The Emerging Security Challenges Division

ANNUAL REPORT 2021

THE NATO SCIENCE FOR PEACE AND SECURITY SPS PROGRAMME

Preface by **David van Weel**

Welcome to the 2021 Annual Report of the NATO Science for Peace and Security (SPS) Programme.

It reflects a year that saw the Alliance take strong measures to tackle evolving and emerging security challenges. At the 2021 Brussels Summit, NATO leaders endorsed policies and agendas that will shape NATO's future in areas like innovation, technology, and the environment – topics that are close to the heart of the SPS. The Programme continues to make important contributions to these efforts, harnessing the benefits of cooperation among scientific communities of NATO Allies and partner countries to face the challenges of tomorrow.

Prominent within the NATO 2030 Agenda, Emerging and Disruptive Technologies (EDTs) such as artificial intelligence (AI), quantum technologies, and autonomy present both risks and opportunities for the future of the Alliance. In 2021, Allies adopted a strategy on EDTs and NATO's first AI policy, while SPS continued to bolster NATO's efforts to maintain its technological edge. It did so by supporting a growing portfolio of research projects in fields such as communication security, sensors and detectors, advanced materials, autonomy, and especially quantum technology.

With the approval of its Climate Change and Security Agenda and Action Plan, NATO recognized climate change as one of the defining challenges of our times. As environmental and energy security are central to the history of SPS, the Programme proved to be well placed to back NATO's strengthened commitment to raise awareness, adapt, mitigate and enhance outreach on climate and security issues. Through research and knowledge exchange among specialists, SPS continued developing systems to increase energy efficiency, enhance the management and disposal of pollutants, reduce greenhouse gas emissions as well as the impact of military activities on the environment.

By supporting practical scientific cooperation, the Programme contributed to the Alliance's continued response to the coronavirus pandemic. As part of this commitment, three SPS multi-year initiatives are developing solutions for the detection and rapid diagnosis of COVID-19. The SARS 3M project is a prime example of this effort. Launched in May, it will enhance workplace safety by designing a detector for the SARS-CoV-2 virus, thus helping to protect personnel and limit contaminations.

This report highlights how SPS engaged experts and scientists from NATO and partner counties on a multitude of other security-related areas, in line with Allied priorities. Notably, delivering on NATO's Counter-Terrorism Action Plan, SPS continued the implementation of the DEXTER flagship initiative, which is developing an affordable sensor-fusion system for the detection of explosives and firearms in public places in real time and without disrupting the flow of pedestrians. The results of DEXTER will be applicable to mass transit scenarios, critical infrastructures and gathering venues, and will bring direct benefits to the populations of NATO and its partner countries.

Engaging partners from all of NATO's partnership frameworks, the SPS Programme has an important role to play in building bridges and scientific networks by promoting cooperation beyond the military dimension. To continue giving visibility to the benefits of cooperation between NATO and its partner nations, SPS engaged NATO leadership, as well as high-ranking officials from Allied and partner nations. To name a few, these initiatives celebrated the achievements of cyber defence capacity building projects in Mongolia and the Republic of Moldova, the publication of research on future scenarios for NATO's Southern neighbourhood, as well as the launch of activities addressing key topics such as the security implications of new technologies and the role of AI in countering disinformation.

I wish you a pleasant read through this Annual Report, which will provide you with an overview of the ambitious and remarkable initiatives that illustrate the work of SPS in 2021.

David van Weel
Assistant Secretary General
NATO Emerging Security Challenges Division

Foreword by
Dr. Deniz Yüksel-Beten

In 2021, the Science for Peace and Security (SPS) Programme continued to be dedicated to bolstering scientific innovation and technical expertise, and to expanding and sharing knowledge in support to NATO's priorities.

The onset of the coronavirus pandemic in 2020 took the world by surprise, and affected populations across the world. Lockdowns, restrictions on travel and gatherings, and closures of institutions and laboratories had an impact also on scientific communities, causing delays and interruptions of research activities. While the Programme was quick to adapt to the new circumstances, a large number of SPS-supported Advanced Research Workshops (ARW) and Advanced Training Courses (ATC) had to be postponed and re-assessed to adapt to a pandemic world. Using online tools, new event formats, and extensive efforts to ensure the safe organization of activities, I am proud to report that the Programme successfully supported 17 of these Events in 2021, gathering more than 900 participants.

Resilience was a key topic for 11 of these activities, which included top-down ATCs on critical energy infrastructure protection at the NATO-ICI Regional Centre, as well as an ARW on strengthening resilience in Eastern Ukraine. SPS Events supported reflections and knowledge exchange on many other topics, such as quantum technology, climate and security, and Women, Peace and Security – all of them relevant to the future of the Alliance, as outlined in the NATO 2030 Agenda.

The coronavirus pandemic has reminded us that science is essential to build a safer environment and address new security challenges. By kicking-off 22 new research and development Multi-Year Projects (MYPs), the Programme has remained at the forefront of scientific cooperation efforts at NATO, addressing priority areas such as CBRN defence, environmental and energy security, advanced technologies, counter-terrorism, cyber defence, human and social aspects of security, and explosives detection and clearance. , Notably, the Programme expanded its portfolio in the field of quantum technology, one of the EDTs expected to have a major impact worldwide in the near future.
The completion of 22 MYPs showed once again the tangible technological solutions supported by SPS. For instance, 2021 saw the inauguration of the first terahertz imaging technology in North Africa, resulting from the first scientific cooperation activity between NATO and Algeria. In the field of crisis management, the Programme completed the adaptation and deployment of the Next-generation Incident Command System (NICS), an excellent example of regional cooperation across the Western Balkans. This situational awareness and coordination tool was used for the first time this year to digitalise the cooperation among first responders from 19 countries participating in the Euro-

Atlantic Disaster Response Coordination Centre (EADRCC) exercise "North Macedonia 2021". Contributing to NATO's work on climate change and security, in 2021 SPS completed a project that developed plant-based methods for the decontamination of former military sites, as well as research on clean energy solutions such as portable hydrogen-fuelled systems.

While demonstrating the commitment of SPS to supporting scientific research and innovation, the Programme's activities continued to engage with partner nations from all of NATO's partnership frameworks. Close coordination with the Public Diplomacy Division contributed to bringing to the public's attention many of the milestones that made 2021 unique. From the inauguration of new cyber defence capabilities in the Republic of Moldova and Mongolia, to the launch of new scientific collaborations responding to the coronavirus pandemic, the SPS Programme continued providing opportunities to highlight the benefits of practical cooperation involving NATO's partner nations, and its ability to deliver against NATO priorities.

This report presents the achievements of the SPS Programme and of its outstanding network of researchers, who are committed to expanding knowledge and sharing best practices to tackle contemporary and future security challenges.

I hope you will enjoy reading it.

Dr. Deniz Yüksel-Beten
Senior SPS and Partnership Cooperation Advisor
NATO Emerging Security Challenges Division

Figure 1 - The Science for Peace and Security (SPS) Programme team with Assistant Secretary General, David van Weel, and Deputy Assistant Secretary General, James Appathurai, of the Emerging Security Challenges Division.

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EXECUTIVE SUMMARY

The Science for Peace and Security (SPS) Programme enhances dialogue and practical cooperation between NATO and its partner nations. Through a balanced 360 degrees approach, SPS promotes cooperation based on four core dimensions: science, partnership, security, and unconventional issues. It does this by supporting demand-driven activities bringing together scientists, experts and government officials that address emerging security challenges through civil science and technology.

SPS provides funding and expert advice for activities in the form of four established grant mechanisms: research and development Multi-Year Projects (MYP), Advanced Research Workshops (ARW), Advanced Training Courses (ATC), and Advanced Study Institutes (ASI). These activities can be either 'top-down' or 'bottom-up'. The first are initiated by NATO International Staff (IS) in cooperation with Allies and/or partner delegations, while the latter are submitted directly to the SPS Programme by independent scientists and experts.

The Programme responds and adapts to a changing security environment in order to support NATO's strategic objectives and political priorities in its relations with partners. All of its activities are tailor-made, and must align with a set of Allied-approved key priorities that address challenges such as counter-terrorism, cyber defence, energy security, CBRN defence, advanced technologies, mine and unexploded ordnance, climate change and security, as well as human and social aspects of security.

In 2021, at the Brussels Summit, Allies highlighted a number of policy areas of great importance for NATO's future. Further considerations aimed at strengthening the Alliance over the next decade and beyond are enshrined in the NATO 2030 agenda, which was also agreed by Allied leaders in Brussels in July 2021. The broad range of topics addressed by its key priorities, as well as its flexibility, have enabled SPS to quickly adapt and deliver results in support of these priorities.

In particular, the SPS Programme continued encouraging cooperative solutions to emerging security challenges. As the development of policies on Emerging and Disruptive Technologies (EDTs) progressed, SPS remained at the forefront of innovation and advanced dual-use technology in the following areas: autonomy, biotechnologies, Artificial Intelligence (AI), and quantum. The Programme's deliverables in the field of counter-terrorism supported the Action Plan on Enhancing NATO's Role in the International Community's Fight against Terrorism. In this respect, the implementation of the DEXTER Programme was paramount to highlighting the potential of technological solutions to address the challenge of detecting explosives and firearms in public venues in real time. At the same time, as the world continued grappling with the coronavirus pandemic, SPS-supported projects investigated scientific solutions to the current and potential future crises of this nature. SPS increased the number of its activities addressing the COVID-19 pandemic by launching a new research initiative aiming to develop an innovative nanotechnology-based platform to detect the coronavirus and other toxic bioagents in the workplace. Other cross-cutting themes, such as Women, Peace and Security, Climate Change and Security and the nexus between hybrid warfare, cyber defence and resilience attracted the attention of numerous scientists and experts in the Programme's network. In particular, against the backdrop of NATO's newly adopted Climate Change and Security agenda, SPS continued the implementation of high impact activities, such as a flagship Multi-Year Project aiming to reduce fossil fuel consumption and energy waste in deployable camps.

Despite the coronavirus pandemic, the SPS Programme did not stop delivering. Adapting to new circumstances, it embraced online and hybrid formats to carry out about 50 events that engaged SPS grantees from both NATO and partner nations as well as high-level speakers and multinational stakeholders. These included 24 kick-offs of Multi-Year Projects, and 6 closing ceremonies marking the completion of key research projects and the delivery of critical capabilities in the field of cyber defence and advanced technology to partner nations such as the Republic of Moldova, Mongolia and Algeria. In addition, 17 SPS-supported ARWs and ATCs were successfully carried out either entirely online or in a hybrid format. These activities helped to complete the backlog of SPS Events that were delayed due to the onset of the pandemic.

Public diplomacy remained an essential component of the SPS Programme. Its activities continued showing the benefit of its tangible deliverables and of practical cooperation between NATO and partner nations. Online interactions were a very important channel to engage scientific networks and the public at large in the context of the pandemic, and required significant efforts to make information available and accessible across the SPS Programme's platforms. The SPS website remained the main source of information about the Programme, and received a similar amount of user traffic as in previous years. It was updated with 7 new articles on cyber defence, advanced technologies, women in science and scientific response to COVID-19. 14 new brochures were added to the website to provide overviews of SPS activities in different research areas, as well as 8 new Science Series volumes resulting from Events supported by the Programme. Through its Twitter account, SPS shared more than 40 tweets to mark achievements and milestones, including the launch of new scientific collaborations and expert meetings. SPS also gained visibility through the initiative of its grant beneficiaries, who worked on over 230 publications covering research and innovation outcomes of SPS-supported activities in journal articles, conference papers and book chapters, as well as videos, radio interviews, and engagements with mainstream media.

By overcoming some the constraints of the COVID-19 pandemic, 39 SPS activities were successfully concluded over the course of 2021 – 22 MYPs and 17 Events – involving partner nations from all of NATO's partnership frameworks. Notable among them is the completion of the adaptation and deployment of the Next-generation Incident Command System (NICS) in the Western Balkans. This 'top-down' key flagship SPS project was launched in 2016, and helped the acquisition, deployment and customization of the NICS to facilitate real-time coordination of first responders in case of disaster. In doing this, the project supported regional cooperation among participating countries, facilitating their collaboration also in the context of cross-border natural and man-made hazards.

17 workshops and training courses took place in online or hybrid formats, gathering a total of 1329 participants and 405 speakers - much larger audiences than they would have engaged had they taken place in person. Among other topics, ARWs enabled discussions and knowledge exchange on topics like the future of drone technologies and the development of quantum-safe cyber infrastructure. They analysed transformations in energy markets and energy security fields, with a particular focus on the Mediterranean region. Experts shared perspectives on policies and technologies for a greener defence sector, and they identified research gaps in the study of gender dimensions of military to civilian transition in Ukraine. Through training, SPS activities built capacity on critical energy infrastructure protection in Algeria and in partner countries part of the Istanbul Cooperation Initiative (ICI) and the Gulf Cooperation Council (GCC); on gender mainstreaming and counter-terrorism for trainees in the Western Balkans; on cyber defence for Azerbaijan, as well as cyber defence professionals from Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia through the NATO-ICI Regional Centre in Kuwait.

In 2021, 22 new MYPs were launched, focusing on the SPS key priorities of counter-terrorism, security-related advanced technologies (including EDTs), defence against CBRN agents, and environmental and energy security. For instance, new research initiatives started developing radar, sensors and detection systems, architectures of unmanned systems for border protection, as well as quantum technologies enabling sophisticated sensing and more secure communications. They are studying a new generation of drugs protecting against neurotoxic industrial chemicals, as well as technological solutions to detect and protect against dangerous chemical and biological agents. To mitigate the impact of climate change, they are investigating how to make the defence sector greener, as well as smart technologies for greater energy efficiency and better storage. These new activities added to a wide range of ongoing MYPs focusing on other SPS key priorities such as the detection of unexploded ordnance, and human and social aspects of security.

In response to one call for proposals for Multi-Year Projects, the SPS Programme received 68 applications for new activities. Following an initial eligibility screening and evaluation by the Independent Scientific Evaluation Group (ISEG), 18 of these activities were recommended to the Partnerships and Cooperative Security Committee (PCSC) for approval. All of them, as well as two proposals pending from the previous year, received Allies' approval. Advanced Technologies and Energy Security represented respectively 35% and 25% of these newly approved activities, reflecting the Programme's capacity to align with NATO's evolving priorities, such as the NATO 2030 agenda.

CHAPTER 1
SPS Highlights in 2021

2021 was a Summit year for NATO: an opportunity to reaffirm unity, solidarity and cohesion in the face of systemic competition, while continuing to respond to the COVID-19 pandemic with increased resilience at home and critical assistance to a number of partner nations. The Summit unveiled a new transatlantic agenda for the future with NATO 2030, which is meant to complement and build on NATO's ongoing political and military adaptation.

The Programme's wide-ranging key priorities enabled a quick integration of the 2021 Brussels Summit guidance into its work. The inherent flexibility of the SPS Programme allowed for a quick adjustment to the circumstances of the coronavirus pandemic in 2020, which affected its way of working also this year. Nevertheless, while carrying out its activities, the Programme continued to find opportunities to draw the public's attention to flagship initiatives in priority areas and highlight the importance of practical scientific cooperation at NATO.

Delivering on Political Priorities

As a partnership programme, SPS contributed to NATO's crisis management and cooperative security core tasks, offering training and capacity building support to partners, and helping them strengthen their own resilience to make both the Euro-Atlantic area and NATO's broader neighbourhood more secure. SPS has also helped foster cooperation between Allies and partner nations, encouraging cooperative solutions to emerging security challenges based on civil science and technology.

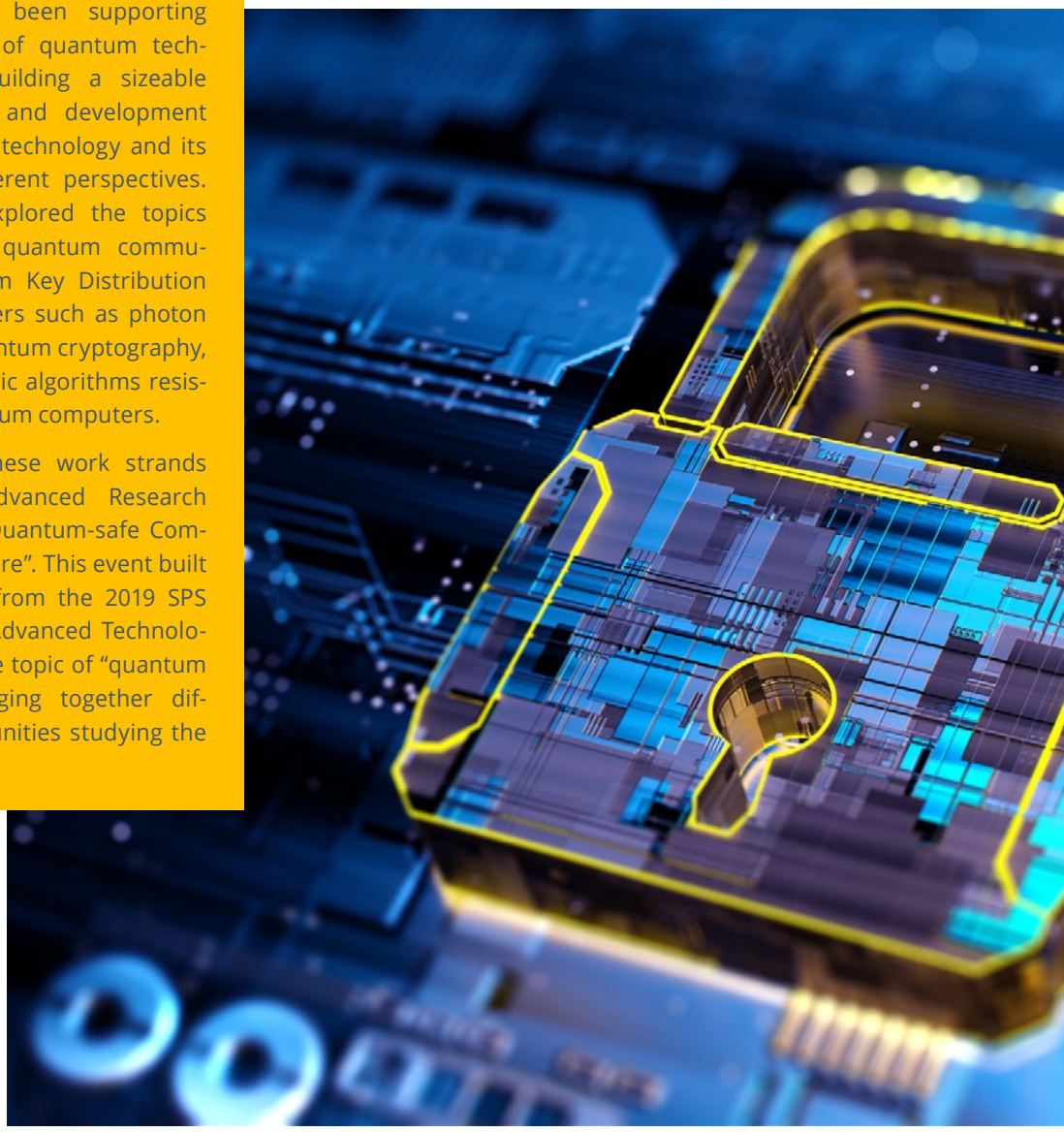
Technology and Innovation

In light of NATO's growing efforts in the innovation field, the SPS Programme has proven well placed to support the implementation of the Emerging and Disruptive Technologies (EDT) Roadmap. The Programme's focus on cooperation based on science and technology creates natural strong connection with the topic of innovation, and its activities have engaged experts in NATO and partner nations in many activities on subjects such as quantum technologies, autonomy, Artificial Intelligence, and bioengineering and human enhancement. In 2021, SPS remained at the forefront of innovation and advanced dual-use technology. Its activities helped to identify key technological trends in line with NATO's Coherent Implementation Strategy on EDTs, and engage with partner nations as appropriate.

SPS and quantum technology

The Programme has been supporting activities in the field of quantum technology since 2017, building a sizeable portfolio of research and development projects exploring this technology and its applications from different perspectives. SPS activities have explored the topics of quantum sensing, quantum communications and Quantum Key Distribution (QKD), quantum enablers such as photon counters, and post-quantum cryptography, to develop cryptographic algorithms resistant to attacks by quantum computers.

In 2021, several of these work strands converged in the Advanced Research Workshop "Toward a Quantum-safe Communication Infrastructure". This event built on recommendations from the 2019 SPS Cluster Workshop on Advanced Technologies, and addressed the topic of "quantum convergence" by bringing together different scientific communities studying the field of quantum.



Fight against Terrorism

NATO remains committed to its leading role in the international community's fight against terrorism through various means, including research and partnerships. SPS activities have continued to support the objectives of NATO's Action Plan on Enhancing NATO's Role in the International Community's Fight against Terrorism. They focused on key areas such as countering improvised explosive devices (C-IED), border and port security, security-related advanced technologies, defence against CBRN agents, unexploded ordnance detection and disposal, as well as human and social aspects of security, including gender sensitive research related to fighting terrorism and combating extremism.

The DEXTER Programme

"Detection of EXplosives and firearms to counter TERrorism (DEXTER)" is an SPS key deliverable in the area of counter-terrorism, and will provide a concrete contribution to NATO's ability to prevent, protect and respond to terrorist threats.

Launched in 2019, this flagship 'top-down' consortium includes 3 MYPs that engage 11 research institutions from 8 NATO and partner nations. In 2021, SPS continued supporting this programme, which seeks to develop an integrated system able to detect explosives and firearms in public spaces, remotely and in real time. Instead of random searches on moving passengers or checkpoints, the final product of DEXTER will allow the identification of carriers of firearms and explosives without affecting the passengers' traffic. DEXTER's outcome will be applicable to mass transit scenarios, critical infrastructures and mass gathering venues, and will bring direct benefits to the populations of NATO and partner nations. As DEXTER's activities are drawing near their completion, an integrated Big City Trial for the demonstration of its technologies in a real-life environment will take place in 2022.

Response to COVID-19

Throughout the year, SPS has continued to play an integral role in NATO's response to COVID-19. It investigated innovative solutions to build preparedness and resilience against the spread of this and potential future pandemics, by tapping into its network of scientists and research institutions. Moreover, several of its ongoing activities included elements relevant to the fight against the pandemic. One such example is the 'top-down' MYP "PROMEDEUS", which was launched in July 2020 to support the development of Mauritania's operational capabilities and emergency management. The project will achieve this goal by improving coordination between Mauritanian Civil Protection, health emergency systems, and participating authorities, notably though the creation of a telemedicine system for medical emergencies. This capability, as well as the crisis management centre established during two previous SPS projects, will help Mauritania to combat COVID-19 and similar emergencies in the future, and ensure better preparedness and effective response.

Building preparedness and resilience through science

Since the onset of the coronavirus pandemic, SPS has been an integral component to NATO's response to COVID-19. In addition to adapting ongoing activities in the field of crisis management and CBRN defence, the Programme has actively sought opportunities to kick-start new scientific collaborations dealing specifically with the impact of the pandemic on security.

The first such project, "New and Validated Tools for the Diagnosis and follow-up of SARS-CoV-2 Infected Individuals - NOCOVID" was launched in May 2020, with the goal of limiting the spread of SARS-CoV-2 by providing new tools for rapid diagnosis that can be used in large-scale settings.

In June 2021, SPS supported the launch of a new research project titled "SARS-CoV-2 Multi-Messenger Monitoring for Occupational Health & Safety - SARS 3M". This MYP, led by scientists from Italy and Austria, will develop an innovative nanotechnology-based platform to monitor the SARS-CoV-2 virus and other toxic bioagents in the workplace.

Cross-cutting Themes

The Women, Peace and Security (WPS) agenda is a core element of NATO's modernization efforts. In 2021, Allies approved a new NATO/EAPC Policy on WPS, and SPS developed and delivered new activities on the topic. In particular, in line with a priority identified by the NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation (JWGSEC), the Programme unveiled a new research agenda to offer a gendered lens on the reintegration of Ukrainian women combatants into civilian life. Knowledge gaps and recommendations on this topic were discussed in November during the Advanced Research Workshop "A Gendered Lens Approach to Military to Civilian Transition and Reintegration for Ukraine Joint Forces Operations (JFO) Women Combatants".

The Climate Change and Security Action Plan was endorsed at the 2021 Brussels Summit and sets out climate change as one of the defining challenges of our times, with considerable impact on Allied security. This is an area where science and technology generally, and the SPS Programme in particular, have and will continue to play a key role. As a result, activities in support of environmental security have drawn increased interest in 2021. Similarly, in the field of energy security, SPS has continued supporting innovative research and development, investing in new possibilities for the military to use new generation batteries and supercapacitors, as well as solar cells.

The nexus of hybrid warfare, cyber defence and resilience continued to generate a number of SPS activities in 2021, as nations continue to face threats and challenges from both state and non-state actors using hybrid activities to target our institutions and citizens. Among other topics, these activities addressed challenges specific to building resilience in north-eastern Ukraine, the risks associated with cyber threats to industrial control systems and critical infrastructure, as well as the role of Artificial Intelligence in fighting disinformation.

SPS and environmental security

For over half a century, the SPS Programme has been involved in addressing the security impact of environmental issues. SPS projects and events in this field have developed environmental prediction models, early warning systems, emergency response and governance mechanisms, and advanced technologies, building both military and civilian resilience. In recent years, the Programme's work addressed specifically the environmental impact of military activities and investigated greener technologies for energy generation and storage.

A chief example of the Programme's efforts towards a greener defence sector is the ongoing 'top-down' MYP "Harmonized Energy Monitoring & Camp Simulation Tools for Energy Efficiency". In the framework of this SPS project, experts from Canada, Australia, France, Germany, Netherlands, and USA are carrying out groundbreaking research on reducing fossil fuel consumption and energy waste in deployable camps.

Achieving Results during the Pandemic

The coronavirus pandemic continued affecting the scientists and institutions supported by the Programme, causing delays, restrictions, and the closure of laboratories. Nevertheless, SPS activities continued delivering and adapting to the circumstances by embracing new online and hybrid formats. About 50 events took place in this format in 2021, engaging the Programme's beneficiaries as well as high-level speakers and stakeholders.

These online and hybrid events included 24 kick-offs of **Multi-Year Projects**, and six virtual closing ceremonies marking the completion of 'top-down' flagship research projects and the delivery of critical capabilities.

The first of these commitments in 2021 marked the inauguration of a new Cyber Incident Response Capability (CIRC) for the Ministry of Defence and General Staff of the Mongolian Armed Forces. This MYP, started in 2017, was designed to strengthen the cyber defence capacity of Mongolia and was implemented in cooperation with the NATO Communications and Information (NCI) Agency. The completion of this SPS MYP was highlighted on 18 January through a virtual ribbon cutting ceremony, with participation from Mongolia's Minister of Defence, H.E. Saikhanbayar Gursed who joined from Ulaanbaatar, and NATO Deputy Secretary General Mircea Geoană joining from NATO Headquarters.

