Conference Booklet
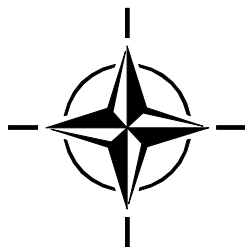
13th ANNUAL OPERATIONS RESEARCH & ANALYSIS CONFERENCE

NATO OR&A Conference
7 - 9 October 2019
Ottawa, Canada

Dear participants,

I am pleased to welcome you to Ottawa for the 13th Annual Operations Research and Analysis (OR&A) Conference. This is the first time that the conference is being held in Canada, and we are honored to welcome you to our nation's capital.

As the Assistant Deputy Minister of Science and Technology with the Department of National Defence, I am pleased that Defence Research and Development Canada, the organization that I represent, has the opportunity to welcome representatives of over 20 countries and six NATO agencies to this scientific conference, which is being attended by over 100 participants from NATO organizations, governments, industry and academia.

The theme of this year's conference, "Challenges for NATO OR&A in a Changing Global Security Environment", reflects the obstacles that the OR&A community must overcome in order to adapt. I know that you are all here in the hopes of providing some clarity and gaining a better understanding of the future operational environment at the strategic, operational and tactical levels. The outcomes of this conference will help determine the direction of our defense institutions and will pave the way towards an innovative and forward-looking defense science and technology ecosystem.

This conference offers a unique opportunity for you to take a look at the work of other high-performing professionals. I hope that you, the participants, will be inspired by the innovations you see and that you will be able to develop new opportunities for cooperation. The conference gives you the chance to learn about what we are doing here in Canada as well.

Last but not least, I hope that you will have the time to discover our beautiful capital and enjoy Canada's rich cultural diversity.

Isabelle Desmartis Ph.D
Assistant Deputy Minister (Science & Technology)/
Chief Executive Officer of Defence Research and Development Canada
Department of National Defence

Canada

Chers participants,

J'ai l'honneur de vous accueillir à Ottawa pour la 13e conférence annuelle de recherche et analyse opérationnelles. C'est la première fois que la conférence a lieu au Canada, et nous sommes honorés de vous souhaiter la bienvenue dans notre capitale nationale.

En tant que Sous-ministre adjointe, Science et technologie, pour le ministère de la Défense nationale, je suis heureuse de voir que l'organisation que je représente, Recherche et développement pour la défense Canada (RDDC), accueille les représentants de plus de 20 pays et 6 agences de l'OTAN. Cette conférence scientifique compte plus de 100 participants des cent représentants des gouvernements et organisations de l'OTAN, de l'industrie et des milieux académiques.

Le thème de cette année « La recherche et l'analyse opérationnelles de l'OTAN face aux défis de l'environnement mondial de sécurité » reflète les difficultés que la communauté doit surmonter pour s'adapter. Je sais que vous êtes tous réunis ici avec l'espoir d'apporter de la clarté et de mieux comprendre le futur environnement opérationnel au niveau stratégique, opérationnel et tactique. Les résultats de cette conférence informeront l'évolution de nos institutions de défense et paveront le chemin vers un écosystème innovateur en science et technologie de la défense.

La conférence vous offre une occasion inespérée de voir le travail des professionnels de haut niveau. J'espère que les participants ici présents seront inspirés de voir les innovations et développeront de nouvelles possibilités de collaboration. La conférence vous offre aussi une occasion d'apprendre ce que nous faisons ici au Canada.

De plus, je souhaite que vous trouviez le temps de découvrir notre belle capitale et d'apprécier la riche diversité culturelle du Canada.

Isabelle Desmartis (Ph.D.)
Sous-ministre adjointe (Science et technologie)/
Chef de la direction de Recherche et développement pour la défense Canada
Ministrère de la Défense nationale

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Conference Programme

Sunday		Location
1900-2100	Pre-Registration	Hotel Holiday Inn Downtown
Monday	**Day 1**	**Location**
0730-0830	Registration	Auditorium Foyer
0830-0850	Welcome: • Mr Han DE NIJS, Conference Co-Chair, NATO Allied Command Transformation • Dr Ana BARROS, Conference Co-Chair, TNO • BGEN Poul PRIMDAHL, Assistant Chief of Staff Requirements Division, NATO Allied Command Transformation • Dr Bryan WELLS, Chief Scientist, NATO Science and Technology Organization • Dr Pavel ZUNA, Director, Collaboration Support Office, NATO Science and Technology Organization	Auditorium
0850-0900	Admin	Auditorium
0900-1000	**Keynote 1: Rear-Admiral Jeffery ZWICK - Chief of Force Development for the Canadian Armed Forces**	Auditorium
1000-1015	ESRI Training Introduction – Mr Pierre BILODEAU	Auditorium
1015-1030	Break (refreshments)	Auditorium Foyer
1030-1200	Stream – **Data Driven Analysis #1** – Lead Mr Matthew MACLEOD (DRDC) 1) Mr Yvan GAUTHIER - Advancing Defence Analytics in Canada: Lessons from the Trenches 2) Mr Filipe VIEIRA, Ms Mihaela RACOTIVA, Ms Jackie EATON - Delving into the data: exploring the Lessons Learned potential of large data pools 3) Dr Philip ELES - Keeping NATO grounded on its path towards embracing data science and related technologies	Auditorium

Conference Programme

	Stream – **Strategic Decision Making #1** - Lead Ms Sylvie MARTEL (NCIA) 1) Dr Steve GUILLOUZIC - The network of dependencies 2) Dr John STEELE - Defence Investment Prioritization 3) Ms Louise HOEHL, Mr Glenn RICHARDS, CDR Mark BUCHAN-STEELE - NATO Defence Planning Process Incorporating the New and the Emerging	Leslie McFarlane room
	Stream – **Methodology #1** – Lead by Dr Ana BARROS (TNO) 1) Prof Dr Armin FUEGENSCHUH, et al - Mission and Trajectory Planning for Unmanned Aerial Vehicles with Mathematical Optimization and Wargaming 2) Dr Nicola FARINA - Multi Agent Path Planning Strategies based on Artificial Intelligence algorithms for Surveillance Missions 3) Mr. Alex BOURQUE, Mr Christopher STRODE - Rough order magnitude costing of maritime unmanned systems	Sheila Watson room
1200-1300	Break (lunch)	Lunch area
1300-1430	Stream – **Wargaming #1** – Lead Mr Han DE NIJS (HQ SACT) 1) Ms Sue COLLINS – NATO STO Research Task Group SAS-139 - State of the Art of Analytical Wargaming 2) Mr Matthew STEVENS - What Simulation-Based Trainings Teach Us About Security, Humanitarianism, and Understanding in Urban Refugee Response 3) Ms Dani FENNING - Analytical Wargaming in Support of NATO's Military Deterrence Response Options	Auditorium
	ESRI Training - ArcGIS solutions for a Changing Global Security Environment – Lead Mr. Pierre BILODEAU	Leslie McFarlane room
1430-1500	Break (refreshments)	Auditorium Foyer

1500-1630	Stream – **Data Driven Analysis #2** – Lead Mr Matthew MACLEOD (DRDC) 1) Col Andrzej LIS, Col Jaroslaw MOKRZYCKI - Bibliometric methods to support strategic analysis of the security environment 2) Mr Ryan VAN WIE, Mr Jacob WALDEN - How varying unit dismounted troop ratios and troop density levels impact district violence 3) Mr Gary HORNE, Mr Wayne STILWELL - Simulation Support for Hybrid Warfare Wargaming and Coalition Decision Makers A Data Farming Approach	Auditorium
	Stream - **Operations #1** – Lead Mr Andy BELL (MARCOM) 1) Ms Shannon COOPER, Mr Valentin POPONETE - Strategic Risk Assessment in NATO Operations 2) Mr Bruce PENNELL, Mr Valentin POPONETE - Crashing through the Stop Lights? Operations Assessment in a Changing Global Security Environment 3) Dr Yazan QASRAWI - Quantifying the extent of permissible dispersion of a Mechanized Brigade Group	Leslie McFarlane room
	Stream – **Methodology #2**– Lead Prof Dick DECKRO (USAF) 1) Dr David MANDEL - Assessing and Communicating Uncertainty Effectively in a Rapidly Changing World 2) LtCol Andrew LEGGE, Dr Maxwell DONDO, Dr Abderrahmane SOKRI - The Cyber Common Operating Picture. An approach to understand the battlespace and inform decision making 3) Dr. Zhigang WANG - The first NATO guidelines for conducting surveys in the military context	Sheila Watson room
1630-1730	**Keynote 2: Ms. Christine FOX - Assistant Director, Policy and Analysis at Johns Hopkins University Applied Physics Laboratory**	Auditorium
1830-2000	Icebreaker	TBD

Conference Programme

Tuesday	Day 2	Location
0830-0900	Admin & Recap • Ms Isabelle DESMARTIS, Assistant Deputy Minister of Science and Technology (S&T)	Auditorium
0900-1000	**Keynote 3: Dr. Peter SINGER - Strategist and Senior Fellow at the New America Foundation**	Auditorium
1000-1030	Break (refreshments)	Auditorium Foyer
1030-1200	Stream – **Wargaming #2** – Lead Dr Janis BERZINS (Defence Academy LVA) 1) Mr Rudy BOONEKAMP, Mr. Vladimir HAZELEGER, Dr Lucia TEALDI, Dr Helma VAN DEN BERG, Dr. Bob VAN DER VECHT (TNO) - Eliciting opponent behaviour in a crowdsourced game 2) Mr Håvard FRIDHEIM, Mr. Stein MALERUD - Wargaming reachback support to military headquarters planning processes	Auditorium
	Stream – **Strategic Decision Making #2** – Lead Mr. Sean BOURDON (DRDC) 1) Ir Clara PETERS, Ms Christina GRÖNWALL (FOI), Mr Adelbert BRONKHORST (TNO), Gitanjali ADLAKHA-HUTCHEON (DRDC) - From Foresight to Impact for Technologies at Low Technology Readiness Levels 2) Mr Mike LARNER - Wargaming for Strategic Decision Makers in the United Kingdom 3) Mr Alf Christian HENNUM, Ms. Mona SAGSVEEN GUTTELVIK – Quantifying the utility of war to explore a small state deterrence capability	Leslie McFarlane room
	Stream – **Methodology #3** – Lead Prof. Dick DECKRO (USAF) 1) Dr Peter DOBIAS, Dr Kendall WHEATON - Use of graph theory to quantify political preference values 1) Dr Altan OZKIL, Dr Andrew STARKEY, Mr. Levent Berke ÇAPLI - Artificial Intelligent Based Best Course of Action Tool for Multi-Domain Operations	Sheila Watson room
1200-1300	Break (lunch)	Lunch area

Conference Programme

1300-1430	Stream – **Wargaming #3** – Lead Ms Katie MAULDIN (JALLC) 1) Dr Pilar CAAMAÑO SOBRINO, Dr Alberto TREMORI, Mrs. Lucia GAZZANEO, Mr. Wayne BUCK - Best practices on the combination of qualitative and quantitative modelling 2) Dr Abderrahmane SOKRI - An analytical wargaming approach to cyber deterrence 3) Mr Wouter NOORDKAMP, Mr Koen VAN DER ZWET – OR game theory analysis potential for military application	Auditorium
	Stream – **Operations #2** – Lead LTC Vaughn DELONG (HQ SACT) 1) LTC Sten ALLIK - Analysing Unmanned Combat Systems with Autonomous Functions (UCSAF) operational impact. Challenges and preliminary outcomes 2) Dr Kerry MALONE, Mr Kees DEN HOLLANDER, Ms Lotte KONINGS, Dr Bob VAN DER VECHT, Mr Tom MEURS - Sensing in a Networked Environment Lessons learned from Automation and Autonomy 3) Mr Gregory HUNTER, Mr J. CHAN, Mr Mark REMPEL - Assessing the impact of infrastructure on Arctic operations	Leslie McFarlane room
	Introduction to Elicit – Lead Dr Dave ALBERTS	Sheila Watson room
1430-1500	Break (refreshments)	Auditorium Foyer
1500-1530	**Keynote 4: Dr Stephen DOWNES-MARTIN - Research Fellow at the US Naval War College**	Auditorium
1530-1600	Awards	1530-1600
1600-1610	ESRI Training Summary – Mr Pierre BILODEAU, Mr Bryan LADDS	1600-1610
1610-1630	Conference Closure	1610-1630
1645-1715	SAS-129 Cyber Game Preparation	1645-1715

Conference Programme

Wednesday	Day 3	Location
0830-1600	A Multi-Domain Wargame - participate in a hybrid between conventional wargame, matrix gaming (argument games), and serious games Lead Dr Altan OZKIL, Mr Berke CAPLI	Leslie McFarlane room
	Wargaming Best Practices course - examine the use of wargames and other serious game techniques for operations analysis and capacity-building Lead Prof Rex BRYNEN	Sheila Watson room
	0930-1000 Break (refreshments) 1130-1230 Break (lunch) 1400-1430 Break (refreshments)	

Distinguished Guests

Ms. Isabelle DESMARTIS, Assistant Deputy Minister of Science and Technology (S&T)

As Assistant Deputy Minister of Science and Technology (S&T), Ms Desmartis oversees the investment in S&T for the Department of National Defence (DND) and the Canadian Armed Forces (CAF). Bringing leadership to national issues of defence and security, Ms. Desmartis is also the Chief Executive Officer of Defence Research and Development Canada (DRDC), a national network of science and technology research centres with 1300 employees supporting the defence and security communities.

