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NATO SCIENCE AND TECHNOLOGY ORGANIZATION 2013 ANNUAL REPORT

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SCIENCE AND TECHNOLOGY ORGANIZATION

2013 ANNUAL REPORT

Foreword

FOREWORD

THE NATO SCIENCE AND TECHNOLOGY ORGANIZATION (STO) LOOKING FORWARD AND STAYING AHEAD

In the foreword to his 2013 Annual Report, the NATO Secretary General states it is necessary that NATO maintains the momentum of its transformation to meet the demands of a fast-moving security environment.

This is the foundation upon which the NATO Science and Technology (S&T) community, and the Science and Technology Organization (STO) in particular, undertake their activities; that is, to support NATO and the Nations to adapt and respond to unexpected and unforeseen challenges in a timely manner.

NATO S&T is the vector to deliver both strategic awareness of future challenges and the innovation that NATO and Nations need for looking forward and staying ahead.

The year 2013 was the first full year of work for NATO's STO, teaming up the Collaborative S&T network and its support structure, NATO's Centre for Maritime Research and Experimentation (CMRE), and the newly established Office of the Chief Scientist (OCS) in the NATO Headquarters (HQ). It was a productive year; the STO successfully met its 2013 transformation objectives, while continuing to deliver a Programme of Work (PoW) with increasing impact.

The Nations tasked us to deliver a NATO-wide approach to S&T. In 2013, important milestones were met involving all NATO S&T stakeholders: the North Atlantic Council (NAC) approved the NATO S&T Strategy, stakeholder strategy implementation plans, and increased S&T programme co-ordination.

Our Collaborative Programme of Work (CPoW) was vibrant, with the level of activities at an all-time high. We are very pleased that the CPoW achieved recognition with the Nations as the preferred multi-national S&T framework, and that its business model, matching commonly identified needs with participants' means ("smart defence"), is considered sound and cost-effective.

Ernest J. Herold, NATO DI DASG and S&T Board Co-vice Chair, Albert Husniaux, MGen (Belgian Air Force), NATO Chief Scientist and S&T Board Chair, Jaroslav Kocian, MGen (Czech Army), NATO IMS L&R Director and S&T Board Co-vice Chair.

The CMRE had a successful year as well, delivering a high-quality Maritime S&T PoW. This was the first year it operated under a customer-funded business model, delivering its PoW to the satisfaction of its customers, meeting targets for quality, delivery schedule and cost.

We, Chair and Co-vice Chairs, are pleased to present this 2013 Annual Report. We trust it will provide an appreciation for the results delivered by the STO, a view of leading-edge scientific and technical accomplishments, and that it will encourage further participation in our PoW.

We wish you excellent reading.

Executive Summary

EXECUTIVE SUMMARY

The 2013 Annual Report of the NATO STO is representative of the 2013 STO PoW, which consists of more than 180 activities that cover all relevant Defence and Security areas of interest.

This report demonstrates that through extensive interaction with senior leadership across the Alliance, NATO S&T is aligned with the priorities of the Nations and NATO. It is intended not only for NATO's S&T stakeholders, it is also meant to reach out to those across the globe who are interested in NATO S&T.

In the section "Corporate Perspectives", the reader is invited to get acquainted with S&T in NATO, including its large community of stakeholders. The most important functions of the STO are addressed, including the fact that the Organization encompasses the largest known network of S&T experts in the world. This part concludes with the 2013 strategic focus and achievements, aimed at governing the STO and developing NATO S&T unified governance, and the 2014 preview.

The section "NATO STO Programme of Work" treats the reader to a representative yet modest set of S&T activities drawn from the STO PoW. All those activities contributed to the three strategic objectives of NATO S&T, i.e., Supporting Capability Development, Fostering Consultation and Partnerships, and Delivering Knowledge, Analysis and Advice. The description of the activities includes explanations of Impact and Exploitation, Synergies and Complementarities and S&T Achievements.

Within the STO PoW there are two executive bodies that play a major role, namely the Collaboration Support Office (CSO) and the CMRE. Both bodies are introduced by their respective Directors at the beginning of this part of the report.

Last but not least, the focus is placed on excellence in NATO S&T, paying tribute the fine women and men that have brought forward S&T for the benefit of the Alliance and its Partners.

The "Annexes" contain a more detailed description of the NATO STO and its functions, including facts and figures, and a list of acronyms.

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Corporate Perspective

NATO SCIENCE AND TECHNOLOGY

Defence S&T, in the context of NATO, is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. The term is broadly inclusive of the physical, engineering, information, human, medical and social sciences.

NATO S&T is comprised of activities that contribute to the generation and exploitation of scientific knowledge and technological innovation, addressing the short-, medium- and long-term horizon. NATO S&T includes programmes and activities that Nations, NATO bodies and Partners elect to perform within the trusted NATO framework. NATO S&T serves the security and defence posture of the Nations and NATO, and supports the core tasks of the Alliance as set out in the Strategic Concept. The vast majority of NATO S&T work is funded directly by the Nations.

NATO S&T is instrumental in enabling state-of-the-art defence and security capabilities, assessing the security impact of emerging (technological) threats and serving public diplomacy by building bridges. Facilitating knowledge generation and exchange in a NATO collaborative context, thereby injecting military relevance, positions S&T as a critical "force multiplier" for the Alliance; influencing, enabling and levering S&T investments in the Nations and NATO will achieve a higher quality and impact at a reduced cost.

NATO S&T has a diverse set of stakeholders including individuals as well as organisations that can affect NATO S&T activities, through guiding, funding or executing, for example; or that can be affected by its results, such as benefiting from their application or exploitation. Due to this diversity, the effectiveness and efficiency of NATO S&T depends critically upon close co-ordination, co-operation and collaboration between all stakeholders.

Unified governance of NATO S&T, without prejudice to the responsibilities and authority of the stakeholders, is of vital importance to avoid unnecessary duplication while maintaining competition of ideas, and to further improve synergies and seek complementarities for burden sharing.

STAKEHOLDERS

A non-exhaustive list of NATO stakeholders (in alphabetical order) is presented in the NATO S&T Strategy: Allied Command Transformation (ACT), the Conference of National Armaments Directors (CNAD) and its subordinate structure (namely the Main Armaments Groups (MAGs) and the NATO Industrial Advisory Group (NIAG)), the Consultation, Command & Control Board (C3B) and its subordinate structure, the Military Committee (MC), the NATO Communications and Information Agency (NCIA), the NATO Science & Technology Organization (STO), the NATO Support Agency (NSPA), the Science for Peace and Security Programme (SPSP), and the supporting staff at NATO Headquarters.

Other stakeholders not listed include the Committee of the Chiefs of Military Medical Services (COMEDS) and its subordinate structure, the NATO Centres of Excellence (CoE), the NATO Defence College (NDC), the NATO Parliamentary Assembly (PA) and its sub-structure, the von Kármán Institute (VKI), institutes, academia and industry.

NATO SCIENCE AND TECHNOLOGY ORGANIZATION

Defence Ministers decided to create the NATO STO in 2012, with the aim to make S&T more visible and accessible for senior NATO leadership and to better link multi-nationally and common funded S&T, while maintaining the quality of services and products.

The STO is built on two important preceding bodies: the NATO Research & Technology Organization (RTO) and the NATO Undersea Research Centre (NURC). This amalgamation not only brings together a legacy of co-operative S&T that dates back to Dr. von Kármán's instrumental support in founding the Advisory Group for Aerospace Research and Development (AGARD) in 1952, it also encompasses the NATO in-house maritime research facility. Furthermore, the NATO Chief Scientist and his staff were introduced and installed in NATO HQ.

The mission of the NATO STO is to help position the S&T investments of the Nations and NATO as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO, Nations and Partners.

The STO is the main venue to deliver S&T in NATO. It encompasses the largest network of Subject-Matter Experts (SMEs) of its sort in the world and is composed of the Science and Technology Board (STB), Scientific and Technical Committees, and three executive bodies.

The STB, in which all NATO S&T stakeholders are represented, is the highest authority in the STO. It exercises governance on behalf of the Council, and reports to the Council through the MC and the CNAD. The STB's main responsibilities in 2013 were:

- **Governing the STO** – This includes overseeing STO policies, management and programmes, guiding and directing STO technical committees and working groups, the Knowledge/Information Management Committee (KIMC) and the three executive bodies.

- **Implementing NATO S&T unified governance** – This includes, without prejudice to the responsibilities and authorities of the stakeholders, developing and implementing the NATO S&T strategy, defining NATO S&T priorities and serving as the focal point for the co-ordination of all S&T programmes and activities within NATO.

- **Supervising the NATO S&T Reform**.

The STB is chaired by the NATO Chief Scientist, who represents the STB to the Secretary General and the Council. The NATO Chief Scientist is also the senior scientific advisor to NATO leadership, and is responsible for the effective co-ordination of all NATO's S&T programmes. The STB and its Chairperson are supported by three STO executive bodies of which the OCS is one, located at NATO HQ in Brussels, Belgium.

The Scientific and Technical Committees, composed of national defence S&T managers and SMEs, are responsible to the STB for the planning and execution of STO's CPoW. In this collaborative S&T business model, Nations and other stakeholders work together to deliver S&T results and to promote information exchange. The STO provides the framework and delivers executive support through the CSO, which is located in Neuilly-sur-Seine, France.

Within this collaborative framework approximately 3,500 scientists and engineers are active in a portfolio of more than 180 activities on a yearly basis. In what is "smart defence *avant la lettre*", NATO S&T stakeholders use their own resources to generate the CPoW, and together with NATO staff mutually focus their efforts on Nations' and NATO's priorities, together with NATO staff.

There are seven S&T content-driven collaborative committees in the STO. They encompass a broad spectrum of scientific fields and are designed to address every relevant military scientific and technological topic. Each committee is chaired, on a rotational basis, by a senior scientist or engineer from one of the participating NATO Nations.

The content-driven committees are: Applied Vehicle Technology (AVT), Human Factors and Medicine (HFM), Information Systems Technology (IST), Systems Analysis and Studies (SAS), Sensors and Electronics Technology (SET), and the NATO Modelling and Simulation Group (NMSG). (See Annex A for more information.)

The CMRE is STO's customer-funded executive body; it is an S&T facility corresponding to the "in-house delivery business model" of NATO S&T.

The CMRE carries out projects and experiments to deliver military relevant state-of-the-art scientific research and technology using its own capabilities, infrastructure and personnel. The Centre is located in La Spezia, Italy, and its main customer is NATO, through ACT.

The Centre's portfolio includes ocean science, modelling and simulation, acoustics, communication, signal analysis and other disciplines. It also contributes new technologies for enabling interoperability with unmanned systems that have the ability to sense, comprehend, predict, communicate, plan, make decisions and take appropriate actions to achieve mission goals. Furthermore, the Centre also provides S&T-based enhancements to unmanned (autonomous intelligent) systems and integrated defence systems.

Lastly, CMRE's customer-funded PoW enables Nations, NATO and Partners to work more effectively and efficiently together by leveraging national needs and focusing on military relevant S&T challenges, both within and outside of the maritime domain in close collaboration with all stakeholders.

2013 STRATEGIC FOCUS AND ACHIEVEMENTS

INTRODUCTION

The 2013 strategic focus of the STB was on transitioning from STO governance towards NATO S&T unified governance, including implementing the various elements of NATO S&T Reform, while continuing to deliver a high-quality defence- and security-relevant STO PoW.

The achievements of 2013 are presented according to the two main responsibilities of the STB, i.e., governing the STO and implementing NATO S&T unified governance. One of the landmarks of 2013 was the approval of the NATO-wide S&T Strategy by the NAC.

STO GOVERNANCE

STO PoW

The STO synergistically integrated the in-house customer-funded CMRE S&T activities and the collaboratively funded S&T activities of the Nations and Partners into one STO PoW.

The links with various stakeholders were strengthened by increasing the visibility of the S&T activities and their results, and by having an intense supply-demand dialogue with stakeholders to improve synergies, leverage and exploitation.

The 2013 STO PoW addressed the three NATO S&T strategic objectives, which collectively support NATO's and the Nations' objectives: *Supporting Capability Development, Fostering Consultation and Partnerships* and *Delivering Knowledge, Analysis and Advice*. In the following sections a representative outline of the connected S&T activities is described.

Lastly, the STB analysed how best to strengthen the links with the Connected Forces Initiative (CFI) and the Smart Defence initiative. Promising exploitation paths were identified, including the notion to further develop the correct processes on how S&T user and provider communities could interact and benefit.

SETTING-UP THE STO

The Council approved the STO personnel structure, i.e., the End State Peace-time Establishment (ESPE).

The integration of the three executive bodies, i.e., CMRE, CSO and OCS, in the STO significantly progressed. Domains of responsibility were delineated, synergies were found, and improved co-ordination allowed for a better leverage of the S&T investments of the various stakeholders, including the Nations.

The newly created OCS in NATO HQ increasingly played a pivotal role, both to the benefit of the STO and the other NATO S&T stakeholders.

NATO'S MARITIME S&T

STO's CMRE became customer-funded in January 2013, according to plan. The Centre successfully operated in this mode throughout 2013, delivering its PoW within the boundaries of its financial plan, balancing planned income and expenses as was forecast.

ACT and the STB jointly delivered a proposal pertaining to the final solution for NATO's Research Vessels (NRVs). This proposal was noted by the Council in December 2013.

NATO S&T COLLABORATIVE ENVIRONMENT

STO's CSO continued to develop and refine the executive support required by the CPoW, responding to the needs of a NATO Restricted collaborative environment. This resulted in cost-savings to the Nations and NATO bodies.

NATO S&T UNIFIED GOVERNANCE

NATO S&T unified governance is one of the new key elements of the NATO S&T reform. It aims at a NATO-wide strategic approach to NATO S&T, including optimal use and leverage of the resources the Nations and NATO invest in NATO S&T.

The STB focused on co-ordinating programmes and activities, in strengthening the role of S&T as a NATO planning domain, in defining and implementing strategic guidance, and on making progress in two particular S&T areas, Maritime S&T and Operations Research and Analysis (OR&A), in accordance with Ministers' guidance.

CO-ORDINATION

The STB meeting formats were adapted to strengthen the links between stakeholders and co-ordinate their programme activities, to further increase investment leverage and synergies.

Co-ordination of multi-national collaborative, customer- and common-funded S&T avoided unnecessary duplication and achieved synergies by close interactions with S&T stakeholders. The presence of the OCS at NATO HQ proved to be instrumental.

The visibility and accessibility of NATO S&T for NATO senior leadership was improved by S&T focus sessions, presentations in various high-level meetings, and focused co-ordination with all NATO S&T stakeholders.

S&T AS A NATO PLANNING DOMAIN

The STO continued engaging in the NATO Defence Planning Process (NDPP) through its nascent cycle, and continued establishing the position of S&T as a planning domain, as well as supporting the efforts to enhance the NDPP for the next cycle. This included providing advice to both NATO and Bi-SC staff on requirements and appropriate concepts and methodologies to expand the focus into the long term.

NATO S&T STRATEGIC GUIDANCE

The NATO S&T Strategy was approved by the Council in January 2013.

The STB endorsed the way forward for implementing the NATO S&T Strategy, based on a NATO-wide co-ordination plan and affiliated action plans for all stakeholders in September 2013.

Stakeholders subscribed to this approach and developed their action plans, based on STB guidance.

The first action plan delivered was the MC-approved, NATO Military Authorities (NMAs) 2014 Consolidated Action Plan (December 2013). The STO initiated the development of NATO S&T Priorities to guide the planning of future S&T activities. Initial inputs included military requirements as defined through the NDPP, Nations' views, Emerged/Emerging to Disruptive Technologies (E2DTs), and the STO PoW.

MARITIME S&T BUSINESS PLAN

Ministers tasked the STB to develop a Maritime S&T Business Plan (BP) that provides a comprehensive view on the Alliance's Maritime S&T. The 2013 version of this plan was delivered, composed of an overarching Maritime S&T strategic view and two BPs: STO's CMRE and STO's CSO.

OPERATIONS RESEARCH AND ANALYSIS

The first steps towards initiating the implementation of a NATO OR&A framework were taken, including strengthening the existing Community of Interest (CoI). ACT and the STO co-operated closely to achieve this.

2014 PREVIEW

INTRODUCTION

The STB focus for 2014 is very similar to that for 2013.

STO GOVERNANCE

The PoW – ensuring customer relevance and co-ordination, and continuing to strengthen the links with the various stakeholders.

Setting-up the STO – implementing the new functions and missions, e.g., the advice function, and rationalising the STB business cycle.

Building NATO's Maritime S&T – further developing the Maritime S&T BP, and continuing to implement CMRE's customer funding and the definition and initial implementation of the final solution for NRVs.

Building the collaborative environment for NATO S&T – further refining the executive support to the CPoW.

NATO S&T UNIFIED GOVERNANCE

Co-ordination – further developing the STO to be the focal point of NATO S&T co-ordination.

S&T as a planning domain – further developing the NDPP and the advisory role therein, especially NATO S&T's role for the long term.

NATO S&T strategic guidance – implementing the NATO S&T Strategy, i.e., stakeholders' Strategy Implementation Action Plans as part of the overarching Co-ordination Plan, and defining and developing the NATO S&T priorities.

Maritime S&T BP – continuing to focus on delivering a long-term vision for Maritime S&T and extending the BP with (individual) Nations' contributions.

OR&A – continuing the implementation of the OR&A action plan and strengthening the CoI through dedicated events.

NATO STO Programme of Work

INTRODUCING THE COLLABORATION SUPPORT OFFICE

ENABLING NATIONS TO GET THE MOST OUT OF THEIR S&T INVESTMENTS

Mr. René LaRose, Director STO CSO

I am very pleased to introduce this brief but representative set of high quality S&T results that have been delivered through the framework of the NATO S&T CPoW.

Less than two years after the establishment of the NATO STO and at a time of generalised financial constraints, the CPoW framework has reinforced its acceptance as the preferred multi-national S&T framework for NATO and Partner Nations. During this last year, our Nations have not only committed to an unprecedented level of activities (more than 180, of which 70 percent were open to Partners), but have also maintained the highest level of quality as recognised by the numerous CPoW activities that won STB Scientific Achievement Awards, and by the awarding of the von Kármán Medal to a long-term CPoW contributor.

The continued success of the CPoW is rooted in its original approach that allows NATO and Partner Nations to identify common interests and collectively address their own needs for science-based Defence and Security knowledge. As such, the CPoW framework brings together seven different Communities of Practice (CoPs) covering the full spectrum of Defence and Security S&T themes including: vehicles, humans, sensors, information, systems concepts and integration, system analysis, as well as modelling and simulation. While the CoPs are focused on these themes, they bring together a diversity of contributors from all environments: air, land, sea, space, information and cyber, and from various organisations such as academia, national laboratories, industry and military. With a network of over 3,500 active contributors, it constitutes the largest known network of Defence and Security S&T.

The network is augmented through participation of numerous NATO entities who add a NATO collective perspective to complement the specific national perspectives, when and where appropriate. In particular, the NATO ACT, Allied Command Operations (ACO), specific Commands such as International Security Assistance Force (ISAF) and Kosovo Force (KFOR), various Centres of Excellence, the NIAG, MAGs, the CMRE, etc., also contribute to and benefit from the significant effort of Nations to generate and exploit S&T knowledge as part of this framework.

As a result, besides the specific S&T outputs, NATO and the Nations also greatly benefit from a network of advisors that have been exposed to the S&T challenges, perspective and capabilities of their Allies with whom they deploy, and consequently benefit from sound advice for decision-making and from the right knowledge to enable the development of adequate military capabilities well suited to address NATO needs.

The examples that follow reveal a diversity of well-focused S&T activities conducted under the CPoW that have delivered high quality S&T outputs, which in turn have had a significant positive impact on the ability of Nations to contribute to NATO, and of NATO to achieve its objectives.

INTRODUCING THE CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION

NATO'S IN-HOUSE RESEARCH FACILITY

RAdm (ret) Hank Ort, Director STO CMRE

CMRE IS NATO'S CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION

Formerly NURC until June 2012, and known as SACLANTCEN prior to 1993, the Centre has a distinguished history of international collaboration in marine sciences, marine environmental acoustics, military oceanography, ocean and acoustic modelling, rapid environmental assessment, signal processing and maritime situational awareness.

CMRE is NATO's knowledge repository for maritime S&T, offering a trusted platform for NATO Nations and Partners to work together on sensitive matters and to share science and technology. CMRE provides a S&T framework through which NATO realises the benefits of ownership by reducing risks and costs, and aligning national interests and ambitions. The intellectual capital thus generated has great value in creating operational advantage and equipping the future force.

2013 – A TRANSITIONAL YEAR FOR CMRE

Along with a name change, came a change to the business model under which the Centre operates. The year 2013 was the first full year of being a customer-funded organisation. Previously, the Centre was supported by NATO Common Funds provided through ACT. Although ACT still provides the majority of funding, the Centre's customer base is expanding to the European Community (EC), national institutes and national industries. The new model ensures that the prioritised requirements of NATO and NATO Nations are met.

GAME CHANGING SCIENCE

CMRE contributes to new technologies enabling the development of unmanned systems that have the ability to sense, comprehend, predict, communicate, plan, make decisions and take appropriate actions. This provides operators with new kinetic and non-kinetic capabilities required to defeat traditional threats decisively and confront irregular challenges in the maritime security environment.

In addition, curated data sets from CMRE instruments at sea are a major product of its ships, robots, gliders, moorings and other sensors, and are used by the scientists of many NATO Nations to augment or replace their own sea-going efforts.

