the coastal waters of Estonia (including satellite remote sensing) • AIS (Automatic Identification System)-based vessel traffic risk monitoring methodologies • Use of Autonomous Underwater Vehicles to support undersea systems in the Baltic Sea • Low-power sonar technologies • Seabed sonar mapping and data management • Passive sensors to monitor underwater sites • Underwater communications network solutions • Modelling and Simulation of processes and complex situations • Analytical methodologies in support of resources planning • Future security and strategy forecasting methodologies
II. Force protection and sustainment	• Technologies for electronic warfare • Camouflage technologies (visible light UV-VIS-NIR, infrared) (including adaptive materials) • Energy technology (fuel cells, solar cells, super condensers, batteries, energy harvesting) (including materials) • Composite materials (ballistic protection) • Information assurance and cyber security (including cryptography) • Maritime de-mining robotics

[12] This is similar to the approach used in the Netherlands, where Knowledge Areas (KAs) serve as broad themes and Knowledge Elements (KEs) are specific topics within them (see Rademaker et al., 2009). This also bears similarity to the Military Critical Technology Lists published by the U.S. Department of Defense (see Versailles & Merindol, 2006).

Areas	Technological competences
III. Human factors and medicine	• Information and psychological operations efficiency • Cognitive engineering solutions • Social networks • Human factors and personnel selection criteria • Human performance enhancement technologies • Health care and rehabilitation of military personnel • Mental health of military personnel (including military psychology) • Physical readiness of military personnel • Performance of military personnel under extreme climatic conditions • Management of military medicine • Technical aspects of telemedicine

In the current system, projects – especially those that fall under Directions 1 and 4 of the Defence R&D Strategy – are initiated and grants are offered only when an RC (or an RC-commissioned) expert analysis shows that an identified specific military requirement, problem or uncertainty needs a novel solution, that there is not a readily available solution on the market and that an R&D project would be able to produce a solution within acceptable cost, risk and time limits. This analysis has to be endorsed by the TAKT and, eventually, by the MOD and the EDF leadership. Project proposals are then invited and assessed by a reviewer assigned by the RC (usually a member of the RC, although an expert is contracted if there is no specific expertise in the RC) who also conducts the evaluation of annual project reports, which serve as the basis for making recommendations to the MOD on whether to continue, modify or close the project.

Continuing the pre-reform practice, each project also has a point of contact (PoC), appointed within the defence organisation, who is made available to a project team to provide advice and feedback on military specifics and requirements, which are often needed to make important choices in progressing further towards project objectives. A PoC also provides a channel through which the potential end-user in the defence organisation can be reached by a project team and vice versa. Thus a PoC forms a critical link between a project team and the end-user. A PoC should be able (and is expected, at least by the HQ EDF) to update the MOD and the EDF authorities on the status of a project whenever requested to do so, which means that it also has a 'project tracker' role.

2.6 International dimension

International cooperation and involvement in NATO knowledge networks and projects are very important tools for individual nations in pursuit of their strategic objectives. According to Robert Walker, Chairman of the NATO Research and Technology Board, it serves as a 'force multiplier', which allows nations to garner a critical mass which each nation individually lacks in its S&T capability and to gain access to the areas where national knowledge base is insufficient or absent (Walker, 2009). Indeed, in the case of some small countries, *quid pro quo* knowledge sharing with the Allies constitutes a major rationale for undertaking their own defence R&D activities – usually in a very specific 'niche' in which they possess 'cutting edge' expertise (Jermalavičius, 2009a).

Within NATO, the activities of RTO panels and groups, NATO 'centres of excellence' and various agencies and research establishments (e.g. the NATO

Consultation, Command and Control Agency (NC3A), the NATO Undersea Research Centre (NURC) and the NATO Defence College) are the main conduits for contributing to and exploiting of the collective S&T competence of the Alliance and its partners.[13] Within the EU, the EDA serves as a major hub for coordinating and pooling the R&D investments of the member states through EDA-funded studies, Joint Investment Programmes (JIPs), targeted R&D projects, technology demonstrators and so-called CapTech groups (Breant, 2011).

Estonia has been an active participant in NATO RTO, contributing to the activities and projects of most of its panels (see Table 6) and heavily drawing from support programme funding made available by the NATO Research and Technology Agency (RTA). The Estonian MOD instituted a requirement for the members of MOD-funded R&D project teams to get involved in RTO technical panels and groups related to their project topics. As of 2011, Estonia's participation in NATO RTO has reached the highest level ever (see Annex A). The country also hosts and contributes substantially to the mission of the Cooperative Cyber Defence Centre of Excellence (CCDCOE). In addition, it participates in NURC. Although there are always possibilities for enhancing collaboration through NATO (e.g. joining more COEs, which is currently under discussion in the Estonian MOD), Estonia has certainly paid substantial attention to NATO's knowledge networks and its defence organisation should have drawn – at least in theory – great benefits from having access to them.

When it comes to cooperation through EDA mechanisms, so far the scope and scale of Estonia's involvement has been smaller compared to NATO. Estonia contributed to the JIP on Force Protection in 2007–2009, focusing on the capability area of secured wireless tactical communication systems in urban environment. However, up to now, there has been no participation in EDA-funded studies or targeted projects. Estonia has only recently identified its areas of interest in the R&D activities of the EDA and assigned experts to some of the CapTech groups (mostly the same experts who participate in similar NATO RTO panels). Joining the JIP on Situation Awareness in 2012 is also being considered (see Table 6). Defence R&D collaboration in the framework of the EU is yet to gain momentum, but it is emerging as a very important instrument for realising Estonia's defence R&D objectives.

A less optimistic picture emerges when it comes to bilateral or multilateral R&D 'strategic partnerships' (i.e. the circle of preferred partners with whom defence R&D collaboration is well established and intensive), which are not stipulated in the Estonian Defence R&D Strategy as part of any of the five directions. Therefore no such partnerships have so far been established in practice because collaboration through NATO and, increasingly, EU mechanisms has taken precedence. In policy terms, the only political statement of preference for defence R&D cooperation partners is a trilateral Letter of Intent signed by the Estonian defence minister with his Latvian and Lithuanian counterparts in May 2010.[14] However, precise contours of this trilateral partnership are yet to

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[13] NATO RTO is currently undergoing a reform, which is part of a broader internal reform effort by NATO. It has been proposed that a new NATO Science and Technology Organisation (NSTO) should be established (with NURC as part of it), led by a NATO Chief Scientist, reporting directly to NATO Secretary General (see NATO, 2011).

[14] Although it hardly rests on any in-depth analysis of the complementarities of competence or objectives of the three countries in defence R&D, this expression of political will reflects a broader push to rejuvenate and expand trilateral Baltic defence cooperation in general, which has been sagging since the nations' accession to NATO and the EU (see

emerge, as three national defence R&D coordinators are trying to work out common interests and mechanisms of collaboration.

Table 6: Estonia's defence R&D – international collaboration

Framework and format		Nature of participation
NATO		
COEs and Research Establishments (REs)*	Cooperative Cyber Defence Centre of Excellence (CCDCOE)	Host nation and major contributor
	NATO Undersea Research Centre (NURC)	Participating nation, representative on the scientific board
RTO technical panels and groups	Applied Vehicle Technology (AVT)	No contribution or representative**
	Human Factors & Medicine (HFM)	Representative on the panel, contribution to projects
	Information Systems Technology (IST)	Representative on the panel, contribution to projects
	System Analysis & Studies (SAS)	Contribution to some projects
	Systems Concepts & Integration (SCI)	Representative on the panel, contribution to projects
	Sensors & Electronics Technology (SET)	Representative on the panel, contribution to projects
	NATO Modelling & Simulation Group (NMSG)	Representative in the group, contribution to projects
EU/EDA		
JIPs†	Force Protection	Financial contributor in 2007–2009 (in total 0.53 million euros)
	Situation Awareness	Contribution being considered when the programme will be launched (in 2012)
CapTechs‡	IAP2: RF Sensor Systems & Signal Processing	Expert assigned
	IAP4: CIS & Networks	Expert assigned
	ESM4: Human Factors & CBN Protection	Expert assigned
Strategic partnerships		
Multilateral	Estonia, Latvia, Lithuania: Ministerial Letter of Intent	Work continues on the concept and practical implementation measures

*Currently there are 15 accredited COEs in NATO. Some organisations within the NATO structure could be called REs due to the nature of their research, although their primary purpose is not R&D (e.g. the NATO Defence College, the Joint Warfare Centre, the Joint Analysis and Lessons Learned Centre, etc.).

**NATO RTO projects with Estonian contribution are listed in Annex A.

†There are currently two JIPs running in the R&D area: Force Protection (FP) and Innovative Concepts and Emerging Technologies (ICET). In addition, one more JIP – Unmanned Maritime Systems (UMS) in the armament area – has an R&D component to it. Plans are being made for three new JIPs (Situation Awareness, CBRN Defence and Unmanned Airborne Systems), which will be harmonised with the objectives of R&D programmes under the auspices of the European Space Agency and the European Commission.

‡The EDA established 12 CapTech groups organised into three broad areas: Information Acquisition & Processing (IAP); Environment, Systems & Modelling (ESM); and Guidance, Energy & Materials, (GEM).

Jermalavičius, 2009b).

3. Mapping the problems and issues: interview results

This chapter provides a summary of the interviews which were conducted for this study. It maps the problems and issues, relates them to the picture presented in Part 2 and lays the groundwork for a more thorough assessment in Part 4. The interviewees were asked similar sets of questions, although some variations were included depending on their background (e.g. whether he or she represented the supply side or the demand side, was involved in NATO RTO panels, etc.). In broad terms, the interviews tried to capture the perspectives, insights and experiences related to: 1) Defence R&D Strategy, including the rationale for defence R&D and the expected outcomes; 2) interaction between stakeholders; 3) the management of R&D projects and the use of their results. This part follows the structure of the interviews in summarising the findings.

3.1 Views about defence R&D and its strategy

The enabling of the Estonian defence organisation (the MOD and the EDF) to be a ‘smart buyer’ and a ‘smart user’ – the possession of necessary knowledge to make wise investments in capabilities and technologies and to manage them effectively and efficiently – emerged as the dominant theme when discussing the rationale for Estonia’s defence R&D. Indeed, there seems to be a broad consensus regarding it. One interviewee said: “As a baseline, it is all about knowing the technology you want to procure and use – its functionality, limitations, components, integration with other systems.” In the words of another interviewee: “Such knowledge, experience and excellence cannot simply be bought outside the country,” the more so as domestic R&D is essential to developing them. This, for instance, pertained to the improvement of equipment life-cycle management and, as underlined by Estonia’s involvement in the campaign in Afghanistan, the resolution of interoperability issues with the Allies. Applied research studies that help to understand and address those issues were regarded as absolutely necessary to maintain the posture of a ‘smart buyer’ and a ‘smart user’. Furthermore, in the same line of thinking, research is necessary to make ‘evidence-based’ defence decisions and policies – across the board, not only in equipment procurement and management. So, if Estonia’s defence organisation wants to be a ‘smart organisation’ delivering ‘smart defence’, it must not forgo investing in R&D – in both NSE and SSH.

The ability to contribute to NATO and the EU also played a very significant part in defining the rationale for defence R&D in Estonia, although this aspect was not always very well thought through. Indeed, some interviewees argued that the main reason behind Estonia’s defence R&D activities was “because this is what they do in NATO” or this was “what NATO requires – spending 2% of your defence budget on R&D”. However, more reflective interviewees went further than that and argued that as a small nation, Estonia had to use R&D as a way to integrate itself deeper into the Alliance and the EU in order to become a more competent and credible partner for those organisations. One interviewee asked: “How can we possibly participate in the future operations of NATO together with the technologically sophisticated Allies if we do not understand the technology they are investing in and will be using?” Gaining access (by means of *quid pro quo* sharing) to ‘cutting edge’ knowledge relevant to Estonia’s own needs, bolstering the country's ability to participate in the operations alongside the Allies and contributing to multinational capability solutions of the future seemed to weigh heavily on the minds of many interviewees, as these points were listed as reasons for Estonia to invest in defence R&D.

When inquiring into the rationale for defence R&D, it appeared that another continuous theme united those seeking to compensate the gaps resulting from technology transfer constraints or to catch up with more state-of-the-art defence organisations with those favouring a degree of self-sufficiency in national defence:

- First, some interviewees considered defence R&D to be instrumental in building national S&T competence and in developing technologies in the areas where technology and knowledge sharing with the Allies was difficult or impossible due to the constraints and limitations defined by the nations who possessed those technologies (e.g. counter-IED was mentioned as being one of these areas).
- Second, there were also suggestions that due to a rather rudimentary level of defence development in Estonia, some of the knowledge and solutions necessary for further growth were quite basic. This meant that other nations with very advanced capabilities might find it difficult to supply those solutions without 'digging deep into their memory'. It was therefore suggested that it would be easier and more beneficial for the defence community in Estonia to catch up through its own R&D activities.
- Third, a few interviewees also mentioned the building of a national S&T ability and an industrial base for supplying the EDF in case of war or aggression, when Estonia might find itself cut off from defence markets.

However, as it transpired from the interviews, the expectation in this line of reasoning – whether dictated by concerns about technology sharing and catching up or about supply security in times of crisis and in wartime – was that Estonia should produce certain military equipment and supplies based on its own R&D outcomes. This would entail substantial investments, which would be necessary for bringing technology to the highest TRLs and would go well beyond R&D. Many admitted that Estonia lacked financial resources and the industrial base for pulling this off and that the nation could probably achieve that in very few technological areas (perhaps only one area).

