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OF WORK
TECHNICAL REPORTS 2023

BOOK OF ABSTRACTS

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The document assembles a collection of abstracts from technical reports published in 2023 under the NATO STO Collaborative Programme of Work. It offers a cohesive overview, neatly arranged in the order of publication dates. Each abstract has an active hyperlink embedded in its reference number, linking users to the full reports within the STO publications database. This improves accessibility, allowing stakeholders, academics, and other interested individuals to locate and access specific documents.

Table of Contents

STO-TR-HFM-270   **FRAMEWORK FOR MODELING AND SIMULATION OF HUMAN LETHALITY, INJURY, AND IMPAIRMENT FROM BLAST-RELATED THREATS**

Explosive Weapons (EW) are a continuing and significant source of casualties in NATO operations. The spectrum of operational scenarios involving these blast threats is broad and includes both mounted and dismounted operations. As EW technology and deployment methods becomes more complex, the same trend is seen for injuries, requiring increasingly sophisticated protective countermeasures and medical interventions. The HFM-270 (RTG) explored a novel conceptual multiscale, multiresolution computational framework that integrates existing and planned models of human responses to blast-related threats. The conceptual framework created a methodology to predict human lethality, injury, impairment, and long-term health effects with the potential to reduce the time required to develop and field effective strategies to prevent, mitigate and treat blast injuries. The three major deficiencies in implementing the new conceptual framework were: a) Lack of end-to-end connection and continuity in current simulation models to address combat injuries utilizing the techniques; b) Insufficient and incomplete material models essential for such simulations; and c) Limited validation of the models based on experimental and clinical data. It is the intention of the HFM-270 (RTG) that each NATO nation should consider the gaps identified by this RTG when planning future investments in computational modeling and prediction efforts.

STO-TR-HFM-292   SKILL FADE AND COMPETENCE RETENTION: A CONTEMPORARY REVIEW

Competences acquired through training inevitably fade if they are not regularly practised. This can jeopardise personnel safety, operational effectiveness, and cost-effectiveness of training. The importance of approaches to minimise skill fade and maximise competence retention is likely to increase in NATO countries, because military personnel will need to learn and retain a greater number of competences across a career to face the instability and uncertainty of future threats. Familiarity with the different factors that influence skill fade, and the strategies to mitigate it, is essential to take proper choices aimed at the retention of competence. To address this need, this report offers a contemporary framework for identifying and understanding such factors. The framework was defined over a period of three years, after a thorough literature search and through a series of expert meetings of the HFM-292 "Understanding and Reducing Skill Decay" Research Task Group. The resulting framework highlights 38 factors that influence skill fade, organised into three categories: person-related, task-related, and training and education-related factors. This report provides a detailed description of each factor, the direction of its effect on competence acquisition and retention, and the supporting evidence from existing scientific literature. Moreover, it summarises the nine main psychological mechanisms that underlie the factors. Finally, key approaches for competence retention and recommendations for future developments are outlined, considering the context of both researchers and practitioners in the field.

STO-TR-IST-164   SECURING UNMANNED AND AUTONOMOUS VEHICLES FOR MISSION ASSURANCE

This report presents the findings of the IST-164-RTG in the form of a framework that can be used to support and facilitate the risk and security assessment of unmanned and autonomous vehicles for mission assurance in military operations. The framework provides a guideline for how to identify and link together risk factors at mission, vehicle and component level, and ready-to-use catalogues of assets, threats and security capabilities. The focus is on the cyber aspect of individual middle-sized vehicles with no crew and with basic automated navigation capabilities. However, the framework can be easily expanded and built upon with additional capabilities and to include the safety aspect of security. Future work should focus more on identifying security implementation trade-offs due to the cyber-physical nature of the vehicles and establish a more comprehensive approach to verification and validation of autonomous vehicles.

STO-TR-SCI-339

ALLIED FUTURE SURVEILLANCE AND CONTROL (AFSC) ASSESSMENT OF THE AFSC HIGH LEVEL TECHNICAL CONCEPTS (HLTC): CRITICAL TECHNOLOGY ELEMENT (CTE) EVALUATION REPORT

The NATO Science and Technology Organization (STO), through the support provided by the Collaboration Support Office (CSO), assembled and prepared a Research Specialists Team (RST) comprised of 35 experts, nominated by the NATO Nations, to assess the technological maturity of the six High Level Technical Concepts (HLTC) proposed by industry partners. This assessment of Technology Readiness Levels (TRL) and Roadmap Confidence is a critical element of the NATO Support and Procurement Agency (NSPA) Project Office (PO) assessment of the Alliance Future Surveillance and Control (AFSC) "System of Systems." The HLTCs will help inform future decisions by NATO, individual nations, or multinational groups to acquire new multi-domain systems in preparation for the AWACS fleet retirement.