Shortly after, on 21 January, a similar ceremony took place to launch the new CIRC for the Moldovan Armed Forces. The CIRC helps to minimize threats resulting from cyber incidents and provides quick and efficient recovery in case of attacks. This capability was the outcome of an SPS MYP tailored to the needs of the Moldovan government, which included technical expertise provided by the NCI Agency. The Minister of Defence of the Republic of Moldova and NATO Deputy Secretary General connected from Chisinau and Brussels, respectively, to attend this virtual ribbon-cutting ceremony.

Figure 2 - The Minister of Defence of the Republic of Moldova and NATO Deputy Secretary General at the virtual ribbon-cutting ceremony of the CIRC for the Moldovan Armed Forces.

In May 2021, SPS celebrated the successful completion of NATO's first scientific cooperation project with Algeria. The project was implemented between 2017-2021, and established the first terahertz imaging technology in North Africa – a scanning system with potential applications in the protection of vulnerable sites from terrorist threats. On this occasion, SPS engaged in an online ceremony officials and scientists based in Algeria, France, and Sweden, as well as the NATO Assistant Secretary General (ASG) for Emerging Security Challenges, David van Weel.

Although most SPS online and hybrid events were open only to a selected audience, some of them were opportunities to present the results of SPS activities to the public. For example, on 16 July a public online roundtable took place with participation from NATO ASG for Emerging Security Challenges, David van Weel, and the Spanish State Secretary for Foreign Affairs and for Ibero-America and the Caribbean, Cristina Gallach. The aim of the event was to discuss the report 'NATO and the South: A Tale of Three Futures', which was the culmination of a two-year long SPS MYP, led by a consortium of research institutes from Jordan, Morocco, Spain and the United Kingdom. The report analysed key variables that are likely to affect NATO's Southern neighbourhood out to 2030, aligning with the horizon of the ongoing "NATO 2030" work strand. The event was streamed online on YouTube and received more than 500 views.

Figure 3 - The Spanish State Secretary for Foreign Affairs and for Ibero-America and the Caribbean, Cristina Gallach, and NATO ASG for Emerging Security Challenges, David van Weel speaking at the presentation of the report "'NATO and the South: A Tale of Three Futures'".

In addition to project kick-offs and closing ceremonies, 17 SPS-supported Events were successfully carried out either entirely online or in a hybrid format. These activities helped to complete the backlog of SPS Events that were delayed due to the onset of the pandemic, and to maintain the Programme's visibility in NATO and partner nations. In many cases, events organized in these formats succeeded in engaging larger audiences than they would have had they taken place in person.

For instance, the two-day ARW "Energy Strategies, Europe and the Mediterranean: trends and scenarios for a connected energy market" held on 24-25 March was recorded and broadcasted live in a professional television format via a customized online platform. Through this event format, the organizers - the NATO Defense College Foundation (NDCF) in Italy and the Policy Center for the New South in Morocco – enabled 21 high-level experts to interact with an audience of over 400 participants in 20 different countries.

Figure 4 - Former NATO Deputy Secretary General, Ambassador Alessandro Minuto-Rizzo at the SPS ARW G5831 "Energy Strategies, Europe and the Mediterranean: Trends and scenarios towards a Connected Energy Market."

On 27-29 October, the SPS ARW "Cybersecurity of Industrial Control Systems" took place in a hybrid format. The event, co-organized by experts from Poland and Azerbaijan, included remarks from Azerbaijan's Ministers of Education and of Transport, as well as from Deputy Assistant Secretary General (DASG) for Emerging Security Challenges, James Appathurai. This workshop aimed at raising cybersecurity awareness and stimulating cybersecurity education and training in Azerbaijan, and was intended to share know-how, lessons learnt and best practices among key stakeholders. Instead of the expected 40 attendees, the delivery of this workshop online allowed over 130 participants to attend, engage with experts and take part in a hands-on table-top exercise.

Another example is the ARW "Fighting Disinformation in a Pandemic World: the role of AI and Cognitive Sciences", which was conducted in a hybrid format on 16-17 November. NATO ASG for Emerging Security Challenges, David van Weel, and Italy's Permanent Representative to NATO, Ambassador Francesco M. Talò, formally opened this event's discussions, and joined the event from NATO HQ and Rome, respectively. Addressing two very timely topics – Artificial Intelligence and disinformation in the context of the COVID-19 pandemic – this workshop brought together world-leading scholars in Artificial Intelligence (AI), cognitive sciences, and related disciplines. Their discussions addressed the need for countermeasures against disinformation campaigns, exploiting the advantages offered by novel technologies, and aimed at formulating clear guidelines for NATO and partner nations.

Highlighting Cooperation through Public Diplomacy

Activities supported by the SPS Programme contribute to showing the value of cooperation and the importance of partnerships. They shine a light on NATO's commitment to cooperative security, and on the benefits of working with partners. Thanks to their high public diplomacy value, SPS activities bring the public's attention on NATO's work in the fields of civil science, technology, and innovation, and expand its understanding of the Alliance beyond the military dimension.

The 2021 Secretary General's Annual Report was an opportunity to present the contribution of SPS-supported practical scientific cooperation to key NATO deliverables, such as the Counter-terrorism Action Plan, Emerging and Disruptive Technologies, and the Climate Change and Security Action Plan. Moreover, in cooperation with NATO's Public Diplomacy Division, SPS made the most of the opportunities presented by its visible and tangible results, using all the tools at its disposal. In 2021, this work included ensuring that SPS visibility outputs aligned with NATO's new Brand Strategy, and updating the NATO website with content on the Programme's cooperation with partner nations.

With the continuation of the coronavirus pandemic into 2021, online interactions remained an essential channel for SPS to inform and engage the public and the scientific community. Therefore the Programme invested significant efforts in updating and enriching the content available on its website and Twitter account through articles and project brochures, as well as in developing content in cooperation with its beneficiaries.

The SPS Website: Relevant Information at a Glance

The SPS website (*www.nato.int/science*) is the main online source of information about the Programme, and is intended as a one-stop-shop enabling all of the Programme's stakeholders to learn about SPS. Members of the public interested in learning more about practical scientific cooperation at NATO can find here webstories, videos, project brochures and publications presenting the Programme's achievements. On the SPS website, scientists and experts willing to develop new SPS applications can find calls for proposals, relevant guidelines and requirements, as well as examples of past activities. Moreover, government officials may use its pages to identify examples of cooperative activities supported by SPS with each of NATO's partner nations, as highlighted in country flyers and in the interactive map of SPS activities.

Figure 5 Source: https://www.nato.int/cps/en/natolive/78209.htm

In 2021, the SPS website received regular updates that showcased the Programme's main engagements throughout the year: from the successful conclusion of flagship cyber defence MYPs, to stories of women in science supported by SPS, to brochures about new scientific collaborations developing smart wearable sensors to better manage crisis scenarios. The greater number of resources available on the website resulted in a greater amount of time spent by the visitors of the website consulting available material.

Webstories

7 new articles, drafted in cooperation with the Public Diplomacy Division, enriched the "Science news" section of the website. Most of them were featured also on the NATO homepage, and helped bringing the public's attention to official ceremonies inaugurating capabilities developed in the framework of SPS activities or launching new scientific projects contributing to NATO's response to the coronavirus pandemic. Several of these articles highlighted the engagement of NATO leadership as well as Ambassadors from Allied and partner nations in these events. Others focused on the personal stories of individual scientists participating in SPS research activities, as well as thematic areas, like

advanced technologies, where research supported by SPS is making great strides.

The three most read webstories were:

- An article published on 18 January to announce the successful conclusion of an SPS cyber defence project that built Mongolia's capacity in the field of cyber defence. On that date, Mongolia's Minister of Defence and the NATO Deputy Secretary General remotely cut the ribbon of the newly established Cyber Incident Response Capability (CIRC) of the Ministry of Defence and General Staff of the Mongolian Armed Forces.
- The announcement of the inauguration of a Cyber Incident Response Capability (CIRC) in the Republic of Moldova. Also this event took place through a virtual ribbon cutting ceremony in January, with the participation of the partner country's Minister of Defence as well as the NATO Deputy Secretary General. With the completion of this project, SPS concluded its contribution to the Defence and Related Security Capacity Building (DCB) package for the Republic of Moldova in the field of cyber defence.
- A story on the achievements of the first SPS scientific cooperation project with Algeria, which established the first terahertz imaging technology in North Africa. This achievement was marked with a virtual ceremony chaired by NATO Assistant Secretary General (ASG) for Emerging Security Challenges, David van Weel, in presence of officials and scientists based in Algeria, France, and Sweden as well as their representatives to NATO.

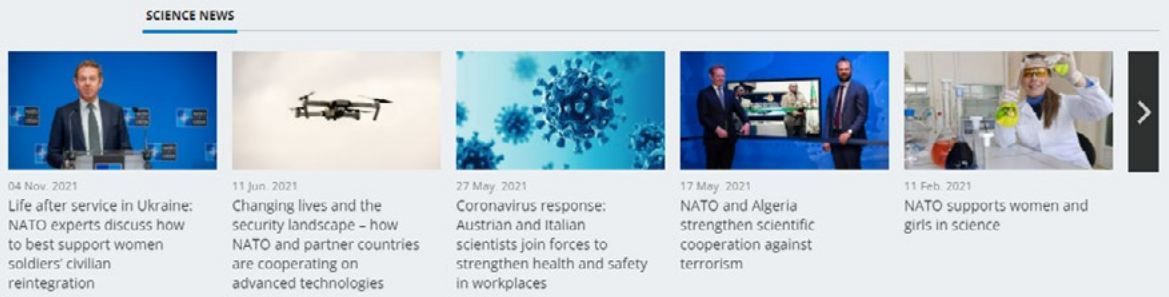


Figure 6 - Source: *https://www.nato.int/cps/en/natolive/78209.htm*

Read all of the SPS stories published in 2021 here:

- NATO helps to strengthen Mongolia's cyber defence capacity, 18 Jan 2021
- Cyber Incident Response Capability established in the Republic of Moldova with NATO support, 21 Jan 2021
- NATO supports women and girls in science, 11 Feb 2021
- NATO and Algeria strengthen scientific cooperation against terrorism, 17 May 2021
- Coronavirus response: Austrian and Italian scientists join forces to strengthen health and safety in workplaces, 27 May 2021
- Changing lives and the security landscape – how NATO and partner countries are cooperating on advanced technologies, 11 June 2021
- Life after service in Ukraine: NATO experts discuss how to best support women soldiers' civilian reintegration, 4 Nov 2021

Brochures

With its brochures, SPS created a dedicated space to give examples of the structure, deliverables and security impact of some of its flagship activities. Throughout the year, the Programme interacts with scientists involved in its activities to gather details and develop explanations about its projects, turning them into visibility products that can be accessible and stimulating for both scientists and the public. Brochures are also a useful tool to give visibility to high-level events and to participating institutions, as well as to outline how multinational project teams can collaborate in in the framework of SPS.

In 2021, the Programme enriched its website with 14 new brochures, giving insights into how SPS activities work in areas such as cyber defence, CBRN defence and advanced technologies.

Find out...

...how scientists from Malta, Slovakia, Spain and USA are working on quantum-safe solutions for fundamental cryptographic algorithms, which are currently the base for securing digital communications.

...how scientists from Austria and Slovenia are developing a sensor relevant for the defence against CBRN agents, environmental protection, energy security, and battlefield safety.

....how scientists from Belgium, North Macedonia, Serbia and Slovakia are using Artificial Intelligence to develop a smart patch that helps to save lives during mass causality incidents.

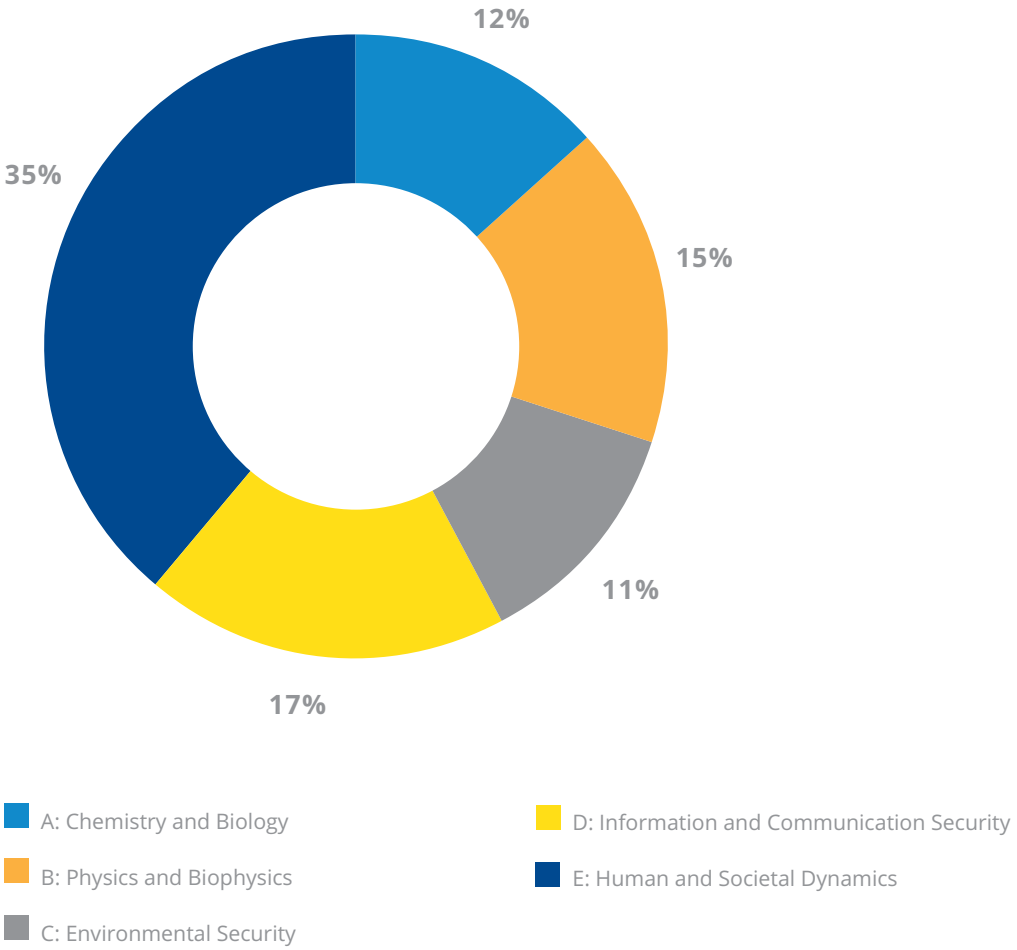
WHAT SPS DOES

Disseminating Findings with the Public at Large

SPS offers the organizers of workshops and training courses the possibility of publishing in the NATO Science Series. Sharing the outcomes and discussion of their activities in a Science Series volume provides co-directors with a pathway to bundle and share ideas with the public and the scientific community. While the content of these publications does not necessarily represent the perspective of NATO, these books still contribute to developing and enriching knowledge and expertise on subjects of relevance to the Alliance. Science Series volumes are divided into five thematic categories: Chemistry and Biology, Physics and Biophysics, Environmental Security, Information and Communication Security, and Human and Societal Dynamics. Since 2015, SPS has supported the publication of 90 such books, touching upon each of these categories, as shown in the image below.

In 2021, 8 new volumes were added to the Science Series, 5 less than in 2020. While changes in the yearly number of publications can be expected as they depend on co-directors' initiative, this figure is likely to be a consequence of the coronavirus pandemic and the smaller number of SPS-supported events that took place in 2020. As the labor-intensive process of drafting and editing these volumes takes place several months after the events, this impact of the pandemic only became apparent in 2021, and is likely to be absorbed in 2022 as the Programme exhausted its backlog of postponed events. A full list of Science Series volumes published in 2021 is available in Annex 4.

Science Series Publications since 2015



@NATO_SPS: The SPS Programme on Twitter

Through its dedicated presence on Twitter (@NATO_SPS), SPS maintained regular engagement with its audience. With more than 40 tweets, it brought to the attention of the public day-to-day achievements and milestones of the Programme, such as the launch of new scientific collaborations, expert meetings and new content published by SPS and related institutions.

Engaging with the Programme's stakeholders, both at NATO and in the scientific and academic community, was essential to amplify the reach of each tweet. Three tweets in particular had the highest number of impressions, demonstrating the interest of the SPS audience in these topics:

- At the end of MYP "Maritime Security - Multistatic and Multiband Coherent Radar Fleet for Border Security – SOLE", @NATO_SPS announced the successful testing of this project's results in the port of Livorno, Italy. With this project, scientists from Italy and Switzerland introduced the break-through concept of distributed radar networks.
- While SPS-supported discussions among scientists working on quantum physics and mathematicians focusing on quantum computing were taking place in Malta, SPS tweeted about the publication of a new brochure presenting one of its scientific projects in this field. This MYP, titled "Secure Communication in the Quantum Era", brings together scientists from Slovakia, Malta, US and Spain to study quantum-safe solutions for fundamental cryptographic algorithms, which are currently the base for securing digital communications.
- As Allies enhanced their efforts in the field of climate change and security in 2021, SPS supported an ARW focusing on technologies and policies needed to make the defence sector greener. @NATO_SPS gave visibility to this event, which was organized by experts from Italy and Finland, and saw the participation of experts and policy-makers, including from the OSCE and the European Union.

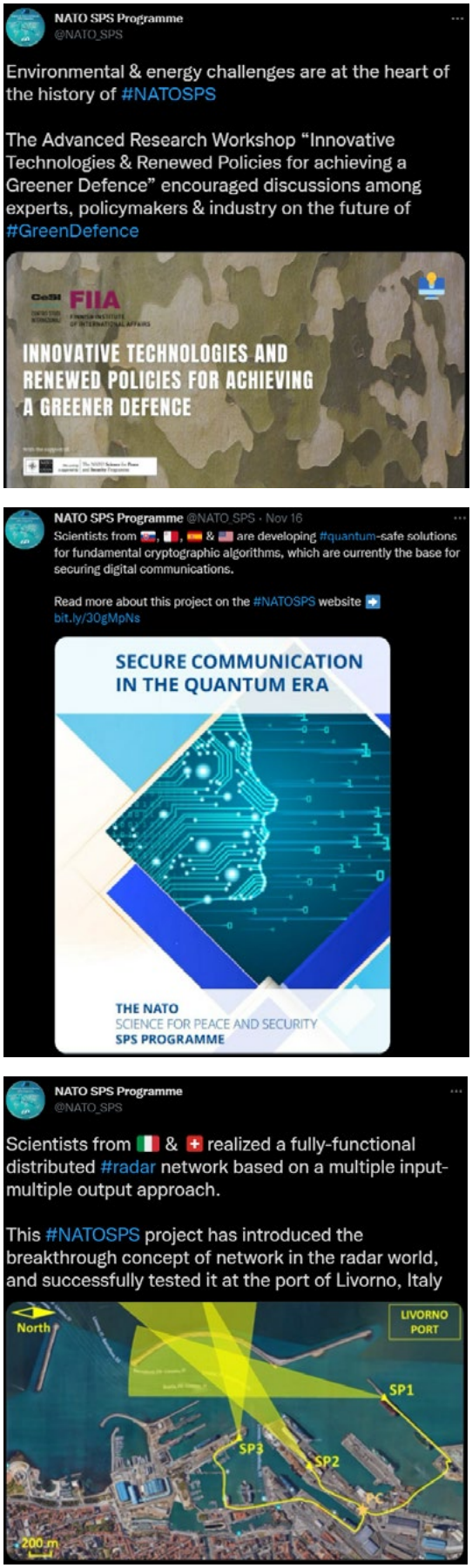


Figure 7 - The three @NATO_SPS tweets with the highest number of impressions in 2021.

How Others Perceive SPS

SPS encourages the beneficiaries of its grants to give visibility to their work and the support they receive from NATO through all available communication channels. This provides them with opportunities to showcase their work, gain greater recognition for their achievements, and expand their networks. The Programme actively collaborates with project teams, as well as with NATO entities, to develop content, publications and multimedia on practical scientific cooperation in the framework of SPS. In the past year alone, this resulted in over 230 publications covering SPS activities' research and innovation outcomes in journal articles, conference papers and book chapters.

Scientists involved in SPS activities also create websites and social media accounts entirely dedicated to the research they are leading. Through these outlets, they are able to share frequent updates, and engage with the scientific community as well as the public on a regular basis.

The **project website** of the MYP "Secure Communication in the Quantum Era" (*https://re-search.info*) is an example of how project teams can use online platforms to outline information about their projects, such as the work division among participating institutions, as well as project-related events and publications, while researching topics such as quantum-safe solutions to secure digital communications.

Dedicated **social media accounts** prove useful also to provide coverage of SPS-supported events as they happen, which is especially important for those whose participation may be limited by pandemic-related restrictions. The account of the ARW "Toward a Quantum-safe Communication Infrastructure" is one such example. As the event was taking place in November in Malta, the channel shared extracts of the discussions between scientists working on quantum physics and mathematicians focusing on quantum computing, thus opening the doors of this invitation-only event to the broader scientific community.

Did you know: Any public material developed in the context of SPS activities must comply with the Programme's visual identity guidelines, which are available on *this page* of the SPS website.

Figure 8 - Source: *https://twitter.com/qpqcrypto*

Videos

Multimedia content on SPS is produced every year, with support from the Programme, or as a result of the initiative of creative project teams involved in its activities. Below are some examples:

To announce the launch of the MYP "New Generation of Drugs Protecting against Neurotoxic Industrial Chemicals" in June, the project team produced a short video explaining how this new project will help dealing with neurotoxic syndromes induced by industrial chemicals used in potential terrorist attacks.

Figure 9 - Source: *https://www.youtube.com/watch?v=Sk5BxOscAJ4*

To summarize the scientific achievements of the MYP "Dynamic Architecture based on UAVs Monitoring for Border Security and Safety – DAVOSS", researchers leading the project developed a comprehensive video on the occasion of the project's closing event. SPS was directly involved in this video to explain how this activity fits within the Programme's work in the field of autonomy, and highlight the potential application of its results in the context of monitoring, reconnaissance and crisis management operations.

Figure 10 - Source: *https://www.youtube.com/watch?v=MJgtKHtJ22Y*

To celebrate growing scientific collaboration, SPS announced the kick-off of the MYP "Cybersecurity for Safe Underwater Acoustic Communications (SAFE-UComm)". On this occasion, SPS shared a video produced by the project team in the context of their recently completed MYP, named "Threat Detect". Benefiting from the experience of working together during the first project, this group of researchers decided to continue their exploration of the applications of advanced technologies at sea by developing a new SPS initiative, which was launched this year.

Figure 11 - Source: *https://www.youtube.com/watch?v=I7TKkciL8Bo*

To give visibility to scientific cooperation with NATO partners, SPS contributed to a video highlighting Ukraine's extensive participation in activities supported by the Programme. The video was released in November as part of a joint initiative of Ukraine's Ministry of Foreign Affairs and the NATO Information and Documentation Centre in Ukraine (NIDC) aimed at showcasing the various dimensions of NATO-Ukraine cooperation. In the video, the First Deputy Foreign Minister of Ukraine, Emine Dzhaparova, and the Senior SPS and Partnership Cooperation Advisor, Dr. Deniz Beten, outlined achievements and current priority areas for practical scientific cooperation.

Figure 12 - Source:
https://twitter.com/NATO_SPS/status/1465263008855334914

SPS in the News

International and local media frequently acknowledge SPS activities through their respective channels. This amplifies the SPS Programme's visibility among a broader audience and encourages interest in security-related topics relevant to NATO. Coverage of SPS activities ranges from newspapers and journals to TV and radio programmes, as exemplified in the following selection of highlights.

In a series of ***radio*** interviews, officials from the NATO Representation in Ukraine contributed to raising awareness among the public on NATO's support to Ukraine and on opportunities for cooperation. In April, an entire episode was dedicated to the SPS Programme and the opportunities it offers to the Ukrainian scientific community, including its young scientists. A transcript of the episode, aired in Ukrainian on Radio Army FM, is available *here*.

Several ***mainstream news outlets*** developed stories about SPS activities launched and completed in 2021. For instance, 2021 saw the completion of MYP "Biological Method (Bees) for Explosive Detection", which over the past four years investigated innovative methods for the detection of landmines in the Western Balkans by using bees. Since its launch, more than 50 articles were devoted to this project, highlighting how trained colonies of bees can locate landmines in conjunction with specialized technologies such as UAVs, thermal imaging cameras and image processing/analysis software. Among them, a *BBC article* interviewed one of the researchers involved in this SPS project to discuss potential applications of this methodology in demining.

SPS activities reached also non-English speaking audiences thanks to the attention of governmental as well as local news outlets, which translated stories published on the SPS website or published new original content. For instance, the conclusion of the MYP "Implementation of a Terahertz Imaging and Detection System" - the first scientific cooperation activity between NATO and Algeria – was announced in French in a *press release* by the Embassy of Algeria in Brussels, as well as in "El Djeich", the monthly review of the Algerian national army. The implementation of the terahertz imaging technology proposed by this project, and its potential applications in the fight against terrorism and the protection of vulnerable sites, caught the attention of local media on several occasions, resulting in more than ten articles devoted to this project.


How bees and drones team up to find landmines

By Chris Baraniuk
Technology of Business reporter

30 March

Figure 13 - Source: *https://www.bbc.com/news/business-56344609*

On the occasion of the launch of the new MYP "SARS 3M", the Italian news agency "*Agenzia Nova*" published several articles in Italian. The opening event took place in a hybrid format, with the Permanent Representative of Italy to NATO, the Ambassador of Austria to NATO and the Kingdom of Belgium, and the Assistant Secretary General for Emerging Security Challenges participating from NATO HQ. Researchers involved in this new project joined online to present the technical aspects of their project, which will help to respond to the ongoing coronavirus pandemic by developing new tools to detect contamination from the coronavirus as well as other toxic bio-agents.

Researchers involved in SPS-supported activities also published news about their work on ***websites and academic bulletins of participating institutions***.

In May, the Gazette of Queen's University highlighted the collaboration of Canadian and Ukrainian researchers and the launch of their research on gender aspects of active duty soldiers' transition into civilian life. The *article* was published on the occasion of the high-level roundtable that kick-started this 'top-down' initiative, which engaged the NATO Assistant Secretary General for Emerging Security Challenges, Canada's Ambassador for Women, Peace, and Security, and the Government Commissioner for Gender Equality Policy of Ukraine.

Following the completion of the ARW "Practical Applications of Advanced Technologies for Enhancing Security and Defense Capabilities: Perspectives and Challenges for Western Balkans", the Euro-Atlantic Council of North Macedonia provided an overview of the event on its website. The *article* developed by the event organizers contributed to sharing with the public a detailed overview of the event and of the keynote interventions, which included messages from the Prime Minister of the Republic of North Macedonia, the NATO Deputy Assistant Secretary General for Emerging Security Challenges, and the President of the Euro-Atlantic Council of North Macedonia.

Ecole militaire polytechnique Taleb-Abderrahmane

Création du système de protection des sites en partenariat avec l'Otan

Ph El-Djeich

DANS le cadre du programme de coopération scientifique entre l'Algérie et l'Otan, l'Ecole militaire polytechnique Taleb-Abderrahmane a organisé, le 17 mai 2021, via visioconférence, la cérémonie de clôture du projet de recherche de technologie d'imagerie térahertz intitulé «La science au service de la paix et de la sécurité».
L'Otan a réussi à développer, en partenariat avec l'Algérie, un nouveau système de protection des sites sensibles.

