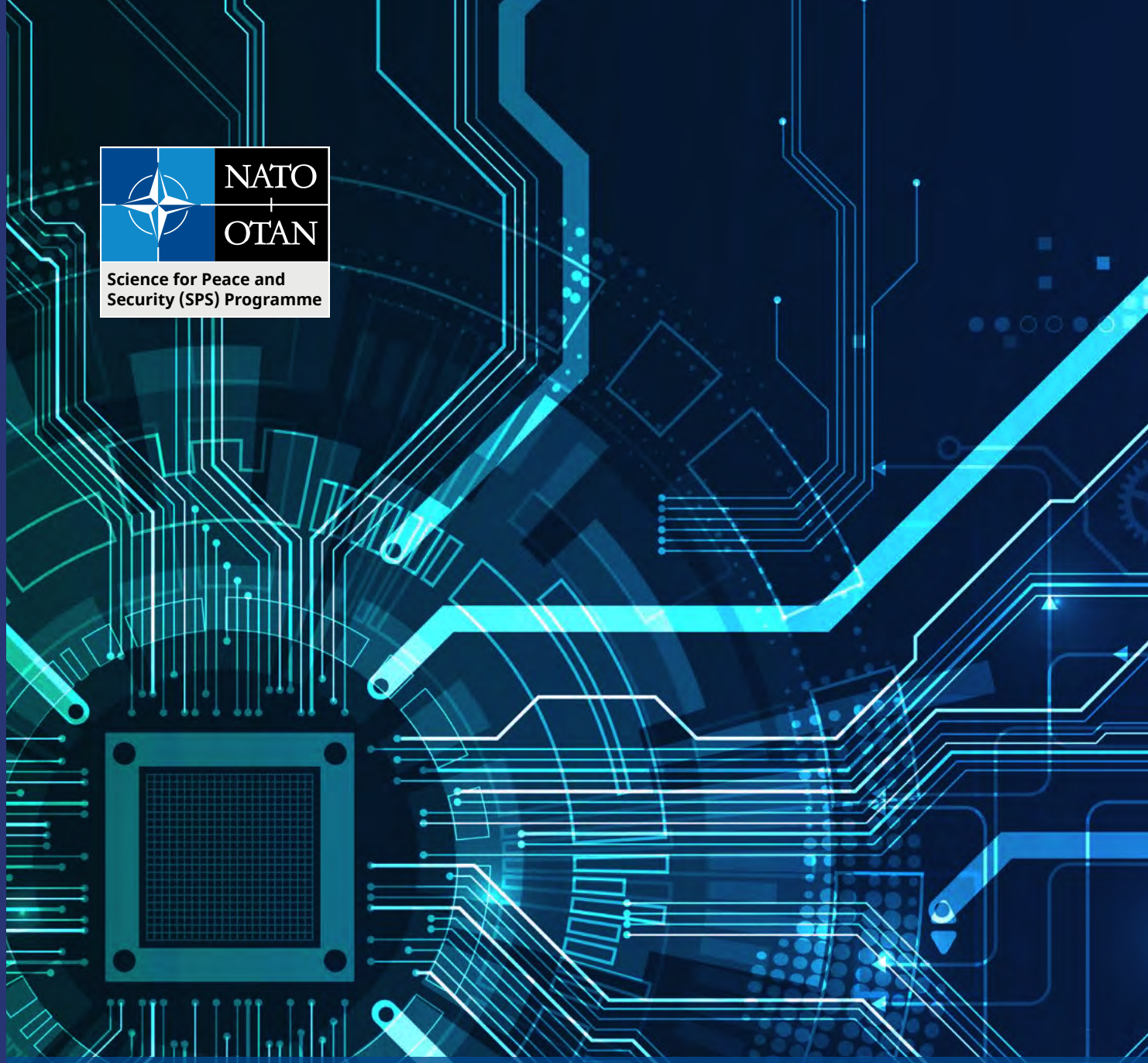

NATO OTAN

Science for Peace and Security (SPS) Programme

ANNUAL REPORT 2023

THE NATO SCIENCE FOR PEACE AND SECURITY SPS PROGRAMME

The SPS Programme provides funding and expert advice for security-related activities in the form of Multi-Year Projects (MYP), Advanced Research Workshops (ARW), Advanced Training Courses (ATC), and Advanced Study Institutes (ASI). Each SPS-supported activity must involve at least one expert from a NATO Ally and one expert from an eligible NATO partner nation, and address at least one of the SPS Key Priorities.

Foreword

In 2023, Russia's brutal invasion of Ukraine extended into a second year, and the intensification of tensions and conflicts around the world exacerbated the fragility and instability of the global security landscape. However, 2023 was also a year in which NATO became stronger, with Finland becoming the 31st member of our Alliance. Finland has substantial and highly capable forces, expertise in national resilience, years of experience working side by side with NATO Allies, and will dramatically increase NATO's capabilities in the Baltic Sea region and in the Arctic. Moreover, many Allies have stepped up investment in high-end capabilities as well as the readiness of their forces. In 2023, 18 Allies spent at least 2% of their GDP on defence—up from three Allies in 2014—while the Alliance as a whole contributed billions of dollars to Ukraine's efforts to counter Russia's invasion.

Russian aggression in Ukraine continues to be a stark reminder of the critical importance of solidarity and cooperation in times of crisis, and the Science for Peace and Security (SPS) Programme, in NATO's Innovation, Hybrid and Cyber Division, has shown over the past six decades what can be accomplished through initiating and nurturing scientific partnerships. SPS supports an expanding range of activities that foster practical cooperation between Allies and partner nations on security-related science and innovation. It also creates opportunities for research and knowledge exchanges, aiming to identify solutions to emerging security challenges. Throughout 2023, the Science for Peace and Security Programme supported the implementation of almost 100 multi-year research and development projects and received nearly 250 proposals for new activities. These cooperative initiatives are building lasting and valuable networks within the international scientific community and making key contributions to Allied priorities, such as increasing support to our Ukrainian partners, exploring the potential of emerging and disruptive technologies—particularly in the realm of quantum technologies—and supporting NATO's commitment to its Climate and Security Agenda.

Since 2014, Ukraine has been the largest beneficiary of the SPS Programme, and cooperation with Ukraine has further intensified in the wake of Russia's full-scale invasion in February of 2022. In May 2023, the SPS Programme met with representatives of Ukraine's Ministry of Digital Transformation and their Ministry of Education and Science at the 17th meeting of the NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation, which oversees cooperation in the field of security-related science and technology. As a result, Ukraine and NATO are increasing collaboration on advanced technologies, as well as on energy security and digital resilience. Two remarkable projects in progress in 2023 were in line with these priorities. Scientists in Ukraine and France teamed up to create smart, wearable alarm badges, constructed of nanomaterials, which can detect toxic gases. And researchers in Ukraine and Estonia joined forces to create an innovative edge-computing concept for Unmanned Aircraft Vehicles (UAVs). The system will be composed of UAVs of varying size (from nano to tactical) and used for a range of monitoring, rescue, counter-terrorism, and police activities.

In addition to its support for Ukraine, the SPS Programme's continued work on innovation and Emerging and Disruptive Technologies (EDTs) was a primary focus in 2023. As worldwide investment in a number of key EDTs surged, SPS cooperation in the development of quantum technologies was particularly fruitful, with the Programme engaged with nearly 40 universities and research institutes in NATO allied and partner countries on 12 multi-year projects. For example, a project launched by researchers in Italy and Switzerland continued to develop novel quantum-sensing technologies for the detection of chemical, biological, radiological and nuclear (CBRN) threats such as the presence of undetected harmful gases, hydrocarbons, post-explosion residues and nuclear waste. And scientists in Czechia and Bosnia and Herzegovina demonstrated practical applications of Quantum Key Distribution in 5G networks, developing simulation tools and practical guidelines for further inclusion of quantum technologies in 5G networks and beyond.

I would also like to highlight SPS contributions to environmental and energy security. Preparing for the global shift away from fossil fuels to renewable sources of energy is a priority for NATO, and the SPS Programme is supporting a number of projects that aim to smooth this energy transition. A project bringing together experts from Italian, Moroccan and Belgian research institutes is developing novel and sustainable technologies for using carbon emissions in the atmosphere as a building block to produce a wide variety of chemicals and fuels. The result will be the mitigation of the impact of greenhouse gases on climate change, while turning pollutants into a feedstock. Another energy-focused project developed at universities in Belgium and Ukraine combines support for energy transition with support for Ukraine by developing mobile energy sources that can provide high power levels to lightweight, wearable, life-saving devices.

The Science for Peace and Security Programme is proof that together—through building connections —we can strengthen our Alliance and our partnerships in the face of rapidly evolving security challenges. While 2023 reminded us that we live in an uncertain world and that we must prepare for whatever happens to be over the horizon, it also made clear that we are stronger together. Certainly, Finland and Sweden believe this to be true; and surely, Ukraine's determined defence against the Russian invasion has demonstrated that NATO's relationships with its partners are both mutually beneficial and fundamental to meeting the challenges of tomorrow. This report explores the activities of the Science for Peace and Security Programme in 2023 and makes a solid case for the increasing importance of strengthening ties across a wide range of disciplines between NATO Allies and partner nations.

David van Weel

Assistant Secretary General for Innovation, Hybrid and Cyber

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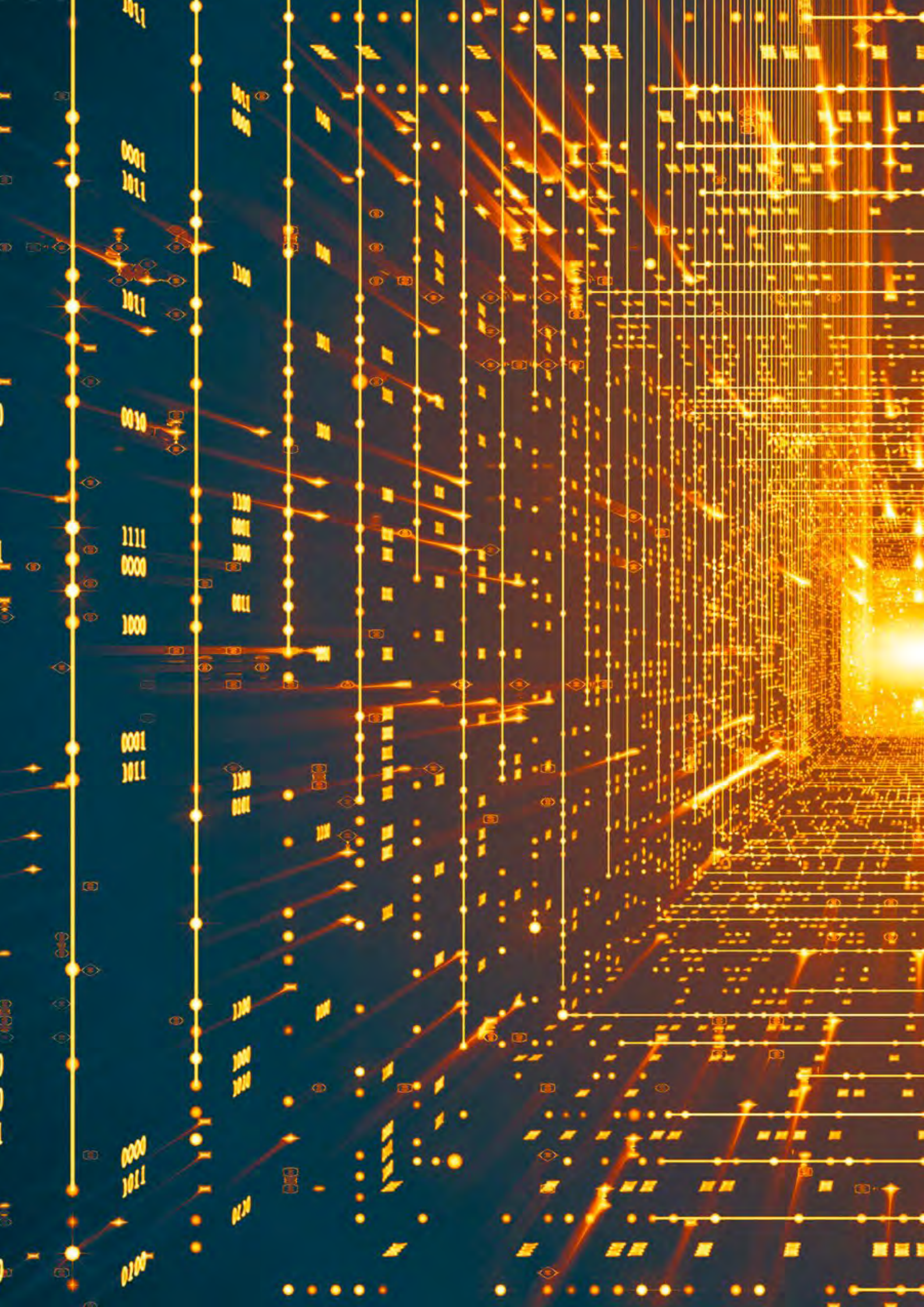


SPS Milestones in 2023

January

SPS Information Day in Bosnia and Herzegovina

Experts from SPS met with representatives of the scientific community of Bosnia and Herzegovina. Officials and researchers from leading universities across the country gathered to discuss current collaborations as well as explore potential opportunities for scientific cooperation at the Parliamentary Assembly of Bosnia and Herzegovina in Sarajevo.

Launch of the project "Indo-Pacific Futures Platform" at NATO HQ

The "Indo-Pacific Futures Platform" Multi-Year Project was launched thanks to a collaboration between SPS and experts from universities and government ministries in Belgium, Australia, France and Japan. The project provides a forum for strategic analysis and dialogue between key stakeholders from the Euro-Atlantic area and NATO's partner countries in the Indo-Pacific.

February

International Day of Women and Girls in Science

On 11 February, the International Day of Women and Girls in Science, SPS published an article focusing on the stories of two SPS-supported scientists. Stephanie Foster led the technical team of the Massachusetts Institute of Technology (MIT) Lincoln Laboratory that adapted and deployed the Next-Generation Incident Command System to meet the crisis management needs of Bosnia and Herzegovina, Croatia, Montenegro and North Macedonia. And Professor Maribel González Vasco of Universidad Carlos III de Madrid was co-director of the SPS project "Secure Communication in the Quantum Era", which designed a tool enabling the exchange of information that is secure even from adversarial quantum computers.

Deadline of the 2023/1 Call for Proposals

The 2023/1 call for proposals closed on 17 February 2023. The SPS Programme received 122 proposals for Multi-Year Projects and Events.

Launch of the SPS Newsletter

SPS launched a newsletter with the goal of strengthening communications with those who are or have been involved in SPS activities, as well as those hoping to receive support from the Programme in the future. The newsletter is a window on the world of SPS, providing a look at its collaborations, partnerships and the work of affiliated experts. It also provides updates about SPS activities, upcoming deadlines and events.

March

ISEG Meeting in Brussels

The Independent Scientific Evaluation Group (ISEG) is a multi-disciplinary body including experts from across the Alliance, who evaluate through peer-review the scientific and technical merit of proposals received by SPS. On 28-29 March, members of the ISEG convened in Brussels to review and evaluate the proposals submitted in response to the 2023/1 Call for Proposals.

April

Launch of the SPS LinkedIn page

The SPS Programme launched its LinkedIn page in order to reach a broader segment of the scientific community. Connecting with SPS through LinkedIn is a great way to get regular updates about ongoing and upcoming scientific and technological cooperation between NATO Allies and partner nations.

Conclusion of the project "Resilient Civilians"

The "Resilient Civilians" project aimed to generate policy recommendations and best practices based on empirical evidence to address the gap between institutional preparation and awareness of civilian agency to counter hybrid warfare and asymmetric attacks. It focused on delivering a mechanism to complement the current NATO and EU focus on reinforcing institutions through a civilian-oriented perspective: the Civil-Military Multi-actor Security & Resilience Model, which prioritizes the role of civilians in crises and conflict scenarios. The project successfully concluded in April 2023 and presented its finding to nations in NATO HQ.

