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

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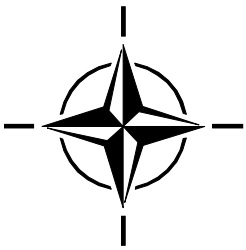
Conference Booklet



2018 NATO OR&A Conference
Abstract Booklet

Sunday	Title	Location
1900-2100	Pre-Registration	Ballroom Foyer
Monday	**Title**	**Location**
0800-0830	Registration	Ballroom Foyer
0830-0900	Welcome: • BGEN Primdahl, Assistant Chief of Staff Requirements Division, NATO Allied Command Transformation • COL Slobodan Čurčija, Dean of Croatian Defence Academy • Mr. Han de Nijs, Conference Co-Chair, NATO Allied Command Transformation • Ms. Jackie Eaton, Conference Co-Chair, NATO Science & Technology Organisation	Section B, Grand Ballroom
0900-0915	Admin	Section B, Grand Ballroom
0915-1000	**Keynote 1: OR - on a cyber perspective [Brigadier General Fleischmann, Cyber & Information Domain Command, Germany]**	Section B, Grand Ballroom
1000-1030	Break (refreshments)	Ballroom Foyer
1030-1200	Stream – Cyber 1 C-1-1 Understanding Strategic Level Decision Making in the Cyber Domain C-1-2 A Knowledge-Based Model for Assessing the Effects of Cyber Warfare C-1-3 A Collateral Effects Estimation Framework for Non-Munitions Targeting Analysis	Section B, Grand Ballroom
	Stream – Logistics 1 L-1-1 Strategic Lift modelling within Defence Planning L-1-2 Gamification of Integrated Logistic Support Training L-1-3 Research of resilience in an Initial Operation	Section A, Grand Ballroom
1100-1200	Workshop – Communicating Benefits of OR&A	Section C, Grand Ballroom
1200-1300	Break (lunch)	Fontana Restaurant
1300-1430	Stream – Other 1 O-1-1 Analytical Wargaming O-1-2 Mastering the Littoral O-1-3 Child Soldiers in the Cyber Domain	Section B, Grand Ballroom

	Stream – SAS-110 Operations Assessment SAS-110-1 Operations Assessments with a Decision Action Focus SAS-110-2 Assessment Gaps in NATO SAS-110-3 Red Teaming and Operations Assessments	Section A, Grand Ballroom
1300-1530	Training – SIMUL8	Section C, Grand Ballroom
1430-1500	Break (refreshments)	Ballroom Foyer
1500-1630	Stream – Other 2 O-2-1 Technology Assessment in future Alliance Operations (TAO) O-2-2 Rethinking the Assessment of NATO Operations O-2-3 Threatcasting: Preventing Strategic Surprise	Section B, Grand Ballroom
	Stream – Analytics 1 A-1-1 Data Collection & Management (DC&M) for Analysis Support to Operations A-1-2 Getting Grip on Big Data with Autonomous Multi-Source Analysis A-1-3 ORBAT Planning by Methods of Operations Research	Section A, Grand Ballroom
1530-1630	Workshop – Communicating Benefits of OR&A	Section C, Grand Ballroom
1630-1730	**Keynote 2: Analytics and Data Lakes [Roy Hasson, Amazon Web Services]**	Section B, Grand Ballroom
1730-1900	Icebreaker	Piano Bar

Tuesday	Title	Location
0830-0930	**Keynote 3: New developments in logistics [Professor Rommert Dekker, Erasmus School of Economics, The Netherlands]**	Section B, Grand Ballroom
0930-1000	Plenary: Logistics L-2-P Operational Analysis Support to Development of NATO Global Support Hub Concept	Section B, Grand Ballroom
0930-1200	Training – Alternative Analysis (AltA)	Section C, Grand Ballroom
1000-1030	Break (refreshments)	Ballroom Foyer
1030-1200	Stream: Logistics 2 L-2-1 Stochastic Mixed-Integer Programming for a Spare Parts Inventory Management Problem L-2-2 Recommendations on the adoption of Modelling and Simulation for analysis and decision making support for Deployment Planning L-2-3 Rail Gauge Logistical Challenges in 21st Century Rapid Deployment and Reinforcement	Section B, Grand Ballroom
1030-1200	Stream: Analytics 2 A-2-1 Internet of Things and Machine Learning for Information Operations Targeting A-2-2 Concept of Conventional Threshold A-2-3 Tackling Combinatorial Explosion in Force Design	Grand Ballroom – Section A
1200-1300	Break (lunch)	Fontana Restaurant
1300-1430	Stream: Cyber 2 C-2-1 Approaches to implementing joint Cyber Defence Situational Awareness C-2-2 How the NATO Alliance can get offensive in the cyberspace domain C-2-3 JUMP: Tactical Cyber Mission Planning	Section B, Grand Ballroom
	Stream: Analytics 3 A-3-1 Analyzing metamodels to make sense of large scale simulations in a military context A-3-2 A Method for Repeatable Data Collection and Assessment of Communications Interoperability A-3-3 Tackling complex Anti Access Area Denial environments using multi-national modelling and analysis	Section A, Grand Ballroom
1430-1500	Break (refreshments)	Ballroom Foyer

1500-1630	Closing Remarks Part 1 - Dr. Pavel Zuna, Director, NATO STO Collaboration Support Office Awards Communicating Benefits of OR&A Closing Remarks Part 2 - Mr. Han de Nijs, Conference Co-Chair, NATO Allied Command Transformation - Ms. Jackie Eaton, Conference Co-Chair, NATO Science & Technology Organisation	Section B, Grand Ballroom
1630	Conference Closure	

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Opening & Closing Speakers

Brigadier General Poul Primdahl, Danish Army, 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.

BGen Primdahl is for 25 years married to Linda and they have three children, a daughter of 23 (Ellen) and two sons of 21 and 17 (Jens and Lars). His interests include fitness level swimming and running, skiing, traveling with the family and current affairs. BGen Primdahl was in 2011 awarded Knight of the Danish Order of the Dannebrog.

Ms. Jackie Eaton, Conference Co-Chair, NATO Science & Technology Organisation

Jackie has been the Science & Technology Advisor in the NATO STO Office of the Chief Scientist at NATO HQ since 2016. She leads production of the STO Technology Trends Reports, co-chairs the NATO Operational Research & Analysis Conference programme committee and co-chaired the SAS-111 study on Data Collection and Management for Analysis Support to Operations. From 2006 to 2016 she was the Senior Operational Research Analyst at NATO Joint Analysis and Lessons Learned Centre (JALLC). Before joining NATO, she spent 3 years as an analyst at Dstl, UK. She has an Operational Research Masters from the University of Southampton.

Mr. Han de Nijs, Conference Co-Chair, NATO Allied Command Transformation

Mr. Han de Nijs is Branch Head Operational Analysis 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, Anti-Access and Area Denial (A2AD) amongst others. He is the program lead for the Alliance Future Surveillance and Control (AFSC) capability requirement. The NATO Command Structure review will convert the Operational Analysis Branch into the Analysis of Alternatives (AoA) Branch, and with that the Branch will perform Capability Requirements, Solutions and Risk Analysis using the AoA approach and methods. Currently, Land C2, SOF C2, Maritime Facilities are three projects in which AoA Branch is involved. Mr. de Nijs is well connected with the NATO national analysis communities. He is the principle member for ACT in the NATO Science and Technology Systems Analysis and Studies Panel.

Colonel Slobodan Čurčija, Dean of Croatian Defence Academy "Dr. Franjo Tuđman"

Colonel Slobodan Čurčija graduated from the Faculty of Economics and Business in Zagreb, defending his master's degree in management, focusing on human resources management. He was actively involved in the development of curricula for the training of the Logistics Officers of the Croatian Armed Forces in the Specialist Graduate Study in Logistics Systems and Process Management, Velika Gorica Polytechnics (VVG). Col. Čurčija developed the curriculum of Human Resources Management for a Specialist Graduate Diploma in Management of Logistic Systems and Processes. He also regularly updates the curriculum, the performance plan and the constructive alignment of the learning outcomes for the subject. In the academic year 2010/2011, he gave lectures on Human Resources Management at the Specialist Graduate Professional Study Logistics Systems and Process Management, VVG. He attended the course in the academic year 2015/2016. Additionally, he is a mentor to students at the VVG study in question. Col. Čurčija participates in the development of professional projects in the field of logistics, training and the development and updating of the curricula and programs of the University Study Programs conducted at the Croatian Academy of Sciences "Dr. Franjo Tudjman" (HVU) in Zagreb.

In the academic year 2015/2016, Col. Čurčija conducted a seminar course in the subject "Military Leadership", in the Military Engineering and Military Management and Management Programs. Col. Čurčija lectures in the functional area of logistics and human resource management at the third and fourth level of military education. He has attended the highest levels of military training at the War School, and accordingly, during the academic year 2014/2015, mentored two attendees. He has been elected lecturer in the field of social sciences, field of security and defense science. He has participated in crisis management conferences where he presented three professional papers. He has a total of five professional and one scientific papers.

Prior to being appointed Dean at the Croatian Defence Academy, Col. Čurčija has also served as: Vice Dean for Development and Cooperation at the Croatian Defence Academy; Logistic Division Chief (CJ4) Deputy at HQ ISAF; Logistic Department Chief at GS CAF, CJ4 Directorate; and as the Logistic Division Chief in the Deanery Office of the Croatian Defence Academy.

Dr. Pavel Zuna, Director, NATO Science & Technology Organisation Collaboration Support Office

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. He represented the Czech Republic Ministry of Defence on the NATO STO System Analysis and Studies (SAS) Panel where he served as Vice-Chairman and Chairman from 2014 to 2018. 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.

