

# 40<sup>th</sup> International Symposium on Military Operational Research

## Royal Holloway University of London, 18th – 20th July 2023

### Abstracts and Biographies

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*Symposium content subject to change without notice*

**Avoiding Strategic Shock in Operational Research – Holistic Approaches and Lessons Learned for Decision Advantage**

In the rapidly-changing environment of our modern world with crisis that can quickly spin out of control, it's imperative that we embrace these challenges holistically and communicate effectively across the decision making process. The conflict between Russia and Ukraine has featured multiple strategic shocks that reinforce the importance of a multidimensional approach to research, analysis, and planning. Analytic miscalculations often reflect an over-reliance on measuring manpower and equipment to assess military success, and an under-reliance on more qualitative human factors. Therefore, as difficult as this sounds, innovative solutions that address the challenge holistically – that consider technology and human elements – can better inform how investments are made in systems and operations, ultimately saving lives.

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**Mr. Y. H. Kim**, Executive Director, Office of Strategic Intelligence and Analysis, United States Department of Defence

Mr. Y. H. “Eric” Kim is the Executive Director of the Office of Strategic Intelligence and Analysis (OSI&A). He serves as the principal analytic officer to the Under Secretary of Defense for Research and Engineering (USD(R&E)), directing exquisite analysis of global comparative, competitive, and asymmetric superiority in critical technology domains.

Mr. Kim oversees the development of comprehensive independent technical and operational assessments in support of more than sixteen billion dollars of USD(R&E) and Department of Defense (DoD) science and technology investment and acquisition decisions. He directs the fusion of DoD science and technology enterprise objectives with intelligence analysis characterizing adversary capabilities to determine mission critical needs and inform Joint innovation efforts for accelerating development of technical solutions to operational gaps.

Mr. Kim was the Director, Defense Technology Analysis Office and Executive Secretary of DoD's Reliance 21 and Science & Technology Community of Interest for USD(R&E)'s predecessor, the Under Secretary of Defense for Acquisition, Technology and Logistics. In this position, Mr. Kim was responsible for planning and managing multiple program elements with an estimated annual budget of more than sixty million dollars to foster Joint service research on common elements of cross-cutting S&T efforts and enabling concept exploration efforts and studies of alternative concepts for the DoD.

Prior to supporting the Office of the Secretary of Defense, Mr. Kim was a senior advisor to the Assistant Secretary of the Army (Acquisitions, Logistics, and Technology) and multiple Deputy Assistant Secretaries of the Army and the Program Executive Offices where he advised on the matters pertaining to Planning, Programming and Budgeting of RDT&E and Procurement program activities.

Mr. Kim holds a Master of Science in mathematics from the University of Tennessee and undergraduate degrees in mathematics and chemistry from Birmingham-Southern College. He is the recipient of the Department of the Army's Commander's Award for Civilian Service and Achievement Medals for Civilian Service and multiple special Civilian Service Awards and Medals.

## MORS' EUGENE VISCO PRIZE-WINNING PRESENTATION

Established in 2019, the Visco Prize recognizes early-career analysts for their excellence in research quality, contributions, and presentation. Named for Mr. Eugene P. Visco, FS, the prize seeks junior or early-career analysts conducting impactful, technically rigorous, and original research that advances the field of national security operations research.

### **Resilient Position Data Fusion with a Generic Kalman Filter Method**

Global Navigation Satellite System (GNSS) technologies, such as the U.S. Global Positioning System (GPS), provide vital positioning, navigation, and timing (PNT) information for military and civilian applications. GPS denial and spoofing poses a risk to the availability and reliability of this PNT information. Combining information from multiple alternative sources of position information—a technique known generally as data fusion—can increase the accuracy and resilience of the PNT solution. In this talk, I will present a generic Kalman-filter-based method for position data fusion. Using a notional trajectory, I show how incorporating additional sensors through our data fusion method can provide robustness against the degradation of position accuracy and precision caused by GPS denial or spoofing. I will also discuss a simple algorithm for detecting and rejecting spoofed GPS solutions. While not intended for operational use, this method can be used as a baseline against which to evaluate other PNT data fusion approaches.