Selon le directeur de l'Ecole militaire polytechnique, le général Serir Aomer, «ce système qui fonctionne via térahertz, peut être intégré dans les systèmes de sécurité traditionnels qui contribuent ainsi au renforcement des capacités en matière de défense et de sécurité». A noter que ce système ne se limite pas à la lutte contre le terrorisme mais s'étend à d'autres domaines qui permettent de contrôler les opérations de trafic d'armes, de drogue... Par conséquent, ce projet aura des applications pour protéger les sites contre diverses menaces. Dans son intervention, l'ambassadeur d'Algérie près le Royaume de Belgique, M. Mohamed Haneche, a souligné que les priorités de la coopération avec l'Otan consistent à «renforcer et développer le potentiel scientifique, technique et technologique, notamment en matière de recherche scientifique et d'échange d'expertise». A la fin de la cérémonie virtuelle, les deux parties, algérienne et celle de l'Otan, ont inauguré cette nouvelle technologie d'imagerie térahertz, en coupant le ruban symbolique, en présence des chercheurs de différentes nationalités qui ont mené la recherche■

El-Djeich N° 695 Juin 2021 67
www.mdn.dz

Figure 14 - Source: El Djeich #695, June 2021

In October, the Department of Homeland Security, Science and Technology, announced the completion of the flagship MYP "Next-Generation Incident Command System (NICS)". The *article* acknowledged the fruitful cooperation among all the parties involved in this four-year project, which developed and deployed in the Western Balkans a communication platform for first responders to artificial and natural disasters.

In November, the article "*Protecting the Spectrum Users with Internet of Things*" outlined the results of the MYP "SOCRATES", which investigated a system to protect wireless infrastructure from attackers and unwanted intruders. The final workshop celebrating the conclusion of this three-year research collaboration included the demonstration of newly developed capabilities to detect anomalies in the electromagnetic spectrum that can help protecting critical services such as cellular networks, aerial communications, and GPS.

Protecting the Spectrum Users with Internet of Things

The SOCRATES project has demonstrated that it is possible to protect the spectrum from malicious intruders by identifying and locating unauthorized transmissions

15 November 2021

Figure 15 - Source: *https://networks.imdea.org/protecting-the-spectrum-users-with-internet-of-things/*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CHAPTER 2
Response to SPS Key Priorities

The Science for Peace and Security (SPS) Programme provides funding and expert advice for security-relevant activities in the form of four established grant mechanisms: research and development Multi-Year Projects (MYP), Advanced Research Workshops (ARW), Advanced Training Courses (ATC), and Advanced Study Institutes (ASI). In addition to 'top-down' initiatives developed with Allies and partners, the Programme also supports 'bottom-up' proposals submitted by researchers and experts in response to calls for proposals announced on the SPS website. SPS activities are guided by key priorities that address security challenges such as: counter-terrorism, cyber defence, energy security, CBRN defence, advanced technologies, mine and unexploded ordnance, and human and social aspects of security.

Over the course of 2021, the SPS Programme achieved remarkable successes, contributing to the Alliance's strategic objectives and key political commitments such as the Counter Terrorism Action Plan, the Coherent Implementation Strategy on Emerging and Disruptive Technologies (EDTs), and the Climate Change and Security Action Plan.

This year, 39 SPS activities were completed and 22 new Multi-Year Projects were launched. In particular, the Programme focused its efforts on the Key Priorities of counter-terrorism, security-related advanced technologies, defence against CBRN agents, and environmental and energy security. Furthermore, 17 workshops and training courses were held in 2021, adapting to the circumstances of the COVID-19 pandemic. They gathered a total of 1329 participants and 405 speakers. This chapter presents a selection of SPS activities that were launched or completed this year to address SPS key priorities.

Counter-terrorism

The newly updated Counter Terrorism (CT) Action Plan agreed by NATO Ministers of Foreign Affairs in December 2021 further enhances the role of the Alliance in the international community's fight against terrorism. NATO's CT efforts contribute to all three core tasks of the Alliance and is an integral part of its 360 degree approach to security. This approach focuses on awareness, capabilities, and engagement. Future work in this field will also take into account strategic orientations in the context of the NATO 2030 Agenda and the forthcoming update of the NATO Strategic Concept.

The SPS Programme supports the Alliance's efforts in CT through research and technological advancement, tailored training courses, and capacity building. In particular, SPS has been supporting NATO's objectives in specific areas of concern, including resilience and preparedness. The Programme's collaborative research activities, training courses, and workshops improve awareness and understanding of terrorist threats, share best practices on CT and countering violent extremism (CVE), develop capabilities and technological solutions, and provide education and training for partner countries. A key effort relevant for the updated CT Action Plan is the flagship top-down initiative Detection of Explosives and firearms to counter TERrorism (DEXTER) that aims to protect public places from the threat posed by concealed explosives and firearms.

In 2021, four MYPs were kicked-off, and one ATC brought together 18 speakers and 55 participants to discuss innovative structures and materials capable of protecting critical energy infrastructure against blast and ballistic threats. In the meantime, four MYPs were completed. They focused on improving sensing technologies, situational awareness and emergency response, as well as infrastructure protection. Scientists from 23 NATO and partner countries, including 26 young scientists, have been involved in leading the completed and new projects, which contributed to enhancing scientific cooperation and research in relation to this key SPS key priority.

RESILIENCE AND PREPAREDNESS

COMPLETED

MYP Next-generation Incident Command System (NICS)

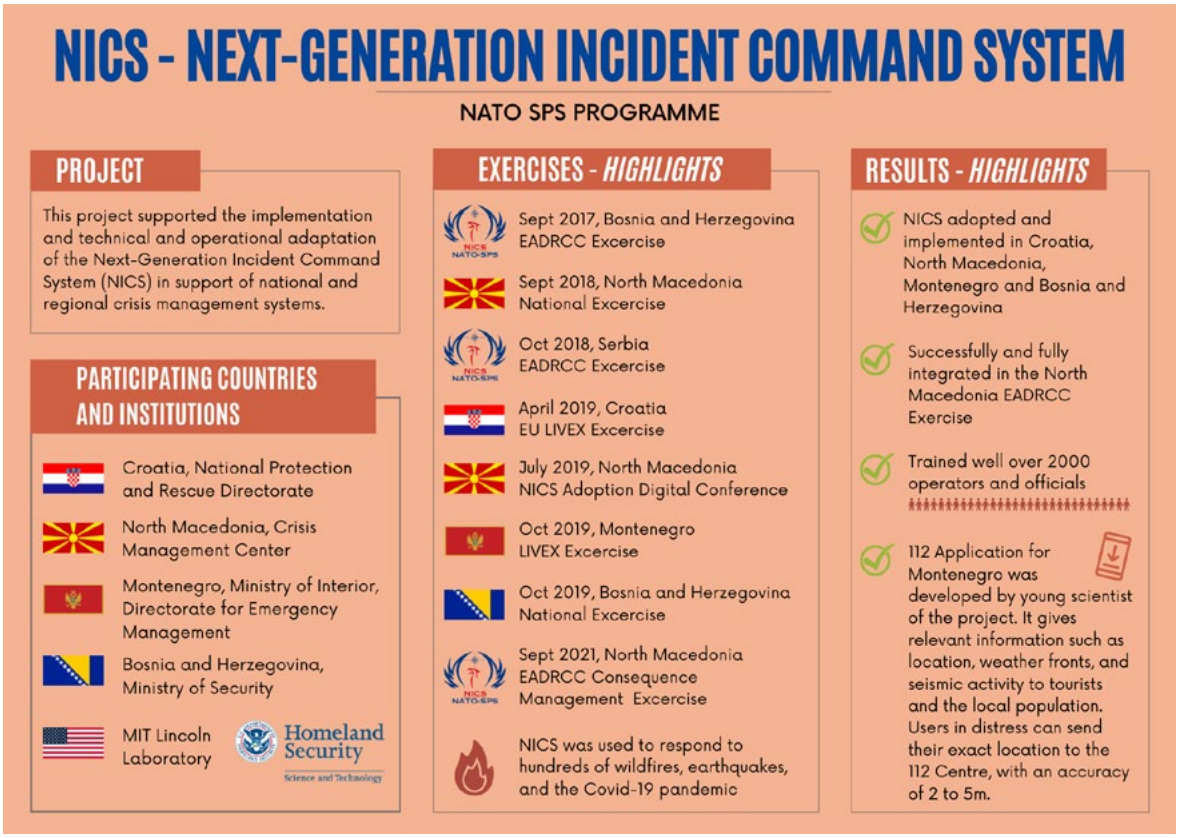
Participating countries: USA, Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia

The 'top-down' flagship Multi-Year Project (MYP) Next-generation Incident Command System (NICS) was implemented to support capacity building in the area of crisis management and resilience across the Western Balkans. NICS is a situational awareness system that enables first responders to exchange information about an event, including GPS locations or images, rapidly and efficiently via mobile devices.

Launched in 2016, this MYP helped participating nations to acquire, deploy and customize the incident command system to facilitate real-time coordination of first responders in case of disaster.

Through this SPS project, NICS was successfully adopted and adapted to national systems by the participating countries. In particular, during its process of accession to NATO, North Macedonia adopted the NICS system to coordinate all parts of government in the event of an emergency. The system was successfully tested and deployed during several field exercises organized by the NATO Euro-Atlantic Disaster Response Coordination Centre. In fact, the most recent exercise in North Macedonia 2021 was fully digital, as all countries involved used NICS to communicate. Around 2000 experts from civil and military institutions in the Western Balkans received NICS operator training, and all relevant public bodies involved in the project integrated the system for common use by the end of 2021. This project is an example of successful regional cooperation through the SPS Programme and received a high level of attention by the press and media.

The project's website can be accessed *here*.



COMPLETED

MYP Public Safety COmmUNication in ConTExt Related to Terror Attacks (Counter-Terror)

Participating countries: Estonia, Pakistan, Italy

Figure 16 - Different receivers and antennas fitted to UAVs in the context of the SPS MYP "Counter-terror".

The Counter-Terror project aimed to significantly reduce the response time following terrorist attacks. Its objective was to develop and demonstrate a heterogeneous network of devices capable of transmitting information in public spaces, such as transport hubs and shopping malls. The project designed a system capable of providing critical information and situational awareness to security forces at the site of an attack, ultimately saving lives and protecting infrastructures. To this aim, Counter-Terror successfully tested small functional prototypes in laboratories and real-life scenarios in the field. The project contributed to technological advancements in device-to-device communication and demonstrated a number of configurations capable of significantly reducing response times by establishing connectivity and rapidly transmitting basic information between devices and to a command center.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/6/pdf/210608-SPSFlyer-G5482.pdf*

COMPLETED

ATC Critical Energy Infrastructure Protection: Innovative Structures and Materials for Blast and Ballistic Protection

Participating countries: Poland, Algeria

This Advanced Training Course (ATC), organized by experts from Poland and Algeria, addressed the issue of critical infrastructure protection from terrorist attacks, with a particular focus on energy, oil, and gas infrastructures. The online training course took place in March and was an opportunity to share knowledge and experiences in protecting infrastructures, supplies, and personnel. The event contributed to sharing best practices in relation to risk management and the deployment of technologies aiming to prevent and respond to terrorist attacks. These technologies address needs such as protection against blasts and explosives, ballistic protection, and against aerial threats. The results and proceedings of the ATC will be published in a NATO Science Series volume.

Figure 17 - Participants in this SPS ATC at the Ecole Militaire Polytechnique (EMP) in Algiers, Algeria.

COMPLETED

ATC Gender Mainstreaming in Counter-terrorism Efforts in the Western Balkans

Participating countries: North Macedonia, Bosnia and Herzegovina

This ATC brought together subject matter experts and decision-makers from relevant state institutions from NATO and partner countries in the Western Balkans and beyond, and provided a platform for discussions and the exchange of best practices. The course was held in May in a hybrid format with participants joining both online and on-site. High-level speakers included the former NATO Secretary General's Special Representative on Women, Peace and Security, Clare Hutchinson, the Minister of Defence of Montenegro, Dr. Olivera Injac, and the National Coordinator for Countering Terrorism and Violent Extremism of North Macedonia, Dr. Borche Patrevski. The audience was composed of military and civilian experts from the institutional and non-governmental sectors, as well as young researchers and professionals predominantly from the Western Balkans.

The main goal of this ATC was to generate knowledge and promote greater understanding and dialogue on the topic of gender mainstreaming and counter-terrorism, as well as gender equality in the defense and security sectors in the Western Balkans. The course investigated the role of gender in enhancing security by discussing and addressing the local factors conducive to women's radicalization in the region. Moreover, it brought together experts and organizations that work in this area to promote women's leadership and participation in CT policies and programmes. Specifically, discussions encompassed a wide range of topics related to gender in the context of CT and countering violent extremism, including the political, socio-economic and psychosocial aspects, and the impact of women radicalization. Briefings included relevant case studies and lessons learned.

Figure 18 - Members of the organizing committee of this SPS ATC.

CBRN Defence

SPS activities in the field of CBRN defence respond to NATO's goal of improving the ability of the Alliance and its partners to protect their populations and forces from such threats, as reiterated by NATO Heads of State and Government during the 2021 Brussels Summit.

SPS activities under this key priority aim to deliver high-quality scientific research, develop technologies, strengthen preparedness and resilience, build capacities, and train young researchers and experts of participating countries. The Programme supports research related to the COVID-19 pandemic as well as detection and countermeasures technologies, and develops situational awareness and response capabilities in NATO and partner countries. In particular, SPS activities focus on building solutions for the defence against chemical agents, the detection of biological agents, the preparedness and response to the COVID-19 pandemic, as well as developing medical countermeasures and human enhancement.

Under this key priority, five MYPs were launched in 2021, involving co-directors from 11 NATO and partner countries, as well as 13 young scientists. They focus on developing a new generation of drugs protecting against neurotoxic industrial chemicals, as well as technological solutions to detect and protect against dangerous chemical and biological agents.

PREPAREDNESS AND RESPONSE TO THE COVID-19 PANDEMIC

NEW

MYP SARS-CoV-2 Multi-Messenger Monitoring for Occupational Health & Safety (SARS 3M)

Participating countries: Italy, Austria

The MYP SARS 3M, launched in May by a multi-disciplinary team of scientists, responds to health and security challenges arising from and brought to light by the COVID-19 pandemic. It will develop an innovative nanotechnology-based platform to monitor the SARS-CoV-2 virus and other toxic bio-agents in the workplace. The project will design new plasmonic nanoporous materials capable of selecting and efficiently adsorbing the virus for identification and quantitative evaluation using infrared and terahertz vibrational spectroscopy and nanotechnology. This technological combination will open the way for a cost-effective alternative to existing detection systems.

SARS 3M offers a solution with significant scientific, technological and socio-economic impacts by introducing a novel high speed, efficient, low-cost, and eco-friendly SARS-CoV-2 monitoring device. It will contribute to guaranteeing safety and occupational health, and to maintaining environmental security in a large variety of settings.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/6/pdf/210608-SPSBooklet-G5889.pdf*

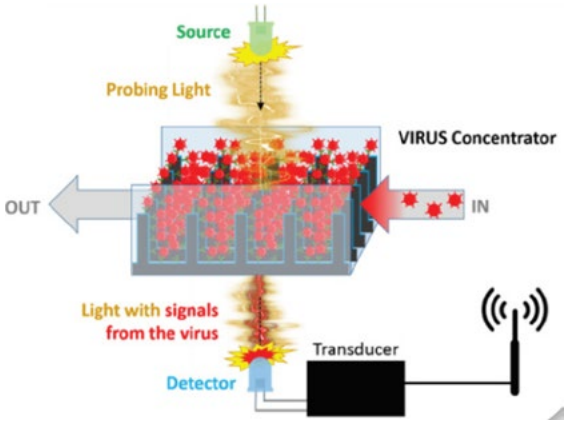


Figure 19 - Overview of the device to be developed by the SPS "SARS 3M" MYP.

NEW

MYP Designing bio-secure metallic surfaces

Participating countries: United States, Israel

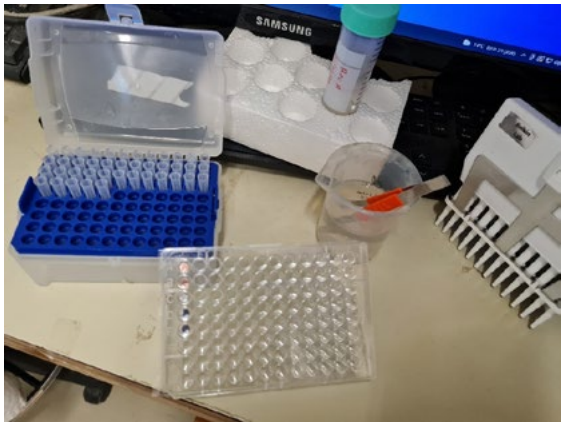


Figure 20 - Experimental setup for anti-bacterial performance testing.

The COVID-19 pandemic demonstrated the vulnerability of humankind to infectious diseases and microbiological attacks. Led by MIT University, this project aims to design novel metallic materials with enhanced anti-bacterial effect. Antimicrobial steels, when subjected to a bacteria-containing environment, release cations to effectively break cell membranes, resulting in the death of the bacteria. This material will have the potential to be used in various fields exposed to such threats, ranging from healthcare to defence. To achieve this goal, the team will combine expertise in microbiology and metallurgy to conduct a thorough exploration of Fe-based alloys along with multiple alloying elements. The design and development of new and feasible antimicrobial metallic materials will offer an enhanced protection against various bio-threats.

DETECTION OF BIOLOGICAL AGENTS

NEW

MYP A Novel Nanoparticle-Based Real-Time Sensor for B. Anthracis and M. Tuberculosis

Participating countries: United Kingdom, Ukraine, Italy

This MYP, launched in January, aims to develop an innovative real-time sensor capable of rapidly detecting dangerous pathogens. More specifically, this project will design and build a nanoparticle-based sensor platform suitable for field conditions to detect Bacillius anthracis (BA) and Mycobacterium Tuberculosis (MT) in less than 30 minutes. The system will rely on microwave extraction systems for the fast preparation of biological sample of any type (e.g. dry, wet, solid, liquid, organic) along with a genetic probe to rapidly detect and analyze the presence of BA and MT.

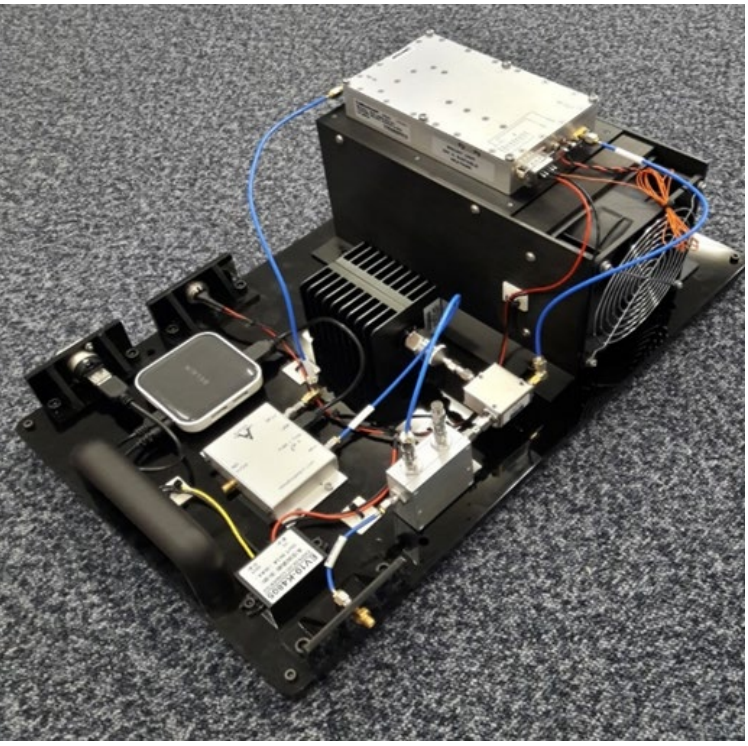


Figure 21 - Microwave power system.

MT is a bacterium mainly spread through the air that causes tuberculosis, an illness that most often affects the lungs and without proper treatment can be fatal. In 2019, tuberculosis caused the death of an estimated 1.2 million people worldwide, with severe financial and economic costs both for patients and households[1]. BA is a bacterium causing Anthrax, a serious infectious disease that can rapidly kill if it is not immediately treated. It is a threat to livestock and humans that can rapidly be contaminated by even a small amount of its spores. BA is easily produced and can be released quietly and without difficulty, which makes it a likely agent for bioterrorist weapons[2]. Both pathogens are endemic in Ukraine, the partner country involved in this project.

Access to a cost effective, simple to use, diagnostic point of care assay will markedly reduce the impact of exposure to BA and MT. It will pave the way for a miniature version of the sensor for first responders and military personnel entering a zone affected by biological terrorism or accidents. In addition, fast benchtop analyzers are important to prepare an efficient response to epidemic threats, and this innovative sensor could be expanded to similar pathogens and applications.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/3/pdf/210301-sps-Anthracis-Tuberculosis.pdf*

1. Global tuberculosis report 2021. Geneva: World Health Organization; 2021.Licence: CC BY-NC-SA 3.0 IGO, pp. 43.
2. *https://www.cdc.gov/anthrax/index.html*

COMPLETED

MYP Developing Capability to Mitigate the Risk of Biological Agents in Moldova

Participating countries: NATO Support and Procurement Agency (NSPA, Luxembourg), Republic of Moldova

Biological agents can cause infectious diseases and have major repercussions on public health, the economy and society. Bacillus anthracis, the bacterium causing Anthrax, is one of them. It can persist for long periods in the environment in the form of spores and cause diseases in animals and humans. This project was a top-down flagship SPS initiative aiming to develop capacities for the surveillance and control of biological agents in the Republic of Moldova using the best available techniques to improve overall security.

This project set up a BioSafety Level 3 (BSL-3) mobile laboratory for the detection and identification of bio-agents and provided operational training to experts. This capability is expected to help decrease exposure to Bacillus anthracis and to reduce risks of contamination. It will contribute to improving the biological safety of the general population, and to reducing and preventing Anthrax cases in both humans and animals.

Figure 22 - Mobile biological laboratory established in the Republic of Moldova through this SPS MYP.

DEFENCE AGAINST CHEMICAL AGENTS

NEW

MYP Biofriendly Decontamination of Chemical Warfare Agents (EnzIL)

Participating countries: Portugal, Finland, Tunisia

The EnzIL project aims to minimize the environmental and human impact of Chemical Warfare Agents (CWA) by developing an integrated system for the decontamination and destruction of CWAs from the atmosphere and surfaces. This MYP, launched in February, proposes a novel approach for the decontamination of CWAs using a new material based on ionic liquids to sequentially adsorb and absorb them into the interior of a fluid where they will be neutralized by biocatalytic oxidation. This innovative technology will offer an eco-friendly solution for the decontamination of even porous surfaces or the atmosphere without impacting human health and the environment as opposed to current decontamination systems. EnzIL will facilitate decontamination efforts in response to the release of CWAs and introduce a new method to protect against, diagnose, detect, destruct, and dispose of chemical agents.

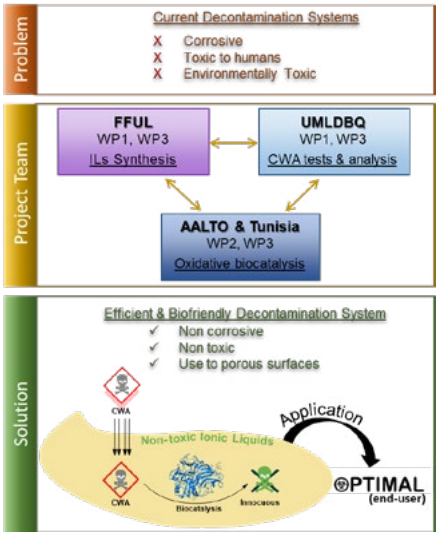


Figure 23 - Overview of the decontamination system of CWAs proposed by this SPS MYP.

NEW

MYP Smart Nanomaterials and a Soldier Alarm Badge to Detect Toxic Gases by Mobile Devices

Participating countries: France, Ukraine

Nerve agents are highly poisonous chemicals that work by preventing the nervous system from working properly, and can be used as Chemical Warfare Agents (CWA)[3]. This MYP aims to develop a wearable, lightweight, alarm and analysis sensor device with a long operation lifetime, capable of detecting these agents. This project, started in January, will help to protect soldiers, first responders, and the general population by developing a new smart and reusable badge reacting to nerve agents gases. In case of a chemical attack, the badge will provide sound and digital alarms and transmit them via Wi-Fi or Bluetooth protocols to soldiers and first responders.

In addition, the project will develop, synthesize and study critical components of this badge, such as new smart nanomaterials (nanocomposites and liquid crystals) capable of reversibly changing their electro-physical properties in the presence of nerve agents, even at low concentrations. The results will provide early warning and inform authorities, soldiers, and first responders of the threat.

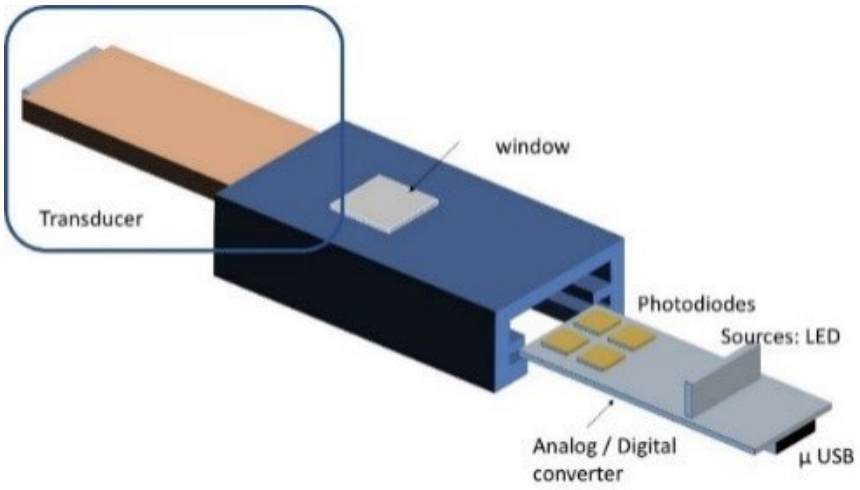


Figure 24 - Optical detection principle for CWA detection using liquid crystal anchoring transition transducers.

3. *https://emergency.cdc.gov/agent/nerve/index.asp*

COMPLETED

MYP Photonic Nano-particle Sensors for Detecting CBRN events

Participating countries: Slovenia, Austria

CBRN warfare agents can have disastrous consequences for public health and the environment if released in modern warfare, terrorist attacks or during unintentional pollution events and natural disasters. They often depend heavily on micro- and nano- airborne particles and aerosols, which also play a key role in climate stability and in the adverse health effects of air pollution. Consequently, improving in-field capability for particle detection and characterization is important for security and defence systems.

