NORTH ATLANTIC TREATY ORGANISATION
ORGANISATION DU TRAITÉ DE L'ATLANTIQUE NORD

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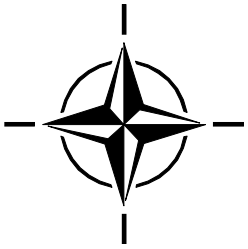
Conference Booklet



Schedule (all times CET – GMT+2)

Time	Day 1, Monday 5 October	Room
1200-1230	Arrival and Setup (Virtual Room will open at 1200)	Plenary
1230-1245	Conference opening + conference rules • Mr. Dale REDING, Conference Co-Chair, NATO STO Office of the Chief Scientist • Ms. Sue COLLINS, Conference Co-Chair, NATO HQ Supreme Allied Command Transformation	Plenary
1245-1300	Opening remarks • Dr. Bryan WELLS, NATO Chief Scientist • Mr. Mircea GEOANĂ, NATO Deputy Secretary General	Plenary
1300-1400	**Keynote 1: Professor Dame Angela MCLEAN - Chief Scientific Adviser for the Ministry of Defence UK**	Plenary
1400-1430	Break	
1430-1600	Stream – **Emerging and Disruptive Technology (EDT-1)** – Lead Mr Dale REDING (NATO STO) 1) Through the Curtain: Methods to Boost the Impact of your EDT Analysis – Ms. Louise HOEHL 2) What Does Resilience-Building to Emerging and Disruptive Technologies Actually Look Like? – Ms. Kulani ABENDROTH-DIAS 3) Emerging and Disruptive Technology and Small Military Power – Dr. Jakub FUCIK	#1
	Stream – **Cyber (C)** – Lead Mr Jan FRELIN (SWE) 1) Cyber Risk to Mission: Assessment Methodology – Dr. David ALBERTS 2) A three-stage machine learning cybersecurity solution for public entities – Mr. Stanisław SAGANOWSKI	#2
	Stream – **Autonomy (AUTO)** – Lead Mr Andy BELL (NATO MCC) 1) The Sky is Falling Down: Unmanned Aerial Vehicles as Emerging & Disruptive Technology Threat Assessment – Mr. Evangelos MANTAS 2) Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles – Dr. Andrej MIHAILOVIC 3) How Can Autonomous Systems Save Money in a Military Context? An Operational Analysis Journey through a System of Systems Perspective – Prof. Martin PARR	#3
1600-1630	Break	

Schedule (all times CET – GMT+2)

1630-1800	Stream – **Strategic Analysis (SA)** – Lead Ms. Sylvie MARTEL (NATO NCIA) 1) Emerging and Disruptive Technology (EDT) in NATO Capability Development – LTC. (Rtd) Bruce PENNELL 2) Towards a dynamic theory of hybrid conflict: An exploration with system archetypes – Mr. Bas KEIJSER 3) Studies by the Center for Strategic and Budgetary Assessments (CSBA) – Dr. Chris BASSLER	#1
	Stream – **Big Data / Advanced Analytics (BDAA-1)** - Lead LTC Juan DOMINGUEZ (ESP) 1) Strategic Analytics for NATO Supply Chain Operations - Dr. Greg PARLIER 2) Recent Developments in NATO's Survey Programme in Afghanistan - How Technology and Data Science can Improve Survey Based Support to Operations – Mr. Nicholas LABSVIRS 3) Making best use of survey data for operational analysis: Pattern analysis using supervised machine learning – Mr. Joris WESTERVELD	#2
	Stream – **Artificial Intelligence / Machine Learning (AIML 1)** – Lead Dr. Ana BARROS (NLD) 1) Application of AI and In-memory Computing for Extracting Vessel Movement Patterns from Historical Data – Dr. Krzysztof WĘCEL 2) Internal Consistency, Alignment, and Traceability in a Body of Documents: Exploring Applications of Natural Language Processing to NATO Texts – Dr. Philip ELES 3) Hierarchical Reinforcement Learning: A Novel Approach to Decision Support Analysis – Mr. Edward POTTRILL	#3
1800-1900	**Keynote 2: VADM (ret'd) Mathias "Mat" WINTER (plenary)**	Plenary
1900-2000	Network Opportunities – Strategic Analysis	#1
1900-2000	Network Opportunities – Autonomy	#2
1900-2000	Network Opportunities – Cyber	#3

Schedule (all times CET – GMT+2)

Time	Day 2, Tuesday 6 October	Room
1100-1200	Network Opportunities – Big Data / Advanced Analytics	#1
1100-1200	Network Opportunities – Artificial Intelligence / Machine Learning	#2
1100-1200	Network Opportunities – Emerging Disruptive Technologies	#3
1200-1230	Arrival and Setup Time (Virtual Room will open at 1200)	Plenary
1230-1245	Admin & Recap (Programme Committee Chairs)	Plenary
1245-1300	Opening day 2 – BGEN Poul PRIMDAHL, ACOS Requirements Division, NATO HQ Supreme Allied Command Transformation	Plenary
1300-1400	**Keynote 3: BGEN Ilmārs A. LEJINS, ACOS Joint Force Development – NATO HQ Supreme Allied Command Transformation**	Plenary
1400-1430	Break	
1430-1600	Stream – **Emerging and Disruptive Technology (EDT-2)** – Lead Prof. Dick DECKRO (USA) 1) Assessing the impact of emerging technologies on Canadian Army – Dr. Alain AUGER 2) Cybersecurity in the Electrical Power and Energy System: an Armour against Cyber and Privacy Attacks and Data Breaches – Mr. Ensar ŞEKER 3) Technology Wargaming: Experiencing future technologies combining multiple approaches – Dr. Pascal VAN OVERLOOP	#1
	Stream – **Big Data / Advanced Analytics (BDAA-2)** - Lead Ms. Jackie EATON (NATO JALLC) 1) A data science approach to Lessons Learned: unlocking hidden value in NATO Exercise Big Data – Dr. Mihaela RACOVITA 2) Distributed Gaming at the EDGE – A Structured Approach for Toolset Selection – Dr. Murray DIXSON 3) Concept for benchmarking in combat simulation for CoA-Analysis – Dr. Hermine REICHAU	#2
	Stream – **Artificial Intelligence / Machine Learning (AIML-2)** – Lead Dr. Janis BERZINS (LVA) 1) LASSO Assistant for Smart Search and co-Operation: A state-of-the-art AI platform that links documents for personalized recommendations in the intelligence community – Dr. Saskia LENSINK 2) AI FELIX, a Quest for Innovation in Artificial Intelligence in NATO – Dr. Arnau PONS 3) TNO Communication Analysis Dashboard: A suite of tools for automated analysis of media and communications to improve real-time situational understanding - Dr. Tom POWELL	#3
1600-1630	Break	

Schedule (all times CET – GMT+2)

1630-1800	Stream – **Emerging and Disruptive Technology (EDT-3)** – Lead Ms Sue COLLINS (NATO ACT) 1) Use of agent-based modeling and data farming for the army ISR capability assessment – Ms. Maude AMYOT-BOURGEOIS 2) The use of FATE for illuminating disruptions – Dr. Gitanjali ADLAKHA-HUTCHEON 3) High-uncertainty technologies – Dr. David HOLLAND SMITH	#1
	Stream – **Big Data / Advanced Analytics (BDAA-3)** - Lead Dr. Sigurd GLAERUM (NOR) 1) Emerging technologies, Disinformation, and Decision-making: a Conceptual and Historical Analysis – Dr. Simona SOARE 2) Data Science in Intelligence: Rethinking Intelligence Processes in the Information Age – CAPT Tess HORLINGS 3) Dealing with Complexity in Assessing Defence and Security-Related Capacity Building – Dr. Valentin POPONETE	#2
	Stream – **Wargaming and Combat Modeling (WCM)** – Lead Dr. Ben TAYLOR (CAN) 1) Wargaming with Monte-Carlo Tree Search – Mr. Christoffer LIMÉR 2) OA Support and Wargaming at the Operational Level: Applied tools, best practices, and lessons learned – Dr. Pascal VAN OVERLOOP 3) Experimental Wargaming and Emerging Military Capabilities in the NATO Context – Dr. Kiran LAKKARAJU	#3
1800-1815	Conference closure	Plenary

NATO OR&A Conference Virtual Meeting Protocol

Prior to and During the Conference:

- **Allow 15-20 minutes to set yourself up** and log in to the meeting - particularly if you are new to Webex. The meeting rooms will open 30 minutes beforehand.
- You must **Enter Title / First name / Surname / Nationality (or NATO organization) as your Webex name when joining the session (example: *LtCol Tim Povich USA* or *Mr. Jeroen Groenevelt STO/CSO*)**. This will be used to verify entry. If we cannot connect the Webex name you use to the registration list, we will expel you from the meeting. If you are using the Webex Desktop Application, please see the following link to assist you in changing your name before connecting: Webex Meetings: How to Change Your Name and Email as a Guest.
- Please **use headphones** with a built in microphone to avoid audio feedback.
- Please **mute your microphone** when you are not speaking to make the audio clearer for everyone.
- Please **deactivate your video**. Only the Session Chair and the person speaking should use their video
- Ensure your **computer / tablet / smart device's security settings allow access to Webex**

Question and Answer

- Please write **questions/remarks in the Group Chat Box** and the Stream Chairs will address it after the presentation as time allows.
- The Stream Chairs will ask the question to the Presenter to answer.
- If the Stream Chairs needs clarification on a question, they may give the floor to the questioner to clarify the question. When you are given the floor, activate your video and microphone; and deactivate them after completion of your discussion item. In general it is a good idea to say your name and organization when you start to speak.

The Chat Room conversations will be downloaded and saved for internal use; consider this when holding private conversations.

The group chat room can be seen by all therefore use polite and respectful language.

Person-to-person chats can be used for private messages.

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Meeting room Plenary, Webex - Meeting number: 163 282 1617 password: ORA2020
Meeting room #1, Webex - Meeting number: 163 529 5700 password: ORA2020
Meeting room #2, Webex - Meeting number: 163 027 3699 password: ORA2020
Meeting room #3, Webex - Meeting number: 163 418 4103 password: ORA2020

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Foreword

Operations Research

The foundations of operational research lie in the challenge of successfully integrating new technologies into military operations. While OR&A has evolved from these early days, into a broader science of organizational systems and decisions, the core tenants remain the same. The need for OR&A to contextualize, operationalize and utilize current emerging and disruptive technology (EDTs) within the milieu of NATO military and enterprise activities is acute.

Equally important, science as a practical discipline is evolving rapidly in response to EDT developments. As we move forward, leveraging EDTs, especially AI, Big Data and Quantum information science, the science of OR&A will expand, allowing the development of new analytical approaches and enlarging the range of problems amenable to study. As the renowned physicist and contrarian Freeman Dyson once wrote, "The great advances in science usually result from new tools rather than from new doctrines. ... Every time we introduce a new tool, it always leads to new and unexpected discoveries, because Nature's imagination is richer than ours."

We come together today, as a scientific and technological community, under the joint banner of NATO's Allied Command Transformation and the Science and Technology Organization to share and explore both issues -- EDT impact and application. A wide range of examples and technical developments will be covered over these two days but the presentations themselves are only part of the value of this meeting to the OR&A community.

Returning again to Dyson, "Scientists are as gregarious a species as termites. If the lives of scientists are on the whole joyful, it is because our friendships are deep and lasting. Our friendships are lasting because we are engaged in a collective enterprise." As such we encourage you to participate in as many sessions as you can, ask questions, use the chat facilities, engage within the virtual meeting spaces and follow up with the presenters.

Have fun and enjoy the conference.

Mr. Dale REDING and Ms. Sue COLLINS,
NATO ORA Conference Co-Chairs

Keynote Speakers

Keynote 1: Professor Dame Angela MCLEAN - Chief Scientific Adviser for the Ministry of Defence UK

Professor Dame Angela McLean DBE FRS was appointed as the Chief Scientific Adviser for the Ministry of Defence in September 2019.

Angela McLean is a Professor of Mathematical Biology in the Department of Zoology at Oxford University, a Fellow of All Souls College and Director of The Institute for Emerging Infections of Humans. Angela's research interests lie in the use of mathematical models to aid our understanding of the evolution and spread of infectious agents.

Angela is also interested in the use of natural science evidence in formulating public policy and has co-developed the Oxford Martin School Restatements: an activity which restructures and presents the evidence underlying an issue of policy concern or controversy in a short, uncharged, intelligible form for non-technical audiences.

Angela established Mathematical Biology at the Biotechnology and Biological Science Research Council's Institute for Animal Health in 1994. Before this, Angela was a Royal Society Research Fellow at Oxford University and a Research Fellow at the Institut Pasteur in Paris.

In 2009 Angela was elected as a Fellow of the Royal Society. She has been awarded the Gabor Medal in 2011 and the Weldon Memorial Prize in 2018. She received her damehood in the 2018 Queen's Birthday Honours List.

Keynote Speakers

Keynote 2: VADM (Rtd) Mathias "Mat" WINTER

Mat Winter is the President of Winter Strategic Solutions, LLC, a Small Business firm conducting Leadership and Motivational speaking forums and providing technical and business consulting to senior defense, private sector companies, non-profits and academic leaders.

He retired as a U.S. Navy Vice Admiral, having served as the 24th Chief of Naval Research/Director of Innovation and as the F-35 Joint Strike Fighter Program Director where he ran the Defense Department's largest acquisition enterprise in history with $30 billion dollars annual budget.

Mat serves on the Boards of Directors for the Support Our Aging Religious (SOAR!) and the Billy Fiske Foundation, as a Trustee to the Board of Directors for the Naval Aviation Museum Foundation and as a member of the ACTIVZ Global LLC Advisory Board.

Prior to establishing Winter Strategic Solutions, Mat had a 35 year military career which encompassed three distinct leadership phases: Operational tours of duty as a naval aviator flying the A-6 Intruder carrier-based attack jet; Numerous Navy systems acquisition tours as chief engineer, chief tester and major program manager; and Seven executive-level command positions in large acquisition organizations where he managed multi-billion dollar portfolios and thousands of personnel capitalizing on his program management expertise and effective leadership.

Mat has a Mechanical Engineering degree from the University of Notre Dame, and a Master of Science degree from the Naval Post Graduate School in Computer Science and another from the National Defense University in National Resource Strategy. He maintains lifetime memberships with the Army Navy Club, Air Force Association, American Society of Naval Engineers, Association of Old Crows, Military Officers Association of America, Navy League, National Defense Industrial Association, Surface Navy Association, The Tailhook Association and the United States Naval Institute.

He continues to be a "Teacher Leader," who fosters a culture of success through positive empowerment, bold moral leadership and personal ethical accountability. He continues to serve through several volunteer and non-profit organizations to include his personal commitment to supporting local, State and National Veterans organizations.