**Dr Paul Fanto, IDA, 2022 Winner**

## PRESENTATION SESSIONS

### Session 1: Assessing and optimising force design and adaptability

#### 1.1 **Military Adaptation in War and Requisite Variety**

Predictions of the unfolding of a coming war has rarely been accurate. There is conceivably scope for increasing the accuracy of predictions, but assuming that the shape of the next war can be predicted any accuracy would be very bold. Thus there will always be a requirement for future military commanders in war to adapt to the circumstances they encounter. Here I propose modelling military adaptation with the law of requisite variety. Successful military adaptation then translates to maintaining, or restoring, requisite variety. This model has been used in a historical study of military adaptation in war, in order identify ways that military forces have used for restoring requisite variety.

**Jan Frelin**, Swedish Defence Research Agency

Jan Frelin is an operations analyst at the Swedish Defence Staff, as well as working at the Swedish Defence Research Agency as a deputy research director. Frelin's interests include support to operations and operations planning, operations assessment and other evaluative activities, organisational learning and adaptation in war.

#### 1.2 **A holistic simulation model to explore the availability and costs of military assets in the exploitation stage**

Effective management of military assets necessitates a comprehensive understanding of the interplay between design, support, and use aspects. To illustrate, design engineers must take operational requirements and maintainability aspects into account, and the user needs to balance operations with maintenance activities. Furthermore, uncertainties surrounding asset design, support systems, and operating environments have a substantial influence on asset performance. Uncertainty arises in, for example, ageing and failure characteristics of design components, the availability of maintenance personnel and spare parts, and changing threat levels and climate conditions. In this light, our research focuses on the development and use of a simulation model that integrates the design, support, and use of military assets to explore the availability and costs in the exploitation stage. The model is intended to be used in early design stages, so that design changes can easily be incorporated. With massive sampling from the uncertainty space, we aim to find (a) scenarios that lead to undesired low availability levels or excessive costs, and (b) mitigating policies that are more or less insensitive across the scenario space (i.e., robust). A limitation of the model is that is relatively coarse. For example, the model does not elaborate on the design structure of asset components and aggregates maintenance crews and missions to more generic concepts. A low level of detail is needed to ease the computational and analytical burden for uncertainty analysis, but it also complicates the

translation of model outcomes to the real world. Further research is needed into the effect of coarse-graining on the usefulness of the model for policy analysis. At ISMOR 2023, we aim to showcase the model and have a discussion about its strengths and weaknesses.

**Stefan Salome**, Copernicos

### 1.3 **Insights from the main execution phase of a large-scale multi-domain wargame**

The presentation will focus on insights from executing a large scale multi-domain wargame. The main execution phase of Planned Force Testing IX (PFT IX) consisted of a wargame designed to test and evaluate the ability of a planned integrated force to conduct a multi-domain, medium scale intervention against a major state actor. The game was used to generate evidence on the strengths and weaknesses of the planned force structure, and develop insights into current and planned capability. It was a large multi-domain game with over a hundred participants from across UK Defence and wider government institutions, representing the full five domains – Land, Air, Maritime, Space, and Cyber - as well as broader political interests. There was a computerised interface for the submission of orders, the management of key information about the assets involved, and to assist with the adjudication process.

**Adam Murton**, Dstl

## Session 2: Analysing and optimising mission effects

### 2.1 **Application of a novel technique to help determine mission success in computation multi-mission modelling**

Dstl, in collaborative partnership with Northrop Grumman UK Limited, has developed 'Decision Maker' (DM); a Python toolset for a complex physics-based simulation software, used to plan and run multi-mission models. DM provides a user-friendly, semi-automated means to input data such as targets, threats, weapon data and Effects Trees. Effects Trees were developed as a means to explore full spectrum targeting options that could be employed to deliver military effect requirements, against multi-element targets in real-world scenarios. A novel technique of determining mission effectiveness based on military actions derived from exploiting the trees was devised, called force mix score (FMS). FMS enables rapid but robust analysis of multiple mission configurations, which aids the user by giving a computationally generated figure that can be included in determining mission success. This presentation explores how FMS is determined, how this information is relayed to the user and how it offers insight into the outcome of different military effects being applied, within complex military scenarios. Consideration will also be given to FMS's limitations and what developments could ensure an even more effective tool in future.