This MYP, launched in January, aims to address challenges related to the early detection of airborne dangerous particles and aerosols. It will develop and design a miniature, fully dielectric, photonic sensor that can be remotely operated in an electromagnetically 'quiet' way to detect CBRN agents. It will provide a remote, unobscured and hard to detect sensor system for the protection of critical infrastructures, supplies and personnel against CBRN incidents.
This novel technology will advance the field of miniature, accurate and robust sensors for gas and aerosols detection. In addition, the project will directly contribute to protecting the environment and human health by providing emergency and military personnel with a reliable and rapid detection system for CBRN events or industrial accidents.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/3/pdf/210301-sps-flyerG766.pdf*

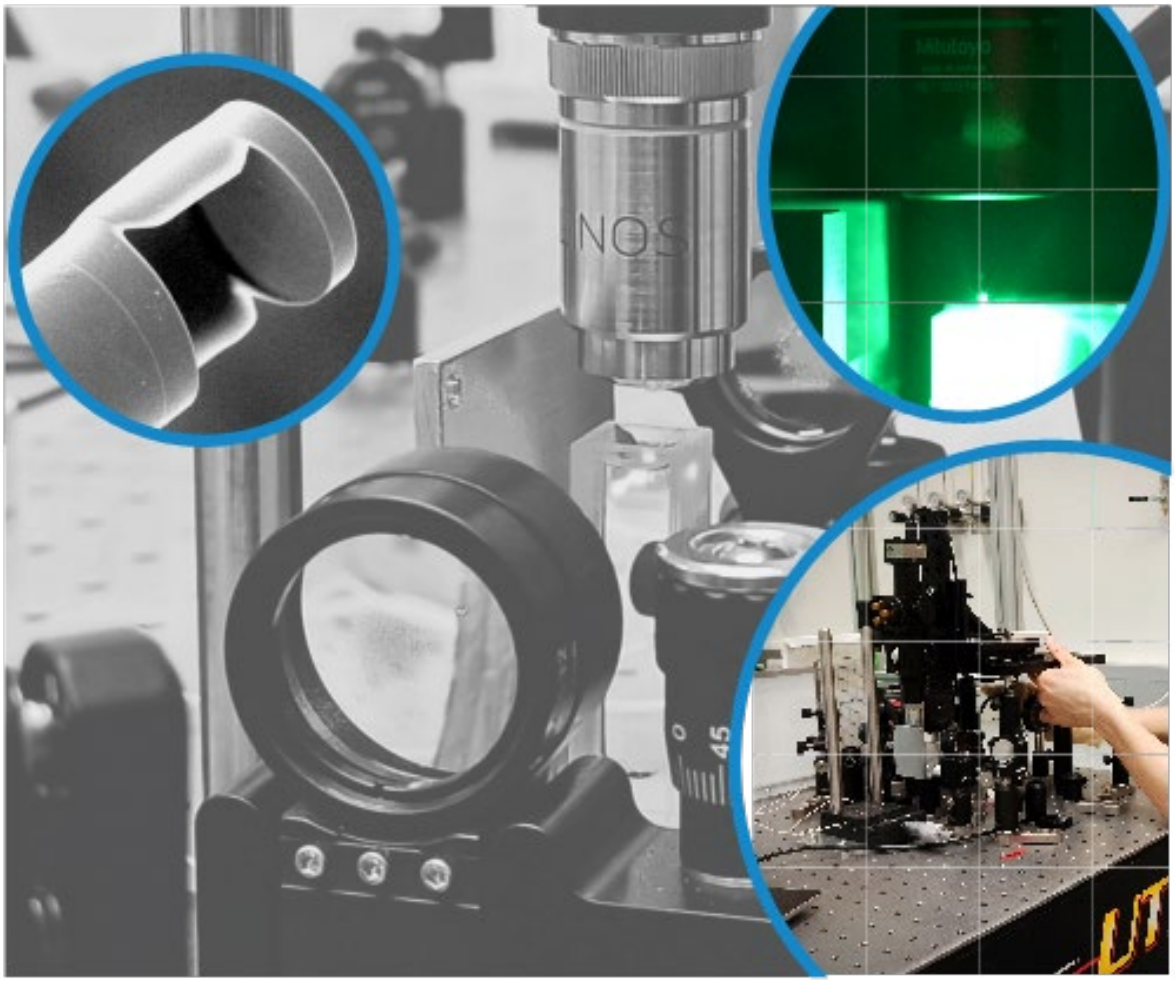


Figure 25 - Microscopic sensing concept applied in the detection of airborne dangerous particles and aerosols.

MEDICAL COUNTERMEASURES AND HUMAN ENHANCEMENT

MYP Smart Patch for Life Support Systems (SP4LIFE)

Participating countries: Slovakia, Serbia, Belgium, North Macedonia

COMPLETED

This MYP, launched in March, aims to design and develop a wearable, real-time monitoring system constructed as a patch-like device. It will be capable of collecting and analyzing information on vital health parameters, such as respiration, heart rate, blood oxygen saturation, blood pressure or body temperature. The device will offer a novel integrated sensor technology using artificial intelligence to generate health-monitoring solutions.

Early detection of physical threats is an effective approach to reduce casualties and increase the safety of operating personnel and civilians during mass casualty events resulting from terrorist attacks or CBRN incidents. The system will identify and communicate about the level of stress, onset of respiratory disorders, or cardiac events of response personnel in action, and help improve decision-making and resource allocation during emergency situations. The device will also be able to set alarms for wounded victims to help prioritize affected individuals for medical treatment and increase their chances of survival.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/4/pdf/0228-21_SPS_Flyer_SP4LIFE_en.pdf*

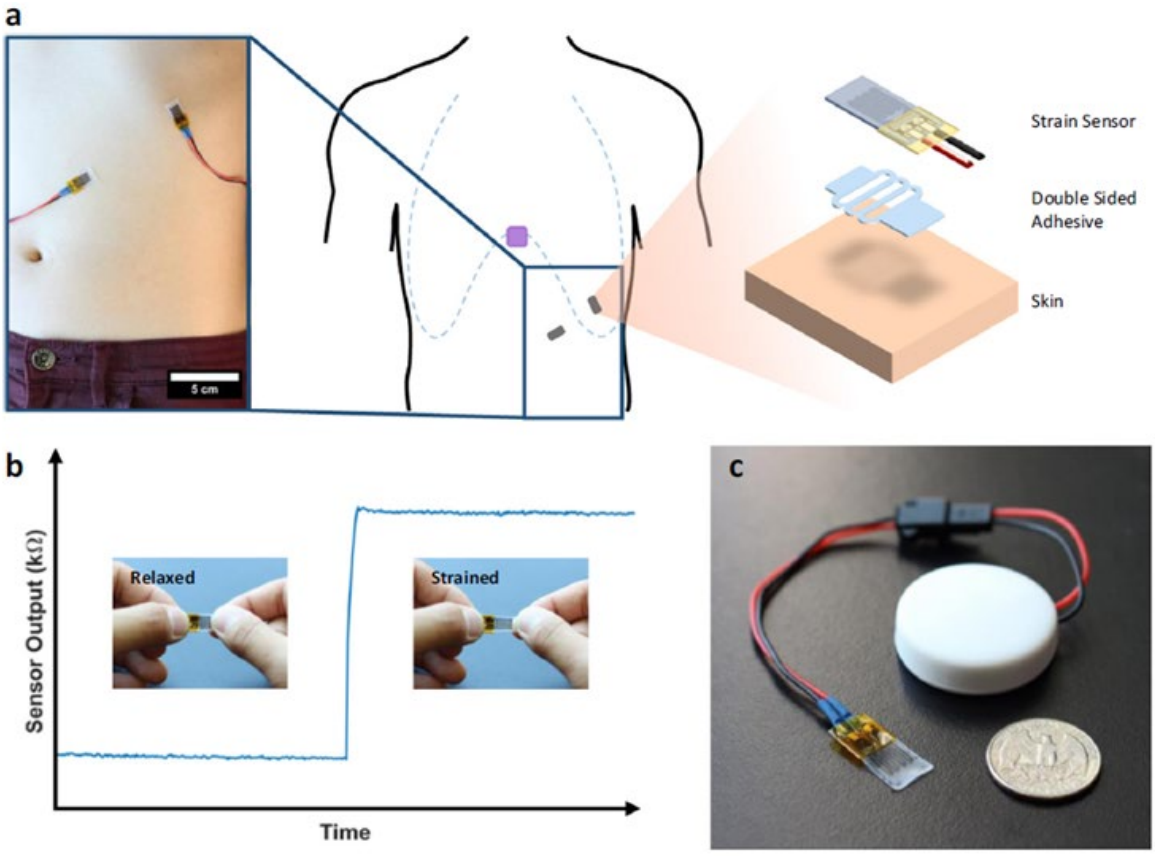


Figure 26

a. The left image shows the strain sensors on the ribcage and abdomen. The middle schematics shows the placement of the accelerometer (purple square) in addition to the strain sensors (Gray rectangles). The exploded schematic on the right shows the strain sensor and double-sided tape in order of attachment on the skin. All subjects test was conducted using a wired data acquisition unit.

b. Change in resistance of the sensor, under strain, measured using the wireless Bluetooth unit.

c. Image of the wireless Bluetooth unit with a single strainsensor attached.

COMPLETED

MYP New Generation of Drugs Protecting against Neurotoxic Industrial Chemicals

Participating countries: Spain, Israel, United States

Launched in June, this project responds to growing concerns about the use of neurotoxic industrial chemicals as "agents of opportunity" by terrorist groups, which constitutes a significant military and terrorist threat for NATO and partner countries. It will explore the therapeutic potential of two blood-brain barrier permeable drugs (NAC-amide and TXM-peptide) in the treatment of acute neurotoxic syndromes.

The project will use zebrafish models to determine the therapeutic value of different combinations of the abovementioned specific drugs directed at potential therapeutic targets identified for each neurotoxic syndrome. The most promising positive hits identified in zebrafish will subsequently be evaluated in rodents. This approach has the key advantage to provide highly predictive results for human applications. The results generated by this project will significantly improve the medical countermeasures currently used to protect soldiers and civilians against neurotoxic syndromes induced by intentional or unintentional acute exposure to neurotoxic chemicals or other hazardous materials. They will contribute to identifying the best and most specific treatment against each neurotoxic syndrome.

Figure 27 - Logo of this SPS MYP and QR code leading to the project website.

Security-related Advanced Technologies

The key priority of security-related advanced technologies includes the bulk of SPS activities and is key to enabling researchers from NATO and partner countries to contribute to maintaining the Alliance's technological edge.

Emerging and Disruptive Technologies (EDTs) are changing the world and the security environment. They present both risks and opportunities for Allies and partners countries. Amongst them, quantum technologies will radically change several disciplines, like communication security, computing, and aircrafts and submarines detection. They are expected to disrupt the confidentiality and integrity of secure digital communications, breaking most methods to securely exchange data in use today. Similarly, Artificial Intelligence will create vulnerabilities that could be exploited by state and non-state actors, including in the cyberspace, critical infrastructure, protection capacities, and civil preparedness.

The SPS Programme responds to NATO's agenda for the future by bringing forward a number of activities in the field of Artificial Intelligence, Autonomy, and Quantum technologies. It represents a key node in the Alliance's innovation ecosystem to adapt to and adopt EDTs. SPS supports NATO's Coherent Implementation Strategy on EDTs adopted in February 2021, as well as the Alliance's first-ever strategy for AI adopted this year.
In 2021, nine MYPs were completed and 10 were launched under this key priority, involving 47 young scientists. They have been developing radar, sensors and detection systems, an architecture of unmanned systems for border protection, as well as quantum sensing and secure communication systems. In addition, five ARWs were held throughout the year, inviting 105 participants and 135 speakers to discuss technological solutions for a range of security challenges including disinformation, drones, post-quantum cryptography, and infrastructure protection.

UNMANNED AUTONOMOUS SYSTEMS

NEW

MYP SeaSec: DroNets for Maritime Border and Port Security

Participating countries: Italy, Qatar

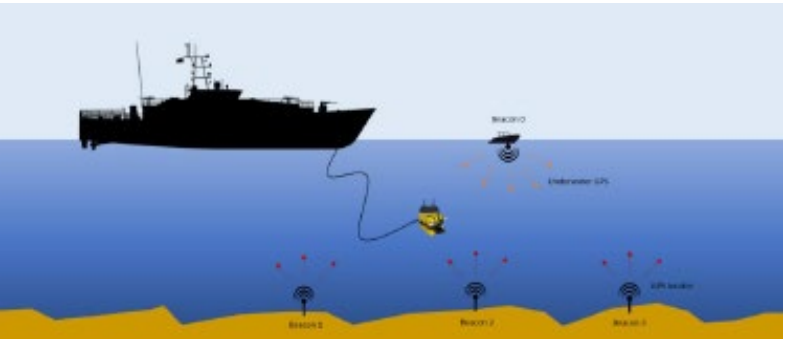


Figure 28 - Testbed design for underwater network: typical range-based localization procedure where reference/beacon nodes are deployed with known coordinates who help an unknown node (ROV) to estimate its coordinates.

This project, launched in January, will contribute to ensuring situational awareness at sea by enhancing traditional border and port surveillance systems. Existing situational awareness solutions rely on a combination of cooperative and non-cooperative sensors and platforms (e.g. coastal detectors, ships, drones, satellites, aircrafts) to monitor a region of interest and achieve comprehensive awareness. These different platforms are used to monitor areas at different resolution and each sensor has different characteristics, such as range and coverage.

The goal of this project is to develop quickly deployable squads of Unmanned Aircrafts Systems (UAS) or drones (DroNet) that autonomously cooperate to deliver relevant, complete and up-to-date information. This project will put into practice novel concepts in the field of maritime security. After validation of these concepts, two test-beds will be established in Italy and Qatar to conduct demonstrations in close-to-real environments. This project will enhance the state-of-the-art of border and port security by providing new techniques that will contribute to the realization of an accurate, complete, and efficient monitoring system for maritime domain awareness.

COMPLETED

MYP Dynamic Architecture based on UAVs Monitoring for Border Security and Safety (DAVOSS)

Participating countries: Italy, Israel

Large and diverse borders can be hard to control in an effective and efficient way. The use of different kinds of unmanned aerial vehicles offers key improvements to border control efforts. Nevertheless, these technologies require a significant amount of personnel, energy and infrastructure in order to be fully operational. Completed this year, the DAVOSS project developed an adaptive-virtualized architecture to improve robustness and resilience of monitoring networks. This innovative architecture allowed the integration of a large number of heterogeneous sensors such as cameras, thermal and noise sensors, and unmanned systems; and therefore, the surveillance of large areas with significantly reduced human interaction and control. The scalability and robustness of this architecture makes it particularly suitable for security scenarios such as border surveillance and crisis management following a terrorist attack.

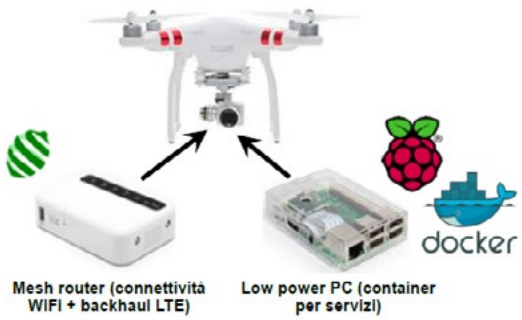


Figure 29 - Example of UAV setup for emergency situations.

ARW The Vulnerabilities of the Drone Age: Strategic Foresight Planning out to 2035

COMPLETED

Participating countries: Denmark, Switzerland

The objective of this top-down Advanced Research Workshop (ARW) was to provide NATO and its partners with strategic-level, tailor-made insights into the emerging vulnerabilities that drone technologies can cause over the next 15 years. Due to COVID-19-related restrictions, this workshop was organized in a hybrid format and separated into three sessions in June, October and December. They were divided into six panels: drones as a threat to both soldiers and civilians, existing drone counter-measures and their success rate, experience of NATO partner countries, countering threats posed by unmanned aircraft systems in NATO and European context, challenges of countering UAS capability development, and future trends in the unmanned systems technology in the next 15 years. These events brought together experts from across the academic, technological, and military communities. They combined information from applied history, strategic foresight, risk assessments, open source analysis to examine the past, present, and future trends in unmanned technologies, autonomy, and innovation.

QUANTUM TECHNOLOGY

MYP Conversion Technologies for Quantum Sensing and Secure Communications

NEW

Participating countries: Türkiye, Ukraine

This MYP, launched in January, aims to conduct theoretical and experimental work on quantum-coherent conversion between microwave and optical frequencies.

The goal of the project is to study novel hybrid spin-photonic concepts with potential applications in quantum-frequency conversion technologies. The project will investigate the use of ferromagnetic material as an effective medium to transfer quantum information from one quantum system to another. Quantum converters, as proposed by this project, can allow such transfer using optical photons as robust carriers for large distances. The current state-of-the-art approach of quantum elaborations requires conditions that are difficult to scale up for practical applications. The quantum converter proposed in this project will open up new possibilities for hybrid quantum systems, which are critical elements for quantum chip interfaces, long-range quantum communication and networks, as well as quantum imaging and radar technologies.

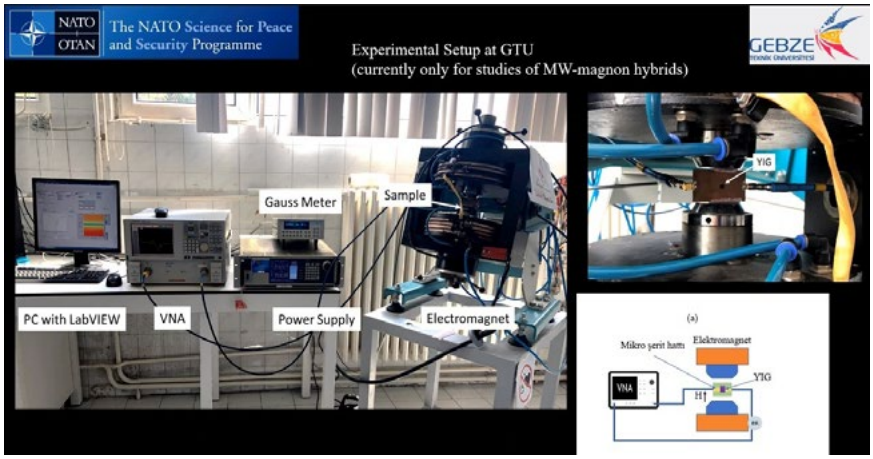


Figure 30 - Experimental setup at Gebze Technical University (GTU).

MYP Quantum Cybersecurity in 5G Networks (QUANTUM5)

NEW

Participating countries: Czech Republic, Bosnia and Herzegovina

Launched in February, this project aims to implement Quantum Key Distribution (QKD) technology in an experimental 5G network within the Technical University of Ostrava campus. QKD is a secure communication method that exploits quantum mechanics to distribute and share keys that are necessary for decryption. In particular, information is encoded on a single photon and its quantum characteristics allow private communication without the risk of being decoded by potential eavesdroppers.

QUANTUM5 directly addresses the issue of cyber security in 5G communication systems. Through theoretical and practical analyses, the project will demonstrate the application of QKD within the University's 5G campus testbed network. It will develop simulation tools and practical guidelines for further inclusion of quantum technologies in these networks and beyond. Additionally, QUANTUM5 will integrate 5G networking management concepts supporting network slicing, network-function-virtualization and software-defined-networking within 5G QKD network. The system will be tested for attack scenarios to ensure optimum settings for secure communications.

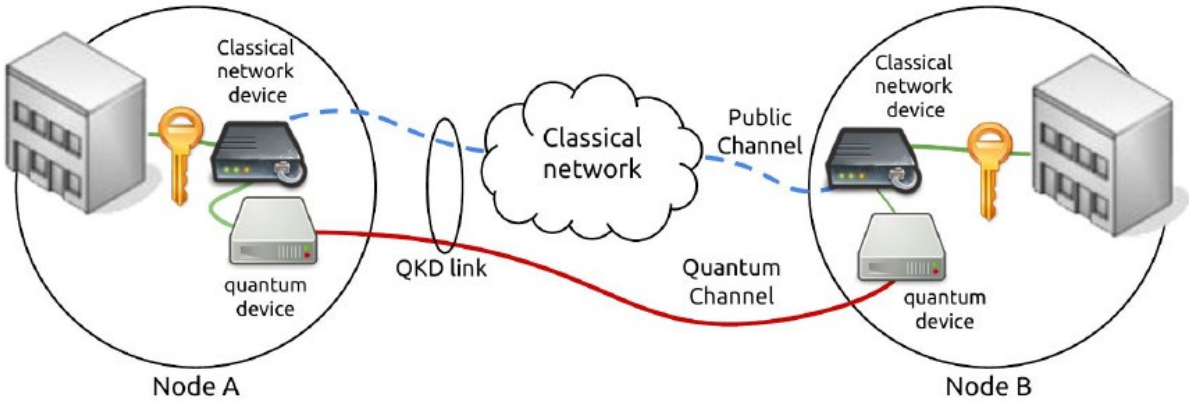


Figure 31 - A logical representation of a QKD link consisting of a quantum channel and a classical network.

ARW Toward a Quantum-safe Communication Infrastructure

COMPLETED

Participating countries: United States, Malta

This ARW aimed to bring together two communities working in the field of quantum technology: the community of scientists currently working on quantum physics (quantum mechanics, photonics entanglement, Quantum Key Distribution) and mathematicians looking at quantum computing and Post-Quantum Cryptography (PQC). This online workshop brought these experts together in order to identify a strategy leading to an effective development of technologies and techniques for a comprehensive quantum-safe cyber infrastructure.

The intent was to define a roadmap for future developments in order to ensure that all elements are taken into account, from architectural considerations and protocol design to implementation and experimental validation. Participants were encouraged to discuss future potential proposals and to ensure adequate circulation of the full architecture within the scientific community.

DETECTION SYSTEMS

MYP Implementation of a Terahertz Imaging and Detection System

COMPLETED

Participating countries: France, Algeria, Sweden

This top-down MYP developed a Terahertz (THz) laboratory – the first of this kind in North Africa – with a number of imaging applications and the potential to help protecting vulnerable sites from terrorist threats.

THz radiation is a promising technology with strong penetrating capabilities. It allows screening through many non-conductive materials such as skin, clothing, paper, wood, cardboard, and plastics. This technology could be used for dangerous material detection, as well as body and luggage scanning. Many substances of interest, such as drugs and explosives, exhibit specific absorption lines in the THz domain. These spectral signatures allow their detection and identification, impossible in other frequencies. In the long term, this promising technology could be exploited for other relevant applications, such as environmental monitoring.

This project was officially completed with a virtual ribbon cutting ceremony on 17 May 2021 in presence of NATO leadership as well as representatives of the nations participating in the project. On this occasion, the scientists and experts from France, Algeria and Sweden who led this project presented their results and achievements.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/5/pdf/SPS_Flyer_G5396_A5_en.pdf*

Figure 32 - Assistant Secretary General for Emerging Security Challenges, David van Weel, at NATO HQ and General Serir Aomar, Head of the Ecole Militaire Polytechnique in Algiers, Algeria, inaugurate the Terahertz laboratory.

COMPLETED

MYP Large Scale Collaborative Detection and Location of Threats in the Electromagnetic Space (SOCRATES)

Participating countries: Spain, Switzerland, Belgium

Protecting the wireless infrastructure and detecting dangerous actions of attackers are essential for the security of our societies. This project created the foundation for an accurate, autonomous, fast and secure system that identifies intruders and attackers in the electromagnetic space before they cause serious damage, gathering information about their characteristics (physical layer features) and their geographic location. This project expanded the Electrosense initiative, a non-profit association for the distribution, crowdsourcing, monitoring and storage of the wireless spectrum, to solve the most dangerous threats in the wireless electromagnetic space. This system can contribute to providing accurate and fast detection, classification and location of intruders in the spectrum in the time, frequency and space domains. Users will be able to significantly reduce threats and have access to advanced methodologies for swift correcting actions. Having this capability is extremely important both in the civilian and military domain to protect communications infrastructures.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/12/pdf/2112-sps-flyer-socrates.pdf*

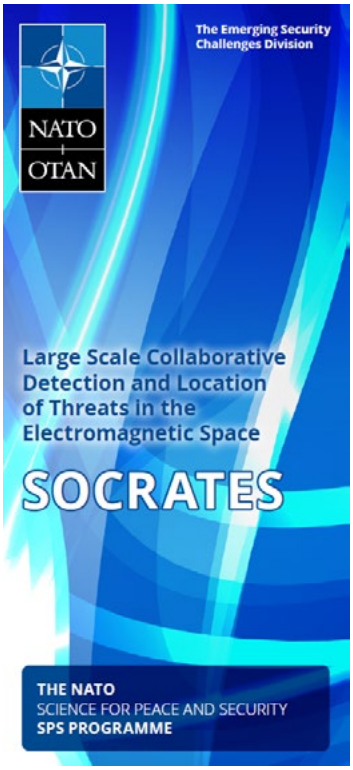


Figure 33 - SOCRATES project brochure.

COMPLETED

ARW Fighting Disinformation in a Pandemic World: The Role of AI and Cognitive Sciences

Participating countries: Italy, Ukraine

Throughout the COVID-19 pandemic, strategic areas have been targeted by massive amounts of malicious disinformation campaigns, directly endangering citizens and challenging the credibility of institutions. This ARW brought together world-leading scholars from Artificial Intelligence (AI), cognitive sciences, and related disciplines to address the need for countermeasures against disinformation campaigns, explore the advantages offered by novel technologies, and formulate clear guidelines for NATO and partner nations. In the quest for adequate countermeasures against disinformation, AI and cognitive science are considered paramount. AI can help create safer and higher-quality digital platforms, while cognitive science can help limiting disinformation by understanding the socio-cognitive vulnerabilities and better assessing eventual risks. To this aim, four sessions explored the problems, solutions, and political and ethical aspects in relation to AI and disinformation, as well as societal vulnerabilities and opportunities brought by misinformation, and socio-cognitive remedies against fake-news. The discussions offered new insights on the cognitive and social mechanisms underpinning the spread of disinformation as well as concrete suggestions on how to best prepare citizens to become risk-literate and increase their resistance to misinformation.

Cyber Defence

Strong and resilient cyber defences are critical to fulfil the Alliance's core tasks of collective defence, crisis management and cooperative security. The work undertaken by SPS in this area follows guidance from relevant policy documents adopted by Allies, including Partnership Framework documents, the 2010 Strategic Concept, as well as the Comprehensive Cyber Defence Policy adopted in 2021. Over the years, the Programme's activities have demonstrated their high practical cooperation value, attracting a growing interest from partner countries.

SPS work strands in this key priority have addressed the areas of resilience, capacity building, and situational awareness. They have also supported multidisciplinary activities that reached into the domain of advanced technologies, tackling topics related to EDTs such as cryptography and quantum technology, artificial intelligence and data analysis, cyber-physical system infrastructures, and hybrid threats in the information domain.

Between 2018-2021, SPS supported a total of 46 cyber defence activities. Out of them, 43% have been top-down SPS flagship advanced training and capacity building initiatives with a strong political, strategic and public diplomacy impact.

