



NATO PARLIAMENTARY ASSEMBLY

## SCIENCE AND TECHNOLOGY COMMITTEE (STC)

# NATO SCIENCE AND TECHNOLOGY: MAINTAINING THE EDGE AND ENHANCING ALLIANCE AGILITY

### Special Report

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## ACRONYMS

ACT	Allied Command Transformation
AFSC	Alliance Future Surveillance and Control
C3	Consultation, Command and Control
CDT	Cooperative Demonstration of Technology
CNAD	Conference of National Armaments Directors
CMRE	Centre for Maritime Research and Experimentation
COMEDS	Committee of the Chiefs of Military Medical Services
CPoW	Collaborative Programme of Work
CSO	Collaboration Support Office
NATO HQ	NATO Headquarters
NATO PA	NATO Parliamentary Assembly
NCIA	NATO Communications and Information Agency
NDPP	NATO Defence Planning Process
NIAG	NATO Industrial Advisory Group
OCS	Office of the Chief Scientist
R&D	Research and Development
S&T	Science and Technology
STB	Science and Technology Board
STC	Science and Technology Committee
STCTTS	Sub-Committee on Technological Trends and Security
STO	Science and Technology Organization

## I. INTRODUCTION

1. On 4 October 1957, the Soviet Union launched *Sputnik*, the world's first satellite. Given the military advantages the technology promised, the launch sent shockwaves through the transatlantic Alliance, and Allies had to race to make up for lost time. NATO cannot be caught off-guard like this again.

2. NATO's most staunch commitment is that Allies stand united to deter any potential aggression and, if deterrence fails, to collectively defend themselves. Consequently, NATO must possess the full range of capabilities to fulfil its duty to deter and defend the citizens of the Alliance. NATO's unrivalled defense science and technology (S&T) edge remains the lifeblood of current and future capabilities. Unfortunately, a real possibility exists that the Alliance could fall behind in defense S&T in the coming years.

3. A brief look at missile technology, artificial intelligence (AI) and quantum technologies illustrates the difficulty of maintaining NATO's S&T edge:

- **Missile technology:** In March 2018, President Vladimir Putin boasted about new nuclear weapons under development, including a heavy intercontinental missile, an 'invincible' cruise missile and an unmanned nuclear-armed underwater vehicle. Shortly after, Russia successfully tested its *Kinzhal* hypersonic missile. China is also investing heavily in missile technology, including two hypersonic weapon systems tested on multiple occasions.
- **AI:** China is investing USD 150 billion in artificial intelligence to become the world's leading AI innovator by 2030. In 2017, China's share of global AI equity funding was 48%, compared to the United States' share of 38% (CBInsights, 2018). Even though Russia appears to be behind the AI curve (global ranking on AI investments: 33<sup>rd</sup> place), President Vladimir Putin clearly recognized AI's potential when he said in 2017: "Whoever becomes the leader in this sphere will become the ruler of the world" (Soumitra, Lanvin and Wunsch-Vincent, 2018).
- **Quantum technologies:** China is making huge strides in quantum technologies. The government is spending USD 10 billion on a new national laboratory. In 2016, Chinese and Austrian researchers successfully held the first intercontinental video call secured through quantum encryption by way of a Chinese satellite. In 2017, China also launched a land-based quantum communications network with the aim of connecting Beijing and Shanghai over 2000 km.

4. Since US Senator Henry Jackson's visionary leadership over 60 years ago, the STC has remained vigilant in guarding NATO's S&T edge. Alas, in 2017, the Committee – supported by the NATO Parliamentary Assembly as a whole – noted its worry "that NATO's technological edge is eroding" (NATO PA, 2017b). Consequently, the STC is redoubling its efforts to identify the challenges in meeting Alliance goals and to lend political support to rectify any shortcomings. Your Special Rapporteur is eager to carry forward this vital work, to communicate our findings to Allied governments, parliaments and – vitally important – citizens and thus to effect a fundamental change in mindsets.

5. Most Allies and NATO entities are beginning to understand the importance of maintaining the S&T edge. However, your Rapporteur would argue that a much greater sense of urgency must prevail. For one, NATO faces an increasingly volatile and unsettling international situation with challenges and threats from all strategic directions. More importantly in the context of this report, a changing global S&T landscape also presents new challenges in maintaining the edge: potentially disruptive inventions and innovations are increasingly driven by smaller and more commercially-oriented companies as well as by nations or companies outside the Alliance. In short, if the Alliance does not intensify its efforts to maintain the S&T edge, the window of opportunity to adapt to the changing circumstances will rapidly close. And if the window were to close, the Alliance could face a capability gap so significant it would be challenging to remedy.

6. This special report is a direct follow-up to the 2017 General Report *Maintaining NATO's Technological Edge: Strategic Adaptation and Defence Research and Development*, which focused on defense research and development (R&D) spending and reforms (NATO PA, 2017b). In this report, your Rapporteur seeks to answer to the following questions:

- What defines the S&T edge?
- What is NATO's overall mission in maintaining the S&T edge?
- How can NATO evaluate its delivery of the S&T mission?
- Does NATO need new institutions, networks, policies or tools to fulfil its mission?

7. Your Rapporteur presented a first special report at the 2018 Spring Session, where Committee members provided valuable input for its revision. To make this report as complete as possible, the STC Director conducted interviews with 30 national and NATO officials on behalf of your Rapporteur (see Annex 1). The analysis contained in this report draws extensively on these interviews.

8. You Rapporteur hopes to paint a good picture of where NATO S&T finds itself today, where it should be tomorrow and where stakeholders dissent in their assessments. She knows that certain recommendations may require refinement through more in-depth analysis, but the task at hand – ensuring that NATO S&T remains fit for purpose – requires bold ambitions. The STC continues to stand ready to support this task.

9. Your Rapporteur had to make choices to keep the report within a reasonable length. Therefore, while NATO S&T has made S&T capacity building within the Alliance and with partner countries and institutions one of the cornerstones of its agenda, this report is squarely focused on NATO and the Allies. By excluding partnerships, your Rapporteur does not mean to diminish the vital role of partnerships in maintaining the S&T edge. Indeed, in the current S&T landscape these will become ever more important. In particular, the STC should continue to engage in proper discussions regarding the future of research and development in the European Union as well as partnerships with NATO's enhanced-opportunity partners.

## II. WHAT DEFINES NATO'S S&T EDGE?

10. Since this Committee was created in the 1950s, its members have been concerned with preserving NATO's advantage in S&T. However, little clarity exists about what defines NATO's advantage in S&T or what the Committee has begun calling the 'S&T edge'. Alas, the research for this report yielded no conclusive answer either. Many interlocutors questioned the premise of the question, arguing that 'S&T edge' could not be properly defined. Even if it could, it would be very difficult to measure – to the point of impossibility. Nevertheless, the conversations generated certain illuminating points.

