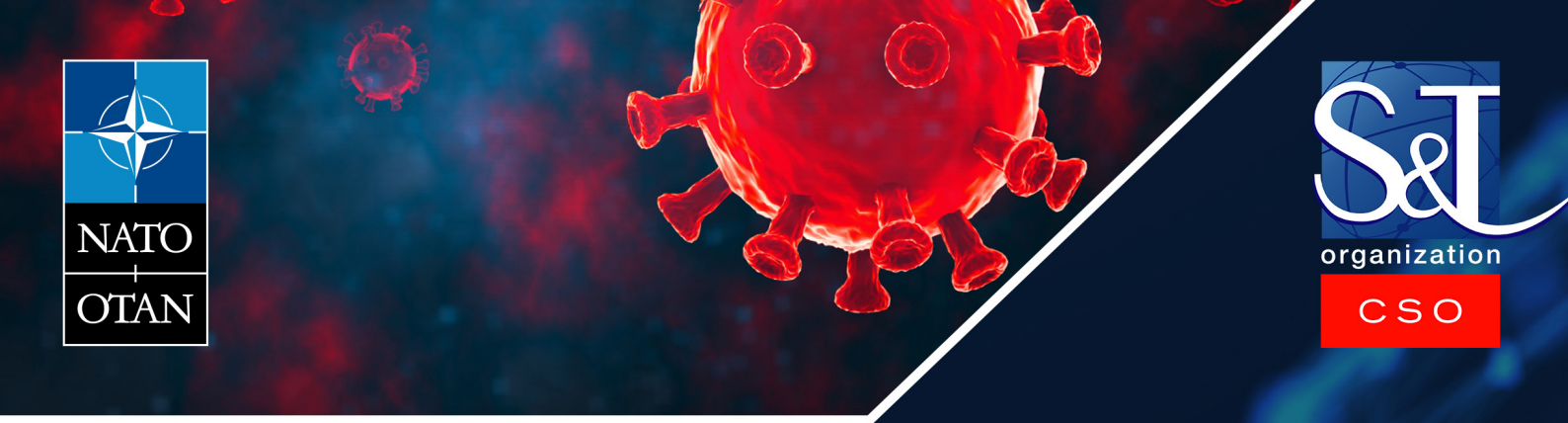

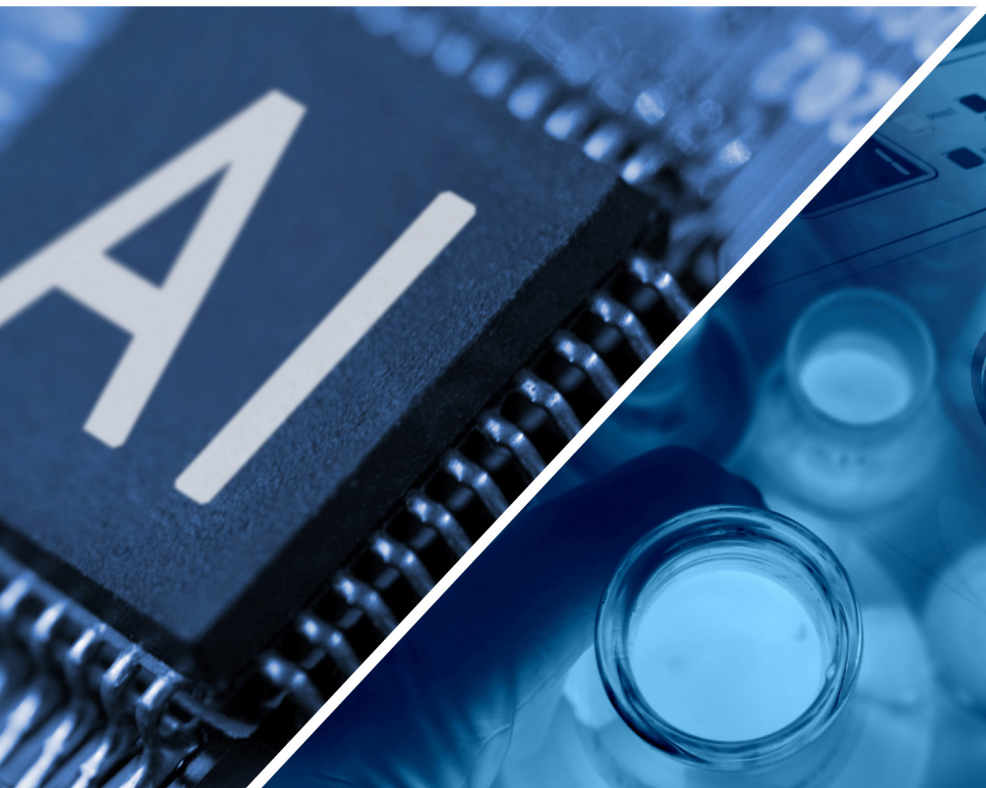

2021 COLLABORATIVE PROGRAMME OF WORK

NATO Science and Technology Organization

PREFACE

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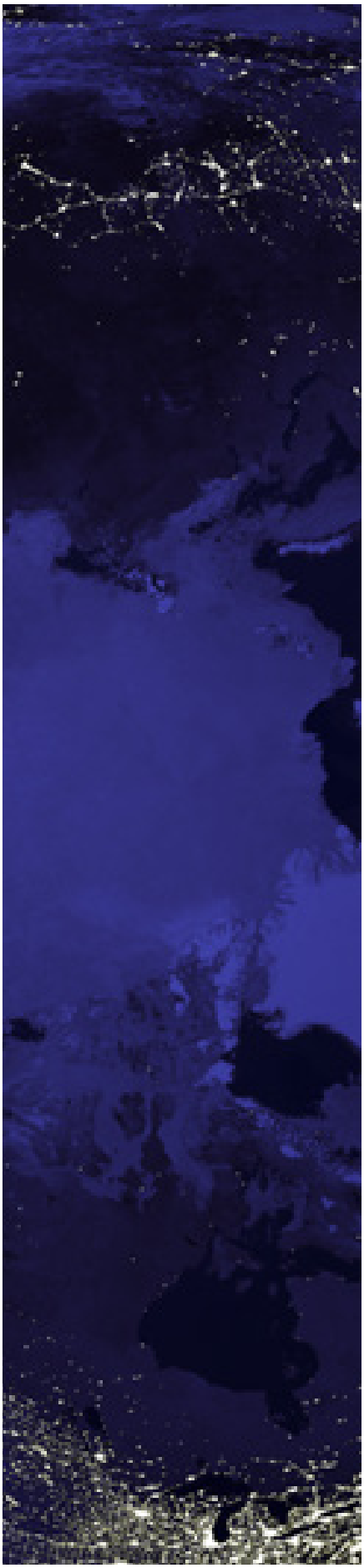

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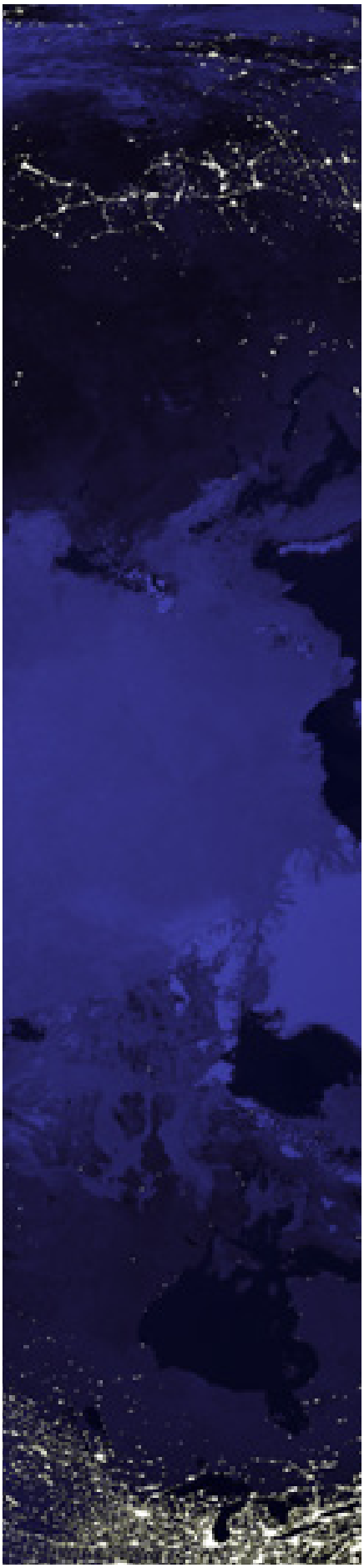

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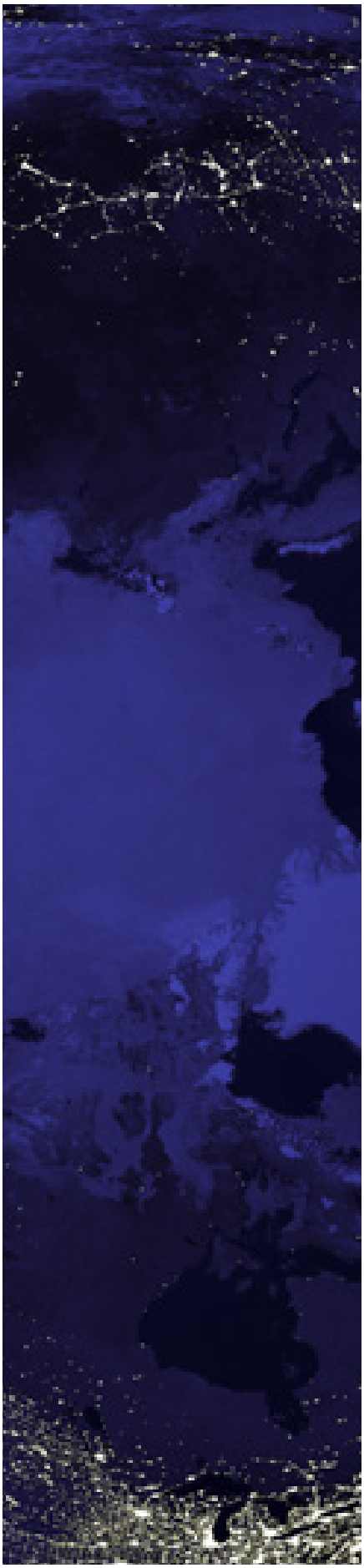

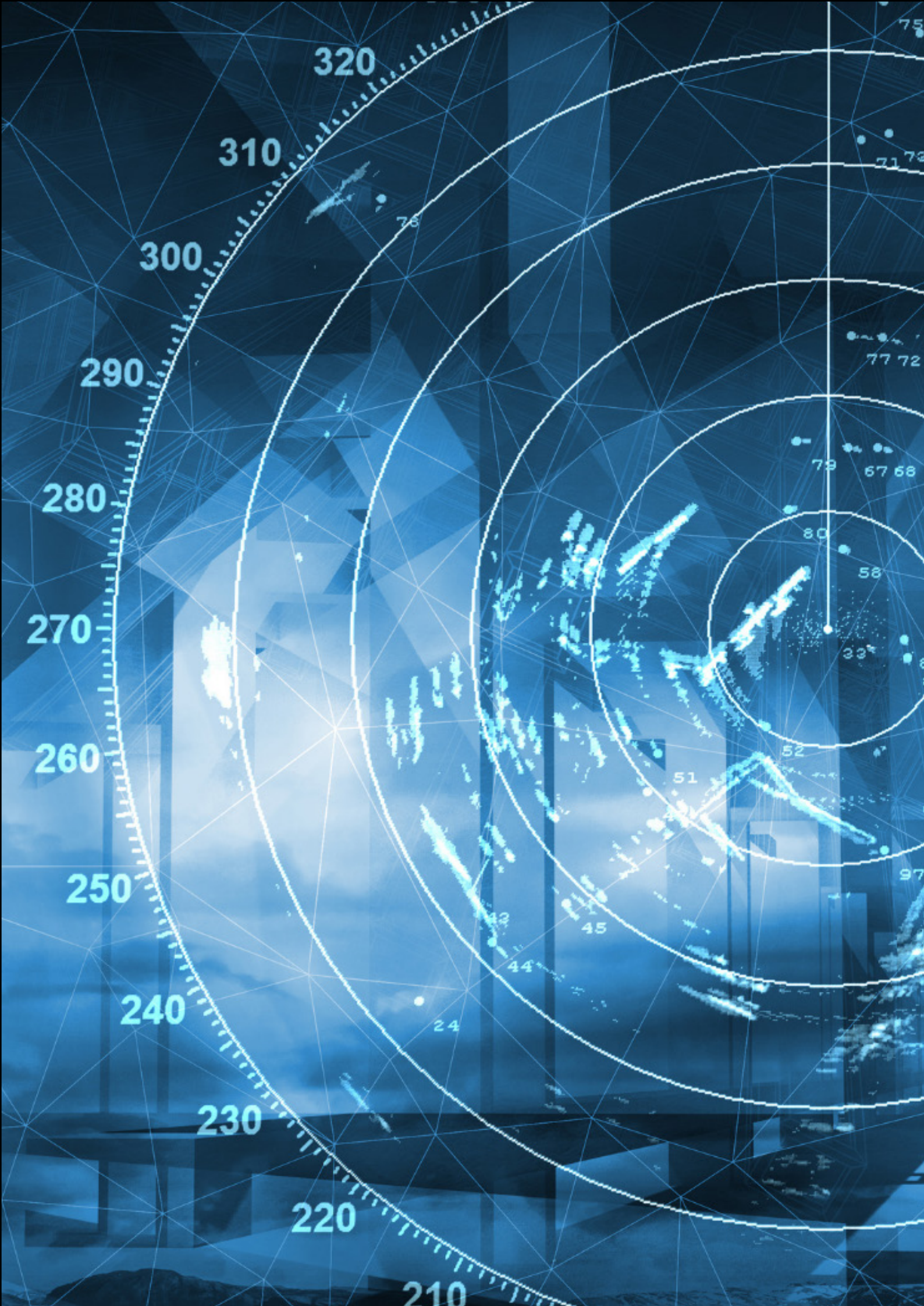
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PREFACE

As we start a new year, I have the pleasure to present in this brochure the NATO Science & Technology Organization's (STO) Collaborative Program of Work (CPoW) for 2021.

The CPoW materializes the STO's collaborative business model, which provides a forum whereby NATO and Partner Nations elect to jointly leverage their national resources with NATO's to define, conduct, and promote cooperative research and information exchange for the benefit of NATO and the contributing Nations.

STO is composed of three executive bodies: the Office of the Chief Scientist (OCS) at NATO HQ; the Centre for Maritime Research & Experimentation (CMRE) in La Spezia, ITA; and the Collaboration Support Office (CSO) near Paris, FRA.

The CSO mission is to provide executive and administrative support to the network of experts that, within the CPoW, conduct defence and security-relevant research and technology development leading ultimately to enhanced operational military capabilities within NATO and the Nations.

In recent years, our goal has been to pursue our long-term efforts in strengthening the CPoW. This collaborative programme is highly appealing to experts and the network has been steadily growing, reaching in 2020 approximately 6,000 scientists, engineers, and analysts originating from 29 NATO and 48 Partner Nations, and representing national laboratories, academia, and industry.

This Collaborative Programme of Work and Budget for 2021 comprises close to 350 ongoing and planned activities (run by Technical Teams). 13 Collaborative Demonstrations of Technologies (CDTs) are planned and more than 100 technical reports and meeting proceedings should be published.

In order to sustain this high tempo and secure effective and qualitative executive and administrative support to the network, the CSO will be reinforced and will implement a reorganization this year, following NAC approval of its new Peacetime Establishment (PE). This reorganization will improve manpower resilience and will provide additional administrative support to the CPoW where needed. It will also synergize structures and processes to improve the network cyber-security, cross-domain coordination, corporate communication, and exploitation of scientific findings to the benefit of our community as well as address NATO Nations' and NATO S&T Stakeholders' requirements for better cooperation and coherence within NATO on S&T matters.

2021 will likely be impacted by continuing COVID 19 pandemic and travel restrictions. Our Technical Teams were not able to meet physically in 2020 and most of the research work was conducted virtually. About one third of the CPoW is currently delayed and some Technical Teams, which require physical meetings such as CDTs and Field Trials, have been postponed until 2021. The ongoing travel restrictions have also had a major impact on our classified Technical Teams and many of these activities have been delayed until 2021 as well. On a more positive note, virtual meetings have provided the opportunity for an increased number of experts to participate and contribute. One of our primary objectives for 2021 is to catch up on the most essential S&T work.

Much of the essential work is related to Emerging and Disruptive Technologies (EDTs). In 2020, the STO published a Technology Trends Report focused on EDTs and the CPoW consisted of approximately 50% of the CPoW activities focused on EDTs and their impact on future main operational capabilities. We will continue to support this NATO effort with short-, mid- and long-term reviews of existing, planned, and proposed activities, across all Panels and Groups, aiming at promoting EDT-related cross-domain research at CPoW level, within the STO with the CMRE and with our NATO S&T Stakeholders.

To conclude, as I have done in previous years, I want to recognize that the core of the CPoW business is managed by the Scientific and Technical Committees of the STO (i.e., the Applied Vehicle Technology (AVT), Human Factors and Medicine (HFM), Information Systems Technology (IST), Systems Analysis and Studies (SAS), Systems Concepts and Integration (SCI), and Sensors and Electronics Technology (SET) Panels and the NATO Modelling and Simulation Group (NMSG)). These seven so-called Level 2 Committees are led, on a part-time basis, by voluntary national contributors who do a commendable job. The entire CPoW network benefits and appreciates their leadership, which is typically in addition to their normal jobs, duties, and responsibilities. Last year, due to the pandemic, the work of all Panel and Group leadership was much more difficult in terms of keeping up the S&T work pace and keeping our network engaged. We warmly thank these volunteers and their Nations for the exceptionally fine work they have done in these demanding positions.

Pavel Zuna

Director, STO Collaboration Support Office

STO: WHO ARE WE?

The STO is a NATO subsidiary body created to meet the collective Science and Technology needs of the NATO Alliance and its partner nations. The STO does this by generating, sharing, and disseminating advanced scientific knowledge, technological developments, and innovation resulting from its many activities completed within the Collective Programme of Work (CPoW).

HOW ARE WE ORGANISED?

The organization is led by the Science and Technology Board that exercises governance through the following executive bodies:

- **The Office of the Chief Scientist (OCS)** provides executive and administrative support to the Chief Scientist to exercise the role of Chair of the Science and Technology Board and as the primary Scientific Advisor for NATO. The OCS promotes the exploitation of the results generated within the CPoW to numerous internal stakeholders and partners.
- **The Collaboration Support Office (CSO)** provides executive and administrative support to collaborative activities, maintains an active network of scientists, and runs six Technical Panels and one Group that organize technical activities.
- **The Centre for Maritime Research and Experimentation (CMRE)** organizes and conducts scientific research and technology development and delivers innovative and field tested S&T solutions in the maritime domain to address the defence and security needs of the Alliance.

HOW DOES CSO FUNCTION?/HOW DO WE STRUCTURE OUR WORK IN CSO?

The CSO provides NATO Nations and Partners Nations with a technical forum where researchers and analysts can define, conduct and promote cooperative research and information exchange. The CSO runs its many activities through a collaborative business model. The international collaborative programme of work is carried out in 7 different technical areas. These technical areas are represented by 6 Panels and 1 Group running their scientific effort within several types of scientific activities (see section 4).

ACTIVITY LIFECYCLE

The Panels/Group take the initiative to create technical activities based upon top-down guidance from NATO and the Nations, and bottom-up initiatives from the NATO scientific community. The Panels/Group usually meet twice a year (in Spring and Fall) during Panel (Group) Business Meetings (PBMs) which are medium-scale, two-to-three day events. Technical activities are organized in teams of national experts with clearly defined scopes and products as goals at the end of the activity. The Activity lifecycle is depicted in Figure 1.

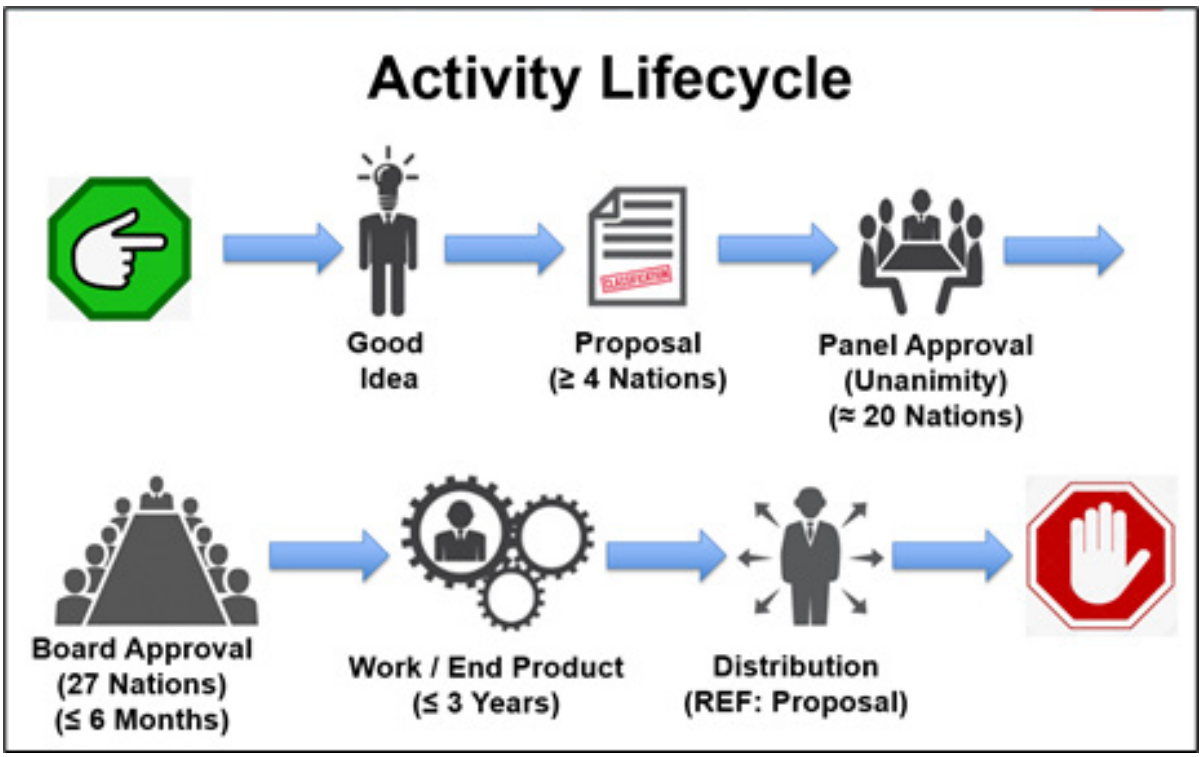


Figure 1: Activity lifecycle

Ideas for new activities may originate from NATO bodies, Panel Members, or scientists or engineers within any of the participating nations. However, it is mandatory that the activity be supported by a minimum of at least four nations before being initiated.