NATO RESEARCH VESSEL ALLIANCE AND COASTAL RESEARCH VESSEL LEONARDO – ACCESS TO THE SEA

NRV ALLIANCE is an ice-capable Global Class ship that is amongst the world's quietest, and is fitted with state-of-the-art scientific laboratories, extensive deck handling equipment and satellite communications with advanced networks and broadband internet access. Coastal Research Vessel (CRV) LEONARDO is a smaller ship able to operate in shallow water and the coastal environment. With two complementary research ships, experimentation can range from concept development to prototype demonstration in any maritime operational environment.

Through the delivery of sea-proven maritime innovation and interoperability solutions, CMRE aspires to be an indispensable source of maritime S&T.

SUPPORTING CAPABILITY DEVELOPMENT

Capability development is supported by NATO S&T in bringing scientific knowledge and technological innovation to bear on the definition, development, demonstration, improvement, cost reduction and evaluation of sustainable, connected and interoperable Defence and Security capabilities for the benefit of the Nations and NATO, in line with NATO defence planning priorities, in the short-, medium- and long-term.

The NATO STO PoW included activities in the areas of maritime warfare and security, operations research and analysis, cyber defence, Countering Improvised Explosive Devices (C-IEDs), unmanned systems, Intelligence, Surveillance and Reconnaissance (ISR), Modelling and Simulation (M&S), and the human, medical and social sciences. The following pages contain a representative outline of the 2013 NATO STO PoW.

RADIO FREQUENCY DIRECTED ENERGY WEAPONS IN TACTICAL SCENARIOS (SCI-250)

Background

Modern society and the military rely heavily on computers and communication. Therefore, Technical Teams in NATO have conducted studies on protecting these vital assets for more than two decades.

Objective

The objective of this Research Task Group (RTG) was to investigate the effects of Radio Frequency Directed Energy Weapons (RFDEW) on military infrastructure and electronic equipment in realistic tactical scenarios.

Summary

Led by von Kármán laureate Dr. Ernst Krogager, the SCI-250 RTG has moved High-Power Microwave (HPM) concepts and technology forward in an extraordinary way, by demonstrating that RFDEW are effective in operational scenarios. In particular, the Group conducted tests to determine threat and working distances in various scenarios as a function of RFDEW categories.

A new capability was convincingly demonstrated during field trials in Norway, where the group used RFDEW to stop a car and boat engine from functioning, thus effectively defeating Improvised Explosive Devices (IEDs). Additionally, Non-Lethal Weapon (NLW) aspects were tested as well.

Figure 1: NATO TV reported on the trials – the video footage is available on YouTube, where the number of views reached 124,000 soon after its release.

Exploitation and Impact

The results of the SCI-250 RTG are expected to serve as a catalyst for developing non-lethal C-IED systems and will further enhance IED-defeat concepts within NATO to save the lives of those men and women serving NATO and NATO Nations.

Synergies and Complementarities

Nine NATO Nations actively participated in the Group, together with representatives from the MAGs of NATO.

The participating Nations provided complementary test objects, simulation software tools, high-power Radio Frequency (RF) sources, and field trial facilities. In addition, during testing the Group used a car stopper system, developed by industry.

Industry, the user community, the scientists and engineers collectively demonstrated effective multi-national technology collaboration in support of NATO capability requirements, and developed the NATO-wide C-IED Action Plan and the CNAD's C-IED Materiel Roadmap.

S&T Achievements

The experimental achievements of this RTG were built upon earlier results from laboratory work. The Group's field trials demonstrated the successful application of RFDEW technology in a variety of scenarios from both offensive and defensive perspectives in NLW and C-IED applications.

Furthermore, the field trials proved it is possible to determine threat and working distances as well as coverage in the various scenarios, as a function of directed-energy weapon categories.

Conclusions

SCI-250 demonstrated a break-through in the effective application of radio frequency directed energy weapons. The RTG created cost-effective synergy between the scientific community, technical experts and the operational community.

SCI-250 proved to be a role-model for collaboration between NATO's STO and other NATO entities.

2013 MULTI-NATIONAL AUTONOMY EXPERIMENT – MANEX'13 (CMRE)

Background

Technologies for autonomous systems are maturing rapidly and becoming increasingly relevant for dangerous, difficult and enduring missions. The goal is to minimise human casualties and the loss of expensive platforms. STO's CMRE has in-house expertise to develop and validate new autonomous systems. As the latest in a series of testing individual components, the MANEX'13 sea trial brought together multiple state-of-the-art autonomous maritime vehicles running cutting-edge software and algorithms.

Objectives

MANEX'13 sought to demonstrate how stand-off Mine Counter-Measures (MCMs) could be accomplished with robotic systems, effectively removing the human (and expensive platform) from the mine field.

Summary

This was the first demonstration of a fully robotic MCM mission, i.e., autonomous search of a mined area as far as target prosecution. Several unmanned systems with high-resolution sensors, including an Autonomous Surface Vehicle (ASV) with a drone for target reacquisition and optical imagery, were demonstrated. This trial also demonstrated increased in-mission awareness whereby detections were transmitted back to the NRV ALLIANCE.

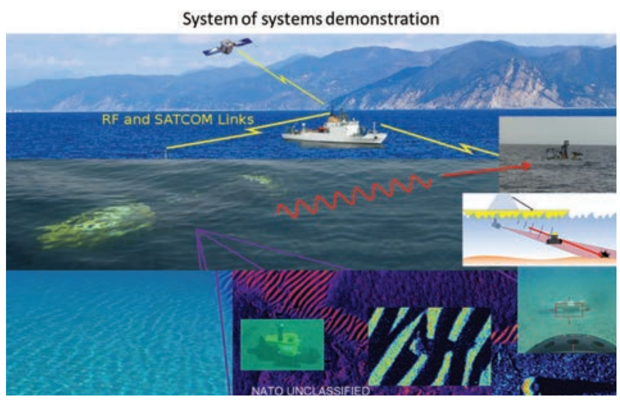


Figure 2: Fully robotic mine counter-measures mission: detection and classification with the CMRE MUSCLE Autonomous Underwater Vehicle (AUV), transmission via underwater acoustic communication of first potential target location, acoustic reacquisition with CMRE GULLIVER (an Unmanned Surface Vehicle or USV) and optical identification with CMRE GULLIVER (an autonomously Remotely Operated Vehicle or aROV).

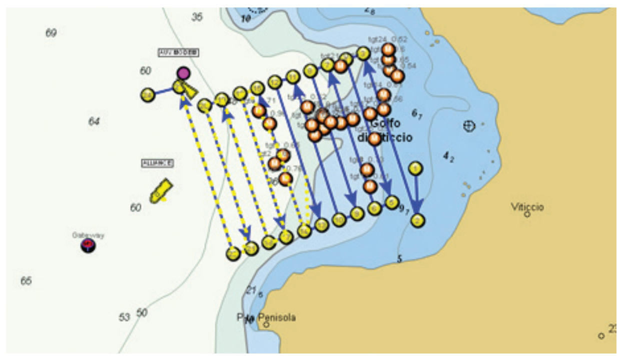


Figure 3: The screen in NRV Alliance's laboratory showing 'in-mission' detections made by the MUSCLE (Minehunting UUV for Shallow Water Covert Littoral Expeditions) vehicle.

Exploitation and Impact

Several Allied and Partner Nations use robotic systems for stand-off MCMs. Their potential impact is great, although full exploitation is challenging given the rapid development of associated technologies. The data collection and analysis from MANEX'13 will help to standardise methodologies for planning and evaluation of autonomous systems operations, thus supporting the increase in reliability and interoperability of stand-off MCMs.

Synergies and Complementarities

Multiple Allied research entities and military organisations participated in MANEX'13: Germany contributed improvement to the CMRE code base and collected data for Automatic Target Recognition (ATR) research; Researchers from the Netherlands executed their algorithms on the CMRE autonomy test-bed vehicle; Scientists and engineers from Norway participated with their autonomous vehicle (Hugin 1000), conducting dedicated tests; The United Kingdom collaborated in ATR to further study the potential for robotic mine disposal; and The United States provided scientific expertise. The interplay between the Allied teams and the co-deployment of multiple systems supported ideas on developing interoperability further, which is one of the key objectives of CMRE's MCM programme.

Military participation was provided by the navies of Germany, Netherlands and Norway, also representing the NATO CoE on Operations in Confined and Shallow Waters, and on Naval Mine Warfare. The interactions of the scientific community with these navies during the sea trial greatly contributed to driving military innovation and S&T forward. The degree of collaboration during MANEX'13 was excellent; the experience gained by all participants, including the robust data collected and ongoing analysis thereof, will contribute to the future well-being of the Alliance.

S&T Achievements

The MANEX'13 sea trial showcased the first known demonstration of a fully robotic MCM mission, from wide area search up to automatic target identification. Results of the trial underlined the quality of the algorithms developed. They stressed the importance of underwater acoustic communications for multiple vehicle networked operations, progress reporting, and data extraction and filtering to keep human operators updated on mission status.

Conclusions

The collaborative nature of the MANEX'13 sea trial and the good results achieved contributed greatly to the Alliance's knowledge on future interoperable MCM operations, and fostered existing and new partnerships.

MANAGEMENT OF HEAT AND COLD STRESS – GUIDANCE TO NATO MEDICAL PERSONNEL (HFM-187)

Background

NATO forces have operated in extreme heat and cold, but have often lacked adequate doctrine, training and equipment to avoid thermal illness and injuries. Because excessive heat or cold stress will degrade mental and physical performance, this topic is of high importance, especially because it degrades the battle strength and sustainability of deployed troops.

Objective

The RTG aimed at: a) producing a heat and cold stress management report that includes guidance that can be readily extracted to understand and identify the risk factors for heat and cold casualties; b) implementing procedures on managing heat and cold stress; and c) sustaining performance and minimising heat and cold casualties during training and field operations.

Summary

Heat and cold stress management doctrines were developed and two best practices brochures were delivered.

Exploitation and Impact

NATO ground forces have operated in the extreme heat of Afghanistan, Africa, Iraq and Lebanon, as well as the severe cold of Afghanistan and Bosnia. In addition, NATO humanitarian efforts have had to deal with indigenous populations exposed to global warming and shortages of potable water.

Figure 4: NATO soldier under heavy thermal load.

Human thermal management problems have been amplified because of: a) modern high-tempo operations; b) new equipment such as body armour, load carriage and electronic devices that require exposed hands to operate; and c) older, less healthy and fit recruit populations.

The RTG outputs helped to solve such problems.

Synergies and Complementarities

Members from eight NATO Nations and one Partner participated in this RTG. As part of their work, the Group interviewed civilian and military members of the forces and departments of defence from Canada, Netherlands, Sweden, the United Kingdom and the United States.

S&T Achievements

The technical report produced by the RTG was divided into two chapters:

- Heat Stress Management Doctrine – heat exchange in hot environments, heat stress/strain and its impact on the military, heat stress and core temperature, heat acclimatisation, work/rest cycles, cooling technologies, fluid and salt replacement.
- Cold Stress Management Doctrine – heat exchange in cold environments, cold stress risk management, wind chill temperature index, cold strain and performance, protective clothing, frostbite avoidance, non-freezing cold injury avoidance, food and fluid requirements.

In addition, the Group issued a brochure on each of the chapters, which serves as guidance on prevention, treatment, and acclimatisation strategies and performance of heat and cold stress management.

Conclusions

The brochures on heat and cold stress management encompass best practices on thermal management and information that can be extracted and translated into the languages of NATO Nations, for distribution on posters and cards, for example.

Unit Commanders, medical staff and Non-Commissioned Officers (NCOs) should work together to implement a training programme based on the principles of the technical report.

All training and field operations should be reviewed to ensure adequate planning, identify the risk of heat/cold stress, provide guidance to soldiers to minimise risk, assess and manage heat/cold injuries, and provide emergency support and evacuation.

AUTONOMOUS ANTI-SUBMARINE WARFARE NETWORKS (CMRE)

Background

Autonomous sensor networks will augment future NATO Anti-Submarine Warfare (ASW) capabilities. They offer persistence, take operators and expensive platforms out of harm's way, and can provide greatly enhanced coverage while keeping costs down. The CMRE develops and employs a multi-static active network of AUVs to explore the performance and challenges of dynamic, agile and mobile ASW networks.

Objectives

The research aimed at developing a real-time autonomous multi-static active sonar network based upon AUVs towing arrays combined with off-board sources, which included testing in an operational environment.

Summary

In 2013 CMRE deployed its network to detect conventional diesel-electric submarines (SSKs) during exercise Proud Manta 2013 (POMA'13). It performed well, with detections and tracks produced in real time on the AUVs and reported through an underwater communications network to a Command and Control (C2) centre on board the NRV ALLIANCE, whence they were also transmitted to a classified reach-back at a CMRE cell via encrypted satellite communications for further analysis.

Exploitation and Impact

The successful deployment of the network in the Proud Manta exercise was a significant achievement for the co-operative ASW programme. The AUVs made unsupervised detections and tracks on SSKs during free play evolutions. The tracks were transmitted in real time to the NRV ALLIANCE via the underwater communications network where they were fused to eliminate ambiguous tracks. Communicating these results in real time, through underwater networks via an encrypted satellite data-link, points to the feasibility of underwater autonomous networks joining tactical data-links to transmit a common underwater picture generated by an autonomous ASW network.

Synergies and Complementarities

CMRE has led the demonstration of real-time AUV networked ASWs. The AUV real-time processor has been ported to CMRE's gliders to support complementary reactive-behaviour development for CMRE's Environmental Knowledge and Operational Effectiveness (EKOE) programme. Applications written for the Mission-Oriented Operating Suite (MOOS) robotic middleware have broad utility for autonomous marine vehicles across a broad range of mission areas.

CMRE's ASW co-operative behaviour research complements NATO's decision support and operations research work, and will dovetail with the proposed Multi-Static Low Frequency Active Sonar (MS-LFAS) Smart Defence Initiative.

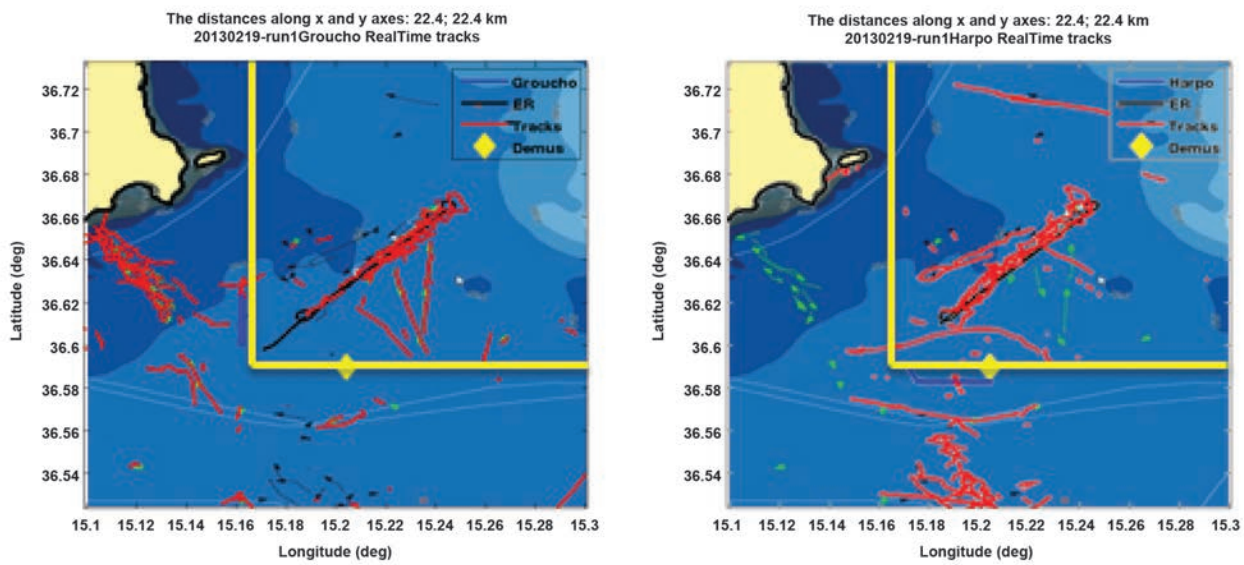


Figure 5: Real-time tracks generated by the on-board processing on AUVs during exercise POMA'13. Note the ambiguous tracks to the west in the left-hand panel, and to the south in the right-hand panel.

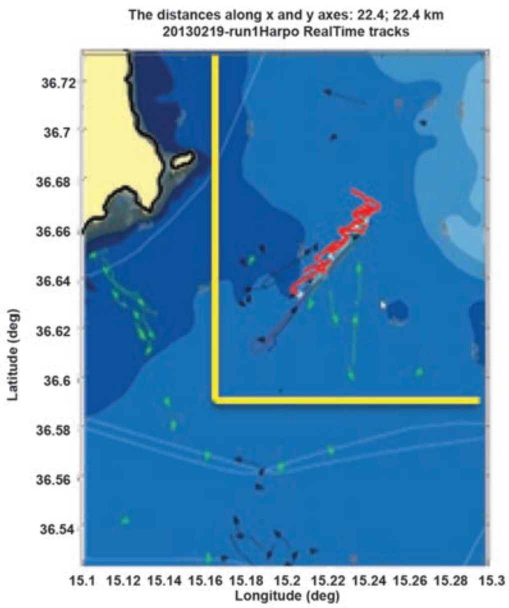


Figure 6: The fused track created on board the NRV ALLIANCE using the tracking results from the AUVs. Note the complete elimination of inconsistent ambiguous tracks and clutter.

S&T Achievements

The development and deployment of the autonomous ASW demonstrator showcased scientific advances in a number of areas, including: a) real-time signal processing, with on-board tracking and classification for the AUV to sift through the clutter; b) data fusion, with the contacts and tracks sent by each AUV fused on board NRV ALLIANCE to reduce ambiguous tracks; c) autonomous behaviour development to allow the AUVs to co-operate to clear a box through the sharing of situational awareness via underwater communications and navigating in concert to pursue tracks and contacts of interest; and d) research into underwater communications, to allow the AUVs to collaborate and report the underwater Common Operational Picture (COP).

Conclusions

An AUV-based autonomous ASW network demonstrated its effectiveness in a NATO ASW exercise. The results illustrated the feasibility of autonomous networked ASW in high-clutter shallow water environments, with the real-time communication of detections and tracks to a C2 centre for situational awareness and data fusion, and the transmission of the AUVs common undersea picture to a classified reach-back cell over a NATO encrypted satellite data link.

NAVAL PLATFORM SIGNATURE MANAGEMENT AND PROTECTION (SET-202)

Background

The signature of a ship is a critical factor in its vulnerability against a threat. In order to better assess state-of-the-art ship signatures, a large multi-spectral ship signature trial entitled "Radar Infra-red electro-Magnetic Pressure Acoustic Ship Signature Experiments (RIMPASSE)", was executed in 2011. Three SET RTGs (SET-144, SET-154 and SET-166) participated in this trial to perform measurements of different ship signatures in the Electro-Optical (EO), Infra-Red (IR), Radar Cross-Section (RCS), and underwater acoustic, magnetic and pressure domains.

Objective

The main objective of the SET-202 Research Specialists' Meeting (RSM), held in Oslo, Norway, in October 2013, was to foster the exchange of results and experiences gathered during the RIMPASSE trial, and to identify areas for further collaboration.

Summary

The RSM gave a clear picture of the developments in the field of naval signature management in recent years – from the more stand-alone approach regarding signature reduction, to the integrated approach regarding on-board real-time signature management, which is now well established.

This RSM focused on multi-national activities on signature management within NATO, and has shown that the interplay between scientific and operational communities is challenging, due to different professional backgrounds.

Exploitation and Impact

Timely knowledge on the dynamic signatures of a ship can be used for mission planning. A well-designed Signature Management System (SMS) can support decisions to improve the signature, such as reducing turbine power, closing hatches, and/or turning off noisy equipment.

Integrated with Electronic Warfare (EW) and combat systems, a SMS can: a) reduce training requirements for EW officers; b) suggest optimal EW tactics; and c) execute EW tactics with less latency.

Synergies and Complementarities

The RSM brought different communities together (in particular, SCI and SET groups, as well as CMRE experts), and it proved to be good vehicle for collaboration among different ship signature communities.

> “ As the SET Chair noted, the exchanges were animated, honest, and informative, with much information conveyed. All participants showed a very deep interest in co-operation and wanted to know how to communicate their information more effectively to NATO military bodies and how their products could be transitioned to NATO systems.

S&T Achievements

The RSM provided solid insight in the main S&T achievements during the RIMPASSE trial.

For the EO signature, the results of the trial conclusively demonstrated that the SMS reduced the ship's signature (see Figure 7), thus increasing hostile missile acquisition ranges and improving the effectiveness of off-board decoys.

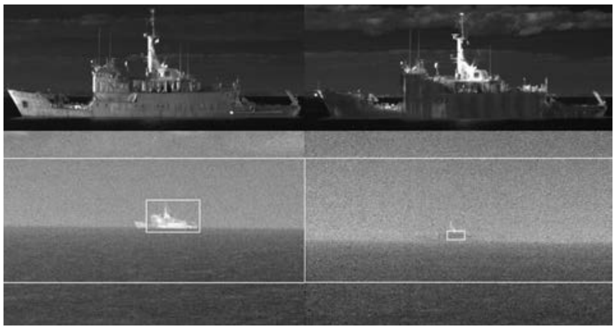


Figure 7: Signature management system: OFF (left), ON (right).

The IR and RCS communities were able to compare and validate signature prediction and propagation codes, and shared national work on signature management systems.