11. For many interlocutors, the more interesting and valid question was "What constitutes the *military* edge?". This question goes far beyond S&T. It must include analyses of military 'hardware' as well as military 'software', including doctrine, organization, training, leadership, or personnel. Defense analysts have a long history of studying the military edge. Nevertheless, such analyses often turned out inaccurate once conflict broke out or when new information shed light on past analyses. Today, such analyses have become even more difficult.

12. If such traditional metrics are already this difficult, designing valid defense S&T metrics for the Alliance would be even more complex. How do you evaluate whether a nation has the right mix of scientists and engineers, effective S&T processes or a healthy defense industrial or research base to support S&T? How do you account for very different approaches to defense S&T? And how would one aggregate analyses at the Alliance level?

13. Only highly-trained specialists in the various S&T domains might be able to design and measure such metrics. The problem is that such analyses would very quickly run into highly sensitive areas where Allies would not want to share much information amongst themselves. Even if such hurdles could be cleared, it is very difficult to see how the results could be communicated at an unclassified level without revealing too much to any potential adversaries. And even if analysts could come up with metrics, would voters, decision makers and defense practitioners be able to understand what these metrics mean in practice?

14. Interlocutors who argued that metrics could be defined or, at least, roughly characterized suggested several big-picture questions that could be examined (see Table 1). Unfortunately, exploring these questions in an exhaustive and valid way goes beyond the scope of this report.

15. Regardless of metrics, some interlocutors strongly argued that the Alliance may be overtaken in the medium to long term or may already have fallen behind in several S&T areas. Interviewees pointed to a number of S&T areas which should be monitored closely (see Table 2).

<b>Table 1: What could characterize the S&amp;T edge?</b>
- What is the global annual distribution of science, technology, engineering, and mathematics graduates?
- What is the global annual distribution of registered patents and research articles?
- Which country has won the highest number of Nobel Prizes in recent years?
- What are the capability and investment trends in key technologies, for example supercomputers, quantum computers or AI?
- How many hypersonic weapons tests have China and Russia performed, compared with the Alliance?
- How much are China and Russia investing into artificial intelligence, compared with the Alliance?
- How long would it take for China and Russia to replicate the cutting-edge capabilities within the Alliance?

<b>Table 2: S&amp;T Areas of Concern</b>
- anti-submarine warfare
- artificial intelligence
- autonomy
- big data analytics
- chemical, biological, radiological and nuclear defense
- cyber defense and security
- directed-energy weapons
- electronic warfare
- heavier conventional capabilities
- hypersonic missiles
- meta-materials
- quantum technologies
- space technologies
- synthetic biology

16. In conclusion, however, a more nuanced ambition for the Alliance should prevail in the absence of clear metrics, which is well reflected in NATO's S&T mission: "maintain NATO's scientific and technological advantage by generating, sharing and utilizing advanced scientific knowledge, technological developments and innovation to support the Alliance's core tasks". That being said, while defining specific and quantifiable scientific metrics might sometimes prove elusive, merely asking the question focuses the conversation and ensures that creative tension and a challenge function remain in the system. Your Rapporteur encourages the Committee to continue to ask these questions and instill the necessary dynamism into the Alliance.

### **III. WHAT IS NATO'S ROLE IN ALLIANCE DEFENCE S&T?**

17. In an Alliance of sovereign states, the primary responsibility to maintain a robust defense S&T base and to discover, develop and adopt cutting-edge defense technologies naturally lies with NATO member states themselves. Allies must expend sufficient resources on military-relevant S&T and continually re-evaluate and adapt their national processes and institutions. However, in an Alliance united in purpose, extensive and meaningful coordination, cooperation and collaboration of defense S&T adds significant value to national efforts, while establishing interoperability and the necessary overarching command and control.

#### **A. THE NATO S&T COMMUNITY AT A GLANCE**

18. To achieve its S&T mission, the NATO S&T community brings together "national S&T capacities, both people and infrastructure, as well as NATO's own research and experimentation capacity" see Figure 1). The Alliance has several NATO entities that support this community.



Figure 1: NATO S&T Community

19. Unified governance of NATO S&T is exercised through the **NATO Science and Technology Board (STB)**, composed of national representatives and NATO S&T stakeholders. The NATO Chief Scientist chairs the STB with the support of two Co-Vice-Chairs from NATO’s International Staff and International Military Staff. The STB promotes coherence of NATO S&T through objectives set out in the NATO S&T Strategy, focuses work through medium-term NATO S&T Priorities (see Table 3) and serves as a focal point for all NATO S&T programs of work.

20. The **Science and Technology Organization (STO)** is the main NATO entity focused on S&T. Led by the STB, it is composed of three executive bodies.

- **The Office of the Chief Scientist (OCS) at NATO Headquarters (HQ):** Managed by the NATO Chief Scientist, the seven-person OCS acts as the bridge between the Collaboration Support Office, the Centre for Maritime Research and Experimentation as well as NATO entities and senior leadership at NATO HQ.
- **The Collaboration Support Office (CSO) in Neuilly-sur-Seine, France:** The CSO in Paris provides a collaborative environment and supports NATO S&T activities through six Panels and one Group (see Table 4). In 2017, the CSO had a staff of 43. The CSO’s core activity is to support and enable the STO Collaborative Programme of Work (CPoW).

Table 3: 2017 S&T Priority Areas
Precision Engagement
Advanced Human Performance & Health
Cultural, Social & Organizational Behaviors
Information Analysis & Decision Support
Data Collection & Processing
Communications & Networks
Autonomy
Power & Energy
Platforms & Materials
Advanced Systems Concepts

**Table 4: STO Panels and Group**

Applied Vehicle Technology
Human Factors and Medicine
Information Systems Technology
NATO Modelling and Simulation Group
Systems Analysis and Studies
Systems Concepts and Integration
Sensors and Electronics Technology

- **The Centre for Maritime Research and Experimentation (CMRE) in La Spezia, Italy:** The CMRE is a customer-funded in-house STO laboratory. Its team of 161 staff (2017) organizes and conducts basic and applied research as well as technology development and demonstrations. Research areas include autonomous surveillance; port and ship protection; maritime situational awareness; and environmental knowledge and operational effectiveness. The Centre also acts as a knowledge repository for NATO.