After an activity draft has been put together, a Technical Activity Proposal (TAP) is presented to the Panels/Group for decision prior to the upcoming PBMs. After the submission, a TAP has to be approved unanimously by the Panel. After the PBM, the new activities, which have been endorsed by the Panel, are submitted to the STB for approval through a two-week silence procedure. Following the silence procedure, the activity is officially approved provided that no objection is raised during the two weeks. Depending on the type of an activity, a technical report or a meeting proceedings publication can be generated as a final result.

Figure 2: All Unclassified STO Scientific Publications are Available on Our Website at: www.sto.nato.int

HOW TO JOIN US

Whether you are a government representative, a military member, a specialist from industry, or an academic interested in any of our research topics, you can join our activities. There are two required steps in order to be a part of the CSO activities:

1) Contact your National Coordinator.

The national coordinator is an individual designated by the nation to facilitate his/her nation's participation in the STO. The list of institutions responsible for national coordination could be found on our website: https://www.sto.nato.int/Pages/national-coordinators.aspx

After you reach out to a national coordinator, he/she can provide you with more details on how your country is involved in activities and put you in contact with national representatives within a panel.

2) Contact the Panel Executive/Assistant.

If you know which panel you are interested in, you can directly contact the Panel Office that would give you directions on how to join activities. Contact information for each Panel can be found at: https://www.sto.nato.int/Pages/contactus.aspx

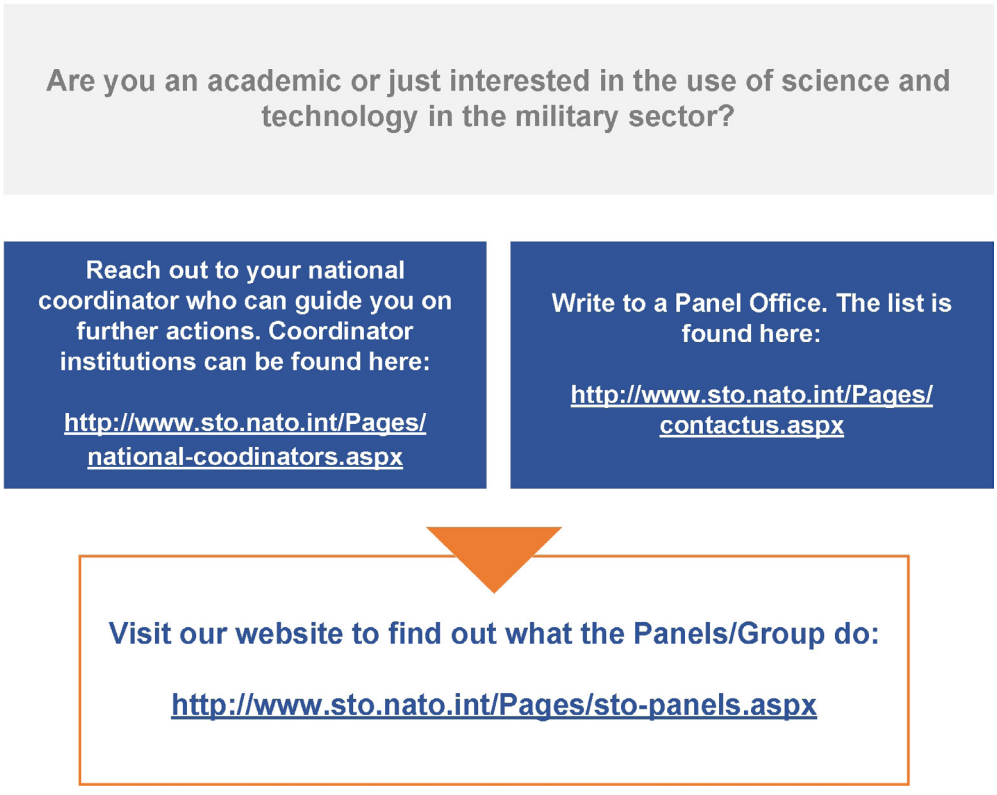


Figure 3: Where to Find the Points of Contact?

STO PANELS, GROUPS AND ACTIVITIES

The scientific and technical committees consist of six Technical Panels that manage a wide range of scientific research activities, and one Group specializing in modelling and simulation. The Panels and Group are the powerhouse of the collaborative model and are made up of national representatives as well as recognized world-class scientists, engineers and information specialists. The Panels and Group are responsible for proposing and managing the scientific work programme. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The current Level 2 committee structure consists of the following six Panels and one Group:

- **Applied Vehicle Technology (AVT)**
- **Human Factors and Medicine (HFM)**
- **Information Systems Technology (IST)**
- **System Analysis and Studies (SAS)**
- **Systems Concepts and Integration (SCI)**
- **Sensors and Electronics Technology (SET)**
- **NATO Modelling and Simulation Group (NMSG)**

Each Panel/Group's Programme of Work will be carried out by Technical Teams made up of national experts. Prior to launching a Technical Team, when a Panel/Group believes that a particular expertise is required to assist or advise it on the technical merit or feasibility of a specific proposal, an **Exploratory Team (ET)** is established. An ET is the CSO's instrument for carrying out a feasibility study to establish whether it is worth starting a bigger activity. During the PBM, each NATO Nation in the Panel/Group is polled to determine if it is willing to allocate resources and participate in a future ET on the topic. If this is the case, the ET finalizes the TAP and submits it to the Panel Office for revision. The step of involving an ET is sometimes omitted if the idea has a strong support and can go straight into a Technical Activity. The ET is, however, an essential supporting instrument for young/new scientists who wish to scope their proposal for a Technical Team.

Technical Teams are assigned by the Panels/Group to perform specific tasks, such as:

- **Research Task Group (RTG) –** study group, up to 3 years;
- **Specialist Team (ST) –** quick reaction;
- **Research Workshop (RWS) –** selected participation, 2 – 3 days;
- **Research Symposium (RSY)** – more than 100 people, 3 – 4 days;
- **Research Specialists' Meeting (RSM)** – up to 100 people, 2 – 3 days;
- **Research Lecture Series (RLS) –** junior and mid-level scientists;
- **Research Technical Course (RTC);**
- **Support Project (SP);**
- **Long-Term Scientific Study (LTSS);**
- **Multinational Exercise (MNE);**
- **Military Application Study (MAS);**
- **Advanced Guidance for Alliance Research and Development (AG – AGARDograph).**

A Research Task Group (RTG) technical team activity allows researchers from different nations to work together in order to solve a particular scientific research and technology development problem. RTGs are sponsored by the Panel/Group to meet the needs of NATO. RTGs are chartered for a maximum of three years after the initial meeting. Among the activities conducted during an RTG, **a Cooperative Demonstration of Technology (CDT)** may be organized. The findings will be documented in an STO publication (Technical Report or Technical Memoranda).

A Research Lecture Series (RLS) technical team activity aims to disseminate state-of-the-art scientific knowledge among junior and mid-level specialists, scientists and engineers in military-relevant domains that are not taught in universities. An RLS is a two-day educational event that is normally organized at three different locations. RLSs can include a roundtable discussion. RLSs are combined with an STO publication (Educational Notes), which will be made available before the first RLS session.

A Research Technical Course (RTC) is an educational technical team activity aimed at transferring practical knowledge and recent field developments through on-site instructor training or lectures to military decision makers. The material is tailored to a specific/specialized audience and is generally more operational in nature than for a Research Lecture Series (RLS). An RTC can be offered up to a maximum of four times lasting from one to three days. The STO publication is not always provided for an RTC.

A Research Workshop (RWS) technical team activity aims at facilitating intensive information exchange and focused discussion on a specific topic among a limited number of invited experts. The prime purpose of an RWS is to enhance the capability of the NATO S&T community to respond adequately to the military requirements of NATO. An RWS (generally not more than 30 participants) is a two to three-day event with no prescribed format. An RWS results in an STO publication (Meeting Proceedings).

A Research Specialists' Meeting (RSM) technical team activity exchanges of state of the-art knowledge among an audience of specialists with invited speakers on an important scientific or applied topic. The prime purpose of an RSM is to enhance the capability of the NATO S&T community to respond adequately to the military requirements of NATO. An RSM is a medium-scale (usually less than 100 participants), two to three-day event. The Programme Committee organizes communications, inviting experts to give Keynote Addresses and arranging oral presentations that include roundtable discussions. An RSM results in an STO publication (Meeting Proceedings).

An AGARDograph (Advanced Guidance for Alliance Research and Development – AGARD) pertains to a single, clearly defined technical subject and comprises material generally agreed to be of lasting interest and value to the technical and war fighter communities represented throughout NATO. The AG material may be the work of a single author or be the coordinated and edited contributions of several authors. An AG team is chartered for a maximum of three years.

A Long-Term Scientific Study (LTSS) technical team activity provides recommendations to NATO and National Authorities based on assessment of the impact on military operations that might be expected from developments in science and technology over both the medium and long term (typically 10 – 20 years). This would include how emerging technologies, systems and methods may affect tactical concepts and doctrines. LTSS are chartered for three years after the initial meeting. Among the activities conducted during an LTSS, a brainstorming meeting, called **Multinational Exercise (MNE)**, is organized. An LTSS results in an STO publication (Technical Report) and in presentations to various NATO or National Authorities.

A Military Application Study (MAS) technical team activity is a short-term rapid reaction study that assesses the application of technology to operational procedures to solve operational and equipment deficiencies.

2021 BUSINESS MEETINGS (PPW/PBM/STB)

All major Science and Technology Organization's business meetings are listed in Table 1.

Table 1: 2021 Business Meetings

2021 PBM/STB/PPW		MEETING DATES	MEETING LOCATION
PPW	PLANS & PROGRAMMES WORKSHOP (PPW)	10 – 11 FEBRUARY 2021	VIRTUAL MEETING
AVT	Spring PBM	17 – 21 May 2021	Virtual Meeting
	Fall PBM	18 – 22 October 2021	Antalya (TUR)
HFM	Spring PBM	12 – 15 April 2021	Zagreb (CRO)
	Fall PBM	11 – 15 October 2021	Rome (ITA)
IST	Spring PBM	03 – 07 May 2021	Virtual Meeting
	Fall PBM	04 – 08 October 2021	Koblenz (DEU)
NMSG	Spring BM	19 – 23 April 2021	Virtual Meeting
	Fall BM	18 – 22 October 2021	Amsterdam (NLD)
SAS	Spring PBM	13 –16 April 2021	Virtual Meeting
	Fall PBM	18 – 22 October 2021	Madrid (ESP)
SCI	Spring PBM	17 – 21 May 2021	Virtual Meeting
	Fall PBM	11 – 15 October 2021	Turku (FIN)
SET	Spring PBM	19 – 23 April 2021	Virtual Meeting
	Fall PBM	25 – 29 October 2021	Marseilles (FRA)
STB	Spring STB	15 –16 March 2021	Virtual Meeting
	Fall STB	15 –17 September 2021	Helsinki (FIN)

STRUCTURE OF 2021 COLLABORATIVE PROGRAMME OF WORK

As of 1 January 2021, the total number of activities in CPoW is 298 (+47 ETs). This represents the sum of number of activities that started before 2021 and will be still active in 2021 as well as number of activities that are going to start in 2021.

Table 2: 2021 CPoW Composition (as of 1 January 2021*)

ACTIVITY		PANEL/GROUP							TOTAL
		AVT	HFM	IST	NMSG	SAS	SCI	SET	
Task Group	**RTG**	43	44	24	16	25	24	37	**213**
AGARDograph	**AG**	-	-	-	-	-	5	-	**5**
Long-Term Scientific Study	**LTSS**	1	1	-	-	-	-	-	**2**
Lectures Series	**RLS**	2	3	-	1	-	4	4	**14**
Specialists' Meeting	**RSM**	3	1	3	1	-	3	4	**15**
Symposium	**RSY**	1	2	1	2	1	1	2	**10**
Technical Course	**RTC**	-	1	-	1	1	-	-	**3**
Workshop	**RWS**	10	1	2	1	-	2	1	**17**
Support Project	**SP**	9	-	-	-	-	-	-	**9**
Specialist Team	**ST**	1	2	-	3	3	-	1	**10**
*Exploratory Team**	***ET***	*12*	*13*	*11*	*-*	*3*	*2*	*6*	***47***
TOTAL		**70 (+12)**	**55 (+13)**	**30 (+11)**	**25**	**30 (+3)**	**39 (+2)**	**49 (+6)**	**298 +47 ETs**

* Formally, Exploratory Teams (ETs) are not activities. An Exploratory Team may be established when a Panel/Group believes that a particular expertise is required to assist or advise the Panel/Group on the technical merit or feasibility of a specific proposal for a technical activity. ETs may also be used to help the Panel/Group develop recommendations on future content of the Panel/Group's Programme of Work.

Note: All data presented in Table 2 as well as in overall document are referred to 1 January 2021. These numbers change daily as some activities end during the year. In addition, a number of new activities will be approved after the Spring PBMs Cycle. The number of new activities varies each year, however based on previous years, the average number of new activities approved during silence procedure after Spring PBMs Cycle is around 30.

2021 BUDGET GENERAL INFORMATION

In accordance with the 2021 Medium-Term-Resource Plan, the S&T Collaboration Support Office (CSO) has projected a funding requirement of EUR 6,370,000 for 2021. This represents an increase of EUR 130,000 over the 2020 budget (EUR 6,240,000) and is necessary to meet increased demand in support of collaborative activities. The North Atlantic Council approved the requested budget in December 2020.

Table 3: 2021 CSO Budget Projections per Category*

BUDGET CATEGORIES	PROJECTED 2021
Personnel	€ 3 650 000
Facility Management	€ 450 000
Operations and Mission Support	€ 300 000
Publications	€ 250 000
CIS	€ 460 000
Collaborative Program of Work	€ 1 260 000
Total NATO Funded Effort	**€ 6 370 000**

* Note: Allocations to categories may vary pending operational requirements.

The majority of the STO CPoW activities are open for NATO Partners under the PfP and MD programs. Funding for Partner-related activities within the STO CPoW is provided through the Outreach Budget of the International Military Staff (IMS). The CSO acts as an agent between the Nations and the IMS for Outreach activities.

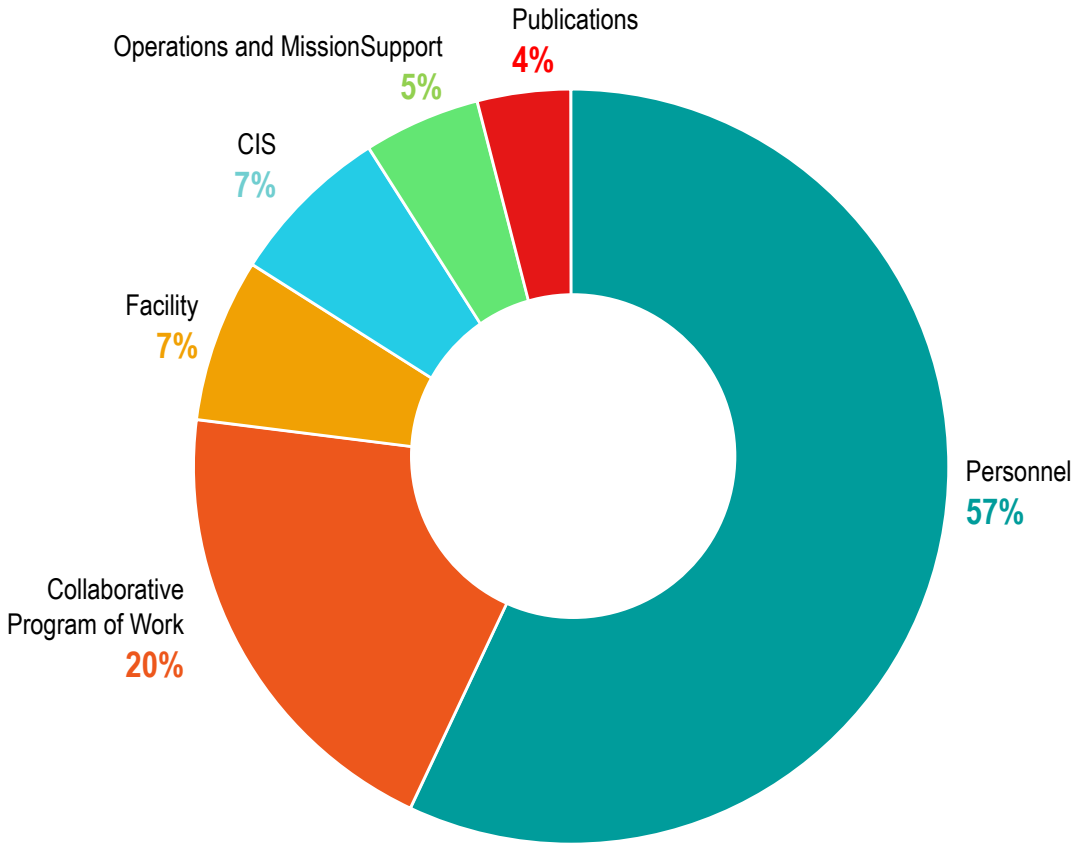


Figure 4: CSO 2021 Budget Composition

S&T STRATEGY, PRIORITIES, STRATEGIC INITIATIVES AND EMERGING & DISRUPTIVE TECHNOLOGIES: "WHAT, WHY AND HOW"

The Collaborative Program of Work (CPoW) is a tool designed to answer the Nations' needs and the NATO requirements within the field of Defence and Security Science and Technology research. Therefore, its construct is based on the strategic orientation provided by the higher NATO centralized organization, and on inputs delivered directly by the Nations during the Panels and Group Business meetings. Ultimately, the Nations, through the S&T Board (STB), remain the collective authority deciding on how the CPoW should develop.

As a first reference, the NATO S&T Strategy provides the overarching guidance to steer the NATO S&T community's efforts in a coherent direction, establishing broad Goals, defining Lines of Effort (LoEs) and Investment Areas. In this three-tier vision, the five Lines of Effort can be considered as the engine of the Strategy. The LoEs set the level of ambition to include the following:

1. Stay at the forefront of S&T to outperform our competitors.
2. Recognize partnerships as a strength.
3. Encourage technical demonstrations to reduce the gap between research and actual delivery of capabilities.
4. Aim at improving the Alliance decision-making, in all compartments (operations, planning, etc.).
5. Concentrate efforts on the crucial requirements of Nations and NATO to achieve visible and valuable results.

This strategy appeals to pragmatism, efficiency, the will to share and cooperate, and excellence.

As a visionary document, the NATO S&T Strategy needs to be complemented by a more practical document linking the strategic thoughts to actionable S&T priorities. Anticipating foreseeable military requirements, the NATO S&T Priorities guidance serves to guide medium to long-term S&T planning across the NATO S&T community and to inform smart investment decisions in Nations and within the Alliance. The priorities are currently organized in 10 S&T Areas,[1] broken down into 42 specific Targets of Emphasis (ToEs). These ToEs must be recognized as key driving references, either to inspire new activities, or to verify that the envisaged new projects are consistent with the NATO S&T Priorities. The current NATO S&T Priorities were adopted in 2017 and they will be updated in 2021.

Aside from the S&T Priorities that provide valuable orientation to develop standard CPoW activities, the STB acknowledged the need for more tailored tools and procedures to focus on specific strategic cross domain areas, topics or problems. The Strategic Initiatives address this need. Their purpose is to focus the attention of the NATO S&T community on important emerging technical challenges and opportunities, to address them from a comprehensive perspective, and to achieve results that are beyond the reach of individual stakeholders or specialized Panels and Group. In a practical sense, they help create Communities of Interest in specific domains across the whole S&T community, and they capitalize on, orient, and bring coherence to the Panels & Group activities while dealing with strategic S&T matters. The Von Karman Horizon Scanning (VKHS) studies, in particular, aim to deliver short-term focused studies (usually one-year long studies) to enlighten the NATO and Nations senior leadership on emerging and/or disruptive S&T issues.

The above-mentioned set of guiding documents, tools and procedures provide the STO community with the relevant and necessary means and frameworks to address the increasing emphasis that the NATO political and military leadership places on Emerging and Disruptive Technologies (EDTs). Seven EDTs[2] have been selected and included into a (classified) Roadmap document approved by the Alliance Defence Ministers in October 2019. A Roadmap Implementation Strategy will soon supplement this Roadmap in 2021. Other S&T areas of strategic interest – such as Novel Materials – are likely to be addressed as additional EDTs in the future. In 2021, the STO community will concentrate on developing knowledge and understanding of these EDTs, combined in clusters that associate S&T areas with operational functions. The 2021 Plans & Program Workshop (P&PW) will define new EDT focus areas and design an EDT multi year programme overview, paving the way to future CPoW activity development.

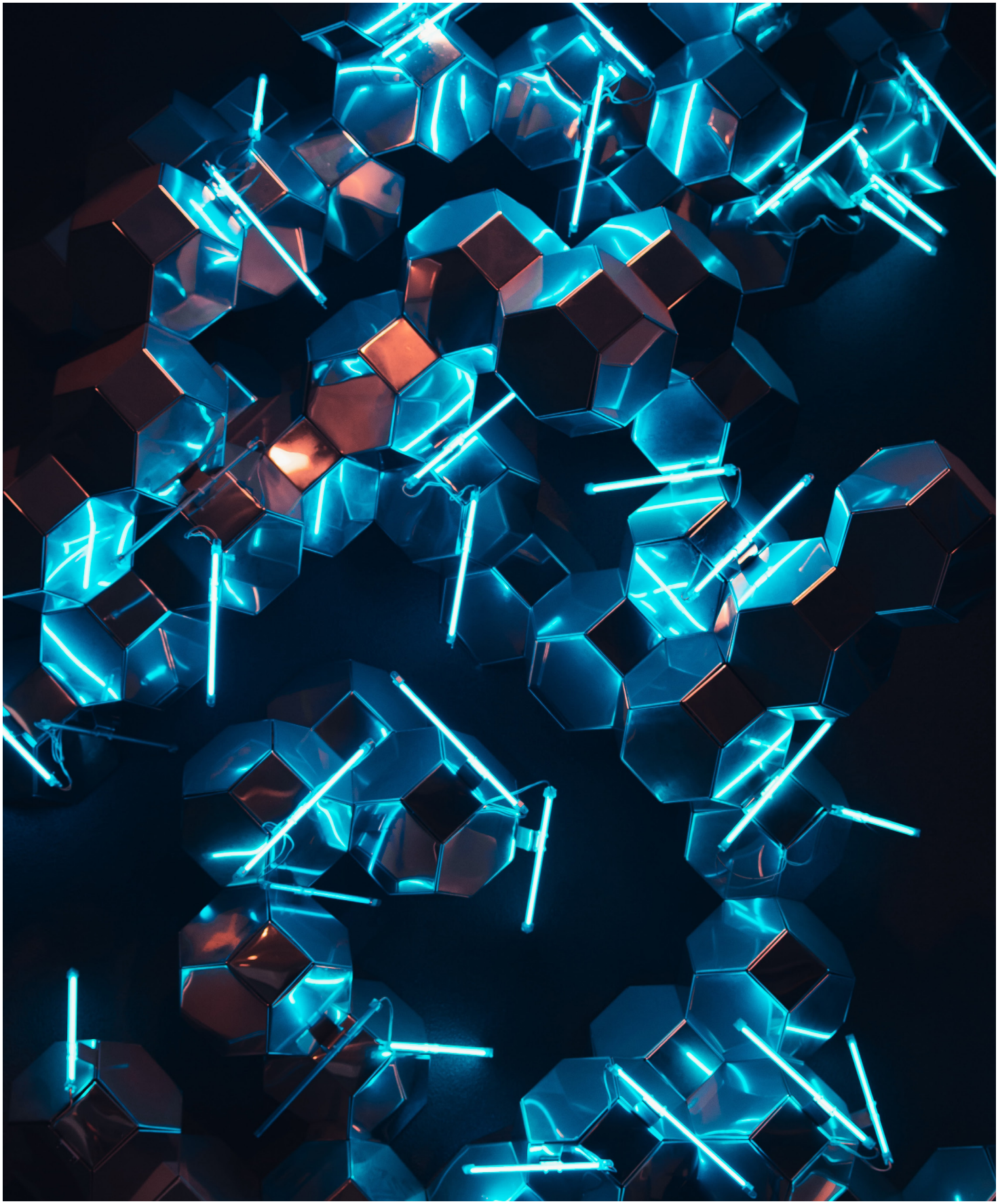
The NATO S&T Strategy, the S&T Priorities, the Strategic Initiatives, and the Emerging and Disruptive Technologies Roadmap, supplemented by the future Roadmap Implementation Strategy, offer key strategic guidance to address

[1] Precision Engagement, Advanced Human Performance & Health, Cultural, Social & Organizational Behaviors, Information Analysis & Decisiom Support, Data Collection & Processing, Communications & Networks, Autonomy, Power & Energy, Platforms & Materials, Advanced Systems Concepts.