STO-TR-IST-141

EXPLORATORY VISUAL ANALYTICS

Information superiority is one of the primary enablers for military dominance; the exploitation of all relevant information from multiple sources is a key factor for NATO's information superiority. Visualization and visual analytics research are essential to address the needs of the 2015 NATO targets of emphasis in Information Analysis (IA) and Decision Support (DS): IA&DS-1 on Decision Support and IA&DS-2 on Big Data and Long Data Processing and Analysis. Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces. The Group investigated, researched and fostered collaborations in knowledge extraction and data analysis for timely situation awareness to support effective decision making. The IST-141 group researched, developed and applied exploratory visual analytics techniques: 1) To exploit and make sense of large and complex data sets, i.e., Big Data; 2) To help make tacit knowledge explicit;3) To provide acute situation awareness, and 4) To support informed decision making across a wide range of defence and security application domains including cyber, maritime, genomics and social media domains, as well as post analysis and in situ visualization for simulation data.

STO-TR-HFM-ET-356

MITIGATING AND RESPONDING TO COGNITIVE WARFARE

The NATO STO HFM-ET-356 performed an assessment of the Science and Technologies (S&T) required to mitigate and defend against Cognitive Warfare (CogWar). CogWar has emerged replete with security challenges due to its invasive and invisible nature and where the goal is to exploit facets of cognition to disrupt, undermine, influence, or modify human decisions (proposed by HFM-ET-356). CogWar represents the convergence of a wide range of advanced technologies along with human factors, used by NATO's adversaries in the 21st century battlespace. CogWar is a risk to global defence and security and threatens human decision making. The ET-356 proposed a S&T Road map to guide NATO and Allied Partners in future research activities and investments. The proposed Road map is based on a "House Model," and linked to the Observe, Orient, Decide, and Act (OODA) decision cycle. The Model represents seven main S&T knowledge areas and enablers that are cross-cutting related: Pillars: Cognitive Neuroscience, Cognitive and Behavioral Science, Social and Cultural Science; and Bars: Situational Awareness and Sensemaking, Cognitive Effects, modus operandi, and Technology and Force Multipliers. This work underpins the NATO Warfighting Capstone Concept and its Warfare Development Initiative Cognitive Superiority, and the NATO Strategic Concept 2022.

STO-TR-SET-217

ASSESSING AND MODELLING THE PERFORMANCE OF DIGITAL NIGHT VISION IMAGE FUSION

Night Vision Goggles optically fused to thermal imagers are currently fielded. Future development will see the Night Vision Goggles replaced by focal plane arrays. This allows digital fusion including advanced signal processing and fusion algorithms. Performance assessment of such devices is mandatory but still lacking. SET-217 made such a performance assessment and tried to derive general rules and methods from the results.

STO-TR-SCI-301   DEFEAT OF LOW SLOW AND SMALL (LSS) AIR THREATS

Detecting, classifying, identifying, tracking and defeating low, slow and small air threats presents a major challenge for existing sensor and effector systems. So-called first generation Counter Unmanned Aircraft Systems (C-UAS) systems often rely on detecting the datalink from the controller to the Unmanned Aircraft (UA) which provides limited capability against current threats. Defeating the UA is mostly based on either jamming or spoofing this datalink. However, this method of detecting and affecting UA is a challenge when operators manipulate standard datalinks and it will not work at all against current and future autonomous UA. Other current methods of detecting UA include, for example, combining radar with optical sensors. These systems have limited performance, can generate large numbers of false alerts, are easily saturated and are often labour intensive to operate. Sensors and effectors often lack necessary range and exhibit other shortfalls. The NATO SCI-301 Research Task Group (RTG) has been working on specifying what second generation C UAS systems should entail. This report outlines the findings of this RTG over the past four years.