An invaluable set of data for underwater signature studies was collected during RIMPASSE, by making use of two research vessels, seven measurement locations and multiple configurations. Moreover, new methods for estimating underwater signature levels, using on-board sensors, were developed and tested.

Conclusions

International co-operation has resulted in progress from early approaches to the operational realisation of effective ship signature management.

Although the nature of infra-red, radar and underwater signatures is quite different, this RSM has shown that the different research communities have significant common ground to build future collaboration.

JOINT MAIN ARMAMENTS GROUPS INITIATIVE – TABLE-TOP EXERCISE (CMRE)

Background

The world is rapidly becoming more complex, and the Alliance is studying potential implications for Defence and Security. Evidence-based knowledge to support decisions is generated and used for strategic directions, concepts, capabilities, procurement and interoperability, for example.

The CNAD and other NATO decision-makers invited STO's CMRE to support the generation of specific knowledge for tailored advice on capabilities for and interoperability of the military forces of the Alliance. To that end, the Centre hosted a Table-Top eXercise (TTX) composed of a large and diverse group of operators and SMEs from the Alliance and Partners, as a joint initiative of the three service-aligned MAGs of the CNAD.

Objective

The objective of the Joint Main Armaments Groups Initiative (JMI) TTX was to identify joint capability and interface gaps regarding the threat from low, slow and small Unmanned Aerial Vehicles (UAVs), and Rockets, Artillery and Mortars (RAMs).

Summary

The JMI TTX approach allowed a very complex topic that spans many inter-service issues, to be explored quickly from a neutral and impartial perspective. The structured problem-space elicitation allowed the audience to reach consensus on a specific list of findings and advice. A diverse facilitation team was assembled to work closely with the sponsor staff to create an operationally relevant and progressive set of vignettes to be discussed over two days. This knowledge was disseminated to the MAGs and the participating Nations two working days after the JMI TTX took place.

Exploitation and Impact

The facilitators of four separate teams guided the TTX discussions to ensure each participant could present their perspective on requirements and compromises. The scenario material was kept consistent with scenarios from the NDPP. This approach ensured that the UAV and RAM threats were discussed free of unnecessary details but still relevant to NATO operational issues. The result was a comprehensive set of critical capability and interoperability gaps for NATO to explore and address. The problem-space elicitation and facilitation are key analysis skills that STO, through CMRE, can leverage to their advantage in a wide range of planning situations.

Synergies and Complementarities

The TTX facilitated by the CMRE enabled a strong level of collaboration from a diverse scientific and military audience. The sharing of insights was made possible by the structure and facilitation which were arranged to ensure that each participant was allowed to make a direct and focused contribution.

S&T Achievements

CMRE applied a simple yet robust TTX method called the "MATRIX Game" that uses stylised turns to foster plenary session and team discussions.

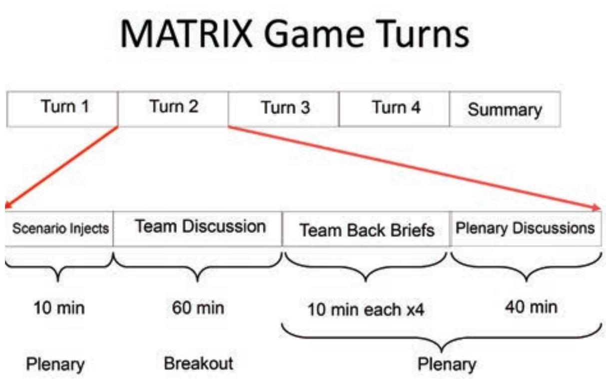


Figure 8: MATRIX Game turns provide structure to discuss inter-service interoperability issues.

The context chosen was a previous NATO naval operation scenario with follow-on phases for amphibious landing and ground operations.

The scenario developed and its stylised map with simple names provided a concise and easy to understand set of high-level logical events. This allowed participants from a wide variety of backgrounds to understand the operational context in the similar way.

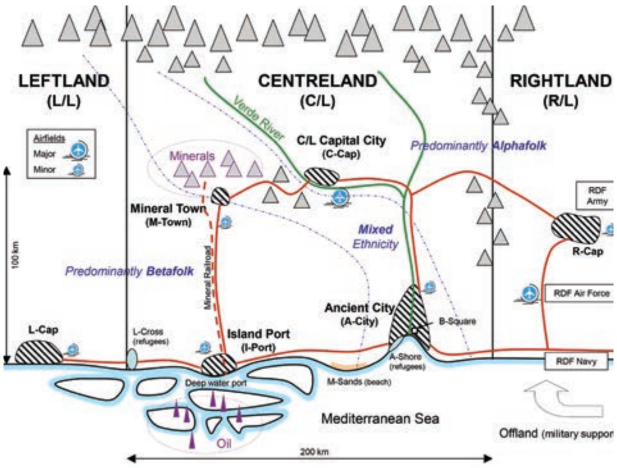


Figure 9: The scenario map used for the JMI TTX provided the participants with a common understanding and context.

Conclusions

The JMI TTX successfully produced specific knowledge to support tailored advice on the capability and interoperability gaps regarding the threats of low, slow and small UAVs and RAMs.

The JMI TTX core components can be adapted easily to other situations. Specifically, it could allow the NDPP to discover the key components of perplexing capability requirements more quickly and then explore potential solutions.

SECURITY IN COLLECTIVE MISSION SIMULATION (MSG-080)

Background

NATO and Partner Nations train and exercise together to improve effectiveness, efficiency and interoperability. Collective Mission Simulation (CMS) is an important enabler to achieve mission objectives in areas such as deployment, training and exercises. However, simulation models often exist in different security domains. Therefore, the models need to be protected, while at the same time information needs to be shared securely, effectively and efficiently between the different simulators.

Objective

The RTG was established to investigate and suggest a way forward for creating a CMS environment that allows multiple security domains to participate.

Summary

The RTG investigated current practices and technologies to develop a CMS, including taking into account security issues. The MSG-080 Workshops and use-cases have provided a number of valuable inputs on user needs and technical approaches. The RTG led to a better understanding of why, where and how M&S differs from live and other domains regarding security. This has resulted in a better awareness of the capabilities and limitations of existing and emerging security technologies, which can be applied to synthetic environments. There is also a better understanding of how security impacts CMS, for example when the tactics used in the training domain are changed from those that would actually be employed.

Exploitation and Impact

The RTG results are expected to be a starting point for developing more adequate procedures and technical solutions to address security aspects in CMS.

Synergies and Complementarities

Six NATO Nations actively participated in the activity providing complementary expertise and experience. The results of this RTG were shared and discussed with several other NMSG groups involved in CMS experiments. The short-term need is a common “security overlay” for the Distributed Simulation Engineering and Execution Process (DSEEP) development process that is used to set-up a CMS. MSG-080 has initiated a Simulation Interoperability Standards Organisation (SISO) Study Group on this topic and recommends that NATO and Nations actively support and participate in that group.

S&T Achievements

MSG-080 has been working on improving the conceptual model of how to classify and structure security related issues in M&S. This group was a starting point for evaluating technical solutions. The conceptual model was also a starting point for integrating security issues in the development process for synthetic environments, and should lead to a DSEEP “overlay” regarding security aspects.

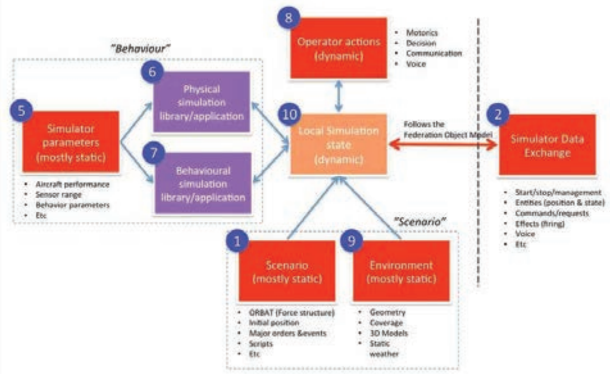


Figure 10: MSG-080 conceptual model of information exchange in a federated network.

Conclusions

The RTG recommended that NATO and Nations continue to develop more adequate procedures and technical solutions to address security aspects in CMS. In the short term, a common security overlay is required for the development process that is used to set up a CMS. In the long term, NATO and Nations are recommended to collaborate in the NMSG to develop and evaluate new technical solutions and accreditation procedures to allow more flexible security solutions for future generations of CMS systems.

HARBOUR PROTECTION DEMONSTRATION – TALON (CMRE)

Background

Protecting maritime critical infrastructure is important from an economic and military point of view. Harbours and ports, commercial shipping and (off) shore installations are for example particularly vulnerable to small boats and divers, which are difficult to detect and identify.

Figure 11: Tactical deployable sensor suite for mobile security personnel.

Objectives

The aims of TALON in 2013 were to set technical requirements for multiple sensors and non-lethal effectors, and demonstrate how they may be used to determine the intent of a possible intrusion, including establishing an understanding of the human/machine division of labour. The work will continue in 2014 with the addition of specific research into live video during boarding operations for up-to-the-minute situational awareness.

Figure 12: The TALON interface.

Summary

CMRE's work on maritime sensing technologies and realistic response measures for harbour and port protection culminated in the TALON system.

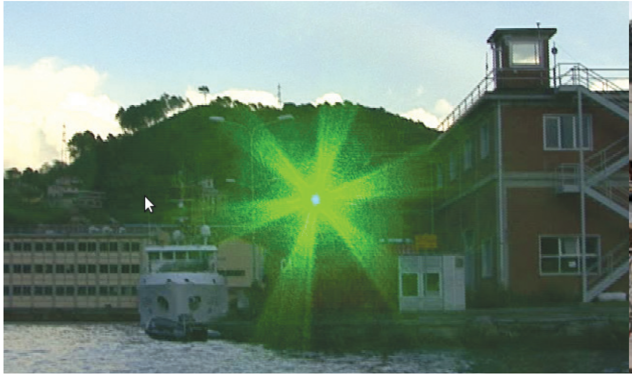
The system was tested in several realistic scenarios comprised of multiple simulated surface and underwater intrusions. The TALON system proved to be able to provide rapid semi-automated responses that were proportional to the threat, including early warning.

Exploitation and Impact

Non-lethal protection of harbours and ports calls for a gradual response when engaging perceived threats. CMRE's work is being exploited by the NATO Specialist Team on Harbour Protection (STHP), informing their work on doctrine and technical requirements, and for NATO's Nations in particular, informing the delivery of systems.

Synergies and Complementarities

The industrial suppliers of sensors and effectors technologies acted as partners during the TALON project. They not only provided integration advice,




Figures 13 and 14: Effectors in action.

but also gained useful feedback from CMRE on the effectiveness of their products in an operationally representative setting.

The Centre has worked with NATO STHP since its inception. Together with several other NATO's and Nations' stakeholders, the STHP was well represented at the TALON event to share insights and knowledge from a user point-of-view.

S&T Achievements

CMRE demonstrated a deployable harbour protection system that is capable of providing first-response semi-automated scalable protection by making use of proportional effectors such as acoustic loud hailers and laser dazzlers. The system is supported by technically appropriate inexpensive multiple sensors, including several types of cameras and sonar, for example. The free movement of security personnel proved to be more effective than remaining static in pre-selected locations. The human/machine division of labour was addressed by integration with CMRE data fusion services and wearable tactical video camera systems.

Figure 15: The digital world.

Conclusions

With TALON, STO's CMRE has demonstrated the efficacy of a compact, modular and deployable harbour protection capability that is aligned to the needs of the Alliance, and in particular to the NATO STHP.

INFORMATION ASSURANCE AND CYBER DEFENCE RESEARCH FRAMEWORK (IST-096)

Background

Information Assurance (IA) and Cyber Defence (CD) capabilities are critical for the effective defence of NATO's Information Infrastructure (NII) and evolving Network-Enabled Capability (NEC) environment. In addition, a common understanding of national research approaches on technological solutions, as well as stronger co-ordination and collaboration, are also needed.

Objective

The RTG aimed at continuing the evolutionary development of an existing initial IA research plan, incorporating concepts and models of defensive cyber operations in a technical framework, and refining the framework and plan over the next four years and beyond.

Summary

The IST-096 group organised an industry Workshop on Cyber Security Capabilities.

The revised document *Communication and Information Systems Security Capability Breakdown*, produced by the NCIA, was validated at the Workshop.

SMEs from industry attended to: a) evaluate the breakdown by identifying potential gaps, areas of overlap, and general improvements; b) assess the value of the breakdown in supporting capability; c) discuss how to evaluate the maturity of individual capabilities and how such a maturity model could help capability development efforts; and d) map the breakdown of currently available products and services.

Industry representatives highlighted issues for various aspects of the breakdown, including specific capability definitions or descriptions, and how the breakdown overall may be used in the future.

Exploitation and Impact

The feedback received is important and will be considered for the next update of the Communication and Information Systems (CIS) security capability breakdown, which will include cyber defence.

Synergies and Complementarities

There were presentations from industry in addition to the presentations from NCIA and the United Kingdom's Ministry of Defence. More than 10 industries from Europe and North America participated, together with representatives from government.

S&T Achievements

An initial/informal mission-based framework and risk assessment methodology for high assurance information sharing within dynamic coalitions was developed, including the further refinement of an initial IA research plan to identify the relevant S&T areas to meet future IA and CD capability requirements.

Conclusions

The Workshop confirmed the value and usability of *Communication and Information Systems Security Capability Breakdown* text.

From an industrial point-of-view, the value primarily comes through a more structured, predictable and clearly expressed way for NATO to convey requirements and investment intent within cyber security. This is especially the case over a longer period of time, when multiple entities and Nations start using the breakdown as the common language, including structuring input.

As such, the breakdown serves primarily as a visual communications tool, illustrating how the reality of limited investment ability should be utilised across the capabilities.

The breakdown has many other uses that go beyond the initial intentions. As an architectural artefact, it illustrates how capabilities can be visualised, with a metric definition based on individual capabilities.

UNDERSEA GLIDERS (CMRE)

Background

The CMRE Engineering Department (ED) provides cutting-edge solutions for sea-going S&T to external clients directly and to other projects within the Centre's PoW. The support provided by the ED range from conventional, ship-operated, tools to game-changing unmanned system technology.

The use of autonomous vehicles in the maritime domain has increased steadily over recent years. Among them, undersea gliders have extraordinary endurance and have been demonstrated to be very efficient for oceanographic measurements.

Objective

CMRE's objective is to determine the potential of undersea gliders for persistent maritime surveillance and monitoring.

Summary

CMRE has investigated possible applications for new technology embodied in undersea gliders and identified their potential for battle-space characterisation.

Figure 16: Wave estimation payload, with integrated inertial measurement unit, gyroscope, accelerometers and compass.

Exploitation and Impact

Networks of high persistence unmanned maritime systems are expected to become game changers in both the civilian and military domain. CMRE is involved through S&T, ocean engineering, contact within the military community, and standardisation efforts, to utilise its expertise for innovative solutions. CMRE has played and continues to play a role in co-ordinating multi-national efforts within NATO.

Synergies and Complementarities

Some of the work is in the ACT PoW, informing all NATO Nations. Part of it takes place through direct collaboration with Nations, as is the case for the GLider Acoustic Sensing of Sediments (GLASS) project of the United States. Dual use applications are appropriate for the European Commission, with CMRE involved in two projects.

S&T Achievements

A payload, with on-board processing designed by CMRE, was integrated into a Slocum glider to record and estimate platform motion at the surface. It was tested in a field experiment and compared to the results of a Waverider buoy (the industrial standard). Although the glider's payload tended slightly to over-estimate those reported by the Waverider, differences were below five percent of the actual value – an acceptable result.

For the GLASS project, CMRE designed and built an eight-channel data acquisition system and a volumetric hydrophone array for sea-going experiments on board a hybrid glider / Unmanned

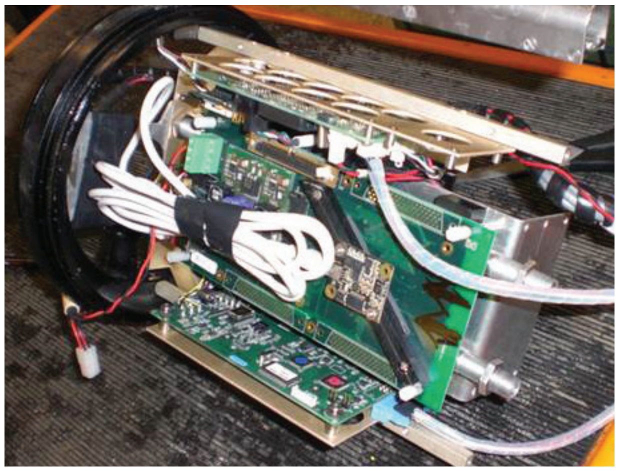


Figure 17: CMRE's eFolaga (Left) and a close-up of the GLASS array (Right).

Underwater Vehicle (UUV), eFolaga. This showed that ambient noise recorded on the array can be used to characterise the sea-bottom, an important factor in predicting sonar performance.

The GLASS set-up may also be used for small surface ship detection, which is relevant for military and border security surveillance. The former was shown for a non-moving observation platform, the latter will be tested in 2014 when a Slocum glider, fitted with a volumetric array (see Figure 18), will participate in a demonstration for the European Union (EU) programme PERSEUS.

Conclusions

While further research is ongoing to estimate directional properties of the wave field, this work has shown that general purpose highly persistent gliders can be used for wave measurements in multi-purpose missions. Capability gaps relative to future persistent unmanned systems' requirements (civilian and military) were addressed, thereby shaping capabilities in the medium- and long-term.

Figure 18: Artist's impression of a Slocum glider equipped with a volumetric array.

ASPECTS OF MULTI-PARAMETER RADAR AUTOMATIC TARGET RECOGNITION IN COMPLEX ENVIRONMENTS (SET-163)

Background

Future military operations will likely take place in complex environments such as populated urban areas and harbours. Therefore, it remains mandatory to avoid non-combatant casualties and collateral damage, as this will compromise NATO's engagement including reducing local support. Timely and accurate identification and localisation of vehicles and personnel that may constitute a threat, preferably from a safe distance, is highly important.

ATR by using imaging radar can provide strategic, operational and tactical decision support, and can contribute to enhanced situational awareness and persistent surveillance.

Objective

The RTG mainly aimed at developing and evaluating ATR techniques and capabilities in complex environments with strong and manifold background clutter, such as urban areas and harbours.

Summary

The targets considered included ground vehicles, ships and humans. The Group's activities focused on current military needs, fundamental theoretical and more practical approaches based on data analysis and simulations, and real-life scenarios.

The existing data-pools from previous activities, such as SET-111 and SET-113, have been extended with data from national measurement and modelling programmes. On this basis, the Group analysed the recognition of targets in a complex environment by gradually increasing the complexity to converge on a real operational ATR situation.

Exploitation and Impact

This RTG allowed contributing Nations to share imaging-radar data collected by their main sensors (Terra Synthetic Aperture Radar or TerraSAR, RADARSAT 2, PicoSAR) as well as from simulation codes (MOCEM), 3D-target Computer-Aided Design (CAD) models, and ad-hoc performance evaluation metrics.

Synergies and Complementarities

Eleven laboratories from seven NATO Nations agreed to share their know-how to progress their skills on ATR; each one providing its own expertise and specialised facilities.

S&T Achievements

Change detection using two different space-borne SARs was demonstrated in the Oslo harbour using RADARSAT-2 (C-band 800 km) and TerraSAR-X (X-band 500 km) images.

> "This is a very interesting result because satellite SAR availability on a precise scene (time + position) is not easy to get, especially for change detection applications: other satellite availability may reduce this weakness.

Model-based ATR was demonstrated on passenger ships using 800 PicoSAR images of four ships, which were evaluated against eight reference ships simulated by MOCEM on 3D-target CAD models.

> "This achievement showed that simulated reference databanks are mandatory because real target SAR images are not often available and radar target signatures are highly variable.

Conclusions

SET-163 successfully demonstrated the potential application of target recognition using reference signatures built exclusively from electromagnetic simulations on 3D-target CAD models. The activity allowed a high level of co-operation among SET Panel activities, STO Panels and NATO initiatives such as the NATO Maritime EW, Maritime Capability Group or MCG/8, and NATO Maritime EW Nemo trials.