Surprisingly, some interviewees were unaware of the existence of the Defence R&D Strategy or were not familiar with its content concerning the objectives of Estonia's defence R&D. One interviewee remarked that this strategy was essentially drafted by two persons – a civil servant and a minister – without conducting broader and inclusive consultations with other stakeholders. Those who were familiar with the strategy mostly agreed with its tenets and expressed a belief that it provided a good basis for conducting meaningful and consequential defence R&D in the future.

However, some put forward the opinion and the concern that the Defence R&D Strategy might be too disconnected from, or might lack clear linkages with, the national RD&I Strategy. Some interviewees suggested that this was because 'military science' was not recognised as a distinct scientific sub-domain in Estonia and because representatives of security and defence organisations were not included in the drafting process of the national RD&I Strategy, meaning that defence priorities were not reflected in the national strategy in any meaningful way. Others, however, pointed out that defence was not a distinct area of research at all and that the defence organisation should simply aim at contributing to and benefiting from those priorities which were laid out in the RD&I Strategy. Some went so far as to suggest that all what the defence organisation should do was to identify those civilian research projects and programmes that were most relevant to defence needs and to simply chip in with the funding and expertise necessary to develop military applications of their results. One interviewee from the military side said: "There are many interesting projects in the civilian sector which we are unaware of, but [we] need to find them and secure a buy-in."

The ongoing drive to better focus defence R&D investments and to even carve out some 'niches' was viewed by most as the right way for making the defence organisation smarter in its R&D programme. However, some interviewed scientists were rather cautious about it for two main reasons. First, they were unsure whether that focus would not be overwhelmingly shaped by special interests of a few influential S&T representatives and they suggested that perhaps technology mapping should be conducted by experts from outside Estonia. Second, there were concerns that unless the selection of defence R&D 'niches' was made very carefully, it might leave Estonia eventually with a portfolio of irrelevant competence if fast developments in S&T or in military affairs rendered that competence obsolete.

All in all, the MOD seems to be gradually leaning in its thinking towards the sort of R&D that: (a) does not lead to 'hardware' as an output, but focuses on 'software', processes, methodologies, systems integration, etc.; (b) does not produce new technology, but seeks new knowledge and 'know-how' (with a focus on applied research rather than experimental development). There is a degree of reluctance to define and fix this approach in the Defence R&D Strategy, since this may be seen as rather controversial or become too constraining in the future. However, the Defence R&D Strategy is already drawing some serious criticism from the stakeholders for the very reason that it fails to establish a clear level of ambition (e.g. sought deliverables, TRLs) and strategic principles (e.g. the division of investments between basic research, applied research and experimental development; priority directions among the five listed in the strategy; the balance between R&D in NSE and SSH, etc.).

The interviews revealed a certain divergence of expectations between scientists and military officers, which may eventually become a serious problem in promoting a long-term viable strategy consensus between the stakeholders. Some scientists argued that the defence organisation, just as any other state organisation, had a duty to support Estonia's science efforts and therefore had to do its part in funding basic research without expecting any direct and immediate benefits. On the demand side, however, some military officers pressed the point that at the most the defence organisation should fund experimental development of 'device technology', preferably based on civilian prototypes sponsored by non-defence sources. Ideally, in their view, there should be no defence R&D – only Testing and Evaluation (T&E) of offered prototypes, i.e. the defence organisation should focus on the activities at the highest TRLs rather than R&D. One military officer said: "The prevailing view in the EDF is that the military do not need R&D – they need weapons and equipment; they need military 'hardware'."

Although, when queried further, some members of the military acknowledged the value of applied research studies that produced relevant knowledge rather than technology and 'hardware', but the 'hardware'-obsessed attitude among the military means that, using the words of one officer, "applied research does not excite us much, not even speaking of basic research". In a similar vein, R&D is not appreciated by the military in the areas where there are "no devices or pieces of equipment to touch" as eventual outputs (the areas of human factors and medicine, cyber security, systems integration, NEC and others were mentioned for lacking such 'visibility'). On the other hand, there is a degree of realisation among military planners that given the capability priorities outlined in the Long-Term Defence Development Plan 2009–2018 (especially ISTAR and C2) and the growing competence and the needs of military structures that deal with people and organisational issues rather than equipment, the importance of these areas will increase in the future.

3.2 Interaction between stakeholders

The interviews revealed a certain degree of frustration that had accumulated between the main stakeholders – the S&T community and the defence organisation (especially the military) – over the attitudes and the behaviour of each other during the last decade or so. Some negative perceptions and experiences were particularly accentuated or even induced during the period of reforming the defence organisation's approach to R&D in 2009–2010. These tendencies continue to affect the dialogue and the amount of goodwill and mutual trust between the stakeholders, although positive perceptions are also emerging.

The views of the S&T community. The members of the S&T community (and even some members of the defence organisation itself) view the defence organisation as lacking the ability to articulate its requirements for R&D and, indeed, as being uninformed about the added value that R&D can produce. The military leadership at various levels of command drew particularly strong criticism for lacking adequate understanding of the nature and value of R&D; for being 'afraid of technology'; for being excessively driven by a flawed notion that 'everything can be bought, so there is no need to invest in R&D'; and, as a result, for treating R&D as a constant 'headache', imposed upon them by the MOD. The MOD drew its own share of criticism for what the scientists perceived as a bureaucratic approach that stifled 'good scientific ideas' and prevented them from receiving the necessary financial support.

To the S&T side, the defence organisation (particularly the EDF) comes across as:

- *Too short-termist, driven by the needs of 'here and now', often related to urgent operational requirements.* According to the interviewed scientists, this cultural characteristic goes against the nature of R&D activities, to which longer time horizons are inherent. One interviewee said that the Estonian military simply did not have "the patience, the maturity and the long-term perspective" necessary for dealing with R&D. Another scientist pointed out that long-term defence planning horizons of 20–25 years were not used in Estonia and that even the most recent plan with a 10-year horizon was already faltering, undermining the stability of long-term requirements and making the planning and execution of attendant investments, including R&D investments, very difficult.

- *Lacking conceptual, organisational and technological sophistication,* which usually goes hand in hand with the need for R&D to resolve problems and uncertainties. According to many interviewees, technological awareness and the level of literacy in the defence organisation are very low and correspond to the level of capability development achieved so far. One researcher said: "R&D presumes [the existence of] an organisation which is sufficiently sophisticated, well developed, data-rich and able to spot deep problems. But the EDF is still growing and many problems are simple enough to be resolved through experiential learning." In his words: "All what the R&D function can do is to survive until the EDF becomes more developed."

- *Lacking the drive for self-improvement and innovation:*
  - Some interviewed researchers expressed their apprehension about the EDF even lacking the very basic 'thirst for knowledge' and a scientific approach to understanding its own 'core business' – military operations. They claimed that doctrinal and operational research was virtually non-existent in the EDF (excluding some units) and that data accumulation about various performance aspects of the EDF was sketchy at best. Such powerful sources of demand for R&D, such as the CD&E (Concept Development and Experimentation) system, are extremely underdeveloped in the EDF. One interviewee said: "The end-user is now the weakest link in the R&D system."
  - It was also suggested that new knowledge about various aspects of the EDF often entailed an imperative to act upon that knowledge in order to make the necessary changes and improvements. One interviewee pointed out that R&D results could often shatter the established military dogmas and "make some decisions appear very unwise". Consequently, it was argued that many military leaders preferred to avoid the embarrassment caused by scientific evidence, together with the additional workload, by denying the need for research or by deliberately ignoring research results.

- *Incoherent in its position and inconsistent in its plans.* The demand side has often been seen as quite unpredictable due to: (a) the rotation of military personnel and frequent replacement of civilian coordinators at the MOD; combined with (b) poor handover practices and deficient internal coordination; (c) a very small administrative capacity; and (d) constantly shifting strategic plans. One interviewed researcher described the situation before the reform of the RC as follows: "There would be one

EDF representative at the RC meeting saying that the project was somewhat relevant. The next meeting would be attended by someone else from the EDF who would be strongly endorsing the project. And yet another military official would be sitting at the next meeting, but already demanding the closure of the project." A bit more stability has been achieved by now through the defence R&D governance reform, plus a somewhat better capability planning process, but the situation is still very tenuous. For instance, as it was pointed out, being a leader of capability working groups (and thus a member of the RC) was still only a part-time activity, which was also subject to military personnel rotation, meaning that much of the tacit knowledge about a particular capability package and R&D activities supporting its development could be easily lost.

The perspective of the defence organisation. The other side – the defence organisation – voiced its frustrations over the lack of understanding shown by the S&T community of the military and their needs. Scientists were viewed as mostly advancing their own scientific interests with scant regard for their connection with the practical imperatives, priorities and abilities of the military organisation. Some members of the defence organisation argued that at the extreme scientists approached defence as yet another pot of money, which they could reach into to finance their own scientific ambitions (sometimes double-selling or even triple-selling their projects to various sources of funding, such as the MOD, Enterprise Estonia, the ETF, etc.).

One scientist admitted: "Before the financial crisis, the MOD acquired a reputation as a source of 'easy money', which approved almost everything that was suggested to it by scientists." An interviewed defence official concluded that the doubling of the R&D budget in 2007–2008 had been totally unjustifiable and had made the situation even worse. As a result, when money became tight during the financial crisis, the military sought to put an end to many of the projects deemed of little value and relevance to EDF needs or most likely to end without any usable results.

MOD and EDF representatives talked about many enormous and continuing difficulties in convincing scientists that military requirements should reside at the heart of decision-making about R&D investments. The main complaint was that some scientists still rejected this notion out of hand by insisting that the defence R&D agenda should be driven by some broader vague considerations and principles, not by the decision-making criteria established during the reform period.

In addition, some S&T representatives often seek to bypass the reformed decision-making system, which subjects 'bottom-up' initiatives and proposals to more rigorous scrutiny in the context of the identified (or identifiable) EDF requirements and priorities. According to the defence officials interviewed for this paper, these people use various tactics to push their scientific and financial interests into the defence organisation through the 'back door': they collude with EDF officers within the defence organisation with whom they have some previous association in order to lobby the military chain of command from within; they try to influence high-level decision-makers through public or private channels; they increase pressure by using international contacts, etc. This is perceived by the defence organisation to highly complicate the transition to a more strategic, orderly, methodical and effective way of managing investments in defence R&D and to undermine the integrity and transparency of decision-making.

In changing the terms of interaction between the defence organisation and the S&T community and in trying to intensify this interaction, the MOD and the EDF are being hampered by a string of issues and problems which were also ascertained in the course of the interviews. The most serious issues concern:

- *Lack of a continuous and effective communication framework.* Some scientists who maintained an interest in defence complained that MOD or EDF representatives appeared only very seldom on their horizon to ask a few questions and then to disappear again for lengthy periods of time. The MOD and the EDF, for instance, did not organise any events for the S&T community – national and international – to present the Long-Term Defence Development Plan 2009–2018 and capability priorities and to discuss what needs or opportunities for R&D stemmed from it. Discussions have mainly been confined to the RC format. So far, there is no regular forum (e.g. an annual conference, thematic workshops) that provides a legitimate, transparent and all-inclusive way for conducting the dialogue between the stakeholders and for exploring various opportunities. Some interviewees, however, considered such a forum would be a little premature and suggested that the defence organisation should first achieve a measure of stability in its own strategic plans and clarify its own needs before reaching out in full force to the S&T community.
- *Lack of a clear R&D 'business process'.* The EDF does not have a clear full-length process and a methodology for moving from an idea and a requirement to an R&D project request and to the use of R&D outcomes in a disciplined fashion. It is understood that the coordination function is now centralised at the HQ EDF (J5/9), but that is all. The MOD part of the process is more or less in place, although it has not been very well explained to the S&T community and it lacks some elements (e.g. one researcher asked: "Who are the curators responsible for each direction of the Defence R&D Strategy?"). But the MOD part of the process is only one of the segments of the entire R&D system, while the MOD as a separate organisational entity from the EDF has very little visibility in and control over what is happening in the EDF before, during and after an R&D input. Therefore many end-users on the military side and suppliers on the S&T side felt that they were not entirely sure about where and how to interact at different stages, what were the 'rules of the game', how the R&D process fit in with other processes in the defence organisation and who was responsible for various process stages or sub-processes.
- *Use of Subject Matter Experts (SMEs).* The EDF seems to lack effective policies and mechanisms to encourage and support SMEs in its ranks, to motivate them properly and then to utilise their knowledge. It was said many times during the interviews that such SMEs constituted a

critical link between S&T and the defence organisation. SMEs can appreciate the nature of both sides, which is why they can act as 'knowledge brokers' (usually, they would be appointed as PoCs for projects). In some fields, there are enough of them in the EDF, but they are often assigned to wrong positions, making them thus unable to bring their knowledge to bear on the enhancement of the organisation's technological competence and on the facilitation of its interaction with the S&T community. One interviewee said: "They are tired of counting socks in warehouses and are eager to use the 'grey cells' of their brains, but they are not given an opportunity to do so." In other fields, the numbers of SMEs are extremely small, which makes them all the more valuable. However, they find little inspiration in working for the EDF if they are deprived of interaction with other SMEs in the civilian sector or abroad. The opportunity to participate in NATO RTO projects often serves them as an important professional incentive. Yet their chain of command frequently obstructs such participation or fails to use its results, instead of utilising it as a tool for linking up with the international S&T community and for increasing the EDF's competence.