Integral to her organization's role is the provision of scientific advice and solutions to the defence team as well as public safety and security practitioners. The defence and security S&T network extends to partnerships with the Canadian public and private sectors, academia, non-governmental organizations, and allied defence and security S&T organizations. Previously serving as the Director General of Policy Planning at DND, Ms. Desmartis led the development of Canada's defence policy Strong, Secure, Engaged, and contributed strategic policy advice to senior DND/CAF leadership on current and emerging global trends in the defence and security domains. Key policy files included strategic defence, the Arctic, cyber and space security, regional and functional strategic analysis on global trends, as well as arms control and non-proliferation.

Particularly in the areas of international and national security, Ms. Desmartis has extensive experience in intelligence and policy issues. From 2011 to March 2015, she served as the Assistant Chief of Defence Intelligence supporting the Chief of Defence Intelligence for DND and the CAF in all leadership functions. As Director of Strategic Analysis at National Defence from 1998 to 2005, she worked in various policy functions including weapons of mass destruction and arms control. From 2006 to 2011, Ms. Desmartis occupied various positions in the areas of national and transportation security, including Director of Intelligence and Senior Director of Aviation Security Policy at Transport Canada. Ms. Desmartis trained as a lawyer and is a graduate of Laval University, where she earned a PhD in international security.

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BGEN Poul PRIMDAHL, Assistant Chief of Staff Requirements Division, NATO Allied Command Transformation

Poul Primdahl joined the Danish Army in 1987 in the Queen's Life Regiment (mechanized infantry). From 1988 to 1990 he served as Military Police before he in 1991 joined the Officer's Academy in Copenhagen. He was commissioned as 1st Lt. in 1994. Upon officer's advanced training from 1998 to 2000 he was promoted to Captain. From 2003 to 2005 he joined the Army- and General Staff course upon which he was promoted to Major. In 2007 he was promoted to Lt. Colonel and in 2015 to Colonel. Upon assuming the position as ACOS Requirements Division in ACT in Sep. 2018, he is promoted to BGen. Whilst serving with the Military Police, Primdahl was stationed in Namibia with the UN/UNTAG mission well over a year from 1989-90. From 1994 to 2003, he held various positions with the Jutland Combat Service Support Regiment; from Platoon leader, Company 2IC, Battalion S3 to Company Commander and teacher at the Army Logistics School. He was twice deployed to Bosnia on six months Op tours; in 1995 as Platoon leader in Sarajevo under UNPROFOR and in 2001 as Company Commander in Doboj under SFOR/NATO. From 2005-07 he served as SO in the Doctrine Branch of the Army operational Command. From 2007 to 2011 Primdahl was stationed in Belgium at SHAPE as Head Planner in J5 within the ISAF team. In 2011 he was

appointed CO and took command over 2nd Combat Service Support Battalion. In 2012 Primdahl assumed the post as Head of Logistics at Army Operational Command, Denmark, with a main task to plan and execute the redeployment of Danish forces from Helmand. Also, he was in charge of developing new joint organizations in regards to Strategic Movement and Transportation, Tactical Maintenance Capability and Military Police by merger of the three Services' capacities. In 2014 he was deployed to Afghanistan as Director HQ Transition Team under NTM-A/ISAF and upon return he took up the position as J4 in the Danish Defence Command. From 2015 to 2018, Primdahl has served with the Danish Military Representative to NATO as military adviser and team leader, responsible for policy and plans including the NATO modernization agenda such as NCS adaptation and a refocus on collective defence initiatives.

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Dr. Bryan WELLS, Chief Scientist, NATO Science and Technology Organization

As of 1 July 2019, the North Atlantic Council (NAC) appointed Chief Scientist is Dr Bryan Wells (UK). In this role, he has three major responsibilities. First, he serves as Chair of the NATO Science and Technology Board (STB). In this context, he serves as the STB's representative to the Secretary General and the NAC and is responsible to the STB for the effective coordination of NATO's Science and Technology (S&T) program. Second, he serves as the senior scientific advisor to NATO leadership, ensuring that appropriate and timely S&T based advice is provided to NATO senior decision makers. Finally, he leads the Office of the Chief Scientist at NATO Headquarters.

Prior to his appointment as Chief Scientist, Dr. Wells was the UK Ministry of Defence's Head, of S&T Policy, Strategic Research and International Engagement. His responsibilities included the provision of strategic policy advice on the international and research aspects of the Ministry's science and technology programme. Additionally, he has recently completed a three-year term (2016-2018) as Chair of the European Defence Agency's Research & Technology Steering Board.

Dr Wells joined the UK Ministry of Defence in 1988. He served as Assistant Private Secretary to the Secretary of State for Defence 1989-1992, and has held a range of other posts, including Deputy Director of NATO Policy 1997-1999, and Director of Counter-Proliferation and Arms Control 2002-2008. During 1999-2002 he was on secondment to the Lord Chancellor's Department (now the Department of Justice) as Head of Administrative Justice. Dr Wells was educated at St Catherine's College, Oxford (1978-85) and Merton College Oxford (1985-1988). He graduated BA(Hons) in Chemistry in 1982 and was awarded a DPhil in 1985. He conducted three years post-Doctorate research at Oxford University as a Junior Research Fellow at Merton College.

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Distinguished Guests

Dr. Pavel ZUNA, Director, Collaboration Support Office, NATO Science and Technology Organization

Dr Pavel Zůna serves as the Director, NATO STO Collaboration Support Office (CSO). Dr. Zůna is a retired Colonel with a 30-year active military service career. He served in different staff and commanding positions in the Czech Republic Ground Forces up to the regiment level and was involved in military intelligence for 20 years.

He retired as Deputy Director of the Military Counter-Intelligence and Military Intelligence Service in 2005. During his military career, he served as the Head of the Military Diplomacy Branch and Assistant Defence Attaché to Belgium, as well as Defence Attaché to the United Kingdom. He also represented the Czech Republic at the NATO Intelligence Board, NATO Special Committee, EU Military Staff Intelligence Board, National Committee for the Coordination of the Foreign Security Policy and Allied Joint Operation Doctrine.

Dr. Zůna earned a Master's degree in Chemistry, specializing in CBRN, from the Ground Forces University of Vyškov in 1984, a post-graduate degree in Information Management and Intelligence from the Military Academy of Brno in 1990, a Master's degree in Strategic Studies from the US Army War College in 2006, and a Doctorate degree in Economics and Management from the Defence University of Brno in 2012.

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Keynote Speakers

Keynote 1 - RADM Jeffery ZWICK, Commander Canadian Fleet Pacific (CAN)

We are in a time of change when traditional models of technology development in defence and security have been overturned. In the past the most important military technologies were developed with government funding for military use. Now we find technologies like Artificial Intelligence emerging from the commercial sector, and we as a community need to work hard to adapt to and adopt these emerging technologies. This is just one aspect of a growing challenge to the International Rules-Based Order that means the collective NATO alliance needs to act now to ensure its future security. Canada's response is the Strong, Secure, Engaged (SSE) defence policy which sees not only recapitalization of major warfighting assets, but major investments in our human capital, including human-machine teaming and human performance enhancement.

Operations Research and Analysis (OR&A) is key to the successful design and development of future capabilities, but the OR&A community must itself adapt to the changing environment and develop novel approaches to inform new strategic decision making. OR&A must also achieve a convergence with data analytics in order to collect, maintain and exploit hitherto unavailable high-fidelity data sets and progress further into predictive analytics. Conferences such as this are key opportunities for the OR&A community to accelerate these developments.

Originally hailing from Vancouver, British Columbia, Rear-Admiral Jeffery Zwick joined the Canadian Forces in 1989 as a Direct Entry Officer, having previously received his Bachelor of Arts Degree in History from the University of British Columbia. As a junior officer from 1993 to 1999 he progressed through initial naval officer training and subsequent naval warfare positions through to Combat Officer in HMCS ALGONQUIN. Promoted to Lieutenant Commander in 1999, he held the duties of the Staff Above Water Warfare Officer for the Commander of the Standing Naval Force Atlantic (STANAVFORLANT) in 2001 and the J5 Maritime Plans in the Canadian Forces Joint Operations Group (CFJOG) in Kingston, Ontario in 2003. He was appointed Executive Officer of HMCS TORONTO in 2004 during OPERATION ALTAIR with his ship's integration into the USS GEORGE WASHINGTON Carrier Battle Group.

In 2005, he was promoted to Commander and joined the naval staff in NDHQ as the Senior Staff Officer for Fleet Management, Policy and Readiness. Completing his staff tour at NDHQ, he was appointed Commanding Officer of HMCS MONTREAL in June 2007.Promoted to Captain(N) in 2010, Rear-Admiral Zwick served as the Director of Strategic Coordination in Ottawa. Following that appointment, he served as the Director of Defence Force Planning and Defence Program Advisor to the Vice Chief of Defence Staff. In 2015, he was promoted to Commodore and appointed Commander Canadian Fleet Pacific and Commander of the Naval Training System. Rear-Admiral Zwick was promoted to his current rank in 2018, and assumed the role of Chief of Force Development in Ottawa.

Rear-Admiral Zwick holds a Master's Degree in Defense Studies and is a graduate of the National Security Programme at CFC Toronto. He was appointed an Officer of the Order of Military Merit in 2015. He and his charming wife Marta are currently residing in Ottawa, Ontario.

Keynote Speakers

Keynote 2 - Dr. Christina FOX, Assistant Director for Policy and Analysis of the Johns Hopkins University Applied Physics Laboratory (USA)

Determining Options in Challenging Times—A Call for Analysis

As leaders grapple with the complex challenges of today's global security environment, they need help understanding their options. This is a call for analysis. In this talk, Ms. Fox will discuss her experiences using analysis to support senior decision-makers as they have grappled with challenging decisions. She will describe the key elements of operations research and analysis necessary to help a decision-maker understand their "decision space" and, through examples, show how relevant and important analysis is to national security leaders, especially today

The Honorable Christine H. Fox became the Assistant Director for Policy and Analysis of the Johns Hopkins University Applied Physics Laboratory on May 12, 2014. As the nation's largest University Affiliated Research Center, APL performs research and development on behalf of the Department of Defense, the intelligence community, the National Aeronautics and Space Administration, and other federal agencies. The Laboratory has more than 6,000 staff members who are making critical contributions to a wide variety of nationally and globally significant technical and scientific challenges. Previously, she served as Acting Deputy Secretary of Defense between December 2013 and May 2014. With her appointment, Ms. Fox became the highest-ranking female official in history to serve in the Department of Defense.

From 2009 to 2013, Ms. Fox served as the Director, Cost Assessment and Program Evaluation in the Office of the Secretary of Defense. In that position, she was the principal civilian advisor to the Secretary of Defense for analyzing and evaluating plans, programs, and budgets in relation to U.S. defense objectives and resource constraints.

Prior to her government service, Ms. Fox served as the President of the Center for Naval Analyses (CNA), a Federally Funded Research and Development Center and as the scientific analyst to the Chief of Naval Operations. During her 28-year career at CNA, Ms. Fox oversaw analysis of real-world operations, from the first Gulf War and the operations in Bosnia and Kosovo in the 1990s, to the operations in Afghanistan immediately following the September 11th attacks, and the operation in Iraq in early 2003. From 2003-2005, Ms. Fox served as a member of NASA's Return to Flight Task Group, chartered by the NASA Administrator to certify the recommendations made by the Columbia Accident Investigation Board.

In 2016, Ms. Fox was appointed by President Obama to the Board of Visitors of the United States Naval Academy in Annapolis, Maryland. Ms. Fox also serves on the Board of Trustees for the Woods Hole Oceanographic Institution, and is a life member of the Council on Foreign Relations.
Ms. Fox earned a Bachelor of Science degree in mathematics and a Master of Science degree in applied mathematics from George Mason University. She is a three-time recipient of the Department of Defense Distinguished Service Medal. She has also been awarded the Department of the Army's Decoration for Distinguished Civilian Service.

Keynote Speakers

Keynote 3 – Dr. Peter SINGER, Strategist and Senior Fellow at the New America Foundation (USA)

NextTech: The Future of Technology, Security, and Threats Robots, Artificial Intelligence, Cyberwar, 3D printing, bio-enhancements, and a new geopolitical competition; the 21st century is being shaped by a range of exciting, and scary, new trends and technologies. A best selling author described by the Wall Street Journal as "one of Washington's pre-eminent futurists," and a consultant for groups that range from the CIA and the Chairman of the Joint Chiefs to Hollywood and the Call of Duty video game series, Singer will explore the key trends emerging today that will shape the world of technology and the battlefield tomorrow.

Peter Warren Singer is Strategist and Senior Fellow at the New America Foundation, the author of multiple award-winning books, and a contributing editor at Popular Science. He has been named by the Smithsonian as one of the nation's 100 leading innovators, by Defense News as one of the 100 most influential people in defense issues, by Foreign Policy to their Top 100 Global Thinkers List, as an official "Mad Scientist" for the U.S. Army's Training and Doctrine Command, and by Onalytica social media data analysis as one of the ten most influential voices in the world on cybersecurity and 25th most influential in the field of robotics.

Described in the Wall Street Journal as "the premier futurist in the national security environment," Dr. Singer is considered one of the world's leading experts on changes in 21st century warfare, with more books on the military professional reading lists than any other author, living or dead. He has consulted for the US Military, Defense Intelligence Agency, and FBI, as well as advised a range of entertainment programs, including for Warner Brothers, Dreamworks, Universal, HBO, Discovery, History Channel, and the video game series Call of Duty, the best-selling entertainment project in history. He served as coordinator of the Obama-08 campaign's defense policy task force and was named by the President to the US Military's Transformation Advisory Group. He has provided commentary on security issues for nearly every major TV and radio outlet, including ABC, Al Jazeera, BBC, CBS, CNN, FOX, NPR, and the NBC Today Show. In addition to his work on conflict issues, Singer served as a member of the State Department's Advisory Committee on International Communications and Information Policy and as an advisor to IDS. In the entertainment sector, he has received awards/support from the Tribeca Film Institute, Sloan Filmmakers Fund, Film Independent, and FAST Track at the L.A. Film Festival.
Dr. Singer is author of the books: Corporate Warriors: The Rise of the Privatized Military Industry, Children at War, Wired for War, Cybersecurity and Cyberwar, and Ghost Fleet: A Novel of the Next World War.