In 2021, two MYPs were completed under this key priority, as well as four ATCs and one ARW. The five events gathered a total of 230 participants and 93 speakers to share knowledge and provide training on advanced infrastructure and network security. In addition, the multi-year initiatives developed secure quantum communication systems, as well as intelligent and resilient cyber defence solutions. The projects were co-directed by scientists and experts from 15 countries, involving eight young scientists.

RESILIENCE AND CAPACITY BUILDING

ARW Cybersecurity of Industrial Control Systems

COMPLETED

Participating countries: Poland, Azerbaijan

Cyber-attacks on industrial and other control systems have a low execution threshold and remain a significant part of current and future conflicts. Consequences of such attacks can be severe: entire industrial, logistics and transport sectors could be immobilized, with a substantial impact on national security. Therefore, to ensure the protection of systems from non-desirable intrusion, adaptive cyber defence capacities must be developed and effectively implemented. The main goal of this ARW was to identify solutions for the protection of critical infrastructure such as pipelines and nuclear facilities. The event provided a forum for discussion on challenges in the field of industrial control systems, as well as on ways to mitigate, predict, and eliminate this dynamic and ever-changing threat.

Delivering this activity in an online format enabled 130 participants to discuss several relevant topics, such as vulnerability analysis, risk management, intrusion detection and prevention, and forensics. They identified gaps in existing cybersecurity education in the area of industrial control systems, which could result in future spin-off activities. Furthermore, this ARW benefited from the participation of the Azerbaijani Ministers of Education and Transport, as well as the President of the Azerbaijani National Academy of Sciences.

Figure 34 - Instructional video developed for a scenario simulation during this SPS ARW.

ATC Advanced Cyber Defense Training Courses for Azerbaijan

COMPLETED

Participating countries: Türkiye, Azerbaijan

Cyber threats and attacks are becoming more frequent, sophisticated and damaging. In this context, Azerbaijan is developing its cyber defence capacities and this field has become an important area of cooperation with NATO. This ATC was delivered online between May and June to employees of Azerbaijani governmental institutions holding key roles in cyber security. For four weeks, 27 civil servants from 12 state ministries and institutions received advanced training on operational cyber security and cyber security technology contents. The primary objective of this course was to provide an intermediate and advanced training on operational cyber security and technology contents to enhance cyber resilience. It contributed to exchanging advanced cyber security concepts, best practices, and experiences at the international level.

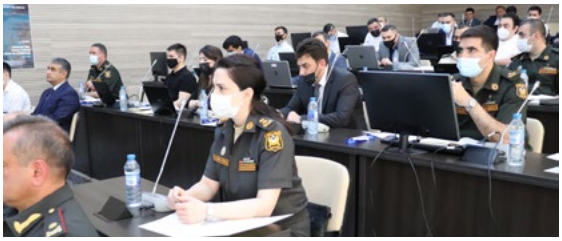


Figure 35 - Trainees in Baku, Azerbaijan, participating in this cyber defence ATC.

COMPLETED

ATC Advanced Cyber Defence Course on Network Security

Participating countries: NATO School Oberammergau, NATO-ICI Regional Center in Kuwait

This 'Top-down' 10-week online ATC was delivered between October-December and had the goal of increasing regional cyber expertise and projecting stability. Building on the successes of introductory cyber courses supported by SPS in 2019 and 2020, this ATC offered - for the first time at the NATO-ICI Regional Centre in Kuwait - an advanced-level training in "Network Security". The course was delivered in cooperation with the NATO School Oberammergau (NSO) and the Naval Postgraduate School in Monterey, and is the first of four courses in the NSO's Cyber Security Professional Certificate Programme.

With this course, 29 cyber defence professionals from national institutions in Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia received information and training that will help them enhance the protection of IT networks in their own countries, identify potential vulnerabilities, and familiarize themselves with tools to mitigate threats. The content focused on three major areas: the function of computer networks; the detection and filtering of malicious network traffic via authentication mechanisms, attack signature recognition, and filtering mechanisms and strategies; as well as the protection of friendly network traffic via cryptologic mechanisms.

This ten-week course offered lectures, classroom and online discussions, videos and online labs, as well as quizzes and assignments. It benefited personnel whose responsibilities require both a broad foundational overview and a strong technical understanding of security issues related to the movement of data between nodes of network systems. Security managers benefited from technical insights that will facilitate informed decision-making and better communications with technicians and engineers, expanding their knowledge and understanding of context in cyber defence.

Figure 36 - Some of the participants from ICI and GCC countries attending this advanced cyber defence SPS ATC.

SITUATIONAL AWARENESS

COMPLETED

MYP Threat Predict: From Global Social and Technical Big Data to Cyber Threat Forecast

Participating countries: France, Morocco, United States

Predicting cyber-attacks can help prevent and reduce their impacts. This MYP aimed to predict various types of incidents well in advance, by developing machine-learning algorithms that capture spatial-temporal dynamics of cyber-attacks and global social, geo-political and technical events. In addition to developing an early-warning capacity, the project aimed to improve the research community's understanding of cyber security as a socio-technical problem by analysing and describing large datasets from multiple sources. Understanding the impact of global technical and societal events on cyber threats provides an opportunity to give an early warning and pre-attack information to potential victims who may ignore that they are being targeted. The project produced a scientific report on prediction models and the implementation of a cyber threat forecasting tool.

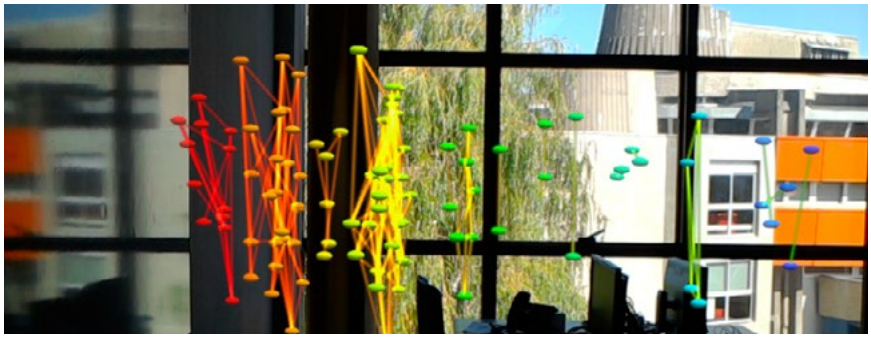


Figure 37 - Attack patterns visualisation using Hololens devices (Augmented reality): augmented reality visualisation of the mapper graph as perceived by the HoloLens user.

QUANTUM TECHNOLOGY

COMPLETED

MYP Analysis, Design and Implementation of an End-To-End 400km QKD Link

Participating countries: United States, Israel, Italy, Pakistan

The increasing amounts of data transmitted and stored online require enhanced levels of protection. Quantum Key Distribution (QKD), which relies on the laws of physics, is considered the only truly secure key distribution technology for cryptography and protected data transmission. The main goal of this MYP was to demonstrate the feasibility of a new method for secure and resilient long-distance communications to allow personnel to connect and communicate safely in the cyber-space. The project focused on the practical implementation of a long-range QKD link with trusted nodes to achieve the highest generation rate of perfectly secure random keys within security and system constraints. This design was implemented and validated through the establishment of long-haul fibre backbones connecting the city of Torino in Italy to two network nodes located 114km and 92km apart for the transmission of quantum cryptographic keys. This experimentation allowed the metrological characterization of QKD devices for a system with enhanced performances. The results of this project contribute to enhancing the resilience of communication systems by reducing their vulnerability to hacking.

Environmental and Energy Security

The two SPS key priorities Environmental Security and Energy Security aim to respond to security challenges arising from the environment, reduce the environmental effects of military activities, and prevent disruptions in energy supplies. Since the 1970s, NATO has been developing and adapting overarching environmental security and environmental protection policies in a military context. They include topics such as waste management, environmentally friendly management practices, responses to natural and man-made disasters, as well as energy efficient technologies and wider energy security considerations. In particular, climate change features in the NATO Strategic Concept and climate issues were highlighted in Summit Statements since the Lisbon Summit in 2010. Furthermore, at the Brussels Summit in June 2021 NATO Heads of State and Government endorsed a Climate Change and Security Action Plan. Alongside environmental security considerations, energy security has been highlighted in the NATO Strategic Concept and in all Summit Statements since 2008.

SPS activities under these key priorities facilitate cooperation amongst experts and scientists, and develop high-quality scientific research and solutions. These include the development and exploitation of cutting-edge sustainable technologies and capacities to mitigate environmental risks, strengthen the resilience of critical energy infrastructure, reduce the military's reliance on fossil fuel and its impact on the environment while maintaining the required levels of effectiveness.

In 2021, three MYPs were completed, and three were launched under the key priorities of Environmental and Energy Security. They have been developing solutions to mitigate the impact of climate change, as well as green defence and smart energy technological solutions. 21 young scientists participated in conducting these research projects. Furthermore, five SPS events took place this year, gathering 824 participants and 80 speakers to explore and expand knowledge about energy solutions and infrastructure protection, environmental security challenges, and innovative technologies to achieve a greener defence.

CLIMATE CHANGE AND ENVIRONMENTAL REMEDIATION

NEW

MYP Technology against Climate Change to Mitigate CO2 Environmental Security Threats (TANGO)

Participating countries: Italy, Morocco, Belgium

The main goal of the TANGO project is to contribute to the reduction of molecules of the greenhouse gas carbon dioxide (CO2) in the atmosphere, to mitigate its impact on the climate. It will develop a novel and sustainable technology for the utilization of CO2 molecules, which can be employed as a building block to produce a wide variety of chemicals and fuels, turning a pollutant into a feedstock. Another goal is to improve the efficiency of industrially relevant approaches to CO2 exploitation by integrating several technologies in the project: catalysis, nanotechnology, flow chemistry, aerosol chemistry, and magnetism. The project also aims to reduce the impact on the environment of CO2 utilization approaches, relying on Green Chemistry principles to guide TANGO activities.

This research activity, started in July, will ultimately develop an optimized integrated aerosol reactor that will improve efficiency in CO2 utilization. Using this gas as a renewable feedstock, the TANGO integrated technology could respond to growing energy needs by offering a greener, non-fossil fuel based approach for chemicals and fuels production.

Figure 38 - TANGO research team members at Porto Flavia harbour.

COMPLETED

MYP New Phytotechnology for Cleaning Contaminated Military Sites

Participating countries: Czech Republic, Ukraine, United States, Kazakhstan

This project participated in enhancing environmental security by developing a phytotechnology to produce biomass in large quantities on contaminated former military lands in Ukraine, the Czech Republic and the United States. Second-generation biofuel crops were grown in contaminated soils, while laboratory and field research were conducted to investigate the impact of the nature of contaminants, soil moisture, concentrations, and nutrients on the biomass production. The project also studied the effect of growing such crops on soil quality, as well as insect and nematode biodiversity. These experimentations conducted on the chosen former military sites identified optimal settings for biomass production and soil improvement within the scope of this project.

INNOVATIVE ENERGY SOLUTIONS AND STRATEGIES

NEW

MYP Innovative Solar Cells

Participating countries: Belgium, Ukraine

Soldiers carry a heavy battery burden and the energy load of their equipment has increased exponentially over the last few decades. Reduction of weight and increase of power for each soldier and the military forces are part of NATO's objectives in the field of energy security.

Launched in April, this MYP aims to develop light mobile energy sources for new wearable devices, with applications in the military. The research team plans to design high-efficiency, hybrid organic-inorganic based, thin film solar cells on flexible lightweight substrates. The results will lead to the development of integrated and wearable photovoltaics. This type of flexible solar cells will provide comparatively high-power levels in a lightweight configuration that can be compactly packaged.

NEW

MYP Carbon-Based Batteries and Supercapacitors (SUPERCAR)

Participating countries: Slovenia, Serbia, Montenegro

The use of Lithium-ion batteries is increasing massively in a broad range of applications, including hybrid electric vehicles and power storage for renewable energy sources. However, the scarcity of lithium reserves has triggered extensive research to develop alternatives technologies.

The SUPERCAR project, launched in March, aims to develop a new generation of lithium-free batteries and super-capacitors, based on biomass-derived, low-cost, and eco-friendly carbon nanotechnology. This project will develop a set of new and innovative carbon frameworks suitable for electrodes, to offer a safe and sustainable alternative to conventional charge storage systems. In particular, SUPERCAR will deliver a set of novel nanoporous carbon electrodes relying on abundant elements such as sodium, magnesium, calcium, and aluminium. It will also produce a prototype for each next generation battery and super-capacitor, capable of storing more energy than available technologies.

The high performance, durability, and reliability of the developed energy storage devices are expected to satisfy not only numerous civilian applications but also a variety of military applications including night-vision systems, GPS tracking devices, lasers, sensors, and vehicles. Furthermore, this technology could reduce the price, improve the safety, and simplify the manufacture of the current Li-ion technology.

MYP Portable Energy Supply

Participating countries: Norway, Ukraine

COMPLETED

Hydrogen plays an important role in the development of the renewable energy systems, because of its high potential for green electricity production. However, the storage technologies for hydrogen remained difficult to implement in portable applications. This MYP developed weight and volume efficient, portable hydrogen-fuelled energy systems that included a hydrolysis unit to produce hydrogen, storage units, and portable fuel cells. The project studied systems using aluminium-based alloys, magnesium hydride, and sodium borohydride. When used at optimized compositions, all three systems can provide a high output of hydrogen gas with high flow rates. This project resulted in the establishment of new promising products – hydrogen-powered autonomous fuel cell systems – offering a clean energy solution in line with NATO's environmental and climate objectives, and advancing research and knowledge on hydrogen storage and energy systems.

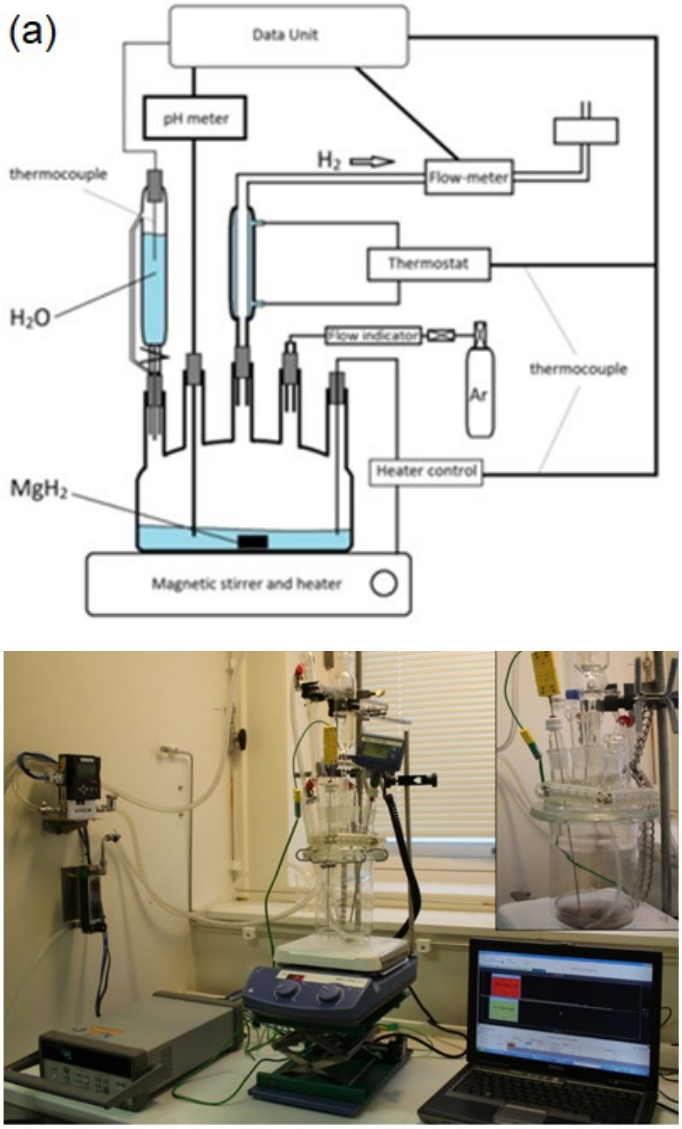


Figure 39 - Scheme and photo of the equipment used to study the hydrolysis process.

COMPLETED

ARW Energy Strategies 2020, Europe and Mediterranean: Trends and Scenarios for a Connected Energy Market

Participating countries: Italy, Morocco

The world is witnessing an energy transition from fossil fuels to renewables that brings new political, economic, and security challenges for the international community. This ARW sought to investigate multiple transformations occurring within the energy market and energy security fields, with a particular focus on the Mediterranean region. The event was organized by the NATO Defense College Foundation (NDCF) in Italy and the Policy Center for the New South in Morocco. It brought together specialists from international organizations and major companies from the sector to addressed key questions related to evolving power production capacities, threats to traditional and advanced energy infrastructures, and the shaping of a collaborative and connected regional energy market. The workshop shaped concrete answers and possible ways ahead for the future of energy markets and security in the region. The workshop was held in March 2021 as a hybrid event, with a limited in-person presence while the majority of its 404 participants attended online. The workshop received significant coverage in conventional and social media, and the contents of the discussions were made accessible to the public via a series of videos. Moreover, the proceedings of this ARW will be published in a NATO Science Series volume.

Videos of the event can be found at this link: *https://youtube.com/playlist?list=PLlSrHYQlI4vtr7QKQLjKDAaH-on5Jwgil*

Figure 40 - Participants in one of the sessions of this SPS ARW.

COMPLETED

ARW Innovative Technologies and Renewed Policies for Achieving a Greener Defence

Participating countries: Italy, Finland

Figure 41 - Poster of this SPS ARW.

This ARW was held in October 2021 as a two-day hybrid event. Its objective was to discuss the innovative technologies and the new policies needed for achieving a greener defence sector. It involved experts ranging from top-level officials to practitioners, and included speakers from the European Union and the Organization for Security and Cooperation in Europe (OSCE).

During the workshop and the brainstorming sessions, speakers, and participants were able to share their views and lessons learned to provide recommendations to NATO and national governments on the way forward for a greener defence. The event contributed to increasing public awareness on this subject, and highlighted NATO's role as a key player in helping to achieve a more sustainable defence sector.

Mine and Unexploded Ordnance (UXO) Detection and Clearance

Improvised explosive devices (IEDs), mines and unexploded ordnance (UXO), and other explosive remnants of war compromise the safety of civilian populations and military personnel across the world. The SPS Programme supports international cooperative efforts, which are crucial for conducting and assisting humanitarian demining. The Programme also sponsors the development of new technologies to support NATO's work "to defend against improvised explosive devices (IEDs)", as highlighted in the 2021 Brussels Summit Declaration and the 2010 Strategic Concept.

SPS activities under this Key Priority assist partner countries in developing technologies as well as robust national operational programmes capable of addressing the threat of mines, UXOs and IEDs. A key example of ongoing SPS efforts in this field is VECTOR. This Multi-Year Project will leverage artificial intelligence and virtual reality technologies to create an integrated solution for identifying, analysing, classifying, and responding to explosive devices. Such effort is in line with NATO's objective to address "the breadth and scale of new technologies to maintain our technological edge, while preserving our values and norms" outlined at the 2019 NATO Leaders' Meeting. Additionally, the SPS Programme provides support through training courses and guidance in the implementation of policies and programmes to manage explosive hazards.

Under this key priority, in 2021 one MYP was completed and one was launched, involving scientists from seven countries, including 15 young scientists. Additionally, there are four ongoing MYPs under this key priority that focus on improving explosive threat detection and indoor monitoring of explosive vapours, as well as accelerating mine clearance and safely recovering ordnance.

MYP Nanomaterials for Explosives Traces Detection with SERS (NOOSE)

NEW

Participating countries: Slovenia, Israel, Greece, Ukraine

Launched in March, the NOOSE project aims to enable a highly-sensitive and ultra-fast trace detection of explosives. It will develop an explosive detector using Surface-Enhanced Raman Spectroscopy (SERS), which promises very high sensitivity. This optimized plasmonic nano-sensor will offer excellent detection performance and will be very easy to operate. The implementation of a reliable, novel, low-cost tool for the rapid and accurate detection of explosives could be expanded to a wide range of potential implementations, spanning from military to environmental safety applications. Such reliable solution for the trace detection of explosives and other potentially harmful substances contributes to NATO's efforts to prevent, protect against, and respond to terrorist threats. This technology could be deployed rapidly, thereby preventing possible terroristic attack, ensuring appropriate public and environmental protection, and enabling more efficient control at critical security points with a high concentration of civilians, such as airports or transport hubs.

MYP Biological Methods - Bees - for Explosive Detection (Bee4Exp)

COMPLETED

Participating countries: Croatia, Bosnia and Herzegovina, United Kingdom

Figure 42 - One of the beehives used in the framework of this SPS MYP.

Landmine contamination in post-conflict areas is an important threat to human lives, as well as to economic and social development. Explosive devices could also fall into the hands of ill-intended actors, and be used for terrorist purposes.

The main objective of the Bee4Exp project was to develop innovative methods and technologies for the detection of landmines and other unexploded ordnance using trained honeybee colonies. This detection system involves a passive method to confirm the presence of explosive materials that relies on exposing environmental samples from the bee colonies to light-emitting polymers, and an active method to pinpoint the location of land mines using a swarm of bees over a suspected area. The active approach involves unmanned automatic vehicles with mounted cameras to conduct the analysis of the distribution of bees on heat-maps and detect the location of explosives. Field experimentations validated this promising approach, with spatial heat-maps showing that the honeybees tended to spend more time in the vicinity of landmines. This project received extensive attention and coverage by the media, and is expected to contribute to surveying and reducing suspected hazardous areas, as well as to conducting post-clearance internal and external quality control in humanitarian demining.

Human and Social Aspects of Security

Since 2013, the SPS Programme has supported practical cooperation in areas beyond "hard" sciences, to include human and social aspects of security. In particular and in coordination with the NATO Secretary General's Special Representative for Women, Peace and Security (WPS), SPS has contributed to the implementation of the WPS agenda, as set forth in several United Nations Security Council Resolutions (UNSCRs). Initiatives in this area offered concrete deliverables in cooperation with partner countries, and provided an important platform for debate, and exchange of views and best practices.

Under this key priority, activities also reinforce the human security approach in countering terrorism. For instance, an SPS flagship project in this field supported the evaluation of Preventing/Countering Violent Extremism (P/CVE) programmes at the local level under the leadership of the Harvard T.H. Chan School of Public Health. Another MYP is exploring societal resilience by drawing from operational experience and conflict drivers within civilian communities in Europe to identify potential hybrid threats and establish hybrid warfare scenarios. The developed scenarios will inform training and planning for hybrid crisis in the region. Other activities under this SPS key priority include the study of contemporary social and human security issues, and their impacts on our societies, policy-making, and the management of emergencies.

In 2021, experts and scientists from 12 countries co-directed three ARWs, one ATC and one completed MYP under this key priority. The events gathered 115 participants and 79 speakers to share knowledge and best practices on resilience building in the context of the COVID-19 pandemic; NATO's role in supporting democracy, stability, and security in the Western Balkans; women's transition from military to civilian life; and on the promotion of a greater understanding and dialogue on gender mainstreaming in counter terrorism. In addition, the completed multi-year initiative analyzed the political and security implications of current regional dynamics in NATO's Southern Neighborhood, and involved nine young scientists.

SUPPORT TO THE WOMEN, PEACE AND SECURITY AGENDA

COMPLETED

ARW A Gender-Lens approach to Military to Civilian Transition and Reintegration for Ukraine Joint Forces Operation (JFO) Women Combatants

Participating countries: Canada, Ukraine

This top-down effort responded to an agreed priority of the NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation. The ARW addressed challenges related to Military to Civilian Transition through a gender lens. Discussions explored specific barriers and difficulties facing women military personnel and Veterans that can impede their reintegration to civilian life, such as post-traumatic stress disorder (PTSD). The event reflected a Ukrainian interest in cooperative efforts dedicated to improving the integration and role of women in the military.

The two-part virtual event gathered more than 47 experts from Ukraine, Canada, and the United States in May and November. The event benefited from the participation of high-level officials, including notably the Canadian Ambassador to Ukraine, Canada's Ambassador for Women, Peace and Security and Ukraine's Government Commissioner for Gender Equality Policy. During the two events, young researchers were able to present their findings and receive support for their work from well-established experts in the field.

A brochure on the project can be found at this link: *https://www.nato.int/nato_static_fl2014/assets/pdf/2021/11/pdf/2021-11-04-sps-arw-g5309-en.pdf*

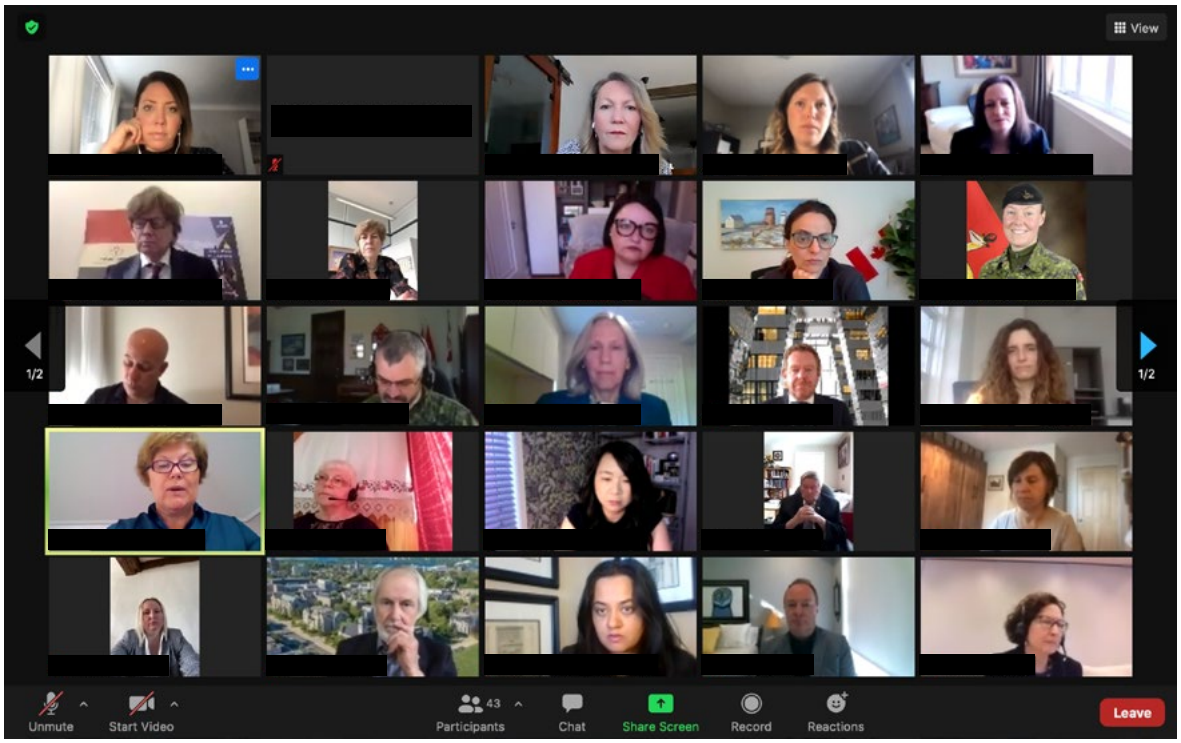


Figure 43 - Researchers and high-level participants in this online "Top-down" SPS ARW.