STO-TR-HFM-301   MILITARY DIVERSITY IN MULTINATIONAL DEFENCE ENVIRONMENTS: FROM ETHNIC INTOLERANCE TO INCLUSION

NATO forces personnel strive to achieve cultural competence to enable interactions that are more effective across multinational military environments. Research shows that ethnic intolerance continues to challenge defence organizations, including NATO's efforts to promote "military diversity as a key transformational element" in overcoming cultural differences (NATO, 2013). The purpose of the Research Task Group (RTG) 301 was to identify the key factors attributed to ethnic intolerance, develop a conceptual model to explain ethnic inclusion and offer evidenced based educational programs intended to support a more inclusive organizational culture in NATO and across multinational defence organizations. Based on international case studies and the literature on ethnic intolerance and inclusion, several key findings highlight the historical, political, economic, social, and socio-psychological factors that explain intolerant attitudes and behaviours, as well as the strategies, tools, and evidenced-based programs designed to cultivate a culture of ethnic diversity and inclusion. Recommendations are put forward to help foster greater ethnic inclusion through diversity management strategies and evidenced-based programs across international defence organizations. The findings and recommendations will inform NATO's strategic efforts, policies, and programs to encourage greater ethnic diversity, inclusion, and improved military readiness and resilience.

STO-TR-SET-246

SHORTWAVE INFRARED TECHNOLOGY: AN INITIAL ATTEMPT TO STANDARDIZE SWIR IRRADIANCE MEASUREMENTS IN ORDER TO PRODUCE A COMPATIBILITY MODEL TO EVALUATE REFLECTIVE BAND SYSTEMS

SET-RTG-246, "Shortwave Infrared Technology: A Standardized Irradiance Measurement and Compatibility Model to Evaluate Reflective Band Systems" focused on three main items. First was the design and testing of a COTS-based SWIR meter for distributed irradiance measurements. The basic design has been completed and tested by various participating nations and seems a reasonable measurement device for large scale distributed measurements. Second was a joint calibration of equipment and validation of data collection and processing. A dark location was selected and participating nations participated in a joint data collection under identical sky and environmental conditions. Finally, a distributed data collection was undertaken to build a large enough statistical sample of SWIR irradiance measurements to better generalize and model conditions a user might realistically expect to encounter in the field. Data collection on this effort was hampered due to COVID-19, but enough has been collected to lead us to believe that this particular task would be ideal for a follow-on effort.

STO-TR-SET-258

DMPAR DEPLOYMENT AND ASSESSMENT IN MILITARY SCENARIO

The NATO STO Research Task Group SET-258 Deployable Multi-band Passive/Active Radar (DMPAR) Deployment and Assessment in Military Scenarios was initiated after the SET-195 group activity demonstrated the potential of considerably enhancing ground-based radar detection capabilities. After SET-195 ended, several commercial passive radar systems emerged with promising detection capabilities, and the field trial "Active PAssive Radar Trials – Ground-based, Airborne, Sea-borne" (APART-GAS) was held in 2019 in collaboration with NATO SET-242. The outcome of the trials has given insight into the capabilities of modern passive radars in collaboration with the active radars, and insight for NATO forces through the Polish Armed Forces on how to successfully incorporate these data in a real-time air surveillance network where the sensor detections and tracks could be monitored by military personnel. On the basis of the trial data, the SET-258 group members have analyzed the possibilities for collocated and dislocated sensor fusion, explored some of the modern sensor fusion methods like Multi-Hypothesis-Tracking and Track-Before-Detect, methods for mission planning and sensor performance prediction, sensor data transmission protocols, and the future perspectives for DMPAR systems. An effort has been made to prioritize the military user's point of view, to ensure military relevance and to enable the results can be used for forming operational requirements for DMPAR systems.

STO-TR-SET-256 **INTEROPERABILITY AND NETWORKING OF DISPARATE SENSORS AND PLATFORMS FOR TACTICAL ISR APPLICATIONS**

SET-256 conducted a live experiment in Portsmouth UK, September 20-28 2022. This Multinational exercise was conducted on a single network. SET-256 achieved interoperability of tactical edge ISR sensors from multiple nations. Further, SET-256 successfully tested draft STANAG 4789 and was able to publish MASINT Reports in NATO STANAG 4716 format.