Prior to his current position, Dr. Singer was the founding Director of the Center for 21st Century Security and Intelligence at the Brookings Institution. He was the youngest scholar named Senior Fellow in Brookings' 101-year history. Prior to that, he was the founding Director of the Project on US Policy. Towards the Islamic World, where he was the organizer of the US-Islamic World Forum, a global leaders conference. He has also worked for the Office of the Secretary of Defense, and the Belfer Center for Science and International Affairs at Harvard. Singer received his Ph.D. in Government from Harvard and a BA from the Wilson School of Public and International Affairs at Princeton.

Keynote Speakers

Keynote 4 - Dr. Stephen DOWNES-MARTIN, Research Fellow at the US Naval War College (USA)

How to exploit small group dynamics during analysis to support the decision you?

The analyst's primary task is to provide the sponsor with useful and actionable information that supports the sponsor's decision-making. A fundamental challenge to good analysis is inappropriate interference by senior executives in the design of two classes of group discussion processes popular within the military. First are those used to elicit data for the analyst and second are those used to communicate the relevance of the analysis conclusions to the sponsor. There are a number of well-researched but mostly ignored pitfalls that warp decisions following small group discussions. These pitfalls can be skillfully or inadvertently exploited to warp the analysis to support a preferred decision established prior to analysis. The analyst and sponsor are jointly responsible for designing the group processes to ensure this does not happen, and to push back against inappropriate, albeit well meaning, interference in the group process design by senior leaders in the analyst's and sponsor's organizations. This presentation describes how the small group dynamics can be used to threaten the integrity of the analysis via intellectual fraud, drills down to root causes and discusses possible exploitations (that build on each other) and mitigations. Finally, it makes recommendations for the professional analyst and the sponsor to assure the integrity of the analysis.

Dr Stephen Downes-Martin is a Research Fellow at the US Naval War College and is an independent scholar and consultant addressing problems at the strategic, operational and tactical levels of warfare and business. He consults with and for a wide variety of government, military, aerospace, and commercial organizations in the US and internationally..

Recent consulting activities for a range of DoD, Industry and Academic clients in the US and UK include wargaming strategic deterrence, wargaming effects of Ballistic Missile Defense in Europe on strategic stability, Futures Studies, teaching wargaming and game theory, running industry working groups on wargaming, teaching Assessments methods, planning and running wargaming conferences in the US and UK, researching force correlation algorithms. A long-term research project known as Puppet Mastery investigates how to manipulate decision support methods to deceive decision makers, how decision makers misuse such methods to deceive themselves, how to detect such attempts and protect decision makers from them.

Dr. Downes-Martin deployed to Helmand Province Afghanistan spring 2010 in response to a by-name request to support Regional Command (South West) / I Marine Expeditionary Force (Forward) as the Commanding General's Assessments Advisor, for which he was awarded the Superior Civilian Service Medal. He deployed to ISAF HQ in Kabul spring 2012 in response to a by-name request to advise General John Allen's Afghan Assessments Group. In 2015 he was awarded a second Superior Civilian Service Medal for achievements that included being "routinely sought by name as the most credible authority to assess and offer solutions to challenging issues, and always delivering brilliant results ... in complex warfare environments".

He regularly participates in and contributes to the Annual Connections US, Connections UK and Connections North Wargaming Conferences. He has briefed senior executives, Flag/General Officers, Officers, NCOs and Enlisted from organizations that include: I MEF HQ, II MEF HQ, AFRL/XPPW, ALSA, Australian Defense College, Canadian Forces College, CENTCOM Maritime Staff, International Security Assistance Force (ISAF) Afghanistan, ISAF Joint Command (IJC), Indian Navy, JFCOM, USAF JIOWC, USMC MAGTF STP, NWDC, Numbered Fleet Staffs, OPNAV, Singapore Government, SOCOM, STRATCOM, UK MoD (DSTL).

Programme Committee Chairpersons

Mr. Han DE NIJS, Conference Co-Chair, HQ Allied Command Transformation (NATO)

Mr Han de Nijs is Branch Head Analysis of Alternatives at HQ Supreme Allied Command Transformation (SACT) in Norfolk, Virginia, USA. Mr. de Nijs received a master's degree in Mathematics from the University of Leiden and a bachelor's degree in Political Science from the University of Amsterdam. Mr. de Nijs has been a NATO employee since 1982 with assignments at SHAPE Technical Center, NATO HQ, SACLANT and at ACT since its inception in 2003. Under his responsibility, analysis was conducted for the Multinational Experiments series, for SHAPE's Comprehensive Operations Planning, for Concepts and Experiments on Maritime Situational Awareness, Operations Assessment, Alternative Analysis, Hybrid Threats, Civil Military Interaction, Logistics Chain Management, Space Deterrence , Ballistic Missile Defence, Cyber Security, Counter-IED, Urbanization, Protection of Civilians, Stability Force Assistance, Stability Policing, Military Strategic Effects, and studies such as Strategic Mobility, Multinational Logistics, NDPP methodologies and Anti-Access and Area Denial (A2AD) amongst others. He is the Bi-SC program lead for the Alliance Future Surveillance and Control (AFSC) capability requirements and the military assessment of AFSC Industrial studies.

With the NATO Command Structure Adaptation, the Branch will support the Capability Requirements, and is responsible for the Courses of Action and Analysis of Alternatives for Common Funded capabilities. Currently, Land C2, SOF C2, Maritime Facilities, ACCS, Air Basing and Cyber are projects in which AoA Branch is involved. Mr. de Nijs is well connected with the NATO and national analysis communities. He is the principle member for ACT in the NATO Science and Technology Organizations's Systems Analysis and Studies Panel and the founder of the annual NATO Operations Research and Analysis Conference.

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**Dr. Ana BARROS, Conference Co-Chair, TNO (NLD)**

Dr Barros is Principal scientist at TNO and fellow at the University of Amsterdam, Institute for Advanced Study (IAS). She has more than twenty years of experience in the operational research/operational analysis field acquired both as university teacher, researcher and supervisor as well as operational and intelligence analyst at TNO. In the last twenty years she has been involved in a wide scope of military and security operational analysis projects in national and international fora varying from intelligence, command and control, air defence, personnel planning, irregular warfare to logistics modelling, including strategic/operational ammunition requirements.

As Principal Scientist, she is responsible for encouraging innovation and knowledge sharing and ensuring technical quality of projects and research programs in the areas of Intelligence and Operational Analysis and Complex Systems. She is also advisor to the TNO focus area of Defence, Safety and Security and in particular to the subareas Missions and Operations and National Security. Her academic experience also includes supervision of several Master and PhD. students, as well teaching, as part of the regular curriculum at several Universities, the Netherlands Defence Academy, the Dutch Defence Intelligence and Security Institute (DIVI), the Dutch Police Academy, and at NATO bodies. Her involvement in several international (cooperation) projects and activities, together with her academic experience and strong communication skills facilitate the establishment of links between practice and theory in an international environment. She was the vice-chair of NATO STO's System Analysis and Studies Panel in 2016-2018 and is currently chair of this panel.

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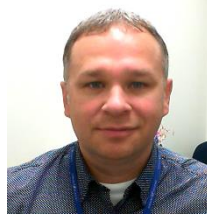
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Stream – Data Driven Analysis

DDA 1-1: Advancing Defence Analytics in Canada: Lessons from the Trenches
Author: Mr Yvan GAUTHIER (DRDC)

Analytics is central to the digital transformation of Defence in Canada and NATO. Canada's new defence policy statement Strong, Secured, Engaged (SSE) asserts that "technological developments point to a future of defence that is expected to be vastly different than today with a greater emphasis on information technologies, data analytics, deep learning" and that "a number of these advances has the potential to change the fundamental nature of military operations." Since 2017, the Department of National Defence (DND) has launched an initiative to develop and operationalize a new Defence Analytics capability governed by a Chief Data Officer. Defence Research and Development Canada (DRDC) has been supporting this initiative, specifically through the development of an advanced defence analytics capability leveraging the broader DRDC community. This presentation will describe some of the early successes of a data science team that was established to support this new Defence Analytics capability, for example new collaborations (internal to DND, with other government departments, industry, and NATO Allies), a systematic prioritization of use cases, and novel applications of machine learning. The presentation will also describe some of the challenges (technical, analytical, political, and data-related) involved in conducting advanced analytics in a government or military setting, how they are currently being tackled in DND, and lessons identified along the way.

Yvan Gauthier is a senior defence scientist with Defence R&D Canada – Centre for Operational Research and Analysis (DRDC CORA). Since 2017, he leads a data science team supporting the Chief Data Officer of the Department of National Defence (DND), a team now embedded with the Assistant Deputy Minister (Data, Innovation, Analytics) organisation. He also chairs the NATO Specialist Team SAS-150 on Advanced Analytics and AI for Enterprise Resource Planning. Before in his career, he has led several operational research projects while working with various branches of DND, including the Strategic Joint Staff, the Canadian Joint Operations Command, Maritime Forces Pacific Headquarters, and the Air Staff. He also worked for two years in the UK as an exchange scientist with Dstl Naval Systems

DDA 1-2: Delving into the data: exploring the Lessons Learned potential of large data pools
Authors: Mr Filipe VIEIRA (JALLC), Ms Mihaela RACOVITA (JALLC), Ms Jacqueline EATON (JALLC)

To match today's rapidly evolving global security threats, NATO's learning capabilities must remain dynamic. NATO missions and exercises yield enormous amounts of data, whose lessons learned potential is largely untapped. These data pools may, contain, for example, observations that are never reported, or can point to gaps in LL training and capabilities that are never addressed. This paper will discuss the challenges in collecting, storing, and utilizing these varied types of data for lessons learned (LL) processes and outlines a few key areas of exploration. The paper will present an adapted methodology for exploring sentiment analysis in the LL context, and highlight the benefits of applying machine learning to improve

text coding. The authors will discuss some of the text mining tools used and discuss their benefits and drawbacks

Filipe Vieira is a Research Analyst working for NATO´s Joint Analysis and Lessons Learned Centre. He retired from the Portuguese Army after 28 years with the rank of Lieutenant Colonel in 2014. As a Research Analyst, he has lead several analysis projects and studies in the context of NATO Operations and Exercises, provided training blocks in several NATO courses and participated in different working groups for the development of NATO guidance. He authored of several articles in Armed Forces and NATO journals, several Portuguese Army Field Manuals and NATO handbooks. Filipe Vieira has been awarded several commendations and military decorations.

DDA 1-3: Keeping NATO grounded on its path towards embracing data science and related technologies
Author: Dr Philip ELES (NCIA)

Artificial intelligence, big data analytics, and related data-centric technologies have increasingly found application in the private sector, leveraging the increasingly globally-connected and digitally-enabled environment. Research into military applications already holds promise in some areas. However, relevant applications of these technologies to the strategic problems facing NATO as a political-military alliance are less obvious. Through its Emerging and Disruptive Technologies Roadmap, NATO is currently assessing how data science and related technologies can be leveraged. This presentation summarises recent work at NCI Agency that supports this broader NATO effort, which focuses largely on applications in natural language processing and text analytics. Recent work includes an evaluation of IBM Watson Explorer through the development of two proof-of-concept demonstrators (on Protection of Civilians and on Defence Planning). The presentation also provides a general overview of other areas where NCI Agency is already applying data science techniques to operational problems, including in support of NATO operations and exercises.

Dr. Philip Eles is a senior scientist in Operational Analysis at the NATO Communications and Information (NCI) Agency. He supports NATO's comprehensive operational assessments of the Resolute Support mission in Afghanistan. He has deployed to Kabul regularly, provides ongoing reach-back support to in-theatre analysts, and since 2014, has been the technical lead for NATO's survey program in Afghanistan. Recently he was involved in an evaluation of IBM Watson Explorer. Prior to joining NATO, Dr. Eles was a defence scientist at Defence Research and Development Canada (DRDC). Dr. Eles holds a Ph.D. in physics from the University of British Columbia.

Stream – Data Driven Analysis

DDA 2-1: Bibliometric methods to support strategic analysis of the security environment
Authors: COL Andrzej LIS (POL MoD), COL Jaroslaw MOKRZYCKI (POL MoD)

As the contemporary armed forces operate in the multidimensional security environment driven by political, legal, economic, socio-cultural, demographic or technological forces, military analysts often are required to expand the scope of their studies beyond the research fields traditionally associated with military strategy, operational art or tactics. To conduct studies in new, unexplored research fields in an efficient and effective way, they need to apply relevant research methods supporting them in recognizing valuable external data, information and knowledge, amassed by civilian scholars cultivating these fields, and identifying relevant contributors to the field in order to develop collaborative networks. Such a challenge has been faced by the analysts of the Polish Armed Forces Doctrine and Training Centre (PAF), appointed by the chief of the General Staff of the Polish Armed Forces to conduct the research project nicknamed NUP 2X35. The name of the project (in translation New Polish Battle Order) refers to the Old Polish Battle Order, which was typical of the Polish art of war between 15C and 17C and contributed to numerous victories of the Polish military. The aim of the NUP 2X35 project is to conduct the strategic analysis of the security environment by 2035. The project assumptions are similar to the NATO's Strategic Foresight Analysis (SFA) accomplished under the umbrella of the Long Term Military Transformation project. What makes the difference is the inclusive approachwhich assumes building networks consisting of cohorts co-operating civilian scholars and experts. Therefore, good understanding of relevant research fields is an issue of paramount importance. The aim of the paper is to explore the potential of bibliometric methods to support strategic analysis of the security environment. The case of urbanization trends will be used to study the usefulness of employing bibliometric methods for military analysis. The research questions are: (1) who are the main contributors (countries, research institutions, journals, authors) to the research field? (2) What are the leading and emerging themes within the research field? (3) What aspects of urbanization are studied in regard to the military context? The applied methodology includes research profiling, keywords co-citation analysis, and systematic literature review. Scopus database is used as a source of data for bibliometric analysis. The VOSviewer software is applied to support co-citation analysis.