**Lydia Smith**, Dstl

## 2.2 **Modelling Task Group Operations Across the Underwater and Above Water Domains**

A naval Task Group (TG) commander must trade off considerations for countering underwater and above water threats when deciding on a TG disposition to protect a high value unit (HVV). TG dispositions to counter submarine threats typically involve escorts with active and passive sonar dispersed ahead of the HVV to form a protective barrier. Conversely, TG air defence against airborne threats, and in particular anti-ship missiles, involves positioning escorts much closer to the HVV. Physics-based engagement models are used in both the underwater and above water domains to help devise tactics, evaluate system performance, and provide inputs for employment of combat systems. These models rarely cover both domains given their unique and differing aspects for sensors, namely acoustics for underwater and radar/infrared for above water. Conversely, higher level operational analysis models offer broader scope, but with lower fidelity. Such a model, developed to investigate TG air defence, was recently used to explore modelling interactions across the two battlespace domains through extensions to include representations of underwater systems and performance. This paper presents an overview of the work conducted to achieve this. This initially involved introduction of acoustic sensors with simple detection models and depictions of TG dispositions for various underwater scenarios. The TG dispositions could then be studied in context of their ability to defend against an air or surface raid. The work has since evolved to explore embedding of sensor detection volumes produced from high fidelity models, and a framework to construct multi-ship tactics. The work is helping support tactics development for new capabilities being introduced by the Royal Canadian Navy through considerations of interactions across the underwater and above water battlespaces.

**Dr. Peter J. Young**, DRDC

## 2.3 **Rapid analysis in a congested environment**

Roke is currently supplying Electronic Warfare capabilities as part of a suite to Collective Training Group (CTG) to capture, assess and manage UK Army visual, thermal, and electronic signatures. These capabilities assess the physical and electronic appearance of Force Elements from the perspective of peer/peer+ adversaries to provide a more realistic training experience. This presentation will show how data from EW sensors reveals identifiable patterns in the emissions generated by tactical land radios, and how our resulting short-loop analysis fed to the exercise's Training Audience and Opposing Force allows near real-time actioning and exploitation of this data. The presentation will also highlight (within classification limits) insights derived from a growing collection of experimentally validated recommendations to enhance the survivability of Command Posts.

**Adam Beckett**, Roke

**3.1 Stochastic Navigation of Unmanned Aerial Vehicles (UAVs) for Border Patrolling: A Response Surface Methodology Approach**

Unmanned Aerial Vehicles (UAVs) have been widely used for military purposes since World War II, particularly in complex and risky operations such as reconnaissance, espionage, and target detection and attack. This study focuses on using UAVs in internal safety, specifically border patrolling operations that require rapid information flow, high precision, and accuracy. We develop an algorithm for a fully autonomous UAV to take its own actions and navigate within given constraints. We test our algorithm through simulation in the case of a border violation, where the UAV is responsible for surveillance and defending the area by searching and pursuing the intruder. The main objective of this study is to develop a stochastic strategy for aspects of UAV navigation that minimises the time required to complete the mission while maximising the probability of success, considering the uncertainty arising from a lack of knowledge about the intruder's movement. The movement of the UAV and intruder is modelled via simulation using a response surface methodology: Radial Basis Function. The developed mathematical tools can be used in various real-life scenarios where no information for the intruder's movement is available or partial information can be collected, including disaster management and the defence industry.

**Busra Biskin, Joerg Fliege and Toni Martinez-Sykora**, University of Southampton

**3.2 Autonomy in Military Engineering**

The Autonomy in Military Engineering Phase II study was challenged with identifying promising concepts within the field of Autonomy & Automation (A&A) for Force Support (FS) Engineering. The study was a follow on from a previous year's iteration that focused on Armoured Engineer units, building upon the success of using a 'TRIZ-lite' approach when breaking down the problem space for personnel and developing concepts.

The study team engaged Royal Engineers (RE), through both workshops and interviews, to generate a collated matrix of pain points within current FS Engineering tasks. A simple TRIZ analysis was performed to identify potential A&A solutions. This approach to the analysis aimed to support creativity - generalising specific problems identified by RE personnel and allow identification of similar paradigms where solutions already exist, or support creativity in finding novel concepts.

Separately, a scanning of current industry and academia research and development was conducted to identify areas with existing funding and research. A longlist of A&A concepts was generated aiming to combat identified pain points from RE FS tasks. The concepts then went through a series of refinements and down select to a final 7 concepts.

These final concepts were assessed within the context of an historical scenario, the UN intervention in Bosnia '93, taking example engineering tasks that were undertaken by contemporary RE.

Of note was a substantial route construction task 'Route Diamond', providing a Main Supply Route for UN humanitarian aid. Each concept was assessed for both benefits, real-world feasibility issues and points of incompatibility with current doctrine/employment plans, from both RE personnel and Study leads.