Keynote Speakers

Keynote 3: BGEN Ilmàrs A. LEJINS, ACOS Joint Force Development – NATO HQ Supreme Allied Command Transformation

Born in a Latvian émigré family 1971 in California, USA, BG Ilmars A. Lejins grew up in Sweden, was schooled in West-Germany and, after the end of the Soviet occupation, he returned to his fatherland where he joined the Latvian Armed forces 1993. Admitted to the Swedish Infantry Military academy, he graduated in 1996 as an infantry officer.

His career with troops has been on every level up to brigade command. Initially with the Baltic Battalion from 1996 to 1999, where he served as a platoon leader and, later, as the second-in-command of the Latvian Infantry company. During this time, he deployed to IFOR/SFOR. After completing the Swedish Junior Staff and Company Commanders' course (MSS TAP) in 2000, he assumed the rewarding task of setting up an Armed forces level (joint) professional NCO training system as well as taking up command of the newly founded NCO Academy. He later took command of the 2nd Infantry Battalion, where he was tasked to finalise the last conscription training and professionalise the unit. He has served as an Infantry Kandak Operational Mentoring and Liaison Team (OMLT) leader for a demanding 9 months ISAF tour in northern KUNAR, Afghanistan during 2009-2010. 2016 he was appointed as the Commander of the Land forces Mechanized Infantry Brigade. A post twinned with being the head of the Land forces as well. During his tenure as brigade commander, he had the pleasure to be instrumental to the NATO eFP (Enhanced forward presence) battle group deployment to Latvia and to the successful integration of more than 8 nations in to an effective deterrence force.

His staff assignments have been on the LVA JHQ level and at NATO. In 2007-09, he served as the section head for International commitments at the LVA JHQ overseeing the redeployment of LVA troops from OIF to ISAF. Returning from ISAF, he took a post at the operational level as the JHQ J3/5/7 PLANS Branch Head with the responsibilities being National (operational) Defence and Contingency planning, Force/Capability development and bilateral/multilateral plans. During his time at the JHQ, he also oversaw and supported the development of the nascent Latvian Joint Terminal Attack Controller (JTAC) program. 2013 to 2016, he served as the Branch Head for Military Cooperation, J9 as well as being the LVA SNR at NATO JFC Brunssum, the Netherlands.

BG Ilmars A Lejins is a graduate of the Baltic Defence College, Higher Command Studies Course, the United Kingdom's Joint Services Command and Staff College (Advanced Command and Staff Course 8) and holds a MA in Defence studies from the King' s College in London. Notable military courses taken are the UN Junior Officers Course at SWEDINT and the UK Combined Arms and Tactics Course at Warminster. He has various LVA service, MOD and Armed forces awards, NATO IFOR and ISAF medals, the Estonian Land Forces Cross, the US Army Commendation medal with oak cluster and is a Cavalier of the LVA state Order of Viesturs. BG Lejins has been invited to join the Royal Swedish Academy of War Sciences.

He is married to Daiga Lejina and father to two sons and a daughter. He enjoys playing and watching football, a good run now and then and has a fondness for military history and single malt.

Programme Committee Chairpersons

Mr. Dale REDING, Conference Co-Chair, NATO STO Scientific Advisor

Mr Reding is the Scientific Advisor to the NATO Chief Scientist at NATO HQ in Brussels. In support of the Chief Scientist, he is responsible for the provision of S&T based advice to military and civilian leaders within NATO, including emerging and disruptive technology trends.

Before joining NATO in 2019, Mr Reding enjoyed a 31-year career as a defence scientist and public service executive within the Canadian Department of National Defence. Notably, from 2013 - 2018, Mr Reding served as the Director-General responsible for Air Force and Navy S&T programs, and the senior scientific advisor to the commanders of the RCAF and RCN. This included the development of strategic national and international research partnerships supporting the Air Force and Navy. From 2010-2013, Mr Reding was Director-General of Canada's centre of excellence for military human performance research and experimentation (DRDC-Toronto). Beginning in 2008, Mr Reding was Chief Scientist at the Center for Operational Research and Analysis, responsible for the conduct and quality of OR&A conducted within National Defence. Prior to 2008, Mr. Reding held a variety of scientific management and research appointments most notably as a principal scientist (2005-2008) at the NATO C3 Agency in The Hague (NL), Director Operational Research and Analysis (2001-2005) in Ottawa, and as the senior Canadian defence scientist (1991-1996) at the North American Aerospace Defence Command (NORAD) / United States Space Command in Colorado Springs (USA).

Mr Reding's research interests cover a wide range of topics, including operational research methods, artificial intelligence, complex systems, modelling & simulation and space-based ISR. He received his Bachelor of Science (1981) and Masters of Science (1984) in Theoretical Physics from the University of Saskatchewan. Following this, he undertook additional graduate studies in Mathematical Geophysics, within the Department of Geological Sciences.

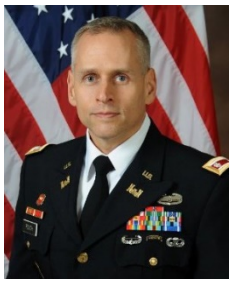
Ms. Sue COLLINS, Conference Co-Chair, NATO HQ Supreme Allied Command Transformation

Mrs Sue Collins is the Section Head for Solutions Analysis, in the Analysis of Alternatives (AoA) branch at NATO Allied Command Transformation (ACT) in Norfolk, Virginia, USA. The AoA branch provides effectiveness, cost and risk assessments to ensure NATO makes decisions about NATO common funding programmes based on evidence and considering all relevant factors including the future defence environment.

She started her career in Government Operations Research and Analysis in 1999 at H.M. Customs and Excise, using simulation models to analyse illegal smuggling into the UK and distribution of the UK's Customs Officers at points of entry. From 2001 – 2008 she worked at the UK's Defence Science and Technology Laboratory (Dstl) running models for Peace Support Operations and analyzing the future of the UK's defence force considering different force mixes and their impact on the UK's ability to conduct simultaneous operations. In 2008 she joined NATO's Allied Command Transformation.

She initially focused on analysis for Concept Development and Experimentation working on a wider range of subjects including Security Force Assistance, Protection of Civilians, NATO Logistics and Maritime Situational Awareness. She is an experienced facilitator, wargamer and experimenter, specializing in tackling particularly complex wicked problems. She published NATO's Alternative Analysis (AltA) Handbook and is a contributor to NATO's Innovation Publication series. In 2019 she transitioned to focus on Analysis of Alternatives methods for NATO Common Funding. She has a bachelor's degree in Management Sciences, is a receiver of the NATO award for Scientific Achievement, and winner of ACT's 2020 Innovation Challenge.

Programme Committee Members



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Panel Executive
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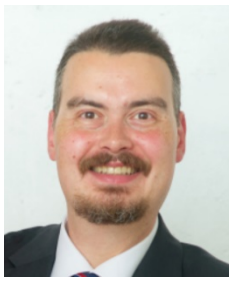
Ms. Sylvie MARTEL
Chief Operational Analysis
NATO Communications & Information Agency (NATO))

Lt Col. Pierre HAN
Operations Research Analyst
HQ Supreme Allied Commander Transformation (NATO)

Mr. Andy BELL
Operational Analyst
HQ Allied Maritime Command (NATO)

Dr. Ana BARROS
Principal Scientist
Netherlands Organisation for Applied Scientific Research (NLD)

Prof. Richard DECKRO
Department of Operational Sciences
Air Force Institute of Technology (USA)



Dr. Janis BERZINS
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National Defence Academy (LVA)

Dr. Ben TAYLOR
Member – Strategic Planning Operations Research Team
Defence Research and Development Canada (CAN)

Lt Col. Juan DOMINGUEZ
Operations Research Analyst
Operations Research Center
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Ms. Jackie EATON
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Joint Analysis & Lessons Learned Centre (NATO)

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Mr. Jeroen GROENEVELT
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AIML 1-1: Application of AI and In-memory Computing for Extracting Vessel Movement Patterns from Historical Data

Authors: Mr. Dominik Filipiak, Mr. Matthias Steidel, Ass. Prof. Milena Stróżyna, Dr. Krzysztof Węcel, Prof Witold Abramowicz

We present an approach for extracting typical vessel movement patterns from historical Automatic Identification System messages that are combined with historical weather information. In the maritime domain, safe and efficient vessel operations depend upon a prescient voyage planning and ship monitoring. Realization of these tasks require IT systems that would suggest a safe route based on past experience and best practices in certain sea areas. The proposed solution consists of a combination of a genetic algorithm and a method for generating a graph representing the maritime traffic network. Our solution applies big data technologies to assure efficiency and scalability and take advantage of fast in-memory computation. The paper presents the current state of the work and an outlook on potential future applications, including application in the military security issues and providing support in decision making

Dr. habil. Krzysztof Węcel is an associate professor at the Poznań University of Economics and Business in the Department of Information Systems. In May 2020 he obtained a habilitation degree from the University of Potsdam at the Faculty of Economics and Social Sciences. His main research interest is the intersection of semantic web technologies, open data, and machine learning. He has also a significant experience in business intelligence technologies, ranging from data management through data warehousing to data mining and anomaly detection. He has worked with big data in several industrial projects. He has been involved in many EC-funded projects, also in management positions, including a flagship project on linking open data – LOD2. He was a visiting scholar in leading research institutions in Europe, e.g. Leopold-Franzens University of Innsbruck and University of Karlsruhe, as well as emerging ones in Asia - Asian Intitute of Technology and Indian Institute of Technology. He has certificates awarded by SAS (Certified Professional) and SAP (SAP Certified Application Associate - Business Process Integration with SAP S/4HANA 1809). He is also a certified project manager (PRINCE2).

Milena Stróżyna is assistant professor in the Department of Information Systems at the Poznan University of Economics and Business (PUEB). She received her PhD in 2018 (Summa cum Laude) on reliability and risk assessment of maritime transport services. Her research areas cover data science, data analytics, reliability of supply services and risk assessment. Since 2012 she participates in various research and development projects realized by the Department of Information Systems, funded by the national and international organizations. Milena has also professional experience of working in IT and consulting, logistics and marketing. She coordinated the work on the SIMMO project, funded by the European Defence Agency, aiming at development of a system for enhancement of quality of maritime-related data and detecting maritime anomalies, and the work on the HANSA project that related to generation of recommended maritime routes for ships. At the moment she participates in the SIMMO II project whose aim is implementation of Big Data technologies for detection of maritime anomalies. Her research areas cover data science, data analytics, reliability of supply services and risk assessment.

Matthias Steidel, M. Sc, started his career as an IT-consultant and works at OFFIS since 2017. His research is focused on the verification and validation of highly automated and intelligent systems, but the main focus is on behaviour prediction of vessels in the context of collision avoidance.

Witold Abramowicz is a full professor and the chair of Department of Information Systems at the Poznań University of Economics and Business, and founder of SmartBrain (Smart and Big Data Research and Innovation Center), whose goal is to conduct research and innovation activities in economy and public administration in the field of Big Data. He is also Head of PhD Studies DaSBA - Data Science for Business and Administration. His particular areas of interest are Big Data, Data Analytics, Information Retrieval and Filtering, Knowledge Management in MIS. He received his M.Sc. from The Technical University of Poznań, Poland, Ph.D. from The Wrocław Technical University, Poland, and habilitation from The Humboldt University Berlin, Germany. He worked for three universities in the Switzerland (ETH Zurich) and Germany for twelve years. He is an editor, author or co-author of 48 eight books (published mostly by Springer) and over 300 book chapters, articles in various journals and conference proceedings.

Dominik Filipiak, MSE has majored in Computer Science at Poznań University of Technology and now he's a Research Assistant and PhD student at Poznań University of Economics and Business. whose area of interests encapsulates artificial intelligence, computer vision, financial econometrics, and theoretical computer science. Although in his PhD he focuses mostly on the quantitative description of the Polish Art Market, he has experience with Deep Learning, Big Data, and data engineering in numerous domains, such as telecommunications or maritime surveillance. He has been awarded a Microsoft Azure for Research Grant in 2017. He teaches under- and post-graduate students a number of subjects related to artificial intelligence, big data, software architecture and cryptography.

AIML 1-2: Internal Consistency, Alignment, and Traceability in a Body of Documents: Exploring Applications of Natural Language Processing to NATO Texts

Authors: Dr. Philip T. Eles, Mr. Riccardo D'Ercole

Text remains a key form of communication in large organizations, and written documents are the eventual output of many business processes. This is especially true within NATO where political-military documents use carefully crafted language and a distinctive vocabulary to convey political and military intent. However, as the body of documentation grows, the task of ensuring internal consistency, alignment, and traceability becomes increasingly difficult. Currently there are few tools to help ensure that new or updated documents are consistent with an existing body of information. Recent developments in Natural Language Processing (NLP) may offer opportunities to assist in this area. The NATO Communications and Information Agency's Operational Analysis Service Line has made initial exploratory steps in this area. In this paper, we present two examples. First, we show how specific themes and topics can be traced across collections of inter-related documents. We apply this approach to NATO documents that are periodically updated to reflect an evolving situation (i.e. the status of a military operation), and to documents that are logically related (i.e. high-level direction and guidance and subordinate implementation documents). Second, we demonstrate an evaluation of the internal consistency of an existing NATO taxonomy, the Bi-Strategic Commands (Bi-SC) Capability Codes and Capability Statements, and the Capability Hierarchy. Both examples are an application of topic extraction, word embeddings, and cluster analysis techniques commonly used in NLP.

Mr. Riccardo D'Ercole is a Supporting Operational Analyst in the NATO Communications and Information Agency, currently providing analytical support to NATO Defence Planning and ACT Data Science projects. He has previously worked as an intern in the Joint Analysis and Lessons Learned Centre (JALLC). His expertise includes Machine Learning and quantitative research techniques applied to text (Natural Language processing) or the analysis of fire mission data. He holds a Master degree in Economics from NOVA School of Business and Economics.

Dr. Philip Eles is a senior scientist in the Operational Analysis Service Line at the NATO Communications and Information Agency. His work has focused largely on providing analytical support to NATO's comprehensive assessments of the mission in Afghanistan through projects for SHAPE, JFC Brunssum, and ISAF/Resolute Support HQ. He has deployed to Kabul on multiple occasions as an embedded analyst in the HQ, and provides ongoing reach-back support to the mission. Since 2014, he has been the technical lead for NATO's survey program in Afghanistan. Prior to joining NATO in 2013, Dr. Eles was a defence scientist at Defence Research and Development Canada. He completed his Ph.D. in physics from the University of British Columbia in Vancouver in 2005.