21. Several other NATO entities carry out their own S&T related activities and contribute to the programs of work of other NATO S&T stakeholders:

- **Allied Command Transformation (ACT):** Based in Norfolk, Virginia ACT leads NATO's initiatives for the transformation of military structures, forces, capabilities and doctrines to enable NATO to meet its level of ambition and fulfil its core missions. ACT's work concentrates on five lines of efforts: future work; the NATO Defence Planning Process; requirements; capability development; and force development.
- **The Conference of National Armaments Directors (CNAD):** The CNAD is the senior NATO committee responsible for promoting armaments cooperation between Allies. Chaired by the NATO Assistant Secretary General for Defence Investment, the CNAD supports Allies in defense planning, standardization and interoperability efforts. The CNAD also acts as an advisory body to the North Atlantic Council (NAC).
- **NATO Industrial Advisory Group (NIAG):** The NIAG is a high-level consultative and advisory body of senior industry representatives under the CNAD. Its role is to facilitate Alliance armaments cooperation; advise on the industrial and technological base; support capability development; and act as an interface between industry and NATO.
- **The Emerging Security Challenges Division:** The Emerging Security Challenges Division at NATO HQ addresses non-traditional risks and challenges. Mostly focused on policy, the Division has two work strands engaged in S&T related work: a Defence Against Terrorism Programme of Work and the Science for Peace and Security Programme.
- **The Committee of the Chiefs of Military Medical Services (COMEDS):** COMEDS is NATO's senior body on military health. It seeks improvement in coordination, standardization and interoperability in military medicine as well as in information sharing between Allies and partners.
- **The Consultation, Command and Control (C3) Board:** The NATO C3 Board focuses on information sharing and interoperability, including on issues such as cyber defense, information assurance and joint intelligence, surveillance and reconnaissance. The Board reports to and advises the NAC, the Defence Planning Committee, and the CNAD.
- **The NATO Communications and Information Agency (NCIA):** The customer-funded NCIA's mission is to guard NATO's networks; offer timely support during operations; deliver C3 technology throughout NATO; and support Allies in their development of capabilities in the fields of C3, computers, intelligence, surveillance and reconnaissance.



## B. THE ADDED VALUE OF NATO S&T

22. Just as with any other policy area in the Alliance, the nations remain fully in the driver's seat – a fact which must be firmly kept in mind when analyzing how to improve NATO S&T. No NATO entity dictates terms to nations on S&T – and none should. This should not be seen as a weakness, however. It ensures that NATO S&T activities are connected to national priorities and directly support national needs and requirements. Moreover, when the NATO S&T community establishes common views and, for example, translates these into NATO S&T Priorities (see Table 3), they have been validated by all 29 Allies.

23. Defense S&T remains firmly anchored within the nations, both in terms of capacities and efforts. At the NATO level, nations *choose* to come together to coordinate, cooperate and collaborate on S&T. Many nations have other forums where they can pursue international defense S&T if they wish to do so. Thus, the quantity and quality of participation depends heavily on the political importance the nation attaches to NATO as well as on national interests, priorities and budgets. As a consequence, it is a question of continued interest for national and NATO S&T leaders to understand how the NATO S&T community can remain a *forum of choice*.

24. Certainly, NATO S&T is not 'the center of the universe' within the Alliance. NATO S&T does not have the resources to compete with defense S&T conducted by nations or even defense companies with large budgets and only has a very limited ability to influence S&T trends. Nevertheless, NATO S&T is a critical enabler to maintain the full range of capabilities necessary to fulfil Alliance missions. The reason Allies choose to invest upwards of EUR 500 million in NATO S&T (mostly through national budgets) is the substantial added value it provides a) in the identification of risks and opportunities and the diffusion of knowledge and expertise, b) in concrete R&D efforts and c) through a range of cross-cutting benefits.

25. **Identification of risks and opportunities and diffusion of knowledge and expertise:** For many Allies – if not all – it is impossible to follow all military-relevant technological trends. For one, governments are no longer the main driver across the whole S&T spectrum. Allies with limited defense budgets can be especially dependent on the knowledge and expertise in the NATO S&T community. The combined Allied perspective provides much better situational awareness and enables NATO S&T to deliver timely, targeted advice and higher-quality cost-effective results.

26. The national and NATO officials interviewed for this process pointed to a number of concrete ways how NATO S&T helps nations and NATO:

- monitoring and understanding key military and dual-use S&T trends;
- staying ahead of S&T trends to avoid strategic surprises;
- improving advice and strategic communications to relevant Allied and NATO decision makers and entities;
- promoting information and knowledge sharing among Allies and within NATO institutions;
- building a consolidated and validated knowledge base in support of national and NATO lines of effort;
- identifying opportunities for coordination, cooperation or collaboration;
- avoiding unnecessary duplication among Allies; and
- encouraging or facilitating the determination of collective S&T targets and priorities.

27. **Concrete research and development efforts:** NATO S&T goes beyond the identification of risks and opportunities and the diffusion of knowledge and expertise. Across NATO entities, the Alliance offers a range of tools to cooperate, coordinate and collaborate on concrete R&D efforts. NATO S&T's role in these efforts is to accelerate capability development through STO activities, as the 2018 NATO S&T Strategy states. Main tools include prototyping, demonstrations, tests and experiments – a topic further examined in the next section.

28. Interlocutors noted in particular that the STO:

- helps sustain or increase S&T and R&D capacity in nations, in particular in those with a smaller S&T base;
- encourages and facilitates high-quality S&T and R&D at the national level; and
- fosters NATO-level and multinational S&T and R&D collaboration.

29. During the interviews, interviewees also identified a range of **concrete cross-cutting benefits** for nations and the Alliance as a whole.

- **Burden sharing:** In the current global S&T landscape and at current budget levels, no NATO member state can shoulder the defense S&T burden alone. NATO S&T enables the sharing of resources; establishes economies of scale; and creates synergies and network effects. Indeed, the return on investment can be very large. One interlocutor argued that his nation leveraged up to 10 times the money put into NATO S&T activities. Even nations with limited defense S&T investment can contribute significantly through niche competencies. Such opportunities will continue to grow. Emerging areas of investment, such as AI, big data analytics, autonomy or cyber, are increasingly driven by software and algorithm development and often only require smart brains – not large capital investments.
- **Capacity building:** NATO S&T brings together scientists, engineers and analysts from government, industry and academia. This helps them gain new knowledge, experience and skills – to the benefit of their nations. Nations who cannot (yet) effectively contribute to NATO S&T efforts or absorb defense S&T developments can volunteer as chairs of activities and build up their capacities over time.
- **Interoperability and standardization:** Interoperability and standardization are key to NATO operations – they are the glue binding NATO’s militaries together on the battlefield. Thus, the earlier in the R&D process member states can work towards interoperability, the better (and cheaper) for the Alliance.
- **Quality assurance:** S&T thrives on peer review. In NATO S&T, national experts can submit their ideas and work to a larger community in classified and non-classified settings – with the former adding substantial value.
- **Building trust and confidence:** The Alliance is built on trust and confidence. Without this, the Alliance could not function. During operations and, at worst, wartime, Allies will need to send troops into harm’s way. Building trust at all levels, including at the S&T level, is therefore immensely valuable.
- **Demonstrating political commitment:** Active participation in NATO S&T demonstrates political commitment to other Allies. This is crucial, especially in times of political strain within the Alliance.
- **Leveraging network effects:** The NATO S&T community provides a network with a well-defined structure. National representatives meet and interface with colleagues outside traditional bilateral relations. This facilitates coordination, cooperation and collaboration in NATO S&T, but can also be leveraged in other NATO entities and lead to bi- or multilateral projects outside NATO S&T.
- **Ease of cooperation:** NATO S&T is a government-to-government relation, taking certain competitive elements out of the equation, especially at lower technology-readiness levels. Allies value the low threshold for initiating collaboration, which normally only requires four nations to start an activity.
- **The US dimension:** For many nations, especially those with limited defense S&T budgets, the continued deep involvement of the United States in NATO S&T is a cornerstone, given that US

defense S&T investment is multiple times the investment in the rest of NATO members. Maintaining a broad and deep presence of the United States in the NATO S&T community must remain a priority.