**Tom Potts, Robin Smith, and Chris Warfield, Arke Ltd**

### 3.3 **Determining the Value of Multi Domain Integrated Swarms (MDIS) to Defence**

MDIS is a 4-year Capability Investigation Programme to produce evidence to inform investment decisions at the Integrated Review 2025. It looks at whether the MOD should develop the capability for Remote Autonomous Vehicles (RAS) which operate in collaborative squads and communicate across domains. Enabled by a common Reference Architecture, these squads must be shown to have a noticeable and economical effect in terms of Operational Advantage and Freedom of Access and Manoeuvre (FOAM) in the 2030 epoch. The study has 4 primary desired outcomes:

- Develop a prototype, multi-domain digital architecture for MDI RAS.
- Accelerate RAS capabilities in all domains.
- Develop pan-Defence mechanisms for accreditation of RAS for operational use.
- Identify operational use cases for MDI RAS, including cost effectiveness analysis.

There are a number of postulated benefits to RAS. Activities such as transporting supplies across the battlefield or conducting surveillance and reconnaissance could be undertaken without risk to human life. The advent of autonomy also offers major advantages – while some uncrewed systems already exist in the form of UAVs, these are piloted in the same way as an aircraft, without true autonomy. RAS would be able to go to a destination without being piloted and maintain distance with other RAS to operate as a collective. They could have pre-programmed mission sets, including the ability to identify hostile forces. There are several regulatory challenges involved in giving systems high levels of autonomy and part of MDIS is to identify these.

Operational analysts have engaged with military subject matter experts to create several Use Cases – military scenarios with which to test the value of MDIS. In each case a “baseline” military force is generated and then compared with an MDIS-enabled force. These are contrasted using “Measures of Merit”, which are metrics such as number of casualties or mission success rates. The term ‘swarming’ conjures up specific behaviours and the idea of a large number of swarm members and has proved to be unhelpful when describing the benefits of a set of RAS acting collaboratively. Therefore, the term ‘collaborative squads’ has been adopted and could be formed by as little as three RAS working together. Initial work saw the running of tabletop exercises, where vignettes within the

scenarios (based on the Use Cases) were discussed by subject matter experts and analysed to generate insights. Potential RAS concepts were explored to understand how they may perform and bring benefit to conduct of the vignette. The current phase of work aims to further test those insights through the creation of simulation models to work out the benefits of various RAS force mixes in terms of their impact and cost.

Concurrent to this work is an ongoing literature search, 'Horizon Scanning', which enables analysts to understand the likely RAS advances by 2030 as well as the threats such systems may encounter. The project uses a multitude of techniques from "Soft OA" (to understand possible uses of RAS) and "Hard OA" (modelling). Going forward, insights from tabletop exercises, judgement from subject matter experts and other research will be combined with simulation modelling and cost modelling to provide evidence on the utility of RAS.

**Matthew Hodge**, TP Group

#### 3.4 **Red's Shoes**

In 2019 DIEM developed the Red's Shoes 'counter-Red Commander AI' proof of concept. It was originally tested with data on 3 Chechen commanders and General Zhukov, and then on 2 contemporary Russian commanders (Serdyukov and Zhuravlev). In 2022 Red's Shoes was presented to the Assistant Chief of Staff (ACOS) Operations of the Standing Joint Force Headquarters (SJFHQ) who then took Red's Shoes to Exercise JOINT PROTECTOR'22. This paper presents how the AI was used by SJFHQ in the exercise, the lessons learnt about the application of AI-based OA tools as part of operations, and how it aligns with the MODs AI strategy and ethical principles.

**Dr Darrell J J Jaya-Ratnam**, DIEManalytics Ltd

### Session 4: OR for strategy and portfolio analysis

#### 4.1 **Eating the Elephant: Analysis and Planning NATO's Acquisition Portfolio**

Portfolio analysis is a well-trodden path, but it has many underlying assumptions. For example, that there is a single and coherent source of enterprise strategy - or that any "strategies" can be differentiated from broader thinking and concepts! What do you do when there is no "single source of truth" for project and programme data; and indeed it is hard to tell what the truth is at all? When it is unclear who even has responsibility or authority for planning the overall portfolio? I will present a portfolio analysis maturity model that allows analysts and decision-makers to target realistic, incrementally achievable portfolio analyses to improve portfolio decision-making. The maturity model identifies analysis activities and attributes at each maturity level to become more mature. I will discuss

the analytical methods and skills required to provide valuable decision-support at each level. Finally, I will tell a few stories from the first year of applying this model to NATO portfolio management.