AIML 1-3: Hierarchical Reinforcement Learning: A Novel Approach to Decision Support Analysis

Authors: Mr. Eddie Pottrill, Mr. Adrian Millea

Human in the loop wargaming uses human experience to determine how systems should behave and how a commander will decide to act but it can be costly and hard to replicate. Traditional reinforcement learning (RL) techniques can be used to overcome these issues. However, this can quickly become computationally expensive as they require all available information about the environment, including actions and objectives. Hierarchical RL (HRL) is a series of abstractions from traditional RL, building a feudal system of commander and subordinate agents each of which has a simpler environment than the full collective shared environment. This enables more complex scenarios to be represented as a series of simpler components, as well as potentially reducing the training burden to learn credible behaviours. A simple example of HRL is that of an agent in a maze. A command agent can see the location of its subordinate and the exit, whereas the subordinate can only see its immediate surroundings. The command agent learns how to set intermediate waypoints that the subordinate learns how to move towards. In this way the command agent creates a 'strategy' for exiting the maze but leaves the lower level learning of how to traverse the maze to the subordinate. Rowden Technologies are developing a wargaming tool with HRL at its core. Initially this is focused on those tasks associated with room clearance, however the number of hierarchies is conceptually unlimited, so strategic command could be considered. The current state of the development along with lessons identified are presented alongside a roadmap for development of this powerful technique.

Edward Pottrill joined Dstl as a Data Scientist after studying Mathematics at The University of Sheffield. Although early in his career in defence he is active in the development of AI and data science capability for the Novel Analytical Techniques group within the Defence and Security Analysis division. His main focus has been to understand and demonstrate how Defence can benefit from using reinforcement learning techniques in decision support scenarios.

Stream AIML #1 - Artificial Intelligence / Machine Learning

Adrian Millea has obtained a Master's degree in AI at University of Groningen with the thesis "Exploration in Echo State Networks". Topics he investigated in more detail over the years range from Variational Inference, Restricted Boltzmann Machines to Information Geometry. Currently he is a PhD candidate at Imperial College London, expected to finish soon, working in Deep Reinforcement Learning and Hierarchical Reinforcement Learning where he hopes to bring his accumulated knowledge to fruition.

AIML 2-1: LASSO Assistant for Smart Search and co-Operation: a state-of-the-art AI platform that links documents for personalized recommendations in the intelligence community

Authors: Mr. Merijn Bakker, Dr. Tim Lamballais Tessensohn, Dr. Saskia Lensink, Mr. Jeroen Wevers

Intelligence requirements, data sets, and data formats continually adapt to keep pace with our rapidly changing world. This changing environment poses increasing challenges for military intelligence analysts, as they need to quickly process data and information from different sources. Therefore a pressing need exists to leverage and connect different Artificial Intelligence (AI) techniques to aid military intelligence analysts in their work.. In this paper we introduce LASSO: a state-of-the-art AI platform for personalized information extraction from pdf documents, specifically created for and tailored to the military domain. It decomposes incoming documents and extracts metadata, textual and non-textual elements using a range of off-the-shelf AI and IT modules. An example of non-textual extraction would be object recognition in figures in the documents. The machine learning models create mathematical representations for the extracted elements and their context. This way, LASSO is less reliant on exact keyword queries and enhances search by incorporating contextual information. Moreover, the representations are stored and related to the profile of a user. This information profile in combination with the learned representations allow LASSO to support the user in explicitly engaging in exploratory search, a type of search which is known to be more complex than look-up search. The user can interact with LASSO through a web-based graphical user interface, showing the most relevant information at a glance. Another advantage of LASSO is that its modules are designed such that they do not require large datasets to be trained on, and are therefore able to perform well within specialized domains that have small datasets and few users. LASSO is designed as a means to aid analysts with the search of relevant documents, based on their information profiles.

Merijn de Bakker, M.Sc. has a background in artificial intelligence and geography (both University of Amsterdam). He has experience in software engineering and specializes in the application of machine learning in various domains. Within TNO he's working in the department Monitoring and Control Services, where he mainly works on designing and implementing machine learning in projects related to energy and subsurface.

Dr. Saskia Lensink works as a research scientist at the Data Science department at TNO, her specialty being natural language processing and text mining. Saskia has a background in linguistics, and obtained a PhD degree from Leiden University, researching how common linguistic patterns are processed by the brain. After her PhD she worked as a data scientist at a consultancy company, where she was involved in several text mining projects.

Jeroen Wevers MA is senior consultant and project leader at TNO DSS. He has a background as a military intelligence analyst for the Dutch Ministry of Defence (MoD). He is currently working on different projects focused on the development and implementation of IT systems for the MoD.

Dr. T. (Tim) Lamballais Tessensohn is a research scientist at TNO DSS working on the intersection between Operational Research, AI, and Autonomous Systems for military applications. He graduated cum laude from the master program Econometrics and Management Science at the Erasmus University Rotterdam. He obtained a PhD degree from the Technology and Operations Management department from the Erasmus University Rotterdam with his work on "Optimizing the Performance of Robotic Mobile Fulfilment Systems", which examined stochastic modeling and optimization methods for robotic systems in warehousing and distribution centers.

AIML 2-2: AI FELIX, a Quest for Innovation in Artificial Intelligence in NATO

Authors: Dr. Arnau Pons, Mr. Simon Purton, SSGT Michael Martin and COL Sean Lewis

In a few years, virtually all areas of the economy will in some way or another be impacted by Artificial Intelligence (AI). This Fourth Industrial Revolution is characterized by a transformation wave through digital technology. We are living in the era of Big Data, Cloud Computing, mobile devices and many other technologies which have the potential to change our society in ways never experienced before. These technologies are spurring a growing demand from users across the NATO enterprise to harness the power of artificial intelligence and big data analytics to manage and synthetize increasing amounts of data received by staff. The Artificial Intelligence Front End Learning Information Execution (AI FELIX) is a machine learning tool developed at HQ SACT. To our understanding, AI FELIX is the first machine learning application operating on the NATO classified system. Each day it processes hundreds of incoming documents received at HQ SACT, it makes recommendations on their distribution and automatically uploads them with a full suite of searchable metadata to enhance knowledge management.AI FELIX also assesses whether the incoming correspondence is likely to require action by ACT staff officers, and will generate draft taskings. This paper presents the evolution of AI FELIX from its development as a minimum viable product prototype, followed by a code refinement through constant iteration, continuing with the Independent Verification and Validation, and finally spiraling out to expand the pool of users and capabilities of the system. This experience has begun to coalesce into a roadmap to employ "DevSecOps", agile development, and continuous iteration based on users' feedback as a more flexible approach to incorporate innovative AI and Machine Learning capabilities in NATO.

Dr. Arnau Pons is an Operational Research Analyst at NATO HQ SACT where he conducts analysis of alternatives for NATO Capability Development programmes. He is the AI FELIX technical lead for IV&V managing the team of developers, as well as coordinating with ACT stakeholders and NCIA. He obtained his PhD in Aeronautics and Astronautics Engineering from Purdue University in West Lafayette, Indiana. Arnau holds a Master's Degree of Aerospace Propulsion Theory and Engineering by Beihang University in Beijing, China. Furthermore, he received his Aeronautical Engineering degree from the Polytechnic University of Catalonia in Terrassa, Spain.

Simon Purton joined NATO HQ SACT in 2007 and currently is Section Head Capability Requirements Analysis within the Capability Requirements Division. He has been conducting analysis on a number of topics including NATO requirements for: expeditionary forces; irregular warfare; counterinsurgency; countering hybrid threats; the impact of adversary anti-access and area denial strategies; and the implications of the global commons on future operations. He has been involved in a number of multinational analysis studies including Joint Operations 2030, for which he received the NATO

award for Scientific Achievement in 2011. Prior to NATO, he worked at the UK Ministry of Defence, Metropolitan Police Service, and London Underground.

Staff Sergeant Michael Martin currently serves as the Artificial Intelligence FELIX lead technical expert at Headquarters Allied Command Transformation, Norfolk Virginia. He oversees project management for 10 developers, development plans and conceptualizes future and current innovation expansions. He enlisted in the United States Air Force in February 2014 and graduated from Keesler Air Force Base, Mississippi as an Knowledge Operations Apprentice. Additionally he deployed in support of Operations Freedom Sentinel, Inherent Resolve and Resolute Support. His efforts earned major accomplishments: 2016 Diamond Sharp Airman, 2017 Non-Commissioned Officer of The Year, and named as the 2017 Lightning Innovation Award recipient.

Colonel S.P. LEWIS is the Tasking and Knowledge Management Branch Head at HQ ACT. A Royal Canadian Air Force Officer, he is the Co-Project sponsor for the AI FELIX algorithm, an experimental Minimum Viable Product (MVP) developed over 4 phases that is the first and currently only AI-enabled tool operational on the NATO SECRET network in both HQ ACT and HQ ACO that leverages the latest in machine learning technology that reads 100s of incoming documents a day, automatically distributes them to action officers, creates a TT, integrates tasks with the HQ's campaign plan, pushes corporate memory to staff officers, learns and improves.

AIML 2-3: TNO Communication Analysis Dashboard: A suite of tools for automated analysis of media and communications to improve real-time situational understanding

Authors: Dr. Tom Powell, Ms. Anne Merel Sternheim, Mr. Ioannis Tolios, Ms. Anne Fleur van Luenen, Ms. Tamar Schaap, Mr. Freek Bomhof

Today's information environment, characterized by unprecedented interconnectedness in and beyond NATO nations, yields an abundance of communications that can be analysed to build awareness, understanding and support for NATO decisions and operations. This is a key goal of Strategic Communications (StratCom) activities and of Information and Psychological Operations analysts. However, a major challenge in this area has yet to be addressed: how should media and communications be effectively analysed to provide meaningful insights in real-time about adversaries' communication strategies and their effects? To address this question we draw on theories from social science and techniques from data science and Natural Language Processing to develop a suite of tools to support analysts in practice: the TNO Communication Analysis Toolkit. The toolkit comprises several modules that analyse different communication sources – online news media, extremist group publications, and discussion fora. The tools include Aspect Extraction for attitude and sentiment analysis, Propaganda Analysis for identifying propagandistic communication features, Topic Modelling for frame analysis, and Communication Style Analysis of extremist group moral discourse. The tools are illustrated in the paper using a case study. In combination, these tools provide answers to the '5 Ws and H' of intelligence analysis: who, what, where, when, why and how. By doing so we expect that this can provide effective analysis of media content and communication to improve situational understanding in real-time

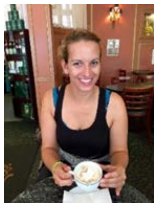
Stream AIML #2 - Artificial Intelligence / Machine Learning

Tom Powell (PhD) is a medior Scientist at the Military Operations department within the Defence Safety and Security Unit of TNO. His research focuses on using data analysis to inform influence operations and intelligence. He has previously worked as an intelligence analyst at UK Defence Intelligence, including a deployment as analyst/liaison officer to a UK headquarters in Kandahar in Afghanistan. He has a PhD in communication science, with a focus on the influence of political communication on public opinion, an MSc in Neuroscience, and a BSc in Psychology.

Anne Merel Sternheim is a junior Scientist at TNO with a heart for natural language, and the (semi-)automatic processing of it. In the two years she has been working at TNO, this has led her to cooperate in projects that aim to get information from (big loads of) textual sources, particularly in the domain of defence, safety and security. In these projects, she explores and applies clever ways (AI / NLP) to abstract information, such as topics, entities and opinions, from textual sources with as little effort as possible.

Ioannis Tolios is a junior Scientist at TNO who specializes in visualisation and machine learning. He studied Informatics & Telecommunications Engineering at the University of Western Macedonia, and got his MSc from TU Delft in the Netherlands (Biomedical engineering), specifically focusing on computer graphics & visualisation. In 2017, he joined the TNO Data Science research group.

Anne Fleur van Luenen is a Language Technology student at Uppsala University in Sweden. She joined TNO for her master's thesis, which was part of the current project. Simultaneously, she got involved in a project concerning bias in word embeddings. Other than that she has been working on natural language processing for dementia recognition in Dutch forum posts, and on topic modelling of Dutch emails.



Tamar Schaap started at TNO in 2019 after focusing most of her previous research within the healthcare domain. She completed her MSc for Behavioural Science at Radboud University and Artificial Intelligence at Utrecht University in the Netherlands. Within the defense, safety, and security department at TNO, she focuses mostly on statistical machine learning and working within the intersection of AI and Psychology.

Freek Bomhof joined TNO in 2003 and has had several positions there in various application domains, having worked on redesigning business processes for large organizations, and innovation management primarily for SMEs. He has been coordinating the TNO research on Big Data a number of years and he is now a senior Consultant and Project Manager at the Data Science department. He has set up, contributed to and coordinated a number of EU R&I projects. Currently Freek is focusing on applications of AI in safety and security, for instance in the H2020 TITANIUM project. He also leads a large internal Integration Flagship project within TNO on Trustworthy AI. His main interest is the interplay between technology, and ELSE (ethical, legal, social, economic) aspects, leading him to put emphasis on explainable AI and related issues; a topic that he also works on in his role as taskforce lead in the Big Data Value Association.

AUTO 1: The Sky is Falling Down: Unmanned Aerial Vehicles as Emerging & Disruptive Technology Threat Assessment

Authors: Mr. Evangelos Mantas, Mr. Constantinos Patsakis

Unmanned Aerial Vehicles (UAVs), or commonly known as drones, have already proven their value in military operations both strategically and logistically efficient, becoming a significant asset to the modern-day military. Although medium-altitude long-endurance (MALE) UAVs are commonly used by armed forces throughout the world, small Unmanned Aerial Systems (sUAS) are used as well, in guerilla and urban warfare, making them extremely difficult to anticipate and eliminate in a timely manner. The continuous decrease in the price of drones makes them available to numerous malicious actors, establishing them as the “new technicals” for the modern battlefield, posing a significant threat for the safety and success of an operation. This work focuses on performing a specific threat assessment, using a UAV as an attack vector, that covers all aspects of a military operation. To this end, we first identify the threats against infrastructure, personnel and vehicles using drones as the main actor to stage an attack using a variety of sensors and payloads. Moreover, we determine the seriousness of the threat depending on the drone mission, developing intervention and mitigation plans that may protect or minimise the risk of loss against them. Finally, we discuss methods to assess the impact of opposing force’s drones in military operations.

Evangelos Mantas is currently employed as Cyber Security Engineer, having obtained a degree in Computer Science at University of Piraeus. He is the author of GRYPHON: Drone Forensics in Dataflash and Telemetry Logs, research published on 14th International Workshop on Security 2019 in Tokyo. He served in the Hellenic Army Special Forces as Sergeant and contributed to the development of General Upper Staff of Hellenic Army cyber-exercise “Panoptis 2019”. He is a peer instructor in University of Piraeus Cyber Security Team hoping to aspire a new generation of cyber security experts.

Constantinos Patsakis holds a B.Sc. in Mathematics from the University of Athens, Greece and an M.Sc. in Information Security from Royal Holloway, University of London. He obtained his PhD in Cryptography and Malware from the Department of Informatics of the University of Piraeus. His main areas of research include cryptography, security, privacy, data anonymization and data mining. He has authored more than 100 publications in peer reviewed international conferences and journals. He has participated in several national and European R&D projects. Additionally, he has worked as a researcher at the UNESCO Chair in Data Privacy and as a research fellow at Trinity College. Currently, he is an Assistant Professor at the University of Piraeus and adjunct researcher of Athena Research and Innovation Center.