- *Absence of 'knowledge hubs'.* This is an extension of the above problem of SME management. So far, the defence organisation has been oblivious to the benefits of concentrating some of its SMEs in 'centres of competence' within its structure. If anything, the trend has been either very slow or even in the opposite direction. As it was pointed out during the interviews, the ICT development and training centre of the EDF was 'hollowed out' when its expertise was transferred to the CCDCOE. Major hopes concerning the start of an in-house competence building programme in the EDF and the building of a research capacity in doctrinal and operational research and in capability and resources planning are associated with the ENDC Applied Studies Centre, but it still has a very few positions (and even fewer of them are filled). Ideas for the development of the Logistics School as a 'centre of competence' have not moved past the discussion stage either. As a result, experts from outside the defence organisation do not know where to locate their military counterparts and how to interact with them. One university scientist said: "It would be nice to have a research centre in the EDF with which to cooperate."
    - Partly as a way to rectify the problem of 'knowledge hub' absence, some scientists advocated the idea of establishing a specialised defence R&D agency outside the defence organisation structure altogether. However, other interviewees expressed their reservations, saying that such a separate agency might lack the trust and involvement of the military and that it might therefore put an even greater distance between the EDF and the S&T community. Furthermore, as it was pointed out, its overhead costs alone would probably be greater than the current defence R&D budget and, as all bureaucracies, the agency would eventually

end up perpetuating itself rather than serving defence interests.

- *Dependence on very few 'active agents'.* Many interviewees, in both the S&T community and the defence organisation, pointed out that the entire progress and momentum in developing the defence R&D system, in implementing the Defence R&D Strategy, in preparing support methodologies and procedures and in keeping the stakeholders actively involved depended on very few individuals (e.g. defence R&D coordinators in the MOD and the HQ EDF) who had established an excellent working relationship between them. If they are rotated or quit their jobs (leaving the positions unfilled for a prolonged period of time), or if they are replaced by less active, committed and knowledgeable individuals, the momentum gained after the reform of the sector could be lost easily. Worse still, another round of radical changes might ensue, which would not be conducive to maintaining trust between the stakeholders. For bringing defence R&D forward and for establishing routine patterns of interaction between the stakeholders, a researcher suggested: "All what we need now is stability, continuity and steady accumulation of positive practices at least for the next five years."

The above summary risks painting too bleak a picture and neglecting the positive elements or developments. In the course of the interviews, the following positive experiences and trends were ascertained as well:

- Military SMEs in various fields (e.g. military medicine, education, logistics, engineering, de-mining, NBC defence, C3I, radars, military geography, etc.) and different services appeared to be strongly interested in R&D, often serving as a constant source of ideas and requirements for R&D input to advance the defence organisation's competence, performance and capabilities. They are always on the lookout for new opportunities to initiate new R&D projects and to draw scientific advice into the defence organisation because they appreciate what the S&T community can offer.
- Many scientists, despite their frustration with and certain mistrust in the defence organisation as a credible long-term partner, are still ready to engage in collaboration. One scientist said: "We are still interested, although not very optimistic." The stated strategic intention to invest in maintaining national S&T competence relevant to defence (one of the directions of the Defence R&D Strategy) is something which, according to one interviewee, "still keeps scientists excited" about working with the defence organisation. Indeed, as a result of their previous projects for the MOD, some of them acknowledged that they had gained a better understanding of the military and that they still continued to exercise a strong interest in defence technology (e.g. they attended defence technology exhibitions abroad, studied specialised literature and research reports) even without the support or the encouragement of the MOD and the EDF.
- A better understanding of EDF requirements is emerging during the analysis, planning and implementation of the capability priorities set out

in the long-term plans and the analysis of the lessons learned from the campaign in Afghanistan. This endeavour is complicated by the fact that the EDF has never possessed some of those capabilities and there are no corresponding experts in Estonia, which is why knowledge about those capabilities has to be built from scratch. Nonetheless, as a result of these efforts, some of the technological competence (and related R&D activities) previously dismissed as irrelevant or premature (for instance, NEC) is now being tentatively brought back to the agenda. In addition, continuous exposure of the EDF to tactical challenges in Afghanistan is starting to stimulate the interest of lower level military 'generalists' in research studies and projects.

- The interviewed members of both the S&T community and the defence organisation largely agreed that the reform of the governance framework was a major step in the right direction, even though some scientists treated the impact of the RC on decision-making with a degree of scepticism and some expressed the view that the TAKT was mainly designed to put up bureaucratic obstacles to good ideas.
  - Members of the defence organisation noted that the reformed system did a lot to facilitate consensus building and coordination between the MOD and the EDF regarding defence R&D, which was considered to be quite an achievement compared to the pre-reform arrangements, under which the MOD and the EDF often were at loggerheads. (The HQ EDF feels that they are a few steps behind the MOD in developing the system, which may serve as a source of frustration for the MOD, but this is what happens if R&D coordination in the EDF is just part-time work.) Currently, the MOD acknowledges its lack of military expertise and, with the express approval of the military, defers to the EDF and military SMEs of the RC whenever R&D has to be justified by a clear military requirement. This is in stark contrast to the previous practice when the MOD largely ignored, or neglected to solicit, military input in its decisions about R&D investments.
  - Many stakeholders are also pleased that due to changes in its composition and roles, the RC is neither a scene of constant quarrels between bureaucrats who have nothing to do with S&T on the one hand, and scientists on the other (as in 2006–2008), nor a tool for scientists to dole out money to other scientists (as in 2001–2006). The reformed RC has better prerequisites for becoming a genuine source of S&T advice and expertise and an interlocutor between military and scientific competence. One scientist made the following observation: "It is good that most members of the RC have ceased to represent institutions and structures and now mostly represent areas of competence."

3.3 Project management

Experiences and insights, which can be gleaned from past and current projects, constituted an important strand of inquiry in this study. During the interviews, questions were asked about project management practices applied by the defence organisation and the contracted research teams. This also included inquiries into how the defence organisation made decisions regarding the continuation or the closure of individual projects and how it facilitated their implementation. Problems with the application of project outcomes were discussed too.

It became clear from the interviews that there was no serious project management capacity and no infrastructure behind the defence R&D programme. Even large projects did not have any dedicated professional project managers to run them. One interviewee said: "There is simply no structure to support big ambitious projects." This is, according to the interviewed officials, one of the reasons why some big projects were halted after first stages, i.e. before they reached a more demanding phase and higher TRLs.

Project management was performed by researchers themselves who relied on the administrative and organisational support of their home organisations. In some cases, there was a distinct lack of support and researchers were seriously hampered by obsolete and unreasonable bureaucratic procedures or even hostile attitudes of their administrative staff or leaders. For instance, commenting on the new requirement to participate in NATO RTO groups as part of project activities and to have universities co-fund them, one researcher complained that the administration of his university was not at all delighted about that. He said: "The administration is more interested in raking money in, not in spending it to support some projects."

Until the reform of 2009–2010, many projects started without any clear ideas about military requirements, as this was not a criterion for project approval, and without a proper analysis of risks or the availability of technology abroad. (One officer said: "Many projects of experimental development should not have been started because foreign products existed and were available for purchase.") In some cases, even appointed military PoCs had no clear idea of what should be sought by their projects. Some project teams made considerable efforts to clarify it in collaboration with their PoCs or through informal contacts with other members of the defence organisation (usually SMEs), while others worked in almost complete isolation from potential end-users and the defence organisation as a whole. (As part of the reform, this is being rectified by the MOD – RC experts will be asked to conduct an analysis of the military requirements of and the need for R&D projects in the context of the already available knowledge and technology and to assess the feasibility of potential projects before they are initiated.)

Even if some clarity had been achieved in a project, there was no certainty it would persist until its completion: new representatives on the user side would bring in completely different considerations, opinions and demands, thus altering (sometimes quite radically) project requirements, but without conducting any thorough re-assessment on how, for instance, project risks, costs, duration and other parameters might change as a result of that. One researcher talked about his project, which could accommodate some of the changes (even benefit from them), but only up to a certain point. This led the military to dismiss the results as not satisfactory, even though it was their inability to determine their own requirements and to adhere to them in the course of the project that had caused the problems in the first place. (Paradoxically, in one particular case, after receiving a prototype from an Estonian project, the EDF went on to procure a foreign equivalent, but with less demanding specifications than those insisted from the Estonian project).

The interviewees had had varied experiences with the PoCs appointed by the defence organisation, who were supposed to provide a vital link between projects and the end-user. In some cases, PoCs were very engaged and responsive, ready to provide their advice and feedback and to promote awareness about the projects inside the defence organisation. These PoCs seemed to have strong professional interests in project results. There had been cases when the continuation of projects or the use of their outcomes became uncertain because such committed PoCs had been rotated and replaced by less interested ones. In other cases, however, PoCs were nowhere to be seen. Project teams either had to work on their own, without a link with the end-user, or to find (sometimes by pure accident or luck) some interested representatives of the end-user by themselves.

In the course of the interviews, it became clear that PoCs had no clarity about how and why it was decided to appoint them to their position. They also did not have any formal terms of reference which would fix the organisation's expectations concerning them or any procedures of interaction with project teams and with the defence R&D administration. Their interaction with project teams (if there was any) was driven by their own professional interests and curiosity. It was also informal, without any formal records of communication, which left many lessons about practical challenges, issues and problems, which had been encountered in the course of various projects, unrecorded for the institutional memory of the defence organisation. In some cases, actively engaged PoCs felt rather disappointed that the MOD and the EDF did not consult them about projects when deciding their fate. This was seen as unwillingness to incorporate the advice of those who were most knowledgeable about the problems and the prospects of projects (apart from project authors themselves, of course).

Some interviewees questioned the transparency, effectiveness and credibility of the assessments made by the reviewers appointed by the RC. It was suggested that in some cases, there might be no other competent Estonian expert than a specific project's author who would be able to make credible judgements about project performance and results. Some authors argued that the assessments of their projects lacked depth and utility, so that they could not be properly used as peer feedback or as a basis for decisions by the MOD regarding further project continuation. Many complained that they had no idea what assessment and decision criteria were used by the MOD to make decisions about projects. Those whose projects had been terminated or suspended during the financial crisis felt that the decisions had been quite arbitrary. Conversely, the MOD had encountered cases where project reports had been delayed considerably by project authors who thus prevented the organisation from assessing the results and making objective decisions about further investments.

As a sub-theme, it also emerged that even the most careful appointment of reviewers could not avoid conflicts of interest or clashes of personalities. Estonia is such a small country with a very small S&T community that a reviewer and a project author (especially if they work or have worked in the same field) might have a record of relationship not conducive to the objectivity of the reviewer. At the same time, formal ethical guidelines for reviewers are lacking and there has been no practice of employing reviewers from outside Estonia. (During the writing of this study, the MOD gave an assurance that draft ethical guidelines in the form of a declaration of interests were ready).

The defence organisation's administrative capacity dedicated to the administration of the R&D process is extremely small (and overburdened with other duties and responsibilities, not to mention the challenge of managing the reform).[15] As a result, projects often had to contend with rather slow movement by the defence organisation in fulfilling its side of the bargain. For instance, there had been cases where it took many months to prepare contracts between project authors and the MOD or where funding transfers suffered significant delays while R&D project leaders had to adhere to their project schedules and to make financial commitments (e.g. to purchase equipment). On the other hand, if something went wrong with a project schedule and funding transfers had to be postponed beyond the end of a fiscal year, it meant that the MOD had to return the earmarked funds to the national budget while being unable to give firm guarantees that the funds would again be available during the next fiscal year.

Many interviewed project authors and participants in NATO RTO panels expressed their disappointment with the use of the results of their work by the defence organisation. They claimed that the defence organisation did not have clear policies and procedures on how to assess the outcomes of R&D projects and how to best utilise the knowledge generated by them or drawn in from NATO RTO knowledge networks. There is little or no feedback from the end-user to project teams and the RC. The deficiencies in the distribution and use of valuable knowledge from NATO RTO were particularly disappointing to those who participated in its activities. A member of a NATO RTO panel said: "I stopped putting much substance into my reports from the panel because I felt nobody was really using them." Another contributor to NATO RTO projects added: "No one in the EDF is interested in what I've been doing in the [RTO] panel and how the results of our research could be applied in Estonia."

This brings us to another interesting sub-theme: the ability and willingness of the defence organisation to learn from failure. Many interviewees noted that the EDF expected 100% success from R&D projects, ignoring the fact that failure was a constant and inherent risk in many R&D programmes. The important thing is whether the organisation can learn anything from this. One interviewee used the example of a Canadian UAV project: it failed to produce a usable outcome in the form of a fielded system, but the knowledge obtained in the course of the project was later very effectively utilised in decision-making in UAV acquisition processes. This is in stark contrast to Estonia's inability to apply the knowledge accumulated through its R&D projects – whether failed or successful, but not carried through to the highest TRL – in defence planning, acquisition, management, operations and training.

[15] In addition to the administration of all contracts, the MOD's R&D coordinator also has to provide staff support for the RC and the TAKT, to organise international events, to draft policies, procedures and methodologies related to defence R&D, to represent Estonia in NATO and EDA bodies, etc. In the meantime, the principle responsibilities of the HQ EDF's R&D coordinator lie in the area of capability planning and implementation rather than R&D (e.g. he is currently also the leader of the armoured capability working group). This means that R&D management is only a part-time responsibility of a staff officer at the HQ and that it is often forced to take a back seat because the military leadership does not treat it as essential anyway.