Programme Committee

Mr. Han de Nijs

Conference Co-Chair & Operational Analysis Branch Head

NATO Allied Command Transformation (ACT)

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Chief Operational Analysis

NATO Communications & Information Agency (NCIA)

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Operational Analyst

NATO Allied Command Transformation

Mr. Ben Taylor

Leader – Strategic Planning Operations Research Team

Defence Research and Development Canada (DRDC)

Col. Andrija Kozina

Officer for Sciences and Development

Croatian Defence Academy

Keynote & Plenary Speakers

KN1 OR - on a cyber perspective

Brigadier General German Air Force (GAF), OF-6, Armin Fleischmann (Director Plans and Policy Directorate at Cyber & Information Domain Command, Germany)

This talk will introduce new cyber command and digitalization as a game changer. Afterwards there will be a discussion on different NATO SAS activities and their relevance for branches of our Cyber and Information Domain Service. Topics will be include cyber security, artificial intelligence and big data.

Brigadier General Armin Fleischmann *joined the Federal Armed Forces (Air Force) in July 1983 and was trained as an electronic warfare und reconnaissance Officer and IT-Officer. Holding increasingly senior roles until 2015, including deployments as Chief CJ6 and responsible for Afghan mission network at ISAF, he became deeply involved in the build-up of the new cyber and information domain responsible for the new MOD Division for Cyber/IT in Berlin and Bonn. With the announcement of the new Cyber Information Domain Command in April 2017 in Bonn, Armin became the Director of the Plans and Policy directorate.*

KN2 How to successfully deploy a data lake on AWS

Roy Hasson (Amazon Web Services (AWS) Global Business Development Manager, Analytics and Data Lakes)

With the explosion of both structured and unstructured data, there has been great opportunities to derive new insights, but also some key challenges faced by customers and key lessons learned from those solutions. In this session, we will scope down to the top five key challenges and lessons learned we've seen and how customers, using the AWS Cloud, have solved those challenges.

Roy Hasson *is a Global Business Development Manager for Analytics and Data Lakes at Amazon Web Services, where he helps transform organizations using data. Roy serves as an expert resource on big data architectures, data lakes and machine learning. Previously at AWS, Roy served as a Technical Account Manager leading strategy and supporting implementation of data architectures with customers. Prior to AWS, Roy spent 15 years in the service provider space designing and deploying large data and telephone network systems.*

KN3 New developments in logistics

Professor Rommert Dekker (Professor of Quantitative Logistics and OR, Erasmus School of Economics, The Netherlands)

Data science and optimisation are driving logistics and transportation to new peaks. In this presentation we sketch some new developments in logistics and especially those where data science and optimisation play a role. We start with service logistics, that is the logistics after the sale of goods. Companies are discovering more and more the profitability of this sector. On the other hand it also poses other problems

than standard logistics. We present results from a 15 year cooperation with leading international companies. We will discuss new contract forms, installed-base approaches and control towers, with a side step to the F35 service chain. Next we discuss 3D printing options for spare parts and data science approaches in maintenance and service logistics: the value of good data is often not well understood, especially in the acquisition of systems. On the other hand it will form the basis of learning and improving operations. Predictive maintenance, based on condition measurement, is highlighted as one of the promising areas of data science, but despite some successes, it needs time to mature and to reap the benefits in the accompanying logistics. The final part of the presentation deals with container logistics, autonomous vehicles and maritime supply chains, where data science and optimisation approaches are becoming more and more popular.

Rommert Dekker *is a full professor of Operations Research and Quantitative Logistics at the Erasmus University Rotterdam. After his PhD in mathematics he joined Shell Research Lab in Amsterdam, working on refinery logistics and maintenance optimisation. A two year job as refinery-analyst at Shell International followed before he took a professorship at the Erasmus School of Economics in 1992. Since then he has been active in research on ports and maritime logistics, on reverse and service logistics as well as supply chain management and maintenance optimisation. He was one of the founders of reverse logistics, leading an EU project on the topic in mid-nineties and helping companies to improve the management of their return streams. He has worked extensively with companies, e.g. ECT container terminal, Fokker Services, NS Railways, Maersk Line, Shell, IBM, Ortec Consultants as well as TNO Research in a variety of optimisation projects. He has supervised over 34 PhDs and over 200 MSc students and has published over 150 papers in ISI journals, including top journals like Management Science, Transportation and Production and Operations Management.*

Plenary – Logistics

L-2-P Operational Analysis Support to Development of NATO Global Support Hub Concept
Mr. Scott Joyce (NATO Communication and Information Agency (NCIA))

In 2013-15 timeframe, NATO undertook work to develop the Global Support Hub Concept (GSHC). This work was conducted in three main phases: Phase 1: Identification of hubs to serve as staging areas for potential Alliance operations conducted at strategic distances. Phase 2: Evaluation of national infrastructure at each of the identified hubs to select the preferred locations for logistic support hubs based on technical factors. Phase 3: Consideration of political factors and hub selection. The aim of this presentation is to summarise the Operational Analysis (OA) support provided to Phase 1 and Phase 2of this work. Specifically, it discusses: The method developed in Phase 1 to support military decision makers in identifying a list of candidate hubs for further down-selection in Phase 2; The method developed in Phase 2 to support the technical assessment and subsequent down-selection of hubs to be taken forward to Phase 3.

Scott Joyce *has worked for the NATO Communication and Information Agency (NCIA) since 2004. He works as a Senior Scientist within the Operational Analysis Service Line (OA SL) primarily in support of the NATO Defence Planning Process (NDPP). He is the lead analyst providing support to the Enabling area of the NDPP, which covers all aspects of Deployment and Sustainment analysis, as well as Medical, Military Engineering etc.*

Stream – Cyber 1

C-1-1 Understanding Strategic Level Decision Making in the Cyber Domain

Ms. Melanie Bernier (Department of National Defence, Canada)

The complexity of cyberspace as an operational domain will bring challenges to the Alliance. Commanders need to have a clear understanding of basic concepts like cyberspace and its relationships to other operational domains, and the nature of offensive cyber operations and the effects they can produce. The outcomes of the NATO SAS-116 research intend to bring an understanding of decision-making modalities in the cyber domain to the Alliance. Decision making in the cyber domain is often perceived to be complex and different from decision making in traditional operational domains due to the unique challenges that cyberspace brings, such as speed, legal frameworks, partnerships, multiauthority, etc. As part of the research objective, group members attended multinational cyber exercises (Cyber Coalition 2016, Locked Shield 2017, EDA strategic decision making exercise in Athens in 2017) and conducted focus group sessions at the NATO Headquarters and SHAPE. The results of the observations collected throughout these events will be presented and recommendations will be provided for enhancing strategic level decision making within cyberspace. At the end of the day, the decision making process as we know it is not broken but it should be improved by understanding the information requirements at the different levels of decision making.

Melanie Bernier *is a Senior Defence Scientist with the Directorate of Science and Technology in Strategic Decision Support. She has a Master's Degree in Electrical Engineering and experience in modelling and simulation, concept development and experimentation, joint C4ISR, and cyberspace operations. She is the current chair for the SAS-116 Research Task Group on Military Strategic Level Decision Making within a (future) framework of Cyber Resilience and until recently, led operational research studies in force development for the cyberspace environment with Defence Research and Development Canada.*

C-1-2 A Knowledge-Based Model for Assessing the Effects of Cyber Warfare

Ir. Clara Maathuis, Dr. Ir. Wolter Pieters (Delft University of Technology, TNO Military Operations, Netherlands Defense Academy, Netherlands) & Dr. Ir. Jan van den Berg (Delft University of Technology, Netherlands)

Cyber Operations such as the ones in Georgia, Stuxnet or Ukraine demonstrated their (cap)ability to disrupt, sabotage or destroy ((ICT based) components of) systems and opened long global security debates. These incidents show that their effects cross geographic and digital borders, prove to be multi-domain and affect both military and civilian actors and systems. Although these incidents contributed to a global awareness and developments of different programs and strategies, limited attention is shown to understanding, classifying and measuring the effects of Cyber Warfare. This is of particular importance when planning, executing and/or assessing the effects of Cyber Operations. In order to cope with the dynamics, interconnectedness and evolving nature of cyberspace together with missing or incomplete data(sets) about targets and their environments, embedded under the umbrella of uncertainty and vagueness, we introduce a new Operations Analysis model as a knowledge-based model for assessing the effects of Cyber Warfare, nominated as Collateral Damage and Military

(Dis)Advantage. This model represents a (knowledge-based) simulation environment, is grounded on empirical research in the cyber and military domains and is implemented in Protégé. At the end, the model is evaluated by military experts and results are presented.

Ir. Clara Maathuis *is a PhD Researcher in Cyber Operations at Delft University of Technology, TNO Military Operations, and Netherlands Defense Academy, in the Netherlands. Her research focuses on Cyber Warfare, Artificial Intelligence, and Military/Defence Studies. She worked as a Senior Software Engineer in telecommunications and control systems industries in several international projects.*

Dr. Ir. Wolter Pieters *is an Associate Professor in Cyber Risk at Delft University of Technology, in the Netherlands. His research focuses on cyber risk management, human factors in cyber security, and philosophy and ethics of information security.*

Dr. Ir. Jan van den Berg *is full Professor in Cyber Security at Delft University of Technology and Leiden University, in the Netherlands. His research focuses on Data Analytics (theory and applications) and Cyber Security (cyber risk management, among others).*

C-1-3 A Collateral Effects Estimation Framework for Non-Munitions Targeting Analysis

A. Ghanmi, A.T. Legge, R.A. McCourt and L.D. Robertson (Department of National Defence, Canada)

Targeting is the process of selecting and prioritizing military targets and matching the appropriate response to them. Most often, targeting refers to selecting kinetic options for use against physical objects. Recently, there has been an increase in the importance of non-munitions targeting, which considers soft capabilities (e.g., Cyber) to achieve desired operational effects. A key aspect of non-munitions targeting is the Collateral Effects Estimation (CEE). While Collateral Damage Estimation for munitions targeting is well understood, CEE for non-munitions targeting has remained elusive due to the difficulty involved in defining what the various aspects of collateral effects might look like to non-physical objects, such as people's beliefs, software and online personas. This problem is further compounded by the fact that characterizations of effects need to be made in a manner that is not necessarily technical while still conveying the operational risk for the commander. In this paper, a CEE framework for non-munitions based targeting was developed and tested using illustrative targets during the Canadian Armed Forces (CAF) Joint Non-Munitions Effects Experiment (JNEX-2). JNEX-2 investigated the integration of offensive cyber operations into the CAF joint targeting cycle. A machine learning algorithm is being developed to implement the CEE framework.