#### IV. THE WAY FORWARD FOR NATO S&T: POLICY RECOMMENDATIONS

##### A. UNLEASHING THE FULL POTENTIAL OF THE NATO S&T COMMUNITY

30. The 2012 NATO S&T Reform aimed to make NATO S&T more effective and affordable. It required NATO S&T stakeholders to break down old barriers, build new effective connections and form a more cohesive NATO S&T community. The community has made huge strides since then. In general, the interviewed stakeholders underlined they were comfortable with the new S&T framework. Within the community there is a growing interconnectivity. Nevertheless, not all barriers have been completely removed nor all connections established or filled with life. The positive aspects of a situation still in flux is that it offers the possibility to make dynamic change before bureaucratic inertia sets in.

31. The distinct parts of the community need to continue building a lively ecosystem where NATO S&T networks can connect and which communities outside the NATO S&T community can tap into or contribute to. Interlocutors argued that this would lead to more coherence, more effective exploitation of existing institutions and networks and more systematic cross-fertilization on key S&T topics.

32. Interviewees singled out a number of communities with which the NATO S&T community needs to better interact: academia; acquisition authorities; defense planners; traditional and non-traditional defense industry; military authorities and operators; national S&T stakeholders; political leadership; and the armaments community. Based on her research, your Rapporteur would thus put forward a number of recommendations.

33. Other communities must be brought into the NATO S&T process earlier to increase the relevance of S&T activities. For example, more defense planners should be brought into the CSO's work during the formulation of the CPoW.

34. The NATO S&T community must work towards more active and systematic engagement with other communities in order to offer S&T perspectives on their problems and needs. For example, the NATO S&T community should engage with national armaments planners to the fullest by engaging with the CNAD framework whenever opportune and meaningful.

35. The NATO S&T community must increasingly engage in the NATO Defence Planning Process (NDPP), making it a focal point for bringing the different stakeholders and communities together (see Table 5). NDPP-driven future requirements are increasingly employed within the S&T community. Nevertheless, substantial work remains to be done. The NATO S&T community should stay ahead of the curve and focus on the 2023-2028 NDPP cycle.

36. The S&T Community must consult more closely and directly with military operators and users and communicate results in a manner meaningful to them. It is clear that military operators and users demand more from the S&T community. The military community desires quick results, which requires mutual expectations management,

<b>Table 5: NATO's Four-Year Defence Planning Process</b>
Step 1 - Establish political guidance
Step 2 - Determine requirements
Step 3 - Apportion requirements and set targets
Step 4 - Facilitate implementation
Step 5 - Review results
<i>Current status: Step 1</i>
<i>Start of next NDPP cycle: July 2023</i>

political leadership from the top and a more agile NATO S&T community that is sympathetic to the military's needs and requirements (see below). This is why prototyping, demonstration, tests and

experiments are crucial (also see below). The new Structured Partnership between ACT and the STO as well as more interaction with Allied Command Operations through this Partnership will further reinforce this. If the NATO S&T community can deliver on this, buy-in from the military community will increase drastically.

37. Building better relationships with national delegations at NATO is central to increasing national buy-in for NATO S&T. It will be difficult and perhaps a strain on resources, but such an effort offers a lot of potential. Building better relationships requires increasing contacts, establishing personal relationships and exploring national needs. The OCS and other NATO HQ-based entities should lead this effort.

38. While NATO and industry are coming closer together, engagement must be intensified. Increased dialogue would enable S&T leaders to indicate what problems they need addressed, and industry can offer insights into current and next-generation S&T. Such industry involvement should start much earlier than it does today, in a more structured manner and at lower levels. It should also include more non-traditional industry players.

39. The interconnectivity of IT systems and databases within NATO and with the nations must be enhanced. To break down barriers and enable more tight interactions, useful data must be easily shared between different stakeholders, including at higher classification levels, for example between the STO and COMEDS.

40. The tight coupling between academia, industry and defense S&T must be strengthened within nations and should be explored at the NATO level. The so-called Triple Helix between academia, government and industry offers great potential for the creation of new knowledge, inventions and innovations.

41. Lastly, frequent parliamentary engagement in national parliaments as well as through the NATO PA is key to delivering better NATO S&T. Parliamentarians are crucial for providing support to robust defense S&T programs. The NATO S&T community must help parliamentary work by providing insight into relevant technological developments and investment opportunities. Your Rapporteur notes that the interaction between the STC and the NATO S&T community – at both the staff and leadership levels – has drastically increased both in frequency and quality, especially after the 2015 and 2017 Letters of Intent between the NATO PA Secretary General and, respectively, the NATO Chief Scientist and the NIAG Chairman. The interactions should continue to improve. NATO and national S&T leaders should increase engagements with parliaments, for example with regular updates on technology trends or by directly supporting NATO PA delegations on S&T matters. Your Rapporteur encourages her colleagues to extend invitations to national and NATO S&T leaders to engage in substantive and regular discussions in their national parliaments. Direct personal discussions are key to understanding the challenges and opportunities that lawmakers must think through to keep their armed forces and the Alliance as a whole at the cutting edge of S&T and, ultimately, preserve the military edge. Your Rapporteur would like to underline that engagement with members of parliament must be targeted and timely. Communications must provide parliamentarians with evidence of the merit and impact of the work performed within the NATO S&T community by showing its relevance to military matters but also to salient societal issues. Engagement must be politically meaningful and digestible, without diminishing the scientific merit behind the messages. The STC should stand ready to provide further insights into what the parliamentary needs are in terms of S&T engagement.

42. Your Rapporteur would also like to note that parliamentarians have a responsibility to increase their S&T situational awareness and knowledge. S&T is ever more present in societies, and parliaments are conducting an increasing number of inquiries focused on S&T risks and opportunities.

## **B. NURTURING A MORE DIVERSE NATO S&T COMMUNITY**

43. As in other parts of the defense and security world, the question of how the NATO S&T community can increase diversity has become crucial. Indeed, the community needs to achieve an improved gender and demographic balance and draw new members into emerging S&T areas where the community's knowledge base is thin. The most pressing concern in the NATO S&T community appears to be the age balance.

44. The STO, for its part, has analyzed the demographics of its network and communicated the results to Allies, who ultimately must drive the change. NATO entities have little leverage over nations, which often want to send their most experienced scientists and engineers. Fortunately, a number of Allies take the challenge of diversifying their defense S&T workforce very seriously. NATO S&T leadership should use its vantage point to the fullest by supporting these efforts and convincing others to do the same.