STO-TM-AVT-ST-007 **MODIFICATION OF NATO STANAGS TO INCORPORATE RANGE CHARACTERIZATION – AJEPP 6.1 STANDARDS RELATED DOCUMENT MANUAL FOR ENVIRONMENTAL SAMPLING PROTOCOLS**

NATO STO panel activities AVT-197, AVT-244, AVT-249, and AVT-291 developed standardized methods for a) Determining baseline environmental conditions in soils and surface water; b) Determining the environmental impact of training activities on soil and water; and c) Reducing error associated with sampling, sample processing and sub sampling. These standardized methods were incorporated into an update of STANAG 6500, AJEPP 6, NATO Camp Environmental File During NATO Operations and were the basis for the development of a new Standards Related Document (SRD) entitled "AJEPP 6.1 Manual for Environmental Sampling Protocols." The SRD provides practical guidance on soil and water sampling protocols for a NATO Environmental Protection Officer on how to plan and conduct sampling.

STO-TR-AVT-319 **HIGH SPEED ROTORCRAFT ANALYSIS AND EVALUATION**

The AVT-RTG-319 High Speed Rotorcraft Analysis and Evaluation Technical Team evaluated the impact of increased rotorcraft flight speed on emerging military capabilities. The study approach was divided into four main tasks: correlate pre-design tools, develop new aircraft concepts sized to a primary mission flight profile, analyze aircraft concepts for other mission flight profiles, and analyze aircraft flight performance, efficiency, and system metrics. Beyond the values given in this report, the comparisons between concepts should be considered through their relative differences (e.g., percentage of variation of each metric with respect to the helicopter concept). Furthermore, concepts generated by the individual nation using the same design rules, models, and assumptions produce good design trends between the different VTOL concepts.

STO-TR-SCI-294   DEMONSTRATION OF RADIO FREQUENCY DIRECTED ENERGY WEAPONS AGAINST VEHICLES, VESSELS AND UAVS

SCI-294 will research the effect mechanism of Radio Frequency Directed Energy Weapons (RFDEW) electronic control unit disruption, assess and demonstrate RFDEW effect against a baseline, relevant mobile system threat target set, evaluate common Test Procedures, develop Concepts of Employment for RFDEW mobile systems stopping, and discuss the potential and limitations of RFDEW in support of military operations.

STO-TR-MSG-147   MODELLING AND SIMULATION SUPPORT FOR CRISIS AND DISASTER MANAGEMENT PROCESSES AND CLIMATE CHANGE IMPLICATIONS

The objective of the MSG-147 project and the CMDR CoE was to develop a reference architecture and implement a technical platform to enable rapid and effective testing of crisis/disaster and climate change response plans. The development included research, theory and concept development, standardization and improvement of interoperability. It was to be set up with various tools and simulations for crisis management and civil protection that are unique to NATO and enable non-military operations. In this context, the establishment of simulation units that enable the exchange of data of disaster-related events in an HLA environment and the simultaneous transmission of this information (reports / unit conditions) to military (NATO and national) and civilian C2 systems was an outstanding result of the technical performance of the MSG-147 group. In order to offer an implemented solution, the Disaster FOM module (compatible and integrable in NETN FOM v2) was developed and successfully tested to provide technical support for the MSG-147 project. A special innovation in the technical investigation of the concept was the application of the CD&E method and procedures for the evaluation of new technical solutions in the field of M&S and their implementation.

STO-TR-AVT-254   ASSESSMENT OF PLASMA ACTUATOR TECHNOLOGIES FOR INTERNAL FLOW

AVT-254 focused on plasma actuation technologies within internal flow applications, covering a wide range of topics, including channel and duct flows, high speed inlet geometries and flows, heat transfer enhancement and optimization, understanding the capabilities for plasma flow control authority in extreme conditions, combustion enhancement by the use of plasma assistance, with a high level of understanding thanks to extensive modelling and simulations of the underlining phenomena. The experimental configurations provide validation platforms for computational fluid dynamic simulations for promoting optimized designs of engine components and operations.

STO-TR-IST-168

ADAPTIVE INFORMATION PROCESSING AND DISTRIBUTION IN DISADVANTAGED TACTICAL NETWORKS TO SUPPORT COMMAND AND CONTROL

This is the final report of the NATO STO IST Panel Research Task Group 168 entitled "Adaptive Information Processing and Distribution to Support Command and Control," which explored approaches to best exploit available resources in the tactical edge domain with disadvantaged network conditions by means of federated tactical cloud architectures. In its studies, the RTG IST-168 has taken the approach to build the federated tactical cloud architecture upon the various, open-source, Kubernetes distributions (K8s, K3s, KubeEdge) and evaluate their performance within the tactical edge domain. The RTG IST-168 ran in the time-period October 2018 to March 2022.