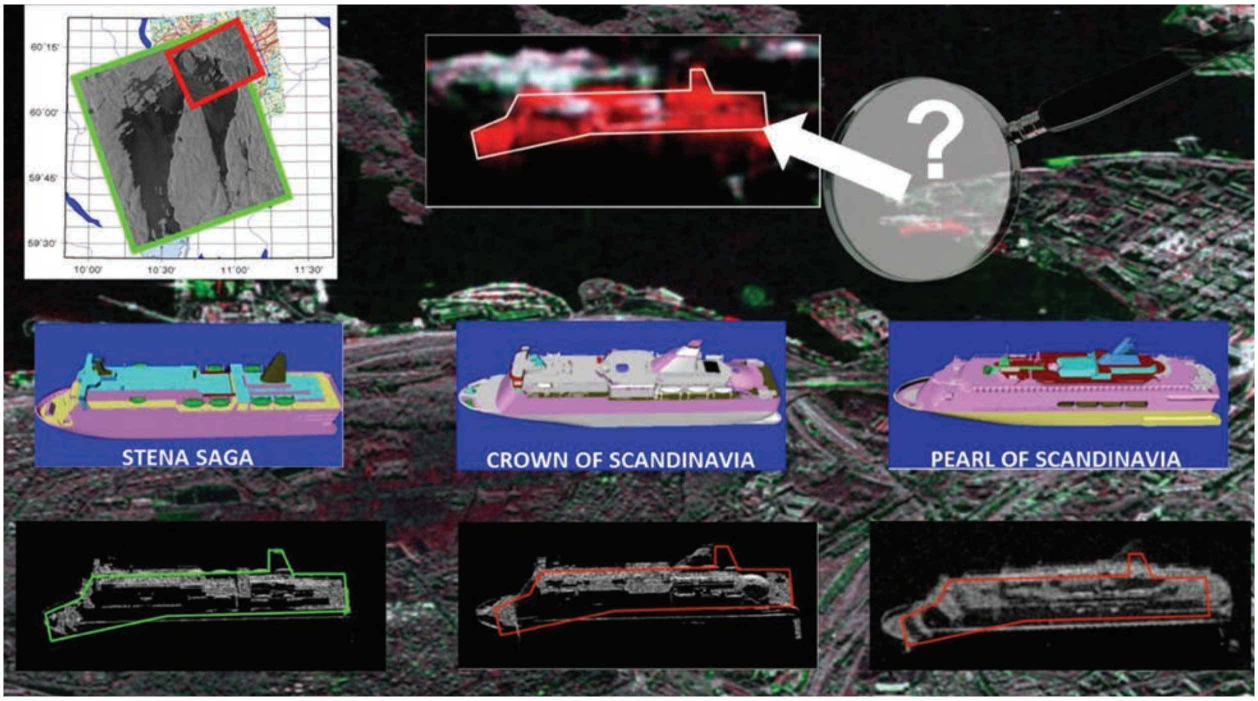


Figure 19: Change detection between RADARSAT-2 and TerraSAR-X SAR images over Oslo harbour, and model-based recognition using 3D CAD models of ferries and MOCEM radar simulations.

FOSTERING CONSULTATION AND PARTNERSHIPS

Political consultation and partnerships objectives are supported by NATO S&T in conducting co-operative S&T activities between the Alliance and non-NATO Nations, in line with NATO's partnerships policy, and thus, over time, fostering strategic and technological interoperability. NATO S&T enhances the security dialogue and mitigates threats by building trusted relationships, even in situations where direct political dialogue is difficult.

The NATO STO successfully used two different approaches to contribute to co-operative security. STO's primary means is opening activities in the STO PoW to non-NATO Nations (approximately 70 percent is open). Secondly, the Emerging Security and Challenges Division (ESCD) funds individual S&T activities with non-NATO Nations through the NATO SPSP.

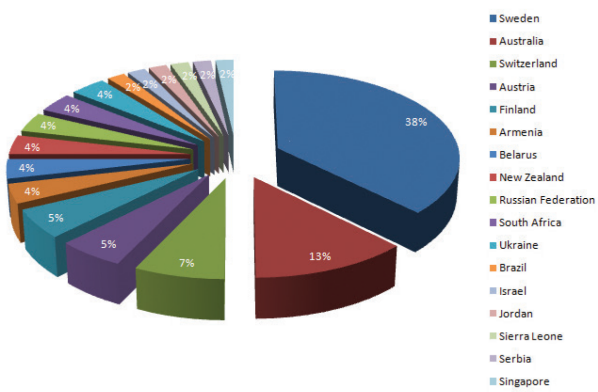


Figure 20: 2013 participation of partners in the NATO STO.

The following pages contain a representative outline of the 2013 NATO STO PoW.

RISK AND RELIABILITY ASSESSMENT AND VALIDATION FOR SMALL SPACECRAFT (AVT-210)

Background

Homeland and global collective security, out-of-area peace-keeping missions with rapid reaction forces, and asymmetric warfare constitute new conditions for armament. To meet these needs, extended Joint Intelligence, Surveillance, and Reconnaissance (JISR) will be a pre-requisite. The upcoming new generation of small satellites and space vehicles offer new ISR potential that benefits the future war-fighter. A previous Exploratory Team identified the need for new approaches and techniques for validation in order to more completely access the benefits of small satellites and identified a proposed plan to identify the elements of these new approaches.

Objective

The RSM sought to investigate best practices and concepts proposed in current small satellite (< 500 kg) programmes to assess and evaluate risk and the associated reliability to tailor design and the verification of standards for low-cost spacecraft.

Summary

It was identified that small satellites represent a disruptive technology for the war-fighter by providing low cost, rapid deployment of space-based communications and reconnaissance. The focus of the RSM was to bring together experts in the field to review and assess the current state-of-the-art and provide recommendations for possible savings of cost and time. These experts shared their knowledge on risk and reliability assessment among NATO Nations, under the umbrella of the NATO STO.

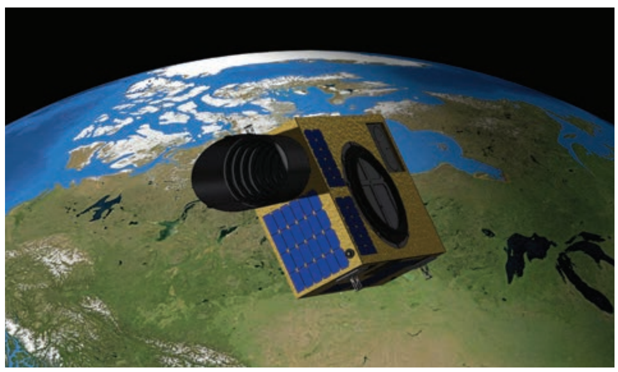


Figure 21: A small satellite in orbit.

Exploitation and Impact

A critical outcome from the RSM was the consensus that enhancements in existing and/or adoption of new novel reliability assessment techniques have the potential to improve the cost and availability of small satellites in the near future.

Synergies and Complementarities

The AVT-210 RSM, which lasted four days, was supported by 24 presentations from nine NATO Member Nations and one Partner Nation (Sweden) that addressed issues of risk evaluation, history of experience with small satellites, benefits and opportunities of verification by simulation and/or test, opportunities for improvement, and new concepts for reliability assessment. Overall, over 80 expert delegates participated in the RSM with presentations and lively discussions. Sweden hosted and participated in the event.

S&T Achievements

Standard spacecraft verification approaches and techniques as defined in MIL-STD-1540 for current (and large) spacecraft impose a heavy burden on verification through test and analysis. New concepts and approaches for verification of performance capability should be rationalised to obtain possible savings in cost and time for a small satellite programme.

From the results of this RSM, the Programme Committee has assembled recommendations for modifications to current procedures or new approaches to proposed concepts of risk and reliability assessment to enhance the value to be derived from small spacecraft.

Conclusions

The AVT-210 RSM was an excellent example of bringing experts together to address a challenging topic resulting in S&T-based advice to support NATO capabilities.

Already underway is a follow-up activity to develop a plan to implement the recommendations of AVT-210 in order to improve confidence in verification of the reliability for cost- and time-effective small satellites, by considering the whole life-cycle of the spacecraft.

COALITION WARRIOR INTEROPERABILITY EXERCISES (CMRE)

Background

Interoperability of NATO's joint forces is of vital importance to the Alliance; therefore it is studied and improved continuously. The Coalition Warrior Interoperability exploration, experimentation and examination eXercises (CWIX) are designed to help bring this about. The CWIX are approved by the MC of NATO and are organised on an annual basis.

In 2013, STO's CMRE participated in the CWIX at the Joint Forces Training Centre (JFTC) in Bydgoszcz, Poland, for the first time.

Figure 22: For the first time in 2013, the CMRE participated in CWIX, displaying the NATO S&T logo.

Objectives

The primary objective of CMRE's participation in CWIX 2013 was to investigate the interoperability of CMRE's capabilities with other Allied systems, and to drive and exploit future S&T in terms of interoperability.

picture dynamically with new sensors which are customised to the operational requirement has always been an implicit requirement.

Exploitation and Impact

CWIX demonstrated that it is possible to interoperate Allied systems directly with the Centre's capabilities. The impact of this is two-fold: on the one hand, CMRE will be able to plan and execute laboratory experiments closer to the expected operating environment, while on the other, CMRE will be able to participate in exercises to provide S&T support and demonstrate what the Centre has to offer.

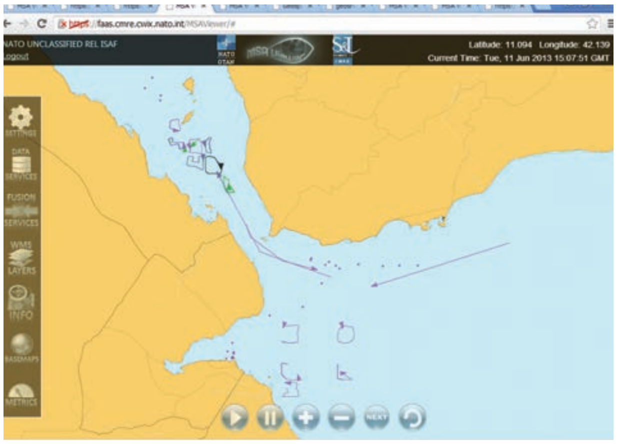


Figure 23: The CWIX maritime scenario is shown in CMRE's Maritime Situational Awareness (MSA) viewer.

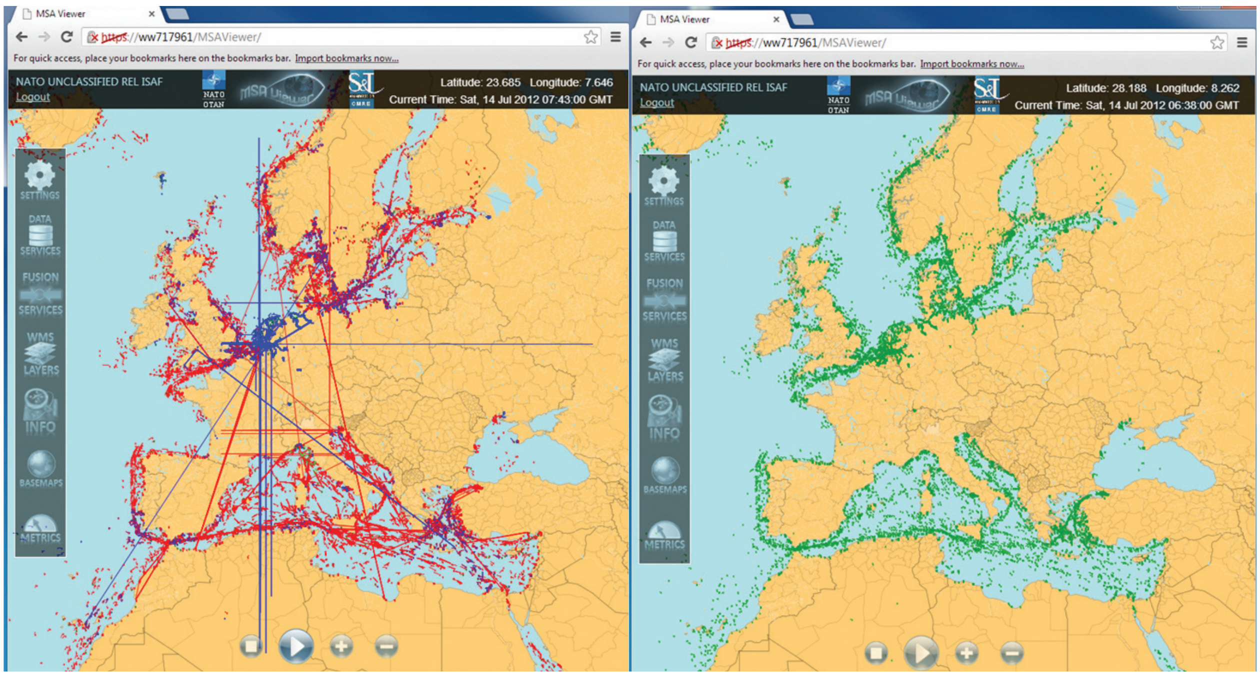


Figure 24: Fusion as a Service (FaaS), a CMRE research product, is visualised. The left view shows two data sources with no automated processing, and the right view shows the result of automated fusion algorithms on the same information sources.

Summary

Federated services, greater interoperability and information sharing is leading to increased availability of information. This is often conflicting, difficult to combine, and confusing. Future C2 systems need to operate in a federated environment and to manage information in a holistic way. During the stand-up of a new operation, or the enhancement of ongoing operations, it is important that the right information is made available in the right areas of interest. The ability to configure an operational

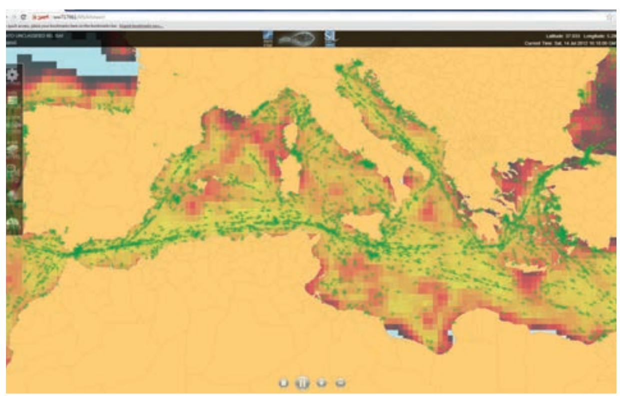


Figure 25: A sensor performance map, another CMRE research product, is displayed as a web map service layer and visualized with commercial surface vessel tracks.

Synergies and Complementarities

CWIX is a large NATO event with participation from most Allied Nations and Partners. CMRE joined Canada, Denmark, Finland, Italy, Sweden and the United States in specific interoperability testing together with NATO capabilities including Core Geographic Information Systems (C-GIS), Maritime Command Control Information System (MCCIS), and Service-Oriented Architecture (SOA) platform services. Newly developed concepts were tested at CWIX, which informed future CMRE programmes and exploitation paths for S&T. Furthermore, CWIX also fostered CMRE's collaboration with the NCIA and ACT's SOA Platform Services.

S&T Achievements

CWIX demonstrated that CMRE's S&T efforts have been successful in achieving interoperability between CMRE's experimental and developmental systems and other Allied and Partner systems. The exercise also supported concept development and testing of federated secure shared-services architecture. Furthermore, a concept of federated services for processing multi-source information for a COP was demonstrated.

Conclusions

CWIX presented a unique bridge between STO's CMRE laboratory and operational environments. Participation provided valuable insight into operationally relevant S&T needs for many maritime domains, thereby improving applicability of future laboratory output. It also provided a powerful test-bed for laboratory and operational systems, while enhancing and accelerating the development of Allied capabilities.

IMPROVING ORGANISATIONAL EFFECTIVENESS OF COALITION OPERATIONS (HFM-163/HFM-232)

Background

This activity was aimed at a direct contribution to one of the NATO Long-Term Capability Requirements (LTCRs), namely human performance improvement in military operations.

Objectives

The RTG aimed to: a) identify critical factors to effective Coalition operations (e.g., leadership, national culture, organisational culture/structure, information sharing) using extant data and research literature; b) investigate potential models and tools for understanding, explaining and measuring different aspects of effective adaptation and co-operation in multi-national Coalitions; and c) make recommendations regarding improvement of education and training of NATO and Partner Nation's militaries for Coalition operations.

The RTG decided to limit its research to the organisational effectiveness of the Coalition's operational HQ, implementing Non-Article 5 Crisis Response Operation, and to focus on the evaluation of internal processes in the HQ. Therefore, factors external to the organisation and to the context of the operation were not examined in the study.

Summary

The RTG developed and tested a model of organisational effectiveness in operational NATO HQs.

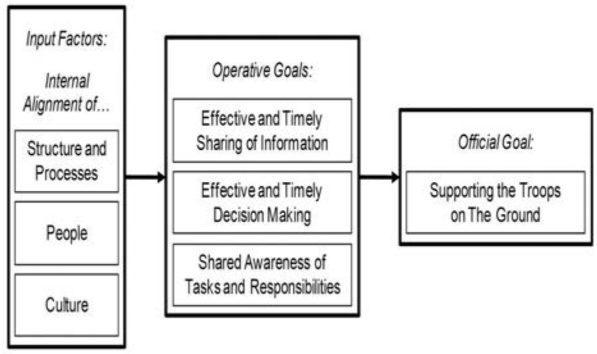


Figure 26: Model for organisational effectiveness of coalition operations' HQs.

The model included input factors, the operative goals of the organisation, as well as the relationships between the input factors and operational goals.

Initial interviews conducted with military SMEs highlighted structure and processes, people and culture as important input factors to consider. Effective and timely decision-making, information sharing and shared awareness of tasks and responsibilities were identified as important operative goals. These aspects were in line with existing general and military models of organisational effectiveness, and in addition, the HFM-163/HFM-232 model also emphasised factors of particular relevance to an operational HQ, such as personnel rotation practices.

Exploitation and Impact

The research findings are expected to help military leaders and Nations to identify training gaps that can be addressed in future pre-deployment training and improve ways of working in a multi-cultural environment. A Lecture Series was held at the end of 2013 to disseminate the results of this activity.

Synergies and Complementarities

Members from eight NATO and three Partner Nations (Israel, Sweden and Switzerland), as well as three NATO Bodies (ACT, NDC and the NATO School) participated in this RTG.

S&T Achievements

The technical report resulting from this activity summarises some practical implications to improve organisational effectiveness of NATO operational HQs, focusing on: a) enhancing the congruence between the way people are accustomed to working and the manner in which the HQ is organised; b) developing and applying transformational leadership in a multi-national environment; c) improving managing processes in the HQ and the rotation practices; d) enhancing trust in multi-national Coalitions; and e) reducing the challenges of multi-nationality.

Conclusion

This RTG was deemed a complete success as it will support human performance improvements in military operations.

DECISIONS IN UNCERTAIN OCEAN ENVIRONMENTS (CMRE)

Background

NATO maritime operations will rely increasingly on spatially and time-variant data from sources such as Meteorological and Oceanographic (METOC) forecast systems, satellites and in-situ sensors. The proper handling of these large volumes of data, for example in mission planning and operations, will saturate cognitive and analysis capabilities, even more so when multiple conflicting mission objectives have to be optimised.

Objectives

The RTG aimed to develop operational planning aids that will process vast sources of information to present environmentally-conditioned risk, transfer uncertainty to system/mission performance, and propose asset allocations and courses of action to use available resources effectively. A generic goal-orientated decision support system (GO-DSS) will be made adaptable for naval or special forces applications.

Summary

The efficient execution of maritime operations requires all available environmental data to be processed in almost real time to optimise decision-making – CMRE's GO-DSS satisfies this requirement.

Exploitation and Impact

A specific implementation of the GO-DSS was initiated in the context of the Operation Ocean Shield (OOS), balancing risk (of piracy activity conditioned by the environment and trained by machine learning), surveillance coverage (surface vessel sensors), and asset cost. NATO Maritime Command (MARCOM) provided feedback on design and functionality, and France (EUNAVFOR) conducted operational evaluation of the risk related to activities in the Indian Ocean.

Synergies and Complementarities

In addition to the aforementioned engagement, CMRE fostered partnerships with the Nations through the Environmentally Conditioned Asset Allocation and Risk Assessment for Operational Planning meeting and implemented a repository to make acoustic and oceanographic data accessible via web services, including tools for search and discovery. These relationships will grow in 2014 with: a) the Decision Support and Risk Assessment for Asset Planning Workshop; b) collaboration with METOC providers and consumers in CWIX14; and c) interfaces with the European Data Infrastructure initiative.

S&T Achievements

A scoping study showed how risks are specified in existing impact matrices, and can be incorporated into GO-DSS, with an emphasis on how probabilistic METOC forecasts could be used in future. An instantiation of the GO-DSS was implemented in the context of OOS to assist with the allocation of surface vessels. It is available through a web service in STO's CMRE Maritime Situational Awareness (MSA) viewer (see Figures 27 – 30).

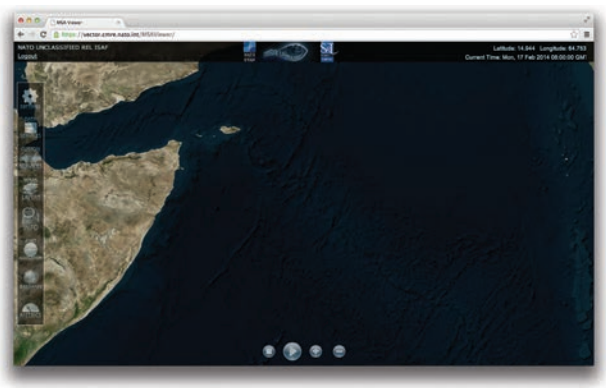


Figure 27: GO-DSS web service: Geospatial information

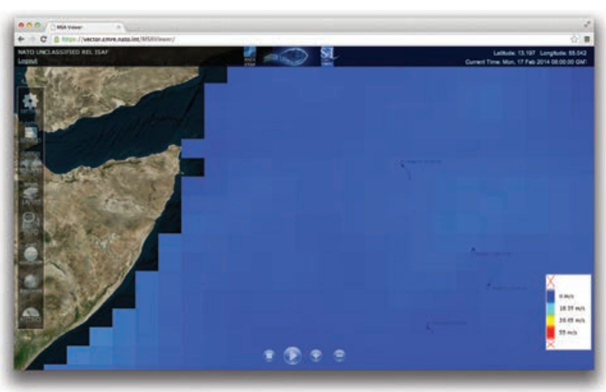


Figure 28: GO-DSS web service: METOC information.