AUTO 2: Towards Augmenting Maritime Surveillance Capabilities via Deployments of Unmanned Aircrafts and Autonomous Underwater Vehicles

Authors: Dr. Andrej Mihailovic, Mr. Nexhat Kapidani, Dr. Enis Kocan, Ms. Aleksandra Nadziejko, Mr. António Brás Monteiro

This paper presents exemplar cases of adjusting the operations and taskings of an existing maritime safety department in the Adriatic towards the emerging technologies for enhanced patrolling in maritime surveillance. This work derives from ongoing COMPASS2020 project that aims to showcase the capabilities of unmanned systems (aerial, underwater) demonstrated in a

novel concept of operation (CONOPS). Results will be presented in: REP(MUS) 2020 – NATO, the largest maritime unmanned systems exercise to be held in Portugal at the end of the project. The Montenegrin Maritime Safety Department reviewed and assessed the deployment of novel assets towards with goal of increased effectiveness (i.e. reduction of costs and responses) of its civilian maritime safety and security missions. This practical approach is presented in two exemplar use-cases: 1) an illicit activity, and, 2) a polluting incident, both with a search and rescue finale. They are presented using the Plan-Do-Check-Act model of analysis together with problem formulations, functional breakdowns for all operational actors (from patrolling boats, maritime operation centre to decision making institutions), and, stages of data deductions. The use-cases are sequentially revealed using the NATO Architectural Framework (NAF), with its glossary and terms, followed by conclusions on the expected results at the operational and tactical levels from COMPASS2020 Mission System.

Dr Andrej Mihailovic received his B.Eng., MSc. and PhD. degrees from King's College London, in '96, '97 and '04 respectively. Since '98, he is a researcher at King's on independent research and collaborative projects with industry and within EU consortia, e.g. BT and Siemens projects, then, numerous EU projects from FP5 programme onwards including standardisation groups activities. Recently, he works as consultant for various academia, industry and government, mostly in Montenegro, including the current work for Maritime Safety Department. Author of over 60 publications in telecommunication areas mostly on Future Internet, new generation of mobile systems, IoT etc.

António Brás Monteiro graduated in 'Communication Sciences' from the Catholic University of Portugal and holds several postgraduate courses from the European Security and Defence College, National Defence Institute, Institute of Police Sciences and Homeland Security, Delft University of Technology, National Security Office and holds the NATO SECRET Security Clearance. He worked as Liaison Officer at SolvX, an intelligence and security services firm in Brussels and since 2017 he is Defence & Security PM at Tekever where he has been participating in NIAG studies, EDA projects and European Commission Defence & Security R&D projects. He is Advisory Board Member at EuroDefense-Portugal, Advisory Board Member at AED Cluster Portugal, Advisory Board Member at IntellCorp, Advisory Board Member at Focus2Comply and Advisory Board Member at the GRC Cyberspace Cluster. He is also Editor-at-Large and Special Correspondent for Portugal on behalf of the 'European Security & Defence' german magazine, Editorial Board Member at the portuguese magazine "Segurança & Defesa", member of the Observatory for Security, Organized Crime and Terrorism (OSCOT) and INTERPOL Drone Expert Group member

Nexhat Kapidani is deputy director at Administration for Maritime Safety and Port Management in Bar, Montenegro and a PhD candidate at Maritime Faculty in Kotor – University of Montenegro. He received dipl.ing.el degree in Electronics in 1995 and M.Sc. degree in Maritime Sciences in 2014 from the University of Montenegro. He has been awarded INVO-HERIC National Excellence Scholarship Programme, for short term PhD research at Faculty of Maritime Studies in Rijeka, Croatia. He has published 16 conference and scientific papers in international journals and peer-reviewed conferences. He participated in the prestigious International Visitor Leadership Program (IVLP) sponsored by the U.S. Government. Scientific interests: Maritime information-communications systems, Maritime safety and security, Maritime surveillance, VTMIS, VTS, Maritime single window.

Aleksandra Nadziejko holds Bachelor degree in Automatic Control and Robotics from the Silesian University of Technology (Poland) and Masters in Electrical and Computer Engineering from the University of Beira Interior (Portugal). Already as the student, she was involved in the development of unmanned aerial vehicles in the student scientific association ´High Flyers´. In 2016 she entered Aerospace, Defence and Security sector at TEKEVER as the Project Manager. She has been involved in numerous EDA, ESA, SESAR, European Commission and national R&D projects. She has hands-on experience as the Project Coordinator of several projects. She participates in the NATO LCG DSS Power Team of Experts.

AUTO 3: How Can Autonomous Systems Save Money in a Military Context? An Operational Analysis Journey through a System of Systems Perspective

Authors: Ms. Georgia Court, Mr. Martin Hagström, Mr. Tim Jefferis, Dr. Jaan Murumets, Prof. Martin Parr

The application of mechanization, automation and/or autonomy in well-defined domains (generally non-operationally critical functions) can yield significant budget savings and efficiency improvements. In some scenarios the application of autonomy can provide capability enhancements and improvements over conventional systems in the operational domain. However, when the operational challenges including environmental conditions, weather demands, operating theatre factors such as terrain and operational tasking activities are considered, it is currently very difficult to replace fully the capability of a conventional system with an autonomous alternative, meaning that both conventional and autonomous systems will be required. Thus, this area is unlikely to yield resource savings at present, but technology is improving and this should be regularly revisited. As well as potentially saving resources there are many areas where technology can save casualties and lives, for example in autonomous resupply to the front line. It is important that research and development in this area of autonomy continues. SAS 146 has not evaluated the cost of casualties in this research as the methods for assessing this can differ between nations. Considerable savings are possible even from the use of non-operational decision support tools. Examples include US fuel savings, through data analytics, that have totaled $12m per month (~2% of the DOD fuel costs and around $222 million saving is predicted from enhancements that enable combat soldiers to service critical equipment themselves. This work is also predicted to have prevented up to 4,500 casualties. Remotely managed UAVs have been shown to be capable of achieving savings in flight hour cost, however these systems do not provide an all-weather capability and cannot undertake all the functions of a manned platform and owning UAV and manned fleets would undermine potential operating cost savings. However, a UAV does have the ability to take operators out of higher risk environments, which is valuable in itself. A similar conclusion has been drawn from a review of UGVs. There is also a need to draw together a view of what the roadmap towards autonomy might look like and where the critical areas for NATO partner nations are likely to be, this could be achieved by collaborating closely with the NATO SCI 331 Autonomy Leadership Team. SAS 146 has focused on the cost-related implications of autonomy using a system of systems approach. This has taken an application-based approach and considered (1) changes in cost and (2) changes in performance when an autonomous system is used in place of an existing system, noting that automation is not always applied directly in place of a conventional system. The costs have included second and third order effects. The changes to the organisation that have been considered range from removing human operators from a platform through to the

changes in the business of delivering defence capability that would take place if an autonomous resupply system was used for the front line.

Georgia Court has worked as an operational research analyst in the UK MOD since graduating with a BSc (Hons) in Mathematics in 1999. She has gone on to have a varied career leading studies in topics from network enabled capability to using science and technology to drive efficiencies for MOD. She has also spent time seconded into MOD Head Office roles leading teams of analysts to contribute directly to policy making, most recently within the Chief of Defence Personnel area and Analysis Directorate. She achieved a MSc in military operational research from the UK Defence Academy. Georgia lives in the English countryside with her husband, two children and cat, she is a keen (but slow) runner.

Martin Hagström is a Deputy Research Director at the Swedish Defence Research Agency (FOI). Martin is the programme manager of the Weapons and protection and Unmanned vehicles and autonomous systems areas and responsible for the support to the Swedish Armed Forces' research planning in these areas. He has served in several different positions at FOI and participated in a number of national and international research projects. Martin has a background in autonomous systems and control and his latest research includes work on regulation and legal aspects of autonomous weapon systems

Tim Jefferis is a Professional Engineer who has worked for the UK Ministry of Defence for over 30 years. During this period he has worked in Project Management, Quality Assurance, Cost Analysis and Reliability and Maintainability. At present much of his time is devoted to supporting UK's Air Command through providing Operational Research and Decision Support to assist in resolving current operational issues and in making robust plans for the future. He is also undertaking a part time PhD examining how and why the costs of Defence systems have changed over time, relative to other goods and services.

Dr. Murumets is acknowledged researcher and consultant in the fields of Defense Policy and Strategy, Defense Resource Management, and Civil-Military Relations. Dr. Murumets held senior positions at the Ministry of Defense of Estonia, the Joint Staff of the Estonian Defense Forces, and the Estonian Military Academy. He is also a Consultant at the US Institute for Defense Analysis. Dr. Murumets holds degrees of Master of Arts from the University of Tartu and the US Naval Postgraduate School, and earned his Doctorate at the University of Zurich

Martin Parr is an honorary professor at the University of Kent and a senior principal consultant at the Defence Science and Technology Laboratory (Dstl). Martin has worked with a number of government departments to establish key strategic initiatives. He has advised on the governance of UK government programmes that have annual budgets in excess of £1 billion, including the Ministry of Defence test and evaluation programme. Martin's research interests include governance, assurance and the use of soft analysis in complex organisations. He regularly teaches at the Defence Academy and on the University of Kent's MBA programme. Martin is a chartered engineer, a fellow of the Institution of Engineering and Technology and a fellow of the Operational Research Society.

BDAA 1-1: Strategic Analytics for NATO Supply Chain Operations

Author: COL (Rtd) Greg Parlier

This presentation focuses on the future of the Operations Research profession supporting NATO. How can we address, in imaginative and creative ways, persisting and seemingly intractable international security challenges that confront us? “Strategic Analytics”, the alignment of analytical methods and OR models with the “ends-ways-means” strategy paradigm, is introduced. To fully capitalize on advances in information technologies and data sciences, the complementary power of operations research, data sciences, and management innovation will be essential. Strategic Analytics integrates the intellectual capacities, strategic planning acumen, and diverse analytical skills represented across our profession, and focuses them on formidable challenges of our time. Functional components and enabling disciplines are described: decision support capabilities, engineering systems, and dynamic strategic planning to focus organizational effort, assess performance, monitor progress, and build in flexible designs for adaptability in complex enterprise systems. Inherent in this ambitious project is an “engine for innovation” to encourage and guide transformational endeavors. This presentation describes the application of Strategic Analytics to US Department of Defense materiel sustainment enterprise systems. To address persisting issues and better understand seemingly intractable logistics challenges, the US Army established the project to Transform Army Supply Chains (TASC). An overview of the origination, evolution, and outcomes derived from applying Strategic Analytics to the TASC Project is presented. Benefits include increased readiness, reduced tactical-level workarounds, dramatic improvement in forecast accuracy, and cost savings on the order of tens of billions of dollars. Contributions to several efforts across operational, educational, technical, scientific, and analytical communities will be discussed.

A retired US Army Colonel, Greg served eight years in the 82nd Airborne Division, completed five deployments, and supported 14 named operations while conducting missions in more than 20 foreign nations during his career. His unique qualifications include building, developing, and leading multi-disciplinary analytical teams in large commands and complex organizations. His contributions to Operations Research include teaching, research, publications, and service as an academy professor, university research scientist, and professional society leader at local, state, regional, national, and international levels. Greg is currently adjunct Professor of Operations Research at NC State University and President, GH Parlier Consulting

BDAA 1-2: Recent Developments in NATO’s Survey Programme in Afghanistan - How Technology and Data Science can Improve Survey Based Support to Operations

Author: Mr. Nicholas Labsvirs

NATO has added several new tools in its arsenal for measuring perceptions in Afghanistan, which give us new ways to assess mission progress against operational objectives. In the past year and a half, in addition to the long-standing Afghanistan Nationwide Quarterly Assessment Research (ANQAR) survey of public perceptions, NATO has added new telephone-based survey techniques that are more reactive to the operational tempo. This paper will provide a summary of how telephone surveys were used to provide Resolute Support Headquarters (RSHQ) with a

rapid assessment of violence across Afghanistan prior to the signing of the US-Taliban peace deal in February 2020, and the analytical pros and cons of using such surveys to capture 'atmospherics'. Data science techniques such as Exploratory Factor Analysis (EFA) in the 'R' software environment have recently been leveraged to identify latent factors, reducing the dimensionality of complex survey data and simplifying the communication of results to stakeholders, as well as identifying candidate questions for removal from future surveys. This paper will describe the approaches taken and challenges faced in applying these methods such as dealing with different data types, imputation, and calibration of the EFA model. An interactive survey analysis dashboard has been developed using Power BI, allowing military and civilian decision makers direct access to nearly a decade's worth of RS population perception data. A demonstration of this dashboard will be provided as part of this paper, including how built-in machine learning algorithms can be used to gain deeper insights from survey data.

Nick Labsvirs is a Senior Scientist within the OA Service Line at the NATO Communications and Information Agency (NCI Agency). He currently works on Defence Planning and Operations Assessment projects, and has spent over nine months deployed to Resolute Support, Afghanistan. Prior to this, Nick worked as an analyst at the Defence Science and Technology Laboratory (Dstl) in the UK, with a focus on C4ISR Capability Assessment. Nick has a master's degree in Physics and in his spare time enjoys bouldering, playing guitar and piano, reading, and watching football.

BDAA 1-3: Making best use of survey data for operational analysis: Pattern analysis using supervised machine learning

Authors: Mr. Joris Westerveld, Dr. Tom Powell, Dr. Phil Eles

As part of its comprehensive assessment of the operating environment in Afghanistan, NATO sponsors quarterly public opinion surveys. Since 2008, forty-eight nationwide surveys have gathered perception data from more than half a million Afghans. AI and big data methods are starting to be used to analyse this data, in combination with operational analysis methods. This facilitates both more efficient processing for assessment purposes and at the same time helps extract hidden structure and complex inter-relationships for improved modelling of military operations. This paper describes different supervised machine learning approaches for exploring patterns of responses in the data, with the aim of identifying important variables for classifying support and opposition towards the Afghan insurgency. A Random Forest classification algorithm was used either in combination with a reduced set of data based on a theoretical model of radicalisation (combined analytical approach), or with the full survey dataset (data-driven approach). These approaches yielded different sets of variables, such as perceptions of security, religious proximity to the insurgency, attention to propaganda, and attitudes towards reconciliation. Key findings show promise for the combined approach that integrates data-driven and analyst-driven techniques. This performed almost equally to the data-driven approach, whilst using far fewer data and producing more interpretable output. Moreover, it identified variables of importance not otherwise identified through traditional descriptive statistics. This technique remains exploratory but represents a step towards making best use of survey data for operational analysis by integrating AI techniques with qualitative analytical insights.

Joris Westerveld is a junior scientist innovator at the Military Operations department at TNO. His work involves research with a focus on data science, agent based modelling and geo-statistics for various projects for Defense and the Police. He graduated from the Utrecht University with a BSc in Psychology, Minor in Criminology, premaster in Computer Science and a Msc in Artificial Intelligence. Before working at TNO he was an intern and afterwards a consultant for the 510, an initiative for the Red Cross. Here he built a model that predicts the transitions of food insecurity using satellite imagery and other data sources.