STO-TR-HFM-283

REDUCING MUSCULO-SKELETAL INJURIES

The high prevalence (20 to 40 %) of Musculoskeletal Injuries (MSkIs) places considerable burden on soldiers throughout their military career, impacts operational readiness, and remains a concern to the NATO military community. The frequency and quality of injury reporting by clinicians and patients varies: reported data tend to focus on injuries that lead to medical discharge or downgrading. Better data on the incidence and causes of MSkI are required to determine the effectiveness of preventative measures. A literature review was conducted on the prevalence, risk factors, and interventions for MSkI in the military to form recommendations on preventive strategies to Commanders. An expert panel prioritized risk factors and a new model was developed, which can guide the planning and implementation of intervention strategies. Recommendations for a successful MSkI preventative program include: prevention strategies based on a multidisciplinary approach; leadership (at all levels of the organization); education of personnel, trainers and leaders; surveillance; adequate resources for program evaluation; and research. Prioritization of preventive measures should take into account the following five elements: importance of the problem; likely effectiveness of the prevention strategy; feasibility of establishing the measure; timeliness of the implementation; and potential for evaluation of its effectiveness.

STO-TR-SAS-157   AUTOMATION IN THE INTELLIGENCE CYCLE

NATO SAS-157 RTG has investigated the improvement and acceleration of the intelligence cycle by techniques in the area of automation and Artificial Intelligence (AI). A methodology was set up ('the Map') to plot various different AI and automation techniques against the different parts of the intelligence cycle, providing an overview of suitability and best practices. In sessions with subject matter experts from various national intelligence services, this approach was tested and improved. The Map is offered to the NATO community as a living document to share lessons learned and as technology watch instrument. The Map will be transferred to a custodian; discussion with the NATO Joint Capability Group on ISR (JCGISR) are taking place. In addition, the participating members of the group each carried out a so-called field experiment: a concept demonstration of application of automation and AI techniques to a specific intelligence use case. The results of these field experiments were plotted in the Map, to further improve the Map. Some effort was put into assessing the improvement of introduction of automation and AI (metrics) and in discussing the consequences of the further use of AI for the intelligence process itself.

STO-TR-SAS-147   ANALYSIS OF ANTI-ACCESS AREA DENIAL (A2/AD) ASSESSING THE CONSEQUENCES – ADDRESSING THE CHALLENGE

In this final report, the SAS-147 research task group presents its assessment of challenges posed by adversarial A2/AD capabilities, providing recommendations on how to address these challenges. The main elements of the study are described, including the execution of a Wargame/scenario based discussion with invited participants. For the capability gap assessment, the group identified generic target types, spanning the air, land, and maritime domains, and defined a simplified kill chain. To address challenges, a range of classified and unclassified sources was reviewed to collect a broad range of potential mitigations. The group transformed a selection of ideas into 40 technology or capability Game Cards, used as a means for exploring potential solutions. Specific solutions, including capabilities allowing effects from a distance in contested space, technologies that enable the force to operate in highly contested electromagnetic spectrum and new capabilities that enhance the survivability of own platform and munitions are discussed. In addition, the report contains a range of brief thematic discussions. Finally, the group suggests a number of future research issues. The group started late 2018 and as it concludes it consists of members from DNK, FIN, NLD, NOR, SWE and USA, as well as ACT and NCIA.

STO-TR-AVT-330   IMPACT OF MUNITIONS AND EXPLOSIVES OF CONCERN (MEC) ON MARITIME SAFETY, SECURITY AND SUSTAINABLE REMEDIATION

The Research Group AVT-RTG-330 examined the problems associated with dealing with underwater dumped munitions. These can be the result of warfare, shipwreck, or planned dumping. Seabed activities have increased in recent years with oil exploration and wind farm construction all producing seabed disturbance. Natural ageing of the materials underwater means that the risk level is rising and the release of toxic substances is affecting marine life as well as washing ashore. The Group reviewed the problems and the national programs that deal with them. This included links with civil bodies who are attempting to dispose munitions of all kinds. The conclusion was that NATO needs to be more aware of the issues and to take a more active part in their management.