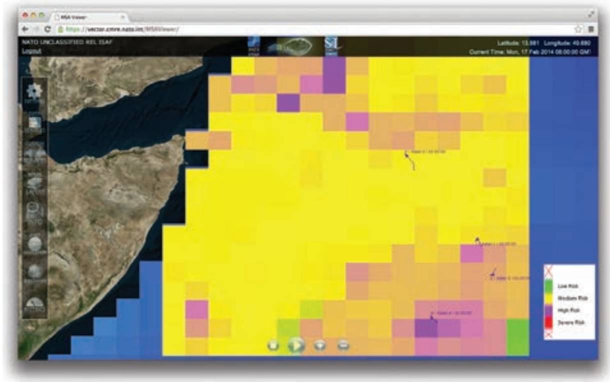


Figure 29: GO-DSS web service: Risk information.

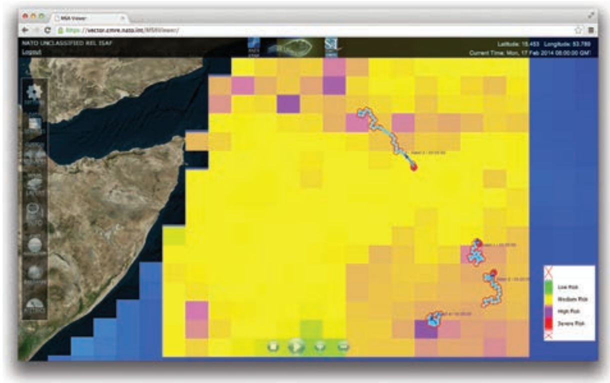


Figure 30: GO-DSS web service: Asset allocation information.

To facilitate access to CMRE's acoustic and oceanographic data sets, a prototype catalogue was implemented for one sea trial. This required reviewing relevant international initiatives, defining meta-data requirements and designing the database schema.

Exploratory work tested three compressed sensing techniques on oceanographic and acoustic signals. These techniques out-performed traditional Fourier-based methods when applied to acoustic data. In the longer term, their application to data acquired by instrumentation deployed in remote locations may reduce the bandwidth and transmission cost required to connect with the METOC data collection network.

Conclusions

The work is enabling interoperability for METOC-related requirements (see Figure 28), introducing uncertainty as a risk that needs to be addressed by operators, and using the GO-DSS to manage and portray risk (see Figure 29) and optimise assets in the face of that risk (see Figure 30).

PERFORMANCE CRITERIA FOR CAMOUFLAGE SYSTEMS DERIVED FROM OPERATIONAL SCENARIOS (SCI-212)

Background

Denial and deception strategies, operations and tactics continue to play a significant role in all military undertakings. However, most NATO Nations are developing their own Camouflage, Concealment and Deception (CC&D) systems, and are using their own procedures for specifications, development, testing and assessment. The resulting diversity in performance characteristics may cause operational and interoperability issues for Coalition forces in future joint operations.

Objective

The objective of this RTG was to improve test methods for the evaluation of CC&D systems typical in modern, highly mobile operations.

Summary

SCI-212 identified the military requirements in co-operation with the NATO Camouflage, Concealment, Deception and Obscuration Working Group – a sub-group of the Joint Capability Group ISR and by conducting an international workshop with military experts in Brno, Czech Republic.

The RTG conducted a two-week field trial in Storkow, Germany, in order to compare the camouflage effectiveness in different tactical scenarios. The RTG applied modern camouflage systems such as Mobile Camouflage Systems (MCS) to moving and stationary vehicles, Battledress Uniforms (BDUs), and multi-spectral camouflage net systems. Ground and air-based visual, infra-red, hyper-spectral and radar sensors served as ISR sensors.

Additionally, computer-based methods and observer trials involving over 200 soldiers were utilised to evaluate the various scenarios.

Exploitation and Impact

SCI-212 is expected to be a significant contributor to NATO efforts regarding the development of new Standard NATO Agreements (STANAGs) for camouflage evaluation. The RTG's findings will be critical during the evaluation of new technologies (MCS and modern BDUs) and CC&D systems in mobile operations that demand new methods to remain viable and relevant.

Figure 31: Example of a mobile camouflage system on a vehicle.

Synergies and Complementarities

Governmental research and procurement organisations and military experts from seven NATO Nations (Canada, Czech Republic, Germany, Italy, Netherlands, Norway and Poland) and two invited Partnership-for-Peace (PfP) Nations (Sweden and Switzerland) contributed to the activities of SCI-212.

SCI-212 combined its efforts together with the SET-141 RTG *Modern Sensor Performance Against Camouflaged Targets* and organised and conducted a two-week field trial.

The co-operation between the two RTGs made available a large number of diverse sensors, sensor models and camouflage solutions.

S&T Achievements

Data analysis of complex situations clearly identified the limitations of computer-based analysis methods. Observer trials are still a key element in the analysis of camouflage performance.

The RTG evaluated some promising concepts and improvements to modern camouflage systems (BDUs and MCS) during the field trials.

SCI-212 presented two papers on estimated detection ranges based on calibrated short-distance measurements at the 8th NATO Military Sensing Symposium in Friedrichshafen, Germany.

Conclusions

Traditional evaluation methods are not easily transferred to operational scenarios. The SCI-212 RTG demonstrated that new approaches are needed to evaluate CC&D systems in operational scenarios. The new methods must describe camouflage effects on mission outcomes.

JANUS (THE ROMAN GOD OF PORTALS, TRANSITIONS AND TIME) (CMRE)

Background

Interoperability of Underwater (UW) digital communications equipment from different manufacturers is of vital importance to the Alliance and its Partners, especially in support of autonomous security networks for ASW and other roles. As a NATO research centre, STO's CMRE is uniquely qualified to foster an aligned community of stakeholders to develop and promote interoperability standards for UW communications.

Objectives

The objective was to create a simple interoperability standard for UW acoustic modems from different manufactures that allows robust node discovery and the exchange of information, enabling the creation of ad-hoc heterogeneous autonomous security networks for ASW and other applications.

Summary

CMRE's Communications Networking project has developed the JANUS UW digital communications standard in partnership with Nations, manufacturers and users. The Centre has succeeded in having both a Standardisation Proposal and Task approved by NATO's Underwater Warfare Capability Group. In addition, a separate NIAG study on UW Digital Acoustic Communications has been approved to facilitate industry engagement.

Exploitation and Impact

The JANUS UW digital communications standard has been extensively tested over several years, culminating in the Communications Networking trial in October 2013. The software modules have been made available via the JANUS WIKI at http://www.januswiki.org, which has a global registered community of more than 100 users. There is broad support for JANUS in NATO, industry and academia. Several key UW acoustic modem manufacturers are participating in the NIAG study on JANUS and have indicated their preparedness to bring their modems into compliance.

Synergies and Complementarities

The JANUS standard has received significant interest from the offshore oil and gas industry's Joint Industrial Partnership programme for the development of UW communication standards, the SWiG (Subsea Wireless Group). In addition, the Institute of Electrical and Electronics Engineers (IEEE) Ocean Engineering Society's Standards Committee has been approached to co-ordinate the promulgation of JANUS as an IEEE standard.

S&T Achievements

The JANUS standard has been developed with the support and advice of industry and is based on robust signal processing properties backed by extensive research and experimentation.

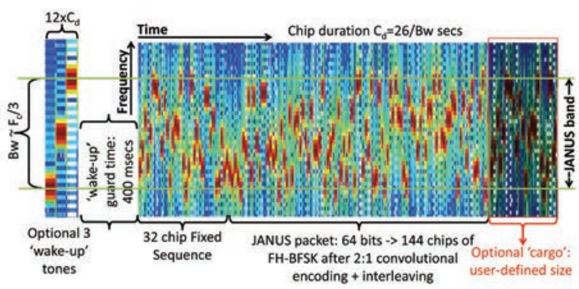


Figure 32: The JANUS underwater digital communications standard packet shown in a time-frequency plot.

The signal uses only simple windowed tones, but employs frequency-hopping to combat frequency-selective fading together with convolution coding and interleaving to provide robustness to transient noise. A cyclic redundancy check verifies decoded signals. While JANUS is deliberately simple to facilitate adoption by legacy systems, significant work has been invested to develop sophisticated signal processing techniques for more modern equipment to improve detection, synchronisation and Doppler estimation of received signals.

Conclusions

The project has developed and tested the JANUS standard and obtained NATO Navy Armaments Group (NNAG) approval for a Standardisation Proposal and Task. A complementary NIAG study has been approved to engage industry. Together these accomplishments represent significant progress in the creation of the first digital UW communications standard to enable the heterogeneous sensing networks of the future.

ADVANCED NON-DESTRUCTIVE EVALUATION TECHNIQUES FOR POLYMER-BASED COMPOSITES IN MILITARY VEHICLES (AVT-224)

Background

Fibre-reinforced polymer composites are nowadays widely used in advanced military platforms and weapon systems. They bring benefits not only in terms of weight, but others such as good environmental resistance, low magnetic signature and stealth attributes. Polymer composites are therefore the material of choice for structural design. As these platforms and systems will be in use for many years, the supportability of these materials is a major issue. The design standards and defect tolerance vary greatly from traditional materials and state-of-the-art of Non-Destructive Evaluation (NDE) needs to be understood by the platform users.

Objective

The main objective of this Workshop was to present recent developments, as well as to discuss and identify needs for existing and future vehicles, by bringing together specialists in the field of NDE, inspection and maintenance.

Summary

The results of a previous Workshop (AVT-211 on "Understanding Failure Mechanisms of Composites for Sustaining and Enhancing Military Systems Structures") were directly exploited in this Workshop. Understanding the failure mechanisms of these new materials is essential for the discussion on NDE techniques and standards.

State-of-the-art of composite NDE inspection at new manufacture and overhaul was established and the emerging technologies from NATO Nation's research communities were covered. Current and required capabilities with respect to ultrasonic, optical, x-ray, thermography, NDE modelling and test pieces were discussed and developed during the meeting. Methods of bridging the gaps were identified as a result of the Workshop.

The figure below shows an example of an x-ray image, indicating a fracture within a composite structure element.

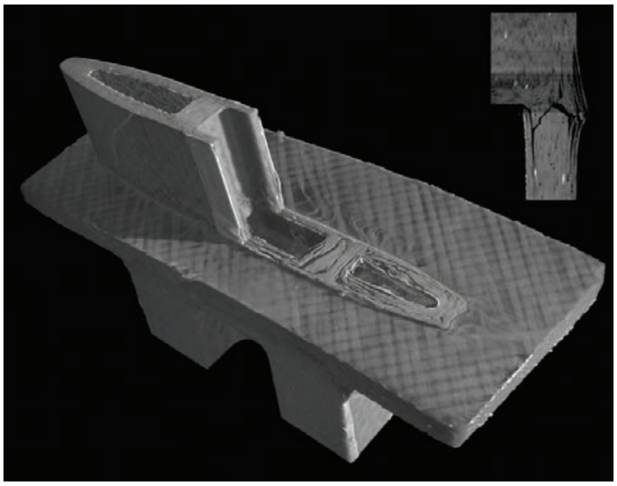


Figure 33: X-ray Computed Tomography (CT) image of compression failure of Carbon Fibre Reinforced Polymer (CFRP) moulding, showing fracture, fibre layup and matrix rich areas.

Exploitation and Impact

The participants shared benchmarking studies that have been conducted within NATO Nations, and the NATO STO gave the platform to provide these results and exploit them directly within the NATO framework. These results should inform the user on which NDE technique to choose.

> "The AVT Chair noted – Developing non-destructive evaluation technologies for advanced materials used in military vehicles is a key driver for evaluating the condition of the structure through the entire life-cycle of a military system.

Synergies and Complementarities

AVT-224 gave the opportunity for NDE specialists from nine NATO Nations, Australia and Sweden to present and share their experience on inspecting polymer composite, primarily carbon fibre based. In total, 16 papers were presented to the audience.

S&T Achievements

Initial outputs from the Workshop are that a register of samples across the Nations, including evaluation reports, should allow for a greater understanding to be gained by each national service. Common platform users would benefit from having specific NDE forums to avoid having to re-develop inspection processes.

Furthermore, as a result of the Workshop, S&T-based recommendations were given that addressed the future work required.

Conclusions

AVT-224, as a science focus activity, successfully confronted the challenges connected with advanced new materials and their evaluation methods. The gained results and given recommendations can now be directly exploited within the Alliance and Partner Nations.

DELIVERING KNOWLEDGE, ANALYSIS AND ADVICE

NATO S&T provides targeted and timely evidence-based knowledge, analysis and advice, either in response to requests or proactively. By using and developing appropriate tools, it contributes effectively to political and military planning and decision-making across the full spectrum of NATO and Nations' activities.

The NATO S&T community demonstrated its ability to respond to the objective of delivering knowledge, analysis and advice; in particular drawing on its strengths in operations research and strategic analysis. The following pages contain a representative outline of the 2013 NATO STO PoW.

POWER AND ENERGY IN MILITARY OPERATIONS (SAS-083)

Background

Power and energy sources are significant strategic, operational and tactical enablers for national security, and the defence and economic development of Nations. In military operations, the increasing demand for operational energy is imposing significant constraints on operational capabilities, which could substantially decrease the sustainability of military forces and their operational effectiveness. Decision support tools to manage requirements for, and/or optimise consumption of, power and energy are thus crucial in operations.

Objective

This RTG aimed to: a) examine the impact of rising power and energy demands in military operations; b) develop a baseline of current power and energy usage data for determining the requirements for power and energy in operations and c) define common performance measures and models for conducting options analysis for power and energy consumption optimisation.

Summary

Rising power and energy demands in military operations were addressed, leading to a better understanding and awareness of where and how to achieve cost savings. In close co-operation, several Allied Nations developed a model framework that captures the complete fuel cycle and provides decision support.

Figure 34: Air-to-air refuelling.

Exploitation and Impact

The results of this RTG have led to the creation of the first Canadian Defence Operational Energy Strategy and its baseline of energy consumption for expeditionary operations.

Additionally, a Fully Burdened Cost of Energy (FBCE) methodology was able to demonstrate cost savings of over 1M CAD by replacing Tactical Quiet Generators (TQGs) with energy-efficient Advanced Medium Mobile Power Source (AMMPS) generators for a Combat Aviation Brigade (CAB) in an Afghanistan RC-East scenario.

Synergies and Complementarities

Experts from six NATO Nations actively participated in this activity and were able to utilise some of the work accomplished by other STO activities, such as the SET-150 Research Specialists' Meeting on "Fuel Cells and Other Emerging Man-portable Power Technologies" and the AVT-209 Research Workshop on "Energy Efficient Technologies and Concepts of Operations".

S&T Achievements

A common FBCE and Fuel Consumption Predication Model (FCPM) framework was developed by integrating different national analytical methods and assumptions, which offers an energy metric that considers all operational factors in the energy supply chain, including transportation, infrastructure, manpower, maintenance, security protection, and storage of energy.

The FBCE model captures the complete life-cycle of fuel in operations, whereas the FCPM provides a methodological framework to determine energy requirements for expeditionary operations.

The FBCE and FCPM are important decision-support tools for analysing national as well as NATO operational energy issues. Indeed, the FBCE could assess alternate forms of energy to inform decisions on the size and focus of investment in S&T programmes related to the development of energy-efficient capabilities. The FCPM could be used to determine baseline of current energy consumption and to assess the impact of different energy targets.

Conclusions

SAS-083 examined specific power and energy issues and developed ready-to-use military operational energy mathematical models and decision-support tools, which NATO and national leaders can use to offset the growing issues of increased demand for power and energy sources in military operations.

Future efforts may examine the development of models to quantify environmental impacts of different energy sources, as well as operational impacts and capabilities.

AUTOMATIC TARGET RECOGNITION FOR MINE COUNTER-MEASURES (CMRE)

Background

Sea-mines are a long-standing threat to harbours and sea-lanes. Efficiently countering those mines, while crucially important, is particularly challenging in all but the most benign of environments. The use of ATR algorithms can help make MCM operations more efficient and effective across a wide range of environments.

Objectives

This research has been aimed at developing and evaluating near real-time algorithms that detect and classify underwater targets accurately in high-resolution acoustic imagery, for minimising the number of false alarms including optimal direction of the vehicle's search path, as well as operating alongside human operators as an aid in Post-Mission Analysis (PMA).

Summary

The performance of automatic ATR algorithms has been quantified and compared with current capabilities. A library of sonar data allows insight into the state-of-the-art, novel ways to support MCM operations and advanced capabilities for autonomous systems.

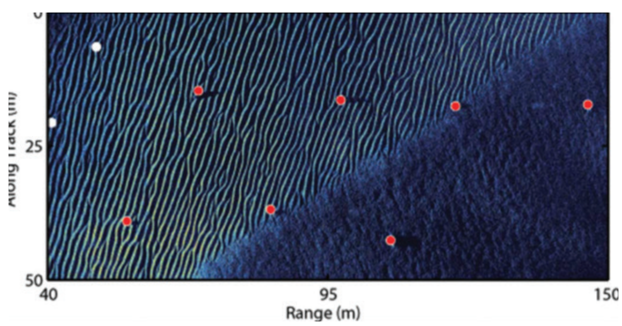


Figure 35: Example of a final detection map obtained on synthetic aperture sonar image. The solid white circles indicate false alarms, while red/hollow-white circles mark correct target detections.

Exploitation and Impact

CMRE maintains an extensive library of underwater acoustic imagery data from side-scan synthetic aperture and multi-beam imaging sonar systems. In diverse underwater acoustic environments, this gives insight into the military requirements for developing robust algorithms across the range of sea-bottom conditions that may be encountered by NATO MCM forces. Large-scale analysis of the detection performance of the algorithms and new designs that exploit environmental information have been documented and made available to Nations.

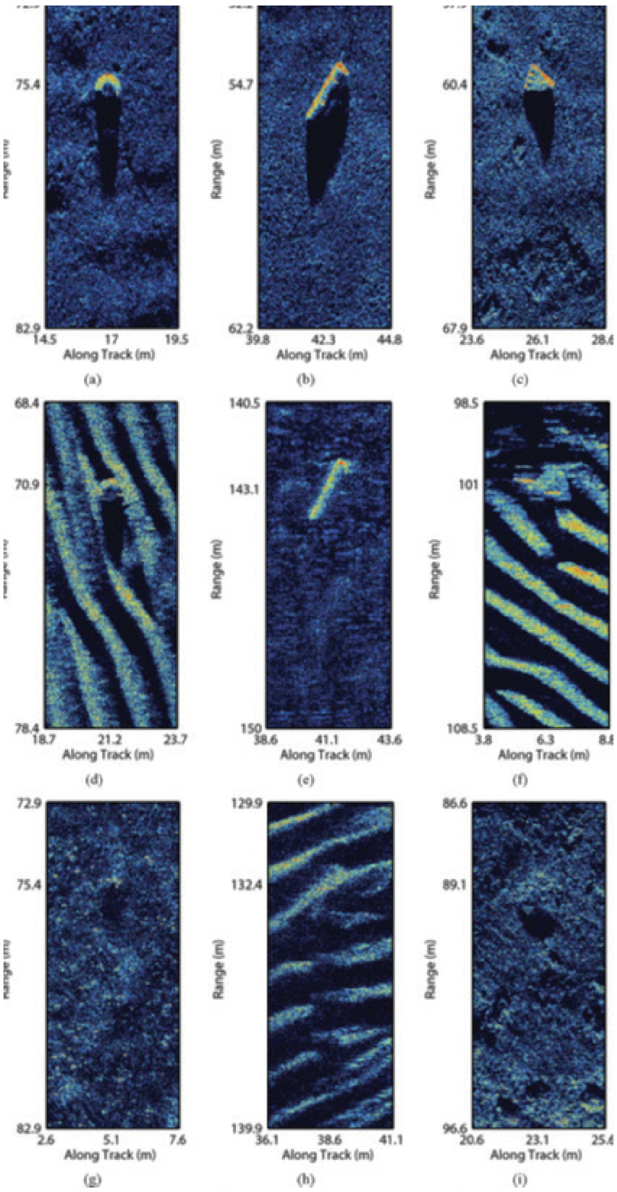


Figure 36: Example Synthetic Aperture Sonar (SAS) mug-shots of targets considered in a large scale study corresponding to (a)–(c) successful detections of easy cases, (d)–(f) successful detections of difficult cases, and (g)–(i) missed detections. (a) Truncated cone; (b) Cylinder; (c) Wedge; (d) Truncated cone; (e) Cylinder; (f) Wedge; (g) Truncated cone; (h) Cylinder; (i) Wedge.

Synergies and Complementarities

The Centre hosted a series of ATR Workshops, in which a closed computer network was used to access data sets that have not been previously distributed. Researchers brought their own algorithms and analysed the data set for detection and classification performance. The last Workshop saw participation from seven NATO Nations.

These Workshops helped to develop a common understanding of the performance metrics for AUV with high resolution imaging sonar systems. In this way fruitful international collaboration was fostered, while demonstrating the overall NATO capability in this area.

S&T Achievements

At sea during the MANEX'13, the CMRE demonstrated the robustness and quality of the developed algorithms through the successful in-mission detection of mine-like targets by an AUV with synthetic aperture sonar, as well as autonomous re-sampling of those targets from different aspect angles.

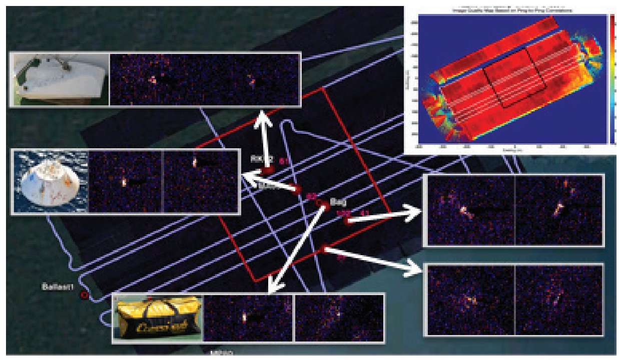


Figure 37: In-mission MUSCLE detections and autonomous re-sampling of targets at different aspect angles.