Tom Powell (PhD) is a medior Scientist at the Military Operations department within the Defence Safety and Security Unit of TNO. His research focuses on using data analysis to inform influence operations and intelligence. He has previously worked as an intelligence analyst at UK Defence Intelligence, including a deployment as analyst/liaison officer to a UK headquarters in Kandahar in Afghanistan. He has a PhD in communication science, with a focus on the influence of political communication on public opinion, an MSc in Neuroscience, and a BSc in Psychology.

Dr. Philip Eles is a senior scientist in the Operational Analysis Service Line at the NATO Communications and Information Agency. His work has focused largely on providing analytical support to NATO's comprehensive assessments of the mission in Afghanistan through projects for SHAPE, JFC Brunssum, and ISAF/Resolute Support HQ. He has deployed to Kabul on multiple occasions as an embedded analyst in the HQ, and provides ongoing reach-back support to the mission. Since 2014, he has been the technical lead for NATO's survey program in Afghanistan. Prior to joining NATO in 2013, Dr. Eles was a defence scientist at Defence Research and Development Canada. He completed his Ph.D. in physics from the University of British Columbia in Vancouver in 2005.

BDAA 2-1: A data science approach to Lessons Learned: unlocking hidden value in NATO Exercise Big Data

Authors: Dr. Mihaela Racovita, Ms. Ivana Ilic Mestric

NATO generates vast volumes of varied data through its operations, exercises, and routine activities, often at a fast pace. However, the Alliance is not yet equipped to process this data for Lessons Learned purposes at the speed of relevance, and as a consequence, potentially valuable lessons are being lost. As part of the Enabling Line of Effort (ELOE) for Lessons Learned of the ED&T Roadmap, JALLC explored how data science tools and approaches can be leveraged to tackle the problem. This paper presents four models of analysis designed by JALLC in partnership with the NCIA Data Science team, to identify and extract value for lessons learned from the Trident Juncture 2018 exercise. Furthermore, the paper discusses the promising results obtained, as well as the challenges that had to be overcome in applying data science analytics to NATO exercise Big Data. Making use of data generated through exercises gives analysts insight into the bigger challenges faced by the operational community and into some possible solutions. Finally, the paper outlines the broader impact of this data science approach for the development of NATO Lessons Learned Capability. It calls for a shift in how we understand and leverage data science in support of lessons learned, from incorporating selected features and tools, to creating an integrated model of use.

Dr. Mihaela Racovita is a Research Analyst at the Joint Analysis and Lessons Learned Center (JALLC) in Lisbon, Portugal. In 2019 she managed the NATO Exercise Big Data Exploration Project, and is currently working on COVID-19 lessons. Prior to joining NATO, Dr. Racovita has worked as a researcher for the Small Arms Survey in Geneva (Switzerland), on small arms control in peace operations, gender and armed violence, and collaborated with the UN, African Union, ECOWAS and the OSCE. She has a Masters and a PhD in International Relations from the Graduate Institute of International and Development Studies in Geneva.

Ms. Ivana Ilic Mestric obtained her Masters degree in Computer Science with a specialty in Data Analytics. She has more than 12 years of professional experience in data science and related areas, including implementations of complex analytics solutions. During this professional experience she has worked on projects across different industries including finance, telco, retail and defence. In the last three years she has worked in the NATO CI Agency as a Senior Data Scientist; involved in a range of Data Science projects across NATO. She has authored multiple scientific papers and actively participated in specialist conferences in the Data Science area.

BDAA 2-2: Distributed Gaming at the EDGE – A Structured Approach for Toolset Selection

Authors: Dr. Murray Dixson, Dr. Patrick Dooley, Dr. Michael Petryk, Ms. Emily Robinson, Dr. Ben Taylor

The COVID-19 pandemic has produced a seemingly ubiquitous need for effective and efficient means to collaborate remotely. Accordingly, to continue informing military decision making we require means to conduct serious games that can no longer be played in person. To that end, we are developing the general-purpose Experimental Distributed Gaming Ecosystem (EDGE) concept. EDGE involves numerous principles, processes, tools, and training materials that we

are developing concurrently and have applied to play seminar and matrix games. In this report, we describe the structured approach that we use to select and configure an apt toolset for playing a particular game remotely. To illustrate that approach, we have used one of several recently played games as an example. Our successful tests of the nascent concept suggest that EDGE (or analogous approaches) could feasibly enable collaborative work that was done in-person pre-pandemic to be conducted remotely both soon and post-pandemic

Dr. Murray Dixson is an Operational Research Analyst with Defence Research and Development Canada (DRDC). Over the course of his career, he has worked on space surveillance and ballistic missile defence, combat ID technology demonstrations and was the science and technology liaison to the 2010 Winter Olympics security unit. Current work is on applying wargaming and force structure analysis to the strategic planning of the Canadian Armed Forces and NATO.

Emily Robinson has worked with Defence Research and Development Canada since 2016. Since then, her research has focused on long-term threat actor future warfare capabilities. Current research efforts include analyses of nearer-term threat actor capability development, the effect of climate change on security in high risk areas, and the use of wargaming to advance capability based planning efforts.

Dr. Ben Taylor is an experienced defence operations research analyst who has worked in the defence industry as well as for the Governments of the United Kingdom and Canada. In the United Kingdom, Dr. Taylor was instrumental in the design and implementation of the MOD Capability Audit process (2000-2001) and subsequently held a number of high-level analysis leadership positions at the Defence Science and Technology Laboratory 2002-2007. Since joining Defence Research and Development Canada (DRDC) in 2007, Dr. Taylor has supported the evolution of the Canadian Force Development process. He is currently the Chair of SAS 164 - 21st Century Force Development.

Dr. Michael Petryk's research has involved the development of new technologies for the spectroscopic detection of chemical warfare agents. Current research efforts include analytics, modelling and simulation, and the applications of natural language processing to government procurement and portfolio design.

Dr. Patrick Dooley worked as a postdoctoral fellow and experimental physicist before joining Defence Research and Development Canada in 2005. Since then, he has developed and applied various techniques, tools, and experiments for concept development, process improvement, and risk assessment in support of public and private defence and security partners in Canada and abroad.

BDAA 2-3: Concept for benchmarking in combat simulation for CoA-Analysis

Authors: Dr. Hermine Reichau, Mr. Maximilian Beenisch

As framework nation, Germany with its very high readiness joint task force (VJTF) provides a guiding role for multi-national combined forces. VJTF will face extensive operational, tactical, and technical tasks, requiring adequate and powerful decision support methods. In the context of VJTF 2023, in-depth course of action (CoA) analysis will play a crucial role to address a variety of planning and decision tasks. In a multitude of potential scenarios, mission planning confronts tactical leaders with a range of military options to generate and analyze their CoA along various

measures of merit (MOM). Considering highly inhomogeneous consisting force structures, CoA analysis has to support the optimization of combat mission and force planning for many different situations. Hence, a primary challenge to master such types of analysis is to establish a stable basis to ground different armament, equipment, country-specific tactics, organizational structures within a scenario on an equal footing that allows for an inter-comparability of the same MOM in different CoA and scenarios. This presentation introduces a first approach of combat simulation benchmarking that allows capturing qualitative and quantitative baselines for inter-comparability of MOM across different scenarios and CoA. It covers a basic concept as well as prerequisites to render appropriate and applicable combat simulation benchmarking baselines.

Dr. Hermine Reichau works as a Data Analyst in the field of capability analysis by simulation and modelling for defense and security affairs at IABG. Since 2017 she is involved in the development of capabilities by NATO Architecture Framework as an Expert Enterprise Architect, especially for scenario based analysis and AI solutions. She is supporting different simulation teams of IABG with data analysis in modelling and simulation for the German Armed Forces, knowledge building and development of new methodologies for OR and Data Analysis. Dr. Hermine Reichau studied computer science with focus on AI and linguistics and received a doctorate in applied physics. She worked as a researcher in the fields of statistical signal processing and prediction, accelerator physics, simulation and theoretical physics. Before starting her career in the field of defense and security, she worked as an architect for building enterprise communication platforms combined with big data frameworks, especially with focus on speech analytics and multimodal biometry solutions.

Maximilian Beenisch is Programme-Manager for OR/M&S Joint & Land Operations with IABG Defense & Security. Since 2017, he conducts tactical analysis supporting the German Federal Armed Forces in the definition of capability requirements for new land systems and platforms. For this purpose, he provides tactical scenario modelling in the Joint Agent Based Simulation System (JASS) in order to transfer military operation plans and tactics/techniques/procedures into constructive simulation. His teams uses these models for data farming experiments and statistical analysis. As a former artillery officer and officer for military intelligence, he translates the language and the requirements of military subject matter experts to the civilian analyst experts of IABG. Mr. Beenisch has lead several simulation-based studies for the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support and other agencies of the German Federal Armed Forces.

BDAA 3-1: Emerging technologies, Disinformation, and Decision-making: a Conceptual and Historical Analysis

Authors: Dr. Simona R Soare, Dr. Joe Burton

This paper asks how and under what circumstances disinformation affects operational decision making. It focuses on this issue at a time of increasing concern about the effects of online, deep fake and AI based disinformation in the political and military spheres. Despite this increased attention, there has been little attention given in the field of social sciences (political, behavioural, International Relations) to how disinformation can find its way into the decision-making processes of military commanders, and how it influences military operations. This paper proceeds in three sections. The first section builds a conceptual framework for disinformation and operational decision making, focusing on where disinformation comes from, what channels are used to disseminate disinformation and manipulate the data commanders rely on for operational decision making, and the subsequent impacts of that malign activity. The second section provides a broader historical overview of when and how the framework we construct can be used to analyse examples of disinformation affecting military operations in the past. The final section is focused on AI, particularly predictive and analytical AI models, and how they can be used to achieve disinformation manipulation. We make the argument in this paper that disinformation should be seen as a growing threat to military command and control, and that the extent of social and cognitive impairment that can be achieved through such attempts is growing. The paper makes three main contributions: it provides a framework for decision-makers to raise awareness of when and how they might be vulnerable to disinformation, particularly in an automated context; it provides a historical overview of successful disinformation operations; and it provides an analysis of emerging technologies' impact on disinformation as it affects operations.

Dr. Joe Burton is a Research Fellow in the International Security Programme at Chatham House, where he manages the Building Anti-Cybercrime Capacity in ASEAN Through Simulation Exercises project. He is also a Senior Lecturer in International Security at the New Zealand Institute for Security and Crime Science, University of Waikato, New Zealand. Joe was recently a Marie Curie fellow at Université libre de Bruxelles (ULB) working on the European Commission-funded project Strategic Cultures of Cyber Warfare (CYBERCULT) and is the recipient of the US Department of State SUSI Fellowship, the Taiwan Fellowship, and has been visiting researcher at the NATO Cooperative Cyber Defence Centre of Excellence (CCDCOE) in Tallinn, Estonia. He is the author of NATO's Durability in a Post-Cold War World (SUNY Press, 2018) and the editor of the forthcoming volume Emerging Technologies and International Security: Machines the State and War (Routledge, 2020).

Dr. Simona R. Soare is Senior Associate Analyst at the European Union Institute of Security Studies (EUISS). Her research focuses on transatlantic and European security and defence, EU-NATO cooperation and defence innovation. Prior to joining EUISS, Simona served as advisor to the Vice-President of the European Parliament (2015-2019), working on European defence initiatives (EDF, military mobility, EU-NATO cooperation), CSDP and transatlantic relations, and as an analyst with the Romanian Ministry of Defence. She has lectured in international relations at the National School for Political and Administrative Studies in Romania and she is a regular contributor to CSDP courses with the European Security and Defence College (ESDC). Since 2016, Simona has been an associate fellow with the Institut d'études européennes (IEE) at Université Saint-Louis Bruxelles where she works on defence innovation and emerging

technologies. Simona holds a PhD (2011) in Political Science and she is a US Department of State fellow. She has published extensively on American and European security and defence, including defence capability development, emerging technologies and defence innovation, arms transfers, export controls and regional defence.

BDAA 3-2: Data Science in Intelligence: Rethinking Intelligence Processes in the Information Age

Authors: CPT Tess Horlings, Dr. Roy Lindelauf

The Intelligence Community (IC) is finding its way in integrating data science into intelligence processes. As the nature of information is changing rapidly, there is a knowledge gap in the integration of data science within the IC. In this paper we present a comparative study into the different frameworks of intelligence processes, such as the Intelligence Web and Activity-Based Intelligence. In addition, we used three computational social science approaches in the field of terrorism research: Agent-Based Models, clustering algorithms from complex network theory, and data driven network analysis. Based on this theoretical foundation, and in cooperation with Dartmouth College, we interviewed fifteen intelligence professionals on the integration of data science in their respective organizations. As a second method of empirical data collection, we conducted an experiment with a group of Dutch and American intelligence analysts to evaluate their experience with data science integration. Our study shows the urgency to reassess traditional views on intelligence processes. In particular it shows the need to change prevailing convictions on implementation of quantitative methods in intelligence analysis.

Tess Horlings is a PhD-candidate at the Intelligence and Security Department of the Netherlands Defence Academy and serves as an Army Reserve Officer. Her research is focused on the integration of data science in the Intelligence Community. Next to her PhD, she works as an academic liaison to a National Police unit, where she previously served in operational support with jihadism expertise. Tess holds a bachelor's degree in Middle Eastern Studies from the University of Groningen and a master's in Military Strategic Studies from the Netherlands Defence Academy. She enjoys working in a multi-disciplinary setting, combining qualitative and quantitative approaches, and civilian and military perspectives.

BDAA 3-3: Dealing with Complexity in Assessing Defence and Security-Related Capacity Building

Authors: Mr. Valentin Poponete, Mr. Javier Hidalgo Tostado

After the illegal annexation of Crimea in 2014 and the rise of Daesh in Iraq and Syria in 2014, NATO realized that it needed to step up its collective defence and deterrence efforts in parallel to projecting stability beyond its borders. As part of the later efforts, NATO decided to increase its support to partners especially in the form of defence and security-related capacity building (DCB).In 2018, SHAPE conducted an analysis of all NATO military DCB activities conducted in support of partners or during missions and operations. Virtually none of these efforts were accompanied by proper operations assessments that could identify long-term improvements in the capacity and effectiveness of the defence and security forces that received NATO's support. This is also valid for the assessment methodologies used by the NATO forces in Iraq and Afghanistan which remained focused on kinetic metrics and measures of performance related to

recruitment, training and equipment. These assessment methodologies failed to assess less tangible aspects such as corruption, poor leadership and the political-economy of the local defence and security forces. The same faults seem to apply to national efforts in assessing DCB efforts. In this context, our paper (1) identifies problems related to assessing DCB efforts and (2) recommends novel methods, techniques and practices for the conduct effective operations assessment of DCB efforts. The authors look at how technology-driven assessment methodologies, such as natural language processing, satellite imagery and remote sensing, could be combined with qualitative analysis and local expertize to enable NATO to deal with the complexity of DCB assessments.