[2] Space, Data, Artificial Intelligence, Autonomy, Hypersonics, Quantum technology, Biotechnology.

vital NATO S&T requirements. In 2021, they will find practical application through the work achieved during the P&PW and the Panels/Group Business Meetings, to successfully frame and execute the Collaborative Program of Work.

This is the What, the Why and the How to do it.



APPLIED VEHICLE TECHNOLOGY PANEL (AVT)

Panel Chair: Mr. Stan COLE (USA)
Panel Vice-Chair: Dr. Tom THORVALDSEN (NOR)
Panel Executive: Mr. David KLASSEN (DEU)
Panel Assistant: Ms. Monika VAVRIKOVA (NATO)

MISSION

The Applied Vehicle Technology Panel strives to improve the performance, reliability, affordability, and safety of vehicles through advancement of appropriate technologies. The Panel addresses platform technologies for vehicles operating in all domains – land, sea, air, and space, for both new and ageing systems.

To accomplish this mission the members of the AVT community, comprising more than 1,200 participants, exploit their joint expertise in the fields of:

1. Mechanical Systems, Structures and Materials;
2. Propulsion and Power Systems; and
3. Performance, Stability and Control, Fluid Physics;

This expertise is augmented by committees bolstering strategic guidance, scientific excellence and bi national support.

By carrying out biannual Business Meeting Weeks including all of its sponsored activities, the Panel guarantees the use of NATO and national resources in the most effective and efficient way. The Panel's work ethic is based on generating synergies by multi-disciplinary and domain overarching approaches; building productive partnerships by a healthy mix of academic scientists, governmental researchers, military operators and industrial engineers; providing timely and targeted advice to NATO and nations; and striving for scientific excellence.

MAIN INTEREST

The expertise of the Applied Vehicle Technology Panel covers a broad range of cross-cutting and technical focus areas. In alignment with its mission statement, the Panel is the STO's focal point for:

- Assessment of and multi-disciplinary cooperation on Hypersonic Vehicles.
- Further development and integration of Autonomous Vehicles in all domains.
- Screening and evaluating novel Materials, Structures and Manufacturing Technologies for military applications.
- International collaboration on a Holistic Virtual Design approach for manned and unmanned future Combat Air Platforms;
- Determination and further compiling of innovative Propulsion as well as Power System Technologies for military purposes.
- Coordination and development of a Future Rotorcraft Requirement trade-space including maturing of key technologies.
- Assessment and advancement of Warship and Fleet Design capabilities.
- Standardization and implementation of a Sustainable Use of Munitions across their life cycles.
- Evaluation and integration of Software-Based Applications on the design, handling and service of platforms.
- Sustainment and Life-Cycle Costs considerations of new and aging platforms as well as fleet considerations.

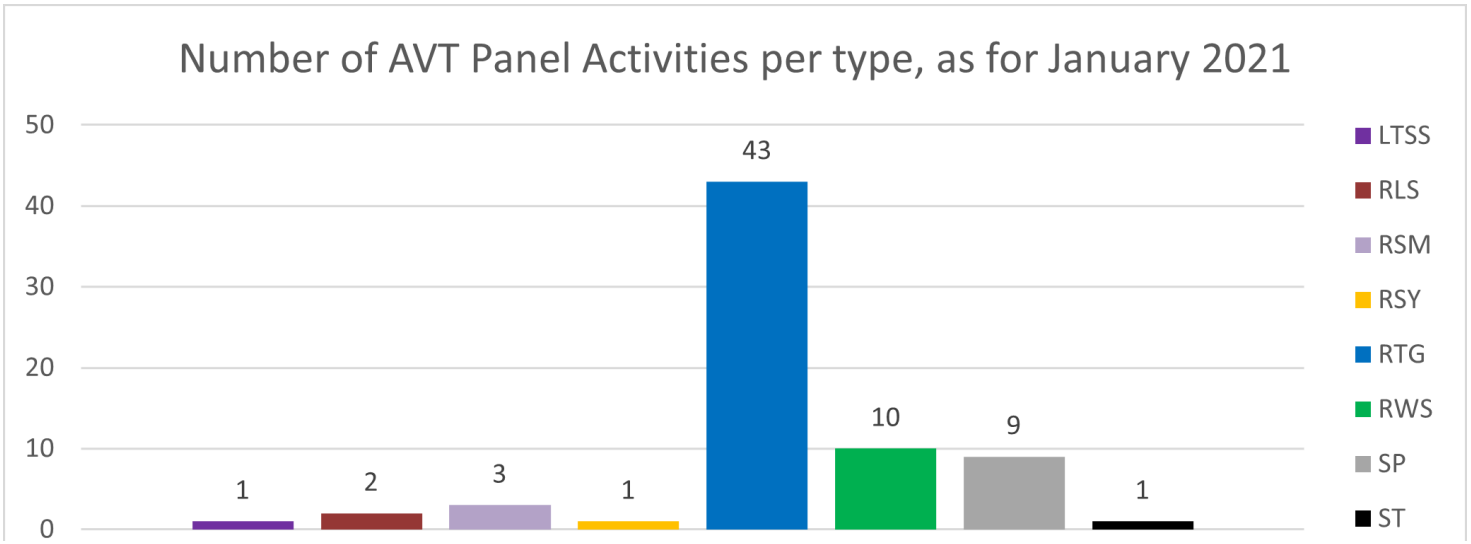


Figure 5: Number of AVT Panel Activities per Type, as of 1 January 2021

Table 4: AVT Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-254	RTG	Assessment of Plasma Actuator Technologies for Internal Flows
AVT-255	RTG	Unmanned Systems Mission Performance Potential for Autonomous Operations
AVT-291	RTG	Range Design and Management for Reduced Environmental Impact
AVT-294	RTG	Towards Improved Computational Tools for Electric Propulsion
AVT-359	LTSS	Impact of Hypersonic Operational Threats on Military Operations and Technical High-Level Requirements
AVT-358 (VKI)	RLS	Advanced Computational Fluid Dynamics Methods for Hypersonic Flows
AVT-335	RSM	Range Design and Management for Sustainable Live Fire Training Ranges
AVT-336	RSM	Enabling Platform Technologies for Resilient Small Satellite Constellations for NATO Missions
AVT-338	RSM	Advanced Wind Tunnel Boundary Simulation II
AVT-356	RSY	Physics of Failure for Military Platform Critical Subsystems
AVT-290	RTG	Standardization of Augmented Reality for Land Platforms in Combat Environments
AVT-292	RTG	Munition Health Management Technologies: Effects on Operational Capability, Interoperability, Life-Cycle Cost and Acquisition of Missile Stockpiles of NATO Nations
AVT-293	RTG	Effect of Environmental Regulation on Energetic Systems and the Management of Critical Munitions Materials and Capability
AVT-297	RTG	Development of a Framework for Validation of Computational Tools for Analysis of Air and Sea Vehicles
AVT-298	RTG	Reynolds Number Scaling Effects on Swept Wing Flows
AVT-300	RTG	Naval Ship Maneuverability in Ice
AVT-301	RTG	Flow Field Prediction for Maneuvering Underwater Vehicles
AVT-308	RTG	Cooperative Demonstration of Technology (CDT) for Next-Generation NATO Reference Mobility Model (NG-NRMM)
AVT-309	RTG	Implication of Synthetic Fuels on Land Systems and on NATO Single Fuel Policy
AVT-310	RTG	Hybrid/Electric Aircraft Design and Standards, Research and Technology (HEADSTART)
AVT-311	RTG	Availability and Quality Issues with Raw Materials for Rocket Propulsion Systems and Potential Consequences for NATO
AVT-312	RTG	Airworthiness Tools and Processes for Complex Rotorcraft Systems Safety
AVT-313	RTG	Incompressible Laminar-to-Turbulent Flow Transition Study
AVT-314	RTG	Assessment and Reduction of Installed Propeller and Rotor Noise from Unmanned Aircraft
AVT-315	RTG	Comparative Assessment of Modeling and Simulation Methods of Shipboard Launch and Recovery of Helicopters

AVT-316	RTG	Vortex Interaction Effects Relevant to Military Air Vehicle Performance
AVT-317	RTG	Trade-Space Exploration to Support the Early Stage Design of Effective and Affordable (Fleets) of Warships
AVT-318	RTG	Low Noise Aero-Acoustic Design for Turbofan Powered NATO Air Vehicles
AVT-319	RTG	High Speed Rotorcraft Analysis and Evaluation
AVT-320	RTG	Assessments of Numerical Simulation Methods for Turbulent Cavitating Flows
AVT-327	RTG	Standardization Recommendation (STANREC) Development for Next Generation NATO Reference Mobility Model (NRMM)
AVT-330	RTG	Impact of Underwater Dumped Munitions and Maritime Safety, Security and Sustainable Remediation
AVT-331	RTG	Goal-Driven, Multi-Fidelity Approaches for Military Vehicle System-Level Design
AVT-332	RTG	In-Flight Demonstration of Ice-phobic Coating and Ice Detection Sensor Technologies
AVT-333	RTG	Integration of Propulsion, Power, and Thermal Subsystem Models into Air Vehicle Conceptual Design
AVT-334	RTG	CDT on Augmented Reality (AR) to Enhance Situational Awareness for Armored Fighting Vehicle Crew
AVT-337	RWS	Anti-Tamper Protective Systems for NATO Operations
AVT-340	RWS	Preparation and Characterization of Energetic Materials
AVT-353	RWS	Artificial Intelligence in Cockpits for UAVs
AVT-354	RWS	Multi-Fidelity Methods for Military Vehicle Design
AVT-355	RWS	Intelligent Solutions for Improved Mission Readiness of Military UxVs
AVT-357	RWS	Technologies for Future Distributed Engine control Systems (DECS)
AVT-SP-001	SP	Development and Evaluation of an Advanced PACVD TiN/TiCN Coating for Military Vehicle Bearing Applications
AVT-SP-002	SP	Turbulence and the Aerodynamic Optimization of Nonplanar Lifting Systems
AVT-SP-003	SP	Investigation of Sub-Idle Gas Turbine Performance
AVT-SP-004	SP	Assessment of Environmental and Toxicological Impacts Associated with Ammunition: Life-Cycle Approach to Assist the REACH Regulation
AVT-SP-005	SP	Measurement of Soil Mechanical Properties Related to the Traffic-Ability of Military Vehicles on Typical Estonian Soils
AVT-SP-006	SP	Development of Simulation Model for Selecting Optimum Maintenance Strategy of Combat Vehicles
AVT-SP-007	SP	Novel Active Fire Modelling and Prediction Methods Using Manned and Unmanned Aircraft Vehicles
AVT-SP-008	SP	Determination of the Traffic-Ability of Military Vehicles in Typical Forests
AVT-ST-007	ST	Modification of NATO STANAGs to Incorporate Range Characterization

Table 5: AVT Activities Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-341	RTG	Mobility Assessment Methods and Tools for Autonomous Military Ground Systems
AVT-342	RTG	Interoperability of Additive Manufacturing in NATO operations
AVT-343	RTG	Novel Materials to Mitigate Rare Earth (RE) Criticality in High Speed Motors
AVT-344	RTG	Assessment of Micro Technologies for Air and Space Propulsion
AVT-345	RTG	Unified Tactical Missile Kinetic Performance Model
AVT-346	RTG	Predicting Hypersonic Boundary-Layer Transition on Complex Geometries
AVT-347	RTG	Large-Amplitude Gust Mitigation Strategies for Rigid Wings
AVT-348	RTG	Assessment of Experiments and Prediction Methods for Naval Ships Maneuvering in Waves
AVT-349	RTG	Non-Equilibrium Turbulent Boundary Layers in High Reynolds Number Flow at Incompressible Conditions
AVT-350	RTG	Innovative Control Effectors for Maneuvering of Air Vehicles – Advanced Concepts
AVT-351	RTG	Enhanced Computational Performance and Stability and Control Prediction for NATO Military Vehicles
AVT-352	RTG	Measurement, Modeling and Prediction of Hypersonic Turbulence
AVT-360	RWS	Environmentally Compliant Approaches to Maintenance and Overhaul of Military Vehicles
AVT-361	RWS	Certification of Bonded Repair on Composite Aircraft Structures
AVT-364	RWS	Environmental Regulation on Energetic Systems and its Impact on Critical Munitions Materials and Capability
AVT-365	RLS	Rotorcraft Flight Simulation Model Fidelity Improvement and Assessment
AVT-366	RWS	Use of Computational Fluid Dynamics for Design and Analysis: Bridging the Gap Between Industry and Developers
AVT-367	RTG	Sea-Ice Collision Risk Prediction and Mitigation for Naval Ships
AVT-SP-009	SP	Evaluation of Hybrid Electric Propulsion Technologies for Unmanned Aerial Vehicles in Military Applications

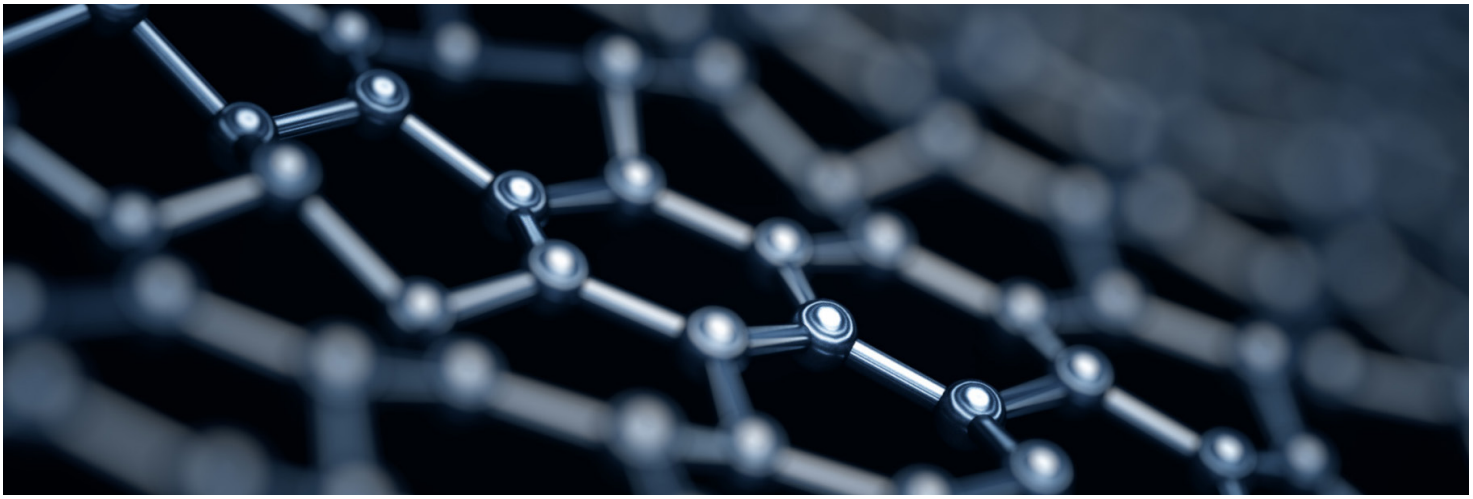
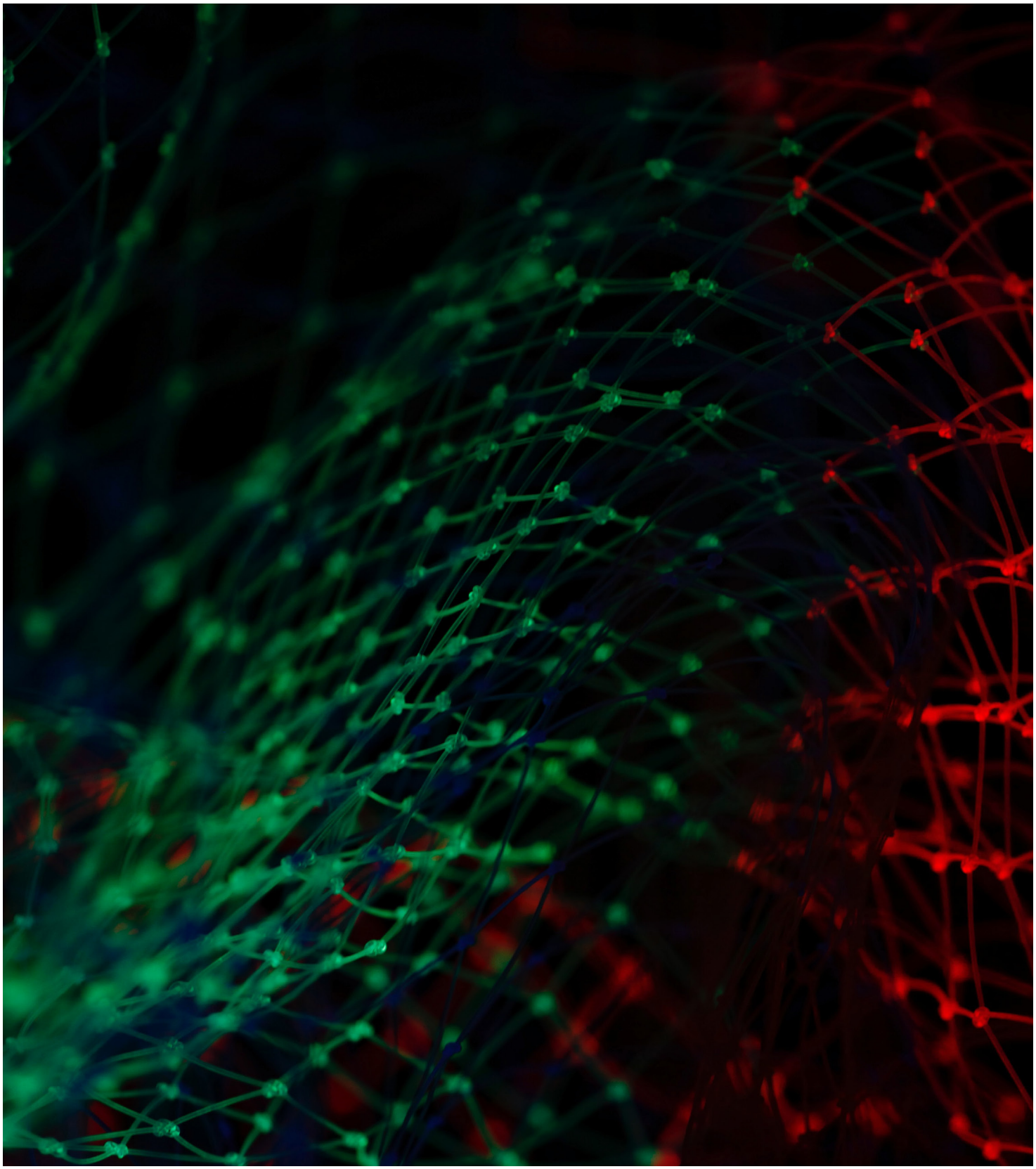


Table 6: AVT Activities Starting in 2022

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-362	RTG	Water Sampling, Monitoring and Control/Remediation for Live-Fire Military Ranges
AVT-363	RTG	Improving the Understanding of Risks from Exposure to Munition Combustion Products



HUMAN FACTORS AND MEDICINE PANEL (HFM)

Panel Chair: Ms. Alison ROGERS (GBR)
Panel Vice-Chair: Dr. Janet BLATNY (NOR)
Panel Executive: Lt. Col. Erik LAENEN (NLD)

Panel Assistants: Ms. Marie LINET (NATO),
Ms. Ezgi YAZICIOGLU (NATO) - temp.

MISSION

The mission of the Human Factors and Medicine Panel is to provide the science and technology base for optimizing health, human protection, well-being and performance of the human in operational environments with consideration of affordability. This involves understanding and ensuring the physical, physiological, psychological and cognitive compatibility among military personnel, technological systems, missions, and environments. This is accomplished by exchange of information, collaborative experiments and shared field trials.

MAIN INTEREST

Combat Casualty Care: Change and innovation in Science and Technology (S&T) development in the field of combat casualty care must keep pace with advances in weapon systems and battlespace tactics, techniques, and procedures that create novel military operational environments. Current combat casualty care and medical planning guidelines are based on rapid evacuation to damage control surgery and critical care. Future operational environments will considerably affect NATO forces' ability to adhere to these guidelines and medically evacuate casualties to provide life, limb, and eyesight saving treatments in a timely manner.

Chemical, Biological and Radiological Defence: Major changes in the security policy and the geopolitical and military situation, as well as evolving agent and weapon technologies, influence the chemical, biological, radiological and nuclear (CBRN) threat and defence. Consequently, CBRN defence requires closer collaboration between military and civilian sectors. Based on the threat out to 2030, S&T areas that can support CBRN defence need to be identified.

Human-Autonomy Teaming: Based on progress in robotics, artificial intelligence and human performance modelling, Human-Agent-Robot Teamwork (HART) systems are being developed and tested in which humans and autonomy dynamically adjust and cooperate to accomplish a joint objective, often in shared spaces. In these systems, team members' responsibilities and commitments are managed such that the human and automation jointly enhance performance and manage contingencies.