In the course of the interviews, it also emerged that the MOD had no policies, capacities and instruments for the management of intellectual property rights (IPRs) acquired as a result of its investments in R&D. (The organisation does not even have a legal advisor on IPR issues.) In particular, this was seen as an issue in cases where project deliverables could have been used to develop a product and to deliver it to the market. As a state institution, the MOD is not supposed to pursue the commercialisation of R&D results for the purposes of profit (or for making a return on its investments) and it does not have, as part of its mission, a mandate to set up commercial enterprises which could exploit MOD-held IPRs.[16] There were suggestions for closer cooperation with Enterprise Estonia in order to put those IPRs out for further use by the private sector, so that it could come up with commercial products, but so far these ideas have led to nothing.

[16] The MOD used to own a state enterprise 'E-Arsenal', which was seen as a repository of MOD-owned IPRs and a vehicle for pursuing further commercialisation of R&D outcomes. However, a political decision has been made to close the enterprise.

4. Discussion: the constant challenge of doing useful R&D and making use of it

In this part, the analysis of and reflections on the most salient aspects of Estonia's defence R&D – its achievements, changes and shortcomings – are presented (they are also provided in the form of a SWOT analysis in Annex B). Those aspects are also considered in the context of the findings about defence R&D of small NATO Allies (Jermalavičius, 2009a) and the literature on management, defence technology and R&D. Thus the groundwork is laid for the conclusions and the recommendations articulated in the closing part of the study.

4.1 Strategic change: putting the horse in front of the cart

There is voluminous literature on strategy, which is generically defined as a relationship between means or resources, ends or objectives, and ways or concepts (Jablonsky, 2006), yet it advances too many concepts, typologies and models to be comprehensively covered and employed in this study. However, for the purpose of discussing Estonia's defence R&D strategy, the following theoretical aspects, drawn from the literature on strategy in defence and on organisation management, are very useful and should be borne in mind:

- There can be a declaratory strategy, fixed in the official documents of an organisation, which may or may not be the strategy that the organisation really believes in and acts upon. There can also be an actual (real) strategy or a strategy that 'addresses the difference between the declared strategy and reality' (Bartholomees, 2006: 83). It is unwritten but often understood and shared across the organisation as the basis for coherent action.
- In complex organisations and fields of activity, there are entire hierarchies of different strategies. Lower level strategy is tactics or an implementation plan for higher level strategy (Luttwak, 2001). There can be several functional strategies at the same level, or dimensions of strategy, which ideally are well-synchronised and coordinated or, in the words of Colin Gray, 'need to be viewed as mutually dependent partners, related essentially horizontally, as well as on a ladder of subordination' (Gray, 1999: 21).
- Strategy-creation is a dynamic process, whereby shifts in the environment of an organisation and changes in its strategies on different levels and in different dimensions require constant efforts to keep a particular strategy relevant, effective and in sync with other strategies. However, it takes time and continuous data gathering to observe the real impact of a new strategy or a strategic change, especially if the time horizon of the strategy spans years or even decades due to the nature of its object.
- Organisations use strategy-creation processes as the means to harness the full creative potential of their members (Hamel, 1996), to build consensus among the stakeholders (Hart, 1992), to advance a unifying

vision of the future and to manage expectations (Johnson et al., 2005). To achieve this, strategy-making has to be an inclusive, democratic and consultative process. Even if it does not result in a formal strategy, there are enormous benefits in the achievement of a shared vision and a consensus over the goals, direction and appropriate means of an organisation.

- Leadership is critical in strategy processes. In its original meaning, strategy, or *strategos* in Ancient Greek, is translated as 'the art of a general'. The success of a strategy very much depends on the exercise of appropriate leadership by many members of the organisation as a community (Ireland & Hitt, 2005). Without it, the phenomenon of 'strategic drift', or misalignment between the organisation's environment and its strategy (Johnson et al., 2005), and a damaging discord between stakeholders assert themselves.

Until 2008, the Estonian defence organisation operated without a formal defence R&D strategy. Its R&D investments were driven mostly by an S&T 'push' and political flag-waving to imitate and impress the Allies, all imposed on a reluctant, conceptually and technologically unsophisticated military organisation. A formal strategy was put in place in 2008 to provide the basis for a more purposeful endeavour. Its financial prerequisites suffered heavily just a year later, when the state budget took a hit from the global financial crisis. Deep cuts had to be administered quickly, which meant there was not much strategy, if any, in the way that defence R&D was curtailed in 2009.

Almost immediately, the opportunity was also realised and seized upon to enact a crucial strategic change: to place military requirements at the very heart of defence R&D. Speaking in figurative terms, the defence organisation mustered its will to stop the practice of the tail (S&T) wagging the dog (the EDF) and decided to put the horse (military 'demand pull') in front of the cart ('supply push'). However, the formal strategy is not so clear-cut about the centrality of military requirements, which means that a gap between the formal strategy and the actual has appeared. Since 2010, as defence R&D has been rebuilt on a new basis, even further gaps between the declared formal strategy and the actual one have been emerging. For instance, everyone agrees that R&D investments are, first and foremost, about helping the defence organisation to become 'smart' – a smart buyer, a smart user, a smart operator and a smart Ally. But this is not even mentioned as the primary objective of defence R&D, let alone that it would dominate defence R&D.

Broadly speaking, that figurative 'horse' should be the national RD&I Strategy. This would imply that the Defence R&D Strategy is just its implementation plan in the realm of defence, which would reflect a broader trend of defence R&D becoming an extension of civilian R&D, mostly with the aim of adapting civilian technologies for military purposes. Defence R&D investments, even by the most powerful nations in military and economic terms, have ceased to be one of the main drivers of innovation in civilian societies and economies. Quite the opposite, civilian R&D and the proliferation of innovation in the civilian sector are now the main sources of knowledge, ideas and solutions that are adapted for military purposes (Mallik, 2004: 5; James, 2004: 28). With 'inside out' (military technologies spilling into civilian sector) increasingly being replaced by 'outside in' (civilian technologies adapted for military uses) in the relationship between military and civilian innovation, the emphasis has shifted to how well the defence organisation manages to 'spin in' civilian technologies by using the available resources for defence R&D. As one expert stated, "being a 'smart user' these days is mostly about being aware of what is happening in the civilian sector and possessing understanding how to use building blocks of civilian technology to re-arrange them for use in military capability"(RIIA, 2011). Thus the question is mostly about awareness and the ability to capture and use the benefits of civilian research.

The interviews for this study revealed a predisposition in the Estonian defence organisation to think along the same lines. Indeed, there is nothing in its new strategic approach to defence R&D that would suggest that it is trying to take it out of the national context. Quite the contrary, its stated criterion that all new R&D projects must rely on national S&T excellence ties defence R&D with the national RD&I Strategy very closely as a co-traveller. It is difficult to imagine that the 'niche' areas, which defence R&D pursues, would reside far from where national priorities and strengths lie. What is completely missing is a dialogue between the two strategy processes about the future: there is a risk that in the future, the defence sector will view the areas of importance to S&T development differently from what the national RD&I Strategy prioritises. Conducting future reviews of the national RD&I Strategy without the proper inclusion of the defence sector (and the broader security sector) in the process and performing reviews of the Defence R&D Strategy without the inclusion of non-defence stakeholders will not help to bring defence R&D in sync with civilian R&D.

What follows from the above considerations about strategy in general and about reliance on civilian R&D in defence is that awareness is critical to ensuring an adaptive and relevant strategy for a 'smart organisation'. Environmental scanning and foresight constitute a very important thrust in strategy formulation of organisations operating in a very dynamic and competitive environment (Bourgeois, 1980). This applies equally to understanding future challenges and opportunities associated with S&T, as the pace of scientific development and disruptive technological change is accelerating furiously. As explained by Cornish, 'the image which best summarizes the contemporary relationship between technology and strategy […] should be that of technology racing ahead and national strategy struggling to catch up' (Cornish, 2010: 880).

An 'awareness capacity' is thus one of the building blocks for an effective defence R&D programme (others being 'absorptive', 'transactional' and 'administrative' capacities – see Wylie et al., 2006). In Estonia, general S&T foresight is mostly geared to the needs of economic policy. In defence, S&T foresight is a complete *terra incognita*: neither the existing formal Defence R&D Strategy nor its emergent new elements address this imperative at all. The new National Defence Strategy of 2011 does not call for that either. The defence organisation is essentially uninformed when it comes to the opportunities offered by S&T foresight to formulating both Estonia's national defence policy and its strategic choices in defence R&D. The expectation that the competence and awareness of individual RC members will somehow suffice to ensure S&T foresight is rather inadequate given the nature of the tasks at hand.

In order to supplant foresight and to avoid clear-cut choices with ensuing long-term commitments, which allegedly may restrict the flexibility necessary for coping with future uncertainties, Estonia's Defence R&D Strategy does not prescribe very clear parameters and principles for making investments. Small nations with limited resources are usually very straightforward about their programme's level of ambition (e.g. the TRL beyond which they will not go or at which they will ensure a takeover by industry), the corresponding focus in the R&D 'value chain' (e.g. on applied research), sought deliverables (e.g. knowledge/'know-how' rather than prototypes for T&E), their 'niches' of specialisation and their main international partners. They communicate all this openly to domestic and foreign stakeholders and they allocate financial resources accordingly. Thus the strategy process serves as a tool for consensus-building and strategy itself is instrumental in communicating and reinforcing this consensus.

Divergent perceptions and expectations between the S&T community and the military about the very meaning of R&D and its outcomes represent a distinct problem for the Estonian defence organisation. Their alignment is a work still very much in progress, as attested by the efforts of the reformed RC and its results such as the published list of 'niche areas' and 'technological competences', which are of interest to defence. However, the formal Defence R&D Strategy appears to be of no use in advancing such consensus and in maintaining communication. Therefore the Estonian military still consider technology to be mostly 'hardware' and even in this regard, they are not enthused by applied research – they expect the outcome of R&D to be new equipment that can be deployed in operations, although in order to achieve that, it is necessary to go through many other stages of the innovation process, which go well beyond R&D. This view does not appear to be shared by members of the S&T community – they think that technology is not only 'hardware' but also processes and methods and that new knowledge is a legitimate and, indeed, the most desirable outcome of R&D. However, from the perspective of the S&T community dominated by NSE representatives, SSH subjects (with the exception of human factors) do not stand in a position of equal importance to other defence R&D areas.

One reason behind the Defence R&D Strategy's failure to advance a broad consensus could be that its drafting process was not as consultative and inclusive as strategy-creation should be. This resulted in very limited awareness of the formal strategy among the stakeholders and even lesser acceptance. Those tasked with the strategy's implementation then faced an uphill struggle to secure its acceptance, while simultaneously re-starting the entire system on its basis. Another reason is the aforementioned reluctance of the defence organisation to make commitments that would allegedly hamper flexibility and narrow down future options. The formalisation (if any) of major strategic choices is being relegated to the level of administrative rules and executive orders – which can be easily changed or discarded and which are less visible – rather than including them in the Defence R&D Strategy and its review. In addition, major strategic choices are expected to emerge through practice.

The question is whether the Estonian defence organisation can continue with such 'strategic ambiguity'. Without making a clear and formal statement about the focus, 'niches', deliverables and principles of its R&D investments in the formal strategy, the management of stakeholder expectations and initiatives will remain extremely difficult. This will also continue to expose the defence R&D system to clashes of interests and hidden influences, which usually thrive in undetermined, vague policy environments. It will be very difficult to ensure the transparency and predictability of defence R&D investments, together with the coherence of the investment portfolio, and to create a stable perspective for the stakeholders, especially the S&T community, without periodically aligning the formal strategy with the actually emerging one. These alignment activities should also include the setting of a realistic, affordable and feasible level of ambition – in the course of doing research for this study, it was difficult to shed the impression that some stakeholders operated under quite unrealistic assumptions about the possible breadth of the Estonian defence R&D agenda, the nature of its deliverables and the amount of capital – both public and private – available for it.[17]

In a similar vein, the need for and the choice of international partners for bilateral and multilateral collaboration are not fixed in the formal strategy. They emerge through the making of defence policy choices (e.g. as part of the rejuvenation of the Baltic defence cooperation agenda), but not through a thorough analysis of common interests or complementarities. The obvious risk is that if they remain outside the process and framework of the Defence R&D Strategy, such collaboration initiatives will produce nothing more but empty promises, short-lived expectations and one-off projects, which are only good for ticking off boxes and reporting to superiors. It has been noted that the 'history of international S&T collaboration is littered with cooperation agreements that stayed only on paper' (Stein, 2011). The identification and naming of preferred international partners in the formal strategy would also help project authors to coax counterparts from abroad into their projects. The interviews revealed that the main obstacles in this regard are the defence organisation's limited awareness of foreign activities in defence R&D and the limited choice of partners who are at a similar level of defence development and who are therefore dealing with a similar set of problems and uncertainties that need R&D contribution.

Participation in NATO RTO and the EDA is a well-established formal strategic objective with a very sound rationale behind it shared by the stakeholders – these participation efforts make it possible to tap into the knowledge networks of the Alliance, to enhance knowledge through collaboration and to share 'know-how'. By now, attempts are being made to better link them with the needs of the EDF and with ongoing R&D projects. By any measure, Estonia is getting involved in an increasing number of groups within this network. If the same degree of involvement is achieved with the EDA, the thrust of the Defence R&D Strategy will certainly deserve the title of 'success story', offsetting the lack of fixed bilateral or multinational partnerships.