May

SPS Information Day in Georgia

With support from Georgia's Ministries of Foreign Affairs and of Education and Science, SPS brought together over fifty participants from public and not-for profit research institutions for an Information Day in Tbilisi. The event highlighted recent SPS activities, including research on resilience and the protection of infrastructure from geological hazards and underground explosions.

NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation and NATO-Ukraine High-Level Innovation Dialogue

On 25-26 May, officials and experts from NATO SPS and Ukraine met in Brussels to chart the way forward on their long-standing cooperation on science and technology. Within the framework of the NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation, Deputy Prime Minister of Ukraine Mykhailo Fedorov and NATO's Assistant Secretary General, David van Weel, launched a NATO-Ukraine High-Level Innovation Dialogue. This Dialogue aims to expand the existing NATO-Ukraine partnership, by exchanging views on the development of innovation ecosystems for both commercial and defence needs, and by sharing lessons learned from Ukraine as it continues to defend itself from Russia's war of aggression.

June

Deadline of the 2023/2 Call for Proposals

The second application round of 2023 closed on 16 June. 121 proposals with a strong focus on advanced technology, cyber defence, environmental security, CBRN defence and energy security were submitted to the SPS Programme in response to this call.

July

Conclusion of the project "2D Material-based Low-cost SENSor of aggressive substancEs (2DSENSE)"

This Multi-Year Project, which brought together researchers in Italy and Finland, successfully developed low-cost sensors for the real-time detection of toxic and warfare chemical substances, based on a novel use of electrical impedance spectroscopy. The sensors utilize nano-membranes composed of 2D graphene structures, which can be integrated into a customized printed circuit board and delivered in the payload of an Unmanned Aircraft System (UAS). They are designed to target two classes of substances: aggressive warfare agents like Sarin gas, and heavily toxic industrial pollutants, such as acetonitrile; and when mounted on unmanned systems, can prevent human exposure to toxic and warfare chemical substances caused by environmental disasters and/or terroristic attacks.

August

Demonstration of the project "Demining Robots"

A demonstration of the project "Demining Robots - Multi-Sensor Cooperative Robots for Shallow Buried Explosive Threat Detection" took place at Franklin & Marshall College in Pennsylvania, US. The project developed a safe landmine- and IED-detection system by using a team of cooperative robotic vehicles, each carrying specialized sensors. This novel approach allows for the collection of data covering a wide range of parameters and involves minimal risk to human life.

September

ISEG Meeting in Spain

On 12 September, the ISEG convened in Madrid to review and evaluate SPS proposals submitted in response to the 2023/2 Call for Proposals. During its second meeting in 2023, ISEG members discussed over 100 proposal focusing on a wide variety of security-related topics, including advanced technology, cyber defence, energy and environmental security, as well defence against chemical, biological, radiological and nuclear (CBRN) agents.

SPS Information Day in Spain

NATO experts and researchers from across Spain gathered in Madrid on 13 September to explore opportunities for scientific cooperation through the SPS Programme. The Information Day, which was organised in cooperation with Spain's Ministry of Foreign Affairs, European Union and Cooperation; the Ministry of Science and Innovation; and the Ministry of Defence, aimed to highlight the achievements of SPS projects in which Spain has participated and facilitate the launch of new research and development activities.

October

Advanced Research Workshop "Biotechnology and Human Enhancement: Present Research and Future Perspectives"

This SPS workshop brought experts, scientists, and early-stage researchers from NATO and partner countries together in Sabaudia, Italy, to discuss the latest advancements and future perspectives in biotechnology and human enhancement – one of the nine Emerging and Disruptive Technologies (EDTs) on which NATO is currently focusing. They outlined a roadmap for how innovative and breakthrough applications can address emerging challenges.

SPS Information Day in the Republic of Moldova

SPS representatives introduced the Programme to government officials, civil society and members of the local academic community in Chișinău. The event aimed to explore possibilities for research and development collaboration between scientists in the Republic of Moldova and in NATO Allied countries. Presenters also highlighted the country's cooperation in the framework of the SPS Programme, which includes more than 55 activities since 1995.

Advanced Research Workshop "Emerging and Disruptive Technologies in Defence: Lessons from Ukraine"

This SPS workshop, held in Mugla, Türkiye, provided a platform for a detailed assessment of EDTs and the military applications of Artificial Intelligence within the context of Russia`s war of aggression against Ukraine. Experts explored the use of these technologies—including UAS, smart phones in a digitized battlespace and the impact on situational awareness of digital open-source intelligence—by both Ukrainian and Russian forces and drew lessons in order to inform NATO's own strategic and technological development, and to help deepen understanding and cooperation among Allies and partners.

Advanced Research Workshop "Emerging and Disruptive Technologies to Enhance Disaster Resilience"

A wide range of experts came together in Adana, Türkiye, to discuss their cutting-edge research in the realm of detecting and monitoring large ground deformations resulting from natural hazards. The workshop provided a forum for exploring how EDTs can be used to better prepare for tectonic events and other hazards and to reduce their potential negative impacts. The workshop also focused on building networks and collaboration among experts in disparate disciplines such as earth science, remote sensing and Artificial Intelligence.

November

Launch of the SPS Grants Platform

In order to streamline the grant application and review processes, SPS launched its own grants platform. The platform allows applicants to explore all available grant opportunities offered by the SPS Programme and to manage and submit applications with increased ease and efficiency.

SPS Information Day in Japan

Co-hosted in Tokyo by NATO and the Japanese Ministries of Foreign Affairs and of Defence, the SPS Information Day provided a forum through which scientists and subject-matter experts from NATO and Japan could engage on current and future work under the SPS Programme, and discussed ideas for future project proposals.

SPS display for the NATO Secretary General's visit to Serbia

While in Belgrade for meetings with the President and Prime Minister of Serbia, NATO Secretary General Jens Stoltenberg met with Serbian scientists who presented new technologies developed within the context of SPS Multi-Year Projects. During his visit, Mr Stoltenberg stressed the importance of NATO and Serbia's partnership and pointed to SPS as a good example of their cooperation.

Publication of the report "Quantum Technologies and the Science for Peace and Security Programme"

As quantum technologies become an increasingly central focus for NATO and governments around the globe, SPS is expanding its portfolio of activities in quantum communications, quantum sensing and quantum computing. With this report, publicly available on the SPS website, the Programme took stock of the achievements of recent and ongoing activities implemented with its support.

Launch of the project “Dynamics above the Epicentre of Climate Change (DECC)”

Bringing together experts from Germany, Norway, Finland and Sweden, the DECC project is monitoring changes in the space environment and atmospheric structure from the Sodankylä Geophysical Observatory. This Multi-Year Project, launched at NATO HQ in Brussels, is strengthening collaboration between research institutes in detecting hazards and extreme events above Northern Scandinavia, where Europe’s Arctic spaceports soon begin operation. The project is also studying winds, which are expected to change due to climate change, and investigating energy transfer throughout the atmosphere.

December

Advanced Research Workshop “Pursuing Quantum Sensing for Reliable Roadmaps”

This SPS workshop brought together experts from 19 NATO Allies and partner countries, who developed methodologies for assessing practical applications of quantum sensing capabilities. They also identified potential opportunities for quantum sensing for detection and evaluated field applications of a wide range of quantum sensing technologies.

Conclusion of SPS Photo Contest

In October, SPS launched a photo contest among those who have been involved in an activity supported by the SPS Programme. The goal of the contest was to allow participants to showcase the wide variety of experiences involved in working on an SPS activity. The contest ended in December with this winning photo, also featured in the NATO Secretary General's 2023 Annual Report. The image was taken in Kharkiv, Ukraine, during field testing of the landmine detection system under development in the SPS Multi-Year Project "MinesEye".

2023 in Numbers

5

SPS Information Days

87

Proposals Approved by the PCSC in 2023

2

Call Deadlines in 2023

- 2023/1: 17 February
- 2023/2: 16 June

Outcomes

Call for proposals	Proposals received	Ineligible	Proposals rejected by the ISEG	Proposals recommended by the ISEG	Proposals withdrawn	Proposals approved by the PCSC in 2023	Proposals approved by the PCSC in 2024
2023/1	122	9	65	48	0	47	1
2023/2	121	18	68	34	1	19	15

Completed activities

20

Multi-Year Projects Completed Addressing the Following SPS Key Priorities

- Counter-terrorism: 5
- Energy Security: 1
- CBRN Defence: 2
- Advanced Technologies: 9
- UXO Detection and Clearance: 3

16

SPS-supported Events Hosted

- 12 Advanced Research Workshops
- 2 Advanced Study Institutes
- 2 Advanced Training Courses

SPS on the Map

Ukraine

Ukraine has been actively engaged in the Science for Peace and Security (SPS) Programme since 1991, and a NATO-Ukraine Joint Working Group on Scientific and Environmental Cooperation (JWGSEC) has been helping to identify priority areas for practical scientific cooperation in the framework of the SPS Programme for more than two decades. Since 2014, in response to Russia's illegal annexation of Crimea, cooperation in the field of security-related civil science and technology has been strengthened, and Ukraine has since become the largest beneficiary of the SPS Programme. Leading areas of cooperation with Ukraine in the SPS framework include advanced technology, counter-terrorism, defence against chemical, biological, radiological and nuclear (CBRN) agents, as well as energy and environmental security. The SPS Programme meets with Ukraine on a yearly basis in the framework of the JWGSEC, which oversees cooperation between NATO and Ukraine in the field of security-related science and technology, and in May 2023, it launched a NATO-Ukraine High-Level Innovation Dialogue in order to accelerate existing collaborations.

G6027 – ARW "Functional Spintronic Nanomaterials for Radiation Detecting and Energy Harvesting"

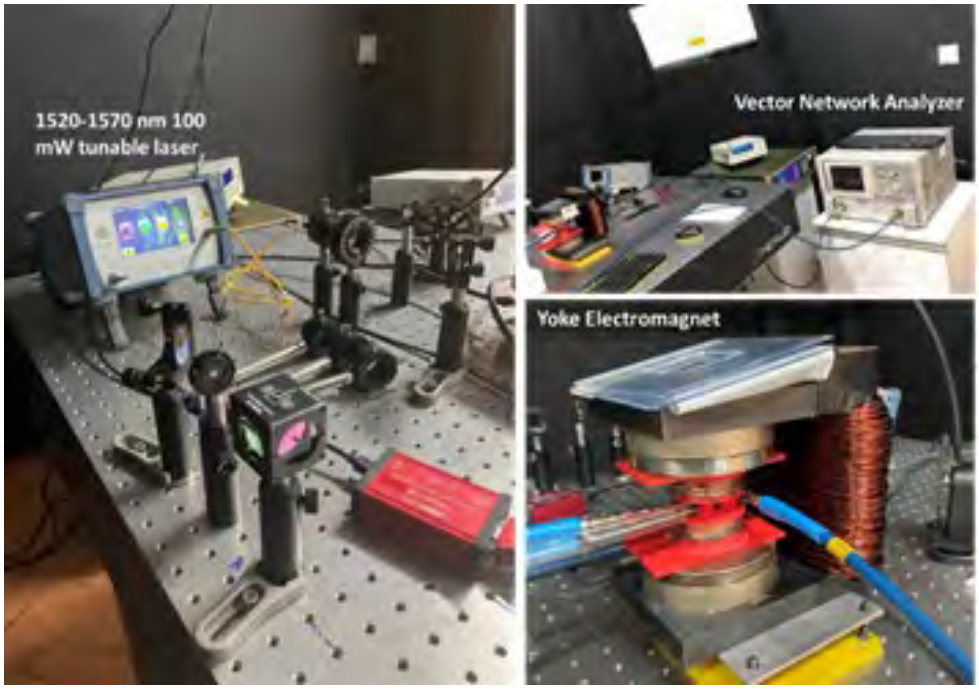
May 2023: Kaiserslautern, Germany, and Kyiv, Ukraine; Organizing countries: Germany, Ukraine

This Advanced Research Workshop took place in May 2023 and brought together scientists from 12 NATO allies and partner countries. It focused on the scientific foundations of spintronic radar detectors and energy harvesters along with potential applications for armoured vehicle threat detection. These devices incorporate spintronic-based oscillators, called Spin-Torque Nano Oscillators, which are compact, easy to fabricate and compatible with conventional silicon technology. In addition, their minimal power consumption makes spintronic radar systems particularly attractive in communications devices and radar systems when compared with conventional electronic systems.

G5859 – MYP "Conversion Technologies for Quantum Sensing and Secure Communications"

Participating countries: Türkiye, Ukraine

The basic concepts of quantum mechanics are fundamental to many of the Emerging and Disruptive Technologies that are changing the security landscape around the globe, and coherent quantum networks are necessary for the proper functioning of many of these technologies. The aim of this Multi-Year Project, which was launched in 2021, is to gain an understanding of novel concepts of hybrid spin-photonic systems with potential applications in up/down quantum frequency-converter technologies. Researchers from Gebze Technical University in Türkiye and the National Academy of Sciences of Ukraine are investigating the use of ferromagnetic (magnonic) material as an effective medium to transfer quantum information from one quantum system to another. They are also looking to develop hybrid quantum structures for efficient conversion of microwave photons to optical photons and assessing meta-material patterns and magnonics implementation in quantum converters.



G6082 – MYP "Electrochromic Metal Oxides for Transparent Superconducting Electronics"

Participating countries: United States, Ukraine

Transparent electronics is an emerging technological field focused on producing invisible electronic circuitry and optoelectronic devices. The technology involves the replacement of opaque semiconductors, which have traditionally been used in electronic devices, with transparent conductors. This Multi-Year Project, a collaboration launched in 2023 by researchers at the University of Texas at Dallas and the Kyiv Academic University, aims to pave the way for an entirely new field of transparent electronics: the electronics of transparent superconductors. This collaboration is identifying materials appropriate for the development of transparent electronics, performing detailed studies of their electrical and optical characteristics, and developing optimized thin-film technologies for single-photon detectors and next generation integrated quantum electronics. The project will demonstrate the technology with a relevant prototype and explore the frontiers of knowledge concerning fundamental physical behaviour of transparent superconductors. It will also support the long-term innovation in cryogenic materials, which have the potential to make a significant impact on the field of security-related science.

G6002 – MYP "3D Metamaterial for Energy Harvesting and Electromagnetic Sensing"

Participating countries: Lithuania, Ukraine

Lithuanian and Ukrainian scientists are developing rectifying antennas (rectennas) for energy harvesting applications, based on metamaterial-inspired dielectric resonator antennas. The innovative rectennas can also convert electromagnetic energy into direct current (DC) electricity, and they have the potential to feed Internet of Things sensors, Radio Frequency Identification systems and can be used for electromagnetic sensing. The primary drawback of existing rectennas is polarization dependence due to the structure of the electromagnetic field at the surface of the antenna. This reduces the energy converting efficiency of alternating electromagnetic fields into DC energy. The novel rectennas emerging from the project will be activated at different frequencies of wireless communication systems and different polarizations of the Radio Frequency energy. As a result, the output current of the rectenna will be higher compared to previous iterations. In addition, application of the metamaterial cell will significantly reduce the mass and size characteristics of rectennas and sensors, and simplify the production of the technology.

G5442 – MYP "Resilient Civilians in Hybrid and Population-Centric Warfare"

Participating countries: Norway, Ukraine, Finland, Denmark, France, United States

In recent years, there has been a renewed global focus on resilience. The Covid-19 crisis and Russia's continued aggression in Ukraine have made clear the need for NATO Allies and their partners to expand their capacity not only to absorb systemic shocks, but also to adapt and transform in the face of unexpected challenges. Additionally, as warfare takes on an increasingly protean, hybrid character in the 21st century, civilian populations are finding themselves in ever more central roles in conflict situations. NATO has sought to address the instability and uncertainty caused by hybrid attacks on civilians, and in 2021, NATO Heads of State and Government agreed a Strengthened Resilience Commitment that lays out a process for building resilient societies. As part of this initiative, NATO's Science for Peace and Security Programme has supported the project "Resilient Civilians".