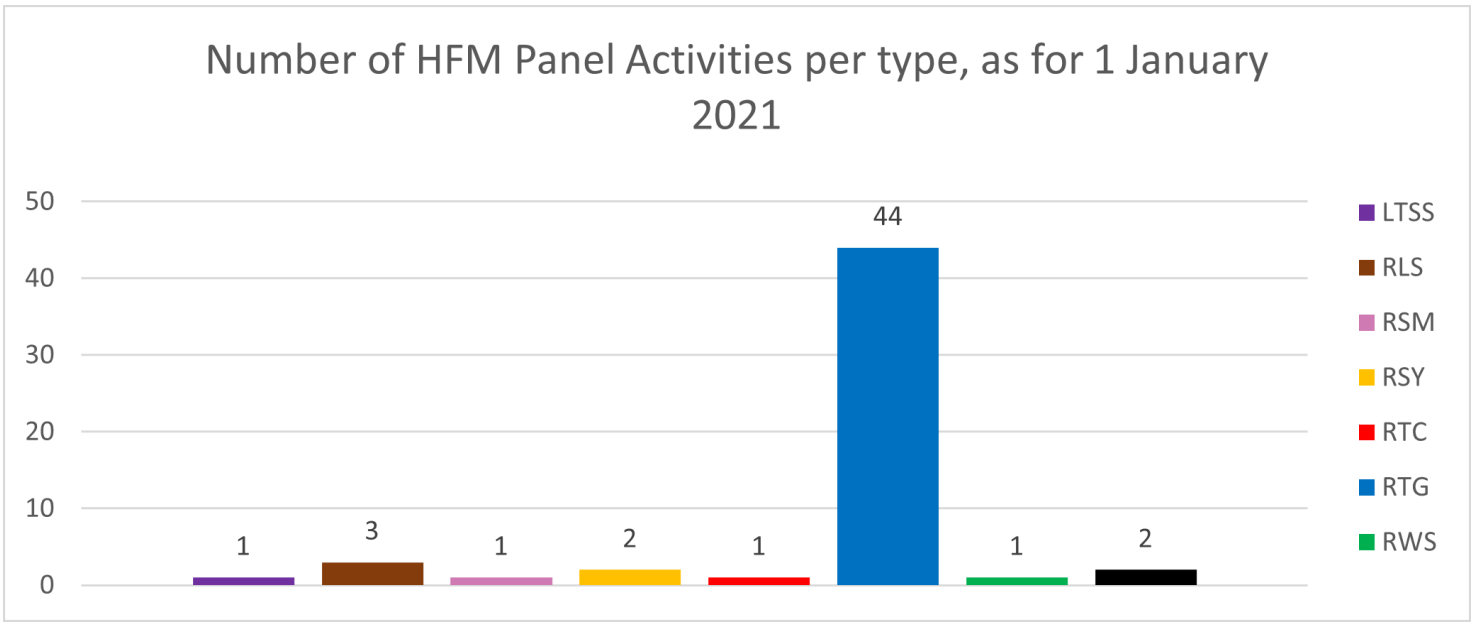


Figure 6: Number of HFM Panel Activities per Type, as of 1 January 2021

Table 7: HFM Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
HFM-317	LTSS	Solutions for Combat Casualty Care
HFM-240	RLS	Mild Traumatic Brain Injury: Post Concussive Symptoms in a Deployed Setting
HFM-314	RLS	Aircrew Neck Pain Prevention and Management Lecture Series
HFM-328	RLS	Collaborations between Military and Civilian Personnel in Defence Organizations
HFM-324	RSY	Symposium; Solutions for Combat Casualty Care
HFM-334	RSY	Applying Neuroscience to Performance: From Rehabilitation to Human Cognitive Augmentation
HFM-333	RTC	Aerospace Medicine: New Technologies – New Approach RAMS USAF/NATO STO HFM
HFM-262	RTG	Health Risk Assessment for Chemical Exposures of Military Interest
HFM-274	RTG	The Impact of Hypobaric Exposure on Aviators and High-Altitude Special Operations Personnel
HFM-276	RTG	Human Factors and ISR Concept Development and Evaluation
HFM-277	RTG	Leadership Tools for Suicide Prevention
HFM-279	RTG	Leveraging Technology in Military Mental Health
HFM-281	RTG	Personalized Medicine in Mental Health and Performance
HFM-283	RTG	Reducing Musculo-Skeletal Injuries
HFM-285	RTG	Speech Understanding of English Language in Native and Non-Native Speakers/Listeners in NATO With and Without Hearing Deficits
HFM-286	RTG	Leader Development for NATO Multinational Military Operations
HFM-290	RTG	Advances in Military Personnel Selection
HFM-291	RTG	Ionizing Radiation Bio-Effects and Countermeasures
HFM-292	RTG	Understanding and Reducing Skill Decay
HFM-293	RTG	Digital and Social Media Assessment for Effective Communication and Cyber Diplomacy
HFM-294	RTG	Big Data In The Military: Integrating Genomics into the Pipeline of Standard-care Testing and Treatment
HFM-295	RTG	Sexual Violence in Military
HFM-297	RTG	Assessment of Augmentation Technologies for Improving Human Performance
HFM-298	RTG	Injury Thresholds of High-Power Pulsed Radiofrequency Emissions
HFM-299	RTG	Pulmonary Screening and Care in Aviators
HFM-301	RTG	Military Diversity: Ethnic Tolerance and Intolerance
HFM-304	RTG	Factors Impacting Ethical Leadership

HFM-305	RTG	Synthetic Biology in Defence: Opportunities and Threats
HFM-306	RTG	Translating Medical Chemical Defence Research Into Operational Medical Capabilities Against Chemical Warfare Agent Threats
HFM-307	RTG	Integrating Gender and Cultural Perspectives in Professional Military Education Programmes
HFM-308	RTG	Optimizing Human Performance in NATO SOF Personnel Through Evidence-Based Mental Performance Programming
HFM-310	RTG	Human Performance and Medical Treatment and Support During Cold Weather Operations
HFM-311	RTG	Cognitive Neuro-Enhancement: Techniques and Technology
HFM-312	RTG	Unexplained Physiologic Events in High-Performance Aircraft
HFM-313	RTG	Re-Introduction of Phage Therapy in Military Medicine
HFM-316	RTG	Expert Panel for State of the Art Cardiovascular Risk Assessment in Aircrew and Other High-Risk Occupations
HFM-319	RTG	Measuring the Cognitive Load on the Soldier
HFM-320	RTG	Fatigue Management in Aircrew
HFM-325	RTG	Performance Nutrition for Fresh Feeding during Military Training and Operations
HFM-326	RTG	Diet Supplementation for Military Personnel
HFM-327	RTG	Development of a NATO STANREC for Physiological Status Monitoring to Mitigate Exertional Heat Illness
HFM-329	RTG	A Psychological Guide for Leaders Across the Deployment Cycle
HFM-330	RTG	Human Systems Integration for Meaningful Human Control over AI-based systems
HFM-331	RTG	Biomedical Bases of Mental Fatigue and Military Fatigue Countermeasures
HFM-332	RTG	Development and Implementation of Autonomous Transport and Medical Systems for Casualty Evacuation
HFM-322	RWS	Meaningful Human Control of AI-based Systems: Key Characteristics, Influencing Factors and Design Considerations
HFM-337	ST	COVID-19; Leadership in Volatile, Uncertain, Complex and Ambiguous world
HFM-MSG-323	ST	Guidelines for Mitigating Cyber-sickness in Virtual Reality Systems

Table 8: HFM Activities Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
HFM-318	RTG	Personnel Retention in the Armed Forces
HFM-338	RTG	Performance Nutrition for Fresh Feeding during Military Training and Operations
HFM-341	RTG	Development of a NATO STANREC for Physiological Status Monitoring to Mitigate Exertional Heat Illness
HFM-342	RTG	Collaborations between Military & Civilian Personnel in Defence Organizations
HFM-343	RTG	A psychological guide for leaders across the deployment cycle.
HFM-AVT-340	RTG	Human Systems Integration for Meaningful Human Control over AI-based systems
HFM-SET-339	RSM	Biomedical Bases of Mental Fatigue and Military Fatigue Countermeasures

INFORMATION SYSTEMS TECHNOLOGY PANEL (IST)

PANEL Chair: Dr-Ing. Michael WUNDER (DEU)
Panel Vice-Chair: Dr. Nikolai STOIANOV, PhD (BGR)

Act. Panel Executive: Ms. Agata SWIATKIEWICZ (NATO)
Panel Assistant: Ms. Armelle DUTRUC (NATO)

MISSION

The Information Systems Technology Panel (IST) implements the STO Mission with respect to Information Systems Technology.

The mission of the IST Panel is to advance and exchange techniques and technologies in order to improve C3I systems, with a special focus on AI, Interoperability and Cyber Security, and to provide timely, affordable, dependable, secure and relevant information to war fighters, planners and strategists.

MAIN INTEREST

The Panel's focus is the advancement and exchange of techniques and technologies to provide timely, affordable, dependable, secure and relevant information to war fighters, planners and strategists, as well as enabling technologies for modelling, simulation, and training.

IST's scope of responsibility covers the fields of Information Warfare and Assurance, Information and Knowledge Management, Communications and Networks, and Architecture and Enabling Technologies.

The IST Programme of Work is organized under three Focus Groups:

1. **Information and Knowledge Management (IWA).**
2. **Architecture and Intelligence Information Systems (AI2S).**
3. **Communications & Networks (COM).**

The activities of the Panel are attached to these focus groups.

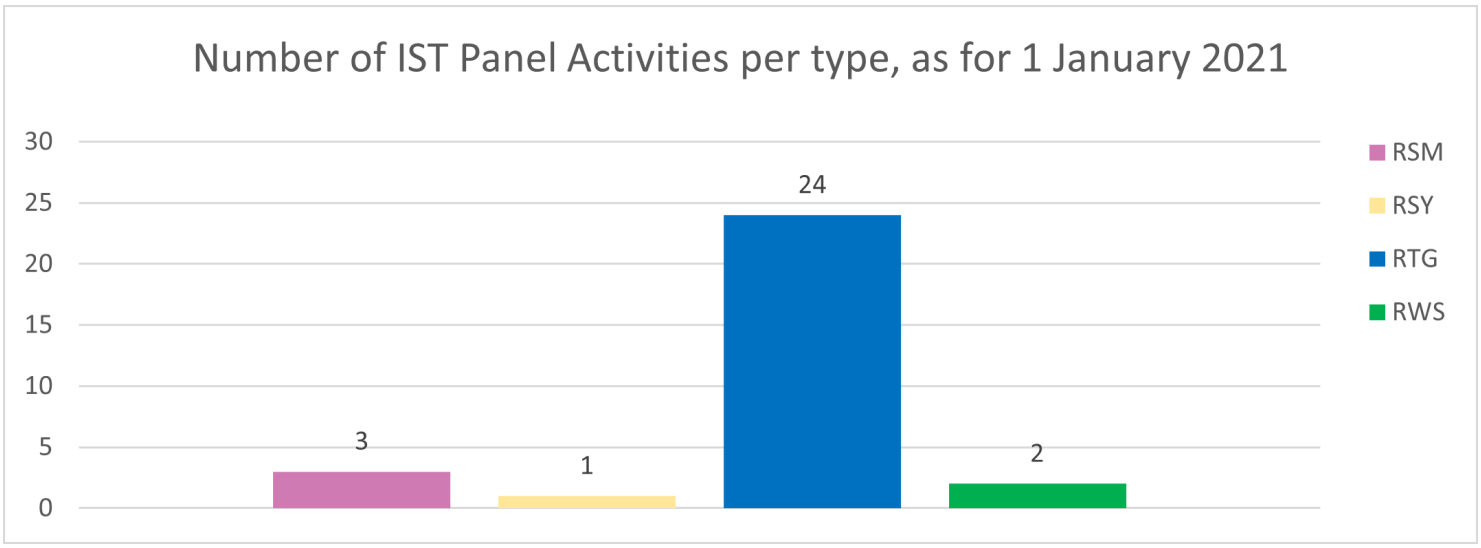


Figure 7: Number of IST Panel Activities per Type, as of 1 January 2021

Table 9: IST Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
IST-146	RTG	Electromagnetic Environment Situational Awareness for NATO
IST-152	RTG	Intelligent, Autonomous and Trusted Agents for Cyber Defence and Resilience
IST-157	RTG	Human in the Loop Considerations for Artificial Intelligence
IST-161	RTG	Efficient Group and Information Centric Communications in Mobile Military Heterogeneous Networks
IST-163	RTG	Deep Machine Learning for Cyber Defence
IST-164	RTG	Securing Unmanned and Autonomous Vehicles for Mission Assurance
IST-165	RTG	High-Level Fusion of Hard and Soft Information for Intelligence
IST-168	RTG	Adaptive Information Processing and Distribution to Support Command and Control
IST-169	RTG	Robustness and Accountability in Machine Learning Systems
IST-171	RTG	FMN Cloud-Based Coalition Security Architecture
IST-172	RTG	Airborne Beyond Line of Sight Communication Network
IST-174	RTG	Secure Underwater Communications for Heterogeneous Network-Enabled Operations
IST-175	RTG	Full Duplex Radio Technology for Military Applications
IST-176	RTG	Federated Interoperability of Military C2 and IoT Systems
IST-177	RTG	Social Media Exploitation for Operations in the Information Environment
IST-179	RTG	Interoperability for Semi-Autonomous Unmanned Ground Vehicles
IST-180	RTG	Network Management and Cyber Defence (NMCD) for Federated Mission Networking (FMN)
IST-181	RSM	Terahertz-Band Communications and Networking
IST-183	RWS	Deep Machine Learning for Cyber Defence
IST-184	RTG	Visual Analytics for Complex Systems
IST-185	RSM	Communication Networks and Information Dissemination for the Tactical Edge
IST-186	RSM	Blockchain Technology for Coalition Operations
IST-187	RTG	5G Technologies Application to NATO Operations
IST-188	RTG	Applying and Validating the Cyber Security Risk Assessment Process for Military Systems
IST-189	RTG	Hybrid Military and Commercial SATCOM Networks
IST-HFM-182	RTG	Synthetic Legal Adviser – AI-Based Decision Making in Hyperwar

Table 10: IST Activities Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
IST-190	RSY	AI, ML and BD for Hybrid Military Operations (AI4HMO)
IST-191	RWS	Rescue Systems for Broken Trust

NATO MODELLING AND SIMULATION GROUP (NMSG)

NMSG Chair: Dr. Robert SIEGFRIED (DEU)
NMSG Vice-Chair: Ms. Julie TREMBLAY-LUTTER (CAN)
MSCO Head: CDR Santiago FERNANDEZ DAPENA (ESP)

MSCO Technical Officer: Mr. Adrian VOICULET (NATO)
MSCO Assistant: Mrs. Renata JAPERTAITE (NATO)

MISSION

The NATO Modelling and Simulation Group (NMSG) is the STO Scientific and Technical Committee in which all NATO Modelling and Simulation (M&S) stakeholders and subject matter experts meet to coordinate and oversee the implementation of the NATO M&S Master Plan (NMSMP).

The NMSMP is a NAC-approved NATO policy document that provides strategic vision and guidance for coordinating and utilizing M&S in NATO. The NATO M&S vision is *"to exploit M&S to its full potential across NATO and the Nations to enhance both operational and cost effectiveness"*.

The mission of the NMSG is to promote cooperation among Alliance bodies, NATO, and partner nations to maximize the effective utilization of M&S. This includes M&S standardization, education, and associated science and technology. The NMSG, as nominated by the Conference of National Armaments Directors (CNAD), is the delegated tasking authority for standardization in the NATO modelling and simulation domain.

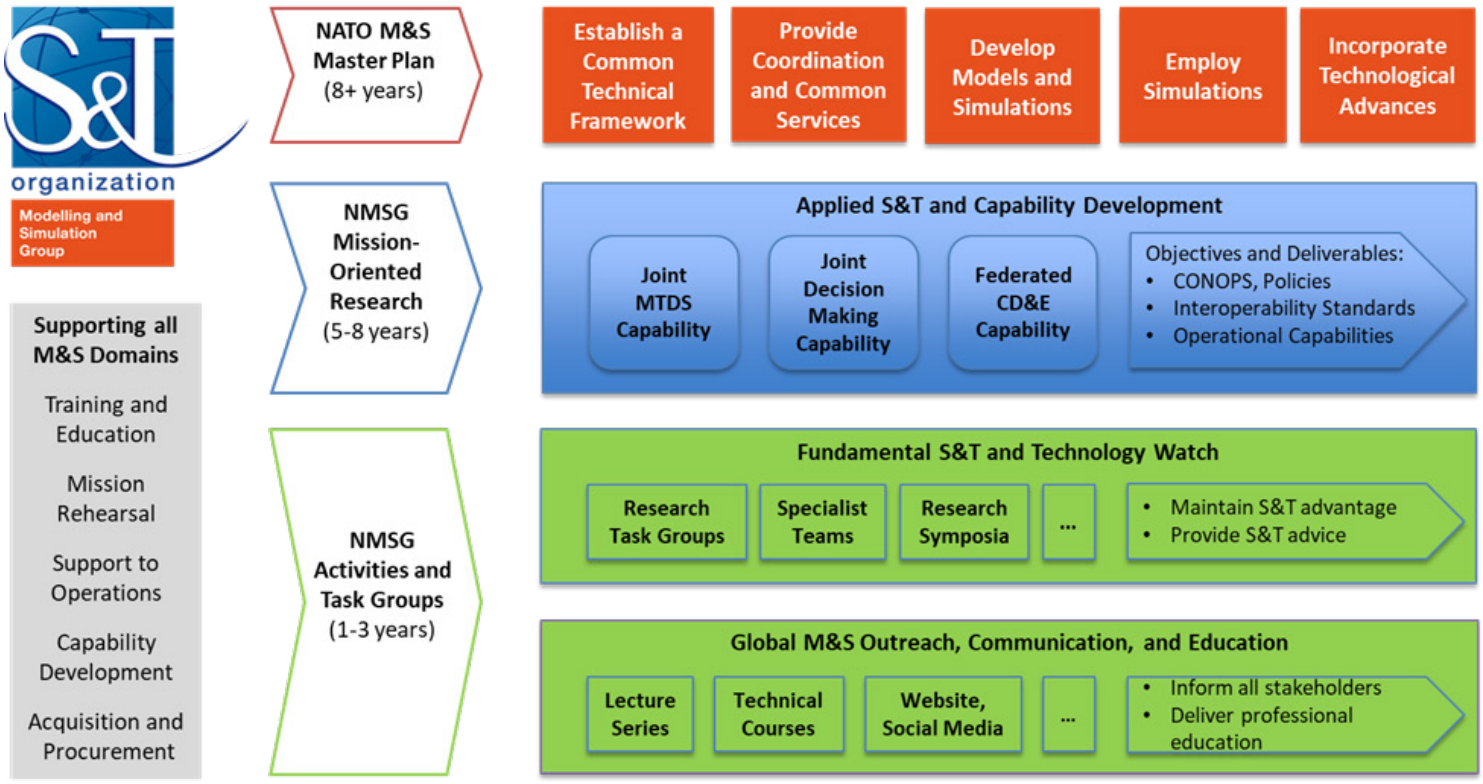


Figure 8: NMSG Mission-Oriented Research

MAIN INTEREST

The NMSMP articulates the NATO vision and guiding principles regarding the use of M&S in support of the NATO mission, discusses the impact that achieving this vision will have on NATO M&S application areas and identifies the governance mechanisms and bodies, and the primary NATO M&S stakeholders.

Under the umbrella of establishing a common technical framework, increasing interoperability and developing models, simulations and standards for M&S, the main current and future focus areas of work are: education and training; decision making; AI & BD; cyber defence; and acquisition.

With the mission to investigate, plan, update and propose the future Programs of Work, the NMSG has three permanent sub-groups: the Military Operational Requirements Subgroup; the M&S Standards Subgroup; and the Planning and Programmes Committee.