**Nicholas Rose**, NATO

#### 4.2 **Finding Space to Play in Wargames**

The UK Defence Space strategy released in February 2022 states that Space is a key enabler for UK Defence operations, and is now to be treated as an operational domain in its own right. Operational Research has been used to support that strategy and continues to provide insights into associated MOD decision making. Among a number of OR applications and approaches employed, a key aspect has been the incorporation of the Space domain into broader wargaming activities. Such wargames are used by MOD to consider interactions across all warfighting domains in an operational context. The outputs of wargames inform MOD strategy, force structure and more detailed capability investment decisions. Accounting for the Space domain in those activities is therefore critical in ensuring that MOD decision-makers have appropriate evidence and insights to consider associated threats and opportunities. A number of Operational Research activities conducted by Dstl over the last several years have looked to enhance the ability of wargames to account for Space. Those activities have involved a range of tasks, encompassing the generation of associated inputs and data, approaches and in some cases used of additional complementary OR techniques. As a result of these activities, the consideration of Space in wargames has been enhanced over a number of iterations of wargames, with attendant development of wider understanding of the Space domain in military operations and generation of underpinning data. Those outputs are being used to support a wide range of decision making in MOD both within Space Command, more broadly across Front Line Commands and MOD Centre.

**Elizabeth Burn**, Dstl

#### 4.3 **Future Materiel Distribution Land (FMDL) Strategy**

In 2021 Army HQ commissioned Dstl to conduct a study using the SCALE system-dynamics (SD) model to inform the Future Materiel Distribution Land (FMDL) strategy. SCALE was originally developed for Dstl, to prioritise logistics research and technology investigations on the basis of potential impact on the end-to-end defence support network (DSN). In this study it was used as a 'rapid operational simulation' i.e. running several scenarios with different assumptions about the application and performance of potential future technologies. This presentation will describe how future concepts were simulated and how the outputs of this SD model were used to inform the FMDL strategy.

**Dr Darrell J J Jaya-Ratnam**, DIEManalytics Ltd

#### 4.4 **OR for the Royal Canadian Air Force future strategy**

In a time of resource constraint, the Royal Canadian Air Force (RCAF) is seeking to succinctly plan its future by establishing a new strategy. The strategic analyst and operational research scientists in Defence Research and Development Canada, Centre for Operational Research and Analysis who are embedded in the RCAF Aerospace Warfare Centre (RCAF AWC) were tasked to help with the construction of this strategy and to help the RCAF use it to plan their future. This talk outlines the method used to develop a strategy as well as the methods that link the strategy's outcomes down to the annual planning cycle. A measure of effectiveness has been developed to allow the RCAF to link their daily outputs to objectives outlined in the strategy.

##### **Dr. Andrew Billyard, DRDC**

Dr. Billyard graduated in 1999 from Dalhousie with a Ph.D. in theoretical physics. His role in the last 21 years at Defence Research and Defence Canada within the Department of National Defence has been to provide scientific advice to senior military officers on a wide range of problems: force protection measure for ships, estimating vertical displacement of tethered mines due to ocean currents, constructing investment and divestment strategies of key military capabilities, force protection against low-slow fliers for Vancouver 2010 Olympics, framework analysis to achieve \$1B savings in 2010 defence budget, analytic support to the RCAF's experimentation programme, maritime recognized picture improvements. He is now a senior researcher at the RCAF Aerospace Warfare Centre's Operational Research and Analysis branch who helps the RCAF AWC with performance measures, lesson's learned accountability framework, process mapping, research methods for guiding documents (operating concepts, strategy, policy), electronic warfare operational assessments, concept experimentation. He also teaches critical thinking to military and science audiences, is an associate editor of the DRDC publication system, and is an instructor at Loyalist College in his home town.

### Session 5: Lessons from leading and managing collaborative OR

#### 5.1 **Electric UAVs: Lessons from collaborative multi-supplier utility studies**

Using a study of UAV use cases in land and maritime operations, we will extract lessons learned that enable informed collaboration between analysts, manufacturers and independent SMEs; and suggestions for manufacturers and task sponsors to improve the clarity and quality of their requirements briefs.