Col. Dr Andrzej Lis is the Chief of the Lessons Learned Branch, Polish Armed Forces Doctrine and Training Centre. He graduated from Field Artillery Officers' College (1999) and post-graduate studies in National Defence Academy (2006). He served in field artillery and logistic units. Col. Lis combines his military career with academic development. He received a PhD degree in Business Administration from Nicolaus Copernicus University (2007) for his dissertation on restructuring processes in the companies of the Polish defence industry. He is an experienced lecturer and researcher in the field of management sciences, focusing his interest on the issues of strategic management and leadership, knowledge management and military logistics. He authored more than 100 papers published in scientific journals and delivered speeches in more than 30 national and international scientific conferences and seminars. He has an academic experience as an Assistant Professor in the Faculty of Economic Sciences and Management, Nicolaus Copernicus University, Toruń, Poland (AACSB Accredited) and a Visiting Professor in the Faculty of Law, Economics and Management, the University of Angers, France.

Stream – Data Driven Analysis

Col. Jarosław Mokrzycki started his studies at the Mechanized Infantry Officer School in Wrocław in 1989. His career includes deployments in the Golan Heights in the UNDOF mission and in Iraq during the 9th rotation of the Polish Military Contingent.
In 2002, he graduated from three-year studies at National Defence University of Warsaw. In 2005-2006, he studied at Joint Forces Staff College in Norfolk (USA) and he is also a graduate from postgraduate studies at War Studies University and Kozminski University. He filled the positions Head of the Allied Commitments Planning Branch in the Planning Division, Land Force Command; Head of the Land Force Commander's Secretariat; Head of International Co-operation Division; and Deputy Commander of 21. Mountain Infantry Brigade in Rzeszów. In July 2018, he took up the position of Director of Doctrine and Training Centre of the Polish Armed Forces in Bydgoszcz.

DDA 2-2: How varying unit dismounted troop ratios and troop density levels impact district violence
Authors: Mr Ryan VAN WIE (University of Michigan), Mr Jacob WALDEN (University of Michigan)

Are some conventional military units better equipped to conduct counterinsurgency operations than others? Do dismounted units with reduced levels of mechanization help or hurt counterinsurgents? If there are divergent unit outcomes at the local level associated with the level of mechanization, then this carries policy implications for how militaries equip, organize, and deploy in counterinsurgency campaigns. Using new panel data on the composition and location of U.S. and coalition combat battalions in Iraq from 2004-2008, we analyze how varying unit dismounted troop ratios and troop density levels impact district violence during Operation Iraqi Freedom. Challenging extant literature, our results indicate that counterinsurgent unit force structure is not a critical determinant of district violence. These empirical results are supported by case studies on two major campaigns in Tal Afar and Fallujah. We find continued support that counterinsurgent troop density plays a key role in local stability.

CPT Ryan Van Wie graduated from the U.S. Military Academy at West Point, NY, in 2010 and commissioned as an Infantry officer. He served as a platoon leader and executive officer in the 101st Airborne Division and as a plans officer and company commander in the 4th Infantry Division. He is currently pursuing a graduate degree at the University of Michigan's Ford School of Public Policy.

Jacob Walden is a doctoral student in political science at the University of Michigan. His focus is on world and American politics, including legacies of violence, civilian trauma and cooperation, and civil-military relations.

Stream – Data Driven Analysis

DDA 2-3: Simulation Support for Hybrid Warfare Wargaming and Coalition Decision Makers A Data Farming Approach

Authors: Mr Gary HORNE (MCR Global BE), Mr Wayne STILWELL (Stilwell Technology and Robotics)

A strong shortfall exists in the availability of useful data required by operational analysts to support coalition simulation exercises and decision-making. For example, gaps routinely occur in development of cyber warfare impacts on infrastructure and economies. Also, operations short of war are often strongly deficient in required data, thus the development of operational research support for coalition level decision-making in the current global security environment requires much more depth given the challenge of Hybrid Warfare. In this paper, we outline 25 planks of Hybrid Warfare and suggest how Data Farming of simulations and Wargaming of scenarios across these planks can work in tandem so that NATO operations analysts can provide better support to decision-makers. We describe this approach in Hybrid Warfare contexts, because Data Farming is a quantified approach that examines questions in large possibility spaces and evaluates whole landscapes of outcomes to draw insights from outcome distributions and outliers. Thus, it can provide significant support in situations where extant data is often sparse or less trusted, but possible outcomes are numerous. By combining this powerful examination of the many possibilities in Hybrid Warfare scenarios with the capabilities of Wargaming to examine what tactics, weapons, activities, and strategies might be employed in these scenarios, analysis gaps can be filled in ways that may not be possible otherwise.

Dr Gary Horne is the Technical Director of M&S Solutions at MCR Global with a doctorate in Operations Research from The George Washington University. During his career in defense analysis, he has led data farming efforts examining questions in diverse areas such as humanitarian assistance, convoy protection, and anti-terrorist response. He chaired the NATO Task Group MSG-088, "Data Farming Support to NATO" that completed documentation of the data farming process and won a NATO Scientific Achievement Award. His current work with NATO includes service as co-chair of the task group "Data Farming Services" where he is focusing on cyber questions.

Dr Wayne Stilwell served in NATO as a US Army Colonel at the Joint Warfare Centre in Stavanger, Norway and at the NATO Rapid Deployable Corps-Turkey in Istanbul. Dr. Stilwell has conducted a number of studies and projects for NATO as a contractor over the past few years. His company, Stilwell Technology and Robotics, holds a US Patent Pending in autonomous systems interfaces and produces technology curriculum for universities and community colleges. Dr Stilwell is also a leader in simulation interoperability and hybrid warfare doctrine development

Stream – Operations

OPS 1-1: Strategic Risk Assessment in NATO Operations
Author: Ms Shannon COOPER (SHAPE J5), Mr Valentin POPONETE (SHAPE J5)

In an increasingly uncertain and changing security environment, the military will find itself more and more involved in complex operations in which it will only play a limited role and will be highly influenced by factors it cannot control. Measuring progress towards objectives in a conventional operation with a linear battlefield is often a straightforward task. However, current and future operations are inherently political in nature; thus, it is not the statistics related to progress towards objectives that matter, it is the circumstances in which these statistics were produced. These circumstances or factors are outside the control of the military and could represent risks to progress towards objectives. And, while the word 'risk' is almost omnipresent in military discussions, particularly when it comes to operations planning and assessment, NATO lacks a methodology to conduct this risk assessment. Throughout these discussions, one can find the famous formula of "Likelihood x Impact = Risk level", spurring continuous debates about the way to actually do the multiplication in order to get an exact numerical values of risk level. Nevertheless, when one wants to find how the exact numerical values of likelihood and impact are determined, there is very little available information except: "This is a commander's art." In the context of current and future operations, at a time when we conduct an analysis for everything, NATO cannot afford to keep repeating the mantra of risk assessment as an art. This paper recommends a methodology for the identification and assessment of strategic risk to mission in NATO operations using the existing processes of operations planning and assessment. It uses the NATO PMESII framework to enable the comprehensive and dynamic identification of strategic risk to mission and its connection to assumptions and preconditions for success. It also recommends the development of a risk assessment framework that allows assessment of risk in a similar way to assessment of progress towards objectives, decisive conditions and effects. While recognizing that risk assessment, like any other type of assessment, will always comprise a certain amount of intuition, this paper intends to support planners and operations assessment teams by increasing the degree of objectivity in risk assessment through the application of sound, evidence-based analysis. The paper focuses on strategic risks, but the proposed methodology could be easily adapted for risks identification and assessment at all levels of command.

Mr Valentin Poponete is a civil-military planner/ analyst in SHAPE J5 Strategic Planning. He has been conducting operations assessment at strategic level since 2010, is representing the Requirements Authority for the NATO Operations Assessment sub-discipline and is the lead for the NATO Operations Assessment Course. Mr. Poponete has been the deputy head planner for Resolute Support, the head planner for the first NATO political-military planning effort for a civilian-led presence post-Resolute Support in Afghanistan and the SHAPE head planner for the Enduring Partnership with Afghanistan. As the chair of the SHAPE Projecting Stability Working Group , he is interested in developing NATO's capabilities to conduct operations assessments related to Defence Institution and Capacity Building. Before joining SHAPE in 2010, Mr Poponete worked at JFC Brunssum as the lead Public Affairs officer for Afghanistan after a 16-year career as a Romanian Mountain Troops Officer in Artillery and Strategic Communications. He has a BA in Sociology, a post-graduate degree in Public Affairs, an MA in Political sciences and is working on his PhD in social sciences at the Freie University in Berlin.

Stream – Operations

Shannon Cooper is an Afghan Analyst working in J5 (Strategic Planning) at NATO Supreme Headquarters Allied Powers of Europe (SHAPE) in Mons, Belgium, although she originally hails from McKinney, Texas. She has previously worked as an archaeologist and data analyst in the Middle East. She holds both a Bachelor ('15) and Master ('17) degree with honors in anthropology from the University of Chicago. In addition to English, Shannon speaks Spanish, Arabic, and Middle Egyptian Hieroglyphs.

OPS 1-2: Crashing through the Stop Lights? Operations Assessment in a Changing Global Security Environment
Authors: Mr Bruce PENNELL (NCIA), Mr Valentin POPONETE (SHAPE J5)

Operations Assessment (OpsA) is a significant function established in NATO, rooted in the traditions of Operations Research and Analysis OR&A. However, OpsA is facing a number of challenges. Firstly, the changing global security environment means OpsA has to be applied to Hybrid Threats, Terrorism, new forms of Deterrence and Assurance and capacity building activities. Secondly - and perhaps more importantly - in a post-Truth information-saturated environment, is there still a role for OpsA to play? This paper draws on recent experience working with a range of NATO and other stakeholders to characterise what has changed in the OpsA environment and what fundamentals endure. Firstly, we characterise the problems of actually doing OpsA in the real world and whether the ubiquitous powerpoint "stop light" briefings are really adding any value. This means a brief look at the analytical underpinning of NATO OpsA and how it has been put under the spotlight in recent NATO missions. Secondly, we look at the specific challenge of the essentially social/ political nature of conflict. We also address leadership deification, and the key cognitive biases which can lead to decision paralysis, exacerbate over-optimism and bring an over focus on the short-term. Finally, we consider how we can improve OpsA in this context – to "crash through the stoplights". If the changing global security environment means conflict is more politics than war, what are mission goals and how should we assess them? Do new data science techniques and opportunities offer potential solutions to the saturated information environment? If we apply an evidence-based approach to our own efforts, what other lessons can we draw for the future?

LTC (Retired) Bruce Pennell is a Senior Operational Analyst in the NATO Communications and Information Agency. He has worked extensively on strategic operations assessment, provided analytical support to NATO Defence Planning and a range of conceptual and doctrine development problems. Prior to joining NATO Bruce enjoyed a 23-year career in the British Army including operational experience in both Gulf Wars, in the Balkans and Northern Ireland, and with the UN following the Indonesian tsunami. Having completed a BSc (Honours) in Mathematics, Bruce subsequently gained postgraduate level qualifications in Mathematical Modeling and Simulation, and in Defence and International Relations.

Stream – Operations

Mr Valentin Poponete is a civil-military planner/ analyst in SHAPE J5 Strategic Planning. He has been conducting operations assessment at strategic level since 2010, is representing the Requirements Authority for the NATO Operations Assessment sub-discipline and is the lead for the NATO Operations Assessment Course. Mr. Poponete has been the deputy head planner for Resolute Support, the head planner for the first NATO political-military planning effort for a civilian-led presence post-Resolute Support in Afghanistan and the SHAPE head planner for the Enduring Partnership with Afghanistan. As the chair of the SHAPE Projecting Stability Working Group , he is interested in developing NATO's capabilities to conduct operations assessments related to Defence Institution and Capacity Building. Before joining SHAPE in 2010, Mr Poponete worked at JFC Brunssum as the lead Public Affairs officer for Afghanistan after a 16-year career as a Romanian Mountain Troops Officer in Artillery and Strategic Communications. He has a BA in Sociology, a post-graduate degree in Public Affairs, an MA in Political sciences and is working on his PhD in social sciences at the Freie University in Berlin.

OPS 1-3: Quantifying the extent of permissible dispersion of a Mechanized Brigade Group
Author:Dr Yazan QASRAWI (Canadian Army Land Warfare Centre)

One consequence of the Changing Global Security Environment is the need to disperse forces over a large area to engage modern adversaries. Quantifying the extent of permissible dispersion would be of great value for planning and research. This paper discusses some of the doctrinal factors that limit the dispersion of a Canadian Mechanized Brigade Group (CMBG) and how to assemble these limiting factors to obtain upper bounds on the level of dispersion of a CMBG. Military subject matter experts identified direct fire mutual support, indirect fire mutual support, resupply, and aggregation as some of the doctrinal factors limiting dispersion. Each limiting factor potentially gives rise to two dispersion upper bounds, one when knowing the location of the adversary, resulting in a linear arrangement, and the second when the adversary's location is unknown, resulting in a non-linear arrangement. This study arrives at these dimensions by arranging the brigade's elements at their greatest dispersion while satisfying a given limiting factor. The paper will also briefly discuss the resulting Areas of Influence with respect to the Canadian Army Doctrine's Tactical Frameworks.