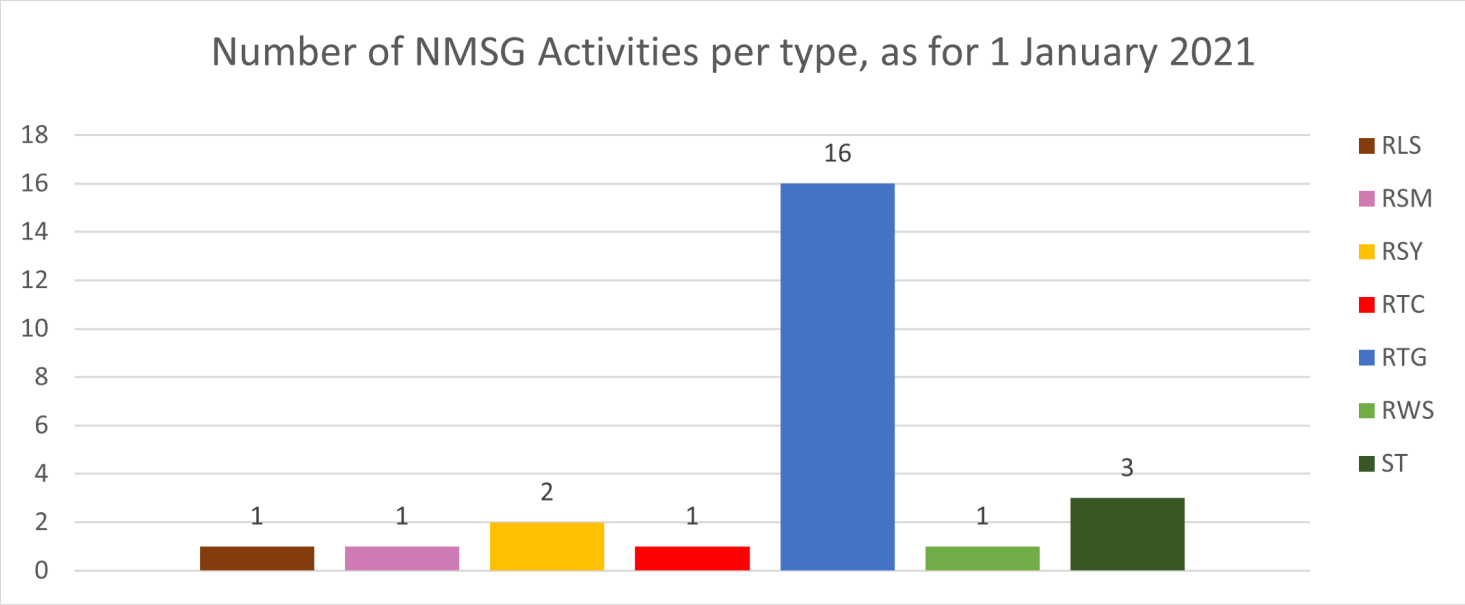


Figure 9: Number of NMSG Activities per Type, as of 1 January 2021

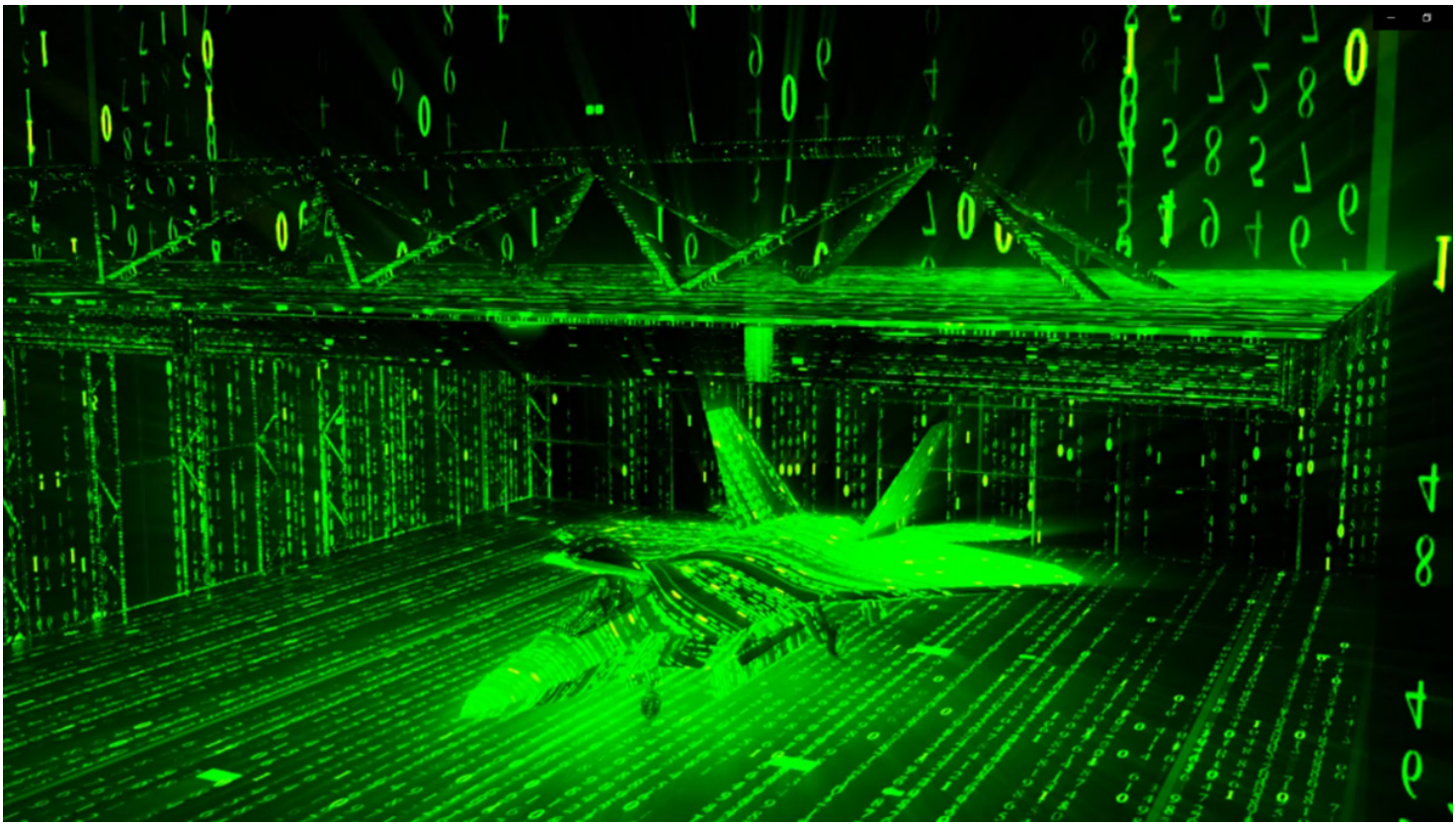


Table 11: NMSG Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
MSG-154	RTG	Low Slow Small Threats Modelling and Simulation
MSG-157	RTG	NATO M&S Resources/Standards Support Team – II
MSG-163	RTG	Evolution of NATO Standards for Federated Simulation
MSG-164	RTG	Modelling and Simulation as a Service – Phase 2
MSG-165	RTG	Incremental Implementation of Mission Training through Distributed Simulation for Joint and Combined Air Operations
MSG-168	RLS	Modelling and Simulation as a Service (MSaaS)
MSG-172	RTG	NATO Modelling and Simulation Master Plan Implementation Update
MSG-173	RTG	Simulation for Training and Operation Group – Next Generation (STOG-NG)
MSG-SAS-178	RTG	Using Simulation to Better Inform Decision Making for Warfare Development, Planning, Operations and Assessment
MSG-174	RTG	Urban Combat Advanced Training Technology Live Simulation Standards (UCATT-LSS) – 2
MSG-179	RTG	Modelling and Simulation for Acquisition
MSG-180	RTG	Implementation of Live Virtual Constructive – Training (LVC-T) in the Maritime Domain
MSG-181	RTG	Physics-Based Electro-Optic/Infrared Simulations – Best Practice Recommendations for Decision Support
MSG-SET-183	RSM	Drone Detectability: Modelling the Relevant Signature
MSG-185	RSY	MSG/MSCO Support to International Training and Education Conferences IT2EC, I/ITSEC and CA2X2 Forum 2021
MSG-187	RTG	Space Weather Environmental Modelling (SWEM)
MSG-188	ST	Modelling and Simulation of Effects of Cyber Attacks
MSG-189	ST	AI Augmented Immersive Simulation in Training and Decision-Making Course of Actions Analysis

Table 12: NMSG Activities Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
MSG-184	RSY	Towards Training and Decision Support for Complex Multi-Domain Operations
MSG-186	RTG	Multi-Dimensional Data Farming
MSG-190	RTG	NATO M&S Professional Certification
MSG-191	RTG	NATO Standards for Federated Simulation and Services for Integration, Verification and Certification
MSG-192	RWS	Commercial Technologies and Games for Use in NATO and Nations
MSG-193	ST	Modelling and Simulation Standards in Federated Mission Networking (FMN)
MSG-194	RTC	Employing the C2-Simulation Interoperation (C2SIM) Standard for Coalition Military Operations and Exercises

SYSTEM ANALYSIS AND STUDIES PANEL (SAS)

Panel Chair: Mr. Espen SKJELLAND (NOR)
Panel Vice-Chair: Mrs. Donna WOOD (CAN)

Panel Executive: LTC Timothy POVICH, PhD (USA)
Panel Assistant: Mr. Jeroen GROENEVELT (NATO)

MISSION

The System Analysis and Studies (SAS) Panel – NATO STO's expert panel for analytical advice – conducts studies and analysis for better decisions in strategy, capability development, and operations within NATO, NATO Nations, and partner Nations. Key drivers in the SAS Panel's work are the exploitation of new technologies, new forms of organization, and new concepts of operation.

Currently, the SAS Panel consists of 43 senior scientific representatives from 23 NATO Nations, 2 Partnership for Peace Nations, 1 Global Partner, and 4 NATO organizations. The SAS Panel leverages analysts and scientists from academia, government, and industry to conduct research.

MAIN INTEREST

The focus of the Panel is on undertaking Operations Analysis activities related to challenges in the evolving strategic environment and the responses that both individual nations and NATO as a whole are making to tackle them. The research can be clustered into 4 focus areas: Policy and Strategy Decision Support; Operations Decision Support; Capability and Investment Decision Support; and Development and Maintenance of Analysis Capabilities.

The development and maintenance of analysis capabilities forms the basis of the Panel work and is essential to providing NATO with innovative and academically sound analytical capabilities that will ensure informed defence decision making. Activities include the development of analytical methods to address upcoming security challenges; information exchange on OA modelling concepts and best practice; research into new methodological approaches; and the development and exchange of models.

The Panel leverages its broad range of analysis capabilities to provide decision support at all levels and in different areas. To illustrate, the Panel identifies and assesses the impacts of geo-political drivers; regional contexts; futures; and technology changes to support policy and strategy decisions. The Panel conducts analysis to improve operational tactics, training and procedures. In addition, the Panel develops better methods to support operational planning. Finally, the Panel supports the development of systems, force element and enabler capability options, including the collection and collation of cost and performance data and defining the necessary missions for these individual systems and capabilities.

The main source for new research projects is proposals made by NATO Nations represented on the SAS Panel. The SAS Panel also addresses requests for such analysis and studies from a variety of other sources. These include the Science and Technology Board (STB) and other NATO bodies, such as the NATO Military Committee; the Conference of National Armament Directors (CNAD) with its Main Armaments Groups; the NATO Industrial Advisory Group (NIAG); Allied Command Operations (ACO); Allied Command Transformation (ACT); and the NATO Communications and Information Agency (NCIA).

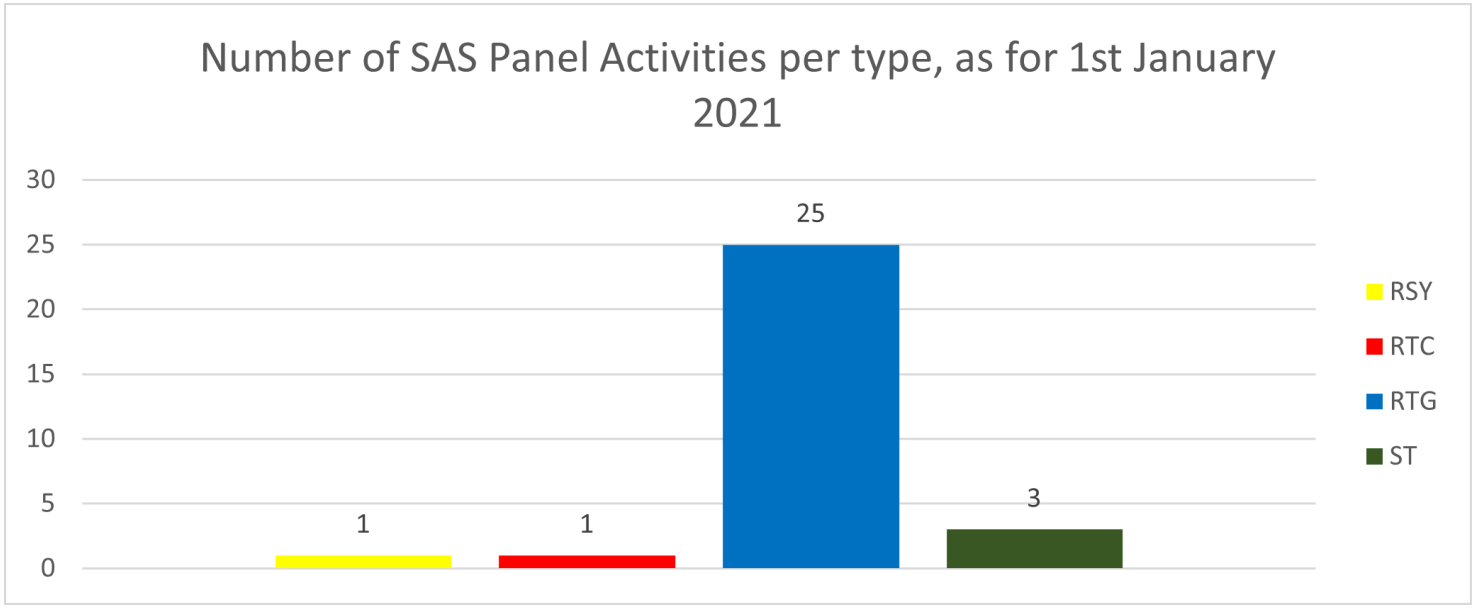


Figure 10: Number of SAS Panel Activities per Type, as 1 January 2021

Table 13: SAS Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
SAS-124	RTG	Visualization Design for Communicating Defence Investment Uncertainty and Risk
SAS-129	RTG	Gamification of Cyber Defence/Resilience
SAS-134	RTG	Linking Strategic Investments and Divestments to Defence Outcomes
SAS-136	RTG	Optimization of Investment in Simulation-Based Military Training
SAS-139	RTG	NATO Analytical War Gaming – Innovative Approaches for Data Capture, Analysis and Exploitation
SAS-140	RTG	Directed Energy Weapons Concepts and Employment
SAS-143	RTG	Agile, Multi-Domain C2 of Socio-Technical Organizations in Complex Endeavors
SAS-144	RTG	Code of Best Practice for Conducting Survey Research in a Military Context
SAS-145	RTG	SWEAT (Soldier System Weapon and Equipment Assessment Tool)
SAS-147	RTG	Analysis of Anti-Access Area Denial (A2/AD)
SAS-149	RTC	Basics of Complex Modern Urban Functions and Characteristics
SAS-150	ST	Advanced Analytics and Artificial Intelligence for Defence Enterprise Resource Planning
SAS-151	RTG	Solutions Enabling Intermediate Force / Non-Lethal Weapon Contributions to Mission Success
SAS-152	RTG	Conceptual Framework for Comprehensive National Defence System
SAS-153	RTG	Best Practices on Cost Analysis of Information and Communication Technology
SAS-154	RTG	Future Strategic Environment Assessment: Framework for Analysis
SAS-155	ST	Providing OR&A Model Sharing Guidance to the Alliance
SAS-156	RTG	Developing a Standard Methodology for Assessing Multinational Interoperability
SAS-157	RTG	Automation in the Intelligence Cycle
SAS-158	RTG	Employing AI to Federate Sensors in Joint Settings
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SAS-160	RTG	Ethical, Legal and Moral (ELM) Impacts of Novel Technologies on NATO's Operational Advantage – The "ELM Tree"
SAS-161	RTG	Military Aspects of Countering Hybrid Warfare: Experiences, Lessons, Best Practices
SAS-163	RTG	Energy Security in the Era of Hybrid Warfare
SAS-164	RTG	21st Century Force Development
SAS-165	RSY	Assessing the Implications of Emerging Technologies for Military Logistics

SAS-166	RTG	Wargaming Multi-Domain Operations in an A2/AD Environment
SAS-167	RTG	Assessing the Value of Cyber Operations in Military Operations
SAS-168	RTG	Coalition Sustainment Interoperability Study
SAS-IST-162	ST	A Hackathon to Determine How Large Exercise Datasets can be Used to Reconstruct Operational Decision Making to Improve Training and Analysis value

SYSTEMS CONCEPTS AND INTEGRATION PANEL (SCI)

Panel Chair: Dr. Karin STEIN (DEU)
Panel Vice-Chair: Mr. Allan CHAN (USA)

Panel Executive: Lt. Col. Roderick BENNETT (USA)
Panel Assistant: Ms. Carlotta ROSSI (NATO)

MISSION

The mission of the Systems, Concepts and Integration (SCI) Panel is to advance knowledge concerning advanced system concepts, integration, engineering techniques and technologies across the spectrum of platforms and operating environments to assure cost-effective mission area capabilities. Integrated defence systems, including air, land, sea, and space systems (manned and unmanned), and associated weapon and countermeasure integration are covered. The SCI Panel's activities focus on NATO and national mid to long-term system level operational needs.

MAIN INTEREST

The scope of Panel activities covers a multidisciplinary range of theoretical concepts, design, development, and evaluation methods applied to integrated defence systems. Areas of interest include:

- Integrated mission systems including weapons and countermeasures.
- System architecture/mechanization.
- Vehicle integration.
- Mission management.
- System engineering technologies and testing.

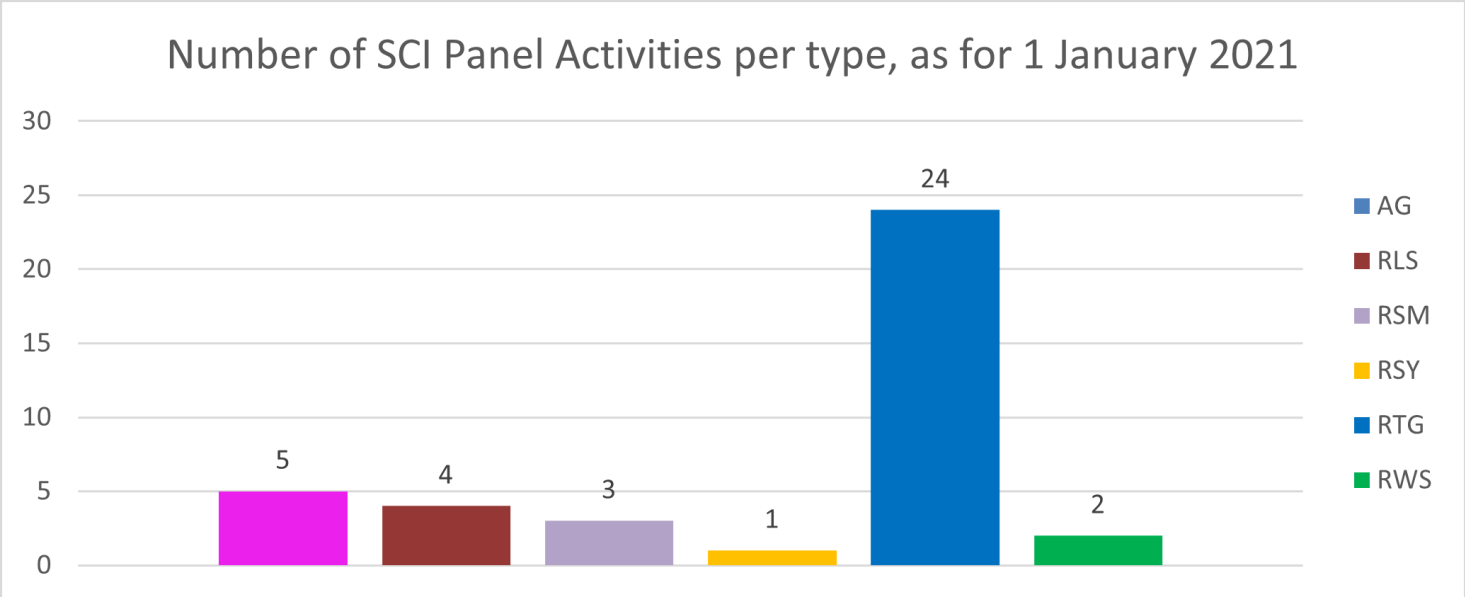


Figure 11: Number of SCI Panel Activities per Type, as of 1 January 2021

Table 14: SCI Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
SCI-277	RLS	Store Separation and Trajectory Prediction
SCI-298	RTG	Identification and Neutralization Methods and Technologies for C-IED
SCI-301	RTG	Defeat of Low Slow and Small (LSS) Air Threats
SCI-302	RTG	DIRCM Concepts and Performances
SCI-303	AG	AG-300 V.33 Flight Test Techniques for the Assessment of Fixed-Wing Aircraft Handling Qualities
SCI-304	RTG	Optimized and Reconfigurable Antennas for Future Vehicle Electronic Counter Measures
SET-305	COM	Flight Test Technical Team (FT3)
SCI-306	AG	AG-300 V.34 Reduced Friction Runway Surface Flight Testing: Issue 2
SCI-307	RTG	FAMOS Framework for Avionics Mission Systems
SCI-310	RTG	Expanded Countermeasure Methods Against IR Anti-Ship Threats in Varied Parameter and Scenario Engagements Using All-Digital Tools Sets
SCI-311	RTG	Collaborative Space Domain Awareness Data Collection and Fusion Experiment
SCI-312	RTG	EO-IR Countermeasures
SCI-314	AG	AG-300 V.35 Ground and Flight Test Methods Used to Assure Aero-Elastic Stability of Fixed Wing Aircraft
SCI-315	AG	AG-300 V.36 Flight Testing of Helmet Mounted Displays
SCI-316	RTG	High Energy Laser Weapons: Quantifying the Impact of Atmospherics and Reflections
SCI-317	RLS	Hands-On with JANUS: Understanding, Implementing and Using the First Digital Underwater Communications Standard
SCI-320	RTG	Scientific Support to NNAG Above Water Warfare Capability Group
SCI-321	RTG	UAV Applications for Military Search
SCI-322	RTG	Scientific Support to NATO Aerospace Capability Group 3 Sub-Group 2 (ACG3/SG2) on Suppression of Enemy Air Defence (SEAD)
SCI-324	RWS	Realization and Evaluation of Robotic Multispectral Decoys for Land Equipment
SCI-325	RTG	Methods of Identifying and Evaluation the Camouflage and Deceptive Properties of the Military Equipment in Land Field Trials
SCI-326	RTG	Electronic Support (ES) Techniques Enabling Cognitive Electronic Warfare (EW)
SCI-327	RTG	Countermeasure Concepts Against Anti-Aircraft Dual Band EO/IR Imaging Seekers
SCI-329	RSM	Capabilities for Sensing, Search, and Surveillance in the Arctic
SCI-330	RLS	Multinational Capability Development Campaign (MCDC) Analysis on Autonomous Unmanned Systems (UAxS)
SCI-332	RTG	Radio Frequency-Based Electronic Attack to Modern Radar
SCI-333	RTG	Multi-sensor Fusion Architecture for the Detection of Person-Borne-Improvised Explosive Devices (PB-IEDs)
SCI-334	RTG	Evaluation of Swarm System for Military Applications

SCI-335	RSM	Autonomy from a System Perspective – Version 2.0
SCI-337	RWS	Combination of Field Measurements and M&S Assessment Methods
SCI-338	AG	AG-300-V.37 Flight Testing of Unmanned Aerial Vehicles
SCI-340	RLS	HEL Weapon Technology, Opportunities, and Challenges
SCI-342	RTG	Explosive Ordnance Disposal (EOD) Tele-Manipulation Robot Technology Roadmap Development
SCI-SET-323	RSM	Above Water EO/IR Signature Requirements from an Operational Perspective

Table 15: SCI Activities Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
SCI-336	RTG	Cyber-Physical Systems Resilience for NATO Operations
SCI-341	RSY	Situation Awareness of Swarms and Autonomous Systems
SCI-343	RTG	Enabling Federated, Collaborative Autonomy
SCI-344	RTG	Future Multi-sensor Threat Defeat Concepts
SCI-346	RTG	Space Risk Assessment Matrix (S-RAM)
SCI-347	RTG	SMART IED Threat Mitigation Technology Assessments SMiTMiTA

Table 16: SCI Activities Starting in 2022

ACTIVITY	ACTIVITY TYPE	TITLE
SCI-328	RSY	Flight Testing of Unmanned Aerial Systems (UAS)

SENSORS AND ELECTRONICS TECHNOLOGY PANEL (SET)

Panel Chair: Mr. Frank VAN DEN BOGAART (NLD)
Panel Vice-Chair: Dr. Alexandre JOUAN (CAN)

Panel Executive: Lt. Col. Isidoro MARCONE (ITA)
Panel Assistant: Ms. Illeana GANZ (NATO)

MISSION

The mission of the Sensors and Electronics Technology (SET) Panel is to foster co-operative research, the exchange of information, and the advancement of science and technology among the NATO Nations in the field of sensors and electronics for defence and security. The SET Panel addresses the development and enhancement of both passive and active sensors, as well as electronic technology capabilities, multi sensor integration and fusion as they pertain to Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR), Remote Sensing, Electronic Warfare (EW), Communications, and Navigation. To fulfil this mission, the SET Panel is organized into three Focus Groups: Radio-Frequency Technology (RFT); Optical Technology (OT); and Multi-Sensors & Electronics (MSE).

MAIN INTEREST

The research activities of the SET Panel predominantly address topics related to target signatures, propagation and battlespace environments, sensors (e.g., Electro-Optic (EO), Radio-Frequency (RF), acoustic/magnetic), antennas, signal and image processing, components, sensor hardening, electromagnetic compatibility and any other phenomena associated with sensors and electronics that may assist NATO war-fighters during future warfare and peace-keeping scenarios.

In principle, the Focus Groups address the following domains:

1. Multi Sensors and Electronics:

- Sensing for ISR;
- C-IED;
- Swarms;
- Navigation.