Dr. Ghanmi *is a principal analyst at the Defence Research and Development Canada. His research includes concept development and experimentation, joint targeting, materiel acquisition decision support, supply chain modelling and analysis, operational energy, and risk analysis for defence acquisition. He has published over 100 papers in international referred journals and conference proceedings, and has authored numerous technical reports on military decision support problems. Dr Ghanmi has established various bilateral agreements with academia, national and international research & development organizations; chaired different NATO and TTCP research groups; and led and managed multiple research programs in the Department of National Defence.*

Stream – Logistics 1

L-1-1 Strategic Lift modelling within Defence Planning

Ms. Roxanne Evering (NATO Communication and Information Agency (NCIA)) & LTC Roland Cardoni (NATO Allied Command Transformation (ACT))

Developing requirements within the NATO Defence Planning Process (NDPP) consists of an initial structural phase to identify a pool of capabilities, followed by a second phase where scenarios are used to 'iteratively stress test' the pool to generate a Minimum Capability Requirement (MCR). The second phase is supported by analytical modelling of requirements. The NDPP has an established methodology to analyse the quantitative requirements for strategic air and sea lift capabilities needed to deploy forces into theatre. However, given the current strategic security environment, there is an increasing emphasis on the use of Inland Surface Transportation (road, rail, inland waterways) to support strategic deployments within SACEUR's Area of Responsibility and the NDPP methodology is currently being adapted to address this new aspect of strategic deployments. This presentation describes the current method used to generate strategic air and sea lift capabilities, the data required and discusses how the method differs from other available tools to determine Strategic Lift requirements. It then highlight show Defence Planners are currently adapting this method to capture the full spectrum of capabilities needed to support Inland Surface Transportation, including consideration of Transportation Network Infrastructure and qualitative issues such as military mobility across borders.

Roxanne *joined the NATO Communications and Information Agency (NCIA) Operational Analysis Service Line (OA SL) in early 2017 following a year of supporting the team as a contracted Consultant from CORDA, BAE Systems. Currently performing a range of analytical tasks to support the NATO Defence Planning Process (NDPP), primarily working within the Enabling domain.*

L-1-2 Gamification of Integrated Logistic Support Training

Mr. Levent Berke Çapli (Ankara Middle East Technical University, Turkey), Dr. Altan Özkil (Ankara Atilim University, Defence Application and Research Center, Turkey)

Contested and degraded environments has creates a whole new sets of considerations for logistic support. Integrated Logistic Support (ILS) is one of the key methods for calculating the real cost of logistic aspect of operations. From the perspective of NATO countries there are two major needs with regards to ILS. First, increasing the cooperation, awareness, and dissemination of ILS workforce training. Second, analyses ILS considerations for Rapid Reinforcement & Force Mobility in contested and degraded environments. This paper will discuss these issues in two parts. First part, will focus on the two-day course on ILS targeted to the defence industry, government employees and military personnel conducted by Turkish MoD, Defence and Technology Training Centre (DTTC).Survey results and the implementation of gamified training method that was implemented will be presented in this section. Second part will discuss modifying the training to include war-game elements to design a new concept of training that would allow for analyses practice of ILS considering contested and degraded environments.

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 center. He retired as colonel from Turkish Armed Forces in 2009. He, who worked for one year in Manpower Analysis Department of Canadian Ministry of Defense, 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. Dr. Ozkil is a member at large in NATO Science and Technology Organization Systems Analysis and Studies Panel where he is providing support on behalf of Turkey since 1999. He is currently a member of SAS-129 on Serious Game Development for Cyber Defence and Resilience and co-chairman of SAS ET-DW on Cost Analysis of Contractor's Price for Defense Research and Development Projects.*

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. At present he is a graduate student in Technology Policies programme at the Middle East Technical University in Turkey working on his thesis titled "Serious Game Development Methodology Based on Behavioral Economics and System Engineering". Since 2015, he has been acting as a Research Task Group on Serious Game Development for Cyber Defence and Resilience Chairman at NATO Science and Technology Organization. As the president of Technology and Innovation Association has been coordinating the award-winning civil movement campaign titled "Kiz Basina" which is aimed at stopping violence and hate speech towards women in Turkey.*

L-1-3 Research of resilience in an Initial Operation

Mr. Harry Hoffmann, Mr. Daniel Kallfas, Johann Christian Körber (Airbus Defence and Space GmbH, Germany), Björn Oliver Seitner (Logistikzentrum der Bundeswehr, Germany)

Sense making of complex systems is difficult because of their nonlinear, multi-dimensional, and interdependent nature. Modeling and simulation with subsequent analytics may be one suitable means to facilitate the sense making process. With the aim to investigate the resilience of an army equipment in e.g. an initial operation logistic discrete event simulation (DES) has been developed. In order to cope with different operations from a permissive to a contested or degraded environment a campaign generator was integrated. A substantial basis for this simulation are logistic data, e.g. data concerning maintenance times and loss rates by battle damage of the regarded army equipment. The challenge caused by the non-availability of these data can be solved by adapting data coming from e.g. a combat

simulation or may be supplied by expert's assessment .The aim is to indicate, under which circumstances the resilience of the army equipment can be achieved. The results could serve to prepare future missions in the above mentioned environments, and to provide recommendations for future equipment, training, logistic processes, maintenance capacities, or stocking of spare parts.

Daniel Kallfass *is expert for operational analysis at Airbus Defence and Space and has more than 10 years of experience as a project manager (PMP) for national, international and Airbus internal studies in the area of simulation-based and operational analysis, distributed simulations, training and machine learning. His main focus is requirements analysis, system design and realization of different simulation models and studies dealing with the development and application of simulation systems such as PAXSEM - especially in conjunction with the Data Farming methodology. He participated in multiple NATO modelling and simulation task groups such as NATO MSG-088 and 124 on Data Farming for NATO and MSG-136 and 164 on Modelling and Simulation as a Service (MSaaS).*

Mr Harry Hoffmann *is currently responsible for the department "National Studies Germany" in Airbus Defence and Space. He is accountable for various studies and internal risk mitigation activities. His Department works as a system house and seeks for synergies along the solution finding process among diverse initiatives, innovations, small and big projects from different domains. He considers technologies, processes or methods which belong to Operations Research, Modelling and Simulation, VR/AR or Capability Development/CONOPS to efficiently and holistically find the "right answer". Harry's personal and professional interests center around comprehension and improving the mutual understanding between Technology and People, Engineering and decision-maker.*

Stream – Other 1

O-1-1 Analytical Wargaming

Ms. Sue Collins (NATO Allied Command Transformation (ACT))

Analytical wargames are serious-but-fun games which can be used to explore problems that are particularly complex or wicked, create innovative ideas, or test potential alternative solutions. The games provide valuable data and evidence to support decisions on how to approach some of NATO's most difficult problems. A case-study will be presented of a game that was set in a future urban city in which territorial integrity has been comprised by an invading force. The case study will explore how the wargame was designed to play with an extremely complex environment with many independent actors, interlinked systems-of-systems and a wealth of conflicting information. The presentation will also include discussion of current problems faced by analysts when designing similar wargames, linking with a current SAS study –SAS-139 NATO Analytical War Gaming –Innovative Approaches for Data Capture, Analysis and Exploitation.

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, and is also experienced in facilitation, experimentation and wargaming. She has a degree in Management Science and eighteen years' experience of applying Operations Research to government and defence issues. Born in Shropshire, England, she now lives in Norfolk, Virginia with her husband Andrew and two young children.*

O-1-2 Mastering the Littoral

Mr. Guido Veldhuis & Mr. Bas Keijser (TNO, The Netherlands)

Urbanisation, littoralisation and connectedness, are the trends that will define the 21stcentury. Population is increasingly concentrated in coastal cities. Inhabitants are increasingly connected amongst each other and with the rest of the world. Urban destabilisation could make littoral operations in a contested and degraded environment a plausible reality in the near future. These changes to the environment demand integrated operations across the land, sea, air, space, cyber and human domain. This requires new concepts of operations, and thus new methods and techniques for sense making of the environment to support commanders in their decisions. NATO, and various member states are investigating how to conceptualise the future operating environment as a complex system. Our research aims to prepare OA methods and techniques for this future. First, aiming to make sense of a complex environment by understanding the 'flows' within the complex system that is the area of operations. Second, new concepts of operations aim for adaptive, dispersed and non-contiguous tactics to face future threats in this environment. Innovation in tactics requires innovations in the OA methods used to plan them. We are revisiting the methods used to plan operations to include these new constraints for course of action development and combat support.

Guido Veldhuis works in various domains with a primary focus on Defence. His work focusses on the development and application of methods and models to support decisionmakers, most notably the Dutch MoD. He develops (simulation) models and tools that support TNO's clients with the procurement of systems and the planning of operations. He has had a significant role in the development and application of the HOLON and MARVEL methods. Together with a strong team at TNO, he facilitates workgroups in which methods such as System Dynamics, Agent Based Modelling, MARVEL and Multiple-criteria decision analysis are used to tackle problems together with groups of stakeholders.

Bas Keijser has been working on various projects within the Defence, Safety and Security domain at TNO since 2016. His work focusses on the development of tooling for decision support and problem structuring, applying both quantitative and qualitative methods. Research projects include e.g. research on counterinsurgency and urban military operations, modelling and simulation of opponent group behaviour, uncertainty analysis of materiel project cost and planning, organized crime analysis and vulnerability assessment for radicalization.