The first major caveat here is, of course, the ability to utilise the outcomes in the defence organisation, which will be discussed later in this part. Second, the question arises to what extent Estonia is willing, ready and able to participate in

[17] As an example of a realistic level of ambition, in Australia – a country considerably larger and richer than Estonia – less than 15% of the budget of its Defence Science and Technology Organisation (DSTO) is dedicated to long-range ('blue sky') R&D, i.e. the development of completely new technologies and capabilities. The rest – 85% – is spent on investigative S&T activities related to the organisation's advisory role (see Ferguson, 2010).

R&D 'pooling and sharing' initiatives, which will proliferate if an overall 'pooling and sharing' philosophy gains momentum within NATO and the EU. More involvement in such initiatives will require Estonia to enter into more multilateral 'coalitions of the willing'. This brings us back to the problem of knowing what other countries are doing in defence R&D. The provision of adequate financial resources to support participation in NATO, the EU and multilateral 'pooling and sharing' arrangements is another serious question.

The dynamic of defence R&D spending appears to be a disaster story, but only if one examines it in isolation from the evolving relationship between S&T and defence in Estonia. The decline in funding has certainly been more precipitous than that in national R&D investments – this is the disastrous part on the surface of things. However, in order to judge the dynamic adequately, one has to appreciate the different drivers of spending before the reform in 2008–2010 and after it.

Until the reform, it was a matter of convincing policymakers that the 'supply push' had to be met with financial resources, whether real demand was there or not. Naturally, this proved to be an unsustainable course of action once the MOD started listening more attentively to the military and heeding their opinion. After the reform, it became a matter of convincing the policymakers that there was real demand before they committed funds. However, either in the years of boom or bust, the R&D benchmark of 2% of the defence budget has not been – and still is not – in sight. This fact is simply a symptom of a deeper issue, namely that R&D is not seen as a strategic investment by those at the top of the defence organisation who make decisions about spending priorities. This, in its turn, reflects the reality in that the defence organisation has not yet reached the level of development and sophistication necessary for greater reliance on more complex and original R&D solutions.

The pressure from a growing demand for new knowledge in the organisation, greater S&T literacy of the leadership and increasing confidence that S&T can deliver useful results will help to change this predisposition in the long term. In the short term, there might be pressures from the S&T community and its lobby to rush towards the benchmark only in order to show off politically and to be in line with the policy of fulfilling the role of an exemplary NATO or EU member. However, this could easily undermine the demand-driven strategy and alienate the military again, leading to the same perceptions and public accusations of 'wasting money' which concluded the pre-crisis period of defence R&D spending. In order to avoid this, to consolidate the results of the reform and to build upon them, strong and enlightened leadership is required from those who are in charge of R&D in the defence organisation, but leadership is often somewhat lacking at the levels above R&D coordinators in the MOD and the HQ EDF.

Some of this short-term pressure to produce appropriate levels of defence R&D investments could be relieved by consolidating spending on research projects that are currently not included in the formal defence R&D budget line managed by the MOD Procurement Department. Of course, this depends on the outcome of discussions (for instance, in the EDA) about whether R&D in SSH subjects qualifies as R&D and raises questions whether it is appropriate to keep the R&D coordination function in the procurement structure of the MOD.

There should be no reasons to exclude SSH and to treat only NSE as a legitimate area of defence R&D investments in Estonia. After all, the OECD standard establishes clearly that the former is part of R&D. There is also a growing trend in advanced military organisations to recognise the rising importance of research in SSH to the enhancement of the effectiveness of military organisations, for instance, in counter-insurgency warfare or in ensuring a comprehensive approach in security and defence (the Minerva program, launched by the U.S. Department of Defense in 2008, is a prime example of this – see Gates, 2008). However, in the long term, sustainable growth towards the 2% benchmark will be impossible if the defence organisation, as the source of demand, does not achieve parallel intellectual and technological growth. This leads us to the discussion of growth problems.

4.2 End-user as the 'weak link'

Two conceptual lines of thought are useful in examining the issues related to the end-user of R&D process outcomes. One explains why an end-user is central to the process, while the other gives some ideas about which characteristics of an end-user best position it to benefit from R&D:

- The first line of thought is based on the observation that in defining and shaping constructive attitudes, behaviours and interactions between several stakeholders, it is often useful to construe their relationship as that of a customer and a supplier. This helps to introduce some sound business-like logic into the relationship between the stakeholders, whereby the customer's need is central to the supplier's effort and therefore the customer should – in the ideal case – be involved in all development stages of a new product or service (Kotler & Keller, 2006).

  The NATO S&T community's leadership is very conscious of the fact that the military is the customer and the S&T community is the supplier: a very strong emphasis is placed on encouraging close collaboration between the two sides and on ensuring that R&D delivers relevant and useful results (Walker, 2009). Embedding military practitioners with recent operational experiences in R&D project teams to guarantee that those projects address relevant issues is seen as 'best practice' (RIIA, 2011). It is equally important that R&D processes and the competence of the supply side are properly linked with the customer's (i.e. the military's) 'core processes', particularly with those that drive military innovation such as CD&E (Harrison & Lestage, 2004) and/or that require high operational performance under very demanding circumstances in the theatre of operations (RTO, 2009).

- The second line of thought is based on the concept of 'learning organisation', defined as 'an organization skilled at creating, acquiring, interpreting, transferring, and retaining knowledge, and at purposefully modifying its behaviour to reflect new knowledge and insights' (Garvin, 2000: 11). Such organisations possess a number of structural and cultural traits that facilitate learning and innovation processes – processes, in which R&D as creative work aimed at enhancing and applying knowledge is a natural, organic part:

- On the structural side, a learning organisation excels at bringing together communities of practice, ‘groups of people informally bound together by shared expertise and passion for a joint enterprise’ (Wenger & Snyder, 2000: 139), and at allowing functional experts to share their knowledge or to spread best practice in their field across the entire organisation and its networks (Marsick & Watkins, 1999). These organisations also have personnel motivation systems for rewarding the pursuit of new knowledge, the enhancement of competence and the application of innovative solutions (Pedler et al., 1997). Last but not least, they have very well developed systems for capturing, storing, analysing and sharing data about the environment and their own performance (Appelbaum & Goransson, 1997), which ‘facilitate collective learning, information sharing, collaborative problem solving and innovation’ (King, 2001: 14).

- In terms of organisational culture, a learning organisation is driven by commitment to continuous learning and improvement (Lindley & Wheeler, 2000). It encourages entrepreneurial behaviour, such as risk-taking, experimentation, innovation and tolerance of failure (Örtenblad, 2004), has a long-term focus underpinned by systems thinking (Senge, 2006) and promotes critical thinking, inquiry and dialogue (O’Keefe, 2002) as a means to constantly challenge the established fundamental assumptions about the organisation and its environment (Argyris & Schön, 1978). In addition, a learning organisation possesses a compelling shared vision of the future that serves the goal of demonstrating a gap between the desired future and the current reality, which should be assessed as objectively and realistically as possible (Senge, 2006).

Currently, a profound strategic shift towards giving military needs and requirements the central role in setting the R&D agenda is being enacted in Estonia, following the logic of a customer-supplier relationship. As it became clear from the interviews, this logic is not easily and readily accepted by the S&T community. Furthermore, it is hampered by a continued ‘strategic ambiguity’ on the side of the defence organisation and by a growing lack of alignment between the formal declared R&D strategy and the actual practice (the emergent strategy). This ‘strategic ambiguity’ makes it very difficult to establish and promote a clear customer-supplier relationship and to set the expectations accordingly. However, the most serious obstacle to entrenching a customer-supplier relationship between defence and S&T in Estonia is that the main customer – the EDF – is not a very enthusiastic and engaging organisation. Indeed, if the customer’s demand determined the supply in a simple top-down manner, there would be no defence R&D in Estonia at all.

As unearthed by the interviews and discussed earlier, the EDF is still growing in many respects. For this reason, together with the shortcomings in organisational leadership, the EDF lacks intellectual and technological sophistication, awareness, learning and innovation habits, which could serve as sources of demand. It has a weak ability to identify opportunities or needs for R&D in connection with military requirements (indeed, to define military requirements in the first place), to understand the implications of new knowledge produced by S&T and to apply it. In many capability areas, both relatively simple and quite sophisticated, the EDF has yet to articulate what it wants on a conceptual level (e.g. in NEC), while the supply side has already been pushing far more advanced ideas. The customer is simply unable to appreciate and utilise those ideas.

It is therefore quite understandable that the S&T community in Estonia became frustrated with the lack of opportunities and customer engagement, while the military got fed up with what they saw as pushy suppliers trying to sell ideas to satisfy a non-existing or very vaguely undersood demand. The latter (and the MOD as an interlocutor) came to see this discrepancy as the main reason why defence R&D investments yielded so poor results and set out to change that. Part of this change, of course, involves restraining the 'supply push' from the S&T side by sending it a firm message that it needs to become more oriented to the level and nature of demands and to better tailor its offerings to these demands.

However, if it is to become a 'smart' customer for R&D, the defence organisation seems to have as great a need to change itself as to change the attitudes and expectations of the supply side. Although the interviews provided only a glimpse of the Estonian defence organisation's characteristics, the exact nature of which would have to be ascertained through more rigorous research,[18] some directions for necessary changes can be posited. They entail:

- *Building the right culture* – that of a learning organisation in its full and genuine sense. This requires, first and foremost, a sustained effort and patience from the leadership side. There is a real risk that the organisational culture of the defence organisation, especially of the EDF, will entrench traits that stifle organisational learning and innovation (e.g. authoritarian leadership, the suppression of uncomfortable evidence by the hierarchy, risk aversion, the avoidance of responsibility, stove-piped internal communication, the lack of lateral collaboration, rigid and overly bureaucratic standard procedures imposed from the top, etc.). Short-termism and the lack of a long-term perspective will only exacerbate these traits. This will diminish the value of new knowledge and thus of R&D.

- *Becoming better at managing and developing people*, especially SMEs, and their networks or 'communities of practice'. If the 'technical brains' of the EDF are not well motivated, stimulated, developed, promoted and organised (into internal knowledge hubs or centres of competence[19]), the organisation will be an inept customer in all respects, not only in the field

[18] ICDS has already made some steps in this direction, which resulted in a research report (Lawrence, A., Jermalavičius, T., Tupay, J. & Kaas, K. (2011), 'Organising Defence at the Strategic Level', Tallinn: ICDS). The data and findings, which were generated as a result of this research effort, helped to validate criticisms directed at the defence organisation by the interviewees of this study and shaped the assessments made in this chapter. However, much more thorough and methodologically sophisticated research would be necessary to ascertain the exact nature of the defence organisation's characteristics and tendencies, identified in this study.

[19] On the other hand, the defence organisation should keep in mind the risk of setting up too many 'hollow' and uncoordinated centres of competence without critical mass and the ability to generate results and to make an impact.

of R&D. Circumstantial evidence suggests that the EDF is not particularly strong in this regard as it places insufficient emphasis on specialist knowledge and expertise. There is also a lack of systematic development of the science and technology literacy of military personnel, especially of the non-specialist leadership. Services and branches such as the Air Force and the Navy, the Logistics Centre and various specialised units realise that they depend on technology and knowledge as well as on SMEs. However, the EDF is dominated by a land component in which generalists seem to show much less appreciation for the technological, doctrinal and organisational complexities of defence and less willingness to invest time, efforts and money in corresponding research, awareness and education. The predicament of the ENDC research arm serves as a constant reminder of that.

- *Establishing management systems and 'business processes'*. The fact that the EDF does not have a clear process for moving from a need to an R&D requirement and then on to testing, evaluation, validation and the application of results is only one part of the story. Important as it may sound, this 'business process' only supports two main processes: (1) capability planning, acquisition and development (which includes CD&E); and (2) operational planning, deployment, sustainment, command and control (including sub-processes and mechanisms of lessons learned, operational analysis, etc.). Apparently, many of those core 'business' processes and sub-processes (together with associated knowledge management systems, including systematic data collection) are not in place in the EDF – at least, not in a coherent, full-fledged and routinely practiced form. This makes it virtually impossible to connect defence and S&T in any meaningful way and to get the customer involved in guiding the suppliers of R&D. The defence organisation is making a commendable effort to link its R&D planning with capability processes – the inclusion of the leaders of capability working groups in the RC was certainly a step in the right direction. However, as they are not full-fledged and full-time capability directors supported by an effective set of processes, methodologies and administrative capacities, this is still a rather symbolic measure.

It will take a long time before the defence organisation in Estonia will sort itself out along the above lines and will grow sophisticated enough to become a 'smart' and involved customer for R&D on an equal footing with the S&T community and able to utilise what it can offer (i.e. will build its 'absorptive capacity'). It is right, in principle, to insist on the centrality of military requirements in the R&D agenda and on a customer-supplier kind of relationship with the S&T. However, this raises the legitimate question of whether or not the customer's current state of affairs and attitudes make it reasonable to insist on a new Estonian defence R&D agenda, which would take identified military requirements as a starting point. After all, it is not unusual for a customer to be educated and informed about new possibilities by a supplier, to realise a latent need and, as a result, to develop the demand for that. This would not mean a return to the dominance of suppliers and their unfettered access to defence funds to sponsor their own scientific aspirations. Instead, it would necessitate the enhancement of opportunities for an open and critical dialogue between the Estonian military and the S&T community, so that mutual education and awareness building could take place.