This project addresses the agency of civil society networks in conflicts that witness the use of hybrid threats for priming, destabilization, or coercion purposes. Resilient Civilians proposed a new approach to civil-military interaction, with the design of an analytical tool based on a combined multi-actor security and civil-military interaction matrix – the Civil-military Multi-actor Security & Resilience (CMSR) model. It prioritizes the role of civilians, and civilian agency, in crisis and conflict scenarios.

Partnership for Peace

The Partnership for Peace is a framework of practical bilateral cooperation between NATO and individual partner countries in the Euro-Atlantic area. It allows partners to build up an individual relationship with NATO, choosing their own priorities for cooperation.

G5894 – MYP "QUANTUM5: Quantum cybersecurity in 5G Networks"

Participating countries: Czechia, Bosnia and Herzegovina

With the emergence of 5G mobile communication systems, the issues of cyber security and consumer privacy are becoming ever more critical, especially in light of future technology convergence. Deployment of networks with higher data rates, lower latency and enhanced performance will enable novel applications, such as autonomous cars, passenger drones, unmanned traffic management, remote medicine and surgery, remote patient monitoring, remote train management and smart-grids. These applications—and many yet to be imagined—will be heavily dependent on end-to-end security and cryptographic techniques.

In contrast to conventional cryptographic solutions that are based on the computational complexity of mathematical problems, Quantum Key Distribution (QKD) provides the secure establishment of a cryptographic key between two points that are connected by a quantum channel. QKD relies on the laws of quantum physics to provide a theoretical secure way of establishing symmetrical binary keys between two geographically distant users. The QUANTUM5 Multi-Year Project demonstrated practical applications of Quantum Key Distribution (QKD) in 5G networks, developing simulation tools and practical guidelines for further inclusion of quantum technologies in 5G networks and beyond.

G6188 – MYP "Enhancement of the Next-Generation Incident Command System (NICS) in Bosnia and Herzegovina (BiH)"

Participating countries: United States, Bosnia and Herzegovina

The Next Generation Incident Command System (NICS) is a web-based collaboration and decision-support platform developed by the MIT Lincoln Laboratory. NICS provides an interoperable, scalable, and open-source capability that allows first responders to coordinate effectively across organizations, jurisdictions and efforts during a large-scale emergency. Through its work with Lincoln Laboratory, the Ministry of Security of Bosnia and Herzegovina is leading the effort to extend the NICS expertise to all levels of government from local to state levels. NICS enables public safety responders to make informed decisions using nearly real-time information. As a result, responders can react more quickly and effectively. This project builds on the success of a completed project, which succeeded in implementing NICS across in four countries, Bosnia and Herzegovina, Croatia, Montenegro and North Macedonia.

G5907 – MYP "Geo-Threats to Azerbaijan's Energy Independence"

Participating countries: Italy, Azerbaijan, Georgia, Belgium, Czechia, Ukraine

Disruptions in energy production have detrimental—and often unpredictable—effects on society. For example, in June 2018 an accident at the Mingachevir Thermal Plant paralyzed ongoing Azerbaijani military exercises and produced mass blackouts throughout the country. This project focuses on mitigating the threats posed by geological hazards on Azerbaijan's energy independence, particularly bolstering the resilience of the Shamkir and Mingachevir hydroelectric-power plants, the largest power stations in Azerbaijan.

Due to the risk posed to a large swath of the country by overflow on the Mingachevir dam, this project is working to calculate the expected Peak Ground Acceleration in the area by integration of data on recent seismicity with paleo-seismicity and local seismic coefficients. It will also quantify static and dynamic slope stability at critical sites around the reservoir and evaluate the scenarios in the context of a tsunami following the failure of the slopes and subsequent impact on the reservoir, as well as the possible scenario of flooding due to dam 'overtopping'. The project will also conduct training activities comprising field exercises and instrumental knowledge to prepare young researchers and technicians to carry out independent work and acquire the necessary skills for seismic hazard evaluation, slope stability and flood inundation analyses, all contributing to increasing regional stability through practical cooperation.

G5690 – MYP "Earthquake hazard and environmental security in Kazakhstan and Kyrgyzstan"

Participating countries: United Kingdom, Kazakhstan, Kyrgyzstan, United States, Germany, France

Earthquakes are a major threat to the environmental security of both Kazakhstan and Kyrgyzstan, posing risks to population centres and to critical infrastructure such as canals, dams, roads and pipelines. This Multi-Year Project is producing active-fault maps and gathering paleo-seismic information across the Tien Shan region of Kazakhstan and Kirghizstan. This and other raw scientific data collected as part of the project will underpin attempts to assess earthquake hazards across the region. The absence of such data

across much of the region has been a major obstacle in effective hazard mitigation, which is becoming ever more acute due to growing urban populations and the increasing vulnerability of critical infrastructure. This project will help train younger researchers and will focus broader attention in the international scientific community on existing geological and seismic challenges faced by communities throughout Central Asia.

Mediterranean Dialogue

The Mediterranean Dialogue is a partnership forum that aims to contribute to security and stability in the wider Mediterranean region, and promote good relations and understanding among participating countries and NATO Allies. Currently, the following non-NATO countries take part in the Dialogue: Algeria, Egypt, Israel, Jordan, Mauritania, Morocco and Tunisia.

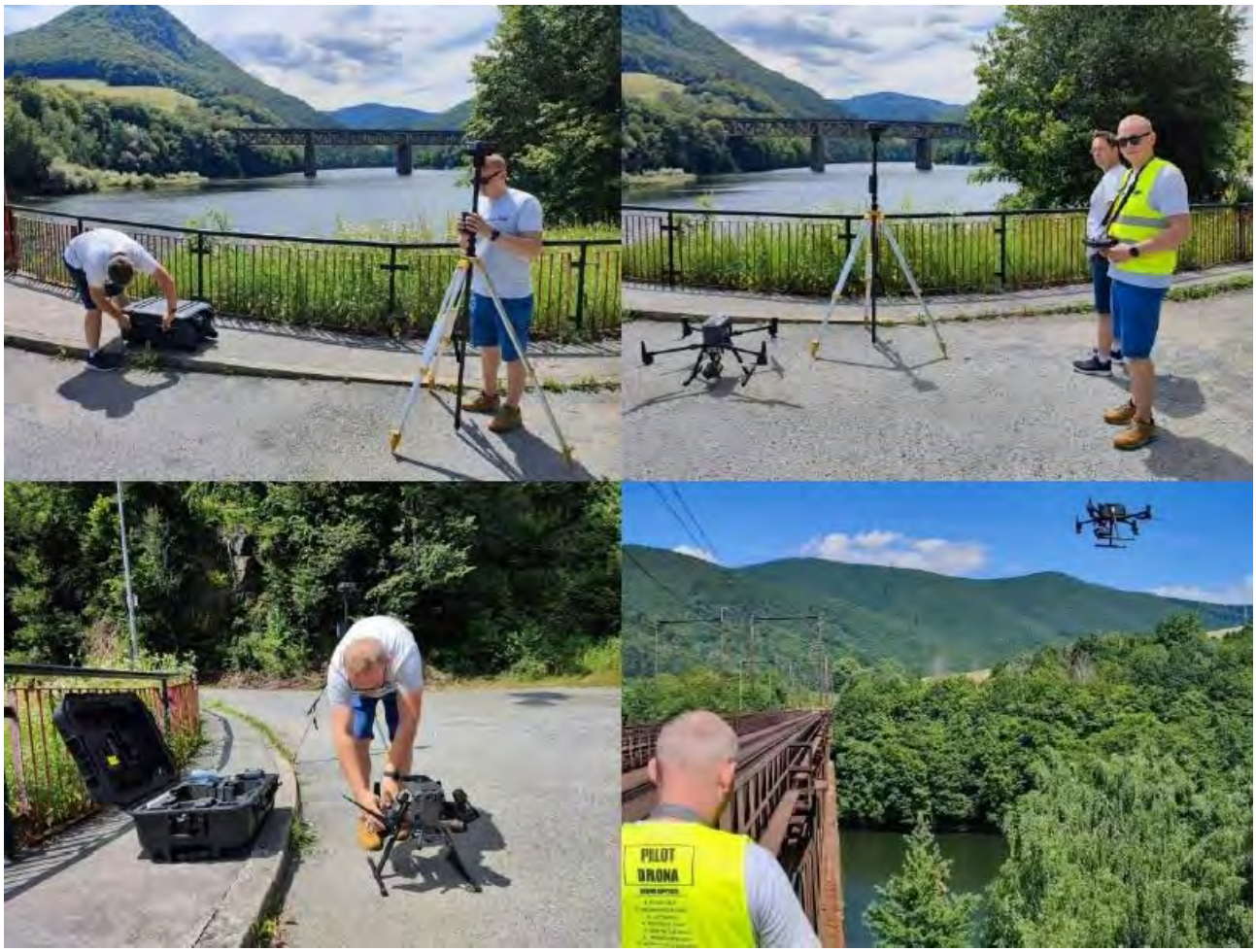
G5885 – MYP "TANGO: Technology against climate change to mitigate CO2 environmental security threats"

Participating countries: Italy, Morocco, Belgium

The TANGO Multi-Year Project is helping to reduce CO_2 emissions in the atmosphere and, consequently, to mitigate the impact of greenhouse gases on climate change. Researchers in Italy, Morocco and Belgium are developing a novel and sustainable aerosol reactor for the utilization of CO_2 , which can be employed as a building block to produce a wide variety of chemicals and fuels, transforming a pollutant into a feedstock. The project is also improving the efficiency of industrially relevant CO_2 exploitation approaches, which TANGO intends to achieve through the integration of several technologies (i.e. catalysis, nanotechnology, flow chemistry, aerosol chemistry and magnetism). A further project goal is the reduction of the impact on the environment of CO_2 utilization approaches. As such, Green Chemistry principles will guide a range of TANGO activities. For example, waste production will be prevented by using an atom-economy approach and recycling catalysts, unreacted reagents and solvents; and only green solvents will be used, with their adoption minimized. Additionally, reactions will be performed at atmospheric pressure and at ambient temperature (or using highly efficient heating technologies). Finally, CO_2 will be directly used as a renewable feedstock, and by-product formation will be reduced, which will contribute to the mitigation of increasing energy needs.

G5924 – MYP "IRIS: Inspection and security by Robots interacting with Infrastructure digital twinS"

Participating countries: Italy, Morocco, Slovakia, Poland



The IRIS project is designing and developing an innovative integrated system comprising autonomous/robotic systems and sensor networks in data acquisition for survey, inspection and monitoring of critical infrastructures. The interaction between data acquisition and storage is managed by the construction of advanced models—the "digital twins" of the infrastructure—which are computer-based models of a mechanical system providing an exhaustive and realistic replica of the system throughout its service life. These digital twins are also completely updatable in real time and capable of reflecting potential realities in post-disaster situations.

Digital-twin models use a wide range of data to identify defects, degradations and possible performance-reduction issues in existing structures. This data also informs automated or partially automated decision-making processes useful in facilities related to critical infrastructure. The digital-twin models being developed in the project take into account both surface and underwater components of potential infrastructures and comprise both surface inspection mechanisms (i.e. land-based robots and drones) and underwater inspection systems.

G5571 – MYP "DIMLAB: Deployable CB analytical laboratory"

Participating countries: Spain, Morocco, Tunisia

Recent years have seen an increase in chemical- and biological-related risks within the context of both conventional and hybrid warfare. The potentially deadly, destructive and disruptive nature of these threats require swift and accurate identification and diagnosis, and deployable field laboratories have formed the backbone in the fight against CBRN threats. These detection, identification and monitoring laboratories (DIMLABs) comprising biological, chemical and radiological, and nuclear modules must meet minimal operational requirements in which the main hazardous CBRN warfare agents can be detected and identified.

The DIMLAB Multi-Year Project successfully designed and built—and in 2023, deployed in Morocco and Tunisia—lightweight, portable laboratories offering optimum identification and detection capabilities that are effectively defending against biological and chemical threats at a considerably lower price point than any preceding solutions. Researchers designed these biological and chemical laboratories utilizing the latest advances in nano-biotechnology; and the fully operational, portable laboratories are helping to mitigate the risks of chemical and biological attacks.

G5732 – MYP "PROMEDEUS : Protection Civile et Medecine d'Urgence Sanitaire en Mauritanie"

Participating countries: Romania, Mauritania, France

This initiative builds on previous SPS-supported projects involving Mauritania by complementing its crisis management system to enable more effective responses to the various risks and threats facing the country. It is supporting the Mauritanian Government's overall efforts to give civil protection services a major role in crisis management. The PROMEDEUS Multi-Year Project is improving emergency medical treatment and assistance by drawing on the full capabilities of the Mauritanian Centre for Crisis Monitoring, Alerts and Management as well as those of the Mauritanian Centre for Public Health Emergency Operations. It is also expanding the operational capabilities of the civil protection service, by creating civil protection units. Related to this is the implementation of a system of medical care through close collaboration with emergency services using telemedicine tools, thus assisting major trauma and medical emergency victims in Nouakchott and in towns within a radius of about 100 km of the capital. This project constitutes a first operational step for medical response services using advanced technologies in Mauritania, and it will lay the foundation for establishing capabilities for alerts, emergency medical dispatching and operational coordination of response teams and pre-hospital emergency medicine throughout Mauritania.

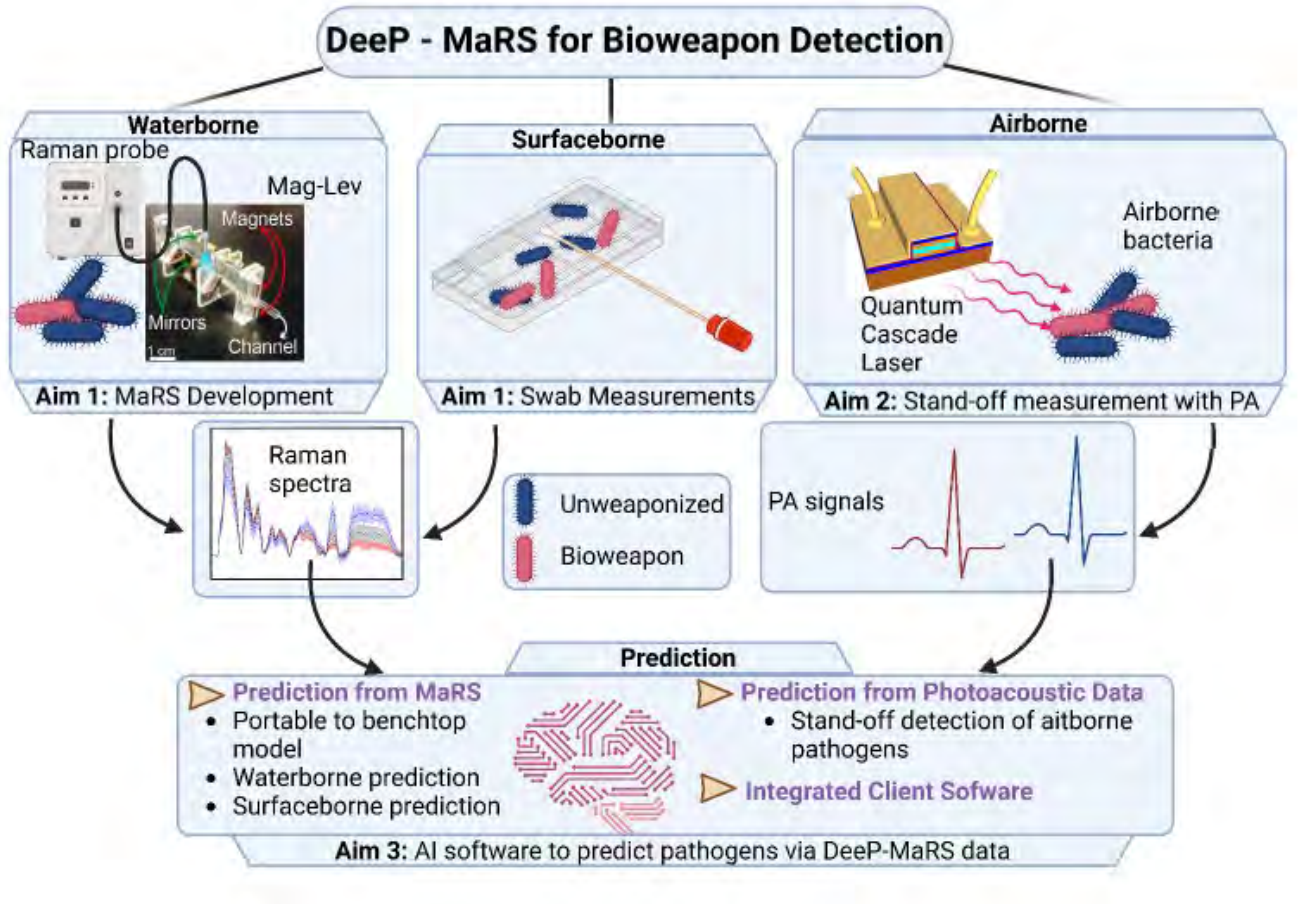
Istanbul Cooperation Initiative

The Istanbul Cooperation Initiative (ICI) is a partnership forum that aims to contribute to long-term global and regional security by offering non-NATO countries in the broader Middle East region the opportunity to cooperate with NATO. Bahrain, Kuwait, Qatar and the United Arab Emirates currently participate in the Initiative.