O-1-3 Child Soldiers in the Cyber Domain

Mr. Dustin Johnson (The Roméo Dallaire Child Soldiers Initiative, Canada) & Mr. Ben O'Bright (Dalhousie University, Canada)

Incidents of children being recruited and used in cyber warfare are on the rise. In 2012, a twelve-year old Canadian was charged with participating in a series of cyber-attacks on provincial websites and ICT systems. The so-called Islamic State has been using social media to recruit disenfranchised children in Western countries. The United Kingdom has started cybersecurity recruitment programme known as Cyber Discovery, offering extracurricular training to children between ten and thirteen years old. While considerable attention has been devoted to understanding the dynamics and characteristics of cyber warfare, little attention has been paid to this involvement of children and youth. While the role of children in physical, kinetic warfare as child soldiers has been widely studied and recognized, it has created a narrative and set of definitional parameters that are ill-suited for war, conflict and terrorism in the cyber domain. The authors present the results of an initial scoping study on child soldiers in the cyber domain, discuss the methods most suited for its investigation by the OR&A community and the challenges involved, and suggest an initial set of questions for further exploration by the OR&A community. This new area of focus will help NATO members and partners understand and mitigate threats and protect children from harm as modern conflict and technologies evolve and shift.

Dustin Johnson *is a Research Officer at the Roméo Dallaire Child Soldiers Initiative based at Dalhousie University in Halifax, Canada. His research focuses on prevention of the recruitment and use of child soldiers, and early warning of mass atrocities. He holds masters and bachelor's degrees from Dalhousie University, and has previously worked in international development, wildlife conservation, and mechanical engineering.*

Ben O'Bright *is a PhD Candidate at Dalhousie University, in Halifax, Canada, where he studies anticipatory policymaking regarding emergent science and technology. With a Masters of Science from the London School of Economics and Political Science, Ben has worked as a researcher with the Centre on Governance at the University of Ottawa, Global Affairs Canada, United Nations University, the African Mineral Development Center, the United Nations Economic Commission for Africa, and the Qatar Foundation.*

Stream – SAS-110 Operations Assessment

OpsA-1 Operations Assessments with a Decisive Action Focus

Dr. Adam Shilling (Strategic Wargaming Division, Center for Army Analysis, USA)

Although doctrine and best practices exist for conducting assessments in long-term stability operations, the complexities of conducting an operational assessment in a fast-paced decisive action fight involving conventional combat, such as that represented in an Army Warfighter Exercise (WFX), can be a challenging endeavor. This paper outlines a framework for an assessment method for Army Corps and Division assessors as their organizations conduct decisive action operations. It explains a method to integrate the warfighting staff with the purpose of assessing the operation's plan. This method seeks to encompass the entire staff into the often least emphasized aspect of the operations process - assessment.

***Adam Shilling**, PhD, is a veteran infantryman with command experience from platoon to battalion. He has served in staff assignments in operations, intelligence, plans, and civil-military operations. He is also a veteran of two assessment tours—in Afghanistan and in the Horn of Africa. His observations on assessments resulted in his assignment to groups writing U.S. joint doctrine, and in his assignment to lead a NATO Panel, both on Operations Assessment. He has spent the past four years helping to write doctrine and providing advice to a variety of organizations. He has taught assessment in a number of venues.*

OpsA-2 Assessment Gaps in NATO

Dr. Ben Connable (RAND Corporation, USA)

NATO conflict assessment methods have improved considerably since the expansion of the alliances' international security engagements in the early 2000s. However, our examination of published articles, reports, and doctrine suggests that there is a dearth of published literature on conflict assessment and lagging integration of advanced assessment techniques into NATO doctrine and practice. Despite the persistence of irregular warfare, humanitarian assistance requirements, and stabilization missions, there now appears to be less interest in determining the pathways and outcomes of these conflicts through structured assessment methods. More can and should be done to translate NATO's resident expertise into general knowledge and practical application for the alliance.

***Ben Connable** is a senior political scientist at the RAND Corporation and a retired Marine Corps intelligence and Middle East Foreign Area officer. He focuses on irregular warfare issues and intelligence methodology, and also works on European regional, Middle East regional, and other warfighting issues in support of U.S. Department of Defense sponsors. Connable has an extensive background in military cultural terrain theory and application, having served as cultural advisor to general officers in Iraq and as the head of the Marine Corps cultural intelligence program. He is currently researching will to fight, the Russian military threat, and instability in the Middle East. Connable received his Ph.D. in war studies from King's College London War Studies Department, his M.A. in strategic intelligence from American*

Military University, his M.A. in national security affairs from the Naval Postgraduate School, and his B.A. in political science from the University of Colorado–Boulder.

OpsA-3 Red Teaming and Operations Assessments

Dr. Anton Minkov (Department of National Defence, Canada)

The paper demonstrates that operation assessments are not confined to formal assessment staff groups, nor they are as centralized as previously thought. Commanders realized the limitations of centralized assessment products, based primarily on quantitative metrics, and sought other sources to augment these products. Decision-support Red Teaming is one such capability that can complement operations assessments. Since the main challenge to any assessment process is whether it is measuring the right things in the right ways, Red Teaming could act as the independent reviewer of critical elements of the assessment process. Methodologically, Red Teaming offers a range of qualitative and contextual analytical methods to decision makers. The paper also provides examples of red teaming products that served as or informed assessment.

Dr. Minkov *holds a PhD in Islamic history from McGill University, and has written extensively on the Soviet experience in Afghanistan, indicators for political instability in the Middle East and North Africa and other security issues in the region. In 2012, he received the NATO Scientific Achievement Award for developing security transition metrics for Afghanistan. Currently, he is a member of the Advisory Cell to the Assistant Deputy Minister (Science and Technology) at the Department of National Defence.*

Stream – Other 2

O-2-1 Technology Assessment in future Alliance Operations (TAO)

Mr. Gabriele Rizzo (Leonardo)

The exponential rate of societal and technological change is a real challenge for the Alliance in a world where the side that adapts their capability the fastest has a paramount, strategic advantage. In order to support strategic decision making and defence planning in this context, it is critical to have a way to scope future technologies and understand their impact in future operations–including how they will shape military decision making and future military response options. The work presented here proposes a novel approach inspired by previous NATO activities and national experience of assessing future technologies structured workshops, including SAS-062 (Assessment of Disruptive Technologies), SAS-066 (Joint Ops 2030), SAS-082 (Disruptive Technology Assessment Game),and SAS-086 (Concept Development Assessment Game). This approach achieves a middle ground between pure scientific technology foresight and pragmatic military operations planning and involves minimal input for maximal output. It introduces ability cards, multiple events in escalating scenarios, blue/red technological force generation, a simplified operational planning process and voting-supported discussion sessions to a 20-person, 2-team, 4-day workshop. The TAO methodology scales up easily and leaves room for creativity and the application of Alternative Analysis techniques. TAO has delivered significant value to the STO Tech Trends Report2018 by bringing military relevance to the future technologies considered.

Gabriele Rizzo *is a visionary futurist and an enthusiastic innovator. Currently Lead Scientist, Strategic Innovation in Leonardo, futurist advisor in NATO, Member at Large for Strategic Foresight, and NATO expert for Cyberspace and Cyber Defence. He held multiple position over 10 years in Engineering staff before moving to Strategy, where he contributed substantially to strategic visions and long-term thinking of Italy, Europe, NATO and international organisations. He also teaches Strategy and Defence of Cyberspace at Sapienza University of Rome. He authored several capstone works on deep futures and is the recipient of national and international awards.*

O-2-2 Rethinking the Assessment of NATO Operations

Dr. Gary Harless, Mr. Igor Fainchtein & Mr. Stuart Smith (NATO Joint Force Command Brunssum)

The assessment process described in the NATO Operations Assessment Handbook (NOAH) and other NATO documents describes the assessment process as if it occurs principally at the operational level, when in fact the assessment process occurs at all levels from tactical to strategic. Regardless of the level of assessment, most of the data originates at the tactical level. The analysis and interpretation of this data is best done at the same level where it is collected, so ideally rather than the operational and strategic levels requesting raw data from the tactical level they should request the analysis and assessment of the data based on a set of questions that are relevant to the operational and strategic levels. The feeding of this hierarchy of analysis and assessments through the command structure should improve the OPSA ability to contribute to the decision making process without slowing down the mid-term management of the operation

Dr. Harless *has over 30 years of combined academic, NATO, and U.S. Army experience to include extensive experience in the analysis and assessment of both actual and simulated military operations. Dr. Harless has experience with multi-dimensional decision analysis, force on force modeling, cost effectiveness analysis, campaign analysis, weapons system analysis, and the use of mathematical, linear, and nonlinear programming techniques. He has deployed numerous times to both the NATO ISAF and RS Missions where he has worked as an analyst in the Afghan Assessments Group. His education includes a PhD in Industrial Engineering from the University of Central Florida and a MS in Industrial Engineering from Texas A&M University.*

Mr. Igor Fainchtein *is an Operational Analyst with Joint Force Command Brunssum, Joint Assessment Division. His focus is operations assessment. He has over 30 years of the military and industry experience, including 13 years in NATO. He has extensive experience in military modeling, simulation, war gaming, capability analysis, requirements engineering, and application of optimization algorithms in decision-making, combined with deep knowledge of joint operations at operational level. Mr Fainchtein holds Master of Mathematics Degree from University of Waterloo, Canada as well as Diploma of Mechanical Engineer and Diploma of Engineer-Economist.*

Mr Stuart Smith *has 25 years of experience as an Operational Analyst in both the UK MoD and NATO. Mr Smith has experience with simulations, systems dynamics, linear and non-linear programming in support of procurement, exercises and operations. Mr Smith has conducted multiple operational deployments to Bosnia-Herzegovina, Kosovo and Afghanistan.*

O-2-3 Threatcasting: Preventing Strategic Surprise

COL Andrew O. Hall, PhD (Army Cyber Institute, USA)

Senior Leaders and analysts often view the complex worlds of future cyber threats uncomprehendable, possibly unimaginable as well as insurmountable. The threatcasting methodology creates a structured process to envision the future based upon the futurecasting concept. Futurecasting was used to envision future computer processer demands by envisioning the future uses of computers and then designing new processors to meet future demands. We seek to envision future threats, and potential flags to highlight decision points towards alternate futures, empowering leaders and organizations to understand the decision space where actions can be taken to avoid and defeat undesirable future threats. These possible futures, created through a systematic process employing teams of diverse experts, allow our militaries to systematically think about the future, dispel myths and clear the way for pragmatic, action based dialogue. We discuss our methodology and provide results from three iterations of Threatcasting executed by a team from the Army Cyber Institute and Arizona State University's Threatcasting lab. We will also explain our efforts to explore and describe these possible futures through employing Science-Fiction Prototyping. We will explain lessons the team has learned from creating graphical novels to describe these future threats.