2. Radio Frequency Technology:

- Radar (including Active, Passive, SAR, Noise, Cognitive, Multi-and Bi-static, Multi-function, SW Defined);
- ATR/NCTR;
- Radar Imaging;
- Radar Signatures;
- Spectrum Management.

3. Optical Technology:

- Infrared and Spectral Sensing;
- Laser Radar Technology;
- Performance Modeling;
- Target Signatures.

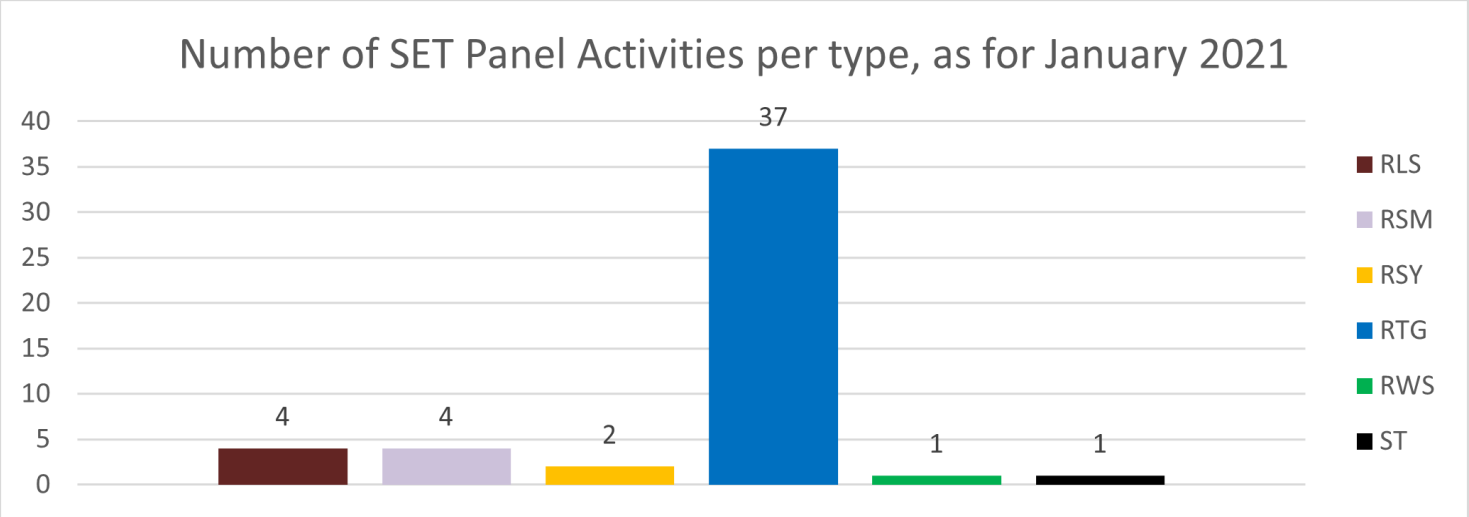


Figure 12: Number of SET Panel Activities per Type, as of 1 January 2021

Table 17: SET Activities Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
SET-217	RTG	Assessing and Modeling the Performance of Digital Night Vision Image Fusion
SET-242	RTG	Passive Coherent Locators on Mobile Platforms
SET-246	RTG	Short Wave Infrared Technology: A Standardized Irradiance Measurement and Compatibility Model to Evaluate Reflective Band Systems
SET-249	RTG	Laser Eye Dazzle Threat Evaluation and Impact on Human Performance
SET-250	RTG	Multi-Dimensional Radar Imaging
SET-252	RTG	Development of a Validation Model of a Stealth UCAV
SET-256	RTG	Interoperability and Networking of Disparate Sensors and Platforms for ISR Applications
SET-257	RLS	Compressive Sensing Techniques for Radar and ESM Applications
SET-258	RTG	DMPAR Deployment and Assessment in Military Scenario
SET-260	RTG	Assessment of EO/IR Technologies for Detection of Small UAVs in an Urban Environment
SET-263	RTG	Swarms Systems for Intelligence Surveillance and Reconnaissance
SET-266	RTG	Multi-Functional EO/IR Sensors for Counter-Surveillance
SET-268	RTG	Bi-/Multi-Static Radar Performance Evaluation Under Synchronized Conditions
SET-269	RTG	EO/IR Ship Signature Dynamics
SET-270	RTG	Overcoming the Technical Barriers that Inhibit Use of Fuel Cells for Dismounted Soldier Applications
SET-271	RTG	Airborne Maritime Radar Based Submarine Periscope Detection and Discrimination at High Grazing Angles
SET-272	RTG	Automated Scene Understanding for Battlefield Awareness
SET-273	RSM	Multidimensional Radar Imaging and ATR
SET-274	RLS	Cooperative Navigation in GNSS Degraded and Denied Environments
SET-278	RTG	Machine Learning for Wide Area Surveillance
SET-279	RTG	Space-Based SAR and Big Data Technologies to Support NATO Operations
SET-280	RTG	Phenomenology and Exploitation of CMs
SET-283	RTG	Advanced Machine Learning ATR using SAR/ISAR Data
SET-284	RSM	Enhanced Situation Awareness Using Active-Passive Radar Systems in Military Scenarios
SET-285	RTG	Multifunction RF Systems
SET-286	RTG	Acoustic and Seismic Sensing of Threats in Urban Environments
SET-287	RTG	Characterization of Noise Radar
SET-288	RTG	Integrating Compressive Sensing and Machine Learning Techniques for Radar Applications
SET-289	RWS	Nanotechnology for Optics and Infrared Photo Detection
SET-291	RTG	Sensitivity of EO TDAs to Environmental Factors
SET-292	RTG	Enhanced Raman Spectroscopy for Defence Applications

SET-293	RTG	RF Sensing for Space Situational Awareness
SET-294	RTG	Advanced Mid-Infrared Laser Technology
SET-295	RTG	Radar Signature Measurements of Maritime Platforms
SET-301	RTG	SimPL Simulation of Low Photon Lidar
SET-303	RTG	Military Applications of Extreme Laser Fields

Table 18: SET Activities Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
SET-276	ST	Quality Assurance and Assessment Team for SPS on DEXTER (Detection of Explosives and Firearms to Counter TERrorism)
SET-290	RLS	AI for Military ISR Decision Makers
SET-296	RTG	Radar Against Hypersonic Threats
SET-298	RSM	Electronic Attack and Protection for Modern Active/Passive Netted Radars
SET-299	RLS	Passive Radars – Technology and Applications
SET-300	RTG	3D Active and Passive EO/IR Sensing for Urban Operations
SET-302	RTG	Cognitive Radar
SET-304	RTG	Modeling, Measuring and Mitigating Optical Turbulence: M3T
SET-305	RTG	Improved Field of View for Night Vision Goggles – Technical Challenges, Concepts, Performance Assessment
SET-306	RTG	Improved Panoramic Situational Awareness for Vehicle Platforms – Technical Challenges, Concepts, Performance Assessment

STO EVENTS IN 2021 CPOW

Among various activities administered by the Collaboration Support Office there are several that represent different types of events. These are: Lecture Series, Technical Courses, Symposia, Workshops and Specialists' Meetings.

Visit our website at: www.sto.nato.int
to learn about STO Events we organize.

LECTURE SERIES IN 2021

A Research Lecture Series (RLS) technical team activity aims to disseminate state-of-the-art scientific knowledge among junior and mid-level specialists, scientists and engineers in military-relevant domains that are not taught in universities. An RLS is a two-day educational event that is normally organized at three different locations. RLSs can include a roundtable discussion. RLSs are combined with an STO publication (Educational Notes), which will be made available before the first RLS session.

Table 19: Lecture Series

ACTIVITY	ACTIVITY TYPE	TITLE	MEETING DATE	MEETING LOCATIONS	DISTRIBUTION AND PARTNER PARTICIPATION
AVT-358 (VKI)	RLS	Advanced Computational Fluid Dynamics Methods for Hypersonic Flows	TBD	TBD	UU
AVT-365	RLS	Rotorcraft Flight Simulation Model Fidelity Improvement and Assessment	Mar 2021	TBD	UU (NATO + EOP)
HFM-240	RLS	Mild Traumatic Brain Injury: Post Concussive Symptoms in a Deployed Setting	Fall	Tbilisi, GEO	UU (NATO + PfP + MD + GP)
HFM-314	RLS	Aircrew Neck Pain Prevention and Management Lecture Series	Fall/Winter	GBR-BEL-USA	UU
HFM-328	RLS	Collaborations Between Military and Civilian Personnel in Defence Organizations	Fall/Winter	USA-SWE-BEL	UU
MSG-168	RLS	Modelling and Simulation as a Service (MSaaS)	28 – 30 Apr	Virtual Meeting	UU (EOP, PfP, ICI, GP, SGP, Other)
SCI-277	RLS	Store Separation and Trajectory Prediction	1 week of Jun	Virtual	UU (participation only NATO + AUS, FIN, SWE)
SCI-317	RLS	Hands-On with JANUS: Understanding, Implementing and Using the First Digital Underwater Communications Standard	TBC	Virtual	UU (participation NATO + PfP + MD)
SCI-330	RLS	Multinational Capability Development Campaign (MCDC) Analysis on Autonomous Unmanned Systems (UAxS)	TBC	TBC	UU (however, participation only NATO + AUS, FIN, SWE + CHE)
SCI-340	RLS	HEL Weapon Technology, Opportunities, and Challenges	TBC	TBC	NU (NATO + AUS, FIN, SWE)
SET-257	RLS	Compressive Sensing Techniques for Radar and ESM Applications	Jun TBD	Ottawa, CAN Naples, ITA Warsaw, POL	NU (NATO + EOPs + PfP)
SET-274	RLS	Cooperative Navigation in GNSS Degraded and Denied Environments	TBD	Dayton USA Linkoping, SWE Zagreb, HRV	UU (NATO + EOPs + PfP + SGP)

SET-290	RLS	AI for Military ISR Decision Makers	Oct – Nov TBD	Wachtberg, DEU Rome, ITA Stockholm, SWE	NU (NATO + EOPs + CHE)
SET-299	RLS	Passive Radars – Technology and Applications	QIV TBD	Varna, BGR Budapest, HUN, Atlanta USA	NU (NATO + EOPs + PfP)

TECHNICAL COURSES IN 2021

A Research Technical Course (RTC) is an educational technical team activity aimed at transferring practical knowledge and recent field developments through on-site instructor training or lectures to military decision makers.

Table 20: Technical Courses

ACTIVITY	ACTIVITY TYPE	TITLE	MEETING DATE	MEETING LOCATIONS	DISTRIBUTION AND PARTNER PARTICIPATION
HFM-333	RTC	Aerospace Medicine: New Technologies – New Approach RAMS USAF/NATO STO HFM	22 – 23 Jun	Virtual Meeting	UU (NATO + EOP)
MSG-194	RTC	Employing the C2-Simulation Interoperation (C2SIM) Standard for Coalition Military Operations and Exercises	24 – 25 Feb 4 – 8 Oct	Online; possible hybrid – Orlando, USA	UU (NATO + EOP, PfP, GP)
SAS-149	RTC	Basics of Complex Modern Urban Functions and Characteristics	Jun 2021	Rome, ITA	NU (NATO + PfP, AUS, NZL)

SYMPOSIA IN 2021

A Research Symposium (RSY) technical team activity aims to promote the exchange of state-of-the-art knowledge among a wide audience on an important scientific or applied topic. The prime purpose of an RSY is to enhance the capability of the NATO S&T community to respond adequately to the military requirements of NATO. An RSY is a large-scale (100+ participants), three-to-four day event. Communications are primarily via invited Keynote Addresses. In addition, the Programme Committee sends out a Call for Papers. The Programme Committee screens the submissions and makes a selection for oral and poster presentations. An RSY results in an STO publication (Meeting Proceedings).

Table 21: Symposia

ACTIVITY	ACTIVITY TYPE	TITLE	MEETING DATE	MEETING LOCATIONS	DISTRIBUTION AND PARTNER PARTICIPATION
AVT-356	RSY	Physics of Failure for Military Platform Critical Subsystems	Oct 2021 TBD	Antalya / Online (TBD Apr 2021), TUR	NU (NATO + EOP)
HFM-334	RSY	Applying Neuroscience to Performance: From Rehabilitation to Human Cognitive Augmentation	11 – 13 Oct 2021	ITA	UU
IST-190	RSY	AI, ML and BD for Hybrid Military Operations (AI4HMO)	5 – 6 Oct 2021	Koblenz, DEU	UU (NATO + EOP, PfP)
MSG-184	RSY	Towards Training and Decision Support for Complex Multi-Domain Operations	21 – 22 Oct 2021	Amsterdam, NLD	UU (NATO + EOP, PfP, GP, BRA, IND, SGP)
MSG-185	RSY	MSG/MSCO Support to International Training and Education Conferences IT2EC, I/ITSEC and CA2X2 Forum 2021			
		IT2EC 2021	8 – 10 Sep 2021	Rotterdam, NLD	UU (NATO + EOP + PfP + GP)
		CA2X2 2021	4 – 8 Oct 2021	Virtual Edition	
		I/ITSEC 2021	29 Nov – 3 Dec 2021	Orlando, USA	
SAS-165	RSY	Assessing the Implications of Emerging Technologies for Military Logistics	Nov/Dec 2021	Rome, ITA	NU (NATO + EOP)
SCI-341	RSY	Situation Awareness of Swarms and Autonomous Systems	18 – 19 May 2021	Virtual Meeting	NU (NATO + EOP)
SET-264	RSY	Quantum Position Navigation and Timing for NATO platforms	22 Mar TBC	Hawaii, USA TBC	NU (NATO + EOP)
SET-275	RSY	Cooperative Navigation in GNSS Degraded and Denied Environments	21 – 23 Apr TBC	Split, HRV TBC	UU (NATO + EOP + PfP + SGP)

WORKSHOPS IN 2021

A Research Workshop (RWS) technical team activity aims to facilitate intensive information exchange and focused discussion on a specific topic among a limited number of invited experts. The prime purpose of an RWS is to enhance the capability of the NATO S&T community to respond adequately to the military requirements of NATO. An RWS (generally not more than 30 participants) is a two to three-day event with no prescribed format. An RWS results in an STO publication (Meeting Proceedings).

Table 22: Workshops

ACTIVITY	ACTIVITY TYPE	TITLE	MEETING DATE	MEETING LOCATIONS	DISTRIBUTION AND PARTNER PARTICIPATION
AVT-337	RWS	Anti-Tamper Protective Systems for NATO Operations	Oct 2021 TBD	Antalya / Online (TBD Apr 2021), TUR	NU (NATO + EOP)
AVT-340	RWS	Neuroscience-Based Technologies for Combat-Oriented Crew Cockpit Design and Operations	2 – 4 and 9 – 11 Feb 2021	Online	NU (NATO + EOP)
AVT-354	RWS	Multi-Fidelity Methods for Military Vehicle Design	Oct 2021 TBD	Antalya/Online (TBD Apr 2021), TUR	NU (NATO + EOP)
AVT-355	RWS	Intelligent Solutions for Improved Mission Readiness of Military UxVs	3 – 5 and 7 May 2021	Online	NU (NATO + EOP)
AVT-357	RWS	Technologies for Future Distributed Engine Control Systems (DECS)	11 – 13 May 2021	Online	NU (NATO + EOP, UKR)
AVT-360	RWS	Environmentally Compliant Approaches to Maintenance and Overhaul of Military Vehicles	Spring 2021 TBD	TBD	NU (NATO + EOP)
AVT-361	RWS	Certification of Bonded Repair on Composite Aircraft Structures	Fall 2021 TBD	TBD	NU (NATO + EOP, NZL)
AVT-364	RWS	Environmental Regulation on Energetic Systems and its Impact on Critical Munitions Materials and Capability	Spring 2021 TBD	TBD	NR (NATO + EOP)
AVT-366	RWS	Use of Computational Fluid Dynamics for Design and Analysis: Bridging the Gap Between Industry and Developers	Spring 2021 TBD	TBD	NU (NATO + EOP)
HFM-322	RWS	Meaningful Human Control of AI-Based Systems: Key Characteristics, Influencing Factors and Design Considerations	Fall	TBD: Aachen or Berlin, DEU	UU (NATO + EOP, PfP, MD, ICI, GP)
IST-183 (IWA)	RWS	Deep Machine Learning for Cyber Defence	TBD, Jul/Aug 2021	TBD	NU (NATO + EOP)

IST-191	RWS	Rescue Systems for Broken Trust	TBD, Jun 2021	TBD, virtual / POL	UU (NATO + EOP, PfP)
MSG-192	RWS	Commercial Technologies and Games for Use in NATO and Nations	4 – 8 Oct 2021	Online	UU (NATO + EOP, PfP, GP)
SCI-324	RWS	Realization and Evaluation of Robotic Multispectral Decoys for Land Equipment	TBC	TBC	NU (NATO + EOP + CHE)
SCI-337	RWS	Combination of Field Measurements and M&S Assessment Methods	Fall 2021 TBC	TBC	NU (NATO + EOP + CHE)
SET-289	RWS	Nanotechnology for Optics and Infrared Photo Detection	May – Jun TBC	Paris, FRA	UU (NATO + EOPs + CHE + JPN)

SPECIALISTS' MEETING IN 2021

A Research Specialists' Meeting (RSM) technical team activity aims to promote the exchange of state of the-art knowledge among an audience of specialists with invited speakers on an important scientific or applied topic. The prime purpose of an RSM is to enhance the capability of the NATO S&T community to respond adequately to the military requirements of NATO. An RSM is a medium-scale (usually less than 100 participants), two to three-day event. The Programme Committee organizes communications, inviting experts to give Keynote Addresses and arranging oral presentations that include roundtable discussions. An RSM results in an STO publication (Meeting Proceedings).

Table 23: Specialists' Meeting

ACTIVITY	ACTIVITY TYPE	TITLE	MEETING DATE	MEETING LOCATIONS	DISTRIBUTION AND PARTNER PARTICIPATION
AVT-335	RSM	Range Design and Management for Sustainable Live Fire Training Ranges	12 – 16 Apr 2021 (3 Days, TBD)	Online	NU (NATO + EOP, PfP, MD, JPN, NZL, BRA
AVT-336	RSM	Enabling Platform Technologies for Resilient Small Satellite Constellations for NATO Missions	Oct 2021 TBD	Antalya/Online (TBD Apr 2021)	NU (NATO + EOP, PfP, NZL)
AVT-338	RSM	Advanced Wind Tunnel Boundary Simulation II	24 – 27 May 2021	Online	NU (NATO + EOP)
HFM-SET-339	RSM	Scientific and Technological Trends Allow for New Approaches Addressing CBRN Challenges	Fall, TBD	Brussels, BEL	NS (NATO + EOP)
IST-181 (COM)	RSM	Terahertz-Band Communications and Networking	TBD, 2021	TBD	NU (NATO + EOP)

IST-185 (COM)	RSM	Communication Networks and Information Dissemination for the Tactical Edge	TBD, 2021	TBD	NU (NATO + EOP)
IST-186 (IWA)	RSM	Blockchain Technology for Coalition Operations	TBD, Mar 2021	virtual	UU (NATO + EOP, PfP)
MSG-SET-183	RSM	Drone Detectability: Modelling the Relevant Signature	28 – 30 Apr 2021	CZE	NU (NATO + EOP, PfP, KOR, NLZ)
SCI-329	RSM	Capabilities for Sensing, Search, and Surveillance in the Arctic	Sep – TBC	DNK	NU (NATO + EOP + CHE, NZL)
SCI-335	RSM	Autonomy from a System Perspective – Version 2.0	24 – 26 May 2021	Virtual	NU (NATO + EOP)
SCI-SET-323	RSM	Above Water EO/IR Signature Requirements from an Operational Perspective	TBD	CAN	NS (NATO + EOP + NZL)
SET-273	RSM	Multidimensional Radar Imaging and ATR	25 – 26 Oct 2021	Marseille, FRA	NU (NATO + EOP, CHE, ZAF)
SET-284	RSM	Enhanced Situation Awareness Using Active-Passive Radar Systems in Military Scenarios	QIII TBC	Warsaw, POL	NU (NATO + EOP)
SET-298	RSM	Electronic Attack and Protection for Modern Active/Passive Netted Radars	TBD	TBD	NS (NATO + EOP)
SET-SCI-297	RSM	Space Sensors and Space Situational Awareness	TBD	TBD	NU (NATO + EOP, PfP)

EXPLORATORY TEAMS

Exploratory Teams (ETs) may be established when a Panel/Group believes that a particular expertise is required to assist or advise the Panel/Group on the technical merit or feasibility of a specific proposal for a technical activity. ETs may also be used to help the Panel/Group develop recommendations on future content of the Panel/Group's Programme of Work.