STO-TR-SAS-164   21ST CENTURY FORCE DEVELOPMENT

Research Task Group (RTG) SAS-164 was established to determine whether the model for capability-based planning published by The Technical Cooperation Programme (TTCP) in 2004 was still fit for purpose as a basis for Force Development by NATO nations in 2020s. The RTG surveyed practices across eight nations with very diverse strategic postures and levels of resources and concluded that an updated and better-defined version of the TTCP mode could still form a template from which any nation could develop a Force Development process suitable for national purposes. The RTG observed that national approaches rightly differ, and should always do so, but nonetheless share certain common elements and underpinning concepts. The model proposed by SAS-164 can thereby serve as a 'translation matrix' between national processes and thereby enable better mutual understanding of Force Development processes and the sharing of analytical tools and techniques used to implement them. The implementation of a community of interest to continue to work on common terminology, to enable the sharing of analytical tools and techniques, and to further explore the analytical treatment of NATO defence planning targets in national Force Development analyses is recommended Development should best be integrated. The Task Group's final recommendation is that a community of interest be established to continue to share knowledge and expertise between alliance members in the Force Development domain.

STO-TR-SAS-145   SOLDIER WEAPON EQUIPMENT ASSESSMENT TOOL: RECOMMENDATIONS FOR PERFORMANCE TEST AND EVALUATION

The SAS-145 Research Task Group (RTG) explored the requirement to develop a standardized approach to assessing the impact of Soldier, weapon and equipment factors on Soldier Combat Effectiveness and Efficiency (SCEE). Three primary factors were identified as main contributors to SCEE: Soldier lethality, mobility, and survivability. While each of these factors is often examined in isolation, they are rarely examined in concert, resulting in difficulties to assess trade-offs and interdependencies between factors. To bridge this gap, the RTG developed a standardized Soldier-in-the-loop assessment course that would allow Soldier lethality, mobility, and survivability to be examined simultaneously. The resulting Soldier, Weapon and Equipment Assessment Tool (SWEAT) is an operationally relevant, live-fire obstacle course designed to assess the three main contributors to SCEE simultaneously in a standardized manner that can be used across NATO nations to achieve consistency in test standards. The recommendations provide standard definitions and equipment for measurements of lethality, mobility, and survivability, and recommended course of fire. Planning and processing tools are also embedded in the recommendations to allow for adjustments based on range specifications and system being assessed. The ultimate recommendation is that this integrated course be incorporated into a STANREC for distribution across NATO nations.

STO-TR-SET-252   DESIGN OF A VALIDATION MODEL OF A STEALTH UCAV

The SET-252 task group designed and manufactured a radar signature validation model of a stealth Unmanned Combat Aerial Vehicle. The design is based on supporting simulations and measurements which identified the hot spots of the aircraft, characterized material properties and evaluated choices in the design. The main result of the group is the actual validation model, which is both a well-defined target (both in shape and the materials used) as well as a military relevant, complex, target. Measurements on the model will be performed in a follow-on group and will be used to validate the numerical prediction tools of the partners.

STO-TR-HFM-304   FACTORS AFFECTING ETHICAL LEADERSHIP

"Factors Affecting Ethical Leadership" shows that the ethical behavior of leaders is the most important factor in shaping an organization's ethical climate. Representatives from ten countries, Canada, Australia, Czech Republic, Finland, Greece, Netherlands, Slovenia, Sweden, United Kingdom and United States of America participated in the research, with six (Canada, Australia, Finland, Netherlands, Sweden and the USA) able to collect data. The goals of RTG HFM-304 included identifying the individual, situational, and organizational variables predictive of ethical leadership, developing a model of ethical leadership, and collating best practice in military ethics education amongst NATO and Partner for Peace (PfP) countries. Findings evidence that ethical leadership is strongly associated with values, in particular with value achievement (e.g., setting high standards and striving for excellence) and person-environment fit. Leaders who have the ability to address an ethical dilemma tend also to be those with high standards, a firm foundation in values (such as helping others and generosity) and belief that their institution shares these values. To engender ethical cultures and attract, train and sustain principled leaders, there is a need for military institutions to emphasize values, reinforce ethical decision-making and promote and value-informed ethical leadership from the beginning.