45. As the Committee learnt on its 2018 visit to San Diego and Silicon Valley, the competition for the best and brightest S&T talent is fierce and the opportunities outside the government and outside defense and security are vast. Allied S&T leaders must be visible and proactive enough to ensure they can attract and retain scientists and engineers of the caliber we will need to maintain the S&T edge. While the private sector can offer financial and certain other incentives that defense S&T cannot, national and NATO S&T leadership must communicate the unique selling points of defense S&T to those it needs to attract into the network. For example, the STO taps into an active network of about 5,000 experts which, in turn, can reach out to an extended network of 200,000 colleagues. The STO network thus constitutes the world's largest collaborative research forum in the field of defense and security. It also offers travel opportunities, a high quality of work and research opportunities the civilian sector cannot provide.

46. Young scientists and engineers often lack enough incentives to engage in NATO S&T work. Scientific and technical work carried out within a NATO context is difficult, albeit not impossible, to transition into publications that count in career advancement. In other words, if young scientists and engineers must go to greater lengths in NATO S&T to advance their careers, why would they bother? The NATO S&T community must investigate how to lower the barriers for meaningful publications.

47. Moreover, the current model of temporary contracts makes it less attractive for young people to apply for NATO positions. Such contracts take them out of national career advancement tracks without being beneficial for their careers. Here, nations need to learn from each other on how to offer opportunities that are not disruptive to budding careers.

48. Three recent laudable initiatives aim to expose more young scientists and engineers to NATO S&T. First, the STB has begun giving out early career awards. Second, the STB hosted a young career event in the side-lines of its last meeting where the young scientists and engineers could present their work and expose it to the senior STB level. These early career efforts should continue. Third, within the CMRE, a career path for young incoming scientists has been recently developed.

49. Moreover, the NATO S&T community should explore:

- how to send a better signal to young scientists and engineers;
- whether to devise a dedicated diversification policy;
- how to establish networks of young scientists and engineers; and
- whether S&T contests could be a good way to tap into new talent pools.

## **C. ENHANCING THE AGILITY OF NATO S&T**

50. Given the challenges the Alliance faces, including an accelerating S&T landscape, increasing agility in the NATO S&T community – in the people, tools, equipment and network – is of utmost importance. Many interlocutors cautioned, however, that this would be difficult and take time. Once

again, the nations are critical, as agility enters NATO S&T through their financial and personnel contributions. Some interlocutors argued that NATO as an institution should not be the leader on agility. For one, the strength of NATO S&T lies in long-term S&T rather than in quick results. Moreover, nations tend to micromanage NATO efforts, which would be counterproductive for agility.

51. The NATO S&T community is indeed working diligently on increasing its agility. The OCS has developed the von Karman Horizon Scanning tool to quickly perform a technology scan on a particular S&T topic (time needed: two to six months) and *ad hoc* initiatives like the Maritime Security Initiative focusing on submarine warfare and naval mine warfare. The CSO has increased its agility through increased leadership by the Director of the CSO; through improved receptiveness and sensitivity to demands by the STB and the NATO Chief Scientist; and through tools such as Technology Watch and S&T Themes focused on operational needs. The CMRE has started to analyze its future options and possibilities from a content, resources and business-model perspective, under the leadership of its Director. ACT is refining the requirement process for development and acquisition and is looking to improve industry cooperation. The NIAG will become more agile by moving away from cumbersome long-term studies and into studies with quicker turnaround times.

52. Throughout the interview process, a number of recommendations stood out favorably for your Rapporteur:

- NATO S&T leadership should actively engage with nations, NATO S&T subject matter experts and military operators and users on the importance of an agile mindset.
- The NATO S&T community should encourage more risk taking in NATO S&T, for example through prototyping, demonstrations, test and experiments (see below).
- NATO S&T leadership should foster a more strategic approach to S&T in the NATO S&T community.
- NATO S&T leadership should encourage nations to make available national experts who are well versed in introducing agility.
- National best practices to increase agility should be collected, analyzed and shared. These best practices should cover such areas as risk management; fast-track development; acquisition; program management; and technology transition. The CNAD Framework for Innovation, which analyzes national innovation initiatives, is a good example that should be applied in other areas.
- New policy tools to facilitate Alliance exploitation of emerging and disruptive technologies must be developed, for example in AI, automation, cyber and big data.
- NATO S&T should continue to foster communities of interest and boost activities focused on autonomy, big data and artificial intelligence, and operations in contested urban environments, i.e. the current STO Themes. The STC will examine the implications of artificial intelligence in the 2019 STCTTS Report.
- A better, more broadly visible and available information management system must be developed to make NATO S&T readily visible and searchable by all relevant national S&T and capability development authorities.
- Information sharing at a higher classification level, including of research data, must be eased to stay at the forefront of S&T. In particular, easing national security clearance processes could facilitate dialogue at the early stages.
- Prepare prototyping, demonstrations, tests and experimentation packages that are ready to be implemented when the demand arises.
- Seed money tools should be developed which can be used without burdensome approval processes, which could be used by military commanders or the NATO S&T leadership to support demonstrations or rapid studies and analyses for example.
- Military commands could create technology ambassadors who could scan the S&T landscape for potential solutions for operational needs.
- Processes at NATO, for example regarding capability development and requirement setting, should be revised and streamlined.

- Competition-based tools, which the NCIA, for example, has experimented with, should be explored.

#### **D. DEMONSTRATING THE VALUE OF S&T TO THE MILITARY COMMUNITY**

53. Increasing the use of prototyping, demonstrations, tests and experiments to demonstrate to military operators and users what S&T can already offer them today emerged as a key recommendation throughout the research for this report. Interlocutors – both the stakeholders who carry them out and those who are the beneficiaries – agreed that such efforts need to be stepped up. Such efforts:

- accelerate capability development by bridging the so-called valley of death between research and development;
- help nations understand where they stand on S&T compared to other Allies;
- showcase concrete practical military relevance today; and
- bring problem solvers into contact with those who must deal with problems in operational environments.

54. The NATO S&T community already conducts prototyping, demonstrations, tests and experiments, most importantly in the CSO, ACT and CMRE. The CSO continues to increase the number of Cooperative Demonstrations of Technology (CDTs). In 2018, the number is expected to rise to 18 (up from eight in 2017 and two in the previous years). ACT's experimentation work is of critical importance as well, as it takes place in a realistic operational setting. The CMRE is also increasingly tying its experimentation work into military exercises. Industry's interest in getting involved in demonstrations, tests and experiments is steadily increasing as well.

55. The Alliance needs to elaborate better processes and tools to facilitate the insertion of S&T into operational settings, especially Allied Command Operations exercises and ACT activities. NATO S&T has now proven that its demonstrations and tests do not 'ruin the exercises', as some military operators had feared. The interplay between operators, S&T and industry has also proven productive. All involved have succeeded in breaking down barriers. However, processes should become much smoother and move away from *ad hoc* interactions that are too dependent on personalities.