Dr Yazan Qasrawi is a Defence Scientist with Defence Research and Development Canada's (DRDC) Centre for Operational Research and Analysis (CORA). His areas of expertise are modelling and simulation and is currently working on simulating military sustainment and logistics. Dr Qasrawi is also a Canadian member of The Technical Cooperation Program's (TTCP) Land Force Logistics Technical Panel.

Stream – Operations

OPS 2-1: Analysing Unmanned Combat Systems with Autonomous Functions (UCSAF) operational impact. Challenges and preliminary outcomes

Author: LTC Sten ALLIK (Estonian Defence Force)

Technical development of Unmanned Ground Systems in combination with AI-driven functions is in a point that in upcoming years number of systems will be fielded and deployed in operations. As the development of these technologies is mainly based on civil-R&D flow into the military, the proliferation is not limited only to the states of traditional edge of the military technology. Number of smaller forces are researching and analysing today operational opportunities of these potential new capabilities. So far, regardless of technical issues the platforms and systems still have, the biggest question is still: „How these systems will provide us new qualities on the battlefield?" At current phase, the analysis is based on number of field experiments as well as wargames. The experiments were conducted during more than one year period (are still ongoing) with regular conscripts-based infantry company. Other experiments were executed during operation BARKHANE in Mali. In order to understand larger operational context, number of wargames were conducted in headquarters level as well as in defence academy. Current results show potentially positive effects as well as challenges when integrating UCSAF into the light infantry units in manoeuvrability, engagement and sustainability wise.

Lieutenant-Colonel Sten Allik graduated from National Defence University, Finland, in 2000. In 2005 and 2006, he studied in France at Ecole de Guerre (Collège Interarmées de Défense) and University Paris II Assas, where he obtained a Master's degree in political sciences. Since 2018, he is a PhD student at National Defence University, Finland. His career includes assignments as Chief of Staff of Infantry Battalion, Senior Staff Officer at Estonian Joint HQ J5 branch and NATO Multinational Corps North-East in Poland, as Chief of Centre for Applied Research at National Defence College in Tartu and as Senior Staff Officer/Future Solutions, HQ of Estonian Defence Forces. In 2010, Sten was deployed to Afghanistan as Team Leader RC-E, J35, ISAF Joint Command in Kabul. In 2014, he led the Estonian Contingent during a deployment to Bangui, Central African Republic and filled the position of Chief J3/FHQ.

OPS 2-2: Sensing in a Networked Environment Lessons learned from Automation and Autonomy

Authors: Dr Kerry MALONE (TNO), Mr Kees DEN HOLLANDER (TNO), Ms Lotte KONINGS (TNO), Dr Bob VAN DER VECHT (TNO), Mr Tom MEURS (TNO)

This paper explores how intelligence functions can take place in future organizational settings, reflecting dynamically changing security environments of both allies and adversaries, such as combined or joint operations in which coordination of asset use takes place. Considering the four intelligence functions direct, collect, process and disseminate, the presentation will explore what can be learned from unmanned autonomous agents in order to make explicit the requirements for interaction in the human realm. Unmanned autonomous agents make explicit the mechanisms or rules for interaction (hierarchy vs self-synchronization (swarming)) as well as their internal motivation (goal function). Additionally, different agents may have different capabilities, and trust needs to be established. This analysis aims to

inform the understanding of the requirements of the organization and influence that the environment can have on the choice of organizing the intelligence process. This presentation will present work to date in a new four-year project, "Sensing in a Networked Environment" (SiaNe). The future organizational settings vary along two axes, the level of coordination in managing the intelligence process (from self-synchronization to maximum coordination), and the level of centralization of the collection and processing tasks, resulting in four archetypes. The paper will present the results to date from the first year.

Dr Kerry Malone received her doctorate in Operations Research at the Massachusetts Institute of Technology in 1995. In her dissertation, she developed a strategic model for estimating delays in a network of airports. She has worked at TNO since 2000, first in the area of mobility, now in the department of Military Operations. She has led international projects, for example, ANACONDA (Assessment of user Needs for Adapting Cobra including Online Database) project in the CEDR Transnational Road Research Program 2014 Mobility & ITS and the 6th Framework Program European project eIMPACT (Socio-economic impact assessment of stand-alone and cooperative intelligent vehicle safety systems in Europe).

OPS 2-3: Assessing the impact of infrastructure on Arctic operations
Author: Mr Gregory HUNTER (DRDC), Mr J. CHAN (DRDC), Mr Mark REMPEL (DRDC)

With the loss of ice coverage in the Arctic, access to Canadian territorial waters such as the North West Passage is becoming feasible over a wider area and time span. As a result, shipping through the area is expected to grow, increasing the likelihood of Canadian Armed Forces (CAF) domestic operations in the region. We present analytical work on the effect of sparse logistical infrastructure on military operations in the Canadian Arctic region undertaken as part of an effort to inform Department of National Defence infrastructure investment decisions. The relative response capability of the CAF was assessed using major maritime disaster scenario involving a large cruise ship. We examine the transportation and logistics component of the problem using a mixed-integer programming capacitated vehicle routing model. Factors considered include the current CAF force deployment and response posture, transit to forward operating locations, vehicle capacity, fuel requirements, degradation of the medical state of the evacuees over time, and triage decisions at loading time. The model was applied over all feasible combinations of forward operating locations and a grid of incident locations to assess performance over the entire region and to measure the impact of procedural and infrastructure changes.

Mr Gregory Hunter has been Defence Scientist with Defence Research and Development Canada (DRDC) – Centre for Operational Research (CORA) since 2003. He currently supports the Canadian Joint Operations Command (CJOC) headquarters in Ottawa.

Stream – Strategic Decision Making

SDM 1-1: The network of dependencies
Author: Dr Steve GUILLOUZIC (DRDC)

In order to fulfil their mandates, armed forces require an extensive suite of capabilities, the development of which involves a large number of interrelated capability development initiatives. The network of dependencies between initiatives is often quite complex. Therefore, changes, delays and cancellations in any one of them can have significant first and second order impact throughout the capability development initiative portfolio. It is important to identify such potential impact as early as possible in the decision process to allow for timely mitigation. Defence Research and Development Canada's Centre for Operational Research and Analysis developed, for the Canadian Army, a prototype schedule risk analysis tool to support this task. Based on estimates of activity duration provided by subject matter experts, the tool uses a Monte Carlo simulation to forecast when high-level activities involved in capability development initiatives may be expected to start and end—taking into account dependencies between initiatives and flagging the impact of potential delays on readiness. The presentation will describe the prototype and report on lessons learned during its development, notably with respect to the minimization of data requirements and the challenges involved in presenting results of the schedule risk analysis to decision makers.

Dr Guillouzic is an operational research analyst with Defence Research and Development Canada. He joined DRDC in 2002 after obtaining a Ph.D. in physics and working as a postdoctoral fellow in biophysics. Since joining the organization, he has applied his knowledge in the modelling and simulation of stochastic systems to a variety of application areas, such as maritime surveillance, fleet mix and schedule risk analysis. Throughout his career, he has had the opportunity to support various parts of the Department of National Defence and the Canadian Armed Forces, including several years as a team leader.

SDM 1-2: Defence Investment Prioritization
Author: Dr John STEELE (DRDC)

At the strategic level, the principal "Challenge for NATO OR&A in a Changing Global Security Environment" concerns how to affordably optimize the capabilities embodied by fielded military forces to meet the national and alliance requirements to address that changing security environment. This necessitates cost-informed trade-offs between capability investments. Getting those trade-offs right is the military investment portfolio decision analysis problem. The presentation will outline what the literature indicates to be best practice for MoD investment prioritization and report ongoing work within SAS-134 to substantiate this with instances from NATO and partner nations touching on portfolio objectives formulation, value modelling, the socio-technical process of investment prioritization and planning, leveraging performance and risk management products and visualizing alternative portfolios and their consequences.

Stream – Strategic Decision Making

Dr John Steele spent his formative years in Saskatoon on the Canadian prairies. Besides a Bachelor of Music, he holds a Bachelor of Science and a PhD, both in Mechanical Engineering from the University of Saskatchewan. He has worked for Defence R&D Canada's Centre for Operational Research and Analysis since 2002, supporting the Canadian Army for three years in Kingston, the Royal Canadian Air Force for seven years in Winnipeg and the Chiefs of Force Development and Programme in Ottawa for the past seven years. He currently chairs SAS-134 "Linking Investment and Divestment to Defence Outcomes."

SDM 1-3: NATO Defence Planning Process Incorporating the New and the Emerging
Authors: Mr Glenn RICHARDS (NCIA), Ms. Louise HOEHL (NCIA), CDR Mark Buchan-Steele (ACT)

How should innovation be incorporated within NATO capability development? This is a key question given the uncertainty and challenges ahead in both the geopolitical and technological environments. The NATO Defence Planning Process (NDPP) is at the core of NATO capability development where it facilitates the identification, development and delivery of a pool of forces and capabilities to meet NATO's Level of Ambition. Ideally, the impact of innovation in future capability requirements should be captured, but the challenge is how? This paper identifies the steps that have been taken to capture innovation in terms of the new challenges NATO may face both now and in the future, emerging threats, new/disruptive technologies, lessons identified, and updated concepts and doctrine. A method is described which takes into account the factors that make an innovative idea suitable for implementation within NDPP. It explains the how, in terms of the tools and processes used, including; capability definitions, qualitative and quantitative requirements, scenarios, and longer term aspects. The paper also describes some of the challenges of capturing future innovation, for example, the as yet undiscovered technologies, or unbounded innovative ideas, and makes recommendations for how best to implement in the future. Lastly, the paper includes consideration of who needs to be included to ensure that NATO retains the competitive edge in terms of ideas, technologies, and solutions.

Glenn is currently the Defence Planning Lead in the NATO Communications and Information Agency (NCI Agency) providing Operational Analysis 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 ISAF, supporting in-theatre OA, manpower and costing studies and many logistics related studies. Glenn has been a practitioner of Operational Analyst since he first joined the Defence Evaluation and Research Agency (DERA) in 1999, before later being transferred to QinetiQ in 2001, prior to that he was a Physicist specialising in Applied Optics.

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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.

SDM 2-1: From Foresight to Impact for Technologies at Low Technology Readiness Levels

Authors: Ms Clara PETERS (TNO), Ms Christina GRÖNWALL (FOI), Mr Adelbert BRONKHORST (TNO), Gitanjali ADLAKHA-HUTCHEON (DRDC)

In a changing global security environment, countering new threats that arise often requires research and development of new solutions. The challenge thus is to identify promising areas of research and fund these in a timely manner. This presentation describes a method that provides this agility by conducting horizon scans through literature search and scientometric methods, narrowing the scope, describing technologies and assessing the impact of technologies in early stages of development. It focuses on technologies at technology readiness levels (TRL) lower than 5, i.e., when the technologies are in the basic research stage and/or in the first stages of applied research. Assessment at low TRL is difficult since often too little is understood about their possible applications to assess their utility. The method was developed jointly by DRDC (Canada), TNO (The Netherlands) and FOI (Sweden) through efforts that began in 2017. During this collaboration, the process from horizon scanning, scoping, technology description and assessment was performed on four topics:

- Cognitive enhancement
- Advanced directional acoustic sensors and Acoustic Stealth
- Metamaterials
- Synthetic Biology

The impact assessment segment uses two criteria to determine how promising the technology is – the expected added value and the expected feasibility. It is an expert-driven process, where a small number of experts are asked to think of possible applications of the technology. The resulting application cards are then discussed and scored on added value and feasibility in a broader group of experts. The assessment method was slightly adapted to fit the specifics of each topic. The assessment results can, for example, then be used as input for making strategic decisions such as funding further research.

Clara Peters (1985) is a research scientist and consultant innovation management in the defence and security domain. She was trained as an Industrial Design Engineer at Delft University of Technology and has been working at the Netherlands Organisation for Applied Scientific Research (TNO) since 2010. Her work includes design and execution of technology assessments and roadmap development. She has recently worked with the Dutch Ministry of Defence, the Dutch National Police and the European Defence Agency. She is an experienced workshop moderator. Clara will move to Norfolk, VA in November to join NATO ACT.

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SDM 2-2: Wargaming for Strategic Decision Makers in the United Kingdom
Author: Mr. Mike LARNER (DSTL)

The Iraq Inquiry (Chilcot) Report suggested that UK Government had a propensity for 'groupthink', didn't properly understand the situation it was getting involved in, didn't exercise sufficient foresight and suffered from multiple impediments to effective decision making. In 2017, the Vice Chief of the Defence Staff (VCDS) identified wargaming as one of the tools that could help to address these issues and commissioned a flagship cycle of strategic wargaming events. The first event in this cycle (the "Modern Deterrence Wargame 17") was hailed as a major success with VCDS noting that it "marked Britain's return to senior wargames" and MOD's Permanent Secretary describing it as a "powerful way of bringing to life some of the issues that we face". A subsequent event (the "VCDS Escalation Wargame 18") was held in March 2018 and a third event ("Hybrid Fusion 18") with a cross-government focus was delivered for the Cabinet Office in January 2019. This talk will briefly discuss the 3 VCDS wargames and the highlights/lessons drawn from them, with a particular focus on the experience of working with very senior decision makers and addressing the Chilcot issues.

Mike Larner is a Consulting Fellow in the Strategy, Policy & Security Group of the Defence & Security Analysis Division in the UK Defence Science & Technology Laboratory. Current responsibilities include: DSA wargaming lead; Principal Advisor for Policy & Capability Analysis; and Independent Technical Assurer for the Emerging Technologies Programme. He has spent 25 years working in Defence as an operational analyst, consultant and programme manager. During this time he has worked extensively with international colleagues – most notably as the Executive Chair for the TTCP JSA Group; Advisory Director to the US Military Operations Research Society; and through ISMOR.