RESILIENCE AGAINST HYBRID THREATS

ARW Resilience Research Workshop in North-East Ukraine

COMPLETED

Participating countries: Estonia, Ukraine

This ARW took place in May in Sumy, Eastern Ukraine in a hybrid format. It built on previous events, including an SPS workshop on early warning systems to counter hybrid threats, held in Vilnius in April 2019. This activity responded to priorities identified in the framework of the NATO-Ukraine Platform on Countering Hybrid Threats. It gathered 30 young professionals, master students, researchers, public figures, local activists, journalists, and volunteers from the Ukrainian government and non-governmental sectors, working in several regions of Ukraine. Approximately 20 speakers and trainers addressed the group following the principle of "train the trainers". On this occasion, the importance of international partnership and collaborative research to address emerging threats to our societies was highlighted.

Figure 44 - Participants in this SPS ARW in Sumy, Ukraine.

SUPPORT TO REGIONAL STABILITY

MYP Responding to Emerging Security Challenges in NATO's Southern Neighbourhood

COMPLETED

Participating countries: Belgium, Morocco, Jordan, Spain, United Kingdom

This MYP aimed to analyze current regional dynamics in NATO's southern neighbourhood at the social, demographic, economic, political, cultural, and climatic levels to better comprehend their political and security implications. It gathered a diverse and geographically relevant range of experts and regional networks to produce a report entitled "NATO and the South: A Tale of Three Futures". The report included a conceptual framework and conclusions of three scenario-based foresight exercises hosted in Brussels, Rabat, and Amman.

The report analyzed key variables that are likely to affect the Southern neighborhood in the coming decade and correspond to priorities identified in the ongoing "NATO 2030" work. It reiterated that the region is an area of both conventional challenges and growing asymmetric threats. In particular, the report outlined sources of change to better understand their implications and provide strategic foresight scenarios for decision-makers in the Alliance and partner countries. It also proposed early warning mechanisms and scenarios to inform policy planning and policy making. The project was officially closed during a virtual public event entitled "Scanning NATO's future to 2030 - Implications for the South" in July, which presented the findings of this project, with participation from the Spanish Secretary of State for Foreign Affairs and for Ibero-America and the Caribbean, Mrs. Cristina Gallach.

A video of the event can be found at this link: *https://www.youtube.com/watch?v=tpoO1al8cd4*

Figure 45 - High-level participants in the virtual public event "Scanning NATO's future to 2030 - Implications for the South".

ARW Integration of the Western Balkans in NATO as a Guarantee for Regional Stability

COMPLETED

Participating countries: Bulgaria, Serbia

This ARW took place in hybrid format in May. Despite difficult circumstances due to COVID-19 restrictions, it successfully brought together participants and speakers from Albania, Bosnia and Herzegovina, Bulgaria, Croatia, North Macedonia, Serbia and NATO. The panels included prominent academics in the field of international relations, political science, and human rights, as well as decision makers, private stakeholders, and international officials.

The event focused on NATO's role in promoting stability and security in the Western Balkans. Discussions addressed security and societal challenges in various countries and analyzed how they were overcome during the NATO accession process. The perception of NATO in the region as well as hybrid challenges were touched upon in order to facilitate a regional dialogue and a better understanding of risks and opportunities for practitioners.

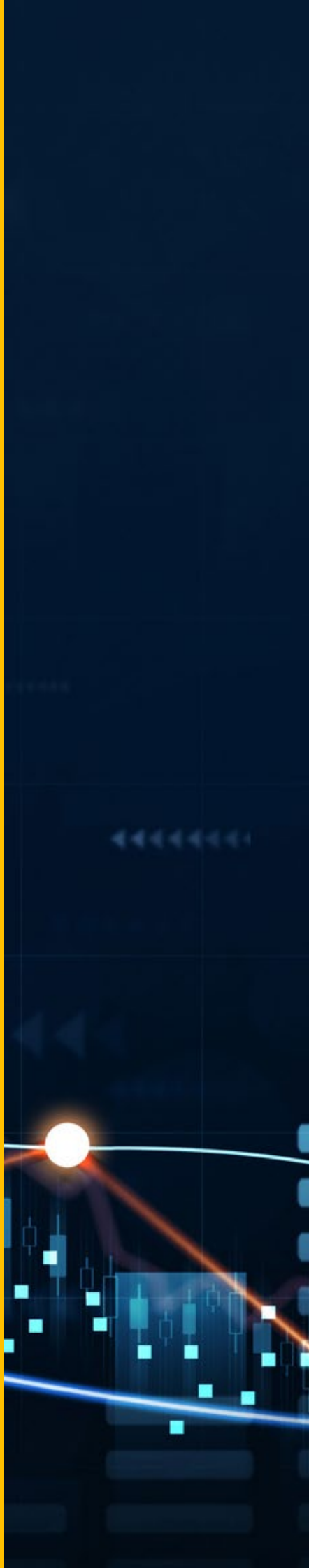
This event raised awareness about the Alliance and challenges in the Western Balkans, and provided suggestions for tangible policy responses. It contributed to enhancing the understanding of the various interconnected risks and threats in the region, in order to help NATO and its partners to better meet these diverse challenges.

Figure 46 - Speakers in this SPS ARW.

CHAPTER 3
Facts and Figures

The SPS Programme serves to facilitate cooperation and collaboration between NATO and partner country scientists, experts, and government officials. To this end, the Programme offers funding, expert advice and support to tailor-made, civil security-relevant activities that respond to NATO's strategic objectives. All SPS applications undergo a comprehensive peer-review and approval process, taking into account expert, scientific, and political guidance.

The SPS Programme supports both 'top-down' and 'bottom-up' activities. A 'top-down' application is initiated by NATO International Staff (IS) in cooperation with Allies and/or partner delegations. 'Bottom-up' applications are submitted directly by independent scientists and experts, in response to calls for proposals advertised via the SPS website. All applications are developed and implemented in line with guidelines and application material available on the SPS website.



Review and Approval of Applications

This section presents an overview of the SPS award cycle process over the calendar year, which includes the number of new applications received by the SPS Programme, pre-screened by NATO experts, evaluated by scientists, and finally reviewed and approved by Allies.

Reception of Applications and Eligibility Screening

In September 2020, the SPS Programme launched a Call for Proposals inviting the submission of applications addressing any of its key priorities, with a deadline on 15 January 2021. Due to the potential impact of the ongoing COVID-19 pandemic, this call for proposals focused primarily on research and development Multi-Year Projects (MYPs). 68 applications were submitted to SPS for consideration.

In line with the Programme's established procedures, NATO experts performed an initial screening to evaluate the eligibility of these proposals, taking into account their relevance to NATO and security, and their link to SPS key priority areas. 56 of these applications were deemed eligible, and were submitted to the Independent Scientific Evaluation Group (ISEG) for review.

The Independent Scientific Evaluation Group (ISEG)

The ISEG is composed of scientists and experts nominated by NATO countries and appointed by the PCSC. The main role of the ISEG is to evaluate the scientific and technical merit of SPS applications. ISEG members are also invaluable in designing and supporting SPS Calls for Proposals, as they can help to identify research trends and future focus areas. In addition, the ISEG members follow and evaluate ongoing SPS projects in their areas of expertise by acting as 'godparents'. This direct involvement of the scientific community is indispensable for the integrity and maintenance of the high scientific standard of the SPS Programme.

In 2021, the ISEG was composed of 32 scientists and experts. The mandate of 12 of these experts ended at the end of 2021, prompting the Programme to issue a new Call for ISEG Nominations. The call was launched in June, and resulted in the appointment of nine new ISEG members, who will start their three-year term in January 2022.

Since the start of the COVID-19 pandemic, the ISEG has been meeting online. On 26-27 April and 26 October 2021, ISEG members discussed 56 eligible proposals received by the Programme, and recommended 18 of them for Allied approval. Moreover, the ISEG experts continued to share updates and summaries on the implementation of the SPS activities that they followed as 'godparents'.

The Partnerships and Cooperative Security Committee (PCSC)

Each activity recommended by the ISEG is reviewed by the Partnerships and Cooperative Security Committee (PCSC) and must be approved by Allies in order to be supported by SPS. The Programme's alignment with NATO's strategic objectives, in combination with the quality of the applications recommended by the ISEG, resulted in a high approval rate of SPS award recommendations by the PCSC in 2021.

Due to the COVID-19 pandemic, since 2020 PCSC members have reviewed and approved electronically all the proposals recommended by the ISEG. In 2021, they approved 20 award recommendations, 18 recommended by the ISEG in 2021 and two proposals pending from the 2020 review cycle. Out of the 20 approved award recommendations, 5 were 'top-down' and 15 'bottom-up'.

Throughout the year, Allies also provided important guidance for the implementation of the SPS Programme, including through the approval of the annual SPS Work Programme. Furthermore, SPS regularly updated the PCSC about the launch of new initiatives, the progress of ongoing projects, and the outcomes of completed activities.

*In the course of 2021, the PCSC reviewed and approved 18 applications received during the 2021 round of applications and two applications received the previous year.

The chart below provides the breakdown of the activities approved by the PCSC in 2021 according to SPS grant mechanism.

Mechanism		Approved activities
MYP	Multi-Year Project	16
ARW	Advanced Research Workshop	0
ATC	Advanced Training Course	3
ASI	Advanced Study Institute	1
	Total	**20**

Implementation of Activities

This section provides an overview of the execution of the SPS Programme in 2021, addressing the impact of the COVID-19 pandemic on SPS activities, as well as the number of completed projects and events throughout the year.

Impact of the COVID-19 Pandemic and Completed Activities

The COVID-19 pandemic has had an undeniable impact on SPS activities, especially in 2020 when, due to the measures imposed by governments worldwide, many institutions had to suspend or limit their activities, which led to delays in various SPS projects. Restrictions on travel and gatherings also affected SPS-supported events, most of which were postponed to 2021, while several had to be cancelled. However, the SPS Programme has rapidly adapted and ensured its business continuity.

In 2021, with the gradual softening of the COVID-19 measures and the Programme's adaptation to new working methods, SPS was able to operate at full capacity. As a result, no less than 22 Multi-Year Projects were officially launched via online meetings, and 22 were completed throughout the year. Combining virtual platforms with on-site presence, NATO and partner countries' experts were able to organize 17 SPS workshops and training courses; the vast majority of these events were approved in 2019 and 2020, but had to take place in 2021 due to the onset of the COVID-19 pandemic in early 2020.

In total, 39 SPS activities were completed in 2021 – 22 Multi-Year Projects and 17 Events. 31% of all completed SPS activities were 'top-down', while 69% were 'bottom-up'. The chart below provides the breakdown of SPS activities completed in 2021 by SPS grant mechanism.

SPS grant mechanism		Completed activities
MYP	Multi-Year Project	22
ARW	Advanced Research Workshop	11
ATC	Advanced Training Course	6
ASI	Advanced Study Institute	0
	Total	**39**

Distribution of SPS Activities

This section provides further details on the distribution of the approved and completed activities across by SPS key priority areas and NATO partnership frameworks.

Distribution of Activities by SPS Key Priority

The SPS Programme is embedded in the Emerging Security Challenges Division (ESCD), which serves as NATO's source of expertise on a growing range of non-traditional risks and challenges, such as terrorism, cyber-attacks, energy security, and hybrid warfare. The focus of the SPS Programme spans across these new security challenges and strives to bring together scientists, experts, and policy makers from NATO and partner countries to tackle them through practical scientific cooperation

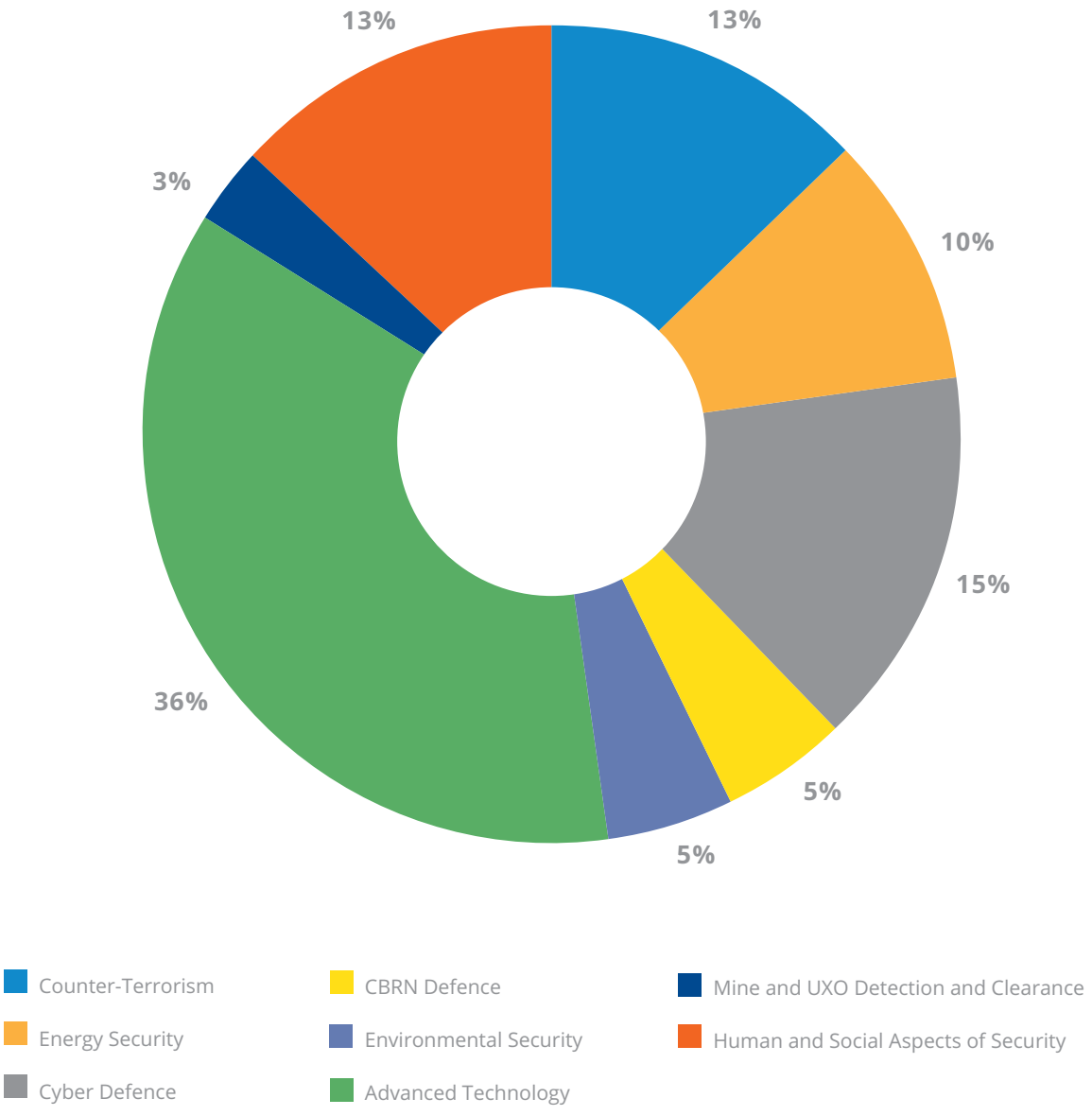
SPS Key Priorities		New activities	Completed activities
1a.	Counter-Terrorism	2	5
1b.	Energy Security	5	4
1c.	Cyber Defence	2	6
1d.	Defence against CBRN Agents	2	2
1e.	Environmental Security	2	2
2.	Support for NATO-led Operations	0	0
3a.	Advanced Technology	7	14
3b.	Border and Port Security	0	0
3c.	Mine and UXO Detection and Clearance	0	1
3d.	Human and Social Aspects of Security	0	5
4.	Other Security Threats Related to NATO's Strategic Objectives	0	0
	Total	**20**	**39**

In 2021, the PCSC approved 20 new SPS activities in line with the SPS key priorities. The most active areas of cooperation were Advanced Technology at 35% and Energy Security at 25%, reflecting the Programme's capacity to forecast and quickly adapt to NATO's evolving priorities, such as the NATO 2030 agenda. They were followed by Counter-terrorism, Cyber Defence, CBRN Defence, and Environmental Security, each representing 10% of the newly approved activities.

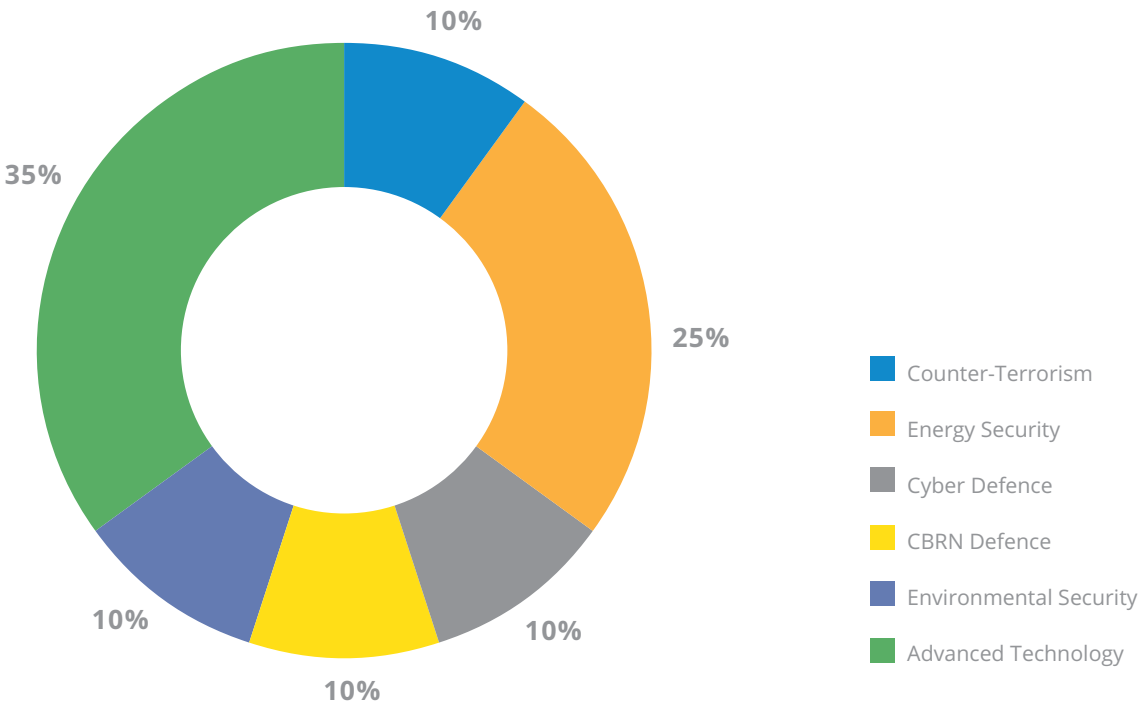
At the same time, 39 activities were completed throughout the year. 36% were implemented in the Advanced Technology field, many of them reflecting the outcome of the 2019 Special Call for Applications in this field, which was launched in late 2019. Furthermore, 15% of the SPS Multi-Year Projects and Events concluded in 2021 focused on Cyber Defence. Activities carried out in the areas of Counter-terrorism and Human and Social Aspects of Security represented 13% each, while the share of initiatives accomplished in the fields of CBRN Defence and Environmental Security were at 5%. Finally, one project pertaining to Mine and Unexploded Ordnance Clearance and Detection (UXO) constituted 3% of the completed activities.

The table above and the charts below provide an overview of new and completed activities by **SPS key priority area.**

Completed Activities by SPS Key Priorities



New Activities by SPS Key Priorities

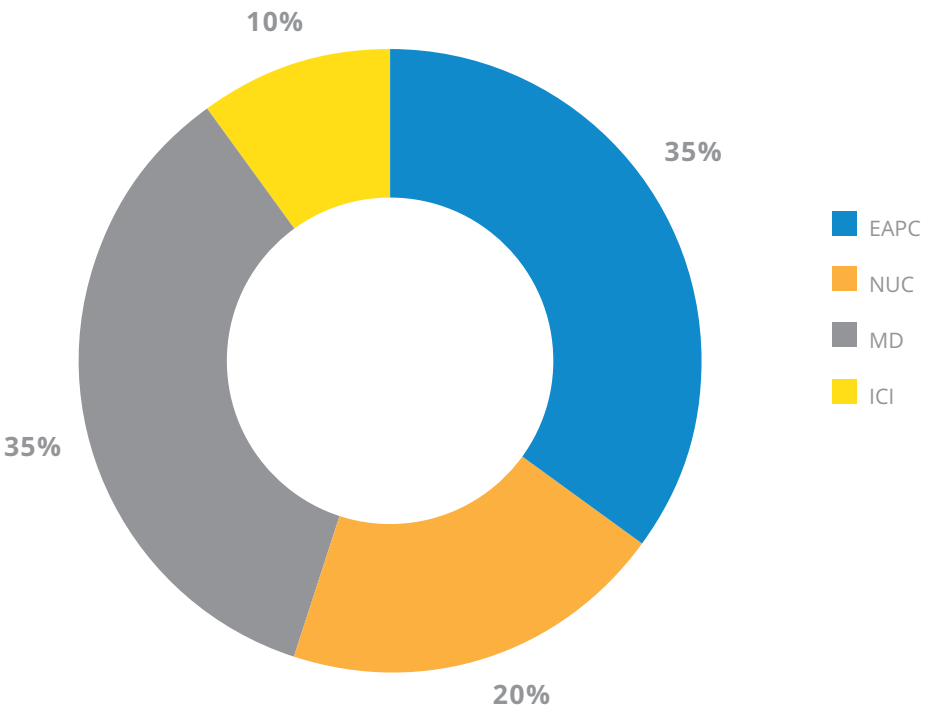


Distribution of Activities by Partnership Framework

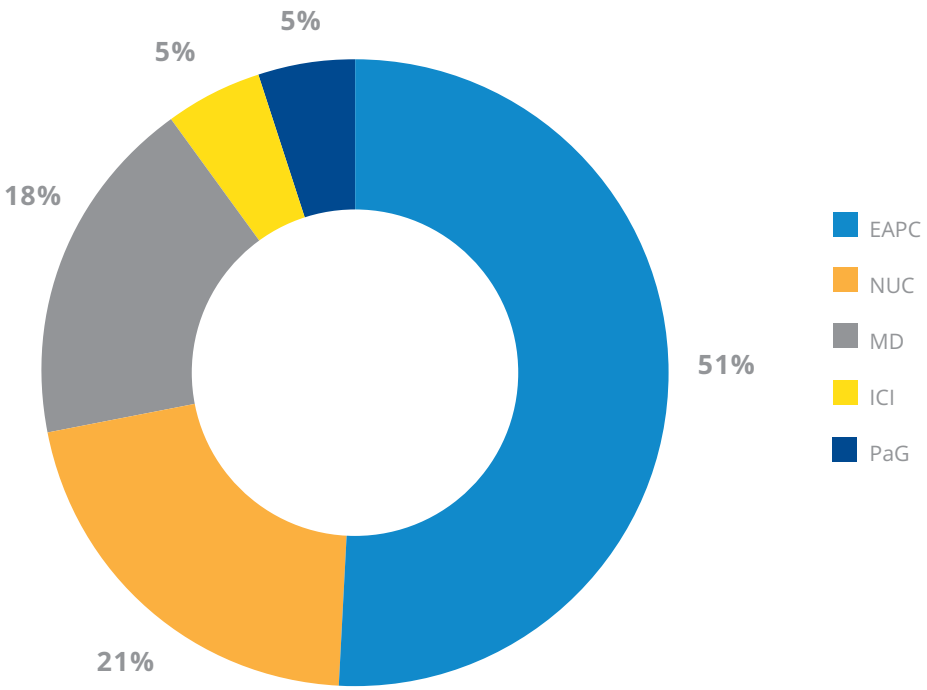
The 20 new activities approved in 2021 involve 10 different partner countries. Moreover, the 39 activities completed this year involved 15 NATO partners. The chart below provides a breakdown of activities approved and completed in 2021 by partnership framework.

Partnership framework		Approved activities	Completed activities
EAPC	Euro-Atlantic Partnership Council	7	22
NUC	NATO-Ukraine Commission	4	8
PaG	Partners across the Globe	0	2
MD	Mediterranean Dialogue	7	7
ICI	Istanbul Cooperation Initiative	2	2
	Total	**20**	**39**

Approved SPS Activities by Partnership Framework



Completed SPS Activities by Partnership Framework



As a result of its balanced, 360-degree approach, SPS activities in 2021 involved partners from all of NATO's partnership frameworks. A large number of the newly approved and completed SPS activities (35% and 56% respectively) were developed in the framework the Euro-Atlantic Partnership Council (EAPC), involving a total of 10 partners from Eastern and Western Europe, the Balkans and Caucasus. SPS also continued to serve as a valuable programme for enhancing practical cooperation with Ukraine throughout the year. About 20% of the newly approved SPS proposals and 21% of the completed activities were developed under the NATO-Ukraine Commission (NUC). They substantiated Ukraine's new Enhanced Opportunity Partner status, Allied political guidance, and the priority areas of cooperation identified and discussed at the 16th meeting of the NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation that took place in Brussels in March 2019.

Reflecting NATO's increased focus on the South, activities involving countries from the Mediterranean Dialogue (MD) represented 35% of the approved award recommendations, and 18% of the activities completed in 2021. The number of activities led by Istanbul Cooperation Initiative (ICI) countries represented 10% of the SPS proposals approved over the year and 5% of the concluded activities. The cooperation with ICI partners took place primarily in the context of the package of ATCs approved and completed at the NATO-ICI Regional Centre in Kuwait. Moreover, two activities (5%) with Partners across the Globe were concluded in 2021 with Australia and Pakistan.

Cooperation with Partners in 2021

The Science for Peace and Security (SPS) Programme provides opportunities for practical cooperation with concrete deliverables in security-related civil science and innovation between experts and scientists from NATO and partner countries. SPS activities span across NATO's network of partners associated with the Alliance through the Euro-Atlantic Partnership Council (EAPC), the Mediterranean Dialogue (MD), the Istanbul Cooperation initiative (ICI), the NATO-Ukraine Commission (NUC), as well as NATO's partners across the Globe (PaG). They also take into account the priorities and requirements of partners, in particular those outlined in approved partnership documents such as Individual Partnership Action Plans (IPAP), Individual Partnership Cooperation Programmes (IPCP), and Individual Tailored Partnership Programmes (ITPP).

With a balanced 360-degree approach, in 2021 the SPS Programme remained open to cooperation with all partners and placed a particular focus on priorities identified in the NATO 2030 agenda, including climate change and security, counter-terrorism, cyber defence, EDTs and innovation, energy security, disinformation, resilience, and the human security and WPS agendas. In 2021, this has led to new flagship initiatives with a strong political, practical and public diplomacy impact. Moreover, many of the Multi-Year Projects completed over the year have left a tangible and lasting impact, including the development of innovative cutting-edge technology, the registration of patents, scientific publications, and sustainability ensured by investments from governmental institutions. Equally important, the SPS Events held in 2021 contributed to capacity building, provided training for young scientists and experts, and forged strong networks between scientific communities in NATO and partner countries.