#### **E. IMPROVING STRATEGIC ENGAGEMENT AND COMMUNICATIONS**

56. A key point noted in almost all interviews was the need to strengthen the NATO S&T community's strategic communications. If defense S&T – regardless of the forum – is out of sight, it is out of mind – regardless of S&T's objective merits. Ultimately, the NATO S&T community must create advocates in other communities who are convinced of the value S&T brings to their problems and needs. The S&T community cannot be its own lone advocate. Ideally, communicating the importance of S&T needs to come from the political leadership. In this context, the NATO Chief Scientist plays an instrumental role to make STO and NATO S&T more visible at NATO HQ and beyond. Concretely, communications should:

- convey messages in a language understandable and meaningful to the audience;
- provide concrete answers to the question: "So what?";
- focus on concrete, individual success rather than presenting complete but abstract documents;
- offer concrete support and advice;
- showcase S&T's impact and importance; and
- help 'connect the dots'.

58. Some very practical suggestions were mentioned by interlocutors. For one, S&T-minded ambassadors could come together for an ambassadorial event in order to raise the visibility of S&T at NATO HQ. Also, NATO S&T should organize events at NATO HQ on salient and current issues,

for example the value of S&T in responding to the Salisbury chemical attack or its contribution to novel capabilities like the F-35. Moreover, a planned CDT at NATO HQ could further raise awareness and visibility of NATO S&T and set a good example for future CDTs at NATO HQ.

## **F. REINFORCING THE SCIENCE AND TECHNOLOGY ORGANIZATION**

59. Almost all interlocutors agreed that the overall set-up was right to deliver on the NATO S&T mission and that the focus should be on getting the best within the existing organizational model. Nevertheless, some questions on organizational adaptation remain open and very much debated in the NATO S&T community. In particular, further adaptation of the NATO STO and its executive bodies appears to be in order. The current manpower allocations were generated in 2012, when the STO carried out a markedly smaller program of work and there were fewer demands on the STO's three executive bodies. Equally importantly, the strategic environment has changed markedly since then as a result of Russia's destabilizing activism in the Euro-Atlantic area, in particular its illegal annexation of Crimea and its military intervention in Eastern Ukraine. Overall defense budgets across the Alliance are rising to meet this challenge. Thus, a complete review of workload, requirements, manpower and organization is appropriate, based on better data and a better understanding of the evolving threat environment. Now that the STO has been in place for 6 years, it is only proper to fully review it and recommend changes, as appropriate, to the NAC.

### **1. The NATO Chief Scientist and the Office of the Chief Scientist**

60. Most interlocutors argued that creating a NATO Chief Scientist position at NATO HQ in 2012 had been a crucial decision. NATO senior leadership and entities in Brussels are beginning to recognize the NATO Chief Scientist and the OCS, even though it has taken longer than many anticipated. Interlocutors cited a number of important reasons having the STO represented with a Chief Scientist at NATO HQ.

61. The STO is a NATO entity. As such, it needs to be represented at NATO HQ, where it can build up political networks and relationships, which are fundamental for effective policy making in the Alliance. Such trusted networks and relationships increase the agility of the STO as a whole. The STO can now much more easily provide S&T advice to senior leadership and NATO entities based in Brussels when appropriate or demanded, both formally and informally. Indeed, the Chief Scientist is part of the NATO HQ Senior Leadership meeting. He regularly briefs the Military Committee, delivers advice to the North Atlantic Council and works hand-in-hand with other parts of the S&T Community to increase program coherence, for example with the Emerging Security Challenges Division. To increase connectivity, some interlocutors called for the OCS to increase its interface with the Private Office of the NATO Secretary General. For the national S&T representatives, who only meet twice a year at the STB level, having the Chief Scientist in Brussels is also a key additional resource to understand and potentially shape NATO policy. For example, tackling the evolving relationship between the European Union (EU) and NATO on S&T could not be handled at the appropriate political and senior level without the OCS in NATO HQ.

62. Some interviewees questioned whether an organizational structure with three executive bodies in the STO continues to be the right model. The NATO Chief Scientist does not lead the STO as a whole. The Directors of the CSO and the CMRE have their own responsibilities and authorities, which can make day-to-day management complex and dependent on personal relationships. Some thus argued that these positions should be subordinate to the Chief Scientist to allow for better oversight of the STO on behalf of the STB. This question requires more analysis, as this view may be a minority view. The current organizational structure of the STO comes from the NATO Reform of 2012.

63. The NATO Chief Scientist position is filled as a voluntary national contribution. A lively debate exists in the STO whether this remains a sustainable model, as the filling of such a critical position relies on the goodwill (and funding) of individual nations.



## **2. The Collaborative Support Office**

64. The CSO is supplied with core funding from the NATO budget (EUR 5.85 million in 2018). The CPoW has seen significant growth, both in overall activities and in the crucial CDTs, since 2012. The number of activities run each year has increased by 77% in the last ten years – from 141 in 2007 to 264 in 2017. This is a sign of the added value NATO S&T can provide to nations. A number of interlocutors noted that, if the CPoW were to grow even more – which is expected – the CSO would quickly reach a limit as to how many more activities it could support. Already, support for the more strategic efforts is becoming increasingly difficult and the CSO does not have the means to support all proposed CDTs. The CSO, in particular the Director, may have to engage in more direct outreach to national representatives to get activities started. Indeed, some nations have appreciated such a push in the past. Such efforts would require the dedication of time and staff as well as backup by STB members. Some interlocutors called for a slight increase in manpower, with perhaps two to four additional staff. One interviewee argued that the main need was to connect nations better with the CSO, which required increased travel budgets to identify synergies.

65. Financial constraints and the lack of human resources, at times, hinder the valuable participation in the CPoW of representatives from the rest of the NATO S&T community, particularly ACT, the CMRE and the NCIA. Some interlocutors argued that these entities should examine ways of increasing their participation in the CPoW. The CSO for its part should explore ways to improve the value added through their participation in the CPoW.

66. If Allies want to be serious about NATO S&T, they also need to remain engaged and even step up their support. Nations provide continuous support through international military personnel and voluntary national contributions. If that support were to disappear, the CSO would collapse. Currently, critical positions are left vacant because no nation is willing to put forward the necessary voluntary national contributions or international military personnel, which make up more than a quarter of the staff. Moreover, at times, the formulation of opinions in the panels and group is driven by personal interests, rather than by a strategic approach. For example, the possibility of engaging in high-risk/high pay-off activities is not given enough attention, according one interlocutor. Moreover, some interviewees questioned whether there is enough renewal and agility in the program. Indeed, visibility regarding underperforming projects is very limited, due to the lack of monitoring. One interlocutor argued that a more strategic approach to CSO activities was not called for, pointing to the national prerogatives.

## **3. The Centre for Maritime Research and Experimentation**

67. The CMRE is the one institution in the NATO S&T community that almost every interviewee argued is under heavy strain. Opinions vary widely on how to adapt the Centre (or not). The current organizational model and even the future of the CMRE appear very much in question. With the NATO S&T Reform, the CMRE became fully customer funded. The Centre has no core funding, putting severe limits on its room for maneuver, especially in terms of business development, sustainment of assets and long-term projects. Many interviewees argued the customer-funded model, as it stands today, is not valid anymore. If left untouched, the CMRE will not be able to survive. A hybrid model that retains a strong market-based logic, incorporates an element of core funding as well as new tools and maybe charges customers more was proposed by several interlocutors.