SDM 2-3: Quantifying the utility of war to explore a small state deterrence capability
Authors: Mr. Alf Christian HENNUM (FFI), Ms. Mona SAGSVEEN GUTTELVIK (FFI)

Deterrence has been the main factor in Norwegian security policy since the Second World War. The Norwegian deterrence is based on the nuclear arsenal of the biggest NATO members and the large amount of conventional allied forces. Norway therefore relies on what is known as external deterrence. But what if an adversary uses means "below" the threshold for NATO involvement? Or, what if the adversary accomplishes a fait accompli that would raise the threshold for NATO's involvement in the conflict? By building a utility function of war inspired by Mesquita's utility theory of international conflict, we use operational analysis to explore a small state's deterrence capability. The paper explores the utility function of war in the perspective of an adversary and discuss what the Norwegians can do to minimize the enemy utility. This is further used to give advice on how to make the deterrence for a small state as effective as possible in support of long term defence planning.

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Alf Christian Hennum has worked at the Norwegian defence research establishment (FFI) since 2003. He has a Master degree in theoretical chemistry from the University of Oslo. At FFI he has worked as an operational analyst, mainly with long term planning for the strategic level. Now, he is heading a research program supporting the MoD and the operational headquarter in Norway.

Mona Sagsveen Guttelvik has worked at the Norwegian defence research establishment (FFI) since 2006. She has a Master degree in astrophysics from the University of Oslo. At FFI she has worked as an operational analyst supporting the Norwegian Navy and the MoD with its long-term planning process. She is now a program manager for FFIs research program supporting the MoD and the Chief of Defence with capability-based planning and scenario development.

Stream – Methodology

M 1-1: Mission and Trajectory Planning for Unmanned Aerial Vehicles with Mathematical Optimization and Wargaming

Authors: Prof. Dr. Armin Fügenschuh (Brandenburgische Technische Universität), Ms. Leonie M. Johannsmann (Bundeswehr), Ms. Sandra Matuszewski (Bundeswehr), Mr. Sönke Marahrens, Mr. Daniel Müllenstedt (Bundeswehr), Mr. Johannes Schmidt (Brandenburgische Technische Universität)

The mission and trajectory planning problem for an inhomogeneous fleet of unmanned aerial vehicles (UAVs) asks for optimal trajectories that together visit a largest possible subsets from a list of desired targets. When selected, each target must be traversed within a certain maximal distance and within a certain time interval. The UAVs differ with respect to their sensor properties, speeds, and operating ranges. If the targets are surrounded by radar surveillance, then the UAVs' trajectories should be chosen to avoid these forbidden areas. In contrast to classical vehicle routing problems with time windows, this problems allows for free-flight routes which are not bound to street-like networks. Additionally, the fuel consumption rates during cruise (at various speed and altitude levels), climb and descend are crucial and thus need to be considered within the model. We formulate the mission and trajectory planning problem for UAVs as mixed-integer nonlinear control problem, and apply discretization and linearization strategies to obtain a mixed-integer linear programming problem which can be solved numerically using available software tools. We discuss the applicability of this approach with respect to the number of potential targets, the fleet size, and the number of restricted areas. Finally, an outlook on wargaming aspects of the problem for training purposes is given.

Armin Fügenschuh studied mathematics from 1995 to 2000 in Oldenburg, Germany, and at the Jagiellonian University in Cracow, Poland. In 2000, he became a Research Associate at the Darmstadt University of Technology where he received a Doctorate degree in 2005. After that he held Post-Doc positions in Darmstadt, Berlin, Atlanta (Georgia, USA), and Erlangen. Between 2013 and 2017 he was an Associate Professor at the Helmut Schmidt University / University of the Federal Armed Forces in Hamburg. Since 2017 he is Full Professor for Engineering Mathematics and Numerics of Optimization at the Brandenburg University of Technology in Cottbus. FŸgenschuhÕs main research interests are linear and nonlinear mixed-integer programming and their applications, in particular to problems from engineering, transportation, and logistics.

M 1-2: Multi Agent Path Planning Strategies based on Artificial Intelligence algorithms for Surveillance Missions

Author: Ms. Nicola FARINA (Pangea Formazione)

Multi agent systems have increased their level of importance in the research community over the years due to the possibility to employ these systems for dual-use applications. In fact, they are adopted in several applications in both military and civilian domain, in industrial and personal applications. In particular, the adoption of teams of multiple unmanned systems permits to share information about situational awareness and planning strategies and to improve the overall performance of the system in executing a particular mission. In this paper we investigate how to determine a collaborative strategy for

a swarm of UAVs in two specific situations: surveillance and SaR (search and rescue) missions. We define a procedure to approach to the optimal strategy given the information available to the control center. We use mathemathical techniques based on the Bayesian Networks (in addition to the Kalman Filter and optimization algorithms) in order to determine the best course of action in a given context.

After getting a PhD in Physics in Rome, Italy, Nicola Farina has been employed by Pangea Formazione, a small company specialized in the development of AI algorithms in the business context. Currently Director of Pangea Formazione, Nicola Farina leads a team of highly educated Data Scientists with the aim of promote, build and deliver data science solutions in many business and academic contexts. Author of several software packages and libraries, manager of many business projects, Nicola Farina is an expert in probabilistic theory, machine learning, bayesian networks and data science tools.

M 1-3: Rough order magnitude costing of maritime unmanned systems
Author: Mr. François-Alex Bourque (DRDC), Mr Christopher STRODE (DRDC)

This contribution develops rough order of magnitude cost estimates of Maritime Unmanned Systems (MUS), which include procurement costs, as well as, costs relating to the operations and support such as personnel. The main challenge of this costing exercise is to span the spectrum of unmanned systems from the smallest to the largest. To conduct an analysis from the ground up for a broad range of platforms is beyond the scope of this contribution. Given these constraints, the model proposed leveraging as much as possible open-source estimates from the US DoD for manned and unmanned systems. The data has the benefit of being consistent and traceable down to specific cost categories and operating and support (O&S) cost elements such as unit maintenance. This simplifies the level of effort required and is one of the main advantages of this approach. The estimation proceeds by defining system categories and then costing each using a reference system. The resulting estimate includes unit procurement and O&S costs adjusted for inflation for each reference system. As well, it encompasses the annual O&S cost to procurement cost ratio, the system depreciation per operational hour, and the O&S cost per operational hour. As part of a cost-benefit analysis, the latter two quantities are useful to cost specific mission profiles.

Dr François-Alex Bourque is a Defence Scientist at the Defence Research Development Canada Centre for Operational Research and Analysis. He was a Senior Scientist at the NATO Centre for Maritime Research and Experimentation from 2015-2018 and a Visiting Scientist in 2013. He holds a doctorate in theoretical nuclear physics from McGill University. As a Defence Scientist, he has provided decision support to the Canadian Department of National Defence on a variety of procurement projects. Additionally, he has explored the potential defence and security use of unmanned systems in mine countermeasures, harbour protection, maritime security and ASW.

Mr Christopher Strode works as an operational analyst with over 20 years' experience in industry (BAE Systems), government laboratory (DSTL) and NATO research centre (CMRE). Currently employed at CMRE

he leads two projects within the MCM and ASW programs. Both projects relate to decision support activities designed to optimise the performance of unmanned systems in the respective warfare areas. The work includes elements of acoustic modelling, the development of tactical decision aids, optimisation, and simulation. Further work has included deployments on board military platforms to both analyse their performance and to demonstrate software.

M 2-1: Assessing and Communicating Uncertainty Effectively in a Rapidly Changing World
Author: Dr David R. MANDEL (DRDC)

Command and policy decision-making alike depend on timely and accurate intelligence. As Sherman Kent had noted in the 1950s and 60s, intelligence assessments are seldom cold, hard facts but rather subjective judgments made by experts under conditions of uncertainty. Since Kent, history (e.g., The Bay of Pigs and Iraq WMD invasions) has taught us that misjudging and miscommunicating uncertainties threaten prospects for operational and strategic successes. Nevertheless, NATO and its members' intelligence communities have persisted in using inadequate methods for assessing and communicating uncertainty, which rely on vague linguistic probabilities that often mean different things to different people and even different things to the same people under different circumstances. Here, drawing on recent scientific evidence including from NATO SAS-114 and other research, I describe the principal reasons why the intelligence community should change course and how it could go about doing so. A key feature of transformation should be the use of numeric probabilities for estimates that support important decisions. This is arguably more important now than ever since changes in global security environment, which augment the importance of non-munitions targeting, call for characterization of deep uncertainties related to second and higher-order effects. These changes call for a shift from reliance on words of estimative probability in static reports to numeric estimation of probabilistic beliefs that can be used in hybrid ³human-machine² methods for forecasting effects across the spectrum of war and that can be updated rapidly on the basis of new information either by the analyst or by formal (e.g., Bayesian) models.

David R. Mandel is a senior Defence Scientist with Defence Research and Development Canada and Adjunct Professor of Psychology at York University. He publishes widely in peer-reviewed journals on the topics of reasoning, judgment, and decision-making and has co-edited or co-authored five books, most recently Judgment and Decision Making: Descriptive, Normative and Prescriptive Perspectives. Mandel is Chairman of the NATO System Analysis and Studies Panel Research Technical Group on Assessment and Communication of Uncertainty in Intelligence to Support Decision Making (SAS-114) and Principal Investigator of multiple Canadian government projects aimed at improving intelligence production through the application of decision science.

Stream – Methodology

M 2-2: The Cyber Common Operating Picture.An approach to understand the battlespace and inform decision making

Authors: LCol Andrew LEGGE (DRDC), Dr Maxwell DONDO (DRDC), Dr Abderrahmane SOKRI (DRDC)

Cyberspace is arguably the most active part of the global security environment, where adversaries assert their will and deny their opponents the freedom of action. An effective Cyber Common Operating Picture (CyCOP) provides cyber command and control (C2) situational awareness (CySA) and enables the operator to make accurate, timely, and informed decisions. While there is a continuing debate over what constitutes a CyCOP, determining the key CyCOP information required to inform decision making remains a mostly under-researched area. This paper proposes an information collection technique based on the cyber operating environment's key terrain and vital ground, covering cyberspace's physical, logical and virtual layers. Our approach uses an intelligence information collection technique to identify the key questions that the CyCOP is supposed to address. Such questions are related to cyber operations (both offensive and defensive), or the CyCOP's integration with common operating pictures (COPs) in kinetic domains. The approach draws up detailed prioritized information requirements and indicators across the cyberspace layers to determine sources of data that could be used to answer the high level questions. From the answers to these questions, we show how the combined attributes of the high level requirements are weighted according to mission roles and translated into decision making metrics that could provide commanders with enhanced CySA. Our results show that our approach can be used by commanders to provide a definite cyber awareness that promotes better decision making than the reliance on a commander's "art" or gutfeel. The approach could inform on requirements of a NATO's CyCOP and other operations in the cyber domain.

LCol Andrew Legge is the Chief of Cyber Threat Intelligence (J2) for the Canadian Armed Forces (CAF) Joint Force Cyber Component Command (JFCCC), based in Ottawa. He is regarded as the "father of Canadian Cyber Intelligence" for his seminal contributions in creating and leading CAF's first-ever offensive and defensive cyber Intelligence capabilities in operations, as well as Cyber Mission Assurance (CMA), and Cyber Intelligence, Surveillance and Reconnaissance (Cyber ISR). He has led the development of cyber effects estimates, as well as techniques for target development and forward defence. He has been published several times on these topics and continues to research areas pertaining to cyber key terrain / vital ground and accurate cyber threat anticipation. He has two master's degrees, including one focusing on cyber defence.

Dr Dondo is Defence Scientist with the Defence Research and Development Canada with a focus on cyber security. He has contributed to cyber security research topics in attack detection, asset criticality, threat, event, course of action, and vulnerability analyses. His research interests are computational intelligence, decision making, and optimisation methods as applied to cyber operations. Maxwell holds a Ph.D. degree in Electrical and Computer Engineering. He is a professional engineer (PEng) and a senior member of the IEEE (SMIEEE).

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Abderrahmane Sokri has a Ph.D. in Administration, a Master degree in economics, and a Master degree in statistics. He serves as Defence Scientist for the Canadian Department of National Defence. His current research interest includes game theory applied to cyber defence and wargaming. He has published in high-level international journals such as European Journal of Operational Research and Defence and Peace Economics.

M 2-3: The first NATO guidelines for conducting surveys in the military context
Author: Dr. Zhigang WANG (DRDC)

Obtaining high-quality evidence from surveys about a broad range of military policy issues is crucial in assisting senior military leaders' decision making. Unfortunately, NATO has no guidelines or standards for conducting surveys in the military context. Many NATO nations have developed their own standards and guidelines to conduct surveys in-house, while others rely on commercial contractors due to limited survey capability and expertise. As a result, the quality of survey results across NATO nations is difficult to determine. NATO Research Task Group SAS-144 has identified scientific techniques in conducting surveys for military use (including for military operations) and is developing concise, best practice guidelines for survey formulation, questionnaire development, sampling design and data collection, data processing and analysis, results documentation and dissemination, which can be used as minimum standards for any military survey conducted by defence analysts or commercial contractors employed by NATO militaries. These state-of-the-art survey methodologies will assist defence analysts and end-users in providing timely and scientific survey results to senior military leaders.

Dr Zhigang Wang is currently working for Director General Military Personnel Research and Analysis (DGMPRA), Department of National Defence Canada, as the Section Head of the Research Methodology Section. Dr. Wang has led several NATO SAS RTGs and ETs, and has provided expert advice on survey research nationally and internationally. Dr. Wang also acts as a peer reviewer for academic journals in social science and academic books on statistics and research methodology. He severed as a (research) adjunct professor and teaches courses in advanced statistics and research methodology at Carleton University.