Table 24: Exploratory Teams Continuing in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-ET-187	ET	Test Protocol Development for New Paint Removal Technologies
AVT-ET-198	ET	Advanced Selectable Yield Unitary (SYU) Warheads
AVT-ET-205	ET	Next Generation EO Vehicle Signature Prediction Algorithms
AVT-ET-206	ET	Vehicle Vibrations Assessment and Reduction Using Innovative Methods
AVT-ET-207	ET	Improving the Understanding of Risks from Exposure to Munition Combustion Products
AVT-ET-208	ET	More Electric Aircraft and Rotorcraft Gas Turbine Engines
AVT-ET-210	ET	Numerical Prediction and Detection of Adhesive Bond Strength for Primary Structural Joints
AVT-ET-211	ET	Digital Twin Technology and Application for Product Development and Sustainment
AVT-ET-212	ET	Materials and Technologies for Electro-Optical Camouflage
AVT-ET-213	ET	Military Value of Graphene Technologies
HFM-ET-166	ET	Evaluation of Treatments of Post-Amputation Phantom Limb Pain
HFM-ET-173	ET	Evidence-Based Aerospace Medicine
HFM-ET-175	ET	Minimum Requirement of Education and Training of Surgeons Deployable in Multinational Missions
HFM-ET-182	ET	Operational Ethics: Preparation and Interventions for the Future Security Environment
HFM-ET-183	ET	Human Impact Exposure Onboard High-Speed Boats
HFM-ET-186	ET	Microbiome Applications in Human Health and Performance
HFM-ET-187	ET	Military Service Member and Veteran Domestic Radicalization
HFM-ET-188	ET	Operations Security and Influence in the Online Information Environment (OPSEC-IOIE)
IST-ET-105	ET	Digital Employees for Network Management and Control
IST-ET-108	ET	Communication in Contested EW Environment
IST-ET-109	ET	Orchestration and Scalability of AI-Driven Systems
IST-ET-110	ET	Blockchain Technology for Coalition Operations
IST-ET-111	ET	Knowledge Representation and Reasoning
IST-ET-112	ET	Machine Learning Ecosystem for the Rapid Research, Development, and Deployment of Artificial Intelligence and Machine Learning Capabilities
IST-ET-113	ET	Unsupervised Machine Learning in the Military Domain
IST-ET-114	ET	Cyber Security in Virtualized Networks
IST-ET-115	ET	Free Space Optical Communication Networks
MSG-ET-051	ET	Development of a Standard for a Generic Tactical Data Link Model

SAS-ET-ER	ET	Optimizing Long-Term Defence Plans with Respect to Resources, Defence Capabilities and Risk
SAS-ET-ET	ET	Distributed Wargaming for a COVID 19 World
SAS-IST-ET-ES	ET	C2 Services in Multi Domain Operations for Federated Mission Networking (FMN)
SET-ET-119	ET	Assessment of EO/IR Compressive Sensing and Computational Imaging Systems
SET-ET-120	ET	NATO PNT Open System Architecture and Standards to Ensure PNT in NAVWAR Environments
SET-ET-121	ET	Design Space Exploration for Autonomous Sensing

Table 25: Exploratory Teams Starting in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-ET-209	ET	Munition Health Management Technologies: Enabling Early Adopters
AVT-ET-214	ET	Operation of Unmanned Aerial Vehicles (UAVs) in Icing Environments
HFM-ET-189	ET	Workforce Analytics Exchange: Standards for Military Personnel Data
HFM-ET-190	ET	Psychosocial Factors of Unconventional Warfare
HFM-ET-191	ET	Treatment Challenges with Combined Injuries
HFM-ET-192	ET	Blast Exposure Monitoring in Military Training and Operations (BEMMTO)
HFM-ET-193	ET	Skills and Chill Pills: Navigating the Cyber-Social Information Environment
IST-ET-116	ET	Formal Modelling of Military Cryptographic Key-Management (COMSEC) Processes
IST-ET-117	ET	Data Hiding in Information Warfare Operations
SCI-ET-055	ET	Air Platform Generic Self-Defence
SCI-ET-056	ET	Role of Data and Decision-making on the Space Ops Floor
SET-ET-122	ET	Advanced Methods for Hyperspectral Data Exploitation
SET-ET-123	ET	Explosive Test Standards and Methods for Stand-Off Detection on Relevant Surfaces
SET-ET-124	ET	Evaluation Framework for Multi-Sensor Tracking and Fusion Algorithms

EMERGING AND DISRUPTIVE TECHNOLOGIES

Eight highly interrelated S&T areas are now considered to be a major strategic disruptor over the next 20 years. These S&T areas, also recognized as Emerging and Disruptive Technologies (EDTs), are either currently in nascent stages of development or are undergoing rapid revolutionary development. **The EDTs are: Space, Big Data, Artificial Intelligence, Autonomy, Hypersonic, Quantum, Biotech and Novel Materials**. Currently, 44% of ongoing STO CPoW activities can be connected to at least one EDT. Tables 26 – 33 present STO activities (together with Exploratory Teams) that are related to different Emerging and Disruptive Technologies.

Table 26: Space

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-336	RSM	Enabling Platform Technologies for Resilient Small Satellite Constellations for NATO Missions
IST-189	RTG	Hybrid Military and Commercial SATCOM Networks
MSG-163	RTG	Evolution of NATO Standards for Federated Simulation
MSG-187	RTG	Space Weather Environmental Modelling (SWEM)
SAS-129	RTG	Gamification of Cyber Defence/Resilience
SAS-159	RTG	How could Technology Development Transform the Future Operational Environment
SAS-166	RTG	Wargaming Multi-Domain Operations in an A2/AD Environment
SCI-311	RTG	Collaborative Space Domain Awareness Data Collection and Fusion Experiment
SCI-316	RTG	High Energy Laser Weapons: Quantifying the Impact of Atmospherics and Reflections
SCI-322	RTG	Scientific Support to NATO Aerospace Capability Group 3 Sub-Group 2 (ACG3/SG2) on Suppression of Enemy Air Defence (SEAD)
SCI-329	RSM	Capabilities for Sensing, Search, and Surveillance in the Arctic
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SCI-345	RWS	Space as a Force Enabler – SPACE
SCI-346	RTG	Space Risk Assessment Matrix (S-RAM)
SCI-ET-052	ET	EOD Tele-Manipulation Robot Technology Roadmap Development; Operators Remotely Handling Objects with Dexterity, 3D Perception and Haptic Feedback
SCI-ET-056	ET	Role of Data and Decision-making on the Space Ops Floor
SET-279	RTG	Space-Based SAR and Big Data Technologies to Support NATO Operations
SET-293	RTG	RF Sensing for Space Situational Awareness
SET-SCI-297	RSM	Space Sensors and Space Situational Awareness

Table 27: Big Data

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-292	RTG	Munition Health Management Technologies: Effects on Operational Capability, Interoperability, Life-Cycle Cost and Acquisition of Missile Stockpiles of NATO Nations
AVT-308	RTG	Cooperative Demonstration of Technology (CDT) for Next-Generation NATO Reference Mobility Model (NG-NRMM)
AVT-317	RTG	Trade-Space Exploration to Support the Early Stage Design of Effective and Affordable (Fleets) of Warships
AVT-327	RTG	Standardization Recommendation (STANREC) Development for Next Generation NATO Reference Mobility Model (NRMM)
AVT-331	RTG	Goal-Driven, Multi-Fidelity Approaches for Military Vehicle System-Level Design
AVT-351	RTG	Enhanced Computational Performance and Stability and Control Prediction for NATO Military Vehicles
AVT-354	RWS	Multi-Fidelity Methods for Military Vehicle Design
AVT-355	RWS	Intelligent Solutions for Improved Mission Readiness of Military UxVs
AVT-ET-211	ET	Digital Twin Technology and Application for Product Development and Sustainment
HFM-294	RTG	Big Data In The Military: Integrating Genomics into the Pipeline of Standard-care Testing and Treatment
HFM-332	RTG	Development and Implementation of Autonomous Transport and Medical Systems for Casualty Evacuation
HFM-343	RTG	Digital Teaching Networks: Fostering Digital Collaboration Among Teachers, Trainers, Instructors, and Coaches in the military
HFM-ET-182	ET	Operational Ethics: Preparation and Interventions for the Future Security Environment
IST-146	RTG	Electromagnetic Environment Situational Awareness for NATO
IST-163	RTG	Deep Machine Learning for Cyber Defence
IST-165	RTG	High-Level Fusion of Hard and Soft Information for Intelligence
IST-168	RTG	Adaptive Information Processing and Distribution to Support Command and Control
IST-176	RTG	Federated Interoperability of Military C2 and IoT Systems
IST-177	RTG	Social Media Exploitation for Operations in the Information Environment
IST-183	RWS	Deep Machine Learning for Cyber Defence
IST-184	RTG	Visual Analytics for Complex Systems
IST-ET-112	ET	Machine Learning Ecosystem for the Rapid Research, Development, and Deployment of Artificial Intelligence and Machine Learning Capabilities
IST-ET-113	ET	Unsupervised Machine Learning in the Military Domain
MSG-184	RSY	Towards Training and Decision Support for Complex Multi-Domain Operations
MSG-186	RTG	Multi-Dimensional Data Farming
MSG-189	ST	AI Augmented Immersive Simulation in Training and DM Course of Actions Analysis
MSG-193	ST	Modelling and Simulation Standards in Federated Mission Networking (FMN)
SAS-124	RTG	Visualization Design for Communicating Defence Investment Uncertainty and Risk
SAS-139	RTG	NATO Analytical War Gaming – Innovative Approaches for Data Capture, Analysis and Exploitation

SAS-143	RTG	Agile, Multi-Domain C2 of Socio-Technical Organizations in Complex Endeavors
SAS-144	RTG	Code of Best Practice for Conducting Survey Research in a Military Context
SAS-156	RTG	Developing a Standard Methodology for Assessing Multinational Interoperability
SAS-157	RTG	Automation in the Intelligence Cycle
SAS-158	RTG	Employing AI to Federate Sensors in Joint Settings
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SAS-160	RTG	Ethical, Legal and Moral (ELM) Impacts of Novel Technologies on NATO's Operational Advantage – the "ELM Tree"
SAS-165	RSY	Assessing the Implications of Emerging Technologies for Military Logistics
SAS-167	RTG	Assessing the Value of Cyber Operations in Military Operations
SAS-168	RTG	Coalition Sustainment Interoperability Study
SAS-IST-162	ST	A Hackathon to Determine How Large Exercise Datasets Can Be Used to Reconstruct Operational Decision Making to Improve Training and Analysis value
SAS-IST-ET-ES	ET	C2 Services in Multi Domain Operations for Federated Mission Networking (FMN)
SCI-311	RTG	Collaborative Space Domain Awareness Data Collection and Fusion Experiment
SCI-322	RTG	Scientific Support to NATO Aerospace Capability Group 3 Sub-Group 2 (ACG3/SG2) on Suppression of Enemy Air Defence (SEAD)
SCI-324	RWS	Realization and Evaluation of Robotic Multispectral Decoys for Land Equipment
SCI-326	RTG	Electronic Support (ES) Techniques Enabling Cognitive Electronic Warfare (EW)
SCI-329	RSM	Capabilities for Sensing, Search, and Surveillance in the Arctic
SCI-337	RWS	Combination of Field Measurements and M&S Assessment Methods
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SET-250	RTG	Multi-Dimensional Radar Imaging
SET-256	RTG	Interoperability and Networking of Disparate Sensors and Platforms for ISR Applications
SET-257	RLS	Compressive Sensing Techniques for Radar and ESM Applications
SET-263	RTG	Swarms Systems for Intelligence Surveillance and Reconnaissance
SET-272	RTG	Automated Scene Understanding for Battlefield Awareness
SET-273	RSM	Multidimensional Radar Imaging and ATR
SET-279	RTG	Space-Based SAR and Big Data Technologies to Support NATO Operations
SET-283	RTG	Advanced Machine Learning ATR using SAR/ISAR data
SET-284	RSM	Enhanced Situation Awareness Using Active-Passive Radar Systems in Military Scenarios
SET-290	RLS	AI for Military ISR Decision Makers
SET-ET-119	ET	Assessment of EO/IR Compressive Sensing and Computational Imaging Systems
SET-ET-124	ET	Evaluation Framework for Multi-Sensor Tracking and Fusion Algorithms

Table 28: Artificial Intelligence

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-329	LTSS	NexGen Rotorcraft Impact on Military Operations
AVT-331	RTG	Goal-Driven, Multi-Fidelity Approaches for Military Vehicle System-Level Design
AVT-353	RWS	Artificial Intelligence in Cockpits for UAVs
AVT-354	RWS	Multi-Fidelity Methods for Military Vehicle Design
AVT-TW-016	TW	Cognitive Solutions for Multi-Source Multi-Format Information Fusion in Autonomous Scenarios
HFM-276	RTG	Human Factors and ISR Concept Development and Evaluation
HFM-281	RTG	Personalized Medicine in Mental Health and Performance
HFM-293	RTG	Digital and Social Media Assessment for Effective Communication and Cyber Diplomacy
HFM-294	RTG	Big Data In The Military: Integrating Genomics into the Pipeline of Standard-care Testing and Treatment
HFM-297	RTG	Assessment of Augmentation Technologies for Improving Human Performance
HFM-311	RTG	Cognitive Neuro-Enhancement: Techniques and Technology
HFM-316	RTG	Expert Panel for State of the Art Cardiovascular Risk Assessment in Aircrew and Other High Risk Occupations
HFM-322	RWS	Meaningful Human Control of AI-Based Systems: Key Characteristics, Influencing Factors and Design Considerations
HFM-324	RSY	Symposium; Solutions for Combat Casualty Care
HFM-330	RTG	Human Systems Integration for Meaningful Human Control Over AI-Based Systems
IST-152	RTG	Intelligent, Autonomous and Trusted Agents for Cyber Defence and Resilience
IST-157	RTG	Human in the Loop Considerations for Artificial Intelligence
IST-163	RTG	Deep Machine Learning for Cyber Defence
IST-164	RTG	Securing Unmanned and Autonomous Vehicles for Mission Assurance
IST-165	RTG	High-Level Fusion of Hard and Soft Information for Intelligence
IST-168	RTG	Adaptive Information Processing and Distribution to Support Command and Control
IST-169	RTG	Robustness and Accountability in Machine Learning Systems
IST-183	RWS	Deep Machine Learning for Cyber Defence
IST-ET-105	ET	Digital Employees for Network Management and Control
IST-ET-109	ET	Orchestration and Scalability of AI-Driven Systems
IST-ET-112	ET	Machine Learning Ecosystem for the Rapid Research, Development, and Deployment of Artificial Intelligence and Machine Learning Capabilities
IST-ET-113	ET	Unsupervised Machine Learning in the Military Domain
IST-HFM-182	RTG	Synthetic Legal Adviser – AI-Based Decision Making in Hyperwar
MSG-184	RSY	Towards Training and Decision Support for Complex Multi-Domain Operations

MSG-186	RTG	Multi-Dimensional Data Farming
MSG-189	ST	AI Augmented Immersive Simulation in Training and DM Course of Actions Analysis
MSG-192	RWS	Commercial Technologies and Games for Use in NATO and Nations
MSG-193	ST	Modelling and Simulation Standards in Federated Mission Networking (FMN)
MSG-SAS-178	RTG	Using Simulation to Better Inform Decision Making for Warfare Development, Planning, Operations and Assessment
SAS-139	RTG	NATO Analytical War Gaming – Innovative Approaches for Data Capture, Analysis and Exploitation
SAS-143	RTG	Agile, Multi-Domain C2 of Socio-Technical Organizations in Complex Endeavors
SAS-157	RTG	Automation in the Intelligence Cycle
SAS-158	RTG	Employing AI to Federate Sensors in Joint Settings
SAS-159	RTG	How could Technology Development Transform the Future Operational Environment
SAS-160	RTG	Ethical, Legal and Moral (ELM) Impacts of Novel Technologies on NATO's Operational Advantage – The "ELM Tree"
SAS-165	RSY	Assessing the Implications of Emerging Technologies for Military Logistics
SAS-167	RTG	Assessing the Value of Cyber Operations in Military Operations
SAS-168	RTG	Coalition Sustainment Interoperability Study
SAS-IST-162	ST	A Hackathon to Determine How Large Exercise Datasets Can Be Used to Reconstruct Operational Decision Making to Improve Training And Analysis Value
SAS-IST-ET-ES	ET	C2 services in Multi Domain Operations for Federated Mission Networking (FMN)
SCI-326	RTG	Electronic Support (ES) Techniques Enabling Cognitive Electronic Warfare (EW)
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SCI-341	RSY	Situation Awareness for Swarm of Autonomous Systems
SET-278	RTG	Machine Learning for Wide Area Surveillance
SET-283	RTG	Advanced Machine Learning ATR using SAR/ISAR data
SET-288	RTG	Integrating Compressive Sensing and Machine Learning Techniques for Radar Applications
SET-290	RLS	AI for Military ISR Decision Makers
SET-302	RTG	Cognitive Radar
SET-ET-122	ET	Advanced Methods for Hyperspectral Data Exploitation

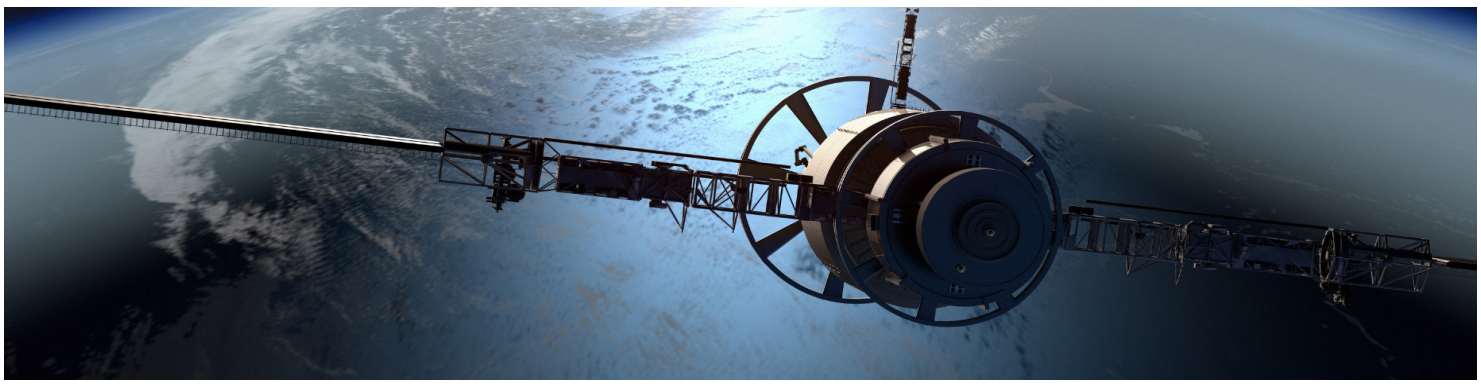


Table 29: Autonomy

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-308	RTG	Cooperative Demonstration of Technology (CDT) for Next-Generation NATO Reference Mobility Model (NG-NRMM)
AVT-327	RTG	Standardization Recommendation (STANREC) Development for Next Generation NATO Reference Mobility Model (NRMM)
AVT-329	LTSS	NexGen Rotorcraft Impact on Military Operations
AVT-341	RTG	Mobility Assessment Methods and Tools for Autonomous Military Ground Systems
AVT-353	RWS	Artificial Intelligence in Cockpits for UAVs
AVT-ET-214	ET	Operation of Unmanned Aerial Vehicles (UAVs) in Icing Environments
HFM-297	RTG	Assessment of Augmentation Technologies for Improving Human Performance
HFM-311	RTG	Cognitive Neuroenhancement: Techniques and Technology
HFM-322	RWS	Meaningful Human Control of AI-Based Systems: Key Characteristics, Influencing Factors and Design Considerations
HFM-330	RTG	Human Systems Integration for Meaningful Human Control Over AI-Based Systems
HFM-332	RTG	Development and Implementation of Autonomous Transport and Medical Systems for Casualty Evacuation
HFM-340	RTG	Neuroscience-Based Technologies for Combat-Oriented Crew Cockpit Design and Operations
IST-152	RTG	Intelligent, Autonomous and Trusted Agents for Cyber Defence and Resilience
IST-157	RTG	Human in the Loop Considerations for Artificial Intelligence
IST-164	RTG	Securing Unmanned and Autonomous Vehicles for Mission Assurance
IST-169	RTG	Robustness and Accountability in Machine Learning Systems
IST-179	RTG	Interoperability for Semi-Autonomous Unmanned Ground Vehicles
IST-ET-113	ET	Unsupervised Machine Learning in the Military Domain
IST-HFM-182	RTG	Synthetic Legal Adviser – AI-based Decision Making in Hyperwar
MSG-154	RTG	Low Slow Small Threats Modelling and Simulation
MSG-SET-183	RSM	Drone Detectability: Modelling the Relevant Signature
SAS-140	RTG	Directed Energy Weapons Concepts and Employment
SAS-143	RTG	Agile, Multi-Domain C2 of Socio-Technical Organizations in Complex Endeavors
SAS-147	RTG	Analysis of Anti-Access Area Denial (A2/AD)
SAS-151	RTG	Solutions Enabling Intermediate Force / Non-Lethal Weapon Contributions to Mission Success
SAS-157	RTG	Automation in the Intelligence Cycle
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SAS-160	RTG	Ethical, Legal and Moral (ELM) Impacts of Novel Technologies on NATO's Operational Advantage – The "ELM Tree"
SAS-165	RSY	Assessing the Implications of Emerging Technologies for Military Logistics

SCI-298	RTG	Identification and Neutralization Methods and Technologies for C-IED
SCI-301	RTG	Defeat of Low Slow and Small (LSS) Air Threats
SCI-302	RTG	DIRCM Concepts and Performances
SCI-307	RTG	FAMOS Framework for Avionics Mission Systems
SCI-310	RTG	Expanded Countermeasure Methods against IR Anti-Ship Threats in Varied Parameter and Scenario Engagements Using All-Digital Tools Sets
SCI-312	RTG	EO-IR Countermeasures
SCI-321	RTG	UAV Applications for Military Search
SCI-324	RWS	Realization and Evaluation of Robotic Multispectral Decoys for Land Equipment
SCI-326	RTG	Electronic Support (ES) Techniques Enabling Cognitive Electronic Warfare (EW)
SCI-327	RTG	Countermeasure Concepts against Anti-Aircraft Dual band EO/IR Imaging Seekers
SCI-332	RTG	Radio Frequency-Based Electronic Attack to Modern Radar
SCI-335	RSM	Autonomy from a System Perspective – Version 2.0
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SCI-341	RSY	Situation Awareness for Swarm of Autonomous Systems
SCI-342	RTG	Explosive Ordnance Disposal (EOD) Tele-Manipulation Robot Technology Roadmap Development
SCI-343	RTG	Enabling Federated, Collaborative Autonomy
SCI-ET-056	ET	Role of Data and Decision Making on the Space Ops Floor
SET-263	RTG	Swarms Systems for Intelligence Surveillance and Reconnaissance
SET-272	RTG	Automated Scene Understanding for Battlefield Awareness
SET-ET-121	ET	Design Space Exploration for Autonomous Sensing

Table 30: Hypersonic

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-346	RTG	Predicting Hypersonic Boundary-Layer Transition on Complex Geometries
AVT-352	RTG	Measurement, Modeling and Prediction of Hypersonic Turbulence
AVT-358	RLS	Advanced Computational Fluid Dynamics Methods for Hypersonic Flows
AVT-359	LTSS	Impact of Hypersonic Operational Threats on Military Operations and Technical High-Level Requirements
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SAS-166	RTG	Wargaming Multi-Domain Operations in an A2/AD Environment
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SET-296	RTG	Radar Against Hypersonic Threats

Table 31: Quantum

ACTIVITY	ACTIVITY TYPE	TITLE
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SCI-314	AG	AG-300 V.35 Ground and Flight Test Methods Used to Assure Aeroelastic Stability of Fixed Wing Aircraft
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SET-264	RSY	Quantum Position Navigation and Timing for NATO platforms
SET-301	RTG	SimPL Simulation of Low Photon Lidar

Table 32: Biotech

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-290	RTG	Standardization of Augmented Reality for Land Platforms in Combat Environments
AVT-329	LTSS	NexGen Rotorcraft Impact on Military Operations
AVT-334	RTG	CDT on Augmented Reality (AR) to Enhance Situational Awareness for Armoured Fighting Vehicle Crew
HFM-281	RTG	Personalized Medicine in Mental Health and Performance
HFM-291	RTG	Ionizing Radiation Bioeffects and Countermeasures
HFM-294	RTG	Big Data In the Military: Integrating Genomics into the Pipeline of Standard-Care Testing and Treatment
HFM-305	RTG	Synthetic Biology in Defence: Opportunities and Threats
HFM-306	RTG	Translating Medical Chemical Defence Research Into Operational Medical Capabilities Against Chemical Warfare Agent Threats
HFM-308	RTG	Optimizing Human Performance in NATO SOF Personnel Through Evidence Based Mental Performance Programming
HFM-339	RSM	Scientific and Technological Trends Allow for New Approaches Addressing CBRN Challenges – New Activities from HFM RTG 273 LTSS Chemical, Biological and Radiological Defence
HFM-ET-186	ET	Microbiome Applications in Human Health and Performance
HFM-MSG-323	ST	Guidelines for Mitigating Cybersickness in Virtual Reality Systems
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SAS-160	RTG	Ethical, Legal and Moral (ELM) Impacts of Novel Technologies on NATO's Operational Advantage – The "ELM Tree"