##### **Clarice Chung, BAE Systems**

5.2	<p><b>Collaboration across Boundaries</b></p> <p>Using a Power and Energy horizon scanning study designed to inform MOD strategy (ASTRID Task 145), we will extract lessons learned that enable engagement and collaboration with academia, industry and the military to be planned and ‘effectiveness evolution’ to be accelerated.</p> <p><b>Richard Brown</b>, BAE Systems</p>
5.3	<p><b>Collaboration across boundaries – An ASTRID perspective</b></p> <p>ASTRID (Analysis for Science and Technology Research In Defence) is a framework contract owned by MOD and managed by Dstl. Its role is to facilitate industry/academic OA/OR practitioners to provide analysis to help UK Government Defence and Security customers with their decisions. With a supply chain of over 180 organisations and having accepted over 300 Tasks to date, ASTRID has lots of experience of seeing collaboration in practice. This presentation will provide an ASTRID eye view of collaboration including what are the ingredients of success, examples where collaboration has worked and lessons from both customers and suppliers.</p> <p><b>Edward Aubrey</b>, CORDA</p>
5.4	<p><b>Operations Research Group in the Israeli ministry of health (MOH) Covid Task Force</b></p> <p>As of Jan. 20, 2020 (when first Israeli Covid-19 patient identified), Israel was gearing up toward dealing with the pandemic. Having impact required setting up – getting into the process of decision making, earning the trust of the decision-makers, and getting heard in the cacophony of advisors. In this talk I wish to share the process of setting up a military OR group in the Israeli MOH – Covid Task Force, the impact of changes in the organization on the problem set, and a few examples of products produced and their impact.</p> <p><b>Ami Mizrahi</b>, Hebrew University of Jerusalem</p>
Session 6: Leveraging and interpreting historical data and analyses	
6.1	<p><b>Juxtaposing Narrative and Numbers: Utilising Quantitative and Qualitative Methodologies in the Historical Analysis of Defensive Operations</b></p> <p>Military theorists have long grappled with offence versus defence, and the virtues of each posture. Media coverage of the war in Ukraine, with scenes from Bakhmut reminiscent of the grinding attrition of the First World War, has generated a renewed appetite to look to history to identify what factors, if any, have featured in successful defensive operations. Combining qualitative analysis of the historical literature with quantitative analysis of 470 battles and campaigns from the updated Helmbold Land Battles Database</p>

revealed some surprising results. Both methodological approaches identified consistent themes around training, morale, and leadership as being at least equally as important as logistics, the air situation, and ISTAR superiority. As revealing as these results were, so too was the implication that utilising blended methodological approaches to historical analysis increases analytical efficacy and confidence in the results. Routinely, military historians seek ways to engage a wider audience in the historical conversation, and juxtaposing narrative with numbers may offer a better approach to achieving this.

**Rebecca Brown, Colin Irwin, Paul R. Syms, Ahmad I. Villasenor, and Elliot Cook, Dstl**

Rebecca joined DSTL as a Principal Historical Analyst in 2022. Formerly she was a national expert in anti-social behaviour, advising the Home Office, National Police Chief's Council and other statutory agencies as CEO of a national charity. Rebecca is an avid military historian with particular interest in special operations. She obtained her degree in War and Security Studies in 2014, her Master's degree in International Relations in 2016, and is in her final year of her doctoral studies at the University of Oxford. Her thesis considers the establishment and evolution of the British Special Air Service with particular emphasis on their deployment to Dhofar in 1970.

## 6.2 **World War 2 Operational Research revisited: Air Power against the U-boats**

This presentation continues the author's revisits to the ground-breaking work of the RAF Coastal Command Operational Research Section (ORS) in World War 2 as described in works by Prof C H Waddington and later by Prof Maurice Kirby. The sometimes "rough and ready" OR methods proved eminently 'fit for purpose' at the time and despite their simplicity, were not considered releasable for wider distribution until the 1970s due to their potential military utility to friend and foe alike. A previous presentation at last year's ISMOR considered "The U-boat Sighting Problem" as addressed during the Battle of the Atlantic and compared the wartime findings with a more numerical, model-based approach that we might adopt today. This current presentation continues the story by reviewing the attempts made to find the most effective methods for attacking the U-boats from the air, revealing the heated debates and sometimes questionable arguments advanced at the time, all in the light of 80-odd years of further development of OR techniques, and a similar degree of hindsight!