Javier Hidalgo Tostado is an analyst working in J5 (Strategic Planning) at NATO's Supreme Headquarters Allied Powers in Europe (SHAPE) in Mons, Belgium, with a focus on the Middle East –namely Afghanistan and Iraq. Previously, he has worked in the Organization for Security and Cooperation in Europe (OSCE) on capacity building and conflict resolution in Eastern Europe. He holds a cum laude master degree in European Affairs from Sciences Po (Paris) and a bachelor degree in Philosophy, Politics and Economics from Pompeu Fabra University (Spain).

Valentin Poponete has been a civil military analyst/ planner in SHAPE Strategic Planning since 2010 with leading roles in strategic planning and assessment of the NATO missions in Afghanistan, Iraq and Libya. H is a retired Romanian officer and, he holds a BA in Sociology, an MA in Political Science and a Postgraduate degree in Public Affairs and Strategic Communications.

Stream C – Cyber

C 1: Cyber Risk to Mission: Assessment Methodology

Author: Dr. Dave Alberts

The emergence of the set of technologies, currently referred to as 'Cyber', has had a profound impact on military organizations and operations. This paper begins by briefly looking at our current dependence on 'Cyber,' how militaries have adapted to take advantage of the opportunities afforded by these technologies, and the disruptive implications of operating in a contested cyber environment. Today, a loss of cyber or cyber-enabled capabilities can pose a significant risk to mission. Given the stakes, being able to appropriately assess the risk and provide recommendations for managing this risk is a must-have analytic capability. This paper presents a conceptual framework for thinking about CRM and an assessment methodology developed for the US DoD

Dr. David S. Alberts is a Senior Fellow at the Institute for Defense Analyses, a consultant to the Johns Hopkins Applied Physics Laboratory, and he also serves as the President of the International Command and Control Institute, a nonprofit organization formed exclusively for scientific and educational purposes. He has more than 30 years of experience developing and introducing leading edge technology into Private and Public Sector organizations. Dr. Alberts' publications include a number of books: The Agility Advantage: A Survival Guide for Complex Enterprises and Endeavors, Planning: Complex Endeavors, Understanding Command and Control, Power to the Edge, Information Age Transformation, Understanding Information Age Warfare, Network Centric Warfare, Unintended Consequences of Information Age Technologies, Command Arrangements for Peace Operations, and Defensive Information Warfare. He has also led international teams. Currently he chairs SAS-143, a NATO STO research group focused on Multi-Domain C2. Prior to this he chaired NATO STO Research Group SAS-085 which has received the 2014 NATO Scientific Achievement Award. Previous NATO groups led by Dr. Alberts have produced the C2 Maturity Model, the C2 Conceptual Reference Model, the NATO Code of Best Practice for C2 Assessment and the Code of Best Practice for Experimentation. He was focused on improving the agility of organizations and systems and issues related to Cybersecurity. At the local level, Dr. Alberts also served as Assistant to the Commissioner, NYPD. Dr. Alberts received a Doctorate in Operations Research and a Masters from the University of Pennsylvania. His undergraduate work was at City College of New York where he received a BA in Statistics.

C 2: A three-stage machine learning cybersecurity solution for public entities

Author: Ass. Prof. Stanisław Saganowski

In the era of universal digitization, ensuring network and data security is extremely important. One of the initiatives targeting cybersecurity is the Regional Center for Cybersecurity (RegSOC) project. Its main goal is to develop and implement a model security center for public entities. The RegSOC unique approach to this task combines management models and organizational procedures with a threat detection within a network (typical features of Security Operation Center system), as well as a threat detection outside the network, i.e., information extraction from social media, news portals, darknet, and abuse reports. We apply machine learning to perform a three-stage security solution consisting of prevention, monitoring, and curation. For the prevention stage, we have created a Named Entity Recognition model to automatically extract threat information from social media, news portals, and darknet. Any software-, system-, or device-related security issues (vulnerability, exploit, patch), as well as information about new malware

or hacking methods, are gathered. We apply numerous solutions at the monitoring stage, to name a few: campaign identification, spam analysis, honey-net, Nessus
scanner, as well as various physical sensors analyzing traffic: IDS, IPS, and honey-pots. Most of them are ready-to-use commercial solutions, but the anomaly detection component based on the deep neural network architecture has been developed from scratch to address the RegSOC needs. The study shows it achieves over 99% accuracy and precision in classifying malicious traffic. Finally, we make use of the abuse reports sent to the network operator to automatically identify and eliminate any intrusions at the local network that passed other security solutions.

Stanislaw Saganowski, PhD, is an Assistant Professor at Wroclaw University of Science and Technology, Poland, and a member of the Top 500 Innovators association. In recent years he spent 15+ months at the top world's universities: Cambridge (UK), Oxford (UK), NTU (Singapore), UC Davis (USA), UTS (AU). His research interests include cybersecurity, mobile and wearable technologies, group evolution analysis and prediction, social network analysis, and emotion recognition from physiological data.

EDT 1-1: Through the Curtain: Methods to Boost the Impact of your EDT Analysis

Authors: Ms. Louise HOEHL, Mr. Mark TOCHER, Prof. Dr. Gabriele RIZZO

In the Defence Environment, the implications of Emerging and Disruptive Technologies (EDTs) can be significant, bringing about discontinuities that could change the character of war, driving changes to doctrine and speeding the obsolescence of major capital equipment. Dealing with this uncertainty often requires actions to be taken in the short-term to adapt to possible ramifications that will only appear many years in the future. But getting decision makers and planners into the required mind-set to fully consider and visualise what could be, especially when what may be coming over the horizon is a revolution not an evolution, can be difficult. This paper will explore the tools and techniques that can be used to grab the attention of decision makers and motivate informed decision-making based on the assessments of the EDTs. Examples from both NATO and National levels will be described, covering Ability Cards, Science and Technology Gaming, and Science Fiction Story telling. The paper will describe a range of methods, tools and techniques, along with associated pros and cons. The use of these methods/tools/techniques could raise what may be weak signals above the ambient noise to generate sufficient interest to instigate actions that are required now. Without these actions, even if correctly identified, EDTs would not have the greatest benefit.

Louise has a professional analysis career spanning 20 years across multiple areas of defence and security, in the UK Ministry of Defence, U.S. Department of Defense, and NATO. Presently Louise is a Principal Scientist in the NATO Communications and Information Agency (NCI Agency) providing Operational Analysis support, primarily to ACT in the NATO Defence Planning Process. Louise has experience providing decision support in multiple areas of defence and security, including force planning, procurement, and science and technology.

Mark Tocher is currently a Defence Planning Analyst at Supreme Allied Command Transformation (SACT) in Norfolk, Virginia. He specialises in the incorporation of foresight and future technology into the derivation of military requirements for the North Atlantic Treaty Organisation (NATO). In the past, he has worked in future policy and operations planning. Previously, he was a Navigator in the Canadian Air Force retiring as a Lieutenant Colonel. He has a Bachelor of Arts in Political Science and a Master of Business Administration from the University of Manitoba, a Master of Science from Florida Institute of Technology and is a graduate of the Canadian Forces Command and Staff College.

Professor Dr. Gabriele Rizzo is a visionary futurist and an enthusiastic innovator. A Ph.D. in String Theory and Astrophysics grown into Defense leading expert in foresight, he is the NATO's Member at Large ("world-class expert drawn from academia, industry or government from the Nations") in Strategic Foresight and Futures Studies. Dr. Rizzo serves as Board member both for policy strategy (in EU organizations surpassing $2B worth and scoring with honors on EU reviews) and for scientific research (leading the world's largest community of 5000+ Defense scientists). He is also Professor of Strategy at the University of Rome "La Sapienza." Gabriele advises Governments and Defenses on long-term strategies, foresight, game-changing technologies, and innovation convergence — the U.S., UK, Italy, Switzerland, NATO, the United Nations, European Defense Agency, and other allied Governments and Fortune Global500 companies all number him among their ranks. He has been leading deep futures vision in the 2060 timeframe of the U.S. Space Force, the U.S. Air Force, the U.S. Air Force Research Laboratories, the Italian Prime Minister's Grand Strategy 2040, and several other senior major engagements on strategic foresight and futures. The works he was an editor for, or

that he has authored, inform $1T (one trillion USD) worth of Defense planning. Some were evaluated "important pillars of strategy and implementation of R&I" by the EU. Others still shape industrial investments in Research, Development & Innovation (more than $1.8B in 2019), from silicon chips to helicopters and aircraft. He is enriched by differing perspectives of 1000+ scientists and military officers. Dr. Rizzo routinely gives keynotes in the U.S. and Europe, and is passionate about complexity, singularity, and peace.

EDT 1-2: What Does Resilience-Building to Emerging and Disruptive Technologies Actually Look Like? A Study Addressing the Public Policy Challenges and Socio-Political Implications of the Development of Artificial Intelligence for NATO Security and Defense in Continental Europe

Author: Ms. Kulani Abendroth-Dias

Digital technologies have proliferated rapidly over the past two decades, from the spread of mobile broadband networks, to the use of cryptocurrencies, to the use and abuse of artificial intelligence (AI) and machine learning (ML) for security and defence (Spiegeleire, Maas, & Sweijs, 2017). AI now has vast implications for not only defence but also economic and social fairness. Uses and misuses of AI and ML-driven technologies have been made clear during the COVID-19 pandemic, with their use in contact tracing and abuse in the spread of misinformation to sow civic unrest and erode public trust in government institutions. The need to build both military and civilian resilience to AI- and ML-driven malignant attacks has become painfully evident. This research brings together often disparate discussions on the development of AI across European NATO nations to present social, economic, political, legal, and technical ways forward to resilience-building. The study presents interviews with 22 European NATO stakeholders, comprising policy-makers, academics, and industry and non-profit actors, on behaviourally informed ways to build resilience to cyberattacks in military and civilian domains across the EU. Ten policy insights operationalising resilience and civic trust-building are presented, based on a content coding of the role of counter-AI agencies, practical approaches to mitigating risk, addressing bias in datasets, developing human-centered automated systems, and current policy and industry priorities in the economics of the development of AI- and ML-driven technologies. The role of the private sector and the asymmetric development and implementation of AI- and ML-driven technologies across European NATO member states are discussed.

Kulani Abendroth-Dias is a PhD student at the Graduate Institute (IHEID) and a Graduate Professional at the United Nations Institute for Disarmament Research (UNIDIR) in Geneva, Switzerland. She works at the nexus of economics, social psychology, and AI. A TEDx speaker on "Why Good People Do Bad Things - And What We Can Do About It", Kulani formerly worked as a behavioural scientist at the UN. She has an Advanced MSc. in European Integration (Economics and Security, External Relations, and Counter-terrorism) from the Institute of European Studies (VUB) in Brussels, Belgium, and an M.A. in Psychology from Princeton University.

EDT 1-3: Emerging and Disruptive Technology and Small Military Power

Authors: Dr. Jakub Fučík, Dr. Josef Procházka

Development and exploitation of emerging and disruptive technology (EDT) represents opportunity for States to transform their military power and change their status in the system of international relations probably with the presumptions of the new Revolution in Military Affairs (RMA). Technologies such as autonomous systems and artificial intelligence, additive manufacturing or genetic manipulations create new possibilities to enhance capabilities of armed forces and their role in protection on national interests. Not-only the most powerful States such as the United States of America, People's Republic of China, or Russian Federation, but practically all State and non-State actors closely scrutinize this process and its implication for the future security environment. This paper aims to examine the implications of EDT for the small State and its power. The focus will be on armed forces and transformation of their main capability areas through exploitation of EDT. This paper will provide a necessary understanding of the new ways of promotion of small States' national interests and their position in the international system.

Jakub Fučík, Ph.D. since 2007 studied International Relations and Security and Strategic Studies at the Faculty of Social Studies of Masaryk University in Brno and graduated as M.A. in 2012 and as PhD. in 2018. Simultaneously, since 2009 studied Law at the Faculty of Law Masaryk University in Brno and graduated as M.A. in 2015. In February 2016 he started working at the Centre for Security and Military Strategic Studies, University of Defence in Brno. Dr. Fučík participates on SAS/ STO NATO panels and workshops and represents the Czech Republic in EDA CapTech "Information". In June 2018 he graduated from the International Law of Military Operations Course of the Defense Institute of International Legal Studies, Newport, RI, U.S. He is also secretary of the Obrana a strategie journal.

Asoc. prof. Josef PROCHÁZKA, Ph.D. is a graduate from the Military Academy in Brno in a design of special vehicle and tank equipment (1990). He occupied several staff positions at the General Staff and Ministry of Defence with the main focus on logistic planning and acquisition. In 2000 he started working as a research fellow at the Institute for Strategic Studies and in 2006 he became a deputy director of the institution. In 2007 he retired from the military active service in rank of Lieutenant Colonel. From 2007 to 2011 he was responsible for strategic planning of the CZE MoD development within the Defence Policy and Strategy Division. In 2011 he served at the Czech Permanent Delegation at NATO with the responsibility for management of NATO Common Resources. After completion of his assignment at NATO in 2014 he was appointed as the deputy director of Centre for Security and Military Strategic Studies of the University of Defence.

EDT 2-1: Assessing the impact of emerging technologies on Canadian Army

Author: Dr. Alain Auger

For a number of years, Defence Research and Development Canada (DRDC) has been engaging with military personnel through a series of workshops to assess the likely implications of emerging technologies on concepts, capabilities and investments. This paper provides an overview of the impact assessment framework that has been designed and used to investigate implications of several emerging technologies. The framework includes both quantitative and qualitative measures as well as an official list of capability elements that are required to support missions. Application of the framework is illustrated through the assessment results for several emerging technology areas on Canadian Army capability elements. Emerging technology areas assessed include quantum technologies, metamaterials, artificial intelligence, printed electronics, human performance enhancement, synthetic biology, additive manufacturing, and many others. Results provide insights into which military capability areas and operational functions will be most impacted by the technologies reviewed. This approach provides additional evidence to Force Developers and supports the review of capability development plans and technology roadmaps.