Colonel Andrew O. Hall *is the Director of the Army Cyber Institute at West Point, New York. In his position as director, Colonel Hall leads a 53 person multi-disciplinary academic research institute, teaches in the Department of Mathematical Sciences, serves as Chairman of the Editorial Board for The Cyber Defense Review; and Conference Co-Chair for CyCon US. He has a B.S. in Computer Science from the USMA, an M.S. in Applied Mathematics from the Naval Postgraduate School, and a Ph.D. in Management Science from the University of Maryland. COL Hall is also President of the Military Applications Society of INFORMS.*

Stream – Analytics 1

A-1-1 Data Collection & Management (DC&M) for Analysis Support to Operations

Ms. Jackie Eaton (NATO Science & Technology Organisation), on behalf of the SAS-111 RTG.

Extensive trusted datasets are essential for analysis to successfully support military decision making. In today's interconnected technology-enabled world, the volume, variety and velocity of data being generated is enormous. Advanced algorithms, such as those developed by Google or Amazon, make this data available to everyone in support of their everyday decision making. Military leaders are demanding the same or more from their decision support systems. However, current approaches to military data collection and management (DC&M) are inadequate to provide the trusted datasets necessary for this level of support. Data is often collected on the fly with little consideration for its reuse and analysts are forced to spend disproportionate amounts of time searching for and preparing data for analysis. For operational analysts to provide the comprehensive and timely decision support for today's complex operations, military leaders need to implement substantial changes to the people, processes and tools in their HQs. The NATO SAS-111 Study on DC&M for Analysis Support to Operations looked at the current situation, reviewed potential solutions, and developed a guide to implementing DC&M in a modern HQ. The paper presents a review of the challenges associated with military DC&M, a generic process that can support holistic DC&M planning across HQ functions (C2, operations assessment, intelligence, logistics, etc.) and a summary of the specialized roles and tools required to support military DC&M.

***Jackie Eaton** has been the Science & Technology Advisor in the NATO STO Office of the Chief Scientist at NATO HQ since 2016. She leads production of the STO Technology Trends Reports, co-chairs the NATO Operational Research & Analysis Conference programme committee and co-chaired the SAS-111 study on Data Collection and Management for Analysis Support to Operations. From 2006 to 2016 she was the Senior Operational Research Analyst at NATO Joint Analysis and Lessons Learned Centre (JALLC). Before joining NATO, she spent 3 years as an analyst at Dstl, UK. She has an Operational Research Masters from the University of Southampton.*

A-1-2 Getting Grip on Big Data with Autonomous Multi-Source Analysis

Dr. B. van der Vecht, Dr. A.C. van den Broek, Mr. Riccardo Satta & Mr. F. Bomhof (TNO, The Netherlands)

Continuous monitoring of open information sources produces enormous amounts of data containing sparse relevant information. Available sources on the internet contain unstructured text (e.g., social media, blogs, news sites), imagery (e.g., photo, video, satellite), or structured data (e.g., traffic information, geospatial information) and more. It is not feasible for human operators to process all data. Therefore, including these sources in the intelligence analysis requires automatic processing to produce answers to relevant intelligence questions. These answers should be explainable, such that they can be a starting point for further and more directed analysis and intelligence gathering. We present a conceptual framework, including examples of implementation and scenarios, for autonomous big-data monitoring that brings together top-down intelligence questions with bottom-up data processing. Autonomous information collectors with scraping, crawling and explaining capabilities are responsible for monitoring specific sources. They trigger cues for other collectors to direct their searching process. Using confirmations or contradictions the data from multiple heterogeneous resources are fused. The results may activate pre-defined, higher-level indicators that alarm a human analyst, who is provided with insight

information and traceability functions. As such open big data sources can be included in intelligence analysis.

Bob van der Vecht *has a background in Artificial Intelligence (AI) and received a PhD in this domain at the Universiteit Utrecht in 2009. He is currently working as researcher at TNO, where he works on the development of new methods and techniques for intelligence analysis and decision support, both for defense and civil applications. He is specialized in computational methods for data analysis, such as social network analysis, scenario analysis and hypothesis management.*

A.C. (Bert) van den Broek *has a Ph.D. in Astrophyisics and since 1991 he is working at TNO Defense, where research projects are carried out for the civil as well as the military market. Bert van den Broek's activities concern: integration of sensor information and military intelligence, time critical situation awareness systems, maritime surveillance concepts, sensor fusion, automatic target recognition, and (radar satellite) remote sensing & cartography applications. He participates in several European projects & NATO working groups. Presently he is also focusing on artificial intelligence applications and information fusion.*

Freek Bomhof *graduated with a specialization in pattern recognition and computer vision from University of Twente in 1990. He works as a senior project manager and business consultant in the Data Science department of TNO, where he crosslinks insights and experiences on Advanced Analytics from different domains to each other, like mobility & logistics, public policy making, safety & security, and the military domain. Currently his focus is on the challenges that emerge related to Explainable Artificial Intelligence.*

A-1-3 ORBAT Planning by Methods of Operations Research

Maj. Gen. (ret.) Georg Nachtsheim & Ms. Alexandra M. Friede (Helmut-Schmidt-University/University of the Federal Armed Forces, Germany)

NATO has experienced manifold ways of force generation processes as part of its operational planning for real world crisis response operations over the past 20 years. Today NATO enters in a new phase of its response planning. NATO needs to leverage and foster multinational formations, ready for quick response, credible for any potential adversary and sufficiently dominant for operations in potentially very challenging operational Art. V environments. However, national and NATO force planning continues to lack standardization and interoperability. Furthermore, high value assets, not least in the fields of C3, recce and intel, indirect effects or SOF are insufficiently distributed amongst NATO's members' force pools. This puts an even heavier burden on the shoulders of national and NATO force and operational force planners. Germany has launched the FNC initiative to help overcome this situation. As a FNC framework nation, Germany has committed itself to leverage multinational joint capabilities for NATO's Art.V purposes. By now, 16 FNC participating nations try to develop coherent harmonized planning to overcome deficiencies, to improve synergy effects, to achieve the highest possible operational effectiveness through common DOTMPLFI and, complementary to the NDPP efforts, in the long run, to achieve at least a converging force planning. German academics and military insiders of the Helmut-

Schmidt-University/University of the Federal Armed Forces have developed a performant tool which can assist these efforts. Furthermore, inspired by the NDPP Capability Codes, a data bank was programmed with all known or available force and capability data of European member states. Today it is feasible to simulate all possible combinations of MN force contributions within the FNC context, to compute the force composition with the highest possible operational effect, to analyze deficiencies of a given force composition thus identifying venues for remedial action and even to assist decision makers in how to further shape cooperation agendas and harmonized force planning..

MG (rtd) Nachtsheim *joined the German Federal Armed Forces in 1972 and went through a formation as cavalry officer, and, as part of that, obtained a Master's degree in Economics from the Helmut Schmidt University in Hamburg. He completed the course for General Staff Officers at the Führungsakademie der Bundeswehr in Hamburg and at the Ecole Supérieure de Guerre in Paris. More recently, he became member of the Royal College for Defense Studies in London.MG (rtd) Nachtsheim has held command functions at the company, battalion and brigade level, sc. the Franco-German Brigade from 1999 to 2001, and served in numerous staff assignments, such as in the politico-military branch of the Federal Ministry of Defence, NATO's HQ SHAPE (Partnership for Peace trainings and exercises), HQ Eurocorps (flag officer) and the German Army Office (Director General Training). He also became Head of the Strategy Department at the Führungsakademie der Bundeswehr in 1997. MG (rtd.) Nachtsheim was deployed 3 times on the Balkans, sc. as the Chief of Staff at the Multinational Division South-East and NATO's HQ SFOR. He finished his military career as Deputy Commander (and acting Commander) of NATO's Rapid Deployable Corps France/HQ.*

Stream – Logistics 2

L-2-1 Stochastic Mixed-Integer Programming for a Spare Parts Inventory Management Problem

1st Lt. Leonie M. Johannsmann (Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Germany), Dr. Armin R. Fügenschuh (Brandenburg University of Technology, Germany), Dr. Emily M. Craparo (Naval Postgraduate School, USA), Thor L. Dieken, Lt. Col. Björn O. Seitner (Logistikzentrum der Bundeswehr, Germany)

The German Armed Forces provide an operation contingent to support the NATO Response Force (NRF). For this purpose, a "ware-house" containing accommodations, food supplies, medical supplies, and spare parts for the systems has to be available. Such a warehouse is restricted in weight, in order to be quickly movable in an upcoming deployment situation. It should be able to supply the NRF troops for ascertain amount of time (e.g., one month) without re-supply from the out-side. To ensure optimal use of such a restricted warehouse, we developed the computer program "The OPtimization of a Spare Parts INventory" (TOPSPIN) to find an optimal mix of spare parts. We focus on the sup-ply of spare parts for vehicles as systems. The failure rate of the troops' vehicles follows a given random distribution, and during deployment it is expected to be higher than in the homeland. Due to the stochastic nature of the problem, we generate scenarios that simulate the actual failure of the systems. Each system is composed of several parts, and it can only be used again in the mission if all broken parts are replaced. The back-bone of TOPSPIN is a mixed-integer linear program that determines an optimal, scenario-robust mix of spare parts and is solved using standard state-of-the-art numerical solvers. Using input data provided by the Logistikzentrum, we analyze how many scenarios need to be generated in order to determine reliable solutions. Moreover, we analyze the com-position of the warehouse over a variety of different weight restrictions, and we calculate the number of repairable systems as a function of this bound.