**John Magill, University of Cambridge Alumni**

### 6.3 **Historical analysis of urban combat casualties and loss rates**

The UK's Land Warfare Centre (LWC) tasked Dstl with researching expected casualty rates in high-intensity warfighting, particularly in urban operations (otherwise known as fighting in built-up areas, or FIBUA), to inform casualty evacuation (Casevac) and medical treatment planning for Headquarters, Allied Rapid Reaction Corps (HQ ARRC). Legacy data from existing UK and US studies were reviewed, most of which rested on Second World War (WW2) battle data. A new dataset of 43 WW2 and post-WW2 urban battles was assembled, together with a similar dataset of 102 rural battles for comparison, starting with the updated Helmbold Database, and researching additional battles where necessary. Comparing these statistically confirmed that FIBUA favoured the attacker, and that this conclusion held for more modern combat as well as for WW2. The loss rates for forces engaged in urban and rural combat under different circumstances and for different organisational levels are calculated, as are the expected splits between losses that are killed in action (KiA), wounded in action (WiA), prisoners of war (PoWs). The implications for medical planning and for FIBUA doctrine, tactics, and training are discussed.

**Paul R. Syms**, Dstl

## WORKSHOPS

Workshops will run in parallel and over two separate sessions, offering delegates the opportunity to participate in up to two different workshops. Schedule and timings will be available nearer the start of the symposium.

- |   |  |
|---|--|
| A | <p><b>Appealing to the New Generation: How do we make a career in Defence OR more attractive to Graduates and Early Careers</b></p> <p>Within our sector, graduate recruitment has been highlighted as a key issue. This interactive workshop will explore the key challenges in recruiting and retaining early careers staff, provide insights into the experiences of early career staff, and identify ways in which the challenges can be met. Participants will be able to hear the views of early careers' Defence OR personnel themselves.</p> <p><b>Jason Potter, Mia Hallsworth and Christy Gahan</b>, BAE Systems</p>   |
| B | <p><b>Have fun, solve problems, make a difference: Volunteering opportunities with The OR Society</b></p> <p>Find out about using your OR skills to inspire young people and contribute to something of societal importance. We'll give you an overview of the OR in Education and Pro Bono OR programmes. Take part in a hands-on activity to get a feel for what volunteering for both of the schemes entails. We'll present a problem to you the way we would present a school resource, and give you tips on how you could do this in a classroom. Once you've solved the problem you will present your results back to us as if you'd done the project for a charity. You'll also get to meet some current volunteers and hear about their experiences and what it's like to work on a pro bono project and go into a school. Come along to ask questions and learn about the benefits of volunteering for your own wellbeing and career development, as well as giving something back to society.</p> <p><b>Evelyn Hardy</b>, The OR Society</p> <p>Eve Hardy is currently The OR Society's Pro Bono OR Manager, and has also held the Education Manager role. Eve coordinates the Pro Bono OR programme, matching data and analytics professionals with good causes who would benefit from some OR expertise. When she was Education Manager, she supported volunteers who go into schools and universities to run workshops and give careers talks. This unique career history makes Eve the expert on volunteering with The OR Society.</p> |
| C | <p><b>Rapid assessment of Whole Life Costs and Benefits through structured judgment - hands-on testing of a new ready reckoner</b></p> <p>This workshop invites participants to trial the use of an Excel-based Ready Reckoner to evaluate a range of unclassified &amp; fictional military concepts.</p>  |

DICER is designed as a means for Analysts and Desk Officers to generate DLOD impact, Whole Life Cost and Whole Life Benefit assessments of future capability Concepts in a wide range of Contexts via a rapid, but evidenced, structured judgement process. It is intended for use in the Concept Phase of a Programme, up to and including support to Strategic Outline Business Cases.

The tool designers are seeking feedback on the workflow, outputs and ease of use as part of their validation activities and are keen to gain your input as defence professionals. The 90-minute session will consist of a brief tool familiarisation presentation, followed by ~50 mins hand-on time, followed by a feedback plenary.

**Dan Page**, Morshead Consulting

**D Field Army Operational Research Branch**

The Field Army Operational Research Branch uses analytics, modelling, problem structuring, simulation, and data science to enable decision makers to make better decisions. It provides evidence for the optimisation of the Field Army operating in a contemporary battlespace. The Field Army Operational Research Branch was newly formed in January 2023 and have begun to augment their standard offering with several new and in development supporting tools and models forming the Operational Research (OR) Electronic battle box.

This workshop will start with an introduction to the Operational Research Branch's (ORB) mission statement, structure, and ways of working. The workshop will then provide an end-to-end walkthrough of a pre-programmed wargame within our new electronic wargame Cirsium. During this walkthrough, attendees will have the opportunity to ask questions, interrogate how the tool is performing calculations, and change courses of action to better understand how the ORB team support Field Army decision making.