Some prioritisation of strategic directions might be helpful in bringing the end-user up to speed and in turning it into a 'smart customer' for R&D. In the medium term, the ambition to produce R&D solutions to satisfy military requirements could remain as the vision, but a much greater priority should be given to one particular direction stipulated in the Defence R&D Strategy – the one aimed at the development of the EDF's competence. But even here the impact of enhanced efforts will remain very limited if there are no parallel efforts by the EDF to build its organisational capacities, to reform itself and to manage itself better. One might ask, for instance, what will be the point of producing all those PhD graduates in military uniform, which is now a key measure of the competence building strand of the Defence R&D Strategy. Anyway, they will return to an indifferent organisation to further 'count socks in warehouses' or to face bureaucratic obstruction and isolation from external knowledge networks; later on, they will become disaffected and leave the defence organisation altogether. This is why defence R&D reforms have to go hand in hand with, capitalise on and perhaps sometimes even inspire other reforms in the defence sector.

Given that 'defence organisation' is a relative term, the MOD's role as the end-user should also be addressed. Many of its functions would benefit from new knowledge generated by R&D in SSH or NSE fields. As a customer, it can (and it often does) bring to the defence R&D agenda considerations that go well beyond purely military requirements (e.g. the need for S&T foresight, inter-agency cooperation and 'soft' non-military security issues). As a strategic-level organisation responsible for long-term policies, strategies and plans, it can also accommodate longer time horizons, together with greater risks and uncertainties inherent to R&D, which would be much appreciated by the S&T community as the supplier. Whether or not it has the prerequisites for acting as a 'smart customer' for R&D in its own right (the extent to which it evolves as a learning organisation, its ability to articulate its own knowledge requirements and to absorb new knowledge into its organisational processes and outputs or its level of S&T competence) will require further investigation. However, it is obvious that without those prerequisites and without its own input into the defence R&D agenda, the MOD runs a risk of becoming just an administrative interlocutor squeezed between the S&T community and the military. This brings us to the analysis of governance issues in the defence R&D sector.

4.3 Governance: re-setting the system

Ideally, a defence R&D governance framework should provide for effective, accountable and objective decision-making, coordination, oversight and management of R&D investments. It also has to create a basis for effective trust-building and knowledge-sharing between the stakeholders within and outside the defence organisation as well as with the Allies and partners. It also has to be supported by a sufficient administrative capacity, which must ensure that the processes move along in an orderly and timely fashion and that the system is responsive (Jermalavičius, 2009a). Different models of governance can be constructed (see, for instance, Rademaker et al., 2009: 32–33), depending on:

- Its degree of centralisation or decentralisation;
- Its capability ownership – governmental, public or private;
- Its primary focus (orientation) – military or civilian.

Broadly speaking, Estonia's model could be characterised as leaning towards centralisation, relying mostly on publicly owned (universities, REs) R&D capabilities and mostly oriented towards civilian R&D. However, this broad generalisation conceals certain important developments, specifics and wrinkles that have to be ironed out in the future.

First, the centralisation of decision-making, oversight and advice is certainly a key feature of the defence R&D governance system in Estonia. The Estonian MOD is the central organisation where decisions about policy, strategy, financing, international cooperation and projects are made, while the TAKT is used as a coordinating board. The MOD is the main contracting authority. It concludes agreements with the suppliers and controls their implementation. At the same time, it uses a single central body for obtaining S&T advice – the MOD RC – and a single chief coordinator for administering the system. The HQ EDF has also transferred to a system of centralised R&D management by concentrating this function in one branch (defence planning). However, there are a number of peculiarities and complications associated with the centralised approach, or deviations from it, which deserve attention:

- Not all R&D decisions of the MOD are discussed by the TAKT and not all investments are overseen by the R&D coordinator at the Procurement Department. In particular, this pertains to projects in SSH (but not only), which mostly are of interest to the departments dealing with defence policy and defence planning in the MOD. (The military side of the defence organisation – the HQ EDF – centralised its R&D coordination fully, not just partially, and transferred it to the defence planning branch where the demand for both NSE and SSH can be handled from within the system in the context of overall capability development plans.) This odd situation, which is a legacy of viewing R&D very narrowly, just in NSE terms and only in the procurement context, makes the MOD look less organised, less consistent, less comprehensive and less holistic in its approach than it should be, while it also perpetuates narrow, 'hardware'-obsessed and procurement-centric views of R&D.

- As it was stated earlier, 'defence organisation' is a relative term used in this study for the sake of convenience to refer to two entities – the MOD and the EDF. This means that many of the reforms, capacities and arrangements necessary for making the defence organisation a 'smart customer' in R&D are contingent upon the EDF's will and ability to implement them, i.e. the MOD has a limited leverage in making it happen. The EDF is also the entity that determines military requirements, which are now so central in setting the R&D agenda. The MOD, in this regard, is essentially just an interlocutor between the military and S&T. It would not matter much in a governance model with higher decentralisation and increased delegation of the decision-making authority and accountability to the end-user. However, in a more centralised model, especially as far as the system of contracts is concerned, the MOD sits in a tricky position: it has to invite bids and to conclude contracts with R&D suppliers, assuming the corresponding duties and responsibilities, but it cannot be certain that the end-user – the EDF – will not pull the plug on military requirements at some point, leaving legal contracts in limbo but bearing no consequences for such behaviour. Given the EDF's reputation for lacking business continuity, a centralised system of contracts (with the MOD as the locus of responsibility, but without full authority over the EDF's processes and decisions) does not appear to be a sound solution.

Second, it is obvious that almost all defence R&D capabilities are decentralised and reside in the hands of public research establishments, which are oriented towards civilian R&D as their primary function. So far, the in-house R&D capacity of the defence organisation is meagre, even though there are some ideas circulating and steps being made to build it in the areas related to core military functions. Thus the defence organisation is almost fully dependent on the civilian S&T community to provide the required R&D services, but the S&T community does not depend on the defence organisation as a major source of demand and funding (with the exception of a few projects in which team members relied solely on MOD grants). From this model, several important implications arise and need to be discussed:

- The governance framework should ensure that the defence organisation is in close touch with the S&T community – in Estonia and abroad – and is aware of what it can offer. In the Estonian system, the MOD RC is seen precisely as the instrument for ensuring such contact and awareness. The reform, which included the removal of senior defence officials and their replacement with SMEs and capability working group leaders, was certainly conducive to building a more substantive and constructive relationship between defence and S&T. However, its limited and exclusive membership means that a broader circle of S&T and defence stakeholders has little or no opportunities for meeting, communicating, interacting and learning more about each other. To strengthen this 'transactional capacity' of the defence organisation, larger regularly-held stakeholder forums and thematic events for military and civilian SMEs (including foreign SMEs) would be needed.

- Publicly-owned civilian research establishments will always struggle to understand military organisations and their requirements if there are no proper structural and procedural arrangements within the governance model allowing military expertise to provide necessary inputs at various project stages. As long as the EDF structure is without specialised centres of competence housing SMEs (knowledge hubs with knowledge brokers) and assigned military PoCs work without any formal methodological guidelines, terms of reference and training, Estonia's defence R&D governance system will leave too much to individual initiative, informal random interaction and luck. Given the current governance model, it is difficult to reach the level of development that would allow military experts to be embedded in defence R&D projects at civilian research establishments without changing various aspects of personnel management in the EDF.

- Dependence on external S&T providers increases the importance of building and maintaining mutual trust between the defence organisation and the S&T community. For instance, if project assessments by the RC are not seen as objective and free of conflicts of interest, if the defence organisation is perceived as unpredictable, capricious and disorganised or if the military think that members of the S&T community just sit in their 'ivory towers' without addressing real defence issues, there will be little trust and also little ground for cooperation. The defence organisation will have to change the governance model by developing government-owned defence-oriented R&D infrastructure, turn to foreign suppliers or even drop its R&D aspirations altogether.

The third consideration is related to the administrative capacity allocated for the management of Estonia's current defence R&D governance model and for project administration. It is quite obvious that the administrative capacity behind Estonia's defence R&D is rather miniscule. When it comes to professional management of complex defence R&D projects, it is virtually non-existent. Given the size of the defence R&D budget and the scope of the programme, it might appear as reasonable, although the steady expansion of involvement in NATO RTO over the last years has already prompted the MOD to temporarily provide some additional manpower. However, this capacity may become stretched to the limit and be grossly inadequate (thus risking turning it into of an unresponsive, a slow or even a paralysed system) if:

- Fundamental changes are initiated and have to be implemented by building a new consensus, by communicating the change to the stakeholders and by thoroughly reviewing the current set of policies, regulations, methodologies, guidelines, etc. If this happens, neither routine matters nor action points behind the planned changes will receive enough attention (which is amply illustrated by the absence of an implementation plan for the Defence R&D Strategy and of a formal R&D process in the EDF up to now);

- A more sustained and serious push is required to put more substance into, and to achieve some progress in, the implementation of one or another direction of the Defence R&D Strategy. Without a dedicated curator and a coordinator for each direction, their implementation will be sporadic at best;

- Major international gatherings related to defence R&D are held in Estonia or if Estonia is required to represent itself abroad. This would distract attention from routine administrative and more substantive managerial or policy issues;

- A defence R&D coordinator – at the MOD or the HQ EDF – vacates the position and does not have an immediate replacement and/or if the temporary arrangements for the provision of administrative support expire.

This is in stark contrast to the provision of administrative capacity and support to projects in countries like the Netherlands and Norway. It is probably this contrast, combined with the deficit of trust in the goodwill of the defence organisation, that prompted some members of the S&T community to advocate the establishment of a dedicated independent defence R&D agency in Estonia. This would logically reflect a preference for greater centralisation in defence R&D governance in Estonia, but it would also mark a significant change in the governance model from a publicly-owned civilian-oriented to a publicly-owned defence-oriented model.

On the surface of things, an independent publicly-owned defence-oriented R&D agency may offer many benefits. It would serve as a central knowledge hub and a broker between military and civilian expertise, provide the necessary capacity for project management and act as a visible partner to foreign defence R&D establishments, the EDA and NATO RTO. If set up with the participation of governmental stakeholders from security and safety sectors, it would be a hub for inter-agency cooperation too. It would also have advantages, for example, for the management of R&D funding because it could carry unused funds over into the next financial year, if project timelines change. The issues concerning the holding of IPRs and partnership with industry in bringing R&D-based products to market would also be resolved. In a less ambitious scheme, one of the entities under the MER in charge of disbursing R&D funding (e.g. the new Estonian Research Agency) could have a separate defence, security and safety arm, very much like TNO, the applied research organisation in the Netherlands.

On the other hand, the opponents of this model also have a point in arguing that so far the amount of defence R&D funding and the size of respective portfolio do not justify the creation of a separate agency. Furthermore, it should be kept in mind that the military might use the transfer of responsibility for R&D management out of the defence organisation as a perfect excuse to withdraw support for any R&D investments, instead of making progress in overcoming their own resistance to R&D and moving towards a more systematic and professional approach in this area. A separate agency may lack even those few leverages that the MOD currently possesses to knock heads together. It may suffer from the same distrust among the military in the real motives of its activity that they currently reserve for other civilian research establishments. Given that this agency may become a hostage to political, business, scientific and even personal interests – or come to be seen as such – the risk of alienating the military is even greater. In short, instead of helping the EDF to become a more competent, engaged and eager customer, the establishment of an independent defence R&D agency outside the defence organisation may have a damaging effect on the EDF's interest in R&D altogether.

If one accepts the above counter-arguments, one has to acknowledge that setting up a separate independent public defence R&D agency might be a very premature step at this juncture. It is now essential to give the EDF time to enhance its competence and to start showing real interest in R&D without alienating the military. It might be reasonable to agree that a dedicated security and defence R&D agency is a desired element in a future governance model, which may produce many benefits. However, before the adoption of this model, it is necessary to have a clear understanding of the prerequisites for its successful operation, to carry out a careful assessment of its risks and to take many intermediate steps for its gradual implementation. Taking the model out of its overall context of strategic defence R&D management and presenting it as a 'silver bullet' solution to all the problems of Estonia's defence R&D would not be the most sensible way to proceed.

4.4 Towards systematic strategic management of defence R&D

It is obvious at this point that the seemingly simple and narrow subject of defence R&D actually extends to areas well beyond the confines of R&D as such. In order to turn defence R&D into a proper instrument for strengthening national defence, Estonia's policymakers and those responsible for implementation have to take into account, weave together and balance a number of factors, including:

- Strategic aims of national security and defence;
- Aims, priorities and mechanisms of the national RD&I Strategy;
- Defence capability development plans and priorities;
- Contribution and participation in NATO and the EU;
- National S&T organisation, competence and interests;
- Internal core and support processes of the defence organisation;
- Structural and cultural traits of the defence organisation;
- Competence and the level of development of the defence organisation;
- Attitudes and expectations of internal and external stakeholders;
- Available financial resources, etc.

It is difficult to bring these factors together, to continuously maintain a balance between them and to monitor the progress made towards the respective objectives. Estonia's defence R&D is not supported by an overarching framework of strategy implementation. As a result, the uneven patterns and imbalances, which characterised defence R&D in the past when there was no formal strategy, remain in place even after the institution of a formal strategy. During one period, certain aspects are ignored or, to the contrary, over-emphasised; during another period, something else acquires prominence, while other important factors are neglected; some aspects (e.g. organisational culture, knowledge management practices) never receive any attention at all.