Table 33: Novel Materials

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-SP-001	SP	Development and Evaluation of an Advanced PACVD TiN/TiCN Coating for Military Vehicle Bearing Applications
AVT-309	RTG	Implication of Synthetic Fuels on Land Systems and on NATO Single Fuel Policy
AVT-311	RTG	Availability and Quality Issues with Raw Materials for Rocket Propulsion Systems and Potential Consequences for NATO
AVT-329	LTSS	NexGen Rotorcraft Impact on Military Operations
AVT-332	RTG	In-Flight Demonstration of Icephobic Coating and Ice Detection Sensor Technologies
AVT-337	RWS	Anti-Tamper Protective Systems for NATO Operations
AVT-340	RWS	Preparation and Characterization of Energetic Materials
AVT-342	RTG	Interoperability of Additive Manufacturing in NATO Operations
AVT-343	RTG	Novel Materials to Mitigate Rare Earth (RE) Criticality in High Speed Motors
AVT-ET-212	ET	Materials and Technologies for Electro-Optical Camouflage
AVT-ET-213	ET	Military Value of Graphene Technologies
AVT-ET-214	ET	Operation of Unmanned Aerial Vehicles (UAVs) in Icing Environments
HFM-305	RTG	Synthetic Biology in Defence: Opportunities and Threats
IST-181	RSM	Terahertz-Band Communications and Networking
SAS-159	RTG	How Could Technology Development Transform the Future Operational Environment
SAS-165	RSY	Assessing the Implications of Emerging Technologies for Military Logistics
SCI-324	RWS	Realization and Evaluation of Robotic Multispectral Decoys for Land Equipment
SCI-325	RTG	Methods of Identifying and Evaluation the Camouflage and Deceptive Properties of the Military Equipment in Land Field Trials
SCI-339	ST	Allied Future Surveillance and Control (AFSC) High Level Technical Concepts (HLTCs) Technology Readiness Level (TRL) Assessments
SET-289	RWS	Nanotechnology for Optics and Infrared Photo Detection

NEW 2021 ACTIVITIES BY TYPE

Table 34: New Lecture Series in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-365	RLS	Rotorcraft Flight Simulation Model Fidelity Improvement and Assessment
SET-290	RLS	AI for Military ISR Decision Makers
SET-299	RLS	Passive Radars – Technology and Applications

Table 35: New Specialists' Meetings in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
HFM-SET-339	RSM	Scientific and Technological Trends Allow for New Approaches Addressing CBRN Challenges
SET-SCI-297	RSM	Space Sensors and Space Situational Awareness

Table 36: New Symposia in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
IST-190	RSY	AI, ML and BD for Hybrid Military Operations (AI4HMO)
MSG-184	RSY	Towards Training and Decision Support for Complex Multi-Domain Operations
SCI-341	RSY	Situation Awareness of Swarms and Autonomous Systems

Table 37: New Technical Courses in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
MSG-194	RTC	Employing the C2-Simulation Interoperation (C2SIM) Standard for Coalition Military Operations and Exercises

Table 38: New Task Groups in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-341	RTG	Mobility Assessment Methods and Tools for Autonomous Military Ground Systems
AVT-342	RTG	Interoperability of Additive Manufacturing in NATO operations
AVT-343	RTG	Novel Materials to Mitigate Rare Earth (RE) Criticality in High Speed Motors
AVT-344	RTG	Assessment of Micro Technologies for Air and Space Propulsion
AVT-345	RTG	Unified Tactical Missile Kinetic Performance Model
AVT-346	RTG	Predicting Hypersonic Boundary-Layer Transition on Complex Geometries
AVT-347	RTG	Large-Amplitude Gust Mitigation Strategies for Rigid Wings
AVT-348	RTG	Assessment of Experiments and Prediction Methods for Naval Ships Maneuvering in Waves
AVT-349	RTG	Non-Equilibrium Turbulent Boundary Layers in High Reynolds Number Flow at Incompressible Conditions
AVT-350	RTG	Innovative Control Effectors for Maneuvering of Air Vehicles – Advanced Concepts
AVT-351	RTG	Enhanced Computational Performance and Stability and Control Prediction for NATO Military Vehicles
AVT-352	RTG	Measurement, Modeling and Prediction of Hypersonic Turbulence
AVT-367	RTG	Sea-Ice Collision Risk Prediction and Mitigation for Naval Ships
HFM-318	RTG	Personnel Retention in the Armed Forces
HFM-338	RTG	Development of Military Loading Exposure Guidelines for Prevention of Chronic Traumatic Encephalopathy
HFM-341	RTG	Validation of Modeling and Simulation Methodologies for Human Lethality, Injury and Impairment from Blast-Related Threats
HFM-342	RTG	C2 Capability Lifecycle Management // C2 Capability Governance
HFM-343	RTG	Digital Teaching Networks: Fostering Digital Collaboration Among Teachers, Trainers, Instructors, and Coaches in the Military
HFM-AVT-340	RTG	Neuroscience-Based Technologies for Combat-Oriented Crew Cockpit Design and Operations
MSG-190	RTG	NATO M&S Professional Certification
MSG-191	RTG	NATO Standards for Federated Simulation and Services for Integration, Verification and Certification

SCI-336	RTG	Cyber-Physical Systems Resilience for NATO Operations
SCI-344	RTG	Future Multi-Sensor Threat Defeat Concepts
SCI-346	RTG	Space Risk Assessment Matrix (S-RAM)
SCI-347	RTG	SMART IED Threat Mitigation Technology Assessments SMiTMiTA
SET-304	RTG	Modeling, Measuring and Mitigating Optical Turbulence: M3T
SET-305	RTG	Improved Field of View for Night Vision Goggles – Technical Challenges, Concepts, Performance Assessment
SET-306	RTG	Improved Panoramic Situational Awareness for Vehicle Platforms – Technical Challenges, Concepts, Performance Assessment

Table 39: New Workshops in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-360	RWS	Environmentally Compliant Approaches to Maintenance and Overhaul of Military Vehicles
AVT-361	RWS	Certification of Bonded Repair on Composite Aircraft Structures
AVT-364	RWS	Environmental Regulation on Energetic Systems and its Impact on Critical Munitions Materials and Capability
AVT-366	RWS	Use of Computational Fluid Dynamics for Design and Analysis: Bridging the Gap Between Industry and Developers
IST-191	RWS	Rescue Systems for Broken Trust
MSG-192	RWS	Commercial Technologies and Games for Use in NATO and Nations

Table 40: New Support Projects in 2021

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-SP-009	SP	Evaluation of Hybrid Electric Propulsion Technologies for Unmanned Aerial Vehicles in Military Applications

NEW ACTIVITIES TO START IN 2022

Table 41: New Activities to Start in 2022

ACTIVITY	ACTIVITY TYPE	TITLE
AVT-362	RTG	Water Sampling, Monitoring and Control/Remediation for Live-Fire Military Ranges
AVT-363	RTG	Improving the Understanding of Risks from Exposure to Munition Combustion Products
SCI-328	RSY	Flight Testing of Unmanned Aerial Systems (UAS)
SET-298	RSM	Electronic Attack and Protection for Modern Active/Passive Netted Radars

CPOW IN NUMBERS

Table 42: Involvement of NATO + EOP Countries in 2020 CPoW	
Country	Number of Activities
United States	254
Germany	236
United Kingdom	224
Netherlands	188
Canada	182
Turkey	141
France	135
Norway	119
Sweden	117
Italy	109
Finland	76
Poland	64
Belgium	60
Australia	57
Denmark	41
Czech Republic	38
Spain	30
Estonia	28
Romania	27
Portugal	22
Bulgaria	17
Greece	17
Slovenia	17
Croatia	16
Lithuania	14
Hungary	11
Latvia	10
Slovakia	3
Montenegro	1
Iceland	1
Luxembourg	1
Montenegro	1

Table 43: Number of Participants in 2020 CPoW per Country (NATO + EOP)	
Country	Number of Participants
United States	785
United Kingdom	445
Germany	440
Turkey	432
Netherlands	275
Canada	243
France	241
Italy	184
Norway	170
Sweden	155
Poland	118
Finland	94
Australia	78
Belgium	61
Spain	53
Denmark	52
Czech Republic	39
Croatia	29
Portugal	28
Romania	28
Estonia	27
Slovenia	19
Greece	16
Hungary	16
Lithuania	14
Bulgaria	10
Latvia	10
Slovakia	3
Montenegro	1

Table 44: Number of Activity Chairs of 2020 CPoW Activities per Country	
Country or Body	Number of Activity Chairs
United States	132
Canada	64
Germany	61
United Kingdom	46
Netherlands	43
France	16
Norway	13
Italy	12
Turkey	8
Czech Republic	7
Poland	7
Sweden	7
Denmark	4
Belgium	3
Estonia	3
Portugal	3
Bulgaria	2
Finland	2
Romania	2
Australia	1
Croatia	1
Greece	1
Spain	1
Montenegro	1

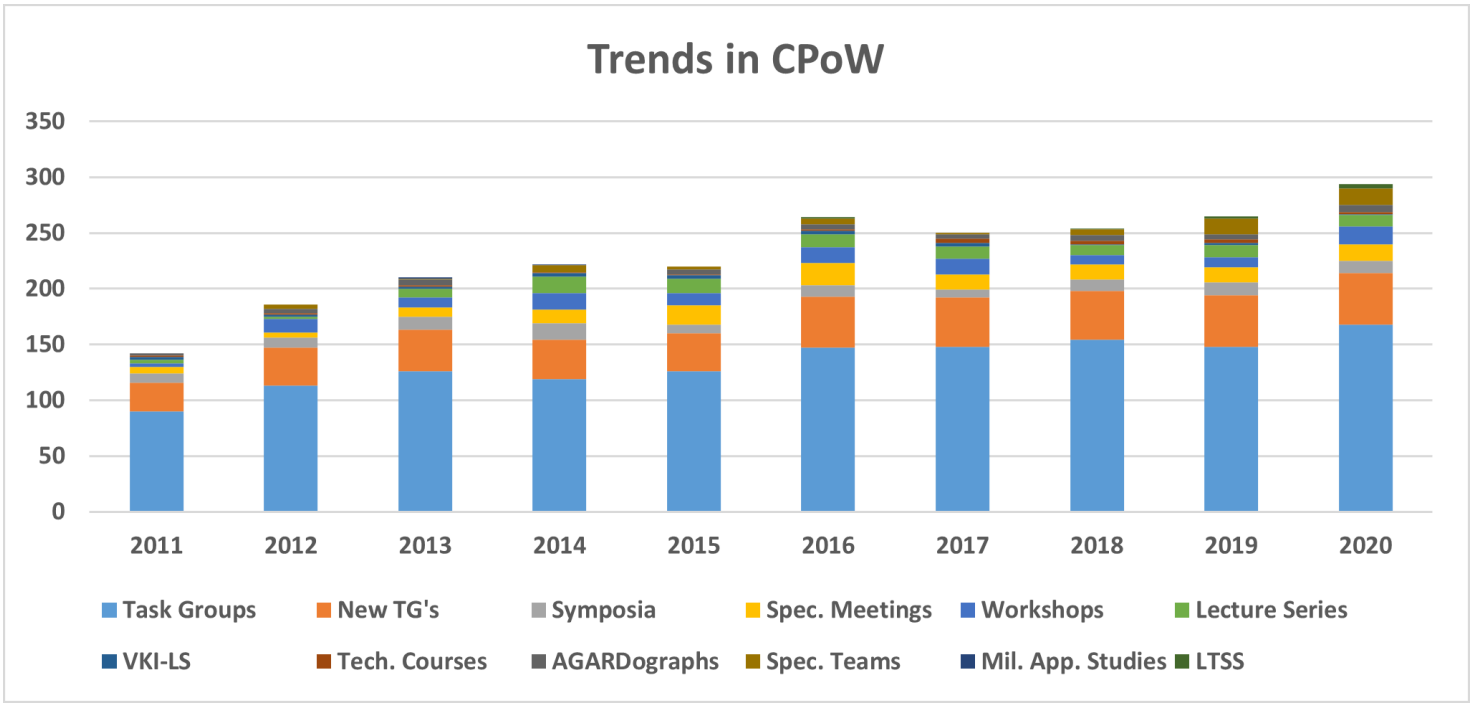
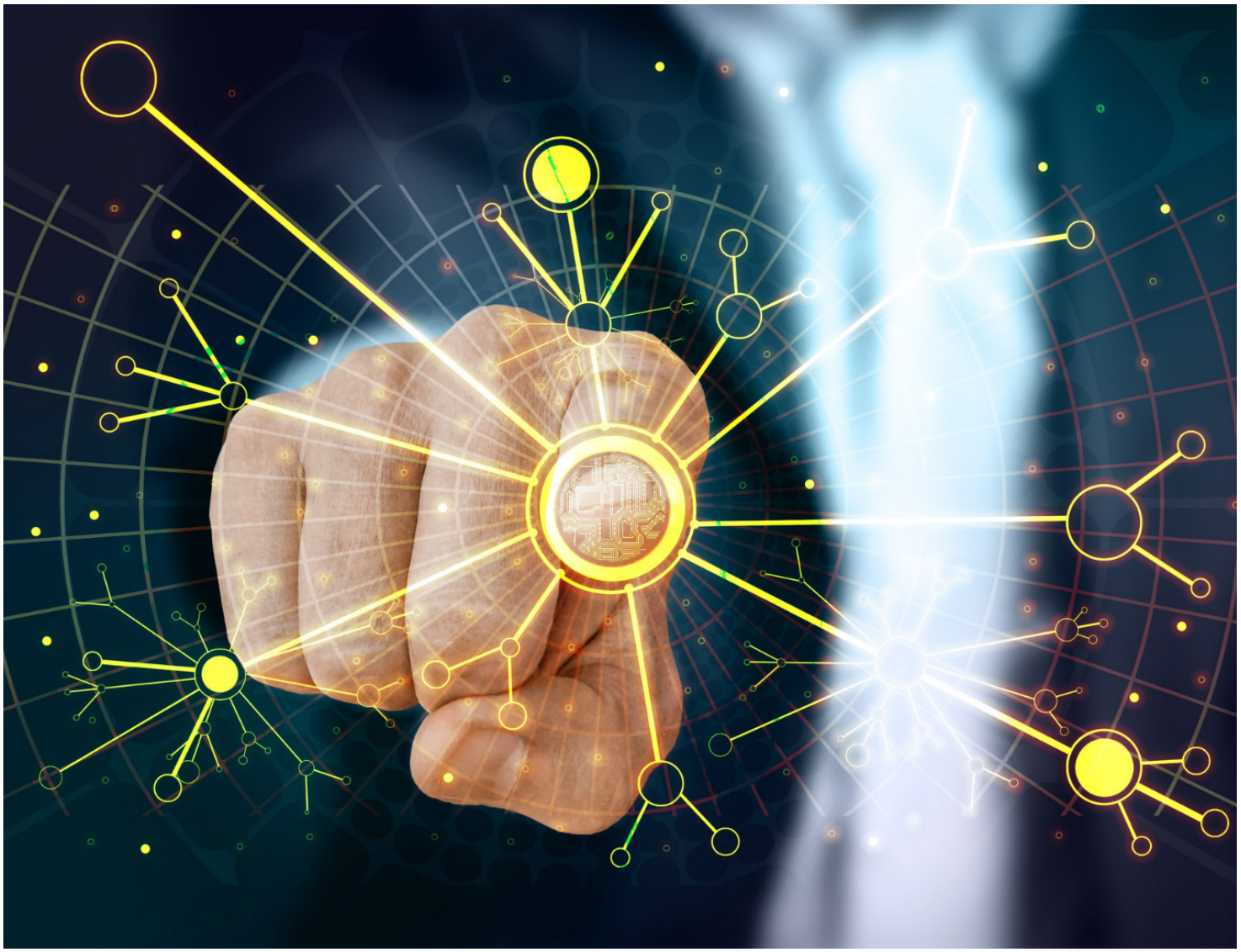


Figure 13: Trends in CPoW, 2011 – 2020



ACRONYMS AND ABBREVIATIONS

(C)-IEDs	(Countering) Improvised Explosive Devices
(NG)-NRMM	(Next-Generation) NATO Reference Mobility Model
A2/AD	Anti-Access/Area Denial
ACG3/SG2	Aerospace Capability Group 3 Sub-Group 2
ACO	Allied Command Operations
ACT	Allied Command Transformation
AFSC	Allied Future Surveillance & Control
AG	AGARDograph – Advanced Guidance for Alliance Research and Development
AI	Artificial Intelligence
AI & BD	Artificial Intelligence and Big data
AI2S	Architecture and Intelligence Information Systems
AR	Augmented Reality
ATR	Automatic/Assisted Target Recognition
AVT	Applied Vehicle Technology Panel
BD	Big Data
BEMMTO	Blast Exposure Monitoring in Military Training and Operations
BM	Business Meeting
C2	Command and Control
C3I	Command, Control, Communications and Intelligence
CA2X2	Computer Aided Analysis, Exercise, Experimentation Forum
CAX Forum	Computer Assisted Exercise Forum
CBRN	Chemical, Biological, Radiological and Nuclear
CC&D	Camouflage, Concealment and Deception
CCDO	Camouflage, Concealment, Deception and Obscuration
CDT	Cooperative Demonstration of Technology
CIS	Communication and Information Systems
CMRE	Centre for Maritime Research and Experimentation
CMs	Counter-Measures
CNAD	Conference of National Armament Directors
COM	Communications & Networks
COMEDS	Committee of Chiefs of Military Medical Services in NATO
COMSEC	Communications Security
CPoW	Collaborative Program of Work
CSO	Collaboration Support Office
D&D	Denial and Deception
DECS	Distributed Engine Control Systems
DEW	Directed Energy Weapons
DEXTER	Detection of Explosives and firearms to counter Terrorism
DFS	Data Farming Services
DIRCM	Deployability and Mobility
DM	Deployable Multi-band Passive/Active Radar
DMPAR	Deployable Multi-band Passive/Active Radar
EDTs	Emerging and Disruptive Technologies
ELM	Ethical, Legal and Moral
EO	Electro-Optical
EO/IR	Electro-Optic and Infrared
EOD	Explosive Ordnance Disposal
EOP	Enhanced Opportunity Partner
EO-TDAs	Electro-Optical Tactical Decision Aids
ES	Electronic Support
ET	Exploratory Team
EW	Electronic Warfare
FATE	Futures Assessed alongside socio-Technical Evolutions
FMN	Federated Mission Networking
FT3	Flight Test Technical Team
GNSS	Global Navigation Satellite Systems
HART	Human-Agent-Robot Teamwork
HEADSTART	Hybrid/Electric Aircraft Design and Standards, Research and Technology
HEL	High-Energy Laser
HFM	Human Factors and Medicine Panel
HLTCs	High Level Technical Concepts
HMP	Health, Medicine & Protection
HQ	Headquarter
HSB	Human Systems & Behavior
I/ITEC	Interservice/ Industry Training, Simulation and Education Conference
ICI	Istanbul Cooperation Initiative
IMS	International Military Staff
IoT	Internet of Things
ISAR	Inverse Synthetic Aperture Radar
ISR	Intelligence, Surveillance and Reconnaissance
IST	Information Systems Technology Panel
ISTAR	Target Acquisition and Reconnaissance
IT2EC	International Training Technology Exhibition & Conference
IWA	Information and Knowledge Management
JANUS	Multiple-Access Acoustic Protocol
LoEs	Lines of Effort

LSS	Low Slow and Small
LTSS	Long-Term Scientific Study
LVC	Live Virtual Constructive
LVC-T	Implementation of Live Virtual Constructive – Training
M&S	Modelling and Simulation
M3T	Modelling, Measuring and Mitigating Optical Turbulence
MAS	Military Application Study
MCDC	Multinational Capability Development Campaign
MD	Mediterranean Dialogue
ML	Machine Learning
MNE	Multinational Exercise
MSaaS	Modelling and Simulation as a Service
MSCO	Modelling and Simulation Coordination Office (CSO)
MSE	Multi-Sensors & Electronics
MSG	Modelling and Simulation Group
NAC	North Atlantic Council
NATO	North Atlantic Treaty Organization
NAVWAR	Navigation Warfare
NCIA	NATO Communications and Information Agency
NCTR	Non-cooperative target recognition
NIAG	NATO Industrial Advisory Group
NIAG	NATO Industrial Advisory Group (IS)
NMCD	Network Management & Cyber Defense
NMCG	NATO Modeling and Simulation Group
NMSMP	NATO M&S Master Plan
NNAG	NATO Naval Armaments Group
NR	NATO Restricted
NRMM	NATO Reference Mobility Model
NS	NATO Secret
NU	NATO Unclassified
OA	Objective Area
OSC	Office of the Chief Scientist
OPSEC	Operations Security
OT	Optical Technology
PACVD	Plasma Assisted Chemical Vapor Deposition
PB-IEDs	Person-borne-Improvised Explosive Devices
PBMs	Panel (Group) Business Meetings
PE	Peacetime Establishment
PfP	Partnership for Peace
PNT	Positioning, Navigation and Timing
PPW	Plans and Programmes Workshop
RAM	Risk Assessment Matrix
RE	Rare Earth
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RF	Radio-Frequency
RFT	Radio-Frequency Technology
RLS	Research Lectures Series
RSM	Research Specialist's Meeting
RSY	Research Symposia
RTC	Research Technical Course
RTG	Research Task Group
RWS	Research Workshop
SAR	Synthetic Aperture Radar
SAS	System Analysis and Studies Panel
SATCOM	Satellite Communications
SCI	Systems Concepts and Integration Panel
SEAD	Suppression of Enemy Air Defence
SET	Sensors and Electronics Technology
SimPL	Simulation of Low Photon Lidar
SMiTMiTA	SMART IED Threat Mitigation Technology Assessments
SOF	Special Operations Forces
SP	Support Project
SPS	Self-Protection System
S-RAM	Space-Risk Assessment Matrix
ST	Specialist Team
STANAG	NATO Standardization Agreement
STANREC	Standardization Recommendation
STB	Science and Technology Board
STO	Science & Technology Organization
STOG	Simulation for Training and Operation Group
STOG-NG	Simulation for Training and Operation Group – Next Generation
SW	Spectrum Width
SWEM	Space Weather Environmental Modelling
SYU	Selectable Yield Unitary
TAP	Technical Activity Proposal
ToEs	Targets of Emphasis
TRL	Technology Readiness Level
TW	Technology Watch (Card)
UAS	Unmanned Aerial Systems
UAV	Unmanned Aerial vehicle
UAxS	Unmanned Autonomous Systems
UCATT	Urban Combat Advanced Training Technology
UCATT-LSS	Urban Combat Advanced Training Technology Live Simulation Standards
UCAV	Unmanned Combat Aerial Vehicle

UU	Public Released
VIRIN	Visual Information Record Identification Number
VKHS	Von Karman Horizon Scanning
VKI	Von Karman Institute