M 3-1: Use of natural language processing for strategic portfolio optimization
Authors: Dr. Peter DOBIAS (DRDC), Dr. Kendall WHEATON (DRDC)

One of the key inputs for capital portfolio optimization is the objective function characterizing the desired end state. While defining an objective function for more tactical problems is usually straightforward, the objective function at the strategic level presents a particular challenge. At this level, many inputs are by necessity qualitative, tied to national policies and political preferences, strategic outcomes, as well to capability requirements. Furthermore, there are often dependencies between different projects that are currently considered at best only implicitly. This often disadvantages smaller enabling projects that do not provide as much political value. Until recently, data collection and populating the objective function

needed to be done manually, relying on the subject matter expertise of military analysts who review project and policy documents and leverage personal knowledge of political announcements. It is very desirable to have a more comprehensive and less subjective methodology. There is a wide range of information available for defence projects, both online and off, that could be leveraged for more comprehensive analysis. Unfortunately, much of this information is in the form of unstructured texts which complicates any analysis. With the maturing of natural language processing, we believe that it could be possible to develop an approach to automate the processing of documents that contain information about capital projects. In order to assess the viability of this approach, we propose using Twitter data combined with the current

government policy documents to identify information about the projects (Who announced it? Where? Is it identified in the defence policy?). This could be used to better quantify the political preferences of individual projects in order to increase the transparency of the portfolio optimization process. This, by extension, would increase the repeatability and effectiveness of decision-making in the capital investment program for the Department of National Defence.

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; he soon moved to the Canadian Expeditionary Forces Command, 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. From 2013 to 2018 he led Maritime Forces Pacific operational research; then he moved to Ottawa and assumed the lead of the Strategic Planning Operational Research Team. Currently he is a Section Head for Land and Operational Command Operational Research.

Dr Kendall Wheaton is an operational research analyst at DRDC's Centre for Operational Research and Analysis in Ottawa, Canada. Over the past three decades he has conducted studies for Air Force, Naval and Joint Force projects. In his current work, he provides support to the Chief of Force Development where he is guiding research on frameworks and tools to support strategic decisions on Force Development.

M 3-2: Artificial Intelligent Based Best Course of Action Tool for Multi-Domain Operations

Authors: Dr. Altan OZKIL (Atilim University), Dr Andrew STARKEY (Athena Intelligent Systems), Mr. Levent Berke ÇAPLI (NATO STO Research Task Group SAS-129)

Effect Based Operations (EBO) can be defined as operations that are conceived and planned in a systems framework that considers the full range of direct, indirect, and cascading effects that can be achieved by both military and civilian instruments. Yet EBOs did not became the solution it was meant to be. Main critique to EBOs rose from the argument that, war is simply too complex to be fully planed ahead. As a reaction, UK broke from the EBO, adopted Effect Based Approach, and started working on Comprehensive Approach to Operations and Systemic Operational Design (SOD). Whereas SOD is a method that builds a process that iteratively, learns from countering force, in order to adjust the plan and execution as the operation develops. However, all boils down to finding a compressive solution the

new challenges posed by the changing global security environment. Currently, future looks asymmetric warfare in urban where the conflict is not limited to the traditional military domains but expended to cyber, space and information domains. All the while decreasing manpower of the west and increasing adversary technical capability is an ever-present threat in the background. As an alternative solution AI based Dynamic Decision Support (DDS) under the best course of action (COA) approach is being adapted. The idea that AI based tools has the potential to become the envisioned planner in EBOs and constantly adapt the operational level through SOD as well as the run the DDS that tells the junior commander tactical best course of action. This study will analysis the literature to derive the needs for such an AI system that will be able to address the challenges to NATO operations in the near future, while the second section will present a Fuzzy Logic Algorithm design for a conceptual COA tool.

Dr Altan OZKIL graduated from Turkish Military Academy in 1986. He received his master degree on Operations Research from Naval Postgraduate School of USA and his doctorate degree on Industrial Engineering from Gazi University. Altan Ozkil, who is one of the founder of Turkish General Staff Headquarters Scientific Decision Support Center, spent almost all of his military career in this centre. He retired as colonel from Turkish Armed Forces in 2009. He, who worked for one year in Manpower Analysis Department of Canadian Ministry of Defence, has been teaching courses on Decision Making, Systems Engineering, Modeling and Simulation, Cost Analysis and Management, Human Resources Management etc. for 20 years. He is currently the Director of Atılım University Defence Technologies Research Center which he founded in 2011 and Deputy Director of Atilim University Civil Aviation School.

Levent Berke CAPLI completed his undergraduate program at Essex University in the field of "Economics and Political Science". During his undergraduate studies at Essex University, he participated in the "Peace and Conflict Studies" program at the University of Haifa in Israel as an exchange student. In 2013, he started to work as a system engineer at the R&D department in an IT Company. In 2014, he started his Master's program on Technology Management in Turkish Military Academy. In 2019, he completed his master program in Technology Policies at the Middle East Technical University working on his thesis titled "Serious Game Development Methodology Based on Behavioral Economics and System Engineering". In 2017, he has been coordinating the award-winning civil movement campaign titled "KizBasina" which aims stopping violence and hate speech towards women in Turkey. Since 2015, he has been acting as a Research Task Group Chair on Serious Game Development for Cyber Defence and Resilience at NATO Science and Technology Organization. His work focuses on developing Multi-Domain Wargame for future officer training.

Stream – Wargaming

WG 1-1: NATO STO Research Task Group SAS-139 - State of the Art of Analytical Wargaming
Author: Ms Sue COLLINS (HQ SACT)

There has been a resurgence in interest and application of analytical wargames across the NATO community in order to address strategic, operational, and tactical decision problems. SAS-139 aims to advance NATO wargaming by improving analytical capabilities in wargame design, data capture, analysis and reporting of results through sharing of best practices. In addition, there have been considerable advances in general analytical practices over the past fifteen years that could be fruitfully applied to wargaming. SAS-139 is investigating these advances and deriving applications to move towards a 'state of the art' wargaming capability across NATO and NATO Nations. The presentation will cover findings to date and provides an opportunity for the wider analytical community to input into the effort.

Ms Sue Collins is Section Head (Solutions Analysis) at NATO Headquarters Allied Command Transformation in the USA. She specializes in analytical techniques to structure and develop solutions for NATO's most complex and challenging future problems. She has worked on a wide variety of projects including Logistics, Maritime, Urbanization, Security Force Assistance and Protection of Civilians. She is experienced in facilitation, experimentation and wargaming, has a degree in Management Science and nineteen years' experience of applying Operations Research to government and defence issues.

WG 1-2: What Simulation-Based Trainings Teach Us About Security, Humanitarianism, and Understanding in Urban Refugee Response
Author: Matthew R STEVENS (Lessons Learned Simulations and Training)

How can traditional wargaming and red-teaming methods be adapted to better prepare us for the humanitarian element of a crisis? How can civilian "green cell" or non-governmental "yellow cell" models be refined to better represent the constraints and choices faced by real stakeholders? This presentation explores an established suite of "social wargaming" methods, developed by blending ethnographic research practice with wargaming techniques, to produce deeper understandings of situated knowledges, decision-making processes, and the emotional and moral stakes of humanitarian crises. We bring a humanitarian lens to the intertwined arena of global security and humanitarian response, bringing external insights to the OR&A community on questions of HADR operations, "security as acceptance", and coordination between humanitarian and military actors.

Matthew Stevens is Director of Lessons Learned Simulations and Training, an Ottawa-based professional development training firm for humanitarian and development workers. Through his work at LLST, Matthew develops simulations which require participants to step into the shoes of a wide range of stakeholders, to consider the unfolding of a crisis or intervention from different points of view. Matthew has worked with refugees and migrants globally since 2008, from downtown Cairo to the Peruvian Amazon. Before returning to Canada, he served as Country Director for an INGO in Amman, Jordan, delivering online higher education to displaced youth.

Stream – Wargaming

WG 1-3: Analytical Wargaming in Support of NATO's Military Deterrence Response Options
Author: Ms Dani FENNING (HQ SACT)

Confronted by a rapidly evolving threat spectrum NATO has reinforced the commitment to deter and defend against any threat of aggression and against emerging challengers. Reinforcing the core commitment to deter and defend cannot be to simply dust off the Cold War playbook, novel concepts must be developed. NATO has been developing the Military Deterrence Response Options (MDRO) construct to support the development of military advice on deterrence response options to the North Atlantic Council. Novel ideas such as the MDRO construct can best be supported by analytical wargames. Wargaming can help to explore new ways of conducting deterrence activities, challenge assumptions, identify information requirements and test the way NATO works with non-NATO stakeholders. Allied Command Operation's inaugural deterrence matrix wargame was designed to analyse the MDROs amongst the complexity of an adaptive system of state and non-state actors. Matrix games are generally well suited for complex issues involving multiple actors, interests and agendas across political, military, economic and social dimensions; ideal for deterrence. The three scenarios developed for this wargame allowed limited through to robust options for deterrence to be challenged within the Baltic region, across multiple threats, domains and geographical locations. This paper explores the utility of a matrix wargame in support of NATO's MDRO construct, presenting lessons identified and a proposal for expanding NATO's deterrence wargaming toolbox.

As a NATO International Civilian Senior Operations Research Analyst, Ms Fenning currently provides impartial analytical advice in support of 4* Supreme Allied Commander Transformation's decision making. Ms Fenning is responsible for the analysis in support of NATO's "Enabling Coherent Deterrence" concept development. Ms Fenning is also responsible for the analysis of Alliance Land Command and Control capabilities, in order to evaluate options and alternatives to existing warfare conduct, plans and capacities. Ms Fenning has previously served in the UK MoD as a senior deployable operational analyst, embedded into HQ ARRC. Ms Fenning was awarded the Member of the Most Excellent Order of British Empire Medal after deployments to ISAF Joint Command and Regional Command South HQs in Afghanistan as an operational analyst.

WG 2-1: Eliciting opponent behavior using gamified online research
Authors: Mr. Rudy BOONEKAMP (TNO), Mr. Vladimir Hazeleger (TNO), Dr. Lucia Tealdi (TNO), Dr. Helma VAN DEN BERG (TNO), Dr. Bob VAN DER VECHT (TNO)

Recent conflicts, such as the conflict in the Donbass region of Ukraine, the Syria civil war propagated by ISIS or the Venezuelan conflicts, have been characterized by the simultaneous use of conventional and unconventional means. The novelty and complexity of the modus operandi require us to acquaint ourselves with the drivers behind these various behaviours. To counter or prevent undesired behaviours, such as violent extremism, enhanced understanding of what motivates these actors is necessary. To increase our understanding of the drivers behind the variety of behaviors, TNO is developing the Opponent Immersion Game (OIG). The goal of this game is to gather data on the drivers of conflict on an

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individual level, which is then combined into group level behaviours. Participants are immersed in a virtual narrative, in circumstances that trigger radical actions. Based on the choices the player makes in this virtual world, we not only learn about the implications and interplay of needs, beliefs, attitudes and emotions on the behavior of conflict actors, but also how group behaviors are affected by individual actions. In addition, the OIG provides for opportunities to engage in experimental research. By using an online crowd-sourced research platform, data can be quickly gathered, analyzed and integrated into new models of opponent behaviour. The paper addresses the game design, the use of an online experimental platform and preliminary results of experimentation.

Rudy Boonekamp is scientific researcher at the Training and Performance Innovations department at TNO. He is a simulation and serious gaming expert and specializes in design and research of interactive technologies for education, training, concept development and experimentation.

WG 2-2: Wargaming reachback support to military headquarters planning processes
Authors: Mr Håvard FRIDHEIM (FFI), Mr Stein MALERUD (FFI)

The lack of relevant, reliable, processed and structured information is a recurring challenge for military operations planning. This is a particular issue for headquarters that have low embedded OR&A capabilities to support information collection and analysis. The HQ may request these services from organizations that are located remotely or not forward deployed, i.e. reachback, but there are several practical issues that must be overcome for a remote capability to be useful in the supported HQ's battle rhythm. Wargaming is widely used to support COA development in operations planning. The technique has many possible additional uses in the planning process, e.g. to answer questions during knowledge development, test planning assumptions or provide input to risk assessment. However, several factors may limit the HQ's ability to run games on its own, e.g. little available time, limited access to relevant computer systems/models, or little available gaming and/or subject-matter expertise. We describe how the HQ can overcome these issues by using OR&A reachback capabilities to run wargames remotely, in response to the HQ's emerging information requirements during the operational planning process. We discuss the challenges, pros and cons of this approach, and we identify success criteria for timely and relevant wargaming reachback support.

Håvard Fridheim is an MSc in experimental physics. He is a principal scientist at the Norwegian Defence Research Establishment (FFI). and worked in the fields of military operational planning, civil military cooperation, societal safety and security, and critical infrastructure vulnerabilities, and he often provides analysis support to military headquarters during exercises. Primary areas of interest in OR include scenario development, wargaming, risk analysis and soft OR/problem structuring methods. He is currently responsible for a project on wargaming support to the strategic military and political level.