G6169 – MYP "DeeP-MaRS: AI-assisted Bioweapon Detection Platform"

Participating countries: United States, Qatar, Türkiye

The DeeP-MaRS project is developing methods for field-based quantitative analysis of water, air and swab samples in order to detect weaponized microorganisms and enable real-time monitoring of municipal- and drinking-water pathogen levels. Through photoacoustic remote sensing, researchers are enabling contact-free pathogen detection using optical methods, which allow for sample inspection while protecting inspectors from infection and contamination. This remote detection method is also helping to simplify sample collection and analysis procedures and allowing for immediate responses to potential bioweapon attacks.



G5828 – MYP "SeaSec: DroNets for Maritime Border and Port Security"

Participating countries: Italy, Qatar

This Multi-Year Project is addressing the challenge of ensuring a proper situational awareness at sea by enhancing traditional border and port surveillance systems with quickly deployable squads of Unmanned Aircraft Systems (UAS) that autonomously cooperate to deliver comprehensive views of potential threats in real time. Monitoring systems providing situation awareness are an invaluable tool in surveillance and hazard-detection scenarios, and the SeaSec project is developing a network composed of UAS that have different capabilities. They can sense a wide range of physical aspects (for example, they may carry on-board video cameras, thermal cameras, sonars or environmental sensors), and can use acoustic modems to communicate with and gather data from underwater sensors. UAS with on-board acoustic modems have water-landing capabilities and allow linking the underwater sensor networks and the human operators, making a connection between the underwater and the aerial networks. In the maritime environment, situational awareness is a complicated task, due to the vast areas to be covered and the lack of a physical communication infrastructure. This project is helping to simplify that task by expanding the area that border- and port-security authorities can monitor with accuracy and efficiency.

Partners Across the Globe

Outside of its formal partnership structures, NATO cooperates with a range of countries – called Partners across the globe – on an individual basis. NATO's engagement with these global partners is taking on increasing importance in a complex security environment, where many of the challenges the Alliance faces are global and no longer bound by geography.

G5975 – MYP "Indo-Pacific Futures Platform"

Participating countries: Belgium, Japan, Australia, France

The Indo-Pacific has emerged in recent years as a key centre of strategic and geopolitical competition, and developments in the region are likely to affect NATO and its member states in a number of direct and indirect ways. The Indo-Pacific Futures Platform, which launched January of 2023, provides a forum for strategic analysis and dialogue between key stakeholders from the Euro-Atlantic area and NATO's partner countries in the Indo-Pacific (Japan, Australia, the Republic of Korea, and New Zealand). Researchers are collaborating to identify emerging region-specific security trends and to understand how they will impact transatlantic security. This network comprises experts from academic, policy, private sector, think tank, civil society circles in Europe, North America, Australia, Japan, the Republic of Korea and New Zealand; and while assessing the evolving strategic landscape of the Indo-Pacific region, they are working together to develop policy recommendation to NATO. Not only is this project helping NATO and its partners in the Indo-Pacific envision and prepare for security developments over the next decade, it is building valuable networks that are deepening cooperation between the Euro-Atlantic and Indo-Pacific regions.

G5850 – MYP "OPTIMIST: Nanoscale Photonic Structures"

Participating countries: Italy, Australia

The proliferation of commercial lasers is an emerging security threat, with lack of regulation exacerbating risks and current laser protection systems limited in their effectiveness. To meet this challenge, scientists from the Italian National Institute of Optics and the Australian National University have been collaborating on the "OPTIcal liMIting and SwiTching with nanoscale photonic structures (OPTIMIST)" Multi-Year Project since 2021. They are designing a novel class of self-activating optical limiting and switching devices, with large angular acceptance and bandwidth, fast response and reset times and high laser damage threshold. To create such devices, the project has assessed the property of metallic and dielectric photonic resonators (thin-film multilayers) and is incorporating phase-change materials, namely vanadium oxide. This multi-year project is currently opening new avenues of research in the field of linear and nonlinear reconfigurable and tunable nano-photonics, and helping to mitigate the damage caused by hostile use of lasers.

G5795 – MYP "Gases and Analytes with TErahertz Sensors (GATES)"

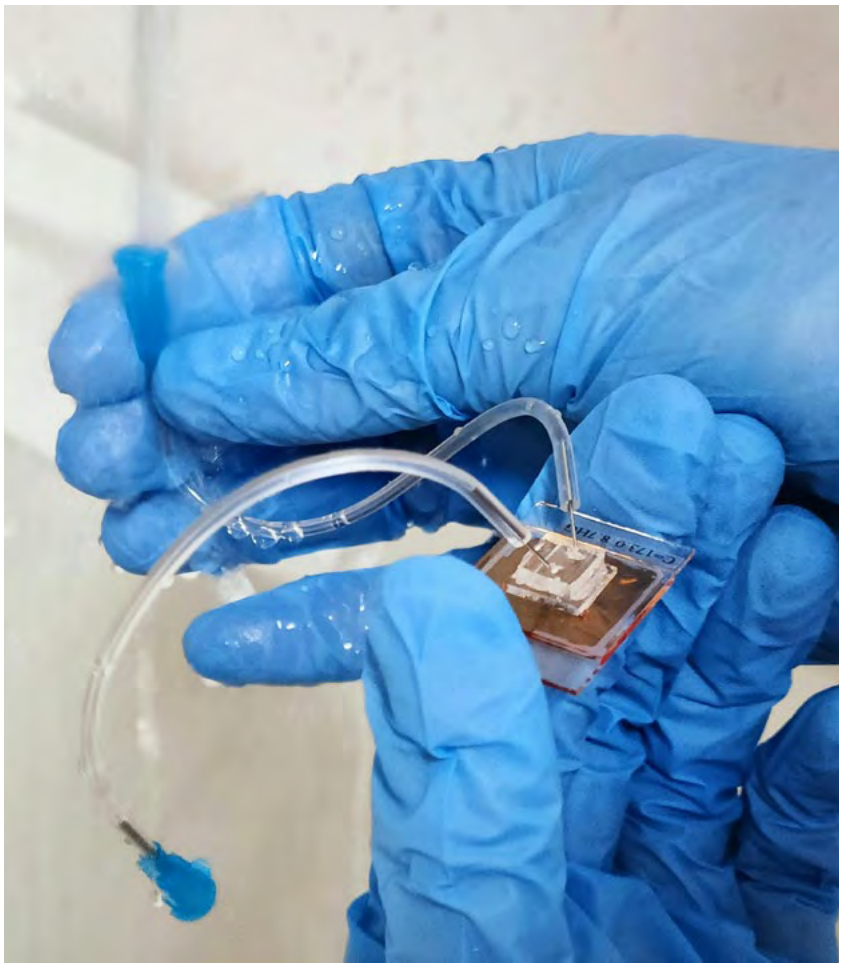
Participating countries: Slovakia, Australia

Recent years have been marked by an increase in the demand for rapid detection of a broad range of gases and biological species in low concentrations. This detection can have applications in the realms of security, environmental monitoring and drug discovery. The GATES Multi-Year Project, which successfully reached its goal in 2023, was able to improve particle detection by applying the terahertz Four-Wave Mixing technique to newly developed, micro-structured polymer optical fibres that confine radiation to the sub-wavelength scale. The advantage of the proposed fibre-based approach over existing technology lies in the flexibility, compactness and reduced complexity of a device that can be immediately integrated with existing detection systems. Furthermore, cryogenically cooled detection of analytes have the potential to reach higher sensitivity levels, in addition to other significant advantages such as substantial size and cost reduction, improved bandwidth and scalability of the system in comparison to available platforms. The GATES project successfully demonstrated and quantified the applicability of the terahertz Four-Wave Mixing technique to a tailored enhanced metamaterial (constituted by microstructured polymer optical fibres), with researchers at the International Laser Centre in Bratislava optimizing the terahertz technique to the novel metamaterial and experts at the University of Sydney designing and producing the optimal enhanced metamaterial.

G5759 – MYP "NANO-LC: Nanotech Biosensor with Liquid Crystals"

Participating countries: Italy, Republic of Korea

NANO-LC was an innovative project implementing cascade-structured biosensors to detect harmful pathogens dispersed in potable water. The biosensor developed in the NANO-LC framework exploited innovative and stimuli-responsive materials such as biofunctionalized gold nanoparticles (e.g., gold nanorods, AuNRs) and light-sensitive liquid crystals (LCs).



AuNRs are firmly immobilized on a rigid platform using a controlled deposition technique. At the same time, photo-sensitive LCs are uniquely utilized for their capability to modify their spontaneous vertical orientation for small changes in the pump/probe UV radiation. Integrating microfluidic channels allows the sampling of potable water using reduced volumes and providing high sensitivity in the detection limit. The photo-thermal properties of AuNRs, which can be suitably activated upon white light illumination, provide sterilization, thus allowing a green reutilization of the realized biosensor.

G5994 – ARW "Biotechnology and human enhancement"

October 2023: Sabaudia, Italy; Organizing countries: Italy, Republic of Korea

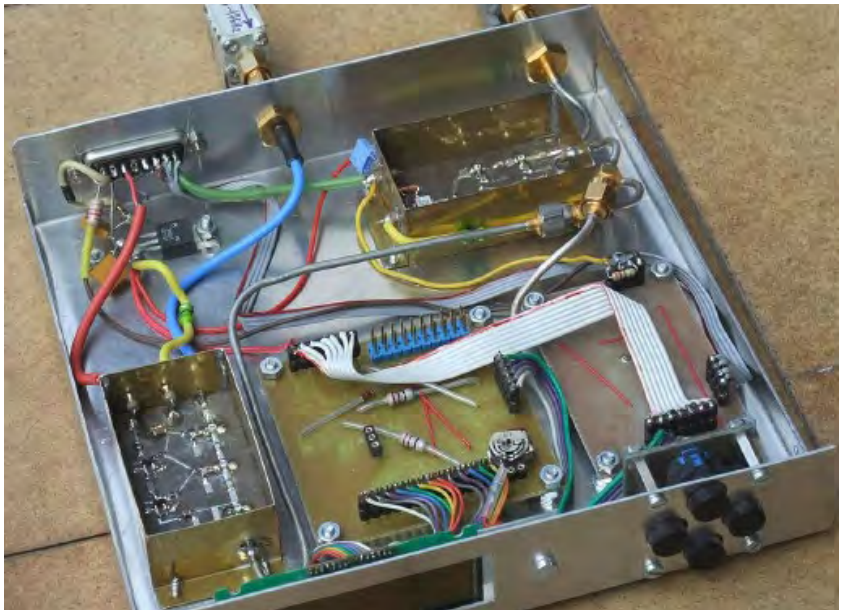
This Advanced Research Workshop gathered internationally renowned scientists and young researchers from both NATO and partner countries to discuss the latest innovations in advanced biotechnologies and human enhancement. The participants outlined a roadmap of the primary achievements in biosensing, human augmentation, and medical biotechnology with the intention of facilitating the growth, development, and synergy of scientific cooperation between NATO and partner countries; and there were three scientific sessions on the topics of Human Enhancement, Biotechnology and Advanced Materials, and Sensing.

Other research topics discussed included quantum technologies, liquid crystals sensing, advanced tissue, magnetic levitation, Raman Spectroscopy, bacteria-killing modeling, and nanotechnology-inspired biosensing. Experts also explored a range of ways in which innovative and breakthrough applications can address emerging challenges. These challenges include terrorist threats emanating from explosive devices, CBRN agents, nanotechnology, optical technology, microsatellites, metallurgy, and the development of Unmanned Aerial Vehicle platforms.

G5888 – MYP "CLARIFIER: frequenCy-agiLe rAdar-lidaR chIp For surveIllancE moving platfoRms"

Participating countries: Italy, Colombia, Slovenia

LiDAR (Light Detection and Ranging) and RADAR (Radio Detection and Ranging) are the two remote sensing technologies that are instrumental in detecting objects in physical space and to creating a recognizable picture for situational awareness. They are considered the foundation for current innovation domains such as autonomy, self-navigating (range finding, collision avoidance) and self-driving vehicles. Both LiDARs and radars exploit the reflection of emitted signals on objects to calculate their distance, size and characteristics. While LiDAR uses laser pulses and can be used for short-distance high-resolution maps, radar uses radio signals and can cover greater distances.



The CLARIFIER project is working to demonstrate an integrated transceiver combining a radar and a LiDAR sensor that share the same photonic core, i.e. the same signal optical sources. This provides a high level of mutual coherence to the two subsystems, enabling high-performance target detection, imaging, and sensor fusion. Hardware sharing, as well as the implementation in photonic integrated technology, dramatically reduce size and encumbrance. Additionally, the combined operation of the two sensors will allow the reduction of power consumption, making the proposed system a promising solution for unmanned vehicles navigation and surveillance applications.

SPS Thematic Realms

SPS in the Air

G5939 – MYP "APE: Additively Printed Engine"

Participating countries: Belgium, Israel, Türkiye

The power system for an Unmanned Aircraft Systems (UAS), as for any aircraft, includes an energy source and conversion mechanism, i.e. a way to convert energy into mechanical lift or thrust force. Typically, small UAS depend on battery-propeller propulsion—and occasionally fuel-cell power plants—but other technologies are emerging. Micro turbines are gaining scientific and commercial attention for small-scale power generation, and they are gradually emerging as a potential propulsion system for small tactical aircrafts because of their performance, efficiency and optimal airframe aerodynamics. These micro-jet engines have extremely high costs, however. In multi-mission platforms, significant efforts are made to prolong the service life of these engines, and maintenance costs can surpass the price of the engine itself.

This MYP is developing a micro-gas turbine for UAS produced entirely using additive manufacturing and 3D printing. The engine can be printed in its final assembly state in a single uninterrupted print sequence. Such technology is making it possible to produce an extremely cheap engine with minimal post-production procedures, while simultaneously significantly decreasing the engine production and delivery time. The Additively Printed Engine project is working to provide an alternative to conventional micro-gas turbines that can be fabricated in its complete assembled state using only a 3D metal printer and an operator, with minimal post-production efforts and consequently no delays. Furthermore, the extremely low cost of the engine allows eliminating costly maintenance procedures by simply printing a new unit when maintenance would normally be required.