***Emily Craparo** is an Assistant Professor of Operations Research (OR) at the Naval Postgraduate School (NPS). Her research and teaching interests focus on mathematical optimization and the design of efficient algorithms. Dr. Craparo has provided analytical and modeling support to the US Army, Navy, and Marine Corps on a variety of topics related to decision making under uncertainty and resource constraints. Her academic publications include topics such as sensor placement, optimal operation of energy systems, and capital planning under uncertainty. Prior to joining the NPS OR faculty, Dr. Craparo completed National Research Council Postdoctoral Fellowship at NPS. Dr. Craparo received her S.B., S.M., and Ph.D. from the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology (MIT).*

*Since 2012 **Lieutenant Colonel Björn Seitner** is Head of the Analysis Unit "Logistic Information Management" within the Department "Supply Chain Management" at the German Armed Forces Logistic Center (Logistikzentrum der Bundeswehr), which is responsible for all logistic services within the forces. He joined the Army in 1999 and got trained as an officer within armoured, studied occupational and operational pedagogy and switched to logistics becoming a professional and staff officer in 2008. He had postings as coy commander in an Airborne Support Battalion, S4-Staff officer*

and Chief of Staff in a Command Support Battalion. He has mission experience in ISAF and UNMIS.

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. Fügenschu's main research interests are linear and nonlinear mixed-integer programming and their applications, in particular to problems from engineering, transportation, and logistics.*

After high school graduation in 2011 and work and travel in New Zealand for 5 months, ***First Lieutenant Leonie Johannsmann*** *joined the Air Force. With a successfully completed officer training she started her study of industrial engineering at the Helmut Schmidt University / University of the Federal Armed Forces in Hamburg in 2013. To complete her study First Lieutenant Leonie Johannsmann wrote her master thesis, during a trimester abroad, at the Naval Postgraduate School in Monterey, USA. In her master thesis she optimized the spare parts inventory for a military deployment with methods of Operations Research. In 2017, she started her pilot training for cargo airplanes for the Air Force.*

L-2-2 Recommendations on the adoption of Modelling and Simulation for analysis and decision making support for Deployment Planning

Dr. Pilar Caamaño Sobrino, Dr. Alberto Tremori, Mr. Giovanni Luca Maglione, Dr. Thomas Mansfield & LtC. Miguel López de la Vieja (NATO Science & Technology Organisation Centre for Maritime Research & Experimentation (CMRE))

Demanding scenarios in contested environments require an improvement to response time and the overall capability of moving multinational forces. These factors have to be analysed and challenged from a logistics' point of view, in order to provide a meaningful assessment of NATO capacities. From experiences in other domains, Modelling and Simulation (M&S) has proven to be a suitable methodology to deal with the complexity associated with supporting the analysis and assessment of challenging scenarios. Furthermore, M&S's intrinsic characteristics allow the extensive and comprehensive testing of potential alternative plans. In this work, the goal of the authors is to provide advice and recommendations on how to, effectively and efficiently, adopt or integrate M&S into the current planning process. This has been achieved by supporting the analysis and assessment of the NATO deployment process. The implementation of the proposed recommendations could provide logistics planners with a new approach, based on simulation and data management that could enhance the critical interaction among the different stakeholders in the decision making process (planners, analyst and simulation experts). The final intent of this work is to support both qualitative and quantitative analysis techniques in the assessment of deployment plan feasibility, robustness and resilience.

Pilar Caamaño *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: from VV&A till CD&E and Analysis and Planning.*

L-2-3 Rail Gauge Logistical Challenges in 21st Century Rapid Deployment and Reinforcement

Mr. Nicholas J. Myers (War Vs Peace Foundation LLC, USA)

The rapid deployment and reinforcement of forces during times of crisis pose timeless challenges on logistics. Since the end of the Soviet Union, conventional force-to-space ratios have dropped precipitously as the large-scale industrial war machines of the Cold War have become long-range precision strike mechanisms. This has increased the importance of rapidity in movement on the ground. During the Cold War, the Soviet Union faced the same problems as NATO does now: rapidly moving forces into theater, including transferring forces from 1.520m to 1.435m rail gauges while potentially underguided missile fire. This paper explores how the Soviet Union improved its ability to transfer war materiel over this barrier during wartime and deploy troops from its ubiquitous rail network into maneuver operations. Using Operations Analysis (OA)to understand expected Soviet deployment times from declassified General Staff documents, this paper explores how modern NATO militaries can learn from this evolution in Soviet military thought to inform plans to deploy troops onto the Eastern Flank for a potential defense of continental Europe from the East.

Nicholas J. Myers *is an analyst of the Russian and Belarusian militaries. He has been studying Russian policy and statecraft for over 10 years and focusing specifically on the Russian and Belarusian militaries for the past 5. He has written a number of reports on the operational capabilities of the Russian military and overseen a wide variety of wargames of potential conflicts in the European Intermarium and Asia-Pacific regions. He is currently pursuing a taught Master's programme in War Studies at the University of Glasgow and received his undergraduate degree from the Georgetown University School of Foreign Service in 2011.*

Stream – Analytics 2

A-2-1 Internet of Things and Machine Learning for Information Operations Targeting

Dr. Ayman Sabbah (Communications Research Centre, Canada), Dr. Mohamed Ibnkahla (Carleton University, Canada), Dr. Ahmed Ghanmi (Defence Research and Development Canada)

The Internet of Things (IoT) and Machine Learning (ML) have been extensively used in several civilian domains including Intelligent Transportation Systems, e-Health, and Smart Electrical Grid, leading to spectacular results in these fields. However, the deployment of IoT and ML in the military context is still new. This paper discusses the use of IoT and ML to address some of the data aggregation and analytics problems in military applications, including Information Operations Targeting Analysis, Joint Lessons Learned Analysis, and Joint Doctrine Development. The study leverages various IoT systems and ML algorithms developed for industrial and business applications to study typical military decision support problems. Practical examples of IoT and ML will be provided and discussed.

Mohamed Ibnkahla *joined the Department of Systems and Computer Engineering, Carleton University, Ottawa, Canada in 2015 as a Full Professor where he holds the Cisco Research Chair in Sensor Technology for the Internet of Things (IoT); and the Natural Sciences and Engineering Research Council of Canada (NSERC)/Cisco Industrial Research Chair in Sensor Networks for IoT. He obtained the Ph.D. degree and the Habilitation a Diriger des Recherches degree (HDR) from the National Polytechnic Institute of Toulouse (INPT), Toulouse, France, in 1996 and 1998, respectively. Prior to joining Carleton University, he has been a Professor at the Department of Electrical and Computer Engineering, Queen's University, Kingston, Canada, from 2000 to 2015.His research interests include IoT, Cognitive Networks, Cognitive Radio, Adaptive Systems, Machine Learning, and Wireless Sensor Networks. Over the past 10 years, he has been conducting multi-disciplinary research projects designing, developing and deploying Internet of Things in several domains including security and military applications, smart homes, health care, smart grid and sustainable energy, public safety, intelligent transportation systems, environment monitoring, and smart cities. He published 6 books and more than 80 peer-reviewed journal papers and book chapters, 20 technical reports, 120 conference papers, and 4 invention disclosures. He is the author of Wireless Sensor networks: A Cognitive perspective, CRC Press - Taylor and Francis, 2012 and Cooperative Cognitive Radio Networks: The Complete Spectrum Cycle, CRC Press - Taylor and Francis, 2015.In the past 5 years he gave more than 30 keynote talks and invited seminars. He received the Leopold Escande Medal, 1997, France, and the Premier's Research Excellence Award, Canada, 2001. He is the joint holder of 5 Best Paper Awards.*

A-2-2 Concept of Conventional Threshold

Jaan Murumets, PhD (Centre for Applied Studies, Estonian National Defence College)

The problem of how a small country can make the threshold for a potential attacker as high as possible within the limits of affordability is of high relevance in the contemporary security environment in

Europe. Stemming from conceptual thinking in Scandinavian countries, an analytical framework of the Conventional Threshold consisting of six dimensions appears a promising way to address the problem of the weak deterring the strong, to include the role of deterrence and resilience, and the importance of creating favourable conditions for Allied assistance. Closely related problem is practical applicability of the Threshold Concept within the routine policy-making and defence planning processes: to what extent it can be utilised via using the generic planning tools (planning assumptions, policy guidance, Missions and Tasks, and required capabilities).For the purposes of collective defence, the analytical process must be standardized and compatibility of results across nations ensured, hence the utility of agreed NATO terms and concepts. To prove the validity of the approach, two generic strategies were assessed against the functions of a threshold, strengths and weaknesses discussed, and findings developed. The study proves that the concept of conventional threshold is applicable within, and using tools of, Western defence planning methods.

Jaan Murumets *has nearly two decades of experience as a senior civil servant in the Ministry of Defense and General Staff combined with that of a professor and research manager in Estonian National Defense College. He is an accomplished Defense Adviser providing advice and practical support primarily to countries in Central and Eastern Europe, but also in Latin America and East Asia, in the fields of policy making, defense planning, and resource management systems and practices. Jaan Murumets is a long-time associate faculty member of the Center for Civil-Military Relations at US Naval Postgraduate School in Monterey, California and consultant at the Institute for Defense Analyses in Washington, D.C. He earned his PhD at the University of Zurich, Switzerland.*

A-2-3 Tackling Combinatorial Explosion in Force Design

Dr. Ben Taylor & Dr. Murray Dixson (Defence Research and Development Canada)

Force Development at the strategic level is about planning the evolution of a military force into future decades. One of the challenges is to manage the complexity of the options space. Creating a portfolio of high value-for-money options through traditional optimisation tools is computationally demanding and risks a force with no coherent design, as these tools do not account for a higher-level vision. Equally, offering senior leadership a small number of customised thematic future force options may not offer real choice as they may in reality be limited to a number of extreme models and one compromise model, which will inevitably be the preferred option.