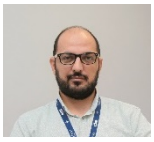
Alain Auger received a Ph.D. degree in Linguistics from Université de Neuchâtel in Switzerland in 1997. He has developed new methods and algorithms to retrieve and fuse semantic information in electronic texts. His main research interests include knowledge representation, terminology extraction, text and audio mining, ontology engineering, machine translation, and natural language processing. He joined Defence Research and Development Canada (DRDC) as a Defence Scientist in 2003 and delivered several innovative capabilities to the Intelligence community. Dr Auger was deployed as the Scientific Advisor to Task Force Kandahar under General Jonathan Vance in 2009-2010 during Op ATHENA in Afghanistan. He is the Chair of an international panel of experts under the Technical Cooperation Program (TTCP) which performs collaborative research to develop new methods and tools to identify emerging technologies and assess their implications on Defence and National Security. He is the Canadian National Lead of TTCP's Executive College Panel on Emerging and Disruptive Technologies (EDT) and a member of NATO SAS 159 RTG on the Future Operating Environment. He has also been appointed as the National Lead and Chair of the international Technology Foresight group of experts in science and technology for public safety and national security under the 5RD Council. He contributed several publications on emerging technologies and the future security environment. Dr Auger is leading DRDC's Science and Technology Foresight and Risk Assessment program with the mandate to identify emerging technologies and assess their potential impact on Defence and National Security.

EDT 2-2: Cybersecurity in the Electrical Power and Energy System: an Armour against Cyber and Privacy Attacks and Data Breaches

Author: Mr. Ensar Şeker

Energy is the indispensable building block of all countries and has a feature that completely affects the economy. Disruptions in the supply chain threaten health, welfare, economy, and national security including military operations. The weaknesses of the energy sector inherent in its nature are among the first issues that policymakers must take into account. Besides, the electrical dependency of all sectors brings with it the obligation and responsibility to increase the

strength of energy infrastructures against possible attacks. Hackers using a wide variety of tools for cyber attackers can easily exploit power systems. Just by targeting the networks of computers, they can break down the service. They can "bot attack" to cause the systems to shut down and/or they may install/advertise malicious software, causing systems to fail. Either they can steal data or they may be seeking to take control of the systems from the control places and disrupt/exploit it and cause serious damage. IEC 61850 is adapted to the smart grid that allows us to overcome the main problem for communication between ICS devices. Nevertheless, network protocols in IEC 61850 are not secure enough which means even the smart grid can be compromised in case of cyberattacks. In this study, we tried to list all possible cyber-attacks to electrical power systems (specifically for the smart grid) with attack vectors and attack scenarios from a red team perspective in able to suggest more secure systems..



Ensar Seker received his bachelor and master degrees in electronics and computer engineering at the New York Institute of Technology University and continued his Ph.D. at Tallinn University of Technology. Between 2016 and 2018, he served as a national representative and a researcher at the NATO Cooperative Cyber Defense Center of Excellence, located in Tallinn, Estonia. He is currently working as a senior researcher in National Research Center Cybersecurity Department. He is also actively working for international organizations such as NATO and the European Union. He has many academic/popular articles published on cyber security, artificial intelligence and blockchain, and has contributed to many international reports.

EDT 2-3: Technology Wargaming: Experiencing future technologies combining multiple approaches

Authors: Dr. Pascal C. van Overloop, Dr. Quentin Ladetto, Dr. Michael Rüegsegger, Mr. Johann Bircher

The authors describe their experience of various wargaming-related methodologies applied in the Technology Foresight research program at armasuisse Science and Technology, also known as DEFTECH (DEfence Future TECHnologies), in order to identify disruptive technology trends, to assess their implications within a military context and to inform the Swiss Armed Forces of possible opportunities and threats. This includes an iterative process, started in 2017 and still ongoing, in which not only an open platform has been created but also several international workshops have been conducted. The applied methodologies ranged from matrix-style wargames on higher aggregated levels, red teaming efforts inspired by the “Idea of System Cards” of NATO’s Disruptive Technology Assessment Game (DTAG), up to storytelling approaches. The special focus on technologies lead finally to the development of a tactical tabletop wargame entitled “New Techno War” that is commercially available. Built as a platform, an internet component allows interaction between interested stakeholders who would like to simulate additional technologies or scenarios and make them available to the community. A digitization of the game integrating multi-agent simulation, decision support, artificial intelligence, and video gaming is in development. The authors present the conclusions of the past research including different design ideas, identified pros and cons, best practices, current developments and vision.

Stream EDT #2 – Emerging Disruptive Technologies

Dr van Overloop works since 2012 at IABG's Defence & Security Division where he is concerned with operator models, training & exercises, analytical support as well as strategic and technological consultancy. He served as officer in the German army for fifteen years until 2011, including deployment abroad, his studies of Economics and Business Administration and three years as Research Associate and Lecturer at the University of the Bundeswehr in Munich. He has been for the coordination of the training in operations research, modelling & simulation in the Bundeswehr.

Quentin Ladetto is research director at armasuisse Science and Technology where he started the Technology Foresight program - https://deftech.ch. The goal of the program is to identify disruptive technology trends, assess their implications within a military context and inform the Swiss Armed Forces of its possible opportunities and threats. After a PhD in Geomatics from the Swiss Institute of Technology in Lausanne (EPFL), Quentin joined Safran Vectronix AG to produce the pedestrian navigation system developed during his thesis, which would be then selected to be part of the US Land Warrior military program. Prior to joining armasuisse he worked with different start-ups companies helping developing various hardware and software solutions in the field of Internet mapping, fleet and asset management, Internet of Things (IoT). In parallel Quentin completed an Executive MBA in management and corporate finance from HEC Lausanne and a diploma in Technology Management from IMD

Johann Rudolf Bircher is responsible for the research activities in armasuisse. This function includes the development of strategic research concepts as well as the lead in the annual implementation planning. The setting of appropriate research topics is focused on building up expertise to advise decision makers of the Swiss armed forces in technology issues and to enable experts to assess military systems under procurement by armasuisse. Beyond the setting of appropriate research topics Mr. Bircher is responsible for the development of a national and international network of experts and for the transfer of research findings to the stakeholders and decision makers within the federal department of Defense, Civil Protection and Sport. Mr. Bircher has a PhD in physical chemistry and an Executive MBA from the University of St. Gallen. He is a member of the Science and Technology executive board in armasuisse.

Michael Rüegsegger is the Head of Operations Research and System Analysis at armasuisse Science and Technology, where he researches in the field of Data Farming, Multi-Agent Simulation and Artificial Intelligence to support decision making within the Swiss Armed Forces. He graduated from the University of Bern, with a PhD in Biomedical Engineering. After graduation, he worked for the Department of Ophthalmology of the Bern University Hospital as Research Scientist and various companies within the medical technology and aviation sector as Development Engineer and Product Manager.

EDT 3-1: Use of agent-based modeling and data farming for the army ISR capability assessment

Author: Ms. Maude Amyot-Bourgeois, Ms. Lynne Serré, Dr. Peter Dobias

The Canadian Army, following the vision of Close engagement: land power in an age of uncertainty: evolving adaptive dispersed operations, is in the process of modernizing its Intelligence, Surveillance, and Reconnaissance (ISR) assets. The desired objective is a digitized ISR network compatible with allies networks, flexible and scalable, with the capability to accomplish various tasks such as detection, identification, data fusion, and tracking in order to create near-real time situational awareness (SA). An improved SA of the battlefield may give a commander tactical advantage over adversary. In order to compare various considered options, it is desirable to be able to test various sensor fleet mixes in the operational context using a set of pre-defined scenarios. Furthermore, the output must generate sufficient data to support meaningful Measures of Performance (MOP) and Measures of Effectiveness (MOE) comparison. In this paper, we evaluate the use of Map-Aware Non-Uniform Automata (MANA), an agent-based model developed by New Zealand's Defence Technology Agency, to assess the performance of various sensor mix fleets consisting of heterogeneous platforms and payloads. The considered scenario involves ISR support to stabilization operations involving force-on-force engagements. We evaluate the possibility of modeling appropriate scenarios, comparing various sensor mixes leveraging MANA's data farming capabilities, and we present possible analytical and data visualization approaches that would enable effective analysis of large data volumes generated from MANA runs in a way informative and relevant to the decision-makers.

Maude Amyot-Bourgeois is a junior defence scientist with Defence R&D Canada –Centre for Operational Research and Analysis (DRDC CORA) since 2019, where she works in collaboration with her colleagues from the Canadian Army Operational Research & Analysis Team on various combat simulation studies. Maude Amyot-Bourgeois obtained her Master's in physics from the University of Ottawa.

Lynne Serré first joined the Department of National Defence in 2013 as a defence scientist under Director General Military Personnel Research and Analysis where she specialized in military workforce modelling and analysis. In 2019, she joined Defence Research and Development Canada's Centre for Operational Research and Analysis and currently provides support to the Canadian Army headquarters in Ottawa. She obtained her Master's degree in computational mathematics from the University of Waterloo, Canada.

Dr. Dobias received his PhD in theoretical physics from the University of Alberta in Edmonton, Canada. In 2005 he started working for Defence R&D Canada, at first with Land Operational Research Team where he worked on wargaming, agent-based modeling, and complex adaptive systems; he soon moved to the Canadian Expeditionary Forces Command where he led the analytical support to the Afghanistan Mission assessment, followed by a deployment as an Operational Analyst with the Canadian Task Force Kandahar, and a three-year tenure as a Quantitative Analysis Team Lead at the US Central Command in Tampa, Florida. He led the work supporting analytics and assessment in support of the International Assistance Force Afghanistan and US Forces Afghanistan. His research included complexity, fractal systems, and near-critical systems. From 2013 to 2018 he led Maritime Forces Pacific operational research team in Victoria, BC; then he moved to Ottawa and assumed the lead of the Strategic Planning Operational

Research Team. Since 2019 he is a Section Head for Land and Operational Command Operational Research. His research interests include complexity, fractal systems, artificial intelligence, and data analytics.

EDT 3-2: The use of FATE for illuminating disruptions

Author: Dr. Gitanjali Adlakha-Hutcheon, Mr. Kevin J Bown, Ms. Anna Lindberg, LTC Thomas Galasz Nielsen, Dr. Silke Römer, Mr. James Maltby

FATE is a new method developed through research conducted by the NATO STO Research Task Group titled Futures Assessed alongside socio-Technical Evolutions - FATE (reference SAS-123). The method was developed for anticipating evolution of technologies that have the potential of being disruptive in the context of social factors that drive or retard their diffusion. This is done systematically by examining technologies as a part of a socio-technical system (STS). Furthermore, this is done in relation to pre-composed descriptions of states of the world in the future or future scenarios. It is our belief that this is a unique, first of its kind, operational research method, one that looks at socio-technical evolutions of emerging or disruptive technologies relative to future scenarios. FATE is a tool that facilitates looking at the inevitable uncertainties associated with social changes that influence technological advancement and adoption in an emerging and complex future. Thus, results of FATE serve to inform decision-makers in a holistic fashion on more than one future scenario. We have looked at several STS and their possible implications on defence and security. The results from one of the trials of FATE held at the Defence Science& Technology Laboratories (Dstl) UK will be shared using measures such as the disruption calculus.

Dr. Gitanjali Adlakha-Hutcheon is a defence scientist working in the field of Operations research, and gaming to integrate scientific, operational, security and policy endeavors at Defence Research & Development Canada (DRDC), an agency of the Canadian Department of National Defence. She has worked at DRDC's Operational Research Centre, on assignment to the Canadian Forces Warfare Centre. Most recently she completed a three year tour as Section Head of the Office of the Chief Scientist, DRDC. For several years she has been an active collaborator with the S&T organization of NATO. Currently she is the chair of the NATO Systems Analysis Studies Panel, 123 which studies futures and socio-technical evolutions concurrently. Also she moonlights as a yoga teacher.

Dr. Kevin Bown, Technology Change Leader at the Defence Science and Technology Laboratory, UK Ministry of Defence, leads on the delivery of strategic advice to Defence on emerging/disruptive technologies, futures, innovation and exploitation; developing new models for the delivery of capability through a seamless end-to-end innovation-exploitation-delivery pipeline. Previous roles include Principal Technology Advisor for the 'Emerging Technologies for Defence' programme and Principal Technologist for the 'Technology Development and Exploration' project, areas in which he maintains currency and is frequently called on for advice across UK Defence. He is a Fellow of the Royal Society of Biology, a member of the Heads of Horizon Scanning Forum, and a Chartered member of the UK Science Council.

Lieutenant Colonel Thomas Galasz Nielsen is director at Institute for Military Technology at the Royal Danish Defence College. He holds two master degrees; one from War Studies Department at King's College London and one from the Royal Danish Defence College. As an army officer, he has served in former Yugoslavia (Croatia), Afghanistan (Helmand), and latest in Iraq (Bagdad) in various positions. He has written several books and articles about counter-insurgency operations and about strategic implications of the use of artificial intelligence in war both as a decision support tool and as a tactical mean in the field.

Dr Silke Roemer, Deputy Head of Tools & Methods, Fraunhofer Institute of Technological Trend Analysis, Germany, studied biochemistry and physics at the Ruhr-Universität Bochum, received a PhD in biochemistry from the University Witten/Herdecke, and joined the Fraunhofer Institute for Technological Trend Analysis in Euskirchen, Germany, as a senior scientist in 2007. Since 2016, she is deputy head of the group Tools and Methods within the department for Technology Analysis and Strategic Planning. Her current work comprises analyses and the support of capability-based R&D planning in security and defence, including methods for identifying relevant technology topics and prioritization, as well as method evaluation and knowledge management.

Anna Lindberg is a senior researcher at FOI, the Swedish Defence Research Agency. Focus of her current work is on forward looking activities serving strategic decision-making. Her previous work includes development and application of operations research approaches and methods to inform strategic to tactical military topics, as well as on societal contingency and risk issues. Anna holds a Master of Science in Engineering Biology.

EDT 3-3: High-uncertainty technologies

Author: Dr. David J Holland Smith, Prof. James C Wilson, Dr. Gillian T Strong

In 2012 the UK Government's Chief Scientific Adviser published a study of 'high-impact, low-probability risks', indicating how these expose vulnerabilities in today's inter-dependent and 'complex' societies, and how specific tools and techniques may be needed. To support the UK MOD's response, and focusing mainly on technological developments, Dstl studied how these conditions have arisen in past decades, and revealed how 'high-uncertainty' is often a defining characteristic. Such uncertainty may be caused for example by high levels of evidential ambiguity or the lack of a 'theory of operation' to explain surprising empirical findings. The bespoke framework for analysis which followed drew much from the judicial practice of building separate cases 'supporting' or 'countering' a proposition before finally 'weighing' one case against the other, but also seeks to draw attention to how much evidence is 'missing' from the calculations. Since 2018, the technique has been applied to a range of technological claims to assess their potential to create 'disruptive' surprise and as appropriate to propose mitigation measures.

Dr. David J Holland Smith has thirty years of experience in the application of signal, data and information processing to tasks including underwater acoustic tracking and classification, and the processing of written text for information discovery and science and technology intelligence. In recent years, David has worked to establish novel processes for horizon scanning to serve the UK Government's research and development community; adding new facets to strategic planning and reducing the scope for technical surprise. Hallmarks include working from first principles, careful integration of theory and practice and focus on exploitation.

Stream EDT #3 – Emerging Disruptive Technologies

Professor James C Wilson has thirty years of experience in materials and fabrication methods for energy and electronics, and is a visiting professor at the University of Kent. Beyond that specialism, in the last ten years James has also taken a broad approach looking at emerging, novel, and more radical science and technologies, including their assessment, supporting the horizon scanning efforts of Dstl and introducing new concepts into the research portfolio.