In the field of strategic management, one of the tools designed to assist in this effort is Balanced Scorecard (BSC), which was originally 'developed to communicate the multiple, linked objectives that companies must achieve to compete on the basis of capabilities and innovation, not just tangible physical assets' (Kaplan & Atkinson, 1998: 368). The tool has strategy and vision at the core and it encompasses objectives, measures and performance indicators in four interacting domains: customers; finances; internal business processes; and learning and growth. The BSC has gained rather widespread acceptance in the private sector and it now enjoys its third generation (Lawrie & Cobbold, 2004). It has also been validated for the management of specific functions such as R&D (Garcia-Valderrama et al., 2008) (see Figure B1 in Annex C).

Consequently, in the drive to improve the public sector by employing 'best practice' from the private sector, the BSC was adopted in strategic management of public sector organisations (Niven, 2003). Defence is one of such public sector areas: for instance, the UK MOD is one of the most advanced users of the BSC framework adapted for defence purposes (MOD UK, 2008), which could serve as a good example and a source of inspiration for such practice (see Figure B2 in Annex C). Admittedly, the process of designing, applying and improving the BSC in relation to various defence functions can be an arduous process, which requires a lot of patience and persistence (2GC Limited, 2004). However, the overall outcome is rewarding, as it makes it possible to steer the entire enterprise towards its vision and strategic objectives.

Although the Estonian defence organisation – neither the MOD nor the EDF – does not employ the BSC framework in its overall strategic management, its tentative introduction in defence R&D management would be beneficial (and it might even pioneer broader adoption of the tool in the Estonian defence organisation). To do so, it would be necessary: to clarify the strategic vision for defence R&D, so that it would be congruent with national security and defence strategies and with the national RD&I Strategy; to sort out the R&D process and its linkages with other 'core processes' in defence through the 'internal business process' dimension; to lay an important emphasis on the MOD's and the EDF's attributes as learning organisations through the learning and growth dimension; to put customer needs and stakeholder interaction in focus through the customer dimension; and to maintain the visibility of the defence R&D spending benchmark in the financial dimension.

Certainly, much work would be needed to design a comprehensive Balanced Scorecard for Estonia's defence R&D, to tailor it to the country's realities and aspirations and to supplement it by a set of impact assessment measures, which are currently lacking too. However, it would represent a move towards more systematic strategic management of defence R&D investments and the respective programme. Together with an inclusive review of the Defence R&D Strategy and the introduction of impact assessment policies, it should be the focus of reform efforts in the short and medium term.

Conclusions and recommendations

This exploratory study aimed to examine Estonia's defence R&D – its past pursuits and achievements, together with its present state of affairs. It asked to what extent the perception, advanced by some stakeholders, about its failure to produce anything useful is accurate. The study also sought to determine the reasons, the nature, the results and the potential impact of the still ongoing changes in the sector. To achieve this, data about Estonia's defence R&D from 2001 to the present – its strategy, national context, project portfolio and the management thereof, together with international collaboration and the financial dynamics – was collected and presented. A series of semi-structured interviews with the representatives of various internal and external stakeholders were conducted to better understand the problems, experiences and perspectives in this field. The findings of the interviews were discussed using theoretical concepts and models from the literature on strategy, management and defence R&D.

The paper adopted the Frascati definition of R&D and a broad interpretation of technology as the basis of inquiry. Thus it did not investigate the policies, processes and results of Estonia's defence investments in technologies that reached higher TRLs or Estonia's defence industry policy and activities. This proved to be beneficial in terms of understanding the expectations mismatch between internal and external stakeholders of defence R&D in the public sector. On the other hand, when it comes to the entire defence innovation chain, a study focus that stretches all the way from basic research to the use of new technologies by the defence organisation might appear too constraining to some: after all, the success of R&D could be defined as the number of new R&D-based solutions introduced in defence, which would unavoidably bring in aspects pertaining to higher levels of technology readiness and, in many cases, the industry's role.

However, new knowledge and solutions generated by various R&D projects and programmes can be employed in other ways by 'smart defence', without the need for industrial/commercial development. It is a matter of whether and how such knowledge is captured and used by organisational processes (e.g. capability planning, defence acquisition, personnel management, training, operational planning, etc.). This puts the onus on the defence organisation and its leadership to develop appropriate mechanisms, to set the right vision and the level of ambition, to direct the S&T community's efforts and to deploy R&D results effectively. In this regard, the focus of the study served well to underscore the challenges in Estonia.

The main research method employed – interviewing – has its disadvantages. Due to a limited sample, it usually favours depth over breadth of inquiry and its results may elevate subjective judgements, interpretations and opinions to a higher level than facts and objective measurements. However, the study benefited from this method – it offered a means to appreciate the nature of experiences and problems as perceived by defence R&D stakeholders. Certainly, many of the identified issues warrant further research with different methods, so that the findings of the interviews could be validated and a more objective picture could be developed. This study should be treated as a collection of insights pointing to actual or potential problems or challenges. It is the very first step towards research efforts that continuously support evidence-based strategy formulation and implementation processes in the field of defence R&D.

Indicative and tentative as they may be, the study’s key findings may be summarised as follows:

- Until the reform period of 2008–2010, Estonia’s defence R&D lacked a strategic and systematic approach. Decision-making in this field was disconnected from the defence organisation’s broader processes and needs, while it was dominated by a ‘supply push’, which was often imposed on the military. The defence organisation had a limited understanding of the role of R&D, the whole R&D process and the possible uses of its outcomes in defence. Financial resources made available for use in defence R&D and international collaboration had been growing and many projects had been completed with positive results, but with a few exceptions, the defence organisation eventually either did not require them or failed to make any use of them.
- The reform period commenced with the institution of a formal Defence R&D Strategy, which laid down the objectives in defence R&D and the mechanisms for achieving them. The strategy is deemed by many stakeholders to be a functional framework to build on, even though its drafting process lacked consultation and inclusiveness, which complicated efforts to secure a stakeholder buy-in. It is largely ineffectual as a tool to manage the expectations of internal and external stakeholders: it does not capture the slowly emerging consensus over the central purpose of defence R&D investments (‘smart defence’), ‘niche’ areas and priorities; it does not set a clear level of ambition; it fails to establish the centrality of military requirements in the R&D agenda and to identify the principles for choosing bilateral/multilateral cooperation partners. Ever since the collapse of funding during the financial crisis, there is no prospect of reaching the R&D benchmark – 2% of the defence budget – which is mostly associated with the perceived limited added value of such investments for the defence organisation.
- From the defence organisation’s perspective, the changes in the governance framework, together with increasing and better directed involvement in NATO RTO and the EDA, are among the major achievements of the sector’s reforms. This has enabled better internal coordination in the organisation, has established a tentative link with the capability implementation process and has separated the provision of scientific and technical advice and assessments from decision-making on requirements and specific investments. Due to the small size of the S&T community in Estonia, some reservations still persist about the impartiality and quality of the RC assessments. Furthermore, the system is still exposed to attempts to bypass and undermine it both from within and outside of the defence organisation.

- The sector's governance reform has not involved the addressing of certain internal arrangements in the defence organisation (e.g. incomplete centralisation of the MOD's R&D coordination function and its subordination to a department that does not deal with overall planning, which is not the case in the EDF HQ; the identification of the locus of legal responsibility with the MOD rather than the main originator of requirements) or the absence thereof (e.g. a management policy for IPRs in the MOD; an internal R&D requirement coordination process in the EDF and its links with other organisational processes; a performance management framework such as BSC). Neither the administrative capacity nor the R&D project management system, which should ensure constant feedback from and the participation of the end-user, have been developed properly, although some progress has been made in improving the system of assessing the need for projects or enhancing the role of PoCs.
- The end-user itself poses a major challenge to the new, end-user-oriented approach and to bringing Estonia's defence R&D to a different level. Over the years, frustrations have accumulated among both internal and external stakeholders with regard to the perceived managerial and cultural shortcomings in the EDF. These frustrations stem from: the lack of technological and organisational sophistication as sources of demand for R&D; the lack of interest in new knowledge and innovation; a concomitant treatment of R&D as annoyance at best; fragmented or absent 'core business' processes with which R&D would have to be linked and the lack of stability or continuity in its stated requirements; the narrow ('hardware-centric') understanding of technology and the failure to appreciate the nature of R&D activities (e.g. longer time horizons, risks of failure, need for feedback), their possible outcomes and use; the absence of a motivating and intellectually stimulating environment for technical specialists (SMEs); the inability to organise these specialists into 'knowledge hubs' ('centres of competence'), etc. To confirm many of these subjective perceptions, further deeper and methodologically rigorous investigation into the EDF's organisational culture, processes and practices would be necessary. However, there are certain objective facts suggesting that the end-user, as the source of demand, is indeed the weakest element in the implementation of the Defence R&D Strategy, which is why a high-priority focus should be set on the development of its competence, capacities and innovation culture.
- In addition, it is equally possible to conclude (again, with the caveat that a more in-depth investigation is warranted) that the S&T community's understanding and appreciation of Estonia's defence needs and military requirements is quite limited, while its scientific aspirations and needs for funding are ever growing. These two aspects – the weakness of the demand source and the assertiveness of the supply side – make it a very challenging undertaking for the defence organisation to sensibly balance between the 'demand pull' and the 'supply push', especially with the lack of effective 'knowledge brokers' with deep understanding of both sides.

Changes in the defence R&D sector in Estonia continue as this report is being written, which means that many of their effects are yet to take place. They can be judged as being broadly on the correct trajectory. For each of the Defence R&D Strategy's broad directions to succeed in the future (provided that they are retained in the future reviews), there is a number of conditions which will have to be created and maintained (see Annex D). As with any changes, there will inevitably be some losers and winners and some compromises and difficult choices will have to be made. The important thing is that there is a continuous effort to build trust, to create opportunities for dialogue and to maintain communication between the stakeholders – the S&T community (including industry), security and defence policymakers and the military.

This study was conceived on the premise that Estonia's defence policymakers are willing to build on past experiences and to improve the defence organisation's approach to defence R&D. All of its recommendations are also driven by the very same premise. Otherwise, without any appreciation of how R&D can be of service to defence interests and without any will to mobilise energy and efforts to bring it to a new level, there can be only one recommendation: to formally declare that Estonia has no aspirations in defence R&D and to close the matter altogether. There is also a less drastic option, which would serve the image of Estonia as a contributing Ally and partner and would maintain its approach in line with the philosophy of 'pooling and sharing': to channel all funding (preferably 2% of the defence budget) into NATO and EDA projects and programmes and to encourage and facilitate the participation of Estonian military SMEs and S&T representatives in them.

However, the ongoing effort to reform the sector – even though driven by very few 'activists' within the defence organisation – seems to indicate that Estonia may have more serious aspirations: to use R&D as an instrument for enhancing the defence organisation's competence, capabilities, efficiency and foresightedness; to increase its interoperability with the Allies and inter-agency cooperation partners; and thus to move towards the vision of 'smart defence'. For that purpose, it is necessary, first and foremost, to strengthen the impetus of the ongoing reforms and to develop the missing elements and capacities of the system by proceeding as follows:

In Defence R&D Strategy

- Conduct an inclusive and consultative review, building on the analysis and consensus developed in the RC (e.g. the identified technology areas where defence interests and S&T competence converge) and taking into account the implications of changes in defence policy and strategy since 2008 (e.g. the new comprehensive national defence strategy).
- During the review, articulate more clearly the central purpose (e.g. new knowledge for use in strengthening national defence), the vision, the level of ambition (e.g. applied research/TRL4), the 'breadth' (the range of NSE and SSH subjects that are of interest to Estonia's defence), the 'depth' (specialisation niche(s)) and the principles that guide decision-making on R&D investments and preferred multinational partners for defence R&D.

- Seek a better balance between the supply push and the demand pull. The centrality of military requirements must be balanced with the need to maintain S&T competences which might be critical in the future but for which specific military requirements do not exist today. In addition, include a measure of funding for 'free play' with the ideas by the S&T community.
- Maintain the momentum of involvement in NATO RTO and EDA programmes in order to continue to have access to multinational knowledge networks and to contribute to 'pooling and sharing' efforts. Start the process of identifying priority bilateral and multilateral partners on the basis of clear criteria.
- In the medium term, give a high priority to the direction of building the defence organisation's S&T competence and 'absorptive capacity'. This should include enhanced training and education of defence personnel on how to articulate requirements for R&D as part of 'core' defence processes, how to utilise R&D results, how to manage technology and innovation, etc.
- Establish a plan for reaching the R&D benchmark – 2% of the defence budget. Allocate the budget in a more structured manner, reflecting the strategic principles, the priorities and the level of ambition established in the reviewed Defence R&D Strategy.
- Seek synergies in R&D investments with other governmental organisations that operate in the national security sector, e.g. expedite the work processes of the dual-use technology working group.
- Set up an S&T awareness and foresight programme in order to assist decision-making in long-term defence policymaking, planning, investing and defence R&D strategy formulation and to better capture the benefits of civilian R&D. Use the S&T advice available through the RC more intensively in defence policymaking.
- Consider using the BSC framework to align various aspects of the Defence R&D Strategy, to manage its implementation and to monitor its impact. Once greater strategic clarity has been achieved in defence R&D, ensure a period of stability and continuity (only with incremental adjustments) in implementing the adopted goals, principles and measures.

<u>In governance and project management</u>

- Define in a better way the core and support processes in defence, especially those related to capability development, knowledge management, organisational learning and innovation (e.g. CD&E in the EDF). Establish their linkages with R&D. Design a process in the EDF for the generation of R&D requirements, the implementation of results and impact assessment.
- Analyse the administrative capacity necessary for running the R&D function and for ensuring its 'business continuity' in the defence organisation.