68. One interlocutor argued that the CMRE is actually not really customer funded, as most of its revenue stream still comes from one customer (ACT), and was not really in a market – the market wants results tomorrow, but the CMRE is mostly focused on the long term. He argued that governments should step in and pay for the vital long-term S&T the CMRE produces, and that he Centre was a common asset and must be funded like one. Those holding this view advocated to seriously explore NATO common funding opportunities. Beyond a set level of such common funding, one interlocutor suggested that a percentage share of the CMRE's revenue streams could be matched with NATO funds. In other words, the more success the CMRE found on the market, the

more it could invest in the future. Some argued that it would also require the CMRE's mission to be updated and sharpened. One suggestion was adding a focus on research and experimentation in AI and autonomy, given the vast data sets the CMRE continues to generate in these areas.

69. The market does not have a lot of customers beyond NATO entities and Allied and partner nations. It is true that new opportunities exist in EU research programs. However, NATO-EU relations are not yet fully formalized, including on crucial issues such as the exchange of classified information. Could the CMRE then fully tap into this potential? Even if the CMRE could find more novel customer-funding streams, another question beckons: would the Centre's activities drift too far away from core Alliance needs and requirements?

70. While the CMRE offers significant value to nations, military operators and users as well as national S&T representatives do not always communicate this. Advocacy by the CMRE itself and by ACT, its main customer, cannot be enough. Increased advocacy from nations and military commands which clearly benefit from the CMRE is fundamental. And they are beginning to do so. At Allied Maritime Command for example, there is significant appetite for the services the CMRE provides, but more systemic interaction between the CMRE and Maritime Command needs to be developed.

71. On balance, your Rapporteur strongly suggests that the current CMRE model be revisited. It goes beyond the scope of this report to devise robust recommendations. However, she would argue that it cannot be an option to just wait and see if an organisation can survive with a model that is not truly geared for survival. If that were the case, tax payers – and your Rapporteur – would not understand why the Allies needed to pay for an experiment facing such high odds. She would therefore urge for a careful analysis with a view towards making the CMRE fit for purpose. The CMRE is a world-class S&T institution, with capabilities that nations individually or in cooperation would struggle to fill if the CMRE were to fail or would lead to unnecessary duplication. In a time when nations are increasingly worried about maritime situational awareness and anti-submarine warfare, making the CMRE fit for purpose must remain the goal – also as a way to send a strong strategic signal that NATO takes these challenges seriously.

## **G. EVALUATING NATO S&T ON MISSION DELIVERY**

72. As the NATO S&T community is strengthening its efforts and adapting to the new strategic reality, it is imperative to evaluate the community on mission delivery. This will be a difficult endeavor, and perfect indicators for such an evaluation may not exist.

73. For one, measuring how high-quality S&T is translated into capabilities is extremely difficult because of the time lag between S&T and successful development. The invention of the transistor in the 1960s has led to unparalleled applications several decades later, and the end is not yet in sight. How does one measure this? Moreover, the rewards of NATO S&T are normally reaped in nations and the visibility of successes quickly gets lost, even when they circle back into the NATO S&T machinery. Unfortunately, NATO S&T does not “put a string” on its activities to track where the efforts lead. This would be an obvious next step to showcase and track NATO S&T results.

74. No specific metric or ‘dashboard’ for the evaluation of S&T mission delivery exists at this point. Several interlocutors admitted that the NATO S&T community was not doing well enough on evaluating itself and called for a concrete plan to do so. One interviewee argued that it was impossible to evaluate S&T much beyond the input side of the equation. The input side is indeed a good start to evaluate NATO S&T because it is more easily measured and is partly captured in the NDPP process.

75. Most agreed that the NATO S&T Strategy provides a good framework to characterize implementation, in particular through its goals, lines of effort and investment areas (see Table 6). Indeed, the STB will need to develop such a framework to report to the North Atlantic Council on the

implementation of the Strategy. One interlocutor argued that the Strategy was “timeless” and should not be changed every few years. In this way, the community could build up a track record. One interlocutor did, however, argue that the Strategy was still too vague for good metrics, especially ones targeted at individual nations, and lacked accountability instruments.

76. Also, the NATO S&T Priorities (see Table 4 above and Figure 2) serve as a reference frame for topical evaluation and overall coverage, by correlating NATO S&T activities and S&T Targets of Emphasis, which are linked to NDPP defined requirements. Indeed, many interlocutors emphasized the need to base evaluation on the NDPP process. Some interlocutors argued that S&T activity strands should be analyzed to see whether they delivered (although it is unclear how delivery would be measured). If they do not, they should be wound down.

77. National participation in NATO S&T activities should continue to be tracked and analyzed and lead to a more proactive NATO S&T approach to engaging with nations. Drops in participation should be analyzed and followed up on, as they could be a result of the (perceived) lack of concrete benefits for that nation.

Table 6: 2017 NATO S&T Goals, Lines of Effort and Investment Areas	
<b>Goals</b>	• Accelerate Capability Development
	• Deliver Timely, Targeted Advice
	• Build Capacity through Partnerships
<b>Lines of Effort</b>	• Stay at the Forefront of S&T
	• Forge and Nurture Effective Partnerships
	• Promote Prototyping and Technology Demonstrations
	• Enhance Alliance Decision Making
	• Focus on Alliance Needs to Boost Impact
<b>Investment Areas</b>	• Enhance the Network of Partners
	• Intensify Strategic Communications
	• Improve the Programs of Work
	• Promote Coherence

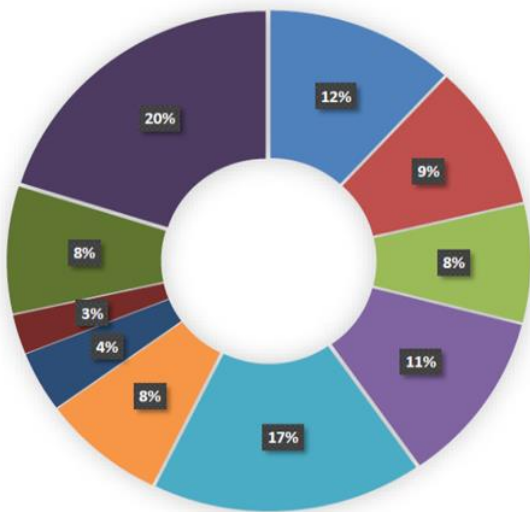


Figure 2: 2017 NATO S&T Activity across the whole NATO S&T Community	
12%	Precision Engagement
9%	Advanced Human Performance & Health
8%	Cultural, Social & Organizational Behaviors
11%	Information Analysis & Decision Support
17%	Data Collection & Processing
8%	Communications & Networks
4%	Autonomy
3%	Power & Energy
8%	Platforms & Material
20%	Advanced Systems Concepts

## H. INCREASING TRANSPARENCY ON DEFENCE S&T INVESTMENTS

78. Currently, public NATO reporting on defense expenditure only has four very broad categories, namely expenditure on ‘equipment’, ‘personnel’, ‘infrastructure’ and ‘other expenditure’. Defense S&T and R&D falls under the equipment category. In other words, in NATO’s public reporting, a dollar spent on buying off-the-shelf artillery is counted in the same way as a dollar spent on AI research. While many Allies publish such numbers individually and publicly, it might be useful to do so at the NATO level. NATO’s Defence Policy and Planning Division tracks these numbers, but these statistics are classified.