STO-TR-HFM-307   INTEGRATING GENDER AND CULTURAL PERSPECTIVES IN PROFESSIONAL MILITARY EDUCATION PROGRAMMES

This report provides those responsible for the national Professional Military Education delivered for senior officers with analyses and recommendations to strengthen curricula that seeks to develop the competencies needed to apply gender and cultural perspectives. This research is in direct support of NATO Bi-SCD 40-1 objectives with implications for enhancing interoperability and the effectiveness of NATO-led missions as well as supporting relevant national-level objectives. This work addresses several key gaps in the professional literature including in understanding national differences in achieving United Nations and NATO objectives and in the academic literature by addressing pedagogy with military learners. The analyses presented start with an examination of the military requirements arising from the Women, Peace and Security (WPS) Agenda and application of gender perspectives. Relevant NATO direction is then situated in the broader context of cross cutting themes and a brief assessment of the national direction related to WPS and gender knowledge. The identified learning is addressed by presenting the issues of the pedagogy inherent in PME curricula. The final chapter integrates the analyses, observations and implications developed to provide recommendations for the inclusion of culturally-informed gender knowledge in senior officer PME.

STO-TR-SAS-161-VOL-V

THE NATO STO SAS-161 RESEARCH TASK GROUP (RTG) – MILITARY ASPECTS OF COUNTERING HYBRID WARFARE: EXPERIENCES, LESSONS, BEST PRACTICES VOLUME V: MILITARY IMPLICATIONS

The NATO STO SAS-161 Research Task Group (RTG) investigating "Military Aspects of Countering Hybrid Warfare: Experiences, Lessons, Best Practices" is meant to inform the full spectrum of military planning at the Alliance and national level. The functionally oriented analysis and the country-specific case studies developed by the RTG touch all aspects of military effectiveness and help inform our collective efforts to account for the challenges of contemporary, and expected future characteristics, of competition, conflict, warfare, and warfighting.

STO-TR-SAS-161-VOL-III

THE NATO STO SAS-161 RESEARCH TASK GROUP (RTG) – MILITARY ASPECTS OF COUNTERING HYBRID WARFARE: EXPERIENCES, LESSONS, BEST PRACTICES VOLUME III: COMPREHENSIVE DEFENCE, CAPACITY BUILDING, AND ENHANCED FORWARD PRESENCE

The NATO STO SAS-161 Research Task Group (RTG) investigating "Military Aspects of Countering Hybrid Warfare: Experiences, Lessons, Best Practices" is meant to inform the full spectrum of military planning at the Alliance and national level. The functionally oriented analysis and the country-specific case studies developed by the RTG touch all aspects of military effectiveness and help inform our collective efforts to account for the challenges of contemporary, and expected future characteristics, of competition, conflict, warfare, and warfighting. This volume presents case studies detailing considerations for the design of comprehensive defence at the national level, the design of capability and capacity building activities in support of partner countries, and lessons related to national deployments in support of Alliance Enhanced Forward Presence activities.

STO-AG-300-V36   FLIGHT TESTING OF HELMET MOUNTED DISPLAYS

This AGARDograph provides an overview of the test and evaluation of Helmet Mounted Displays (HMD) for air systems with the aim to provide a reference guide for the test community to inform future test programs. The focus is on helmet mounted displays but many aspects are equally applicable to head worn displays. This testing is becoming more critical as greater reliance is placed on HMD systems and the visual cues they provide. As technology advances, the use of light weight wearable displays and simplified head tracking technology, such as virtual or augmented reality, will enable HMDs to be used nearly every new and legacy aircraft. Two case studies are presented along with numerous lessons learned, test techniques and design considerations that will remain valid as these systems evolve.

STO-TR-SCI-264   HIGH ENERGY LASER WEAPONS: TACTICAL EMPLOYMENT IN THE SHARED BATTLESPACE

In 2011, the Systems Concept Integration (SCI)-227 Specialist Team provided the North Atlantic Treaty Organization (NATO) with a clearer background of how and when Directed Energy Weapons (DEW) may potentially be fielded for future operational use; however, the demand for operational DEW/fielded laser weapons has spurred progress beyond SCI-227's initial projections. DEW will play an increasingly important role in future conflicts. The SCI-264 Task Group updated SCI-227's findings with a new timeline and capability projection for laser weapons, concluding that one or more NATO countries will possess and operate laser weapons in a coalition setting in the future. SCI-264 has developed tactical scenarios and the associated kill chains as a basis to identify the interoperability issues and opportunities presented by laser weapons. Collaborative testing and analysis of surrogate target reflectivity and laser propagation was performed to assess the measurement techniques, and modelling tools used by various NATO countries to conduct safety reviews. This report provides an introductory briefing on the unique attributes of laser weapons to broaden awareness; observations on interoperability, safety, and policy issues; and recommendations for future activities to better prepare the NATO community to integrate laser weapons into coalition operations.