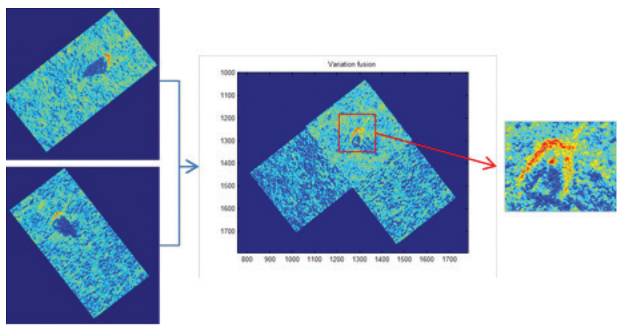


Figure 38: Fusion of MUSCLE detection SAS snippets to re-construct target highlight.

CMRE has also begun initial work in the area of human-machine collaboration, with ATR algorithms working alongside human operators for PMA tasks. This work is documented in submissions to the 2014 International Conference on Pattern Recognition, and has ties to RTG HFM-247 on "Human-Autonomy Teaming".

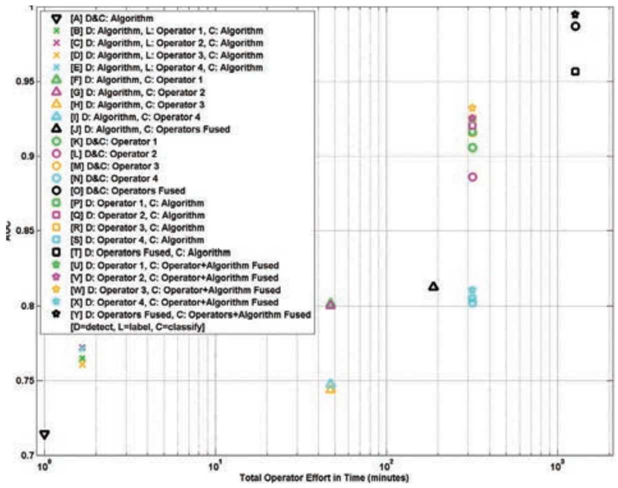


Figure 39: Classification performance as a function of human operator effort and for various human-computer combinations of detection and classification.

Conclusions

STO's CMRE and the Allied Nations showed that ATR algorithms have the potential to enable more effective force-multiplication from autonomous systems, and to aid human operators in their data analysis tasks. This research will continue at CMRE, with the goal of providing higher performance levels.

PROCESSES FOR ASSESSING OUTCOMES OF MULTI-NATIONAL MISSIONS (HFM-185)

Background

The assessment of multi-national missions is still a weak spot that requires further attention.

Objectives

The RTG aimed at developing a common understanding of current assessment practices for "whole of government" activities, including identifying NATO requirements for an assessment framework and a set of core indicators and frameworks, e.g., Measuring Progress in Conflict Environments or MPICE. Adaptation and experimentation in a field trial of the most applicable framework against NATO requirements, and formulating recommendations for refinement and implementation of the framework were also aimed for.

Summary

The RTG examined current measurement and assessment practices by its participating Nations in current and recent theatres of operations in order to identify and characterise limitations of current assessments and therefore identify best practices.

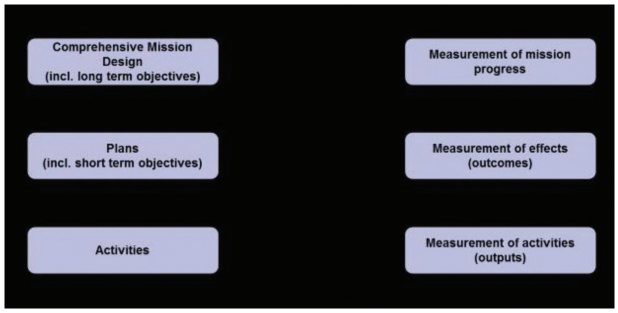


Figure 40: Connecting assessments and planning.

It also conducted a preliminary study to identify a potential set of core indicators that would be able to assess macro change in a region over time and allow for meaningful comparisons of results between missions.

As part of the research, interviews were conducted with individuals who either performed assessments or were the consumers of assessment products.

Results demonstrated that there is diversity within and between Nations on concepts, approaches and quality, highly driven by the individual Commander.

The RTG concluded that there is a great need for well-defined and consistent terminology, standard assessment practices that link assessments to the planning process, and for core measures that are consistent across mission assessments to allow for comparisons between missions outcomes, and yet are complementary to specific campaign intervention assessments.

Exploitation and Impact

A coherent process for assessing the outcomes of multi-national missions will be an enabler for a transparent and accessible data and knowledge management system.

Synergies and Complementarities

Members from five NATO Nations and one Partner, as well as NATO ACT, participated in this activity. Participants in the interviews included civilian and military members of the American, British, Canadian, Dutch and Swedish militaries and departments of defence.

S&T Achievements

A method for determining a small set of core variables was developed to assess change across some geographical area over time.

A set of 33 variables was identified that described seven principal components: demographics, economy, education, health, infrastructure, law/security and social constructs.

The RTG identified common concerns that could be grouped into three general types:

- The lack of standard assessment procedures and core measures resulting in unreliable, and at times inconsistent and personality-driven assessments, which hinder comparable measurement of perceived mission progress across geography, time and troop rotations.
- The need for transparent and widely accessible information and knowledge so that knowledge reliably gained is not lost across geography, time, and troop rotations.
- The lack of practices that link assessment staffs with planning activities, while also ensuring that both military and non-military assessments are used as part of the planning process, and vice versa.

Conclusion

There is a need for a small comprehensive set of variables that is observable, culture-free, independent, and counted the same way by everyone.

TRAFFIC ROUTE EXTRACTION AND ANOMALY DETECTION (CMRE)

Background

The use of data to enable better decisions is a pervasive trend in business and science. The maturity of government-to-government, commercial, and open source data networks collecting Automatic Identification System (AIS) reports has created a data explosion and significantly changed the military's "white picture", or information available on commercial vessel traffic. However, as the number of dots on the screen has grown exponentially, operators cannot exploit all available information as it has simply become overwhelming. Knowledge discovery techniques using both real-time and historical data demonstrate the potential to significantly improve an operator's ability to exploit available information by synthesising the information to understandable, actionable components.

Objectives

The objective was to develop machine learning techniques and to understand their potential for informing the military on understanding commercial surface vessel traffic patterns of life. The methodology has been named "Traffic Route Extraction and Anomaly Detection" (TREAD), and features as part of CMRE's work in MSA. The project's objectives have been demonstrated to be equally relevant in dual-use civilian applications, especially in the area of vessel monitoring for safety and security.

Summary

TREAD is an unsupervised learning methodology able to generate patterns of life from historical traffic data. It extracts a synthetic representation of vessel behaviours automatically and produces information layers of maritime historical patterns of life. The capability has been demonstrated even in busy and/or large-scale areas. The final goal is to support decisions in the maritime domain.

Exploitation and Impact

The main focus of this work has been on use within the NATO MARCOM as a means of improving the quality of information available to current operations. The information layers generated by TREAD have given operators a novel means of generating pattern of life from historical data and this is being evaluated in the context of operation active endeavour. Derived traffic patterns from historical data provide enhanced situational awareness.

The techniques have been published in NATO and scientific publications and presentations, promoting synergies with national research programmes.

Synergies and Complementarities

As information layers such as those derived from the TREAD model are a useful input to more general work in maritime anomaly detection and decision support, TREAD has been a useful input into the work of other collaborative projects. For example, CMRE is a member of a European Commission project, New Service Capabilities for Integrated and Advanced Maritime Surveillance (NEREIDS), which brings together collaborators from industry, academia and end-user communities to develop pre-operational techniques for the integration of data from space-based assets into maritime surveillance.

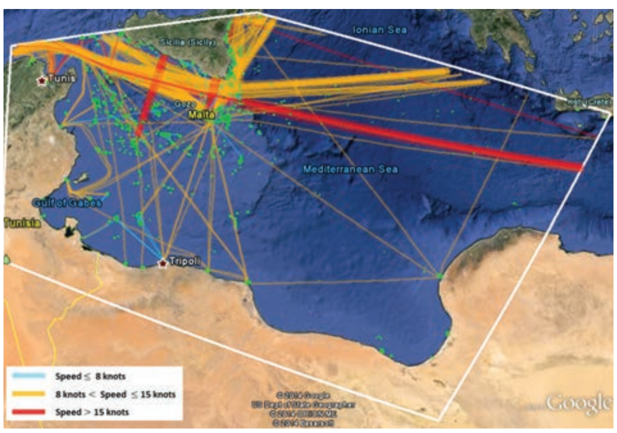


Figure 41: TREAD main synthetic routes from AIS data in support of NEREIDS.

S&T Achievements

TREAD has shown that historical data can be used to derive meaningful layers for enhanced situational awareness using techniques by the machine learning community. The model has been used on both large and small scales for both military and civilian communities.

The CMRE paper "Traffic Knowledge Discovery from AIS Data" was a prize-winner at an international Information Fusion Conference in Istanbul, Turkey, demonstrating the interest from the academic community. The work was honoured at the European Co-operation in Science and Technology, in a dedicated Workshop on Moving Objects at Sea and in the final invited showcase, and at "Big Data from Space" at the European Space Agency.

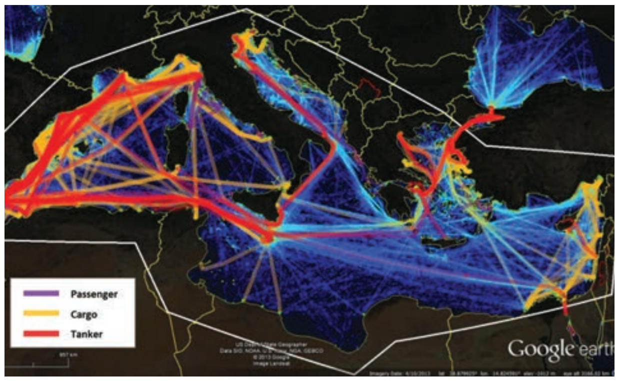


Figure 42: AIS density map and TREAD routes organised in three main ship-type layers (i.e., cargo, tanker and passenger) overlaid.

Conclusions

Knowledge extraction techniques to generate pattern of life information from moving object data have been met with significant interest by both the scientific community and operational end users.

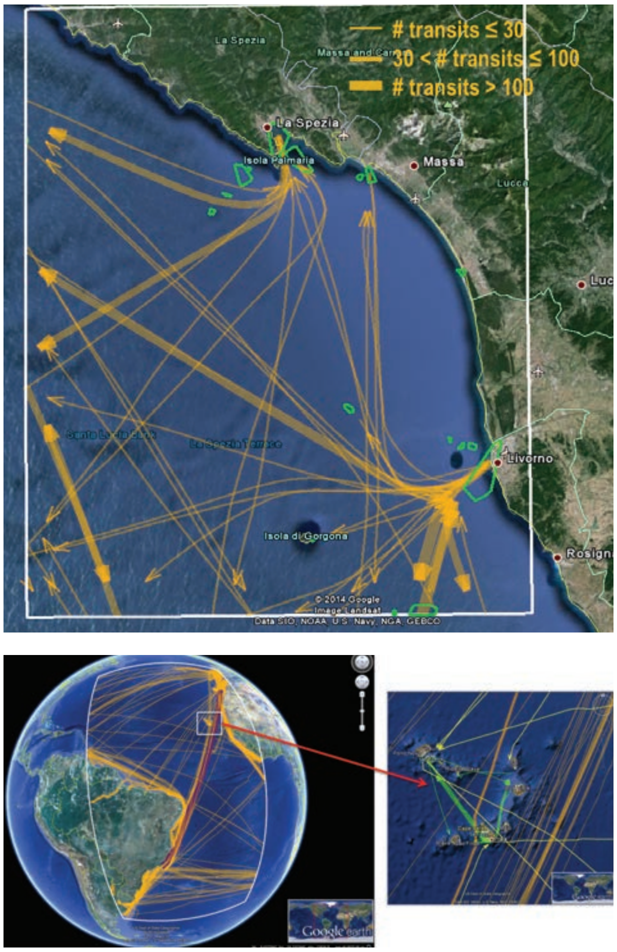


Figure 43: Weight of routes by number of transits (small scale).

DATA FARMING IN SUPPORT OF NATO (MSG-088)

Background

Data Farming is a process that has been developed to support decision-makers by focusing on and answering questions. It uses an inter-disciplinary approach to examine questions of interest with a large number of alternatives. Data farming continuously asks the question "what if?" and allows for the examination of uncertain events with numerous possible outcomes and provides the capability of executing enough experiments so that both overall and unexpected results may be captured and examined for insights.

Objective

The MSG-088 RTG was to assess and document the data farming methodology to be used for decision support.

Summary

The RTG documented the six domains of data farming and how they combine to support decision-making. The domains are collaborative processes, rapid scenario prototyping, model development, design of experiments, high-performance computing, and analysis and visualisation. The work also included a humanitarian assistance and a force protection case study that served as proof-of-concept explorations of the data farming concept.

Figure 44: MSG-088 force protection modelling.

Exploitation and Impact

Through the codification of the data farming process, MSG-088 provided a concept for simulation-based analysis that improves NATO's decision-making capability. The two case studies were very relevant and the work has already catalysed two additional teams using data farming in the important areas of operational defence planning – a critical need in this era of constrained defence budgets – and in cyber security, an area that undoubtedly will continue to increase in importance to ensure the success of NATO missions in the future.

Synergies and Complementarities

Participants from more than 10 Nations contributed to MSG-088. The work leveraged the efforts of the greater data farming community and the authors of the final report hailed from nine different countries. The RTG had open collaboration among the Nations. The collaborators were world experts in their areas and that fact was essential in contributing to the quality of the work. They came from various academic disciplines that were synergistic and complementary, and included both military and scientific backgrounds.

S&T Achievements

In MSG-088, experts in all six domains and whose countries have begun practicing the art and science of data farming, were brought together to advance the technology. New technology was also developed in bringing the scientific capabilities inherent in the six domains together. As a result, MSG-088 has provided the basis for applying data farming to areas of importance to NATO. Up to this point, the International Data Farming Community has performed successful work in the development of data farming, and MSG-088 has utilised those efforts to advance the S&T and transition the capabilities into the context of NATO needs.

Conclusions

The essence of data farming is that it is a question-based approach where “what if?” is asked repeatedly. Data farming engages an iterative process that enables obtaining insight into the questions. Harnessing the power of data farming to apply it to our questions is now available to NATO decision-makers – thanks to MSG-088. This support is critically needed in answering questions inherent in the scenarios NATO is expected to confront in the future as the challenges NATO forces face become more complex and uncertain.

MULTI-STATIC TACTICAL PLANNING AID (CMRE)

Background

The ability to detect submarines using active sonar is difficult to predict for a number of reasons. Sensitivity to the environment, uncertainty in target strength and aspect, and a plethora of system parameters must be combined comprehensively to generate reliable predictions for various platform and sensor configurations in realistic scenarios. For bi-statics and multi-statics, the challenge is even more difficult. Furthermore, there is a commensurate lack of tools which can be used for fast multi-static performance prediction to support In-stride Debrief Team (IDT) activities. (The IDT performs daily analysis of task force Situation Reports or SITREPs during ASW exercises to provide timely feedback of achieved ASW performance to unit Commanders.)

Objectives

The objective is to provide a tool capable of producing reliable estimates of multiple mono-static and/or multi-static active system performance and to use it in the context of NATO ASW exercises to explain observed detection performance.

Summary

The Multi-Static Tactical Planning Aid (MSTPA) was deployed to the IDT during the Proud Manta exercise in February 2013 and used successfully to predict sonar performance for submarine detection. In 2014, MSTPA was deployed at sea on board the Standing NATO Maritime Group command ship during the Dynamic Mongoose exercise and demonstrated a real-time decision-support capability.

Exploitation and Impact

In the Proud Manta exercise, MSTPA was used to explain the dynamics of the submarine detections obtained by the participating platforms. The tool was deployed with the support of a SME to the IDT at Sigonella Naval Air Station. A new automated capability to ingest SITREPs for the re-creation of ASW serials and predicted detection opportunities was tested during the trial. In 2014, MSTPA was used in real-time mode during exercise Dynamic Mongoose to provide fast sonar coverage predictions for multiple assets geo-referenced on a map of the exercise area.

Synergies and Complementarities

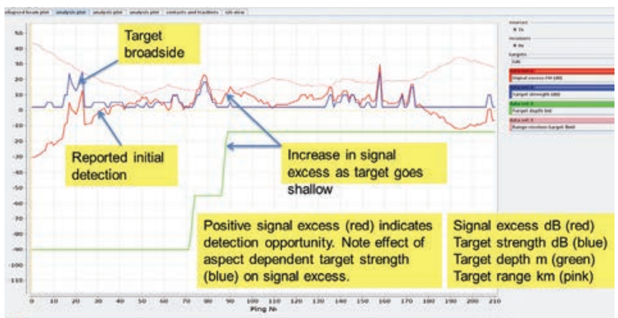


Figure 45: Detection opportunities during POMA’13, predicted successfully by MSTPA.

MSTPA was tested and compared with NATO's and Nations' tools as a part of the Multi-Static Tactical Decision Aid Specialist Team of the NATO Underwater Warfare Capability Group, and participated in the Advancing Multi-Static Operational Capability of The Technical Co-operation Programme (TTCP). Also, AUVs in the autonomous multi-static ASW network utilised MSTPA performance predictions for Bayesian model-based control. There is significant interest among the Nations for using this tool for the development of multi-static tactics and for tactical optimisation.

S&T Achievements

MSTPA is the repository of CMRE's best practice and experience in sonar performance prediction, wrapped up in a platform-independent tool with a user-friendly Graphical Information System (GIS) based user interface. Significant effort has been put towards upgrading the acoustic propagation and scattering module ARTEMIS (developed at CMRE) which has highly favourable performance characteristics that make the running of acoustic performance predictions feasible. MSTPA has been improved significantly to allow rapid performance evaluation for a spectrum of source/receiver depths and multi-static target locations and aspects without recalculation. Lastly, it has been benchmarked extensively against other tactical decision aids and its component modules, especially the propagation engine, have been compared similarly to standard acoustic models.

Conclusions

The MSTPA was successfully deployed with the assistance of an SME to the Proud Manta ASW exercise in February 2013 to support the IDT. The results obtained by MSTPA through the automated ingestion of SITREPs transmitted by surface ASW forces were central in explaining observed detection opportunities.

FRAMEWORK FOR SEMANTIC INTEROPERABILITY (IST-094)

Background

The expansion of machine-to-machine information exchanges among Coalition C2 systems in network-enabled environments requires a concomitant capability to ensure that the recipient systems understand messages exactly as the source intended.

The ability to achieve "semantic interoperability" has not kept pace with improvements in interoperability at the physical (signal transmission) and syntactic (rules for the assembling of signs) levels. Usually semantic interoperability problems might be seen as unexplainable anomalies and treated by ad-hoc solutions or procedurally.

Problems are easier to solve when they are reproducible, clearly linked to identifiable technical assets, occurring between a limited number of affected elements, appearing without delay, and when not embarrassing for involved parties; thus they can be well documented. If complicated failures occur, and at the first glance no clear reasons can be identified, it is difficult for the case studies to concentrate on possible concept mismatches or at least take these aspects into account.

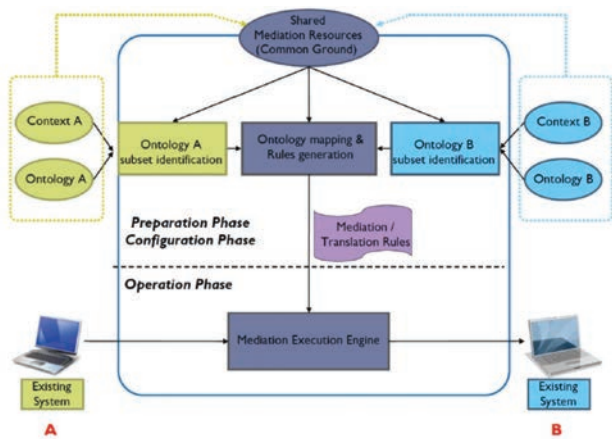


Figure 46: Semantic interoperability logical framework architecture.

Objective

A certain amount of semantic tools, methods and theories is already available, but mainly used by a small but growing scientific community. These assets promise to overcome semantic interoperability problems and align the developments towards a higher level of interoperability.

Summary

The Semantic Interoperability Logical Framework (SILF) uses modern semantic technologies and aims for their proper orchestration. SILF provides a logical framework and strives to emphasise the benefit of semantics for interoperability in general.

SILF explores technology solutions for ensuring semantically correct interoperability, adapted to new missions and scaled to the growing number of systems.

Exploitation and Impact

SILF is a framework for creating rules for enabling “good enough” semantic. It defines mediation methods without system modifications; provides design artefacts to develop mediation software and services; and exploits cutting-edge semantic technologies, for machine-to-machine communications for operational contexts.

SILF eliminates only the semantic gaps relevant to the execution of a specific task.

Synergies and Complementarities

The Group brought SILF to a higher maturity level by refining and elaborating the technology approach and the organisational requirements for a cost-effective and sustainable solution.