- Maintain the current decision-making, coordination and S&T advisory structure, developed during the reform period. Consider appointing dedicated curators for each direction of the Defence R&D Strategy.
- Centralise the coordination of all R&D requirements and policies in both SSH and NSE subjects. Reconsider the location of the R&D coordinator in the MOD structure, so that the position is transferred to the unit 'mirroring' the HQ EDF structure where R&D coordination takes place (J5/J9).
- Assess very carefully the risks and opportunities associated with the idea of outsourcing the management of parts of the defence R&D project portfolio to an agency outside the defence organisation (e.g. the new Estonian Research Agency, ERA).
- Reconsider the policy and practice of managing R&D contracts in the defence organisation. If a contract is drawn up on the basis of a military requirement submitted by the EDF, vetted by the RC and approved by the TAKT, the EDF should share legal responsibility with the MOD in fulfilling the terms of the contract.
- Concentrate more military SMEs in centres of competence (or virtual communities of practice) or in a single centre for applied studies (e.g. in the ENDC) in the EDF structure and enable them to interact with members of the S&T community in the civilian sector and abroad (e.g. NATO RTO). Provide additional incentives and rewards for scientific and technical competence and its advancement.
- In order to increase the availability of S&T expertise in the management of the R&D portfolio, consider including foreign experts in the process of assessing requirements, project proposals and project reports.
- Provide better guidance, clearer terms of reference and a formal system of reporting to project PoCs in the defence organisation and demand continuous feedback from the defence organisation to project teams.
- Provide opportunities for enhancing communication, raising awareness and building trust between the S&T community, industry and the defence sector: consider holding a general annual S&T/R&D conference and smaller focused seminars concerning specific knowledge and technology areas.
- Craft a management policy for IPRs and strengthen the MOD's legal expertise in dealing with issues related to IPRs in order to facilitate further innovation processes (in collaboration with the commercial sector) on the basis of R&D outcomes.

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ANNEX A

ESTONIA’S PARTICIPATION IN NATO RTO PROJECTS

Panel	Project	Organisation	Number of involved researchers /specialists	Period
HFM	Development of an Assessment Technology for Demonstrating Usability, Technical Maturity and Operational Benefits of Advanced Medical Technology	Curonia Research Ltd.	1	2003–2009
	Impact of Lifestyle and Health Status on Military	TAI	1	2009–2011
	Medically Unexplained Physical Symptoms in Military Health	ENDC	1	2008–2011
	Mental Health Training	ENDC	1	2011–2013
	Military Suicide	ENDC	1	2011–2014
	Psychological and Physical Selection of Military Special Units	ENDC	1	2008–2011
	Psychological Aspects of Health Behaviours on Deployed Military Operations	ENDC	1	2007–2010
	Stress and Psychological Support in Modern Military Operations	UT	1	2003–2006
IST	Information Assurance/Cyber Defence Research Framework	TUT	1	2010–2012
NMSG	Security in Collective Mission Simulation	ENDC	2	2010–2012
SAS	Costing Support for Force Structure Studies	ENDC	1	2011–2013
	Long Range Forecasting of the Security Environment	ICDS	2	2010–2011
SCI	Design Considerations and Technologies for Air Defence Systems	TUT	2	2006–2009
	Electronic Warfare in Joint Littoral Operations	EDF	2	2007–2009
	System Design Considerations and Technologies for Safe High Tempo Operations in Degraded Visual Environments	TUT, UT	2	2010–2012
	Urban Camouflage for the Individual Soldier System	TUT	1	2005–2009
	Utilisation/Dynamic Control of Adaptive Camouflage Materials	TUT	3	2006–2009
SET	Noise Radar Technology	TUT	2	2005–2008
	Smart Textiles for the NATO Warfighter	TUT	1	2007–2009

ANNEX B

SWOT ANALYSIS OF ESTONIA'S DEFENCE R&D

	Strategy	Governance	Project management
Strengths	• Formal strategy in place, with clear objectives and main directions • User requirement as the key criterion for R&D investments • Growing cooperation through NATO and EDA knowledge networks • Reliance on civilian R&D	• Separation of S&T advice (RC) and decision-making coordination (TAKT) structures • Inclusion of the leaders of capability working groups in the RC • Consensus and collaboration between the MOD and the EDF • Centralisation of the R&D coordination function in the planning branch of the HQ EDF	• New project assessment system • Requirement for project teams to contribute to NATO RTO panels
Weaknesses	• 'Smart defence' not established as central rationale for R&D • Management of expectations: formalised level of ambition, niches of specialisation, prioritisation of directions (continuing 'strategic ambiguity') • Financial resources for defence R&D and their long-term perspective • S&T awareness and foresight, S&T literacy of the defence organisation • Implementation plan, impact assessment and performance management tools of the strategy • Use of strategy-making as a tool for building consensus and trust • Limited knowledge of defence by the S&T community • Insufficient end-user drive for learning and innovation and its 'absorption' capacity (culture of new knowledge application)	• Breadth of scientific expertise in the RC and the country • Fragmented R&D investments and management of knowledge requirements by the MOD (lack of centralisation) • Management of the strategy's directions • Location of the R&D coordination function in the MOD Procurement Department • R&D 'business process' in the EDF linked with 'core processes' of the defence organisation • Dispersed SMEs in the EDF and absence of knowledge hubs in its structure • System of contracts for which the MOD has legal responsibility, but the EDF is the end-user • 'Transactional capacity' between the end-user and S&T, knowledge brokering between them • Management of IPRs	• Administrative capacity in the defence organisation • Involvement of the end-user in projects • Guidelines and terms of reference for project PoCs in the defence organisation • Project management competence in the defence organisation and REs • Retention of institutional memory from past projects • Infrastructure to support projects that require testing and evaluation • Leadership attitudes and administration of REs towards co-funding of participation in NATO RTO panels
Threats	• Disconnect with the national RD&I Strategy process • Resistance to a customer-oriented approach from the S&T community • Defence leadership ignorant of R&D's nature, role and added value • Too frequent changes in overall priorities and requirements of the defence organisation; change for change's sake • Negative publicity based on defence R&D's misunderstood nature and purpose	• Weak personnel, knowledge and competence management in the defence organisation • Lingering distrust among the S&T community in the integrity and validity of RC analyses • Parallel informal processes driven by factional interests, hidden agendas and the rejection of the formal system • Premature creation of a defence R&D agency	• Instability of military requirements on the basis of which projects are launched • Annual budgetary cycle and budget adjustment decisions during an ongoing financial year
Opportunities	• Multilateral 'pooling & sharing' policy within NATO and the EU • Participation in the network of NATO REs and COEs • New strategy with a comprehensive approach to national defence • Possible synergies of R&D investments with civilian security organisations • Involvement in joint multi-national inter-agency operations (e.g. in Afghanistan)	• Reforms by the defence organisation aimed at increasing its efficiency and effectiveness and at strengthening civil-military cooperation • NATO S&T organisation reforms aimed at raising the profile of R&D • Willingness to share 'best practice' in defence R&D governance by the Allies and partners • System of national programmes and civilian R&D management	• Outsourcing to project management organisations • Use of foreign experts in requirement and project assessment

ANNEX C

BALANCED SCORECARD (BSC) EXAMPLES

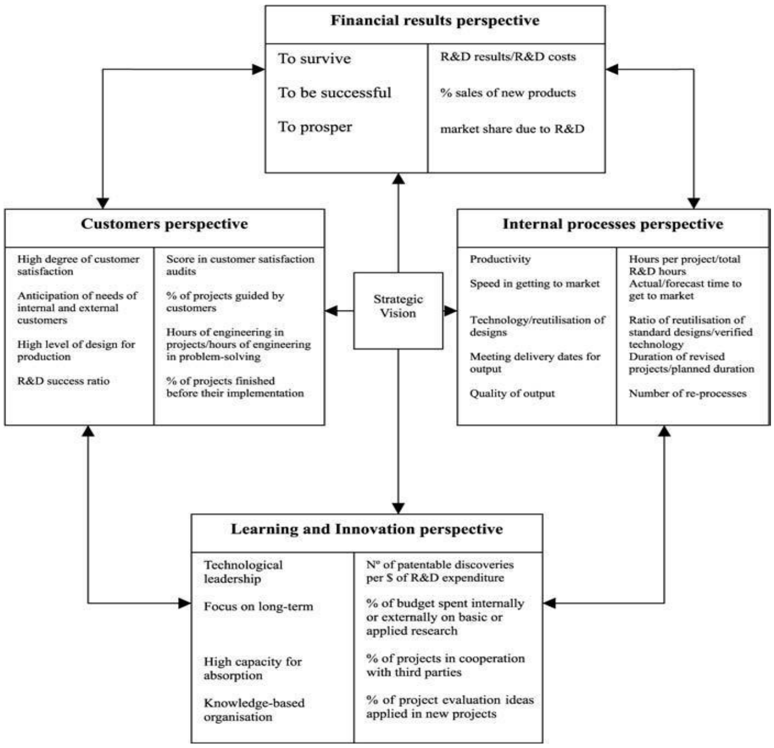

Figure B1: BSC in R&D (Garcia-Valderrama, 2008).

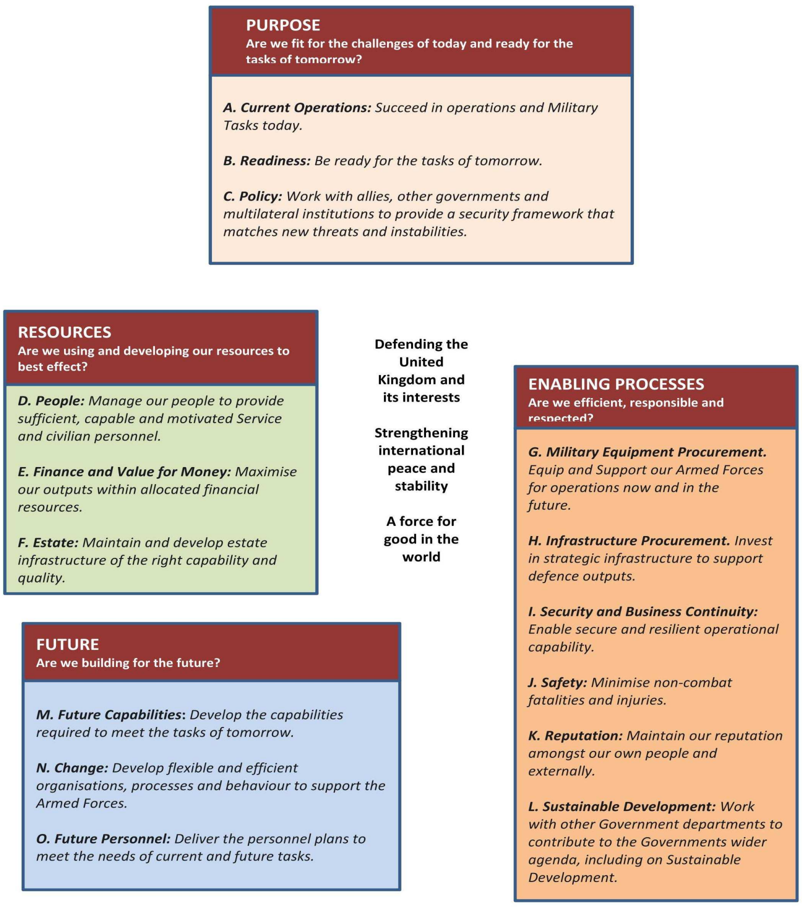

Figure B2: Defence BSC (MOD UK, 2008).

ANNEX D

ESTONIA'S DEFENCE R&D STRATEGY: CONDITIONS FOR SUCCESS

- **Overall:**
  - Learning organisation / 'smart defence' posture of the defence organisation, effective knowledge & technology management;
  - Multiple linkages of R&D process with various core and supporting processes in defence;
  - Growing technological, organisational, doctrinal sophistication of the EDF;
  - Realistic level of ambition, effective leadership, communication and management of expectations;
  - Framework for transparent stakeholder interaction to build awareness and trust;
  - Ability of the MOD to balance various aspects of defence R&D and assess its impact;
  - Integrity and credibility of S&T advice (including project assessments and reviews);
  - Sufficient funding and administrative capacity.
- **Directions 1 & 4 (military capability):**
  - Ability of the defence organisation to identify, define and sustain military requirement for R&D;
  - Awareness of civilian research programmes as platforms to develop military applications;
  - Knowledge of international technology markets (to avoid duplicating investments);
  - Involvement of end-user in all stages of projects;
  - Industry's capacity to use R&D outcomes;
  - Project management capacity (including T&E infrastructure, IPRs management etc.).
- **Direction 2 (national S&T competence):**
  - S&T foresight programme as a basis for identifying scientific competences of importance to defence in a long-term;
  - Willingness of the civilian S&T community to get involved in defence sector;
  - Linkages with national RD&I Strategy process, inter-agency cooperation.
- **Direction 3 (NATO & EU):**
  - Identification and focus on a few 'niches' of excellence;
  - Willingness of S&T representatives of those 'niches' to contribute to NATO and EDA projects and programmes;
  - Ability and willingness of the defence organisation to absorb and utilise knowledge made available through participation in multinational knowledge networks;
  - Identification of preferred strategic partners for bilateral and multilateral collaboration.
- **Direction 5 (research competence in the EDF):**
  - Identification of necessary in-house research competences;
  - Effective management of SMEs in the EDF, including their organisation into one or several 'knowledge hubs';
  - Active use of opportunities to interact with civilian (Estonian and foreign) REs.