G6026 – MYP "Implementation Vulnerabilities in QKD Components for Fiber and Drone Applications"

Participating countries: United States, Israel, Italy

Quantum cryptography has gained significant attention in recent years, leading to the development of commercial products that utilize Quantum Key Distribution (QKD), which is a secure communication method that exploits quantum mechanics to distribute and share keys necessary for cryptographic protocols. Information is encoded on single photons and relies on the quantum characteristics of the photon to remain secure and private between communicating parties. This is due to a fundamental feature of quantum systems: by observing photons, or disturbing them in any way, quantum characteristics are altered and communicating parties are made aware of potential attackers.

The goal of this MYP, launched in 2023, is to use next-generation components to identify loopholes in QKD technology and propose protocols and/or algorithms able to minimize the risk of eavesdropping both on fiber and free-space optical (drone) channels. Experts are using machine learning and artificial-intelligence techniques to future-proof the transmission of information, protecting it from increasingly advanced hacking systems.

Communication networks are a fundamental part of today's information technology infrastructure, and the rapid advance of quantum technologies is having a paradigm-shifting effect on secure communications. The scientists collaborating on this project are assessing the vulnerabilities of QKD devices to potential attackers and exploring mitigation techniques able to take into account the realistic constraints and impairments of real-world system. As such, it will contribute in advancing state-of-the-art of quantum communication technology, especially on free-space optical channel, with particular attention to UAS applications.

G6187 – MYP "SAPIENCE: Sense & Avoid - a cooPeratIvE droNe CompEtition"

Participating countries: United Kingdom, Austria, United States, Netherlands

Unmanned Aircraft Systems (UAS), have the potential to play a significant role in the management of crises and civil emergencies. In recent years, UAS technology has advanced significantly and has been adopted by many organizations and governments for various purposes, including disaster response. In such environments where response time is critical, multi-UAS systems can enhance effectiveness by increasing coverage and speed, and offer greater versatility compared to single UAS platforms.

The goal of this project, launched in September 2023, is to develop innovative solutions for crisis management in civil emergencies by employing multi-agent UAS systems. Such systems have been hypothesised many times, but as of yet no such system is fully operational and able to cope with harsh environments. SAPIENCE approaches this challenge through a competition, in which teams from different universities compete in developing such a system to complete tasks in simulated real-world scenarios.

The competition will consist of three events, planned to take place in the United Kingdom, the United States, and the Netherlands over the course of 32 months. The events will increase in difficulty, and will address the key technical challenges of data fusion, sensing and avoidance and fault tolerance.

By encouraging a competitive approach, SAPIENCE will stimulate innovative solutions in these areas, which can be applied in a variety of security-related scenarios. On the other hand, at the end of each event, cross briefings and training are envisaged to allow all the researchers and especially the young scientists involved to learn and improve their systems.

SPS on Land

G5731 – MYP "Demining Robots: multi-sensor cooperative robots for shallow buried explosive threat detection"

Participating countries: Italy, Ukraine, United States, Jordan

According to the International Campaign to Ban Landmines, in 2022 there were more than 4,300 civilian casualties of landmines—more than half of them children. Ukraine is now considered the most heavily mined country on earth, and Ukrainian authorities have spoken about a severe shortage of men and equipment capable of clearing the minefields.

The "Demining Robots" project—a collaboration between experts from research institutes in Italy, Ukraine, USA and Jordan—was concluded in September of 2023. The primary goal of the "Demining Robots" project is to demonstrate the feasibility of a safe landmine- and IED-detection system by using a team of cooperative robotic vehicles, each carrying specialized sensors (ground-penetrating radar, optoelectronic, metal detector, holographic radar). This novel approach allows for the collection of data covering a wide range of parameters and involves zero risk to human life.

A remote operator completely out of harm's way can deploy the robots in sequence with the aims of detection, multi-data imaging, and classification (differentiating between explosives and harmless debris). Potential threats can then be digitally mapped in a geo-referenced coordinate system and appropriately neutralized. The robots are designed to relay data in real time, through secure channels with remote terminals and portable devices. The shared data can then be collated to generate a data-fusion display, which classifies explosive threats. The robots will be agile, lightweight, and optimized for the unique challenges presented by minefield environments.

The "Demining Robots" project builds on the previous SPS project "Holographic and Impulse Subsurface Radar for Landmine and IED Detection (U-GO 1st)", which developed a remotely operable, multi-sensor, robotic device for the detection of land mines, unexploded ordnances, and IEDs. With enormous swaths of Ukrainian territory having been transformed into minefields since Russia launched its full-scale invasion, the "Demining Robots" are well placed to make an immediate and positive impact where it matters most.

G6190 – MYP "Post-earthquake Monitoring of Seismically-induced chains of Landslide Hazards (SHAKEN) for Protection of Critical Sites and Infrastructure"

Participating Countries: Türkiye, Pakistan, United States, Netherlands

This Multi-Year Project aims to assess post-seismic landslide hazards in the area hit by the February 6, 2023, Kahramanmaraş earthquake sequence. The project will help document spatial and size distributions of co-seismic landslides and—through detailed field surveys coupled with remote sensing analyses—identify deformed hillslopes that could lead to catastrophic failures in the post-seismic period. Scientists at five research institutes are utilising optical images, UAV and LiDAR data processing and InSAR technologies to capture and monitor hillslope deformations. This information will deliver risk or close-to-risk estimates that are useful to plan adequate mitigation actions for critical infrastructure, lifelines and food supply chains. The resulting outputs of the projects will also help raise awareness in local communities and assist local administrators in taking more appropriate risk-mitigation actions. Overall, the project is providing technical guidelines for post-event monitoring of critical sites and infrastructure that can be utilised in hazard and safety assessment in other earthquake-prone areas of the world.

Monitoring and early detection of potential hazards in the aftermath of devastating earthquakes are vital to the sustainability and safety of critical infrastructure such as roads, energy transmission lines and dam reservoirs. The monitoring system and further integration of AI established by this project will help reduce casualties and increase the safety of operating personnel and civilians. In addition, raising awareness of secondary hazards that can be experienced after similar strong earthquakes—and developing a platform with similar approaches—has the potential to help create a new tool to prevent and counteract and remediate in loco and rapidly the effects of the exposure to various critical situations, including hazard prediction capacity.

G5814 – MYP "Nanomaterials for Explosive Traces Detection with SERS (NOOSE)"

Participating countries: Slovenia, Israel, Ukraine, Greece

Explosive devices used in terrorist attacks remain a foremost global concern, and there is an urgent need for an effective, cheap, portable and reliable tool for trace recognition of explosive agents. Among the various laser-based sensing methods, not only is Raman Spectroscopy capable of trace recognition, but modern nano-engineering techniques can further increase the potential of the Raman Spectroscopy method by operating at ultra-low concentrations—allowing for accurate detection of explosive traces.

This Multi-Year Project is developing devices for ultra-fast detection of explosives in the traces of several molecules, using rubbing samples and gas-like sensors. These devices under development use Surface-Enhanced Raman Spectroscopy (SERS), which is capable of high-speed detection as well as a high degree of sensitivity. Researchers have been aware of the general mechanism of such detectors for several years, but the difficulty of producing the required nanoscale-surfaces in a sufficiently controlled and economic manner has been a significant barrier to progress. Recent advances in the field of optical sensing, however, prove that SERS, which is induced by localised plasmon waves, can be used as a physical mechanism for developing novel detectors with a sub-molecular resolution ability. The ultimate focus of the proposed project is to explore and develop simple cost-effective plasmonic substrates for rapid and effective detection of common explosives, as well as of nerve agents such as such as Sarin, VX and Soman and other hazardous chemical weapons.

There has been a genuine need for novel approaches to fast and accurate quantification and classification of the increased number of materials with explosive potential, and this project enhances NATO's efforts to prevent, protect against and respond to terrorist threats. And because this technology can be rapidly deployed, it can help prevent potential terrorist attacks and enable more effective control at critical security points such transportation hubs and other public space with high concentrations of civilians.

SPS at Sea

G5884 – MYP "Cybersecurity for Safe Underwater Acoustic Communications (SAFE-UComm)"

Participating countries: Italy, Israel, Canada, United Kingdom

Under-Water Acoustic Networks (UWANs) consist of sensors and autonomous underwater vehicles interacting to perform specific applications. They are increasingly being used as a cost-effective means for ocean exploration and monitoring. Growing interest in UWANs is highlighting the need to defend these networks against eavesdroppers and attackers. In this context, security techniques developed for terrestrial wireless radio networks are typically not suitable for underwater scenarios, due to physical and performance limitations such as signal propagation delay and insufficient bandwidth.

This Multi-Year Project is developing a complete cybersecurity framework for underwater acoustic communications, with a novel and practical solution for message authentication, key exchange, analysis of bounds for low probability of detection and low probability of interception. It is building upon existing standards and available products, providing a full security envelope which can be installed in existing networks, rather than focusing on a complete redesigning of the communication systems and associated hardware. The prototype framework is being tested in multiple field experiments in a range of sea environments. The outcomes will be both theoretical and practical, and will encompass the design of security algorithms, their analysis, as well as software implementation and field demonstrations. The project will provide both scientific and technological contributions to four security areas: key generation; authentication; detection and interception of low-probability-of-detection and biomimetic signals; and the prototyping of a secure communications layer applicable to any modem.

G6028 – MYP "Numerical Models for Black Sea Pollution Risks"

Participating Countries: United States, Georgia, Ukraine, Türkiye, Romania, Bulgaria

The Black Sea's role and influence on the socio-economic situation of its region is of great importance, particularly considering its rich reserves of biological, natural and mineral resources, and interest in environmental monitoring of the Black Sea has significantly increased in recent decades. One of the reasons is the growing pollution with various anthropogenic pollutants, which harm the marine ecosystem. The Black Sea's coastal and shelf zone, including the Georgian sector of the Black Sea, where the Batumi and Poti ports are located, is experiencing unusually high anthropogenic pressure, linked to factors such as fishing,

toxic substances, increasing salinity, increasing turbidity and over-exploitation.

This project's objective is to develop a mathematical modelling system with appropriate software that will help predict the spread of oil products and other pollutants caused by anthropogenic acts in the Black Sea. In addition, the project is developing models to analyse sediment movement and the pollution sources of the Türkiye side of Chorokhi River, two dams (Borçka and Muratlı dams built on the river), and streams feeding the Chorokhi River. These models are facilitating the study of natural conditions of the basins, river network, climate and vegetation cover, industry and agricultural activities, transport, waste, wastewaters, livestock, landfills and water chemical monitoring in the Black Sea regions.

The modelling system developed in the project will have both practical and scientific impact in making possible predictions of the hydro physical parameters of the sea-flow, temperature and salinity, and in case of emergencies, the spread of oil and other impurities. In addition, the modelling system will be the scientific basis that will allow researchers to conduct studies in the Black Sea and its separate regions to study the patterns of circulation parameters and impurities in different hypothetical scenarios and circulatory regimes.

SPS in Space

G6158 – MYP "QSCAN: Quantum-enabled computation for space surveillance tracking"

Participating countries: Portugal, Austria

As a result of rapidly increasing demand for artificial satellites that provide communication, navigation, remote-sensing, as well as other services, the threat of collisions is growing; and it is critical that satellite positional data is shared in order to predict and avoid potential collisions. With security consideration of utmost importance, however, it is often necessary for a trusted third party to privately compute collision probabilities on behalf of satellite operators—the so-called "conjunction analysis": operators provide private and accurate information to a trusted third party, who will then perform the conjunction analysis and return results to the operators. Unfortunately, trusted third parties can be hard to find due to the potential advantages of accessing the locations of an adversary's satellite.

The QSCAN Multi-Year Project, which launched in 2023, is addressing this problem through a quantum-enabled Secure Multiparty Computation (SMC) protocol for conjunction analysis. This protocol allows the secure computation of the probability of collision between space objects without disclosing to other parties its own inputs. The implementation of the quantum-enabled SMC protocol requires the generation and distribution of oblivious keys, which utilizes a Quantum Key Distribution protocol. The project will demonstrate the SMC protocol for Space Surveillance Tracking within the Portuguese Quantum Communication Infrastructure, currently under the supervision of the Portuguese National Security Office. The approach put forward by QSCAN will make an enormous impact, allowing all interested parties to have access to the widest possible orbital-objects datasets to inform computations, without the risk of disclosing proprietary data. QSCAN can support this process through quantum-enabled, secure, multiparty computation software, allowing the inputs of each stakeholder to be made available, while remaining protected.

G6122 – MYP "DECC: Dynamics above the Epicentre of Climate Change"

Participating countries: Germany, Finland, Sweden, Norway

The DECC Multi Year Project aims to strengthen collaboration between research institutes in detecting hazards and extreme events above Northern Scandinavia, where Europe's Arctic spaceports will begin operation. The project is studying the effect on winds due to climate change and investigating energy transfer throughout the atmosphere. The goal of this research is to extend the observing and forecasting capabilities of high-altitude winds and close an observational gap in the region by adding two new multi-static radar links to existing monostatic radar facilities.

This information will increase the understanding of the impact of extreme weather events on critical infrastructure and transportation systems, particularly Europe's Arctic Spaceport. A critical understanding of wind transformation is also key to operating hyper-glide vehicles and launching nanosatellites. In addition, high-altitude atmospheric dynamics can have a significant impact on environmental hazards such as wildfires, droughts, and floods; and understanding these dynamics is essential for developing strategies to mitigate these hazards in an era of climate uncertainty.

Quantum Technologies

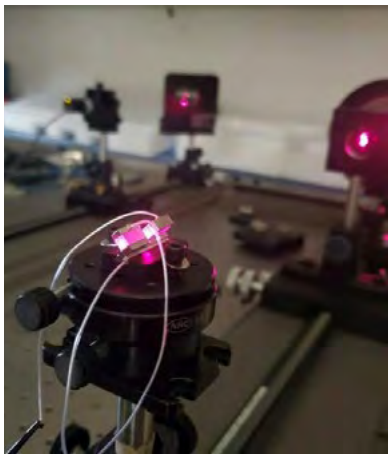
G5985 – MYP "Secure Communication via Classical and Quantum Technologies"

Participating countries: United States, Finland, Slovakia, Spain

Post-quantum cryptography (PQC) and quantum communication, including quantum key distribution (QKD), offer different capabilities for securing sensitive transmission. However, the two research communities have engaged in minimal collaboration. Launched in 2023, this Multi-Year Project is designing, analysing and looking to implement a cryptographic protocol for secure group communication on distributed, hybrid networks, integrating PQC and QKD as available on the distributed network infrastructures.

Traditional cryptographic protocols commonly assume a network topology that offers connections among most parties, including broadcast channels. Quantum links, on the other hand, are by default point-to-point, and establishing secure group communication is non-trivial. This project is developing a security model that allows the design of cryptographic protocols for secure group communication on a hybrid network structure comprising PQC and QKD components. Going beyond the theoretical stage, a prototype of the identified solution on a distributed hybrid network will be implemented, and the integration of PQC and QKD components will be demonstrated in two countries.

Additionally, the project seeks to integrate work on PQC and QKD implementations, ensuring direct collaboration of young researchers with a classical cryptography background and young researchers with a quantum physics background, in order to ensure the maximum benefits for the scientific community at large.