To address this problem, a novel approach has been implemented in a high-level prototype model. This approach allows the utility of a force structure in meeting policy objectives to be explored, while working within financial, personnel and/or structural constraints. The prototype model can be taken as a starting point by any nation and re-implemented with different tools and/or in increased levels of fidelity to meet specific decision maker and/or national needs (such as whether force options are military units or capital assets, or using it to develop just naval force options rather than whole of force options). The approach allows rapid development and evaluation of future force options to support Force Development decision makers in their efforts to achieve national policy goals, whilst avoiding unnecessary levels of detail and complexity. The intent is to provide a tool to allow force developers to scope the solution space before launching more detailed examination of potential “sweet spots”.

Dr Ben Taylor *is an experienced defence operations research analyst who has worked in the defence industry as well as for the Governments of the United Kingdom and Canada. In the United Kingdom Dr Taylor was instrumental in the design and implementation of the MOD Capability Audit process (2000-2001) and subsequently held a number of high-level analysis leadership positions at the Defence Science and Technology Laboratory 2002-2007.Since joining Defence Research and Development Canada in 2007 Dr Taylor has supported the development of the Canadian Force Development process and currently leads the Strategic Planning OR Team.*

Over the course of his career as an Operational Research Analyst with Defence R&D Canada, ***Dr. Dixson*** *has worked on issues related to air defence, ballistic missile defence, surveillance of space, combat identification (CID), concept development and strategic planning. He led analysis teams supporting CID Exercises Urgent Quest and Bold Quest. His current work is on applying wargaming and force structure analysis to improve the strategic planning methods used by the Canadian Armed Forces. He is the Co-Chair (with NCIA) of NATO SAS-130 on course of action analysis in the 21st Century.*

Stream – Cyber 2

C-2-1 Approaches to implementing joint Cyber Defence Situational Awareness

Mr. Torgeir Broen, Mr. Torbjørn Kveberg, Mr. Aasmund Thuv & Mr. Ronny Windvik (*Norwegian Defence Research Establishment)*

In future operations where Communications and Information Systems (CIS) are contested or degraded, Cyber Defence Situational Awareness (CDSA) is a pre-requisite for maintaining combat capability; it is the tool with which the Commander understands and assesses the situation in his cyberspace and its relation to other operations. Integrating knowledge about operations, threats and infrastructure, CDSA helps the joint headquarters move beyond traditional CIS-security thought, and on to cyber defence. This paper combines established knowledge from civilian situational awareness research with knowledge about technology and military operations to describe how to generate CDSA. It aims to describe a way to turn thisinto a capability for use in day-to-day operations. We argue that CDSA requires awareness and understanding in three main areas; own CIS, operational requirements from the CIS, and adversarial activities within and outside of the cyber domain. From that baseline, we discuss several important aspects of CDSA, and how OA methods can be applied to help the Commander achieve this required understanding. First, requirements for building CDSA are presented. We then discuss how CDSA can be used to support planning and conduct of operations, how military CDSA differs from civilian CDSA, and, finally, possible approaches for implementing CDSA at joint headquarters.

Torgeir Broen *has a master's degree in information security from the University of Oslo. He has worked with research on cyber security and cyber operations both on a technological and operational level at the Norwegian Defence Research Establishment since 2005*

Torbjørn Kveberg *has a Master of Science in Political Science from the Norwegian University of Science and Technology. He has worked with research on cyber operations and influence-related topics at the Norwegian Defence Research Establishment since 2012.*

Aasmund Thuv *has a master's degree in information security from the University of Oslo. He has worked within the fields of cyber security, cyber operations and influence from the technical, to the operational and the conceptual. He has been employed by the Norwegian Defence Research Establishment since 2005.*

Since 1999, ***Ronny Windvik*** *has worked as a scientist in cyber security, cyber operations, information operations, risk management and societal security. Today he works as chief scientist and program manager at Norwegian Defence Research Establishment.*

C-2-2 How the NATO Alliance can become Operational in the cyberspace domain

Mr. Jonathan Searle (NATO Communication and Information Agency (NCIA))

Cyberspace is now recognised by NATO as an 'operational domain' –just as land, sea or air [1]. In order to achieve superiority within any domain, the NATO Alliance needs to be able to undertake the full spectrum of operational activities, both defensive and offensive; this is no different in the cyberspace domain. While the NATO enterprise's remit within cyberspace is purely defensive, many NATO Alliance members have declared that they are developing or aspire to develop offensive cyberspace capabilities. To enable national capabilities to be used most effectively and in a coherent manner within a coalition, it will be necessary for the NATO Command Structure to be able to undertake some level of Command and Control of these effects. The Operational Functional Services (OPS FS) Baseline Project is using mission threads to support those working within this new domain. Mission threads provide a description of the end-to-end set of activities required to execute a mission or mission task. These can then be used to support the generation of evidence related to information exchange and functional services requirements. This paper will provide an introduction to the OPS FS Baseline project and detail how the mission thread approach is being used to support the integration of cyberspace into the NATO Joint Targeting, Intelligence, Surveillance & Reconnaissance (ISR) and Effects processes.

[1]: MC 0665: Military vision and strategy on cyberspace as a domain of operations. 2018

Jonathan Searle *has been an Operational Analyst at the NATO Communications & Information Agency (NCIA) since September 2017. In his role he focuses predominantly on Maritime Defence Planning and requirements definition for Command & Control capabilities. He is currently leading a work package supporting the identification of requirements and process flows for the newly formed Cyberspace Operations Centre in SHAPE. Prior to joining NCIA Jonathan worked for the UK's Defence Science and Technology Laboratory (Dstl) leading studies related to Command, Control, Communications, Computers, Intelligence Surveillance and Reconnaissance (C4ISR) with a particular focus on Electronic Warfare and Signals Intelligence.*

C-2-3 JUMP: Tactical Cyber Mission Planning

Mr Tim Dudman, Mr Sowdagar Badesha (Riskaware, UK) & Mr Marco Casassa Mont (BMT Defence & Security, UK)

The Joint User Mission Planning (JUMP) application is a concept demonstration environment to understand the impact of land, air and sea activities on the cyber domain and vice versa for joint force missions using state-of-the-art analytics and interactive visualisations. JUMP will provide the underpinning research to the defence community on where analytics and visualisation can be implemented to best effect within a coherent mission planning context .It will also provide prototype tools and techniques to support a military commander to accomplish a wide-range of mission-planning tasks, including mission rehearsal immediately ahead of the mission, re-planning during the live mission, and following the mission as part of de-briefing. JUMP is being developed for the UK Ministry of Defence by a consortium of BMT, Riskaware and Cyberlytic, pulling together visualisation, game theoretic and graph-based technologies. These technologies were originally developed as part of a 2015 themed challenge for novel approaches to human interaction with cyberspace to increase military situational awareness. JUMP was recently demonstrated at the NATO Information Systems and Technology (IST) workshops on cyber resilience and cyber modelling and simulation. The current focus is to support complex socio-technical systems, Electro-Magnetic (EM) activity and NATO Command and Control (C2) interoperability.

Tim Dudman*, CEng MBCS - Tim leads the development of Mission Impact Assessment (MIA) and cyberattack analytics at Riskaware for the UK Ministry of Defence JUMP programme. He has been developing defence simulation software for over a decade and has completed courses in Information Security and Ethical Hacking. Tim recently presented JUMP at NATO Information Systems and Technology (IST) workshops on Cyber Resilience and Cyber Modelling and Simulation, co-authored a US Army Research Laboratory paper section titled Mission Models for Cyber-Resilient Military Operations.*

***Sowdagar Badesha**, BSc MBCS - Sowdagar is responsible for the development of the JUMP cyber-attack analytics. He has a degree in Information Systems and over 3 years' previous experience in the research and development of cyber solutions for the UK Ministry of Defence. Specifically, he has delivered large scale data analytics projects tackling complex social-technical research problems underpinned by modern, scalable visual analytics. He recently attended the NATO Information Systems and Technology (IST) workshop on Cyber Resilience and co-authored a US Army Research Laboratory paper section titled Mission Models for Cyber-Resilient Military Operations.*

***Marco Casassa Mont**, MSc CISSP - Marco is a Principal Cyber Security Consultant at BMT Defence & Security, UK. He leads the development of cyber risk analytics at BMT for the UK Ministry of Defence JUMP programme. He has over 25 years of experience at strategic, business and technical levels, CTO and R&D offices. He was the lead of various cyber security projects/programmes in the areas of cyber analytics, big data, risk assessment, situational awareness, policy and identity and access management. He is the co-author of about 60 peer-reviewed papers and articles, accepted at international conferences & journals, covering various cyber security topics.*

Stream – Analytics 3

A-3-1 Analyzing metamodels to make sense of large scale simulations in a military context

Mr. Wouter Noordkamp & Mr. Tim Lamballais Tessensohn (TNO, The Netherlands)

To provide decision support in a military context, such as to evaluate and assess new platform concepts and tactics, simulation models are required to model complex interactions between opposing forces. This evaluation can require a large number of simulation configurations, because of the variation and uncertainty of input parameters. Therefore, it is only feasible to simulate a small subset of configurations. In this research, a metamodeling method (i.e. Kriging) is applied to a stochastic simulation setting. We simulate an Anti-Submarine Warfare (ASW) operation with the aim of determining efficient tactics and providing advice before and during the execution of a mission. One simulation using one configuration may take a significant amount of time. We use the simulated configurations to build a metamodel that can predict the output of configurations that were not simulated. The metamodel can hence be used to explore the entire space of possible configurations. The main motivation for using metamodeling in this context is to achieve accurate predictions within a limited time span. In the current study, we explored the performance of Kriging for metamodeling in terms of prediction error and computation time for both a theoretical case as well as the ASW case.