In 2021, **Ukraine** remained the Programme's largest beneficiary. During the course of the year, eight activities co-led by Ukraine were kicked-off and five were completed. Among the newly launched activities, it is worth noting Ukraine's contribution to the fight against CBRN threats via two projects aiming to develop a wearable alarm and analysis sensor device capable of detecting nerve agents to protect soldiers and first responders; and an innovative real-time sensor platform able to rapidly detect dangerous pathogens. Responding to the NATO 2030 objective to support new innovative energy solutions, Ukrainian and Belgian experts have started to develop mobile light energy sources for wearable life-saving devices for the military. Along with this new initiative, a Multi-Year Project led in cooperation with Norway was concluded with the development of a lightweight, reliable and silent electrical power supply combining hydrogen

Figure 47 - Researchers working on the SPS MYP "New phytotechnology for cleaning military sites".

storage and generation, and a portable fuel cell. These new hydrogen fuelled portable energy systems will allow soldiers to carry less weight, while providing more energy for an increased operation time. Ukrainian scientists contributed to addressing environmental security through two completed Multi-Year Projects, which developed a novel material for a thermo-regulating textile for military uniforms and fatigues, and a phytotechnology to produce biomass on contaminated military lands. Advanced Technology continued to be one of the most active areas of cooperation with Ukraine. Related deliverables included a new type of photonic crystal sensors for detecting small quantities of biological and chemical toxins; an upgraded hand-held gamma detector based on High Pressure Xenon gas (HPXe). Building on previous events, which tackled hybrid threats in Eastern Europe, an Advanced Research Workshop on resilience took place in May 2021 in Sumy, Ukraine and was featured in the framework of the NATO-Ukraine Platform on Countering Hybrid Threats. Moreover, reflecting a concrete deliverable to an agreed priority of the NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation (JWGSEC), a top-down workshop aimed to ensure that key stakeholders remain committed to better understand how women experience Post-Traumatic Stress Disorder (PTSD) and other common mental health conditions when they return from active duty to civilian life.

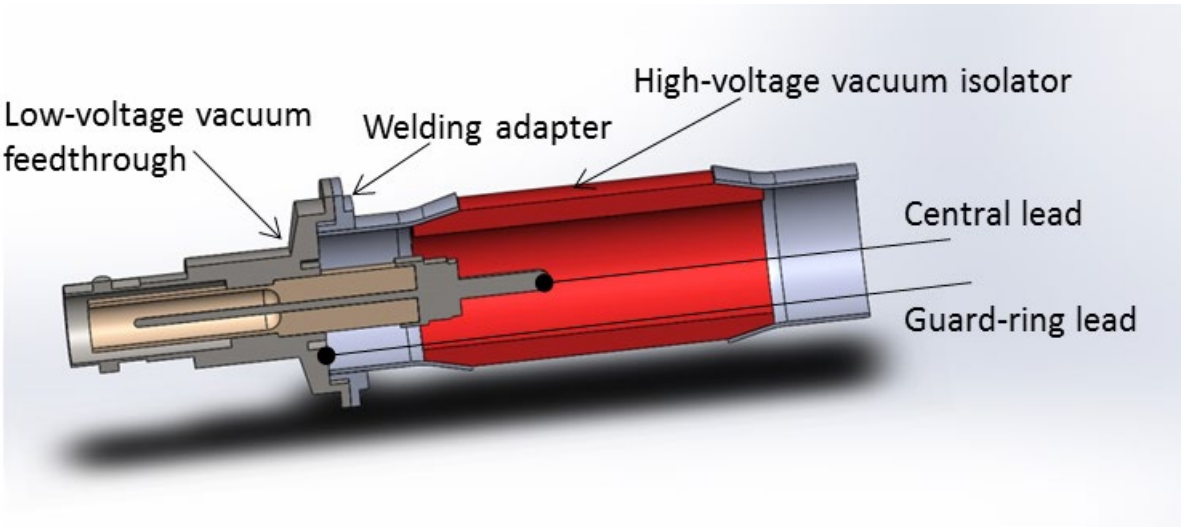


Figure 48 - Complex High Voltage (HV) feedthrough concept from the SPS MYP "Upgrade and improvements of the hand-held gamma detector based on HPXe gas".

Cooperation with the **Republic of Moldova** was marked by the successful completion in March 2021 of the key flagship top-down project 'Developing Capability to Mitigate the Risk of Biological Agents in Moldova'. Implemented in cooperation with the NATO Support and Procurement Agency (NSPA), this Multi-Year Project provided the Moldovan Ministry of Health with a mobile biological laboratory to better counter threats posed by infectious biological agents, mainly Anthrax. In addition, training was delivered to Moldovan experts with the aim of enhancing surveillance capability, early detection and rapid response.

In the Caucasus, Azerbaijan's participation in the SPS activities has progressively intensified throughout the year following the implementation of two SPS Events in the field of cyber defence, and the approval of a new Multi-Year Project pertaining to energy security area. In particular, with a view to contribute to increasing stability in NATO's neighbourhood by preventing the threats posed by geological hazards to Azerbaijan's energy independence, the newly approved MYP will focus on improving the resilience and safety of the hydropower plant systems in Azerbaijan, as well as on proposing remediation measures in case of natural disasters. This project, which

is foreseen to be launched at the beginning of 2022, will also represent a platform for knowledge sharing and extensive collaboration between scientists from various NATO and partner countries, including in the Caucasus.

In the **Western Balkans**, along with NATO's Open Door Policy, the SPS Programme continued to promote regional cooperation by engaging scientists and experts in cross-border activities. To this end, no less than seven SPS activities were initiated throughout the year jointly by NATO and partner countries in the region. They are addressing key priority areas such as Counter-terrorism, Energy Security, CBRN Defence, Advanced Technologies, and UXO Clearance. For instance, two Multi-Year Projects were launched by Serbian and Slovenian researchers in cooperation with counterparts from North Macedonia and

Figure 49 – Young scientists from North Macedonia undergoing training at the Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia in the framework of the SPS MYP "Nanocoatings for Multi-Protective Textiles used for Military Clothing (MULProTex)".

Montenegro, to develop a new generation of Lithium-free batteries and supercapacitors, and a compact Ground Penetrating Radar (GPR) system for landmine detection. In order to facilitate medical care and triage in crisis management operations, scientists from Serbia and Slovakia have embarked on the new 'SP4LIFE' project with the aim of creating a wearable patch-like device using artificial intelligence for real-time diagnosis and monitoring of vital health parameter. In addition, experts from the Western Balkans have worked together in the implementation of a series of workshops and training courses. In this regard, three SPS events, led by experts from Bosnia and Herzegovina and North Macedonia, addressed Western Balkan challenges relating to the practical applications of advanced technologies for enhancing security and defense capabilities; strengthening the cyber defence against hybrid threats; and raising awareness of women's role in tackling radicalization and violent extremism in the region. In the same manner, an ARW organized by Serbian and Bulgarian academics, discussed the role of NATO in enhancing stability and security in the Western Balkans.

Equally important, Western Balkan partners have also been very active in engaging in practical cooperation with Allies beyond their neighbourhood. One project, kicked-off in cooperation with Serbia, US and North Macedonia, aims to obtain multi-protective military clothing against fire, microorganisms, nerve agents and ultraviolet light. In another newly launched project, researchers from Bosnia and Herzegovina and the Czech Republic are working on demonstrating the application of QKD in 5G networks, developing simulation tools and practical guidelines for further inclusion of quantum technologies in 5G networks.

Figure 50 – Project team members installing Quantum Key Distribution (QKD) systems in the context of the SPS MYP "Quantum Cybersecurity in 5G Networks (QUANTUM5)."

2021 also saw the successful conclusion of an SPS top-down flagship Multi-Year Project, which developed and implemented a Next-generation Incident Command System (NICS) in the Western Balkans. In the past four years, this project has supported NATO and partner countries in the region in their efforts to acquire, deploy and customize NICS to their national systems as

well as to test it in various national, regional and NATO crisis management exercises. The deployment of NICS in the Western Balkans has enhanced the capacity of the participating countries to respond in a coordinated manner to various emergencies and fostered their collaboration both at high-level and on the ground. In addition to NICS, two MYPs in the fields of UXO Clearance and Counter-terrorism were completed during the past year. Whereas one project developed and tested a novel method to detect landmines by employing honeybees, the other project put forward a novel approach for the detection of improvised explosive devices by developing a fast, portable, sensitive, and reliable early-warning gas sensors for detecting traces of explosives in the air.

Cooperation with the **South** within the Mediterranean Dialogue (MD) and Istanbul Cooperation Initiative (ICI) frameworks remained an important part of the SPS Programme's engagement to deliver on NATO priorities. Seven new SPS activities with **MD partners** were initiated in response to policies and agendas endorsed at the 2021 NATO Summit in areas that will shape the future of the Alliance, including innovation, technology, and environment. In this regard, three Multi-Year Projects were launched under the key priority of security-related advanced technologies, involving scientists from Israel and Morocco. They focus on the development of a novel electromagnetic field for far-field sensing as well as of an additively printed engine, and on the mitigation of carbon dioxide emissions in the atmosphere. Three other projects were approved by Allies in the fields of environmental and energy security, and will be launched at the beginning of 2022. Among them is the 'RESCUE' project, co-led by scientists from the United Kingdom, Morocco and Jordan. This project will develop improved early-warning systems for natural disasters, contributing to national and global efforts

Additively Manufactured Incessantly Printed Engine (APE)

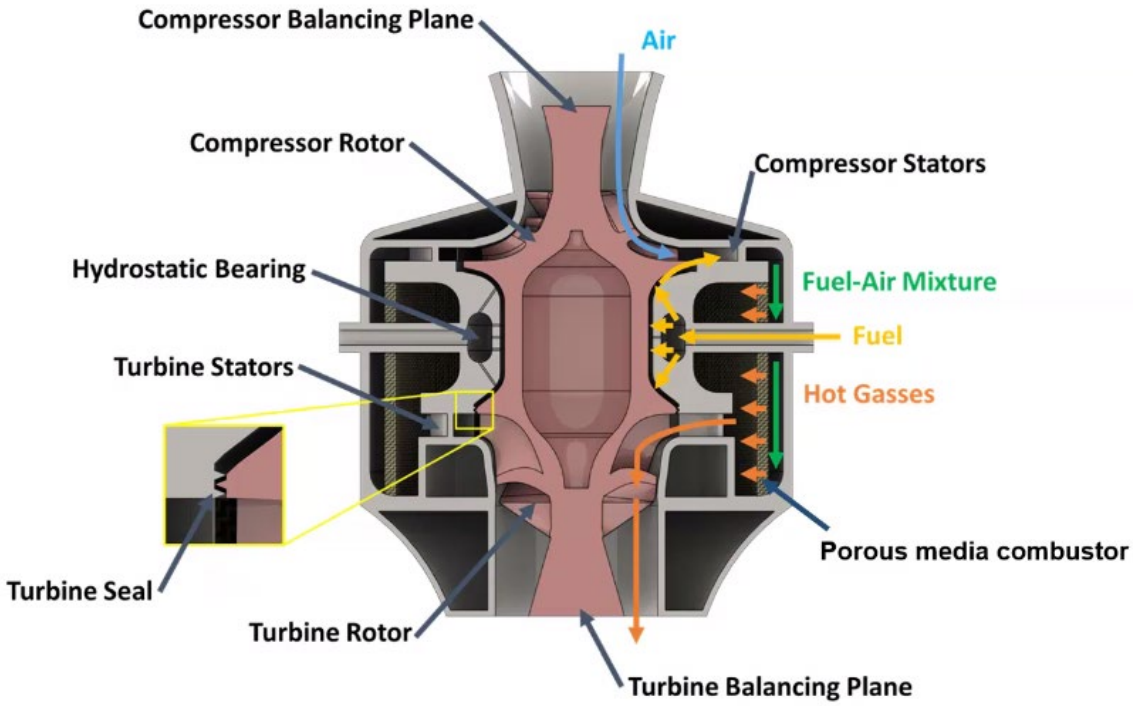


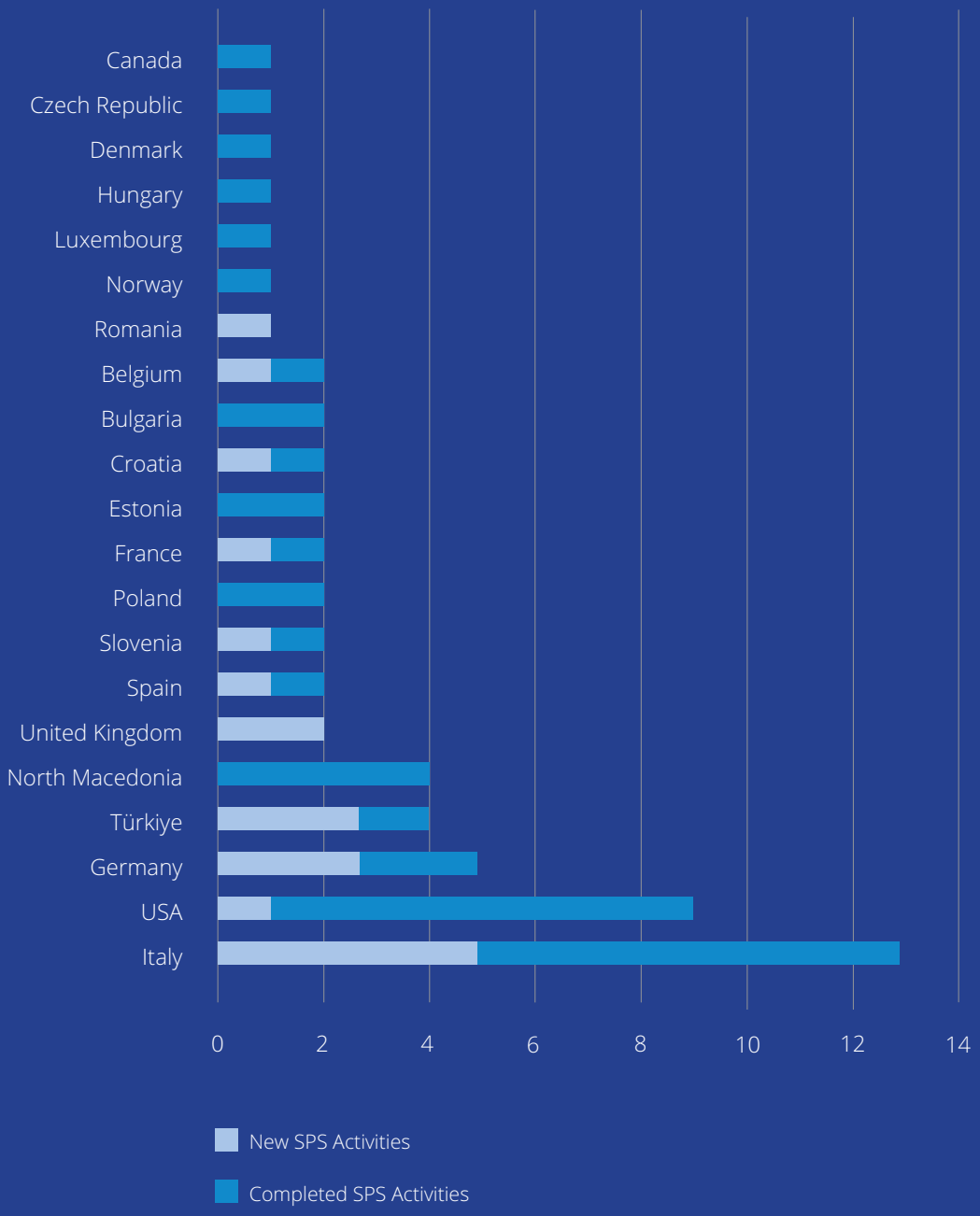
Figure 51 – Concept of the SPS MYP "Additively printed engine".

to mitigate the impact of natural disasters on human and environmental security. Furthermore, contributing to NATO's Action Plan on Climate Change and Security, the 'Cube4EnvSec' project, co-led by researchers from Israel and Germany, will demonstrate how datacubes can contribute to observing natural and human-made threats of any kind combining ground, space, and airborne (spatio-temporal) sources in real-time. Finally, in the framework of the 'ESCAPE' project, Israeli and Italian researchers aim to develop an innovative solar cell platform, based on the latest nanotechnologies, which could be useful for military personnel during operations. Moreover, a 'top-down' proposal put forward by French and Algerian experts in the field of counter-terrorism was approved by Allies in late 2021. It follows a previous 'top-down' flagship SPS project, completed in May 2021, that equipped the Ecole Militaire Polytechnique (EMP) in Algeria with a THz laboratory capable of inspecting people and luggage. This newly approved initiative will extend the laboratory and develop complementary facilities in the co-directors establishments to enhance the selectivity and sensitivity of the system, increase the stand-off distance to which the system can be operated, and improve the quality of the THz information.

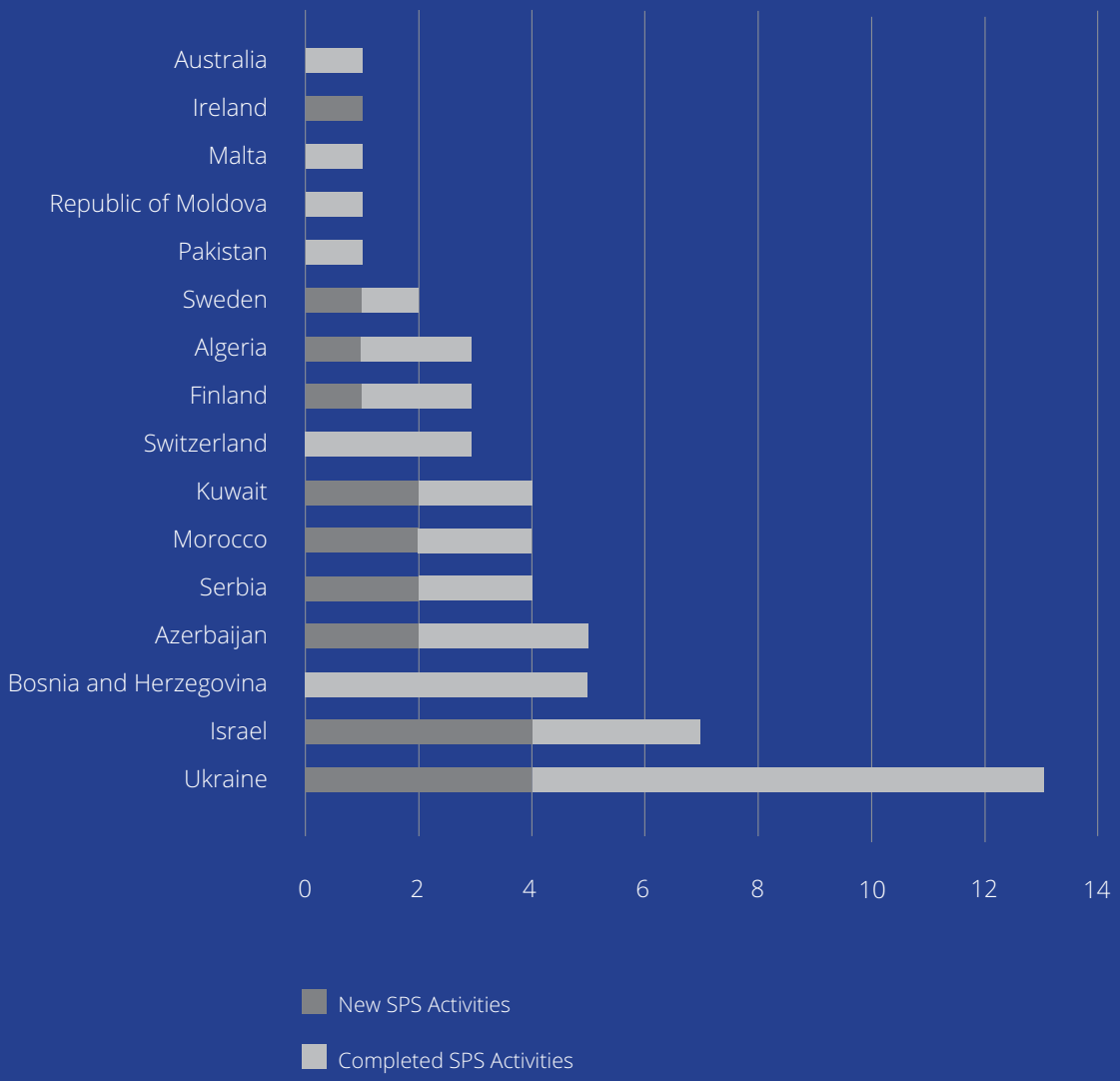
Additionally, six other projects were successfully completed in 2021. A project co-led by Israeli scientists responded to security concerns linked to emerging and disruptive technologies by demonstrating the feasibility and specifications of a long-range Quantum Key Distribution link for secure long-distance communication and protected cyber-space. A 'top-down' initiative, conducted by experts from Morocco, Spain, Jordan and the UK, analysed key variables likely to affect NATO's Southern neighbourhood in the coming decade, which corresponds to the horizon of the "NATO 2030" work. It outlined sources of change in NATO's South to better understand their potential political and security implications and to provide strategic foresight scenarios for decision-makers in NATO, Allied and partner countries. Another 'top-down' hybrid Event, co-directed by experts from Poland and Algeria, focused on the topic of critical infrastructure protection, with a particular emphasis on energy, oil, and gas infrastructures. Moreover, a workshop held in March 2021 in a hybrid format by Moroccan and Italian experts, investigated the multiple transformations occurring within the energy market and energy security fields, with a particular focus on the Mediterranean.

Engaging with partners within the **Istanbul Cooperation Initiative (ICI)** framework through the NATO-ICI Regional Center (NIRC) in Kuwait, SPS supported two-tailored Advanced Training Courses (ATC) in the fields of cyber defence and critical energy infrastructure protection. The courses built on the success of previous ATCs delivered at the Centre since 2017, and online since the start of the pandemic. These two new courses contributed to complementing the educational offer provided by other NATO entities at the Centre, and gathered a total of 48 participants from ICI and GCC countries in total. A week-long course in critical energy infrastructure protection helped to enhance operational resilience in the energy domain against malicious cyber and terrorist attacks or natural disasters. In the field of cyber defence, the 10-week ATC delivered this year provided much more advanced and comprehensive expertise in the field of network security compared to previous years, and enabled participants to enhance the protection of IT networks in their own countries, identify potential vulnerabilities, and use specialized tools to mitigate them.

Approved and Completed SPS Activities by Lead NATO Ally



Approved and Completed SPS Activities by Lead Partner Nation



* All of the approved and completed activities involving Kuwait were implemented in cooperation with the NATO-ICI Regional Centre in Kuwait.

Over the last year, cooperation with **Western European partners** in the framework of the SPS Programme has been considerably boosted with the kick-off of 9 new activities. These are mainly Multi-Year Projects and Advanced Research Workshops covering a wide range of security-related areas. Notably, in view of supporting NATO's response to the COVID-19 pandemic, Austrian and Italian scientists have launched in June 2021 the 'SARS 3M' project, which is developing an innovative detection tool for the SARS-CoV-2 virus and other toxic bio-agents in workplaces. Moreover, in the framework of the new 'Enzil' project, researchers in Finland have started to develop an integrated system for decontamination and destruction of Chemical Warfare Agents (CWA) from atmosphere and surfaces. Advanced Technology remained one of the most prominent areas of cooperation with Western European partners in 2021. Whereas Austrian experts are developing a sensor technology for environmentally relevant gases and aerosols to assess air quality and detect CBRN agents, Swiss researchers are exploring novel quantum sensing technologies for CBRN threats. In addition, experts from Switzerland have been involved in the organization of the 'top-down' Advanced Research Workshop 'The Vulnerabilities of the Drone Age: Strategic Foresight Planning out to 2035', which took place during the second half of 2021. Co-led by the Center for War Studies University of Southern Denmark and the Center for Security Studies ETH Zürich from Switzerland, the event focused on the past, present, and future of drone technologies. Moreover, building on a previous SPS project, the new 'CANDO 2' project, co-led by Finnish scientists, is developing an indoor-outdoor collaborative navigation system for blue tracking and human-machine teaming in urban environment in real life.

Figure 52 - Device used in the context of the SPS MYP "HADES: Hazards Detection with Quantum Sensors" for on-the-spot detection and identification of biological agents, where an attack is suspected to have occurred.

Tangible deliverables resulting from the SPS activities with Western European Partners have been attained through the completion of a number of Multi-Year Projects. For example, the project 'Intelligent and Resilient Cyber Defense in Supply Chains and Logistics', implemented by experts from Finland in response to a Special Call for Proposals on Cyber Defence, developed an efficient cyber defence for intelligent systems, such as modern automated supply chains, military supply chains as well as logistics systems of 4th generation. As part of the MYP 'Large Scale Collaborative Detection and Location of Threats in the Electromagnetic Space', Swiss researchers have contributed to creating a secure system to identify intruders and attackers in the electromagnetic space. Finally, a social science project, co-led by researchers in Sweden and the US, engaged with practitioners and policy makers to improve the effectiveness, transparency and accountability of countering violent extremism (CVE) programmes at the local level.

SPS outreach and cooperation with **Partners across the Globe (PaG)** was particularly successful in 2021. In this vein, two new Multi-Year Projects, co-led by Australia and Colombia in partnership with Italy, were launched in the field of Advanced Technology. In the framework of the 'OPTIMIST' project, scientists from the Australian National University are committed to design and realize a novel class of self-activating optical limiting and switching devices. As such, the project expects to set the scientific foundations of low-power optical limiters in laser eye/sensor protection. Moreover, the 'CLARIFIER' project, involving researchers from the Universidad Pedagógica y Tecnológica de Colombia, aims to develop an integrated transceiver combing a radar and a LiDAR sensor sharing the same photonic core. The combined operation of the two sensors will allow the reduction of power consumption, providing a promising solution for unmanned vehicles navigation and surveillance applications.