79. Your Rapporteur explored whether NATO should publish defense S&T and R&D numbers for the Allies, i.e. peeling them off the equipment category. Alas, no clear answer emerged. Of those asked, more than half supported such a move; a fifth answered with a firm no; and the rest did not know what the best move would be.

80. Many – even among those who advocate publishing the numbers – underlined that it would be very difficult to come up with correct and quality-assured definitions and data that would capture the true state of affairs. One could end up comparing apples and oranges. Some even questioned how robust the numbers under the NDPP truly are. Nations vary widely in how they conduct and account for defense S&T and R&D. Some smaller Allies – by choice or due to limited budgets – do not conduct much or any defense S&T, for example. Some Allies do not report all the military relevant S&T and R&D data because the money spent is overseen by ministries or institutions outside the Ministry of Defense’s purview. Allies have widely differing S&T and R&D systems, for example regarding the balance of state and private funds, defense versus broader security-related S&T and R&D spending as well as dual purpose and military S&T and R&D.

81. Those who did not advocate publishing the numbers often cited these difficulties, but also pointed to other factors. Publishing the data might:

- reveal too much to potential adversaries;
- create internal tensions within the Alliance similar to the strain related to the Wales Investment Pledge; or
- would not enhance the public debate, as the trade-off between long-term and short-term benefits of defense S&T/R&D is a complex matter.

82. However, among the latter group, many argued that the NDPP numbers should be made more visible within NATO institutions. Others also suggested that the NATO S&T community might want to get more actively involved in data collection and scrutiny, as it gives insight into the Alliance’s and Partners’ S&T portfolio choices.

83. Those who advocated full transparency used other arguments:

- Public and peer pressure on those Allies not spending enough on defense S&T and R&D should lead to increases in those who undervalue defense S&T and R&D.
- The political mandate lies with the parliament and the people, and transparency should thus be the default option.
- Many nations do publish these numbers already, and it would not be a huge leap to systematize data collection and publishing.
- National S&T leaders could use such numbers to position their nation among its peers and communicate this to political decision makers.
- Publishing these numbers could increase awareness and investment.

84. On balance, your Rapporteur would argue in favor of engaging in a serious discussion with NATO and national leadership to see if these numbers could be published in a meaningful way. They must at least be made more visible within NATO structures.

85. A related question, raised during the discussion of the first report at 2018 Spring Session, was whether the Alliance should define specific budget levels for defense S&T and R&D to complement the Wales Investment Pledge. On this question, the answer was almost uniform: defining specific budget levels for defense S&T and R&D makes little sense. Your Rapporteur would agree.

86. Most importantly, Allies have very different levels of ambition when it comes to defense S&T/R&D. Some nations see themselves as smart developers of military capabilities; others as smart specifiers who want to understand enough S&T to engage with industry in how to develop military capabilities; and a third category of nations see themselves as smart users and customers who will buy off the shelf but understand the deals industry can offer them. As the global leader, the United States will always spend much more on defense S&T/R&D than other Allies – not just in absolute numbers, but also as a percentage of its overall defense budget. At the lower bands of defense expenditure, however, the bandwidth to engage in serious defense S&T/R&D diminishes drastically. Some nations almost exclusively opt for off-the-shelf solutions.

87. Setting a minimum level for all nations might also lead to a degradation of output in other areas. If a nation would argue that sending personnel into military operations rather than spending marginal dollars in defense S&T and R&D, would it be beneficial for the Alliance to force the nation? Setting specific targets could also reduce the flexibility to move resources to favor development, procurement, training, operations or other areas according to NATO needs and requirements. Also, a nation with a small GDP and therefore a small absolute defense budget should perhaps concentrate more on the acquisition of equipment developed by others rather than on developing its own equipment. Others pointed to the fact that reaching the 2% and 20% numbers is hard enough. In Europe, the European Defence Agency (EDA) has identified a 2% target for defense spending on Research and Technology (R&T). However, EDA nations are, in aggregate, at less than 1%. One interlocutor argued that defense S&T/R&D is less about certain targets and more about budget stability, given the long lead times in turning S&T into capabilities.

## V. CONCLUSION

88. This report has underlined that Allied governments and parliaments must ensure that the Alliance stays ahead and maintains the S&T edge. The urgency of this strategic challenge is great. As US Congressman and former STC General Rapporteur Tom Marino wrote in 2017: "NATO's technological edge is eroding. Therefore, to safeguard our freedom and shared values, strategic defense R&D policy decisions are necessary and urgent" (NATO PA, 2017b).

89. To meet the challenge, it is essential, first, that Allies live up to the Wales Defence Investment Pledge and move towards spending a minimum of 2% of Gross Domestic Product on defense and more than 20% of defense budgets on major equipment, including related R&D. Your Rapporteur welcomes that Allies have committed themselves to delivering annual national plans which detail how they intend to meet the Defence Investment Pledge in three major areas: cash, capabilities, and contributions. Your Rapporteur laments the fact that these national plans will not be made public. Lawmakers and citizens of the Alliance need to know if NATO and the Allies are achieving their commitments and goals.

90. Second, it is also essential that Allies adapt to the new S&T landscape at the national level, as business as usual is no longer viable. Your Rapporteur thus welcomes recent national initiatives to spur defense technological innovation, for example the new Defence Innovation Agency to be established in France.

91. A third aspect to make NATO fit for purpose on defense S&T and R&D is to increase the added value of NATO. Your Rapporteur believes that much work needs to be done in this area. This report has laid out NATO's role in maintaining the S&T edge and the NATO S&T community's contribution to this effort. Your Rapporteur has laid out a range of concrete and realistic policy recommendations on how to advance NATO S&T and strengthen its contribution to maintaining NATO's S&T edge. These recommendations form the basis of an STC Resolution to be adopted at the 2018 Annual Session. Your Rapporteur hopes that the Resolution will send a strong signal to NATO senior leadership as well as Allied governments and parliaments to get serious about defense S&T in the Alliance. In conclusion, the Committee should continue to closely follow NATO and national efforts to maintain the S&T edge and Alliance agility, keep Allies and NATO on their toes and stand ready to support them.

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## ANNEX 1: LIST OF INTERVIEWS

### **NATIONAL DELEGATIONS TO NATO HQ**

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**Alan SHAFFER**, nominee for US Deputy Undersecretary for Acquisition and Sustainment; former Director, Collaborative Support Office

**Catherine WARNER**, Director, NATO Centre for Maritime Research and Experimentation

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