Stream – Wargaming

WG 3-1: Best practices on the combination of qualitative and quantitative modelling

Authors: Dr Pilar CAAMAÑO SOBRINO (STO CMRE), Dr Alberto TREMORI (STO CMRE), Ms Lucia GAZZANEO (STO CMRE), Mr Wayne BUCK (HQ SACT)

NATO aims at developing a concept for the elicitation of actionable insights, which are the result of extensive data analytics and processing. Actionable insights enable to draw conclusions to make better informed decisions, providing analysts and planners with the ability to confirm suppositions, refute or challenge knowledge and quantify the outcomes of decisions. The elicitation of actionable insights requires the combination of subjective and objective knowledge. Subjective knowledge depends on individuals' experiences and interpretations, whilst objective knowledge is independent of individuals' preferences and it is purely based on facts. NATO is analysing the benefits of combining qualitative and quantitative wargames supported by computer based Modelling and Simulation. On the one hand, qualitative wargames encourage discussion taking advantage of out-of-the-box thinking of the participants. They help on the development of narrative and alternatives, assisting a more subjective analysis of "what-if" scenarios. Whilst, quantitative wargames allow for a more comprehensive coverage of the problem space, helping operational analysts on the generation of data for a more objective investigation of "what-if" scenarios. The investigations carried out help on the identification of the elements of the two different approaches which complement each other, boosting their strengths and overcoming the drawbacks of their stovepipe application.

Pilar Caamano is a Computer Scientist with a PhD in Computer Science and Artificial Intelligence. Her research activities have been focused on the application of Computational Intelligence techniques and M&S approaches, mainly in the maritime domain. She has been a member of the Integrated Group for Engineering Research at the University of A Coruña (Spain) from 2006 to 2016. Currently, she is an M&S scientist at NATO STO CMRE working on projects related to the use of M&S in its wide area of application: support to VV&A, CD&E, Analysis, Planning, or Wargaming.

WG 3-2: An analytical wargaming approach to cyber deterrence

Author: Dr Abderrahmane SOKRI (DRDC)

Cyber risk is one of the most serious challenges the NATO nations are currently facing. Its impact can immediately or gradually harm a nation safety and reputation. Deterrence strategies may be used to protect defenders from cyber threats. Deterrence dissuades would-be attackers from committing unwanted behavior by manipulating their cost-benefit analysis. Deterrence in the cyber domain is very complex and faces many enduring problems. The most challenging of them is the attribution dilemma. An analytical wargame is designed in this paper to show that cyber deterrence is possible if conducted properly. A metric derived from data gathered in-game is employed to characterize the effectiveness of different cyber deterrence strategies. This paper builds a bridge between game theory and wargaming. It also shows that wargaming reasoning is well-suited to cyber defense problems.

Stream – Wargaming

Abderrahmane Sokri has a Ph.D. in Administration from HEC-Montreal and a Master degree in Economics from the University of Montreal. He also received a Master degree in Applied Economics and Statistics from the National Institute of Statistics and Applied Economics (Morocco). He served as economist for many organisations including the Canadian Department of National Defence. He taught economics and statistics at many universities including HEC-Montreal. His current research interest includes game theory applied to cyber deterrence and wargaming. He has published in high-level international journals such as European Journal of Operational Research and Defence and Peace Economics.

WG 3-3: OR games for the acquisition of deployment spares packages for military aircraft operations

Authors: Mr Koen VAN DER ZWET (TNO, UvA), Mr Wouter NOORDKAMP (TNO)

In this paper we address the application of OR game theory to enable the analysis of possible cooperation strategies for inventory access of military equipment. This is particularly important in a changing security environment wherein the readiness of equipment needs to be guaranteed at a minimal cost or risk. We introduce our analysis method for cooperation strategies with the example of determination of spares packages and availability of air fleet capacity for deployment of an upcoming air force operation. While these spares packages are optimized nationally, depending on the fleet size, expected fleet use and objectives on availability of weapon systems, collectively nations can reduce the overall costs through cooperation in the procurement and maintenance of spare parts. By applying an OR game theory approach, the benefits and disadvantages of possible cooperation strategies in a coalition can be analytically found. In particular we examine strategies for sequential and simultaneous usage of shared spare packages and analyze the characteristics of the resulting OR games to identify the implications for cost saving coalition formation. The potential of this approach will also be demonstrated for an application in the intelligence area to provide insight into the possible IED adversary strategies. In particular, we examine strategies of different insurgent groups to ensure production of IEDs and identify the implications of these strategies in terms of risks and availability. These two application examples show the potential of the application of OR Games to analyze perceived cooperation opportunities.

Koen van der Zwet is a PhD student at the University of Amsterdam and TNO in the Netherlands. His research focusses on the emergent behavior of insurgent organizations. During his research he is interested in complex systems modelling and analysis, data science projects and applications of operations research.

Training

Esri ArcGIS Training Workshop.

Mr Pierre BILODEAU, Mr Bryan LADDS

ArcGIS is a complete GIS software platform that connects people, locations and data using interactive maps. Using the cloud-based ArcGIS Online software, you will learn how to create interactive web maps from multiple sources and use web applications to visualize and analyse (big) data to answer complex queries and make smart decisions. Using Esri Story Maps, you will combine maps with narrative text, images, and multimedia to create compelling, user-friendly, and convincing web apps. You will then learn how to publish your geospatial products to an ArcGIS Online organizational site or Enterprise portal website for more effective collaboration and shared situational awareness. Come see what others can't. Workshop Facilitator: Pierre Bilodeau, Industry Manager Defence and Security, Esri Canada ArcGIS Instructor: Bryan Ladds, Technical Solutions Specialist, Esri Canada To attend this training, you accept that your Name and Email is provided to Esri Canada in order to create a named user account for ArcGIS online. Own device is needed with WiFi and:

- Google Chrome (best performance, recommended)

or

- Microsoft Edge
- Microsoft Internet Explorer 11 or higher
- Mozilla Firefox
- Safari

Pierre Bilodeau joined Esri Canada in 2008 as the Industry Manager responsible for business development in the Defence and Security sectors. Pierre retired from the Canadian Armed Forces in April 2008 after 32 years of service as a Military Engineer Officer, including 18 years with the Defence Geospatial community. Pierre holds a B.Sc. in Civil Engineering from the Royal Military College in Kingston and a Post Graduate Diploma in Surveying Engineering from the University of New Brunswick. He is a graduate of the Land Force Command College and Canadian Forces Command and Staff College

Bryan Ladds joined Esri Canada in the fall of 2017 after completing a graduate degree in GIS at Algonquin College in Ottawa. He began with the Esri Canada's associate program and developed his technical expertise working with the ArcGIS Desktop and Enterprise support teams as well as the corporate Marketing department. In September 2018, Bryan was transferred to the National Capital Region Defence and Security team as their Technical Solution Specialist, responsible for pre-sales demonstrations and provision of technical advice.

Training

Introduction to ELICIT

Dr David S. ALBERTS

ELICIT is the acronym for the Experimental Laboratory for the Investigation of Collaboration Information–sharing and Trust. ELICIT is a flexible, DoD CCRP-developed, instrumented, on-line, multi-user environment with a set of analysis tools and a Community of Interest (CoI) that has supported the C2 research, CD&E, and education communities. ELICIT can be employed with humans-in-the-loop, software agents that have been developed to stand-in for humans or acting as non-human intelligent support or collaborators, and with mixed teams. ELICIT is also well-suited to support the Cyber research and operational communities as well.

ELICIT was undertaken in order to encourage and facilitate the exploration and understanding of new, network enabled approaches to command and control and the factors that enable or inhibit their effectiveness, efficiency and agility. ELICIT was designed to identify the appropriate C2 Approach as a function of mission challenges and cyber-related capabilities under a variety of circumstances including a cyber contested environment.

ELICIT experiments and analyses have been undertaken at a variety of military and civilian institutions including: Army Research Laboratory, Air Force Research Labs, Naval Postgraduate School, West Point, Naval War College, National Defence University, Harvard Business School, Boston University, George Mason University, and military schools and/or research labs in the UK, Canada, Portugal, Singapore, Germany, and Chile. Currently SAS-143 is using ELICIT to explore a variety of hypotheses related to Multi-Domain C2.

This session provides an introduction to ELICIT's capabilities, examples of how it can be configured, and how is has been employed to explore various C2 and Cyber-related hypotheses.

Dr. David S. Alberts is a Senior Fellow at the Institute for Defense Analyses. 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. This extensive applied experience was augmented by a distinguished academic career in Computer Science and Operations Research and Government service in senior policy and management positions. Dr. Alberts' experience includes serving as a CEO for a high technology firm specializing in the design and development of large, state-of-the-art computer systems (including expert, investigative, intelligence, information, and command and control systems) in both government and industry. He also led international teams. Currently he chairs NATO Research Task Group SAS-143, a research group focused on Multi-Domain C2. Prior to this he chaired NATO Research Task 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.

Training

A Multi-Domain Wargame - participate in a hybrid between conventional wargame, matrix gaming (argument games), and serious games

Dr Altan OZKIL, Mr Levent Berke ÇAPLI

NATO's Strategic Foresight Analysis (SFA) identified urbanization as a key trend with the potential to significantly impact NATO. The current rapid pace of urbanization and a lack of effective governance in large and mega-cities (urban population greater than 10 million) are expected to be a source of instability, with the resiliency of urban areas becoming a national security issue for many nations. The United Nations estimates that urban areas worldwide will absorb 3 billion new people over the next 30 years. Also, a new fifth domain is being introduced to the multiple dimension urban environments. This 5th Domain encompasses the information space that includes cyberspace, electromagnetic spectrum, and the information environment. Multi-Domain Operations calls for cracking open high-tech defences with relentless, coordinated attacks from every domain of conflict: land, air, sea, space, cyberspace, as well as the electromagnetic spectrum as well as an information environment. This gives rise to a new military problem: How should NATO forces be trained, organized, and equipped to comprehensively understand, execute and sustain joint operations, and create desired effects across the multiple dimensions of increasingly complex and dynamic urban environments?

U.S.A. National Defense Strategy stated that professional military education has stagnated, and demanded more history instruction, as well as directed a move to a 'great powers' intellectual paradigm. Learning through gaming is rising as a strong alternative to classroom one-way learning. Ever increasing wargames and serious game applications are testing this new notion. The STO Research Task Group SAS-129 is developing a Multi-Domain Wargame that is a hybrid between conventional wargame, matrix gaming (argument games), and serious games. The purpose of this effort is to change the current military mind-set towards more multi-domain approach and enable a motivational learning environment for non-technical personnel on the use of cyberspace in the near future operations.

The wargame is played by two teams Red and Blue with four sub-groups, with approximately two persons each sub-group. The four sub-groups represent the Tactical (Battalion) Commander, Joint Staff, STRATCOM Office and Cyber Command. Finally, the city is a green/white cell which is a non-playable character reacting to the team's activities. All of these groups need to coordinate their activities both before and during the conflict. SAS-129 has already conducted demonstrations and prototype testing of the game at the National Informatics Congress in Ankara, Turkey, Command and Staff College of the German Armed Forces Hamburg, Strategic Reconnaissance Command Grafschaft, Germany, Turkish General Staff Partnership for Peace Training Centre, Ankara and Land Training Centre, Amersfoort the Netherlands. For experts who have a knowledge or background in Tactical and Operational Level Urban Operations, STARTCOM, PSYOPS, Cyber Security, Electronic Warfare and military planning, the team will conduct a one-day workshop where participants will learn about and play this new serious game.

Training

Dr Altan OZKIL graduated from Turkish Military Academy in 1986. He received his master degree on Operations Research from Naval Postgraduate School of USA and his doctorate degree on Industrial Engineering from Gazi University. Altan Ozkil, who is one of the founder of Turkish General Staff Headquarters Scientific Decision Support Center, spent almost all of his military career in this centre. He retired as colonel from Turkish Armed Forces in 2009. He, who worked for one year in Manpower Analysis Department of Canadian Ministry of Defence, has been teaching courses on Decision Making, Systems Engineering, Modeling and Simulation, Cost Analysis and Management, Human Resources Management etc. for 20 years. He is currently the Director of Atılım University Defence Technologies Research Center which he founded in 2011 and Deputy Director of Atilim University Civil Aviation School.

Levent Berke CAPLI completed his undergraduate program at Essex University in the field of "Economics and Political Science". During his undergraduate studies at Essex University, he participated in the "Peace and Conflict Studies" program at the University of Haifa in Israel as an exchange student. In 2013, he started to work as a system engineer at the R&D department in an IT Company. In 2014, he started his Master's program on Technology Management in Turkish Military Academy. In 2019, he completed his master program in Technology Policies at the Middle East Technical University working on his thesis titled "Serious Game Development Methodology Based on Behavioral Economics and System Engineering". In 2017, he has been coordinating the award-winning civil movement campaign titled "KizBasina" which aims stopping violence and hate speech towards women in Turkey. Since 2015, he has been acting as a Research Task Group Chair on Serious Game Development for Cyber Defence and Resilience at NATO Science and Technology Organization. His work focuses on developing Multi-Domain Wargame for future officer training.

Training

Wargaming Best Practices course - examine the use of wargames and otherserious game techniques for operations analysis and capacity-building.

Prof Rex BRYNEN

This one-day course will examine the use of wargames and other serious game techniques for operations analysis and capacity-building. Sessions will explore:

• Why game? The use of wargames as a research methodology
• The wargamer's tool kit: approaches and techniques
• Game design
• Game control and facilitation
• Game analysis

The course will be taught by Rex Brynen, professor of political science at McGill University and editor of the conflict simulation website PAXsims (http://www.paxsims.org).

Professor Brynen has taught wargame design for NATO ACT and the UK Defence Science and Technology Laboratory as well as in courses at McGill and Carleton universities in Canada, and has worked closely with Defence Research and Development Canada in developing wargame techniques. He has also designed and facilitated games for a variety of other government departments, UN agencies, and others. He is organizer of the annual Connections North professional wargaming conference in Canada, and has served on the advisory board for the Connections US and Connections UK conferences too. In addition to his work on serious games, he is also author or editor of a dozen books on various aspects of political development

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Floorplan

Main Auditorium

Foyer

Breakout room 2 – Sheila Watson room (154)

Breakout room 1 – Leslie McFarlane room (156)

Lunch Area

Wellington Street

Building Entrance