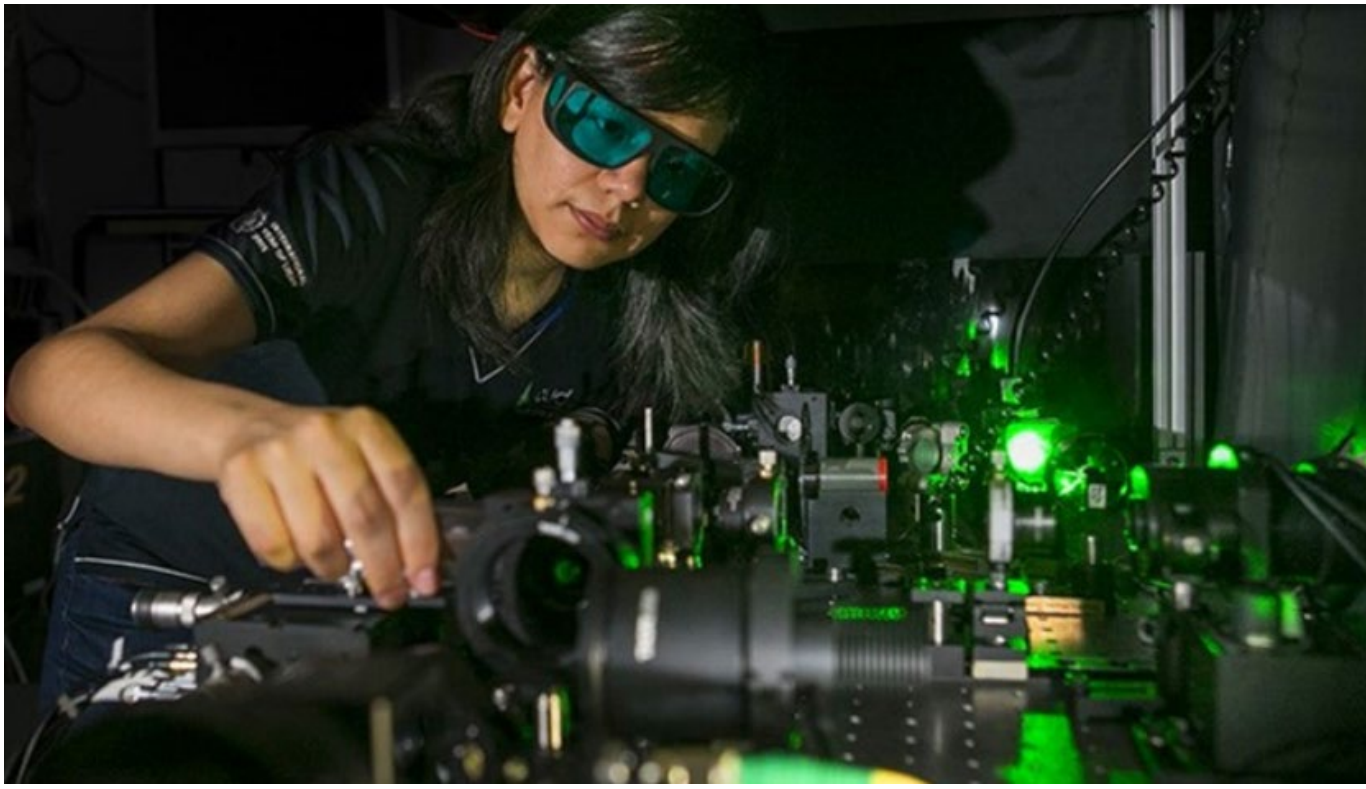


Figure 53 – Scientist from Research School of Physics, The Australian National University, Canberra working in the SPS MYP 'OPTIcal liMIting and SwiTching with nanoscale photonic structures (OPTIMIST)'.

In addition to the newly launched activities, two Multi-Year Projects involving experts from Australia and Pakistan were successfully concluded during the year. Launched in 2017 by Australian and Italian scientists, the 'High Altitude Balloon-Borne Radar' project developed and delivered a prototype of a Synthetic Aperture Radar system carried by a High Altitude Platform and Balloon. The project's main output consists of a miniaturized radar system mounted on a novel platform employing high-altitude balloons. Moreover, with the completion of the MYP 'Public Safety COmmUNication in ConTExt Related to Terror Attacks (Counter-Terror)', experts from Pakistan designed and developed technologies for the transmission of information from devices, such as smartphones, during crisis management and disaster recovery operations. The ingenuity of this first SPS project with Pakistan lies in the employment of machine learning techniques to extract valuable information and to ensure optimal resource and throughput management.

The SPS Programme continued to reach out to other **NATO bodies, agencies and international organizations** in order to exploit synergies, forge networks and avoid duplications.

Within NATO, SPS has regularly interacted with the Public Diplomacy Division, the Political Affairs and Security Policy Division, the Operations Division, and the Office of the NATO Secretary General's Special Representative on Women, Peace and Security with the aim of ensuring proper coordination, coherence and effective implementation of new SPS activities. The Programme remained engaged in regular programmatic coordination with the Science and Technology Organization (STO) and the Office of the Chief Scientist via the active participation of two STO representatives in the ISEG.

Beyond the headquarters, the SPS Programme kept working with NATO agencies such as the NATO Support and Procurement Agency (NSPA) and the NATO Communications and Information Agency (NCIA) as well as with the NATO School Oberammergau in Germany to implement high-quality SPS projects. Particularly relevant for 2021 is the cooperation with the NCI Agency, which was marked by the completion of the SPS flagship Multi-Year Project that deployed a Next-Generation Incident Command System (NICS) in the Western Balkans. Remarkable was also the combined effort of the experts from the NATO School Oberammergau (NSO) and the Naval Postgraduate School (NPS) in Monterey in the implementation of two Advanced Training Courses at the NATO-ICI Regional Centre (NIRC) in Kuwait. One of these courses, which focused on Critical Energy Infrastructure Protection, also drew on the expertise of the NATO Energy Security Centre of Excellence (ENSEC CoE) in Vilnius.

In an effort to develop impactful flagship activities, the SPS Programme maintained close contacts with a range of external stakeholders through the Independent Scientific Evaluation Group, academies of sciences, national ministries as well as research institutions, think tanks and non-governmental organisations. For instance, the SPS workshop 'Energy Strategies 2020. Europe and the Mediterranean Security Trends towards a Connected Energy Market' provided experts from the NATO Defense College Foundation (NDCF - Italy) and the Policy Center for The New South (Morocco) with a platform to bring together around 400 specialists from international organizations, think tanks, and major companies from the energy sector. Their discussions investigated the multiple transformations occurring within the energy market and energy security fields, with a particular focus on the Mediterranean.

The SPS Programme is actively contributing to the NATO-wide cooperation efforts with other ***international organizations*** like the European Union (EU), the United Nations (UN), the Organization for Security and Cooperation in Europe (OSCE), and the African Union (AU). In 2021, interaction with the ***European Union*** took place especially in the form of active participation of EU officials and experts in various SPS activities focusing on the topics of drones and quantum technologies, and climate and security. Moreover, SPS continued to be involved in thematic and country-specific EU-NATO staff-to-staff talks, which paid particular attention to cyber defence as well as to the EU-NATO cooperation on six countries: Bosnia and Herzegovina, Georgia, Jordan, the Republic of Moldova, Tunisia, and Ukraine. The Programme also engaged closely with the OSCE, particularly in the framework of the SPS workshop 'Innovative Technologies and Renewed Policies for a Greener Defence', which provided a platform for professional experts to address key aspects related to shaping a more sustainable defence sector and elaborating on the way forward. Equally important, SPS has maintained a close contact with the ***African Union*** in view of exploring and preparing the grounds for a potential SPS counter-terrorism training course to be delivered to civilian-military experts from the African Centre for Study and Research on Terrorism, representatives of the AU Counter-Terrorism (CT) architecture, and AU member states CT experts.

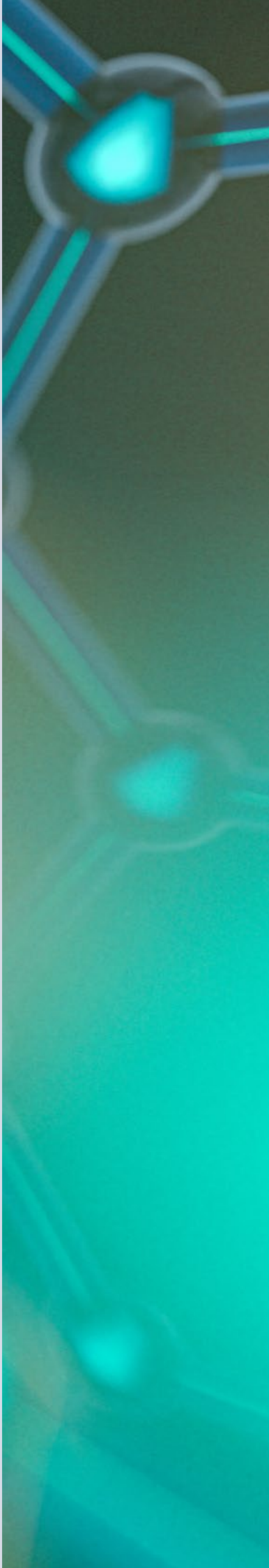
CONCLUSION

This year, the NATO SPS Programme continued to provide experts from NATO and partner nations with opportunities to work together to address emerging security challenges through science and technology. The efforts supported by the Programme shone a light yet again on the tangible benefits of practical scientific cooperation, while showing the Programme's ability to adapt to the evolving priorities of the Alliance.

In 2021, the NATO Brussels Summit and NATO 2030 agenda provided new direction to the Alliance and its relations with partners, and highlighted policy areas of growing interest for NATO. Topics like innovation and Emerging and Disruptive Technologies (EDTs), the impact of climate change on security, and resilience already are, and will be even more part of NATO's outlook moving forward. The SPS Programme has followed these developments and continued to seek ways to support scientific innovation in relevant fields, in line with its key priorities.

SPS activities implemented in 2021 clearly showed the convergence of the Programme's initiatives with Allied priorities. For instance, in the fields of technology and innovation, SPS explored Emerging and Disruptive Technologies (EDTs) such as quantum technologies, autonomy, Artificial Intelligence, bio-engineering and human enhancement, bolstering NATO's efforts to maintain its technological edge. Delivering on Allied commitments in the fight against terrorism, SPS supported the advancement of the DEXTER Programme, which aims to protect mass transit and gathering venues from terrorist threats. Moreover, as the coronavirus continued to affect the daily lives of billions, SPS enabled scientists to be part of NATO's response to the pandemic.

Looking to the future, as NATO continues to work to make sure the Alliance is ready to face tomorrow's challenges, the SPS Programme will endeavour to support its key work strands through civil science, technology, innovation, and capacity building. In line with its 2022 Work Programme, it will maintain and encourage new connections between scientists and experts in NATO and its partner countries, enabling them to cooperate on security-related civil science. Finally, it will highlight the public diplomacy value of its activities, and give visibility to their tangible impact as well as their relevance to the future of the Alliance.



List of Abbreviations

ACSRT	African Centre for the Study and Research on Terrorism
AP4	Asia-Pacific partners (Australia, Japan, Republic of Korea, New Zealand)
ARW	Advanced Research Workshop
ASI	Advanced Studies Institute
ATC	Advanced Training Course
CBRN	Chemical, Biological, Radiological, and Nuclear
C-IED	Counter-Improvised Explosive Devices
CIRC	Cyber Incident Response Capability
CoE	Centre of Excellence
CT	Counter-Terrorism
CVE	Countering Violent Extremism
DCB	Defence Capacity Building
DEXTER	Detection of EXplosives and firearms to counter TERrorism
DIMLAB	Deployable Biological and Chemical Analytical Laboratory
EADRCC	Euro-Atlantic Disaster Response Coordination Centre
EAPC	Euro-Atlantic Partnership Council
ESCD	Emerging Security Challenges Division
EU	European Union
ICI	Istanbul Cooperation Initiative
IO	International Organisation
IPAP	Individual Partnership Action Plan
IPCP	Individual Partnership Cooperation Programme
ISEG	Independent Scientific Evaluation Group
MD	Mediterranean Dialogue
MENA	Middle East and North Africa
MYP	Multi-Year Project
NAC	North Atlantic Council

NATO	North Atlantic Treaty Organisation
NCIA	NATO Communications and Information Agency
NICS	Next-Generation Incident Command System
NPS	Naval Postgraduate School
NSO	NATO School Oberammergau
NSPA	NATO Support and Procurement Agency
NUC	NATO-Ukraine Commission
OSCE	Organization for Security and Co-operation in Europe
PaG	Partners across the Globe
PCSC	Partnerships and Cooperative Security Committee
SEE	South-East Europe
SPS	Science for Peace and Security
STO	NATO Science and Technology Organisation
UAV	Unmanned Aerial Vehicles
UAS	Unmanned Aircraft Systems
UN	United Nations
USA	United States of America
UNSCR	United Nations Security Council Resolution
UXO	Unexploded Ordnance
WPS	Women, Peace and Security

Annex 1: New SPS Activities approved by PCSC in 2021

Key Priority	SPS reference	Top-Down	Grant Mechanisms	Title	NATO Country	Partner Country	Other Countries	Partnership Framework
CT (1a)	G5969	X	MYP	DEXTER Big City Trial	ITA	FIN	FRA, NLD, SRB, UKR, DEU, KOR	EAPC
CT (1a)	G5973		MYP	Implementation of a terahertz systems dedicated to identification of illicit substances	FRA	DZA	SWE	MD
ES (2a)	G5907		MYP	Prevention of Geo-threats to Azerbaijan's Energy Independence	ITA	AZE	BEL, GEO CZE, UKR	EAPC
ES (2a)	G5910		MYP	High Energy Calcium-Oxygen Batteries	HRV	SRB	SWE	EAPC
ES (2a)	G5936		MYP	Ultra-light, wearablE Solar Cells As Portable Electricity source (ESCAPE)	ITA	ISR		MD
ES (2a)	G5949		MYP	Light-Weight 600 °C Solid Oxide Fuel Cells for Energy Security (LW-SOFC)	TUR	UKR	AZE	NUKR
ES (2a)	G5966	X	ATC	Critical Energy Infrastructure Protection and Resilience Course	DEU	KWT		ICI
CD (3a)	G5967	X	ATC	Advanced Cyber Defence Course on Network Security	DEU	KWT		ICI
CD (3a)	G5972	X	ATC	Intermediate and Advanced Course on Post-Quantum Cryptography	TUR	AZE		EAPC
CBRN (4a)	G5913		MYP	Enhanced Radiation Detection for Nuclear Security and Incident Response	UK	UKR		NUKR

Key Priority	SPS reference	Top-Down	Grant Mechanisms	Title	NATO Country	Partner Country	Other Countries	Partnership Framework
CBRN (4a)	G5937		MYP	Learning a lesson: fighting SARS-CoV-2 Infection and get ready for other future PandEmic scenaRios (VIPER)	ITA	SWE		EAPC
ENV (5a)	G5932		MYP	A HybRid WirEless Sensor Network for Early Warning and IdentifiCation of NatUral DisastErs (RESCUE)	UK	MAR	JOR	MD
ENV (5a)	G5970		MYP	Cube4Sec: Big Earth Datacube Analytics for Transnational Security and Environmental Protection	DEU	ISR	DNK	MD
ADV (3a)	G5860		MYP	Constructing novel non-classical states of electromagnetic field for far-field sensing	USA	ISR	UK, BLR	MD
ADV (3a)	G5879		ASI	Nanomaterials and Nanoarchitectures II. Composite Materials and their Applications	ROU	IRL		EAPC
ADV (3a)	G5912		MYP	Development of New Quaternary Crystals for Security Applications	TUR	UKR		NUKR
ADV (3a)	G5916		MYP	3D Printed Functional elements for Flexible Electronic Devices	ESP	UKR		NUKR
ADV (3a)	G5924		MYP	IRIS - Inspection and security by Robots interacting with Infrastructure digital twinS	ITA	MAR	SVK POL	MD
ADV (3a)	G5939		MYP	Additively Printed Engine (APE)	BEL	ISR	TUR	MD
ADV (3a)	G5953		MYP	Advanced UAV Based GPR Imaging Techniques for Explosive Detection	SVN	SRB	NMA	EAPC

Annex 2: SPS Events (ARW, ATC, ASI) hosted in 2021

SPS Ref.	Top-Down	Grant mechanism	Title	NATO Country	Partner Country	Location	Dates	Format
G5718	X	ATC	Critical Energy Infrastructure Protection: Innovative Structures and Materials for Blast and Ballistic Protection	POL	DZA	Algiers, Algeria	22-25 March 2021	Online/ On-site
G5831		ARW	Energy Strategies 2020. Europe and the Mediterranean: Security Trends towards a Connected Energy Market	ITA	MAR	Rome, Italy	24-25 March 2021	Online/ On-site
G5924		ATC	Gender Mainstreaming in Counter Terrorism Efforts in Western Balkans	NMA	BIH	Ohrid, North Macedonia	16-21 May 2021	Online/ On-site
G5667		ARW	Integration of the Western Balkans in NATO as a Guarantee for Regional Stability	BGR	SRB	Sofia, Bulgaria Skopje, North Macedonia	18-19 May 2021	Online/ On-site
G5811		ARW	Resilience Research Workshop in North-East Ukraine	EST	UKR	Sumy, Ukraine	19-21 May 2021	Online/ On-site
G5813	X	ATC	Advanced Cyber Defense Training Courses for Azerbaijan	TUR	AZE	Baku, Azerbaijan	31 May - 25 June 2021	Online/ On-site
G5754	X	ARW	The Vulnerabilities of the Drone Age: Strategic Foresight Planning out to 2035	DNK	SWI	Zürich, Switzerland	15 June - 1 December 2021	Online
G5759	X	ARW	Security-related Advanced Technologies in Critcal Infrastructure Protection	HUN	SRB	Budapest, Hungary	24-25 August 2021	Online/ On-site

SPS Ref.	Top-Down	Grant mechanism	Title	NATO Country	Partner Country	Location	Dates	Format
G5818		ATC	Strengthening SEE Resilient Cyber Defense against Hybrid Threats (STRENGTH)	NMA	BIH	Ohrid, North Macedonia	26 September - 2 October 2021	Online/ On-site
G5967	X	ATC	Advanced Cyber Defence Course on Network Security	DEU	KWT		3 October - 9 December 2021	Online
G5966	X	ATC	Critical Energy Infrastructure Protection and Resilience Course	DEU	KWT		10-14 October 2021	Online
G5802		ARW	Practical Applicatons of Advanced Technologies for Enhanding Security and Defence Capabilities: Perspectives and Challenges for Western Balkans	NMA	BIH	Ohrid, North Macedonia	14-17 October 2021	Online/ On-site
G5819		ARW	Innovative Technologies and Renewed Policies for achieving a Greener Defence	ITA	FIN	Rome, Italy	27-28 October 2021	Online/ On-site
G5744		ARW	Cybersecurity of Industrial Control Systems	POL	AZE	Baku, Azerbaijan	27-29 October 2021	Online/ On-site
G5903	X	ARW	A Gendered Lens Approach to Military to Civilian Transition and Reintegration for Ukraine Joint Forces Operations (JFO) Women Combatants	CAN	UKR	Kyiv, Ukraine	4 November 2021	Online
G5756		ARW	Toward a Quantum-safe Communication Infrastructure	USA	MLT	Valletta, Malta	14-18 November 2021	On-site
G5862		ARW	Fighting Disinformation in a Pandemic World: the Role of AI and Cognitive Sciences	ITA	UKR	Rome, Italy	16-17 November 2021	Online/ On-site

Annex 3: SPS Multi-Year Projects (MYP) completed in 2021

SPS Ref.	Top-Down	NATO Country	Partner Country	Other Countries	Title	Key Priority Area
G4687		CZE	UKR	USA SVK KAZ	New Phytotechnology for Cleaning Contaminated Military Sites	1e Environmental Security
G4898	X	LUX	MDA		Developing Capability to Mitigate the Risk of Biological Agents in Moldova	1d CBRN Defence
G4968	X	USA	BiH	HRV FYR MNE	Advanced Regional Civil Emergency Coordination Pilot	1a Counter-Terrorism
G5233		NOR	UKR		Portable Energy Supply	1b Energy Security
G5263		USA	ISR	ITA PAK	Analysis, Design and Implementation of an End-to-End 400km QKD Link	1c Cyber Defence
G5267		ITA	SWI		Maritime Security - Multistatic and Multiband Coherent Radar Fleet for Border Security (SOLE)	3a Advanced Technology
G5291		USA	UKR	BEL FRA EST ITA	A Novel Method for the Detection of Biohazards	1d CBRN Defence
G5322		ITA	AUS		High Altitude Balloon-Borne Radar	3a Advanced Technology

SPS Ref.	Top-Down	NATO Country	Partner Country	Other Countries	Title	Key Priority Area
G5330		USA	UKR	UK	Functional Textiles for Uniforms	1b Energy Security
G5351		ITA	UKR	DEU	Nanocomposites Based Photonic Crystal Sensors of Biological and Chemical Agents	3a Advanced Technology
G5355		HRV	BIH	UK	Biological Method (Bees) for Explosive Detection	3c UXO
G5373		USA	UKR		Upgrade and Improvements of the hand-held gamma Detector based on HPXe Gas	3a Advanced Technology
G5396	X	FRA	DZA	SWE	Implementation of a Terahertz Imaging and Detection System	3a Advanced Technology
G5423		ITA	AZE		Portable Sensors for Unmanned Explosive Detection	1a Counter-Terrorism
G5428		ITA	ISR		Dynamic Architecture based on UAVs Monitoring for Border Security and Safety	3a Advanced Technology
G5453		USA	ISR		Radiation Hard UV Detectors against Terrorist Threats	3a Advanced Technology
G5461		ESP	SWI	BEL	Large Scale Collaborative Detection and Location of Threats in the Electromagnetic Space	3a Advanced Technology
G5482		EST	PAK		Public Safety COmmUNication in ConTExt Related to Terror Attacks (Counter-Terror)	3a Advanced Technology

SPS Ref.	Top-Down	NATO Country	Partner Country	Other Countries	Title	Key Priority Area
G5511		BGR	FIN	FRA UKR	Intelligent and Resilient Cyber Defense in Supply Chains and Logistics	1c Cyber Defence
G5550		SVN	NMA		Gas Sensors for Preventing Terrorist Attacks	1a Counter-Terrorism
G5556	X	USA	SWE		Evaluation Support for Countering Violent Extremism at the Local Level	1a Counter-Terrorism
G5570	X	BEL	MAR	ESP JOR UK	Responding to Emerging Security Challenges in NATO'S Southern Neighbourhood	3d Human and Social Aspects of Security

Annex 4: NATO Science Series Publications in 2021

SPS reference	Title	Editors	Series	Publisher	Volume
G5613	Modern Technologies Enabling Safe and Secure UAV Operation in Urban Airspace	**Sniatala**	D: Information and Communication Security	**IOS Press**	59
G5473	From Territorial Defeat to Global ISIS: Lessons Learned	**Goldstone**	E: Human and Societal Dynamics	**IOS Press**	151
G5610	Terrorism Risk Assessment Instruments	**Corrado**	E: Human and Societal Dynamics	**IOS Press**	152
G5730	The Safety and Security of Cultural Heritage in Zones of War or Instability	**Romiti**	E: Human and Societal Dynamics	**IOS Press**	153
G5824	Gender Mainstreaming in Counter-terrorism Efforts in the Western Balkans	**Hadji Janev**	E: Human and Societal Dynamics	**IOS Press**	154
G5255	Biomarkers of Radiation in the Environment	**M. Wood et al**	A: Chemistry and Biology	**Springer Netherlands**	
G5493	Terahertz (THz), Mid Infrared (MIR) and Near Infrared (NIR) Technologies for Protection of Critical Infrastructures Against Explosives and CBRN	**M. Pereira, A. Apostolakis**	B: Physics and Biophysics	**Springer Netherlands**	
G5489	Emerging Threats of Synthetic Biology and Biotechnology	**B.D. Trump et al**	C: Environmental Security	**Springer Netherlands**	

Annex 5: SPS Grant Mechanisms

The SPS Programme provides funding and expert advice for security-related activities in the forms of Multi-Year Projects (MYP), Advanced Research Workshops (ARW), Advanced Training Courses (ATC), and Advanced Study Institutes (ASI) involving at least one expert from a NATO Ally and one expert from a NATO partner nation, and addressing at least one SPS key priority.

Multi-Year Project (MYP)

MYPs are research and development projects related to NATO's Strategic Objectives and aligned with the SPS key priorities. Projects involving more than one partner nation are encouraged, as is the participation of young scientists. The projects aid scientists from partner nations in growing their networks within the NATO scientific community, while contributing to a strong scientific infrastructure in their home country. These projects have an average duration of two to three years.

Advanced Training Course (ATC)

Through ATCs, specialists share their security-related expertise in one of the SPS key priority areas with participants from NATO and partner countries. An ATC is not intended to be lecture-driven, but interactive. The course contributes to the training of experts in partner nations and enables the formation and strengthening of international expert networks. The tailor-made modular courses respond to the needs of partner nations. Trainees are chosen on the basis of their qualifications and experience, and the benefits they may draw from the ATC in their future activities. ATCs typically take place over five to seven working days.

Advanced Study Institute (ASI)

ASIs are high-level tutorial courses on the latest developments in SPS key priority areas for advanced-level audiences. An ASI lasts roughly seven working days. Lecturers of international standing report on new advances in different aspects of security-related civil science to pre and post-doctoral level scientists with relevant backgrounds in the subject. Young scientists from NATO partner nations are especially encouraged to participate.

Advanced Research Workshop (ARW)

ARWs are dedicated expert workshops, providing open platforms for experts and scientists to share their experience and knowledge in order to promote spin-off SPS activities such as MYPs. ARWs typically take place over two to five days and gather 20-50 participants. Workshops are preferably held in the participating partner nation.

Annex 6: SPS Key Priorities

All activities funded by the SPS Programme must address at least one of the SPS key priorities and have a clear link to security. The SPS key priorities are based on NATO's Strategic Concept agreed by Allies at the Lisbon Summit in November 2010, and the strategic objectives of NATO's partner relations agreed in Berlin in April 2011. The current SPS key priorities are:

01 Facilitate mutually beneficial cooperation on issues of common interest, including international efforts to meet emerging security challenges

a Counter-Terrorism

- Methods for the protection of critical infrastructure, supplies and personnel;
- Human factors in the defence against terrorism;
- Detection technologies against the terrorist threat for explosive devices and other illicit activities;
- Risk management, best practices and technologies in response to terrorism.

b Energy Security

- Innovative energy solutions for the military; battlefield energy solutions; renewable energy solutions with military applications;
- Energy infrastructure security;
- Maritime aspects of energy security;
- Technological aspects of energy security.

c Cyber Defence

- Critical infrastructure protection, including sharing of best practices, capacity building and policies;
- Support in developing cyber defence capabilities, including new technologies and support to the construction of information technology infrastructure;
- Cyber defence situational awareness.

d Defence Against CBRN Agents

- Methods and technology regarding the protection against, diagnosing effects, detection, decontamination, destruction, disposal and containament of CBRN agents;
- Risk management and recovery strategies and technologies;
- Medical countermeasures.

e Environmental Security

- Security issues arising from key environmental and resource constraints, including health risks, climate change, water scarcity and increasing energy needs, which have the potential to significantly affect NATO's planning and operations;
- Disaster forecast and prevention of natural catastrophes;
- Defence-related environmental issues.

02 Enhance support for nato-led operations and missions

- Provision of civilian support through SPS key priorities;
- Provision of access to information through internet connectivity as in the SILK-Afghanistan Programme;
- Cultural and social aspects in military operations and missions;
- Enhancing cooperation with other international actors.

03 Enhance awareness on security developments including through early warning, with a view to preventing crises

a Security-related Advanced Technology

Emerging technologies including nanotechnology, optical technology, micro satellites, metallurgy and the development of UAV platforms.

b Border and Port Security

- Border and port security technology;
- Cross border communication systems and data fusion;
- Expert advice and assessments of border security needs and best practice.

c Mine and Unexploded Ordnance (UXO) Detection and Clearance

- Development and provision of advanced technologies, methodologies and best practice;
- Solutions to counter improvised explosive devices (IED).

d Human and Social Aspects of Security Related to NATO's Strategic Objectives

04 Any project clearly linked to a threat to security not otherwise defined in these priorities may also be considered for funding under the SPS Programme. Such proposals will be examined for links to NATO's strategic objectives

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