S&T Achievements

There is no realistic alternative for achieving interoperability in NATO forces. SILF applies knowledge-based techniques to identify the presence of semantic gaps, and aims to close these gaps using in-line mediation techniques that involve the configuration and operation of automated mediator software.

The meaning in SILF is represented as a machine-understandable artefact called “ontology”.

Deep meaning defines relationships among concepts within and across ontologies. The underlying logical formalism makes it possible for a general inference engine to “understand” the semantics of the knowledge thus represented, without needing to have the semantics implicitly encoded and thus “hidden” from view in custom software.

Conclusions

The study defined a SILF life-cycle, including preparation and post-operation phases.

It identified requirements for “making SILF real”. Actions included: a) soliciting realistic use cases, training, and testing personnel; b) flushing out SILF methodology and design details; c) defining an actionable set of technical and organisational steps for creating and sustaining SILF; and d) developing a prototype.

The last step is to evaluate the operational applicability and the cost efficiency of SILF.

EXCELLENCE IN NATO SCIENCE AND TECHNOLOGY

NATO's STB highly values S&T excellence within the Alliance. The quality of S&T, the breadth and depth of the collaboration within NATO, and the potential impact and exploitation are the key elements for recognition.

Every autumn, the STB considers granting two prestigious NATO S&T awards, the von Kármán Medal and the Scientific Achievement Award (SAA). These landmarks of excellence will be granted only when the STB considers that appropriate candidates were nominated. Tradition has it that the NATO Chief Scientist, in his capacity as Chairperson of the STB, ceremonially presents the achievements to the successful candidates during the STB meeting in the autumn.

The von Kármán Medal is the most prestigious scientific and technological award; it is a personal prize that recognises either the whole STO oeuvre or a single outstanding STO achievement of the laureate. Exemplary service and significant contribution to the enhancement of progress in S&T collaboration among NATO, NATO's Nations and Partners within the STO are key. The medal is presented together with an accompanying citation, signed by the STB Chairperson.

The SAA can be awarded to a person or a team; it recognises excellence and originality of scientific and technical work, as well as outstanding results in terms of military benefit over recent years. The SAA consists of a certificate and an accompanying citation, signed by the STB Chairperson.

In 2013, the STB awarded one von Kármán Medal and three Scientific Achievement Awards.

THE 2013 von KÁRMÁN MEDAL

The 2013 von Kármán Medal was awarded to Prof. Dr. Maurus Tacke (Germany) for his steadfast dedication and leadership within NATO S&T.

Prof. Dr. Maurus Tacke (Germany) received the 2013 von Kármán medal from the NATO Chief Scientist, MGen Albert Husniaux (Belgian Air Force), in his capacity as STB Chairman.

Prof. Tacke is an internationally renowned physicist, who has demonstrated exceptional dedication to the field of optronics, in which he has led holds several patents. In addition to optronics, he contributed significantly to NATO's scientific activities in the fields of infra-red sensors, laser radars and image exploitation.

Prof. Tacke has served the NATO scientific and technical community for 12 years. During this long and distinguished tenure, he led or contributed to dozens of technical activities in the NATO STO, notably within the SET Panel and the NATO SPSP.

Prof. Tacke exemplified singular leadership as Chair and Vice-Chair of the SET Panel, where he advanced over 50 projects in fields ranging from signal processing and sensor data fusion to detection of biological warfare agents. As a SET Panel member, he personally led multi-national research in technologies to counter camouflage, effective use of advanced sensors during asymmetric military missions, state-of-the-art antenna design, and integrating surveillance systems with small UAVs. In addition to his contributions to the NATO STO, he has an extensive record of close collaboration in a myriad of other research and technology organisations within Germany, and throughout NATO.

THE 2013 SCIENTIFIC ACHIEVEMENT AWARDS

SAFE RIDE STANDARDS FOR CASUALTY EVACUATION USING UNMANNED AERIAL VEHICLES (UAVs) (HFM-184)

BGen (ret) Dr. Erich Rödig (Germany) received the 2013 Scientific Achievement Award from the NATO Chief Scientist, MGen Albert Husniaux (Belgian Air Force), in his capacity as STB Chairman.

Background

The use of UAVs in multiple roles has shown great progress in recent years. It appears evident that logistics-capable UAVs that can carry casualties will be present on the battlefield, as part of the forces of several Nations, within the short to medium term. Many doctrine developers are beginning to plan for the use of these vehicles for casualty extraction or evacuation on "back-haul", after delivery of its cargo.

Objective

The RTG aimed at investigating and making recommendations regarding the potential use of military UAVs for the transportation of casualties.

Summary

Led by BGen (ret) Dr. Erich Rödig, the RTG performed a review of all aspects of this type of vehicle, the legal and ethical considerations for such use, the operational and clinical considerations, and the development of possible scenarios in which such use could be beneficial to the casualty.

This led to a set of recommendations for future research and development to support such potential usage, as well as some recommendations for doctrine development by various NATO bodies and clinical guidelines for such usage.

Exploitation and Impact

The issue the technical report addresses is both operationally and clinically relevant.

Initially sceptical about such potential usage, the RTG has come to believe that these aircraft will be used for casualty movement soon after their appearance on the battlefield, with or without doctrinal guidance.

NATO and national Special Operations Forces have clearly indicated their interest in such use, as have several Nations' conventional military forces, when regular aerial evacuation means are either not available or are operationally undesirable. This potential use of UAVs, as a solution to the need for evacuation, demands the creation of safe ride standards for such use.

The RTG has developed a set of guidelines to make this modality safe to use in certain circumstances.

Synergies and Complementarities

Members from three NATO Nations and one Partner participated in this activity. Participants included civilian and military members of the American, British, German and Israeli militaries and departments of defence.

S&T Achievements

The technical report prepared by the RTG reviews the current state of UAV development, NATO doctrine and policy addressing this issue, legal and regulatory issues, as well as the clinical aspects of such transport, and presents a set of recommendations for NATO.

The RTG has suggested changes and additions to NATO doctrine in this regard, as well as encouraged continued research to develop solid evidence-based safety-of-flight recommendations.

The RTG also identified improvements in medical equipment which are necessary before any detailed consideration can be given to future use of UAVs for true medical evacuation.

Conclusions

The RTG concluded that the potential use of UAVs for CASualty EVACuation (CASEVAC) is ethically, legally, clinically and operationally permissible, so long as the relative risk for the casualty is not increased through the use of the UAV. The use of this type of vehicle for MEDical EVACuation (MEDEVAC) is neither technologically possible nor acceptable at this time (primarily due to lack of capability of in-flight medical equipment), though it is believed that such use will be possible in the medium- to long-term.

COALITION BATTLE MANAGEMENT LANGUAGE (MSG-048)

Background

Coalition Battle Management Language (C-BML) is a language that allows for interactions among C2 systems, simulation systems and autonomous systems, permitting them to work together as part of distributed system-of-systems or C2-simulation federation.

Mr. Wim Huiskamp (Netherlands) received the 2013 Scientific Achievement Award from the NATO Chief Scientist, MGen Albert Husniaux (Belgian Air Force), in his capacity as STB Chairman.

Objectives

The RTG mainly aimed at: a) establishing requirements for the C-BML standard; b) assessing the usefulness and applicability of C-BML to support Coalition operations; and c) educating and informing the C-BML stakeholders concerning the results and findings of the Group.

The RTG considered use cases for Coalition mission planning, command post training and mission rehearsal. The RTG performed analysis activities (e.g., to establish a set of stakeholder requirements) and also executed an experimentation programme comprised of two major demonstration efforts and a final experimentation event.

Summary

Led by Mr. Wim Huiskamp, the RTG focused on providing a proposal for a NATO C-BML specification. The Group delivered valuable feedback to the SISO regarding future C-BML and organised several workshops and symposiums to raise awareness of potential benefits for Coalition operations. Lastly, the Group performed experiments where simulation systems executed orders that were received from C2 systems via a C-BML interface.

Exploitation and Impact

C-BML provides a means to achieve C2-simulation interoperability, which in turn, can help the Coalition forces to be more efficient, to improve force readiness and to save lives.

The work performed by the Group focused on providing a proposal for a NATO C-BML specification by analysing and adapting the currently available specifications and implementations from the SISO or other NATO Nations. MSG-048 assessed the operational benefits for NATO C2 and M&S communities by conducting experiments, and concluded with a final demonstration with existing systems that have been made compliant with this specification.

Synergies and Complementarities

The RTG provided valuable feedback to the SISO on the requirements for future C-BML standardisation, including recommendations for addressing technical issues such as C2-simulation federation initialisation. The Group also recommended that a future version of C-BML be considered for ratification as a STANAG.

The RTG also organised several workshops and symposiums with participation from academia, industry and government – one of which was the MSG-079 Workshop (C-BML) in 2010. These events have proven instrumental in raising the awareness of the potential benefits of the use of C-BML technologies for Coalition operations to a broader community of C-BML stakeholders.

S&T Achievements

In 2009, MSG-048 held its final experimentation event with the participation from eight Nations and included six national C2 systems and five simulation systems (see Figure 47). Simulation systems executed orders that they received from C2 systems via a C-BML interface. The simulations then sent back reports to the C2 systems that were used to constitute the C2 systems' COP.

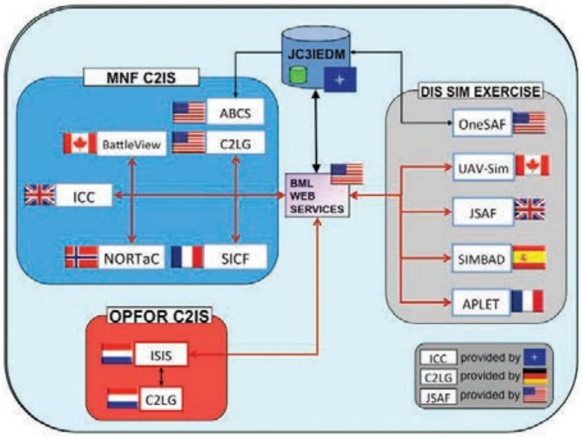


Figure 47: NATO MSG-048 Final Experimentation Architecture.

In addition, MSG-048 reached out to the operational community as well as to C2 standardisation bodies such as the Multi-lateral Interoperability Programme (MIP), authors of the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM) – a standard to which C-BML is strongly related.

Conclusions

Through analysis, experimentation and educational activities, MSG-048 contributed to advancing the state-of-the-art of C2-simulation interoperability, while engaging a large community of potential users. The results of the MSG-048 technical activity set the stage for the follow-up activity, MSG-085 Standardisation for C2-Simulation Interoperation that has built on this work over the past four years.

CODE OF BEST PRACTICE FOR JUDGEMENT-BASED OPERATIONAL ANALYSIS (SAS-087)

Background

The SAS Panel identified the need for a state-of-the-art resource that describes the field of judgement-based Operations Analysis (OA) and best practice in its application to the many difficult problems faced by military decision-makers.

Mr. Diederik Wijnmalen (Netherlands) received the 2013 Scientific Achievement Award from the NATO Chief Scientist, MGen Albert Husniaux (Belgian Air Force), in his capacity as STB Chairman.

Objective

The objective of this RTG was to demonstrate that, even though an issue may be extremely complex or complicated, sufficient guidance and insights may be presented to decision-makers so that sound defensible decisions can be made.

Summary

Led by Mr. Diederik Wijnmalen, the RTG analysed problems where there is considerable uncertainty in the nature of issue, a multitude of stakeholders and viewpoints, no clear and logical route to a solution, and where a convincing supporting case needs to be made before any change processes may be initiated. In particular, the team addressed the three aims of validity, credibility, and acceptance of an analytic study based on judgement.

Exploitation and Impact

The scientific research undertaken by the SAS-087 team allowed them to tailor the Code of Best Practice (CoBP) and thus create three separate documents, tailored for myriad levels of supervision and leadership that can be utilised throughout NATO Nations and Bodies. These documents are:

- the Analyst-Oriented Volume – the most extensive volume of the three, sets the “rules of the road” for analysts;
- the Client-Oriented Volume – the volume that explains judgement-based analysis and what one can expect from it, addressing potential questions from military clients; and
- the Executive-Oriented Volume – a concise, folded A3-format brochure that summarises the client-oriented document and is written for executive defence decision-makers, including high-ranked officers, and addresses the following issues those decision-makers are likely to find relevant.

Synergies and Complementarities

Experts from nine NATO and Partner Nations, including NATO ACT, actively participated in this RTG, productively employing their extensive expertise to create an outstanding body of work.

S&T Achievements

SAS-087 created a CoBP for judgement-based OA, which takes a military client’s needs for support as a starting point, to include expectations of the validity of that support, and:

- Sets rules of the road for analysts when conducting judgement-based analysis for military clients;
- Creates an understanding of what a judgement-based approach is, and what it can and cannot achieve; and
- Creates a roadmap for decision-makers so that they can identify which kind of problem they are facing and what OA methods they should use to solve it.

The RTG successfully bridged the gap between the academic society and the military society in a very effective and efficient manner. By specifically addressing military problems – with problem situations at the full range of tactical, operational and strategic levels – it was possible for this RTG to create an inventory of existing methodological approaches, which were then assessed to determine their ability to deal with this problem spectrum.

Conclusion

SAS-087 created three outstanding products for senior NATO and national leaders which can be immediately utilised in order to solve myriad complex problems.

ELECTRONIC COUNTER-MEASURES TO RADAR WITH HIGH RESOLUTION AND EXTENDED COHERENT PROCESSING (SCI-190)

Mr. Dietmar Matthes (Germany) received the 2013 Scientific Achievement Award from the NATO Chief Scientist, MGen Albert Husniaux (Belgian Air Force), in his capacity as STB Chairman.

Background

Imaging radars such as SAR and Inverse Synthetic Aperture Radar (ISAR) pose a significant threat to NATO military forces. Conventional jamming techniques are generally not effective against these types of imaging radars, making further development and testing of Electronic Counter-Measure (ECM) technologies and techniques essential.

Objective

The objective of this RTG was to explore and apply leading edge technologies to demonstrate and validate newly developed, advanced ECM techniques.

Summary

Led by Mr. Dietmar Matthes, SCI-190 investigated the concept that jamming and deception might be possible by transmitting delayed and Doppler-shifted versions of illuminator signals, with delays and Doppler shifts corresponding to valid target parameters. SCI-190 addressed the concept by assessing and evaluating counter-measures to multi-static and passive radar by theoretical analysis, modelling and demonstration testing.

Exploitation and Impact

SCI-190's detailed trial analyses validated the effectiveness of the ECM and gave valuable recommendations to improve applied test systems and the design of future operational ECM system architectures. Further, the application of modern digital signal processing capabilities developed in the SCI-190 work offers opportunities for multi-functional use of hardware elements, with benefits in cost, size and weight.

Synergies and Complementarities

Eight NATO Nations actively participated in the RTG. Despite the very sensitive nature of ECM, the RTG facilitated excellent collaboration in the sharing of information and the planning and conduct of two major field trials. The outcome of the trials offered results not feasibly acquired and analysed by the individual Nations involved. Excellent intra-STO collaboration was achieved with experts from SET-112 and SET-154.

S&T achievements

Along with its final report, the RTG produced two papers in support of the SET-160 Symposium on Non-Co-operative Identification /Automatic Target Recognition (NCI/ATR) in Air-Ground and Maritime Applications Based on Radar and Acoustics. The significance and quality of the RTG's work has been recognised by the user and scientific community. Additionally, the RTG's work created the foundation for a related follow-on activity, SCI-252 RTG on Coherent Electronic Attack to Advanced Radar Systems, which will pursue intelligent deception jamming techniques and technologies.

Conclusions

SCI-190 clearly identified and demonstrated vulnerabilities of both imaging and passive radar systems when affected by advanced ECM. Awareness of the existence of these techniques is critical. A continuation of the investigations is highly recommended to further develop advanced jamming and deception techniques against evolving radar systems and counter-measures to protect friendly systems.

Annexes

ANNEX A – NATO SCIENCE AND TECHNOLOGY ORGANIZATION

The NATO STO is a NATO subsidiary body to the NAC, and to which the NAC granted a clearly defined organisational, administrative and financial independence by approval of the Charter of the STO on 1 July 2012. It was established with a view to meeting, to the best advantage, the collective needs of NATO, NATO Nations and Partner Nations in the fields of S&T. The STO conducts and promotes S&T activities that enable the Nations and NATO to cost-effectively augment and leverage their S&T investments in support of the core tasks of the Alliance.

The STO comprises organisational bodies and committees on three levels, i.e., governance, programmes and activities. The governance level is represented by the STB. The programmes level reports to the STB; it is composed of the Scientific and Technical Committees (STCs) and the CMRE. Lastly, the activities level, on which experts do the actual S&T work, reports to the programmes level. In addition, there are several supporting and co-ordinating committees, and executive bodies within the STO, to ensure smooth and transparent operation.

THE SCIENCE AND TECHNOLOGY BOARD

The STB, in which all NATO S&T stakeholders are represented, is the highest authority in the STO. It exercises governance on behalf of the Council and reports to the Council through the MC and the CNAD. The STB's main responsibilities are governing the STO and implementing NATO S&T unified governance.

The membership of the STB is comprised of up to three leading senior defence S&T representatives from each NATO Nation, one of those being the principal board or voting member. Decisions of the STB are taken by unanimous consent. STB members are appointed by the Nations and may come from government, academia, institutes or industry. In addition, the STB has also ex-officio members, representing the other stakeholders including the NATO structures and industry. The STB is chaired by the NATO Chief Scientist.

The inter-related nature of the main responsibilities of the STB introduces the necessity for the STB to meet in different formats. To that end the STB meets twice a year, in spring and autumn. In the spring session the STB has three different formats: Plans and Programmes, Strategy and Policy, and Executive. In the autumn the STB meets in Executive format only, together with Partners.

The STB is supported by several sub-groups, all consisting of STB members, to ensure smooth and transparent STB operations.

CHAIRMAN'S ADVISORY SUB-GROUP (CASG)

The CASG provides recommendations to the STB Chairperson pertaining to all issues requiring formal executive action by the STB.

FINANCE AND AUDIT SUB-GROUP (FASG)

The FASG provides recommendations to the STB pertaining to the financial governance of the STO and STO's executive bodies, including audits and risk aspects.

MARITIME S&T SUB-GROUP (MASG)

The MASG provides recommendations to the STB pertaining to NATO Maritime S&T and the CMRE.

SCIENTIFIC AWARDS SUB-GROUP (SASG)

The SASG provides recommendations to the STB pertaining to the yearly selection of those to receive the von Kármán Medal and the STO Scientific Achievement Award.

SCIENTIFIC AND TECHNICAL COMMITTEES

The STCs are responsible for the planning and execution of STO's CPoW. They are composed of national defence S&T managers and SMEs from all stakeholders, i.e., government, academia, institutes and industry. The STO provides the framework and delivers senior support through the CSO, which is an executive body of the STO and is located in Neuilly-sur-Seine, France.

There are seven STCs in the STO. They encompass a broad spectrum of scientific fields and are designed to be able to address every relevant military scientific and technological topic. Every committee is chaired, on a rotational basis, by a senior scientist from one of the participating NATO Nations.

APPLIED VEHICLE TECHNOLOGY (AVT)

The mission of the AVT Panel is to improve the performance, affordability and safety of vehicle, platform, propulsion and power systems through the advancement of appropriate technologies.

The scope of this Panel is to address technology issues related to vehicle, platform, propulsion and power systems operating in all environments (land, sea, air and space), for both new and ageing systems. The areas of interest are grouped into two main areas, i.e., vehicle and platform technologies, and propulsion and power technologies.

HUMAN FACTORS AND MEDICINE (HFM)

The mission of the HFM Panel is to provide the S&T base for cost-effectively optimising health, protection, well-being and performance of the human in operational environments. This involves understanding and ensuring the physical, physiological, psychological and cognitive compatibility among military personnel, technological systems, missions and environments. This is accomplished by exchange of information, collaborative experiments and shared field trials.

The scope of this Panel is multi-disciplinary and encompasses a wide range of theory, data, models, knowledge, and practice pertaining to Health, Medicine and Protection (HMP), Human Effectiveness (HE) and Human System Integration (HSI). These three domains are complementary and represent the three “Area” committees of the Panel.

INFORMATION SYSTEMS TECHNOLOGY (IST)

The mission of the IST Panel is to advance and exchange techniques and technologies in order to improve Command Control and Communications and Intelligence (C3I) systems – with a special focus on interoperability and cyber security – and provide timely, affordable, dependable, secure and relevant information to war-fighters, planners and strategists.

The scope of this Panel includes the information warfare and assurance, information and knowledge management, communications and networks and architectures, and enabling technologies.

NATO MODELLING AND SIMULATION GROUP (NMSG)

The mission of the NMSG is to promote co-operation within the Alliance, together with Partner Nations, to maximise the effective utilisation of M&S.

The NMSG has been designated by the NAC to supervise the implementation of the NATO Modelling and Simulation Master Plan (NMSMP) and to propose updates.

The scope of this Group includes M&S standardisation, education and associated S&T including support to customers, users and suppliers in the five areas of simulation: operations, capability development, mission rehearsal, training and education, and procurement.

SYSTEM ANALYSIS AND STUDIES (SAS)

The mission of the SAS Panel is to conduct studies and analyses of an operational and technological nature, and to promote the exchange and development of methods and tools for OA as applied to defence problems.

The scope of this Panel includes studies, analysis and information exchange activities that explore how operational capability can be provided and enhanced through the exploitation of new technologies, new forms of organisation or new concepts of operation, as well as activities to develop and promote improved analysis methods and techniques to support defence decision-making.