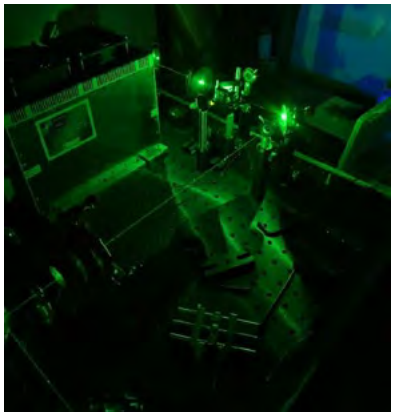
G6112 – MYP "LiGAlert: Laser-printed Early Warning Sensors: Quantum Detection of Chemical and Biological Agents"

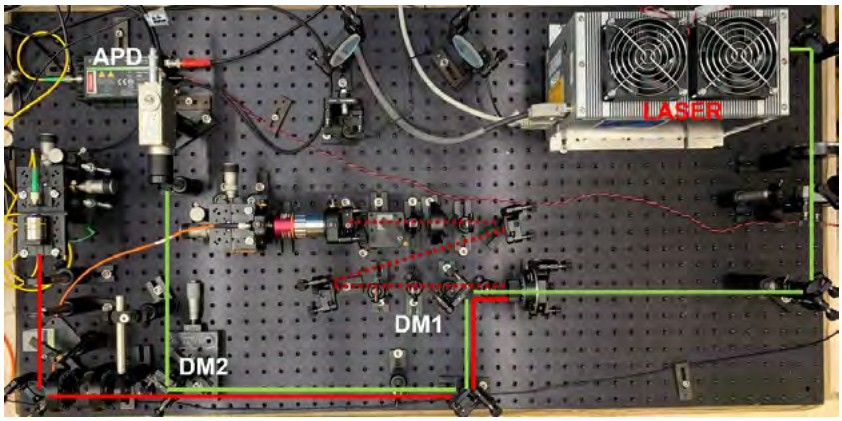
Participating countries: Poland, Austria, United States, Czechia

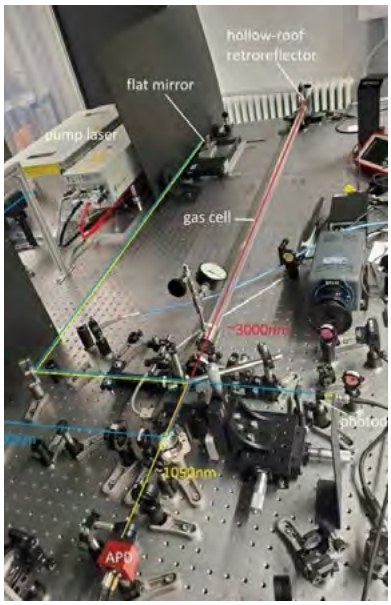
Launched in 2023, this Multi-Year Project aims to develop a flexible, cost-effective electrochemical sensor based on voltammetry analysis to detect explosive and chemical warfare substances. Researchers are designing the novel sensor to detect specific groups of substances including primary and secondary explosives, solid propellants, and chemical warfare agents, and will have the potential to improve the effectiveness of crisis management in preventing terrorist attacks. The project is a collaboration between research institutes in Poland, Austria, the USA and the Czechia that is incorporating AI algorithms for data analysis, using neural networks and genetic algorithms to recognize chemical compounds based on their impedance characteristics. Work is also focusing on designing and implementing dedicated readout systems for the LIG electrical characterization results.

G5839 – MYP "HADES: HAzards DEtection with quantum Sensors"

Participating countries: Italy, Switerland







The HADES Multi-Year Project, launched in 2021 by researchers at a number of research institutes in Italy and Switzerland, is using novel quantum-sensing technologies for the detection of chemical, biological, radiological and nuclear (CBRN) threats such as the presence of undetected harmful gases, hydrocarbons, post-explosion residues and nuclear waste. In particular, the project is exploring Quantum Ghost Spectroscopy and Quantum Fourier-Transform Infra-Red Spectroscopy, two techniques that generate photons at a desired wavelength, and will develop a final prototype that will be tested in field conditions. The project is advancing state-of-the-art technology in the field of CBRN detection, providing improved capabilities of security assessment in a wide array of potentially hazardous environments.

G6067 – ARW "Quantum Sensing for Reliable Roadmaps"

December 2023, Frascati, Italy. Organizing countries: Italy and Australia

This Advanced Research Workshop was held in Frascati, Italy, in December 2023, and marked a significant step forward in bringing innovative hardware from the lab to the field and in developing a promising roadmap for future quantum sensing technology. It brought together experts from 19 NATO Allies and partner countries, who developed methodologies for assessing practical applications of quantum sensing capabilities. They also identified potential practical opportunities for quantum sensing for detection and evaluated field applications of a wide range of quantum sensing technology, creating prototypes and transitioning to operational use.

G5792 – MYP "Spintronic Devices for Microwave Detection and Energy Harvesting"

Participating countries: Greece, Ukraine, Germany, France, Spain, Hungary

Spin-based electronics, or spintronics, is a branch of quantum physics that addresses the storage and transmission of information based on the spin of electrons and their charge. This technology can be used to develop novel devices that overcome the limitations of conventional electronics, e.g. chip size, power consumption, frequency stability, sensitivity, etc., enabling a number of potential practical applications, including non-volatile memories, radar systems, magnetic field sensing, microwave generation and detection, and microwave energy harvesting. The goal of this Multi-Year Project is to investigate novel materials for fabricating spintronics-based devices for microwave detection and energy harvesting. The project brings together scientists from research institutes in Greece, Ukraine, Germany, France, Spain and Hungary in order to develop a high performance Spin-Torque Microwave Detector (STMD) device for microwave generation, detection, and energy harvesting, using a novel materials (ferromagnetic manganese-based chemically ordered alloys). Additionally, the project aims to install such materials and devices on commercial silicon wafers, ensuring compatibility with standard microelectronics processes and allowing the development of a low-cost, commercially viable sensor technology.

G5796 – MYP "Single Microwave Photon Counter Based on Tunable Flux Qbit"

Participating countries: France, Ukraine, Slovakia, Sweden

The current state-of-the-art approach to measuring qubits involves low-noise cryogenic amplifiers and substantial hardware and electronics, which are difficult to scale up for increased qubit arrays. This Multi-Year Project is developing an advanced microwave single-photon counter based on a superconducting flux qubit with a widely tunable reception frequency, a significantly reduced dark counting rate, and elevated speed. The project has brought together experts from research institutes in France, Ukraine, Slovakia and Sweden, and its results will further the understanding of superconducting qubit operations in single-photon counting.

Energy security

G5729 – MYP "OFICeR: Optimizing Fuel Cell Catalyst Stability upon Integration with Reforming"

Participating countries: Slovenia, Bosnia and Herzegovina, Serbia

Fuel cells work like batteries, but they do not lose power or need recharging. They continue to convert energy as long as fuel is supplied; and they are playing a key role in reducing carbon dioxide emissions, thanks to their high efficiency and their ability to produce electrical energy by dissolving carbon dioxide in an aqueous solution. Improvements in fuel cell performance—combined with their relatively low cost—have the potential to lead to their mass-scale production and to wider use in many fields. This Multi-Year Project, which reached a successful conclusion in 2023, developed an integrated fuel-cell prototype based on highly efficient platinum-based electro catalysts and non-platinum electro-catalysts on graphene-based supports. This allows for the conversion of chemical energy stored in hydrogen or hydrocarbon into electric energy; this technology is particularly attractive because the energy levels of hydrogen are more than three times higher than that of petrol or diesel fuel. The fuel cells developed by this project can be developed into stationary or portable/mobile forms, making them useful for a wide range of applications, in civilian as well as military and security contexts. They are ideal for portable-power applications for soldiers in the field, as well as for auxiliary power units for vehicles, distributed power generation for base camps, and autonomous systems (e.g., robots and UAVs).

G5853 – MYP "Innovative Solar Cells"

Participating countries: Belgium, Ukraine

In recent years, NATO has increased its focus on developing innovative renewable energy solutions with military applications, and the primary goal of this Multi Year Project is the development of mobile light-energy sources that can power wearable, life-saving devices for military use. The research team is using hybrid organic/inorganic-based high-efficiency photovoltaics on flexible lightweight substrates to provide integrated and wearable solar cells for soldiers. The project is innovating technological solutions in the realm of thin-film solar cells, particularly flexible polymer substrates that can provide high power levels in a lightweight, compact configuration. Field-deployed units in modern, high-tech militaries face the constant challenge of keeping its range of electronic devices—portable computers, cameras, sensors and communications systems—charged and operational. They require increased energy, and this project is developing lightweight, flexible solar panels that can be folded to fit in a soldier's cargo pocket. Increasing demand for innovative solar panels also requires an optimal combination of power efficiency, high durability, UV stability, low weight and competitive costs. This project is developing solar cells tailor-made for meeting these demands.

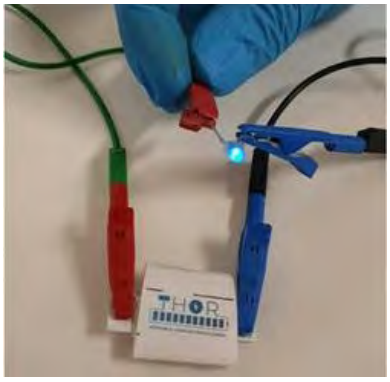
G5949 – MYP "Lightweight 600°C Solid Oxide Fuel Cells for Energy Security"

Participating countries: Türkiye, Ukraine, Azerbaijan, Czechia

The aim of this Multi-Year Project is the development of a lightweight Solid Oxide Fuel Cell (SOFC) that can operate at 600 ºC using hydrogen and propane gas as a fuel. This innovation takes its inspiration from two previous projects developed by the researchers leading this project and is combining the best aspects of both projects. Researchers are utilizing titanium in place of the steel typically used in metal-supported SOFCs in order to produce a lighter-weight and stronger SOFC suitable for wearable and mobile applications, as well as for UAVs, marine and space vehicles and wider military applications. The project is also exploring possibilities to develop a lightened SOFC based on scandium-stabilized zirconia electrolytes deposited on a porous substrate using a dense interconnect and casing made of heat-resistant titanium composites.

G5772 – MYP "Portable Chargers for Soldiers"

Participating countries: Italy, Ukraine, North Macedonia



The purpose of this Multi-Year Project, which was successfully completed in 2023, was the development of a lightweight, efficient and wearable self-charging energy system. The energy system is composed of two independent units: an energy-harvesting unit and an energy storage unit. The first works by converting mechanical energy into electrical energy, using advanced piezoelectric multi-level ceramic-polymeric nanocomposites that combine the excellent performance of ceramics with the mechanical toughness and easily processable characteristics of polymers to achieve lightweight and flexible units with improved piezoelectric properties. The second, the energy storage unit, comprises new, lightweight and flexible

devices that can store a large amount of energy (also known as supercapacitors). This novel, portable charging system provides individual soldiers with constant access to vital energy sources, and has the advantage of partially replacing heavier and environmental-dependent photovoltaic cells as a source of energy. The diversification of energy sources results in a more dependable energy supply and can serve a wider range of energy needs, which can make all the difference in the unpredictable environments that make up contemporary battlespaces.

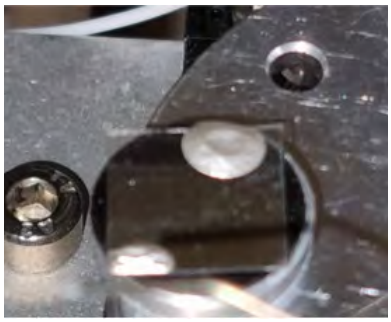
G5836 – MYP "Carbon-based Batteries and Super-capacitators"

Participating countries: Slovenia, Serbia, Montenegro

Batteries are vital pieces of equipment, supporting a wide array of military equipment from equipment that consumes low amounts of power (e.g., night-vision systems, military UPS systems, GPS tracking device, unmanned aerial vehicles, communications systems) to more energy-consuming systems that require systems such transport vehicles, boats, shelter applications, aircraft and missiles. Increasing battery efficiency can provide decisive advantages, and the goal of this Multi-Year Project is the development of a new generation of Lithium-free batteries and supercapacitors based on biomass-derived, low-cost and eco-friendly carbon nanotechnology. Researchers are building a prototype based on a set of novel nanoporous carbon electrodes for the next generation of rechargeable batteries and supercapacitors, relying on abundant and readily available elements such as Sodium, Magnesium, Calcium and Aluminium. Lithium-ion battery technology is experiencing a significant expansion in a broad range of applications, including hybrid electric vehicles, power storage for renewable energy sources and a range of military applications. The scarcity of lithium reserves, however, has triggered extensive research in alternatives to lithium-based battery technology. This project is resulting in more sustainable electrochemical storage systems that make use of significantly cheaper materials. These more accessible materials can help producers avoid the safety risks related to lithium batteries.

G5936 – MYP "ESCAPE: Ultralight wearablE Solar Cells As a Portable Electricity source"

Participating countries: Italy, Israel



The goal of this Multi-Year Project is to develop and realize a novel solar-cell platform that will be ultralight, flexible and wearable and can therefore operate as a portable clean-energy supply capable of supporting soldiers in the field. Researchers are developing a solar-cell device that has at its core two of the most promising nanomaterials currently being used in solar-cell technology: graphene and semiconducting inorganic nanotubes (INTs). The wearable solar cell offers three major advantages over the solutions currently available. They provide longer environmental stability, higher potential efficiencies, and they require cheaper fabrication costs.

Not only will the ESCAPE project develop a cleaner, more reliable, wearable and portable photovoltaic solar cell solution that can be used in a range of operating environments—including in those with harsh conditions such as high temperatures and/or high humidity—it will also advance current technological understanding regarding the potential for exploiting the 'bulk photovoltaic effect' (BPVE). Solar cells based on BPVE are expected to eventually surpass conventional solar cells because they are not constrained by the 'Shockley–Queisser' limit, which is the maximum theoretical efficiency of a solar cell, and will be able to generate high, more efficient photovoltage.

G5910 – MYP "High Energy Calcium-Oxygen Batteries"

Participating countries: Croatia, Serbia, Sweden

Batteries are indispensable in the process of de-carbonisation of the energy sector and the implementation of renewable energy sources. They are of particular importance are their use for energy storage in power plants and in the transportation sector. This Multi-Year Project is developing new and advanced technologies for energy storage and conversion. Researchers are exploring the use of calcium-oxygen (Ca-O2) batteries and their potential to surpass the limitations of lithium-ion batteries. They are combining a calcium metal anode with a metallic oxide catalysed oxygen cathode with the goal of developing a rechargeable, high energy density Ca-O2 battery and making post-lithium battery technologies more efficient and more widely available. Not only does lithium extraction harm the soils and causes air contamination, but also potential lithium scarcities on the horizon are prompting researchers to explore potential alternatives for energy storage. This project has the potential to provide a practical alternative using two abundantly available elements.

Climate change and Environmental security

G5932 – MYP "RESCUE: Sensors for early warning of natural disasters"

Participating countries: United Kingdom, Morocco, Jordan

Early Warning Systems (EWSs) are one of the major applications for wireless sensor networks (WSNs). EWSs are designed to predict or provide early detection of the presence of a risk requiring a fast response. EWSs are especially useful in natural disaster scenarios. Since most natural disasters occur suddenly, effective early warning techniques are highly desirable to mitigate and manage the impact of events. While seismographic data can help societies prepare for natural disaster such as volcanic eruptions and earthquakes, Project RESCUE is focusing its efforts on helping to prepare for flash floods, frost damage, and wildfire. This project is developing EWSs that can exploit recent advances in WSNs in order to improve detection accuracy, response time, energy efficiency and reliability, including the use of hybrid transmission and unmanned aerial vehicles to gather results. The project team is also using the latest developments in artificial intelligence and machine learning to develop bespoke algorithms that can further enhance the proposed EWS. This project could have a significant impact on alleviating the impact of wildfires, frost damage and flash floods, which have extremely adverse effects on regional economies and ecosystems. The system will also enable prompt action to be taken in case of disasters, saving human lives and alleviating the impact on infrastructure.