Finally, the workshop will showcase the other tools within the OR electronic battle box and discuss how, alongside Cirsium, we provide complete support to Field Army operations and exercises at the Corps, Divisional and Brigade level.

The workshop will cover how we provide:

1. Force Ratio Analysis.
2. Combat Resolution Modelling.
3. Casualty Estimating.
4. System and Equipment loss estimating (including those lost to non-kinetic effects)
5. Logistical modelling and movement times.

	<p>The workshop will close with our current areas of research and where we are looking to explore further opportunities to support Field Army operations and exercises.</p> <p><b>Mr Callum Woodhall</b>, MOD Land Warfare Centre, Op Research Branch, Deployed Scientific Services</p>
E	<p><b>Programme Evaluations as an Example of Multidisciplinary Working</b></p> <p>Session exploring how analytical techniques can be used to monitor and evaluate the effectiveness of Defence projects and programmes, drawing on techniques and expertise from a range of analytical professions to provide robust insights.</p> <p><b>Emma Bishop</b> and <b>Luke Heley</b>, MOD Defence Economics Evaluation Team</p>
F	<p><b>The Beer Game</b></p> <p>The beer distribution game (also known as the beer game) is an educational game that is used to experience typical coordination problems of a supply chain process. It reflects a role-play simulation where several participants play with each other. The game represents a supply chain with a non-coordinated process where problems arise due to lack of information sharing. This game outlines the importance of information sharing, supply chain management and collaboration throughout a supply chain process. Due to lack of information, suppliers, manufacturers, sales people and customers often have an incomplete understanding of what the real demand of an order is. The most interesting part of the game is that each group has no control over another part of the supply chain. Therefore, each group has only significant control over their own part of the supply chain. Each group can highly influence the entire supply chain by ordering too much or too little which can lead to a bullwhip effect. Therefore, the order taking of a group also highly depends on decisions of the other groups.</p>
G	<p><b>Scoring - It's More Than Just Numbers</b></p> <p>Martyn Anthony Principal Consultant at Sirius Analysis will demonstrate the effective use of scoring in this interactive workshop. The main purpose of this workshop will be to ensure that those who are partaking in decision analysis can find useful ways of defining scores for their analysis. The different types of scoring methodology will be discussed, as well as the importance of defining the consequence of the score to help enable better evaluation of options or tenders.</p> <p><b>Martyn Anthony</b>, Sirius Analysis</p>

H	<p><b>Be part of defining appropriate Analytical Quality standards for OR</b></p> <p>This is an opportunity to come along and contribute to the update of the Analytical Quality (Aqua) Book 2nd Edition, which provides guidance for Analysis for UK Government. This then becomes one of the published documents defining how we as a profession understand appropriate analytical quality is achieved.</p> <p>Attendance at this workshop requires no prior knowledge, except your view concerning how you establish the credibility, verification and appropriate validation of your work.</p> <p>Your inputs will help to identify:</p> <ul style="list-style-type: none"> <li>• What the 2nd Edition of the Aqua Book should signpost, or continue to signpost, so as to provide clear guidance on how to deliver appropriate Analytical Quality for work done for UK Government</li> <li>• What if anything should be dropped or heavily amended, surfacing insights concerning the way in which this is best done</li> <li>• New material or coverage that is needed in the revised publication</li> </ul> <p><b>Paul Glover</b>, Dstl</p> <p>Paul has been working in OR for 36 years and leading on the delivery of appropriate analytical quality since 1995. He was third author of the 1st edition of the Aqua Book, and has been actively engaged in setting and delivering appropriate standards ever since.</p>
I	<p><b>Tactical Wargame Methodology Workshop</b></p> <p>In wargame design there is a tension between realism and playability, the accuracy and detail of the representation in the game and the ease and speed of play. To help attendees gain an appreciation of wargame design and implementation, a small battle will be fought at least twice at different scales with the attendees as commanders of one side. The participants will be asked to subjectively assess the relative merits of each approach.</p> <p>The tension is even stronger in wargaming for research purposes as too much simplification may obscure or unconsciously pre-assess important factors but unlike a hobby game the players will not have the time to learn complex rules or play long games. Selecting the key scales of unit, ground and time is an important part of methodology development.</p> <p><b>Alasdair Hood</b>, Sirius Analysis</p>