SYSTEMS CONCEPTS AND INTEGRATION (SCI)

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

The scope of this Panel includes a multi-disciplinary range of theoretical concepts, design, development and evaluation methods applied to integrated defence systems. Areas of interest are integrated mission systems including weapons and counter-measures; system architecture/mechanisation; vehicle integration; mission management; and system engineering technologies and testing.

SENSORS AND ELECTRONICS TECHNOLOGY (SET)

The mission of the SET Panel is to foster co-operative research, the exchange of information, and the advancement of S&T in the field of sensors and electronics for Defence and Security. To fulfil this mission, the Panel has three focus groups: Radio-Frequency Technology (RFT); Optical Technology (OT); and Multi-Sensors and Electronics (MSE).

The scope of this Panel includes topics pertaining to Reconnaissance, Surveillance and Target Acquisition (RSTA), EW, communications, and navigation and the enhancement of sensor capabilities through multi-sensor integration and fusion.

CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION

The CMRE is located in La Spezia, Italy, and is an executive body of the STO. The Centre is STO's customer-funded S&T facility. It carries out projects and experiments to deliver military relevant state-of-the-art scientific science and technology. For that purpose it has its own capabilities, infrastructure and personnel. The main customer is NATO, through the ACT.

The Centre's portfolio includes ocean science, M&S, acoustics, communication, signal analysis and other disciplines. It also contributes new technologies for enabling access to unmanned systems that have the ability to sense, comprehend, predict, communicate, plan, make decisions and take appropriate actions to achieve mission goals.

The CMRE has an engineering department to design, build and modify maritime advanced platforms and (underwater) sensors, including the required signal processing and communication. This important department of the Centre is also capable of providing S&T-based enhancements to unmanned (autonomous intelligent) systems and integrated defence systems.

NATO owns two research vessels, which are both operated by CMRE's Ship Management Office (SMO): the NRV ALLIANCE and the CRV LEONARDO.

The NRV ALLIANCE, designed especially for underwater acoustic research, is capable of operating in all the oceans of strategic importance to NATO and the NATO Nations. It is equipped with extensive and sophisticated navigation, communications and computer equipment, winches, cranes, loading frames and other deck machinery for the deployment, towing and recovery of a variety of sensor arrays and oceanographic instrumentation in all sea conditions. A sophisticated windows-based integrated navigation system, which utilises Differential Global Position Systems (DGPS), includes the ARCS (electronic chart system) and ensures that the ship‘s position is logged with great precision to provide precise time-tagged navigation strings to other fixed vessel sensors such as the Swathe Mapping System and the Acoustic Doppler Current Profiler. NRV ALLIANCE enables scientists from the Centre to conduct a wide range of experiments. The vessel has been designed for eight different noise states; the quietest one operates on batteries to minimise the noise generated by the ship in order to reduce interference with the environmental measurements and acoustic experiments.

The CRV LEONARDO has been designed to provide a stable yet flexible sea-going scientific platform suitable for operations in shallow waters. Like NRV ALLIANCE, CRV LEONARDO has a state-of-the-art communication and navigation system, as well as substantial deck handling equipment. The vessel has significantly enhanced NATO‘s capabilities, especially in shallow seas. It has one very silent low speed condition and enjoys the benefits of diesel electric propulsion driving twin azimuth thrusters and one azimuth pump jet bow thruster controlled by a fully automated Dynamic Positioning (DP) and a power management system.

STO SUPPORTING AND CO-ORDINATING COMMITTEES

The proficient and transparent operation of the STO is supported by the following bodies and committees.

LEVEL TWO CO-ORDINATION COMMITTEE (L2CC)

The L2CC supports the STB and its Chairperson in co-ordinating the optimisation of the NATO STO CPoW by seeking synergies and complementarities, while avoiding unnecessary duplication. The L2CC meetings are composed of the STC Chairpersons and STO staff and is chaired by the Director of the CSO.

NATIONAL CO-ORDINATORS COMMITTEE (NCC)

The NCC consists of government representatives who support their STB members and facilitate the participation and smooth running of the STCs by effective planning, co-ordination, administration and publication including public relations matters. The NCC is chaired by the Deputy Director of the CSO.

MARITIME SCIENCE AND TECHNOLOGY COMMITTEE (MSTC)

The mission of the MSTC is to provide solicited and unsolicited scientific advice in the maritime domain, including seeking leverage between CMRE’s and Nation’s maritime S&T activities.

The scope of this committee includes NATO and its Nations’ maritime S&T, with particular focus on the activities of the CMRE. The MSTC is composed of S&T experts and customers from the Centre and the Nations, and is chaired by a senior scientist from one of the NATO Nations on a rotational basis. The MSTC reports to the STB through MASG.

KNOWLEDGE/INFORMATION MANAGEMENT COMMITTEE (KIMC)

The mission of the KIMC is to provide expert advice to the STB, its Chairperson and the STO on knowledge, information management, technology and policy matters for supporting effective and secure exchange of knowledge and information within the STO. The KIMC supports also the development of mechanisms to facilitate the discovery and secure exchange of NATO and shared national information.

The scope of this committee includes processes and mechanisms that touch the entire life-cycle of information and knowledge, including its creation and acquisition, security, processing, retrieval, storage, exchange, distribution and disposition. This includes facilitating information and knowledge exploitation and exchange between the Nations regardless of the form it is exchanged in.

NATO STO EXECUTIVE BODIES

NATO STO is composed of three executive bodies: the CMRE; the CSO; and the OCS.

CENTRE FOR MARITIME RESEARCH AND EXPERIMENTATION (CMRE)

The CMRE is described above.

COLLABORATION SUPPORT OFFICE (CSO)

The CSO is located in Neuilly-sur-Seine, France, and is an executive body of the STO. The primary responsibility of the CSO is to provide executive support to the STCs, and to prepare the CPoW for STB approval. The Director of the CSO attends all STB meetings and chairs the L2CC to co-ordinate cross-cutting activities between the STCs.

OFFICE OF THE CHIEF SCIENTIST (OCS)

The OCS is located in NATO HQ. It is an executive body of the STO which supports the STB Chairman, the STB and its sub-groups. The NATO Chief Scientist is the chairperson of the STB and the Director of the OCS. Furthermore, the OCS supports the NATO Chief Scientist in his responsibilities within NATO, as senior scientific adviser to NATO senior leadership and decision-makers, and is a focal point for NATO-wide S&T co-ordination and outreach.

ANNEX B – FACTS AND FIGURES

NATO STO

The STO of NATO has three executive bodies, the CMRE, the CSO, and the OCS, which enable the organisation to function smoothly and effectively.

RESOURCES

Resources for the STO encompass human and financial resources related to STO's executive bodies. In 2013 the NATO Security Investment Programme (NSIP) was not used by the STO.

HUMAN RESOURCES (STAFF)

Centre for Maritime Research and Experimentation – In 2013 the CMRE employed 131 people (effective 31 December 2013):

- 126 NATO International Civilians,
- 5 NATO International Military Staff (voluntarily contributed by Nations).

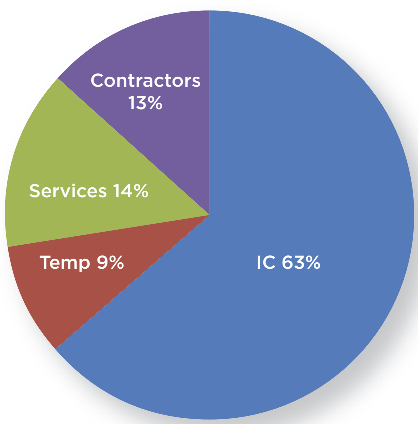


Figure 48: 2013 CMRE Workforce.

Collaboration Support Office – In 2013 the CSO employed 45 people:

- 30 NATO International Civilians,
- 15 NATO International Military Personnel (voluntarily contributed by Nations).

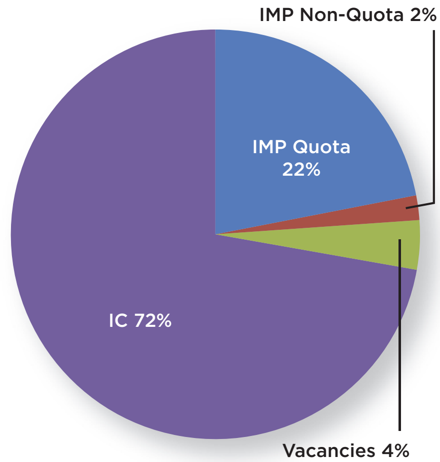


Figure 49: 2013 CSO Workforce.

Office of the Chief Scientist – In 2013 the OCS employed 9 people:

- 6 NATO International Civilians,
- 3 NATO International Military Personnel (voluntarily contributed by Nations).

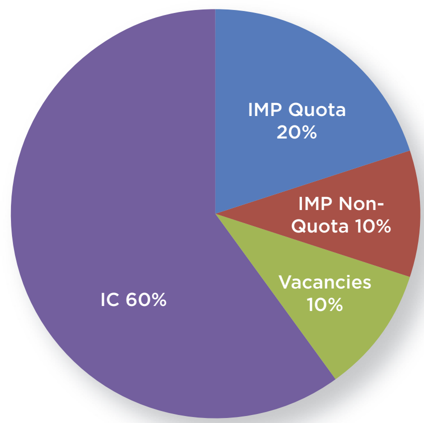


Figure 50: 2013 OCS Workforce.

FINANCIAL RESOURCES

Centre for Maritime Research and Experimentation – The 2013 overall customer-funded financial volume was 29 MEuro (slightly less than the year before). No NSIP funds used in 2013.

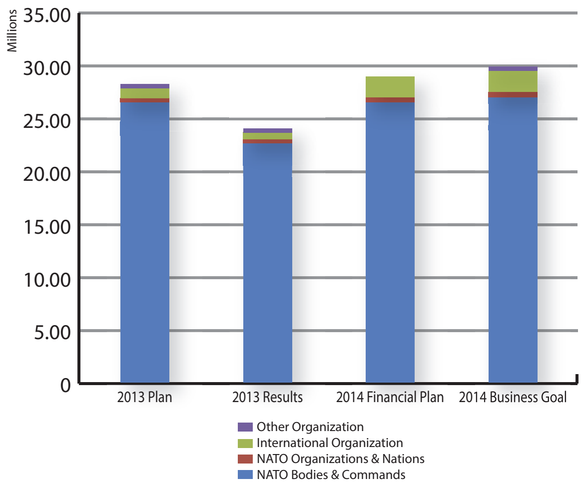


Figure 51: 2013 CMRE Revenue.

Collaboration Support Office – The 2013 overall common funded budget was 5.4 MEuro (the same as previous year). No NSIP funds used in 2013.

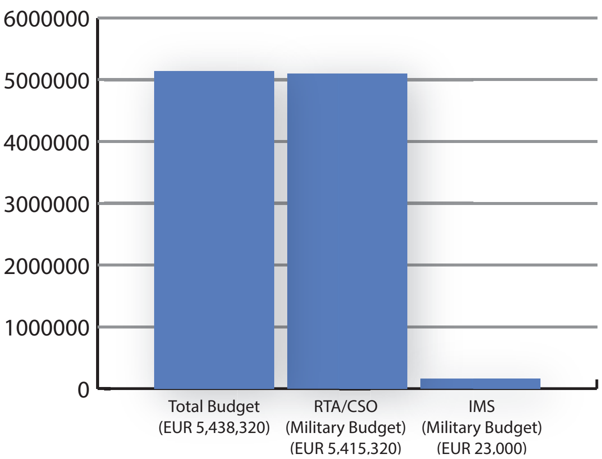


Figure 52: 2013 CSO Budget.

Office of the Chief Scientist – The 2013 budget was approximately 0.68 MEuro. No NISP funds used in 2013.

ACTIVITIES PORTFOLIO/DISTRIBUTION

NATO STO PANELS/GROUP

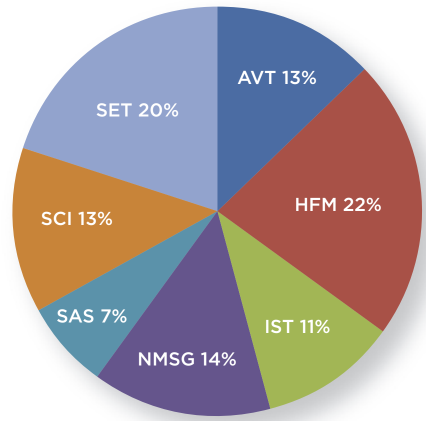


Figure 53: 2013 Distribution of Activities per S&T Committee.

CMRE

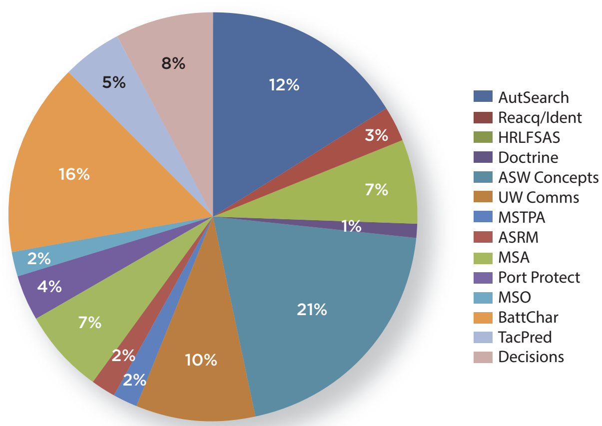


Figure 54: 2013 Distribution of Activities over the CMRE Portfolio.

ANNEX C – LIST OF ACRONYMS

ACO	Allied Command Operations
ACT	Allied Command Transformation
AGARD	Advisory Group for Aerospace Research and Development
AIS	Automatic Identification System
AMMPS	Advanced Medium Mobile Power Source
aROV	autonomously Remotely Operated Vehicle
ASRM	Active Sonar Risk Mitigation
ASV	Autonomous Surface Vehicle
ASW	Anti-Submarine Warfare
ATR	Automatic Target Recognition
AutSearch	Autonomous Mine Search
AUV	Autonomous Underwater Vehicle
AVT	Applied Vehicle Technology (Panel)
BattChar	Battlespace Characterisation
BDUs	Battledress Uniforms
BP	Business Plan
C-GIS	Core Geographic Information Systems
C-IED	Countering Improvised Explosive Device
C2	Command and Control
C3B	Consultation, Command and Control Board
C3I	Command Control and Communications and Intelligence
CAB	Combat Aviation Brigade
CAD	Computer-Aided Design
CASEVAC	Casualty Evacuation
CASG	Chairman's Advisory Sub-Group
C-BML	Coalition Battle Management Language
CC&D	Camouflage, Concealment and Deception
CD	Cyber Defence
CFI	Connected Forces Initiative
CFRP	Carbon Fibre Reinforced Polymer
CIS	Communication and Information Systems
CMRE	Centre for Maritime Research and Experimentation
CMS	Collective Mission Simulation
CNAD	Conference of National Armaments Directors
CoBP	Code of Best Practice
CoE	Centres of Excellence
CoI	Community of Interest
COMEDS	Committee of the Chiefs of Military Medical Services
COP	Common Operating Picture
COPs	Communities of Practice
CPoW	Collaborative Programme of Work
CRV	Coastal Research Vessel
CSO	Collaboration Support Office
CT	Computed Tomography
CWIX	Coalition Warrior Interoperability exploration, experimentation, and examination eXercises
DASG	Deputy Assistant Secretary General
DGPS	Differential Global Position Systems
DI	Defense Investment
DP	Dynamic Positioning
DSEEP	Distributed Simulation Engineering and Execution Process
E2DTs	Emerged/Emerging to Disruptive Technologies
EC	European Community
ECM	Electronic Counter-Measure
ED	Engineering Department
EKOE	Environmental Knowledge and Operational Effectiveness
EO	Electro-Optical
ESCD	Emerging Security and Challenges Division
ESPE	End State Peace-time Establishment
EU	European Union
EW	Electronic Warfare
FaaS	Fusion as a Service
FASG	Finance and Audit Sub-Group
FBCE	Fully Burdened Cost of Energy

FCPM	Fuel Consumption Predication Model
GIS	Graphical Information System
GLASS	GLider Acoustic Sensing of Sediments
GO-DSS	Goal-Orientated Decision Support System
HE	Human Effectiveness
HFM	Human Factors and Medicine (Panel)
HMP	Health, Medicine and Protection
HPM	High-Power Microwave
HQ	Headquarters
HRLFSAS	High Resolution Low Frequency Synthetic Aperture Sonar
HSI	Human System Integration
IA	Information Assurance
IC	International Civilian
IDT	In-Stride Debrief Team
IED	Improvised Explosive Device
IEEE	Institute of Electrical and Electronics Engineers
IMP	International Military Position
IMS	International Military Staff
IR	Infra-Red
ISAF	International Security Assistance Force
ISAR	Inverse Synthetic Aperture Radar
ISR	Intelligence, Surveillance and Reconnaissance
IST	Information Systems Technology (Panel)
JC3IEDM	Joint Consultation Command and Control Information Exchange Data Model
JFTC	Joint Forces Training Centre
JISR	Joint Intelligence, Surveillance, and Reconnaissance
JMI	Joint Main Armaments Groups Initiative
KFOR	Kosovo Force
KIMC	Knowledge/Information Management Committee
L&R	Logistics and Resources
L2CC	Level Two Co-ordination Committee
LTCRs	Long-Term Capability Requirements
M	Million
M&S	Modelling and Simulation
MAGs	Main Armaments Groups
MANEX	Multi-National Autonomy Experiment
MARCOM	Maritime Command
MASG	Maritime S&T Sub-Group
MC	Military Committee
MCCIS	Maritime Command Control Information System
MCG	Maritime Capability Group
MCM	Mine Counter-Measure
MCS	Mobile Camouflage Systems
MEDEVAC	Medical Evacuation
METOC	Meteorological and Oceanographic
MGen	Major General
MIP	Multi-lateral Interoperability Programme
MOOS	Mission-Oriented Operating Suite
MPICE	Measuring Progress in Conflict Environments
MSA	Maritime Situational Awareness
MSE	Multi-Sensors and Electronics
MSG	Modelling and Simulation Group
MS-LFAS	Multi-Static Low Frequency Active Sonar
MSO	Maritime Security Operations
MSTC	Maritime Science and Technology Committee
MSTPA	Multi-Static Tactical Planning Aid
MUSCLE	Mine-hunting UUV for Shallow-water Covert Littoral Expeditions
NAC	North Atlantic Council
NATO	North Atlantic Treaty Organization
NCC	National Co-ordinators Committee
NCI	Non-Co-operative Identification
NCIA	NATO Communications and Information Agency
NCOs	Non-Commissioned Officers
NDC	NATO Defence College
NDE	Non-Destructive Evaluation
NDPP	NATO Defence Planning Process
NEC	Network-Enabled Capability

NEREIDS	New Service Capabilities for Integrated and Advanced Maritime Surveillance
NIAG	NATO Industrial Advisory Group
NII	NATO's Information Infrastructure
NLW	Non-Lethal Weapon
NMAs	NATO Military Authorities
NMSG	NATO Modelling and Simulation Group
NMSMP	NATO Modelling and Simulation Master Plan
NNAG	NATO Navy Armaments Group
NRV	NATO Research Vessel
NSIP	NATO Security Investment Programme
NSPA	NATO Support Agency
NURC	NATO Undersea Research Centre
OA	Operational Analysis
OCS	Office of the Chief Scientist
OOS	Operation Ocean Shield
OR&A	Operations Research and Analysis
OT	Optical Technology
PA	Parliamentary Assembly
PfP	Partnership for Peace
PMA	Post-Mission Analysis
Port Protect	Port Protection
PoW	Programme of Work
RAMs	Rockets, Artillery and Mortars
RCS	Radar Cross-Section
Reacq/Ident	Mine Reacquisition and Identification
ret	Retired
RF	Radio Frequency
RFDEW	Radio Frequency Directed-Energy Weapon
RFT	Radio-Frequency Technology
RIMPASSE	Radar Infra-red electro-Magnetic Pressure Acoustic Ship Signature Experiments
RSM	Research Specialists' Meeting
RSTA	Reconnaissance, Surveillance and Target Acquisition
RTG	Research Task Group
RTO	Research and Technology Organization
S&T	Science and Technology
SAA	Scientific Achievement Award
SAR	Synthetic Aperture Radar
SAS	Synthetic Aperture Sonar
SAS	System Analysis and Studies (Panel)
SASG	Scientific Awards Sub-Group
SCI	Systems Concepts and Integration (Panel)
SET	Sensors and Electronics Technology (Panel)
SILF	Semantic Interoperability Logical Framework
SISO	Simulation Interoperability Standards Organisation
SITREPs	Situation Reports
SME	Subject-Matter Expert
SMO	Ship Management Office
SMS	Signature Management System
SOA	Service-Oriented Architecture
SPSP	Science for Peace and Security Programme
STANAGs	Standard NATO Agreements
STB	Science and Technology Board
STCs	Scientific and Technical Committees
STHP	Specialist Team on Harbour Protection
STO	Science and Technology Organization
SWiG	Subsea Wireless Group
TacPred	Tactical Prediction
TerraSAR	Terra Synthetic Aperture Radar
TQGs	Tactical Quiet Generators
TREAD	Traffic Route Extraction and Anomaly Detection
TTCP	The Technical Co-operation Programme
TTX	Table-Top eXercise
UAV	Unmanned Aerial Vehicle
USV	Unmanned Surface Vehicle
UUV	Unmanned Underwater Vehicle
UW	Underwater
VKI	von Kármán Institute