G6053 – MYP "PHYBI: Inhibition of Bacterial Settlement and Biofilm Formation through Physical Control of the Environment "

Participating countries: Belgium, Ukraine, United Kingdom

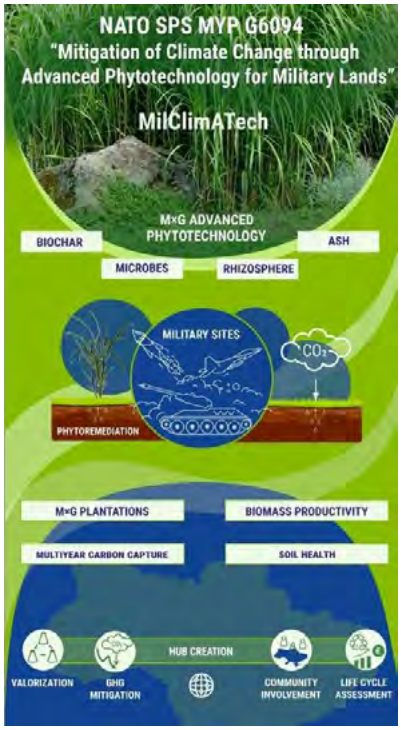
Bacterial biofilms are often detrimental to proper operation of industrial infrastructure (from energy pipelines to installations in contact with water) because they cause microbial corrosion and fouling of membranes. Other biofilms act as a source for antibiotic resistance genes or nosocomial infections, for example, in medical installations. While these biofilms are usually treated by chemical means (e.g., disinfectants added to the water, toxins added to paint layers), the treatment of industrial and human-produced wastewater with these

chemical agents can result in the release of dangerous residues into the environment.

This Multi-Year Project is investigating the potential of three novel metal surface treatment technologies to limit bacterial attachment and subsequent biofilm formation. Researches are exploring the laser-based nanoscale surface-texture smoothing of metal surfaces as well as testing the application of a low voltage perpendicular to metal surfaces and water as a form of impressed current cathodic protection, whose original purpose was as an anticorrosion treatment for ships and port facilities. Lastly, they are transmitting low frequency electromagnetic waves along metal pipelines. These technologies are being rigorously tested within the context of contributing to both energy security and maritime security, given that bacterial growth is able to block fuel lines and attack steel assets in contact with contaminated water. Improved protection, therefore, saves money, effort, and time for maintenance of these assets. Bacterial biofilms are also a source of industrial blockage in pipelines for the transportation of water, wastewater, and for water-filtration membranes. This project, therefore, has the potential to greatly improve civilian water supply networks as well as helping to protect military assets.

G6094 – MYP "Mitigation of climate change through advanced phytotechnology for military lands"

Participating countries: Czechia, Ukraine, Germany, United States, Canada



Military conflicts cause widespread damage and contaminate lands in complex and unpredictable ways. The Russian war of aggression against Ukraine has been as ecological disaster for the country and has had a tremendously negative effect on its natural resources. This includes direct contamination, remnants, pollution from weapons, destroyed military equipment, and the bombing of all Ukrainian territory. The goal of this Multi-Year Project is to environmentally regenerate former military sites and other contaminated lands while also mitigating climate change. Researchers aim to accomplish this by using biomass as an alternative source of energy, which has the potential to make a significant contribution to the mitigation of climate change while also providing alternatives to fossil fuels. They are exploring the thermochemical processes, including gasification and pyrolysis, required for the efficient conversion of biomass into fuel. This project is developing innovative and low-carbon advanced phytotechnologies for the remediation of contaminated military lands, while decreasing Green House Gas release via multiyear growth of C4 plants, which are plants that fix a relatively high volume of carbon into the soil. It is also utilizing biochar from waste as carbon storage and soil enrichment, as well as gasified miscanthus biomass as alternative energy. While repairing the ecological damage to Ukraine will take years, projects such as this are already starting the healing process.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Conclusion

Looking forward to 2024 and beyond, we can remember 2023 as a year when NATO rose to meet the challenges of an increasingly dangerous and unstable world. While the Alliance responded by paving the way for Finland and Sweden to become members, it also proved that support for its partners is far more than rhetorical; and the SPS Programme played a significant role in facilitating many of the relationships that have been fundamental to that support.

The most salient example of the effectiveness of the Programme's work in 2023 is the accelerated cooperation with Ukraine as it fought to maintain its sovereignty against Russian aggression. Amid much uncertainty in the political, security and strategic environment, SPS strengthened its links with the Ukrainian scientific community, and ensured the continuation of scientific cooperation. These collaborations, which focus increasingly on advanced technologies, energy security and digital resilience, are yielding practical and in some cases lifesaving results.

Throughout 2023, SPS played a pivotal role in strengthening scientific ties across partnership frameworks. For instance, the "Indo-Pacific Futures" Multi-Year Project, which started in January, involved all four NATO partners in the Indo-Pacific region—Australia, Japan, New Zealand, and Republic of Korea. Additionally, Colombian scientists engaged in the "CLARIFIER" Multi-Year Project focusing on remote-sensing surveillance were invited to demonstrate the results of their endeavour in the course of 2024.

With an eye to the future, SPS took the opportunity in 2023 to re-examine its Key Priorities in order to better align them with NATO's evolving strategic objectives and political priorities. Just as NATO has had to adapt to new realities in the ever-changing global security landscape, the SPS Programme is preparing to face the uncertainties of the coming years. The last revision of SPS Key Priorities took place in 2012, and agreeing on updated points of focus will allow the Programme to continue supporting security-related cooperation on science, technology and innovation in line with NATO's broader strategic direction. This will ensure the Alliance is agile enough to meet the challenges that lie ahead and allow the Programme to continue seeking more opportunities to engage with scientific communities, making connections between Allied and partner countries and serving as an example of scientific cooperation at its best.

Claudio Palestini
Head, Science for Peace and Security
and Programme Management and Coordination Unit

Annex 1: SPS Activities approved in 2023

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NATO Country	Partner Country	Other Countries
G5980	MYP	Bottom-Up	3a ADV	Flexible Nano-Ferroelectrics for Rapid Cooling of Combat Electronics (FRAPCOM)	SVN	UKR	
G5984	MYP	Bottom-Up	3a ADV	metasuRfacE baSed Platforms fOr devices aND pErsonnel pRotection (RESPONDER)	ITA	SWI	USA
G5990	ASI	Bottom-Up	1c Cyber	Safety and Security through Formal Verification	DEU	SWE	
G5992	ARW	Bottom-Up	1a CT	Countering Hybrid Threats against Critical Infrastructures	ROU	BIH	
G5996	ARW	Bottom-Up	1e Env	Achieving Sustainability in Ukraine through Military Brownfields Redevelopment	ROU	UKR	
G5998	ARW	Bottom-Up	1a CT	Critical Infrastructures Protection in Response to Terrorist Attacks	TUR	UKR	
G6002	MYP	Bottom-Up	1b ES	3D Metamaterial fo Energy Harvesting and Electromagnetic Sensing	LTU	UKR	
G6006	MYP	Bottom-Up	3a ADV	Acoustic Multi-Functional Composites for Environmental Risks and Health Hazards Reduction	BGR	SRB	UZB
G6011	MYP	Bottom-Up	1d CBRN	Conductive Composite Based Flexible and Wearable Chemical Sensors (CONSENSE)	ESP	SRB	NMA DEU

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NATO Country	Partner Country	Other Countries
G6023	MYP	Bottom-Up	3a ADV	Cyberattack Resistant Field Programmable Gate Array (FPGA) Design	TUR	UAE	
G6027	ARW	Bottom-Up	3a ADV	Functional Spintronic Nanomaterials for Radiation Detection and Energy Harvesting`	DEU	UKR	
G6028	MYP	Bottom-Up	1e Env	Control of Black Sea Safety and Pollution Risks Using Numerical Models	USA	GEO	UKR TUR ROU BGR
G6030	MYP	Bottom-Up	3a ADV	New Photosensitive Polymers with Embedded Intelligence	USA	UKR	
G6031	MYP	Bottom-Up	4 Other	Wearable Smart Patches for Multimodal Wound Healing - DRESWOUTRE	ITA	SRB	NMA UKR
G6036	MYP	Bottom-Up	3a ADV	DEPot: A New Dosimetric Emergency Protocol based on Natural Quartz	ITA	SWI	POL GRC GBR
G6037	MYP	Bottom-Up	1b ES	Development of Hydrogen Compressors (NO-DEPENDENCE)	MNE	SRB	ESP
G6040	ARW	Bottom-Up	1d CBRN	Biosecurity: Technological Convergence and Information Hazards	USA	COL	
G6043	ARW	Bottom-Up	1e Env	Building Resilience: Preparing NATO for Climate-Related Security Challenges	GBR	FIN	
G6051	ASI	Bottom-Up	3d HUM	Security of Territorial Communities: Evidence from the Eastern European Countries	POL	UKR	
G6053	MYP	Bottom-Up	1b ES	Inhibition of Bacterial Settlement and Biofilm Formation through Physical Control of the Environment (PHYBI)	BEL	UKR	GBR
G6063	MYP	Bottom-Up	3a ADV	Multisensor Drone Technique for different types of Mine Detection	TUR	UKR	
G6072	MYP	Bottom-Up	3a ADV	Electrical radiation-defects mitigation in deep-UV Ga2O3 p-n junction detectors	USA	ISR	

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NATO Country	Partner Country	Other Countries
G6075	ARW	Bottom-Up	1b ES	Transatlantic Cooperation and New Security Architecture	HRV	ISR	
G6077	ARW	Bottom-Up	1b ES	Renewable energy from anaerobic digestion in remote and off-grid applications	USA	IRL	
G6079	MYP	Bottom-Up	1b ES	Gulf of Aqaba water waves monitoring for environmental safety and security	ITA	ISR	ISR JOR
G6082	MYP	Bottom-Up	3a ADV	Electrochromic metal oxides for transparent superconducting electronics	USA	UKR	
G6083	ATC	Bottom-Up	1b ES	Building the energy security of the state - Support for the energy security of the Republic of Moldova	POL	MDA	
G6085	MYP	Bottom-Up	1e Env	Creating a Strategy for Assessing and Restoring War-affected Aquatic Ecosystems	LTU	UKR	UKR
G6087	MYP	Bottom-Up	1d CBRN	Water Reuse and Membrane Separation Processes for a Reliable and Sustainable Water Supply	HRV	SRB	HUN
G6090	ARW	Bottom-Up	1d CBRN	Regional Strategy for Medical Response as part of the Disaster Management in case of Radiation Emergency caused by the War in Ukraine	ROU	MDA	
G6091	ARW	Bottom-Up	1b ES	Tabletop Exercise: Defending Offshore Energy Infrastructure in the Black Sea	ROU	GEO	
G6094	MYP	Bottom-Up	1b ES	Mitigation of climate change through advanced phytotechnology for military lands	CZE	UKR	UKR, DEU, CZE, USA, CAN
G6096	ARW	Bottom-Up	1b ES	Anion-Exchange Membrane Fuel Cells – A new source of innovative green energy generation	DEU	ISR	
G6101	ARW	Bottom-Up	3a ADV	Full-Spectrum Drone Warfare: Autonomy & AI in Drones Across All Physical Domains Out to 2050	DNK	SWI	
G6106	MYP	Bottom-Up	1e Env	Smart Portable Nanosensors for on-site Biomedical and Environmental Analysis (TERRITORY)	SVK	AUT	CZE
G6107	MYP	Bottom-Up	1d CBRN	Polymeric Hydrogels for Save and Efficient Vaccines	TUR	UKR	

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NATO Country	Partner Country	Other Countries
G6110	ARW	Bottom-Up	1b ES	Post Russia-Ukraine War energy security opportunities	Usa	GEO	
G6111	MYP	Bottom-Up	1b ES	Batteries for Low-temperature Operation < 0C (B-LO Zero)	USA	SWI	
G6112	MYP	Bottom-Up	1a CT	Laser-printed Early Warning Sensors: Quantum Detection of Chemical and Biological Agents (LiGAlert)	POL	AUT	USA POL CZE
G6115	ATC	Bottom-Up	3a ADV	Modern technologies enabling innovative methods for maritime monitoring and strengthening resilience in maritime critical infrastructures	ITA	MAR	
G6116	ASI	Bottom-Up	1d CBRN	Monitoring and Assessment of dumped munitions in the global ocean: an integrated approach	POL	MLT	
G6118	MYP	Bottom-Up	3a ADV	High-resolution chain home radar on optical fiber	LVA	ISR	
G6119	MYP	Bottom-Up	3d HUM	Increasing the capacity of local communities to counteract crisis situations	POL	UKR	
G6122	MYP	Bottom-Up	1e Env	Dynamics above the Epicentre of Climate Change (DECC)	DEU	FIN	SWE, NOR
G6123	ASI	Bottom-Up	1c Cyber	Cybersecurity in the era of quantum computing: threats and challenges	POL	MAR	
G6124	ARW	Bottom-Up	1a CT	Emerging Threats: Implications for Gulf Security and the Role of NATO	TUR	QAT	
G6128	MYP	Bottom-Up	3a ADV	Self-healing and self-lubricating nanocomposites for atmosphere/vacuumbearings	ESP	UKR	EGY
G6131	MYP	Bottom-Up	1b ES	FM-I SYSTEMS WITH IMPROVED MAGNETOTRANSPORT PROPERTIES FOR SPINTRONIC DEVICES	SVK	UKR	
G6132	ATC	Bottom-Up	1b ES	Critical Energy Infrastructure Protection and Resilience Course	DEU	KWT	
G6133	MYP	Bottom-Up	1c Cyber	Symbolic rewriting methods for safety and security of critical cyber-physical systems	ESP	GEO	NOR, UKR, ROU, KOR, FRA

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NATO Country	Partner Country	Other Countries
G6134	ARW	Bottom-Up	3a ADV	Emerging Disruptive Technologies (EDTs) in Defence: Lessons from Ukraine	TUR	SWI	
G6137	MYP	Bottom-Up	1e Env	MaritimE Sea Laser Instrumentation for Tectonic dynamics Exploration	FRA	ISR	GBR POL ITA
G6140	MYP	Bottom-Up	1a CT	Advanced technologies for Physical ResIlience Of cRitical Infrastructures (APRIORI)	ITA	MDA	SVA, ITA, LVA
G6141	MYP	Bottom-Up	1e Env	Federated laboratories for testing formations of responsive satellites	ITA	SWE	GBR
G6147	ARW	Bottom-Up	1a CT	Digital Technologies for Enhanced Cyber Resilience in Countries in Transition	USA	UKR	
G6153	MYP	Bottom-Up	3a ADV	Stealth coatings based on 3D architectures of high entropy materials	ROU	MDA	CZE
G6158	MYP	Bottom-Up	3a ADV	QSCAN - Quantum-enabled secure multiparty computation for space surveillance tracking	PRT	AUT	
G6166	MYP	Bottom-Up	1b ES	Ultra-durable and efficient nano-engineered full cells (URANUS)	ITA	UKR	
G6169	MYP	Bottom-Up	1d CBRN	DeeP-MaRS: An AI-assisted Bioweapon Detection Platform	USA	QAT	TUR
G6176	MYP	Bottom-Up	3a ADV	Composite Metamaterials for Aerospace Structures - CoMetA	ITA	UKR	
G6181	ARW	Bottom-Up	4 Other	Addressing systemic legal and policy challenges of mercenaries and related actors in contemporary armed conflicts: Beyond the Wagner Group	DNK	SWI	
G6182	ARW	Bottom-Up	1b ES	Running on Empty – Increasing Military Mobility on the Eastern Flank	POL	UKR	
G6187	MYP	Top-Down	3a ADV	SAPIENCE: Sense & Avoid - a cooPeratIvE droNe CompEtition	GBR	AUT	NLD, USA
G6188	MYP	Top-Down	1e Env	Enhancement of the Next-Generation Incident Command System (NICS) in Bosnia and Herzegovina (BiH)	USA	BIH	