STO-TR-IST-141-ANN

INTERACTIVE EXPLORATION OF NATO PANELS' ACTIVITIES

NATO STO is the world's largest collaborative research organisation in the field of defence and security. It conducts many different types of activities: Research Task Groups (RTGs) and Exploratory Teams (ETs); lecture series, specialists' meetings, symposia, workshops etc. These activities operate under the auspices of the six different Technical Panels (AVT, HFM, IST, SAS, SCI and SET) and the NATO Modelling and Simulation Group (NMSG). They all work on different aspects of the various defence and security challenges. The large volume and scope of scientific and technological programmes means that it is difficult to gain insight into, and understanding of, the large number of activities undertaken. IST-141 applied visual analytic capabilities, developed during the RTG's work, to explore and present the NATO S&T activities. The aim being to research and develop an efficient and intuitive means of interactive visualization enabling the exploration, analysis and understanding of the various activities. This leads to actionable results, such as: the discovery of temporal trends or patterns of topics of interests; identification of activities where there might be shared or complementary interests or applicable technologies; and recognition of technological gaps and possible future trends. The outputs from this activity are described.

STO-TR-HFM-271

INJURY ASSESSMENT METHODS FOR VEHICLE OCCUPANTS IN BLAST-RELATED EVENTS

This report summarizes the objectives, methods, and outcomes of the HFM-271 RTG. The objectives were to review, update and where applicable, define appropriate injury criteria and injury assessment methods for mounted warfighters based on contemporary battlefield, live-fire, and laboratory data in order to inform STANAG 4569 and the wider NATO community. Based on the research focus areas identified by the STANAG 4569 team of experts, the RTG examined existing and emerging data on occupant response and injury criteria from biomechanics research with military focus; investigated the effects of human body posture and protective equipment on injury severity and to evaluate the applicability of current injury criteria; investigated appropriate injury criteria for 'overmatch' loading scenarios; examined ATD and human models for applicability of use in test planning. In this report the RTG presents test and measurement improvement recommendations for repeatability, the effects of the footwear and temperature on the ATD measurements, and additional information on the limitations of the HIII lower leg and the standing posture injury mechanisms. A refined shoulder injury criterion is presented, and a detailed assessment of the thorax and abdomen injury assessment values and criteria and the derivation of the injury probability curves with highlighted limitations has been included.

STO-TR-SCI-HFM-351

VERIFICATION IN TRUST ENABLED REGIMES (VITER)

Since the end of the Second World War, arms control and disarmament agreements have been implemented to reduce the spread of Nuclear, Chemical and Biological (NBC) weapons and the risks of armed conflict. A critical part of these treaties has been the development of verification regimes that include language, monitoring, inspections, analysis, and dispute-resolution mechanisms. Nevertheless, the emergence of revolutionary technologies is pushing the boundaries of the verification concept. These technologies offer new ways and means to verify or avoid treaty compliance. Despite extensive research on verification, particularly in nuclear verification, the dynamics of associated complex systems, psychological and social aspects, such as Trust, have been under-examined despite their implicit and explicit importance in verification regimes. The SCI-HFM-351 team explored the role of Trust in verification regimes, concluding that considering Trust as an enabling aspect of the associated sociotechnical system provides value in understanding the social and technical aspects underlying verification regimes and may support new approaches as part of behavioural arms control. Our research adds to the study of NBC verification by exploring the role of Trust in complex systems, developing an abstract sociotechnical model of verification regimes and creating a conceptualization of Trust in such regimes. The conceptualization provides a valuable checklist for the design of an effective NBC arms control strategy. In addition, SCI-HFM-351 identified a wealth of multidisciplinary research on team, organizational, technological, and analytical methods from the open literature and current and past STO activities, which could be effectively applied to the verification challenge.