Dr. Gillian T Strong has twenty five years of experience in information science. She helped to set up the S&T horizon scanning capability in Dstl and for the past fifteen years has worked on the identification and exploitation of new and emerging science and technology, both from an opportunity and threat perspective, for a diverse range of customers across the defence research portfolio. She has also supported the development of new processes to support strategic planning.

SA 1: Emerging and Disruptive Technology (EDT) in NATO Capability Development

Authors: LtCol (Rtd) Bruce Pennell, Mr. Glenn Richards

The desire to leverage leading edge science and technologies in NATO Capability Development (CAPDEV) is almost as old as the Alliance itself. Gaining and maintaining a technological edge over adversaries, and thus "piercing the fog" of chaotic conflict, have long been seen as essential NATO efforts. Current Alliance focus on innovation and Emerging and Disruptive Technologies (EDT) are the most recent examples. At the same time, the NATO Defence Planning Process (NDPP) remains the Alliance's primary means to identify and prioritise NATO's medium-term capability needs and to promote the development and delivery of solutions to meet NATO's Level of Ambition (LoA). This paper therefore explores the tension between the medium-term focused, capability-based, threat-informed NDPP and efforts to promote innovation and EDT, and examines to what extent these areas are currently explored within NDPP. The paper concludes that while the current NDPP covers aspects of EDT, allowing Allies to propose EDT solutions to meet agreed requirements in novel ways, there are areas of potential enhancement, but these would not be without cost and risk, and there are certainly no guarantees of success..

Lt. Col. (Retd) Bruce Pennell (left of picture) has worked since 2009 as an operations analyst for the NATO Communications and Information Agency (NCIA). His work has included operations assessment for NATO missions and tasks, in addition to supporting a range of NATO Concept/Capability Development programmes. He has a particular interest in scenario-based analyses and interdisciplinary Operational Analysis (OA). Before joining NCIA, he enjoyed a 23-year career as an Army logistician and faculty member at the UK Joint Command and Staff College. He holds a BSc (Hons) in Mathematics, an MSc in Modeling and Simulation, and an MA in Defence Studies.

Mr. Glenn Richards is the Defence Planning Lead in the NATO Communications and Information Agency (NCI Agency) providing Operational Analysis (OA) support to ACT in the NATO Defence Planning Process (NDPP). He has worked in NATO since 2006 as a Principal Analyst and project manager, where he has provided a wide range of support including managing strategic assessment of the former NATO mission in Afghanistan, the International Security Assistance Force (ISAF), supporting in-theatre OA, manpower and costing studies, stockpile planning and many logistics-related studies. Glenn studied as a Physicist specialising in Applied Optics before joining the UK Defence Evaluation and Research Agency (DERA) in 1999, later being transferred to QinetiQ in 2001.

SA 2: Towards a dynamic theory of hybrid conflict: An exploration with system archetypes

Authors: Mr. Bas Keijser, Mr. Guido Veldhuis, Mr. Peter van Scheepstal

Hybrid conflict between state actors has been researched for several years. However, investigations of the dynamic interaction between actors involved in a hybrid conflict are mostly lacking. This work builds on literature in international relations and deterrence, conflict analysis, and system dynamics combined with existing analyses and case studies of hybrid conflict. We propose a set of system archetypes that characterise actor behaviour in hybrid conflict between states. Proposed archetypes of actor behaviour include: raising the threshold and boiling the frog, tit-for-tat escalation and horizontal escalation, deterrence mechanisms, competing narratives and competing spheres of influence. The archetypes are illustrated with vignettes on

China's Belt and Road Initiative, Russian interference in Ukrainian society and competing narratives of Iran and the U.S. in Iraq. The archetypes can be used to analyse hybrid conflict between state actors. Understanding the actions, interactions, perceptions, drivers, and decision making of state actors in hybrid conflict supports a better understanding of relevant dynamics. This should be part of a broader cross-governmental hybrid analysis strategy integrating collation across relevant domains of hybrid conflict with emerging data gathering technology. Such a strategy serves decision making focused on finding sustainable, beneficial outcomes when confronted with hybrid threats

Bas Keijser is a researcher and advisor in the Military Operations department within TNO Defence, Safety and Security since 2016. His work focusses on problem structuring and decision support for complex societal security issues. In his research and advisory projects, he applies and develops both quantitative and qualitative methods. He actively works on strengthening analysis capabilities in various types of security organisations. He has worked on hybrid warfare and many of its component fields including insurgencies and counterinsurgency, terrorist group behaviour, urban operations, organized crime, radicalisation and political violence.

Guido Veldhuis focusses on the development and application of methods and models to support decisionmakers, most notably the Dutch MoD and Ministry of Justice and Security. He develops (simulation) models and tools that support TNO's clients with understanding complex environments, the procurement of systems and the planning of operations. Together with a strong team at TNO, he facilitates workgroups in which methods such as System Dynamics, Agent Based Modelling and MARVEL are used to tackle problems together with groups of stakeholders. During the COVID crisis he was part of the Dutch national operational team.

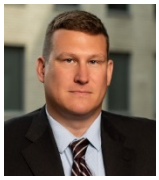
Peter van Scheepstal is a senior scientist at TNO Defence, Safety and Security. He has a background in econometrics and operations research. His main research topics address the development of methods and tools to support strategic defence analysis, long term defence planning and hybrid conflict analysis. As a member of the Dutch national security analyst network he contributes to the periodic national risk assessment and the development of supporting methodologies. During the COVID crisis he was part of the long term plans cell of the Dutch national operational team.

SA 3: Studies by the Center for Strategic and Budgetary Assessments (CSBA)

Authors: Dr. Chris Bassler, Mr. Peter Kouretsos, Mr. Harrison Schramm

A common trend has emerged in new 21st Century defense concepts, for both the United States and her allies and partners. This trend is focused on the dispersal of forces, to counter an adversary's ability to attack with masses of low-cost munitions and effects, while also retaining coordination and syncopation across these disaggregated forces, in order to achieve decisive effects in a operationally relevant timeline, while altering cost-imposition approaches to allied advantage. These defense operational concepts, such as: Multi-Domain Operations (MDO), Distributed Maritime Operations (DMO), and Mosaic Warfare, all rely on foundational assumptions of fighting at machine speed. These concepts highlight a key assumption- that further advances in warfare innovation and effectiveness are more likely to come through faster and better decision-making, when they are also augmented by bespoke, purpose-built artificial intelligence that is utilized in various command centers. While this has been typically viewed as

a technological problem, the human dimensions of this emerging trend are also of key importance, specifically training, teaming, interoperability, and also the policy implications of these approaches. This presentation will serve as an integrated retrospective of several key projects which have been executed over the past few years by the Center for Strategic and Budgetary Assessments (CSBA), in coordination with the U.S. Department of Defense and military Services. It will focus on highlighting the understanding of both the technical demands, as well as the policy implications, of these approaches. We expect that these insights will be of interest to members of the NATO Alliance, as they address common emerging challenges and implementation considerations for the Operations Research and Analysis community, both within individual NATO Nations, as well as across the Alliance, in order to obtain and maintain decisive advantages for future warfighting and deterrence.



Dr. Chris Bassler is Senior Fellow at the Center for Strategic and Budgetary Assessments (CSBA), where he researches technology & innovation, joint aerospace capabilities, maritime operating concepts, and overall U.S. & allied military strategies. He joined CSBA in 2020, after previously serving nearly two decades as a civilian in the U.S. Department of Defense in various assignments, in both leadership and technical roles. His last assignment was as the inaugural Chief Strategy Officer for the F-35 Lightning II Joint Program Office; and prior to that, various assignments at the Office of the Chief of Naval Operations in the Pentagon, the Office of Naval Research, and a U.S. Navy research lab. He has worked in various capacities to enhance capabilities and interoperability across all missions and warfighting domains, including with allies/partners on five different continents, and in NATO (both the Science & Technology Organisation and the Naval Armaments Group). He has received two Department of Navy Meritorious Civilian Service Awards- from the Secretary of the Navy and the Chief of Naval Research and holds has two U.S. Patents. Dr. Bassler has a Ph.D. in Aerospace Engineering from Virginia Tech; a M.A. in Security Policy Studies from the George Washington University Elliott School of International Affairs; and a Diploma in Strategy & Innovation from the University of Oxford, Saïd Business School.

Peter Kouretsos is an Analyst at the Center for Strategic and Budgetary Assessments (CSBA) where he focuses on U.S. defense policy and strategy, force development, and U.S. and foreign military capabilities. In addition, he assists in the design and analysis of CSBA's operational level wargaming and concept development efforts for the U.S. government and its allies. Prior to CSBA, Mr. Kouretsos served in the Office of the Undersecretary of Defense for Policy's Office of Strategy & Force Development and was the Research Assistant at the Philip Merrill Center for Strategic Studies. He is a member of the Military Operations Research Society (MORS), where he serves on the Emerging Techniques Committee; The Military Writers Guild; and has published in several notable forums. Mr. Kouretsos received a M.A. in International Relations & International Economics from the Johns Hopkins School of Advanced International Studies (SAIS) and a B.A. in History from Loyola University Maryland.

WCM 1: Studies by the Center for Strategic and Budgetary Assessments (CSBA)

Authors: Mr. Christoffer Limér, Mr. Erik Kalmér

AI for strategy games has undergone a dramatic development during the last couple of years. Today, artificial players defeat human players in challenging realistic war games such as StarCraft II and Dota, something that until very recently was widely regarded as distant science fiction. At FOI Swedish Defence Research Agency, we have applied Monte-Carlo Tree Search, a core component of AlphaZero, the celebrated recent AI from Google DeepMind, to a number of strategy games, most recently to the classical war game Risk. The long term aim of this line of work is to develop decision support for Course of Action (COA) Wargaming, providing COA Wargaming with the kind of computer intelligence that has long been available for Chess and other abstract strategy games; the immediate result is an AI that plays Risk with unprecedented skill.

Erik Kalmér is an engineering student about to start his master's in Systems, Control, and Robotics at the Royal Institute of Technology (KTH) in Stockholm. He has recently worked in collaboration with the Swedish Defence Research Agency to explore applications of articial intelligence in wargaming for his bachelor thesis.

Christoffer Limér is born in Stockholm, Sweden. Started studying engineering at KTH 2017 and finished his bachelor in spring 2020. His bachelor's thesis was a collaboration with the Swedish Defense Research Agency to investigate the application of AI on wargaming. He now studies his master's in Applied and Computational Mathematics at KTH in Sweden.

WCM 2: OA Support and Wargaming at the Operational Level: Applied tools, best practices, and lessons learned)

Authors: Dr. Pascal C. van Overloop, Mr. Stephan Leitner

The authors describe their experience in operational analysis support and wargames conducted as part of the Operational Planning Process according to NATO's Comprehensive Operational Planning Directive (COPD) at various command and staff colleges. This encompasses not only the application of simulation systems (e.g. in order to make the transport feasibility estimate for a required deployment or combat simulations) but also approaches to make use of various data. Such data can be provided by cooperative planning tools or other sources of documentation, for example system analysis, troops-to-actions assignment, and other intermediate results by the Joint Operational Planning Group (JOPG) during their planning. The paper shows how some of the simulation systems with significantly different design principles, data, and levels of detail have been developed and improved over time. The authors assume three main reasons for that: the need to adapt to actual requests for information from the planning staff, the need to make best use of the available data and documentation for Operational Level Planning, and the need to harmonize the processes and information-flows within the involved planning cells. Therefore, the authors present an overview of processes, procedures, and tools, besides practical examples and best practices that help the JOPG to prepare and execute best possible wargames. This makes an important contribution to the objective of testing, refining, and comparing their courses

of actions as well as to identifying and mitigating planning flaws in major operations within a very limited timeframe

Dr van Overloop works since 2012 at IABG's Defence & Security Division where he is concerned with operator models, training & exercises, analytical support as well as strategic and technological consultancy. He served as officer in the German army for fifteen years until 2011, including deployment abroad, his studies of Economics and Business Administration and three years as Research Associate and Lecturer at the University of the Bundeswehr in Munich. He has been for the coordination of the training in operations research, modelling & simulation in the Bundeswehr.

Stephan Leitner is a system analyst and research fellow at ITIS/Bundeswehr University Munich. He worked before as senior analyst at NC3A's Operations Research Division and served as officer in the German Navy including deployments abroad. He holds a master in computer sciences of the Bundeswehr University Munich.

WCM 3: Experimental Wargaming and Emerging Military Capabilities in the NATO Context

Authors: Mr. Andrew Reddie, Dr. Kiran Lakkaraju

The development and deployment of emerging military capabilities raises new questions concerning whether and how these capabilities alter the likelihood of conflict escalation and decrease strategic stability. These questions, like many others pertaining to military capabilities, lack the necessary observational data with which to test them. Wargames are a common tool for investigating the impact of emerging and disruptive technology and have a long history of informing military and strategic study. Historically, wargames have been built for scenario exploration rather than for developing data-driven analytical conclusions, and it has been difficult to rigorously collect wargame data. Experimental wargaming, a wargaming approach that employs the principles of experimental design to facilitate an objective basis for exploring fundamental research questions around human behavior (such as understanding conflict escalation), represents a potential tool that can be used in combination with existing wargaming approaches. Experimental wargames systematically vary game elements and track player actions which allows for quantitative analysis of player behavior, demographic characteristics and game outcomes. In this talk, we describe the strengths of the experimental wargaming approach to investigate nascent and emerging military capabilities and outline the types of insight this method provides through discussion of the SIGNAL experimental wargame. We are currently deploying this methodological approach to explore a series of scenarios involving military alliances—exploring patterns of cooperation and coordination inside a wargaming environment.

Dr. Kiran Lakkaraju is a Senior Member of the Technical Staff at Sandia National Laboratories, California in the Systems Research & Analysis III group. Kiran's research has been marked by extensive interdisciplinary efforts that bring together the social and computational sciences. Currently, he is investigating how wargaming techniques can be used to systematically and quantitatively study national security relevant topics, such as cyber deterrence, conflict escalation, and consensus building. Kiran has a background in artificial intelligence, multi-agent systems and computational social science. He holds a M.S. and Ph.D. in Computer Science from the University of Illinois at Urbana-Champaign.

Andrew Reddie is a senior systems engineer at Sandia National Laboratories and a postdoctoral fellow at the University of California, Berkeley where he previously served as deputy director for the Nuclear Policy Working Group and as a researcher for the Department of Nuclear Engineering, Goldman School of Public Policy, Center for Long-Term Cybersecurity, Berkeley Asia-Pacific Study Center, and Carnegie-sponsored Project on Nuclear Gaming. He is also serves as a Bridging the Gap New Era Fellow, DoE Nuclear Science and Security Consortium Fellow, and Krulak Center Non-Resident Fellow at the Marine Corps University.