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NATO Country	Partner Country	Other Countries
G6189	MYP	Top-Down	1a CT	Enhancing Tunisian Counter-IED Capabilities	GBR	TUN	
G6190	MYP	Top-Down	1e Env	Post-Earthquake Monitoring of Seismically-induced Chains of Landslide Hazards (SHAKEN) for Protection of Critical Sites and Infrastructure	TUR	PAK	USA NLD TUR
G6191	ARW	Top-Down	1e Env	Emerging and Disruptive Technologies to Enhance Disaster Resilience	USA	AUS	
G6192	ARW	Bottom-Up	3d HUM	Digital Tools for Prevention, Mitigation, and Treatment of Traumatic Stress Responses in Terror and War - Contemporary Practices and Novel Insights	NLD	GEO	
G6194	MYP	Bottom-Up	3a ADV	Blending Silk and Gallium Nitride Electronics for Detection Technology	USA	ISR	
G6203	ARW	Bottom-Up	1e Env	Fact Sheet: Low dose radiation risks: present research and future perspectives	CAN	ARM	
G6216	ARW	Bottom-Up	2 OPS	Facilitating Ukraine's transition to the NATO standards: military, doctrinal and legal aspects	POL	UKR	
G6218	ARW	Bottom-Up	1c Cyber	Isogeny-based Post-Quantum Cryptography	USA	ISR	

Annex 2: SPS Events (ARW, ATC, ASI) hosted in 2023

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NPD Country	PPD Country	Event Location	Starting Date	Ending Date
G5994	ARW	Top-Down	1d CBRN	Biotechnology and Human Enhancement: Present Research and Future Perspectives	ITA	KOR	San Felice Circeo, Italy	03/10/23	05/10/23
G5996	ARW	Bottom-Up	1e Env	Achieving Sustainability in Ukraine through Military Brownfields Redevelopment	ROU	UKR	Oradea, Romania	18/12/23	21/12/23
G5998	ARW	Bottom-Up	1a CT	Critical Infrastructures Protection in Response to Terrorist Attacks	TUR	UKR	Istanbul, Türkiye	23/10/23	25/10/23
G6027	ARW	Bottom-Up	3a ADV	Functional Spintronic Nanomaterials for Radiation Detection and Energy Harvesting`	DEU	UKR	Kyiv, Ukraine / online	25/09/23	27/09/23
G6043	ARW	Bottom-Up	1e Env	Building Resilience: Preparing NATO for Climate-Related Security Challenges	GBR	FIN	London, United Kingdom	25/09/23	26/09/23
G6052	ARW	Top-Down	1b ES	Energy Strategies 2022 – Integration and Diversification in the Mediterranean	ITA	ISR	Rome, Italy	25/11/23	25/11/23
G6067	ARW	Top-Down	3a ADV	International Workshop: Pursuing Quantum Sensing for Reliable Roadmaps	ITA	AUS	Frascati, Italy	05/12/23	07/12/23
G6075	ARW	Bottom-Up	1b ES	Transatlantic Cooperation and New Security Architecture	HRV	ISR	Zagreb, Croatia	19/10/23	21/10/23
G6090	ARW	Bottom-Up	1d CBRN	Regional Strategy for Medical Response as part of the Disaster Management in case of Radiation Emergency caused by the War in Ukraine	ROU	MDA	Bucharest, Romania	19/09/23	21/09/23
G6134	ARW	Bottom-Up	3a ADV	Emerging Disruptive Technologies (EDTs) in Defence: Lessons from Ukraine	TUR	SWI	Instanbul, Türkiye	27/10/23	29/10/23
G6182	ARW	Bottom-Up	1b ES	Running on Empty – Increasing Military Mobility on the Eastern Flank	POL	UKR	Warsaw, Poland	12/12/23	13/12/23

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NPD Country	PPD Country	Event Location	Starting Date	Ending Date
G6191	ARW	Top-Down	1e Env	Emerging and Disruptive Technologies to Enhance Disaster Resilience	USA	AUS	Adana, Türkiye	13/10/23	15/10/23
G5990	ASI	Bottom-Up	1c Cyber	Safety and Security through Formal Verification	DEU	SWE	Markto-berdorf, Germany	01/08/23	12/08/23
G6051	ASI	Bottom-Up	3d HUM	Security of Territorial Communities: Evidence from the Eastern European Countries	POL	UKR	Krakow, Poland	13/11/23	17/11/23
G6070	ATC	Top-Down	1c Cyber	Network Security Course	USA	DZA	Algiers, Algeria	20/11/22	26/01/23
G6071	ATC	Top-Down	1c Cyber	Network Vulnerability Assessment & Risk Mitigation Course	DEU	KWT	Kuwait City, Kuwait	05/03/23	11/05/23

Annex 3: SPS Multi-Year Projects (MYP) completed in 2023

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NPD Country	PPD Country	Other Countries
G5395	MYP	Top-Down	1a CT	Microwave Imaging Curtain (MIC)	FRA	UKR	KOR
G5486	MYP	Bottom-Up	1d CBRN	Early Detection and Diagnosis of Emerging Biological Threats	ITA	KAZ	
G5526	MYP	Top-Down	1a CT	Explosive Trace Detection for Standex (EXTRAS)	ITA	SRB	UKR, NLD, DEU
G5568	MYP	Top-Down	3a ADV	Mobile Adaptive/Reactive Counter Unmanned Aerial System (MARCUS)	USA	SWI	
G5605	MYP	Top-Down	1a CT	INtegrated System for Threats EArly Detection (INSTEAD)	ITA	FIN	
G5607	MYP	Bottom-Up	3c UXO	Accelerating Mine Clearance by Introducing a User-Friendly and Cost-Effective Dual-Sensor Detector in Humanitarian Demining Operations	NLD	JPN	BIH
G5618	MYP	Bottom-Up	3a ADV	Biological and Bioinspired Structures for MultiSpectral Surveillance	HRV	SRB	
G5638	MYP	Bottom-Up	3a ADV	Development of Micro-Scale, Bio-Inspired Passive Drone System	CAN	KOR	
G5647	MYP	Bottom-Up	1d CBRN	Determination of Exposed Dose and Radioactive Source Identity in Radiological Emergency	TUR	ISR	USA, POL, UKR, NZL
G5674	MYP	Bottom-Up	1a CT	Enhancing Security at Borders and Ports (E-SiCure2)	HRV	JPN	SVN, PRT
G5721	MYP	Bottom-Up	3a ADV	Miniaturized Terahertz sources for Humans and Environmental SEcUrity (THESEUs)	ITA	SWI	ISR

SPS Reference	Activity Type	Origin	Primary Key Priority	Title	NPD Country	PPD Country	Other Countries
G5729	MYP	Bottom-Up	3a ADV	Optimizing Fuel Cell Catalyst Stability upon Integration with Reforming - OFICeR	SVN	BIH	SRB
G5731	MYP	Bottom-Up	3c UXO	Demining 4.0: Multi-Sensor Cooperative Robots for Shallow Buried Explosive Threat Detection	ITA	UKR	USA, JOR
G5748	MYP	Bottom-Up	3a ADV	Radiation and Electron Injection in Gallium Oxide for deep Ultra Violet Detection	USA	ISR	
G5751	MYP	Bottom-Up	3c UXO	The Optical Nose Grid for Large Indoor Area Explosives' Vapours Monitoring - ORION	GBR	SRB	USA
G5772	MYP	Bottom-Up	1b ES	Portable chargers for Soldiers	ITA	UKR	NMA
G5773	MYP	Bottom-Up	3a ADV	Advanced material engineering to address emerging security challenges	USA	UKR	
G5777	MYP	Bottom-Up	3a ADV	2D material-based low cost SENSor of aggressive substancEs (2DSENSE)	ITA	FIN	
G5795	MYP	Bottom-Up	3a ADV	Gases and Analytes with Terahertz Sensors (GATES)	SVK	AUS	
G5969	MYP	Top-Down	1a CT	DEXTER Big City Trial	ITA	FIN	FRA, NLD, SRB, UKR, DEU, KOR

Annex 4: The Independent Scientific Evaluation Group in 2023

The ISEG is composed of scientists and experts nominated by NATO countries and appointed by the Partnerships and Cooperative Security Committee (PCSC) for a mandate of three years. Once appointed, ISEG members do not represent their respective nations. They are selected on the basis of their scientific and technical expertise in one or more of the SPS Key Priorities, as well as their experience and potential to contribute to the Group's work. The NATO Science and Technology Organisation (STO) also nominates up to two experts as members of the ISEG.

The main role of the ISEG is to evaluate the scientific and technical merit of SPS applications. ISEG members contribute to defining the boundaries of 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.

At the end of 2023, the ISEG was composed of 27 experts:

- Dr. Vojtech Adam, Czechia
- Assoc. Prof. Dr. Fehmi Akgün, Türkiye
- Dr. David Jean-Paul Alexander, United States of America
- Dr. Konstantinos Balomenos, Greece
- Prof. Miguel Bastos Araujo, Portugal
- Dr. Maria-Louise Clausen, Denmark
- Prof. Dr. Ing. Habil. Mihai Datcu, Romania
- Assoc. Prof Lucia Figuli, Slovakia
- Prof. Dr. Luca Fiorani, Italy
- Assoc. Prof. Matteo Gerlini, Italy
- Mr. Peter Grognard, Belgium
- Dr. Zoltan Jobbagy, Hungary
- Dr. Lukasz Jurczyszyn, Poland
- Assoc. Prof. Stamatios Kalligeros, Greece
- Dr. Cagatay Karabat, Türkiye
- Lt. Col. Claudiu-Silviu Lazaroaie, Romania
- Prof. Petar Marinov, Bulgaria
- Prof. Jadranko Matusko, Croatia
- Assoc. Prof. Dr. Karol Nemoga, Slovakia
- Dr. Ulrik Neupert, Germany
- Lt. Col. Antonio Palermo, NATO Office of the Chief Scientist
- Mrs. Andreea Paulopol, United States of America
- Prof. Dr. Delphine Resteigne, Belgium
- Assoc. Prof. Mariusz Ruszel, Poland
- Mr. Raúl Rodríguez Sánchez, Spain
- Dr. Hana Stredova, Czechia
- Dr. Tamas Szadeczky, Hungary

Annex 5: SPS Grant Mechanisms

Multi-Year Projects (MYP)

MYPs are Research and Development (R&D) projects. They enable scientists from NATO and its partner nations to collaborate on applied R&D and capacity building projects that result in new scientific advancements with practical application in the security and defence fields. MYPs enable participating countries to increase contacts in scientific communities while building a stronger scientific infrastructure in their home countries. Sustainability is ensured through the involvement of end-users offering advice and guidance throughout the lifetime of the projects with the aim of taking up and implementing the results. Projects involving more than one NATO and one partner nation are encouraged, as is the participation of young scientists. These projects have an average duration of two to three years.

Advanced Study Institutes (ASI)

ASIs are high-level tutorial courses conveying the latest developments in topics of relevance for NATO and the SPS Key Priorities to an advanced-level audience. 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 Training Courses (ATC)

Through ATCs, specialists share their security-related expertise in one of the SPS Key Priority areas with participants from NATO and partner countries. ATCs are not intended to be lecture-driven, but to be intensive, interactive and practical in nature. Courses contribute to the training of experts in partner nations and enable the formation and strengthening of international expert networks. These tailor-made modular courses respond to the needs of partner nations. Trainees are chosen based on their qualifications and experience, and the benefits they may draw from the ATCs in their future activities. ATCs typically take place over five to seven working days.

Advanced Research Workshops (ARW)

Advanced Research Workshops (ARW) are advanced-level discussions that provide a platform for experts and scientists from different countries to share their experience and knowledge on security-related topics. These events aim to identify directions for future action to address contemporary security challenges, and often are the starting points for follow-on activities such as SPS Multi-Year Projects. ARWs typically take place over two to five days and gather 20-50 participants.

Annex 6: SPS Key Priorities from 2024 onwards

1 Environment, Climate Change and Security

- Understanding, mitigating and adapting to the impact of climate change on security, including military operations and missions;
- Increased awareness on security issues arising from key environmental and climate change challenges, including health risks, scarcity of resources, increasing energy needs, and space weather events;
- Approaches to reduce the environmental impact of military activities;
- Disaster forecast and prevention of climate-related natural catastrophes.

2 Energy Security

- Dual-use innovative energy solutions; battlefield energy solutions; renewable energy solutions with dual-use applications;
- Energy infrastructure security, including technological aspects of energy security;
- Energy transition by design, i.e. transition from fossil fuels to innovative and more sustainable energy sources;
- Energy supply chain.

3 Innovation and Emerging Disruptive Technologies (EDTs)

- Emerging technologies with the potential of having a profound impact on security, including:
  - artificial intelligence (AI);
  - autonomy;
  - quantum;
  - biotechnologies and human enhancement;
  - space;
  - novel materials and manufacturing;
  - energy and propulsion;
  - next-generation communications networks;
- Defence against adversarial use of EDTs;
- Advanced and novel technologies in the field of security.

4 Counter-terrorism

- Detection technologies against the terrorist threat of explosive devices and other illicit activities;
- Solutions to Counter Improvised ExplosiveDevices (C-IED);
- Defence against terrorism misuse of technology, for example Countering Unmanned Aircraft Systems (C-UAS);
- Human factors in the defence against terrorism, including Preventing/Countering Violent Extremim (P/CVE);
- Risk management, best practices and technologies in response to terrorism, including Chemical, Biological, Radiological and Nuclear (CBRN) Defence.

5 Chemical, Biological, Radiological, and Nuclear (CBRN) and Explosive Hazards Management

- Mine and Unexploded Ordnance (UXO) detection;
- Methods and technology regarding the protection against, diagnosing effects, detection, decontamination, destruction, disposal and containment of CBRN Agents;
- Risk management and recovery strategies and technologies;
- Medical countermeasures against CBRN Agents.

6 Defence against Hybrid Threats

- Technological solutions and approaches to prepare, deter and defend against the coercive use of political, energy, information and other hybrid tactics by states and non-state actors;
- Solutions and approaches to prepare, deter and defend against hybrid tactics, both directly and through proxies, as authoritarian actors challenge our interests, values and democratic way of life;
- Practical tools to monitor, analyse, raise awareness on, and counter disinformation, including through cooperation with technological industries and social media platforms, such as generative artificial intelligence and deep fakes;
- AI tools, including reverse image technology, to detect malicious information activities;
- Early warning tools to detect potential hybrid activities, including in the information space.

7 Resilience

- Solutions to strengthen national preparedness;
- Crisis management and civil preparedness, including inter-agency coordination mechanisms;
- Digital resilience, including methods, procedures and technologies to ensure continuity of digital services during crises;
- Protection of critical infrastructure, supplies and personnel;
- Border and port security technologies.

8 Critical Underwater Infrastructure

- Monitoring and protection of critical underwater infrastructure;
- Technology for the detection of threats on surface and underwater;
- Protection of harbours and infrastructures in shallow waters.

9 Cyber Defence

- Technologies to ensure confidentiality, integrity and availability of communication networks;
- Support in developing cyber defence technologies and infrastructure;
- Best practices and information sharing;
- Cyber defence situational awareness;
- Cyber support to operations and missions.

10 Assessing and addressing threats posed by the Russian Federation

- Approaches and tools to counter hostile information activities (including disinformation) against Allies and Partners;
- Identification of trends and lessons learned for hybrid threats emanating from the Russian Federation.

11 Strategic Foresight

- Main trends in international security and associated implications;
- Regional strategies in the field of defence and security;
- Understanding of the future security environment;
- Early warning systems and indicators.

12 Human and Social Aspects of Security

- Women, Peace and Security (WPS);
- Human Security;
- Cultural and social aspects in operations and missions.

13 Operational Support

- Identifying and sharing best practices in operations and missions;
- Civilian support to operations and missions.

14 Other

- Any other proposal clearly linked to the implementation of NATO's core tasks may also be considered for funding under the SPS Programme.

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0526-24 Printing & Graphics (EM(ICTM)AIM)