Wouter Noordkamp *graduated in Applied Mathematics at the University of Twente in Enschede in 1999. Since then he has been working at the Operational Analysis department of the Dutch research organization TNO. His main activities are building quantitative models and using them in support of the Royal Netherlands Navy in the fields of acquiring new materiel and improving the deployment of new systems. He started in Anti-Air Warfare, but currently works on the deployment of sensors and systems in Anti-Submarine Warfare and the evaluation of the operational effectiveness of new ship designs and concepts with a focus on signatures.*

Tim Lamballais Tessensohn *has been working as a junior scientist at TNO since 2017, with a focus on operations research and (semi-)autonomous systems. Before coming to TNO, he worked at the Erasmus University Rotterdam as a PhD candidate on the topic of stochastic modeling of material handling systems, specifically robotic mobile fulfillment systems. He graduated cum laude in the master program Econometrics and Management Science with a specialization in Operations Research and Quantitative Logistics.*

A-3-2 A Method for Repeatable Data Collection and Assessment of Communications Interoperability

Ms. Elena C. Krupa (Center for Army Analysis, USA)

The Center for Army Analysis (CAA) was tasked by the U.S. Army Director of Force Management (DFM) to develop a methodology and tool to evaluate how capable U.S. Army forces are at communications interoperability with our joint and multinational mission partners. This tool's purpose is to collect information from the field as structured data that leaders can use to understand the current capability level with specific mission partners and manage operational knowledge related to Doctrine, Organization,

Training, Materiel, Leadership/Education, Personnel, Facilities, and Policy (DOTMLPF-P) elements that limit or enable communications. The data collection methodology is structured by mission partner, echelon, US Army Warfighting Functions (WfF), and US Army Tasks (ART). Standardized definitions of the levels of interoperability (according to NATO AAP-06 and US AR 34-1) for tasks within each WfF provide the framework for objective assessments of interoperability. The structured, repeatable nature of the data allows for quantitative and longitudinal analysis of information that is typically analyzed and assessed subjectively. CAA is currently testing and developing the prototype tool during multinational exercise events.

Elena Krupa *is an Operations Research Analyst at the Center for Army Analysis (CAA) at Fort Belvoir, Virginia. Elena is assigned to the Resource Analysis Division of CAA which conducts mostly institutional analyses. Studies she has participated in include an occupational capacity analysis, interoperability assessment, and a space allocation study for Arlington National Cemetery. She holds bachelor degrees in Chemistry and Security and Intelligence and is currently pursuing a graduate degree in Government Analytics from Johns Hopkins University. In her free time, Elena enjoys cooking, yoga, and watching movies.*

A-3-3 Tackling complex Anti Access Area Denial environments using multi-national modelling and analysis

Mr. Tom Baldwin (NATO Allied Command Transformation)

Tackling complex Anti Access / Area Denial (A2AD) environments presents significant challenges for NATO forces. An adversary deployingA2AD capabilities can constrain NATO forces' access to, and limit their freedom of manoeuvre within, an operational theatre. To determine the potential impact of an A2AD environment on NATO operations and identify how best to mitigate them, NATO requires robust, timely analysis support. However, current NATO modelling and analysis capabilities to address this problem are constrained by outdated models, the costs of new model development and extensive data requirements. NATO recognizes these problems and seeks to address them through enhanced collaboration with nations. This presentation illustrates how a multi-national collaborative modelling and analysis approach was used to assess the challenges of such a complex A2AD environment and identify how they could be overcome. It describes the A2AD problem, the modelling and analysis constraints faced and how they were addressed by drawing on NATO and nations' modelling and analysis capabilities. Benefits and risks of multi-national collaboration are shared and implications are discussed for a more persistent arrangement to support NATO's needs. Rather than duplicating national owned capabilities, if NATO can leverage them then NATO and nations will benefit.

Tom Baldwin *is an operational analyst at NATO Allied Command Transformation (ACT) responsible for supporting concept and capability development. Prior to joining ACT in 2017, Tom spent ten years providing analysis support to UK MOD, which included support-to-operations, concept / capability development and business case support, predominantly in the C4ISR domain. Tom previously worked at Polaris Consulting, the Defence Science and Technology Laboratory (Dstl) and SIMUL8 Corporation. Tom has a BSc (Maths, Statistics and Operational Research) and an MSc (Operational Research). He is an active member of the UK OR Society and is on the 2018 NATO OR&A Conference program committee.*

Workshops

Communicating Benefits of OR&A
Ms. Jacqueline Eaton, S&T Advisor, STO Office of the Chief Scientist

Is there a project you want to communicate more effectively? We'll work on it together to help you build a strong message you can take away with you. Join us in this interactive workshop where you will learn some tried and tested communication techniques from marketing and journalism. Working in small groups you'll conduct a target audience analysis and refine your message to make it memorable and effective.

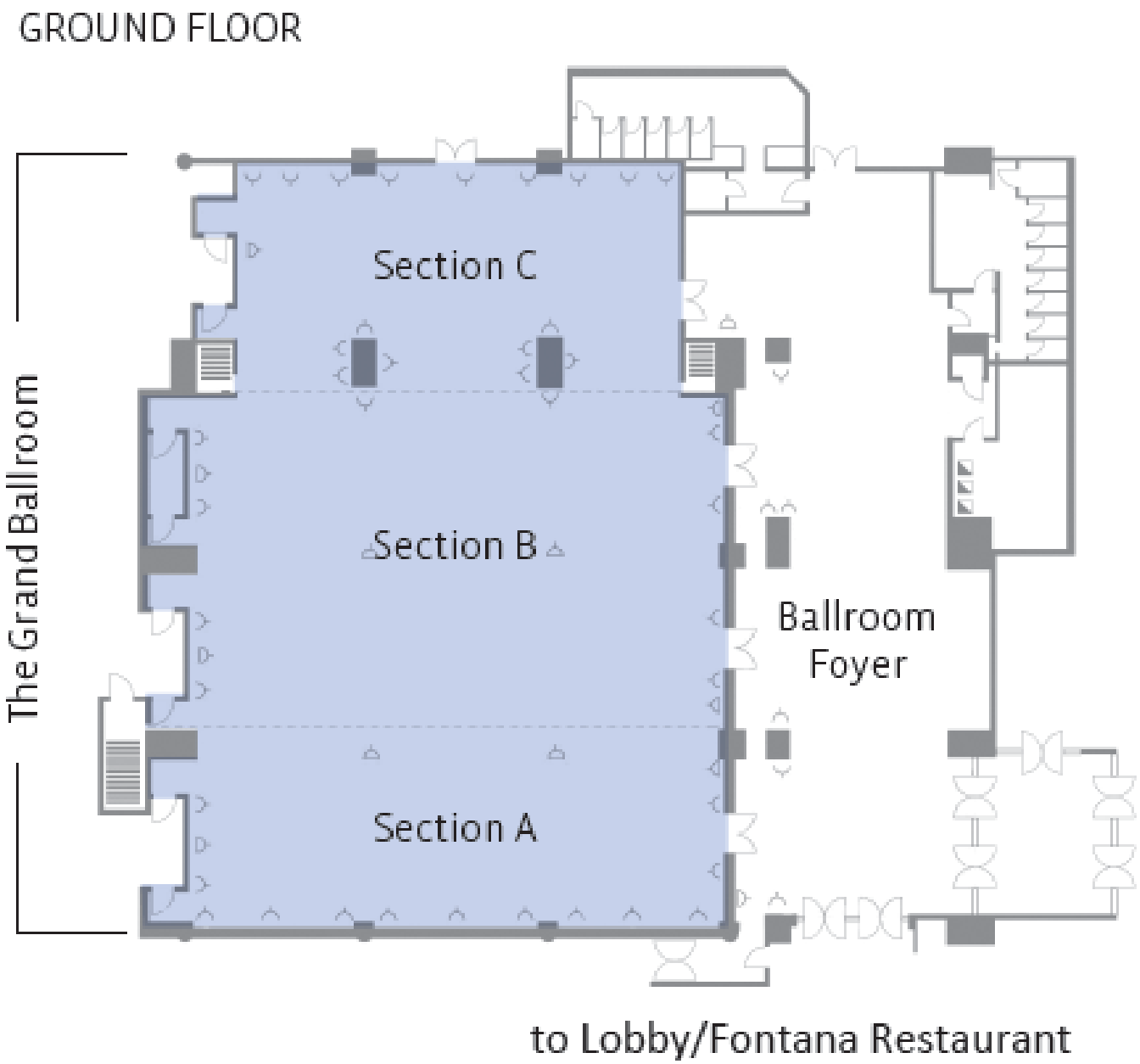
SIMUL8 Training
Ms. Corinne Freeman & Mr. Liam Hastie, SIMUL8 Corp

SIMUL8 is a powerful, intuitive simulation software that anyone can use to get results fast. Join SIMUL8's Corinne Freeman and Liam Hastie for a session on how to get started with SIMUL8, focusing on challenges facing NATO regarding Rapid Reinforcement, Force Mobility and its Logistics Aspects. *Please note, attendees must have previously registered for this training course.*

Alternative Analysis (AltA) Training
Ms. Sue Collins & Mr. Tom Baldwin, NATO ACT

Alternative Analysis (AltA) comprises of a set of simple techniques that supports the inclusion of independent, critical thought and alternative perspectives to support decision-making. They have been taken from industry, intelligence, and academic best practices and are tried-and tested approaches for problem-solving and decision-making. Some techniques such as mind mapping or brainstorming will be familiar to many, others may be less so. This training workshop will provide an introduction to AltA and use example problems to give attendees practical experience of applying AltA techniques.

Floorplan


GROUND FLOOR
Section C
Section B
Section A
The Grand Ballroom
Ballroom Foyer
to Lobby/Fontana Restaurant