Preface

The primary objective of the NATO Advanced Research Workshop (ARW) titled "Technological Innovations in CBRNE Sensing and Detection for Safety, Security, and Sustainability" was to discuss and exchange views as to how fusion of advanced technologies can lead to improved sensors/detectors in support of defense, security, and situational awareness. The ubiquitous presence of sensors provides enhanced situational awareness of pollution and contaminants – anthropogenic, inadvertent, and intentional.

The current geopolitical landscape is quite complex, dynamic, and unpredictable. From security viewpoint, notwithstanding the unparalleled level of military/ technological dominance that the United States and NATO Allies have demonstrated within several war-theatres, the evolving asymmetric, kinetic, and unconventional threats from non-aligned terrorist groups continue to grow and evolve. Adversaries and terrorist groups have demonstrated a strong will and interest to wage unconventional war against Western targets despite their limited technological capabilities and lack of sophistication in conducting such operations. In fact, the unsophisticated compositions of Chemical Biological Radiological Nuclear high-yield Explosives (CBRNE) threats pose more technical challenges in countermeasures. Rapid advances in both science and technology (S&T) coupled with universal internet ramp access have inspired both state and non-state-sponsored actors to new levels of creativity in the development of novel and non-traditional threat agents. It is apparent that asymmetric threats have changed the traditional nature of the battlefield, where conventional rules of engagement are not followed. Accompanying the evolution of asymmetric threats is the relative ease of their transport and employment, thus broadening the potential battlefield and virtually eliminating the generally accepted premise of homeland as a safe haven from catastrophic and man-made disasters. Finally, the terrorist toolkit includes direct attacks against persons, basic human values, economic and critical infrastructure, and the environment in pursuit of their own personal and political agendas.

In the current financially austere environment, it is prudent to employ a nexus of technological innovations to find appropriate solutions and strategies that are consistent with the Smart Defense program of NATO. One such technology

is nanotechnology, where materials approaching nanoscale dimensions exhibit characteristics that uniquely enable novel characteristics in unprecedented ways. Advances in synthesis of such materials in reduced dimensions and characterization methods allow the means to study, understand, control, and even manipulate the transitional characteristics between isolated atoms and molecules and bulk materials. Technological advances arise from the potential of nanoscale materials to exhibit properties that are attributable to their small size, physical characteristics, and chemical composition. In addition, the nanoscale geometrical dimensions are comparable to the smallest engineered entity, the largest molecules of living systems, and several fundamental physical quantities. This allows development of application specific materials. Recent functional and architectural innovations in nanoscale materials have initiated applications in chem.-bio agents' interrogation, environmental pollution sensing, monitoring, mitigation and remediation, energy harvesting and storage devices, plasmonics, *in-vivo* analysis of cellular processes, and nano-biotechnology based futuristic health and clinical medicine platforms. A nanotechnology-based sensor platform enables direct detection of chemical and biological agents in a label-free, highly multiplexed format over a broad dynamic range. Nucleic acid layers combined with nanomaterials-based electrochemical or optical transducers produce affinity biosensors for converting hybridization events into analytical signals for obtaining sequence-specific information. Examples further include commission of quantum dots (QDs) for remote detection of threat vectors. The field is very active and rapidly developing, and covers a wide range of disciplines.

The subject of clean water is critical. The contamination in water can range from classical to non-traditional chemical agents, toxic industrial chemicals (TICs), and/or toxic industrial materials (TIMs). Conventional methods employed to sense/detect contaminants use commercial off -the-shelf (COTS) systems and broad-spectrum analytical instruments with interpretive algorithms. The current threat environment requires detection of complex contaminant signatures in addition to recycled pharmaceuticals present in water supplies. Hence it is critical to seek revolutionary solution pathways to such challenges, by using advanced sciences convergence (ASC) involving inter-/trans-disciplinary nexus of science and technologies.

The ARW aimed to address several important and relevant issues related to enhancing security using advanced technological solutions. The ARW was attended by participants from 23 countries, thus exemplifying the international vision of NATO Science for Peace for Security endeavours. Lectures covering the basic principles and state-of-the-art applications of nanostructured and advanced materials for chemical-biological sensors were conducted by experts widely recognized for advances in nanotechnology. Focused seminar sessions, poster sessions, and interactive feedback sessions stimulated extended interactions between participants and subject matter experts. As a venue for collaborative learning, the interactive lectures and sessions drew enthusiastic response and sharing of information and ideas from all participants.

The ARW was held at the Golden Tulip in Yerevan, the capital and largest municipality in the Republic of Armenia. The facility supported formal and informal settings for structured and spontaneous learning and sharing of ideas. The meeting lasted 3 days. The sessions were packed with agenda. The meals were arranged in the city – walking distance from hotel. This provided a much needed break from the conference room environment and most everyone stayed engaged despite the inevitable post-lunch slowdown. The unique balance of technical and social interactions materialized in alliances among participants, which have been evidenced by continued correspondence in the months following the ARW. The co-directors interpret the ongoing interaction and positive feedback from participants as an affirmation of a successful ARW.

Such a constructive ARW is the outcome of efforts by participants, speakers, and co-directors in addition to a host of caring individuals who supported their work. Much appreciation is extended to Golden Tulip management who ensured gracious hospitality to all participants. We would like to acknowledge tireless logistics support by Anne Stammwitz, Aleksandra Buha, Didem Demir, Luiza Gevorgyan, David Khudaverdyan, and Ashot Khudaverdyan and editorial support provided by Yulia Mutafchieva and Didem Demir.

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The co-directors are confident that ARW participants will continue research collaborations that began in Yerevan in the advancement of nanotechnology and ASC to enhance safety and security for all mankind in support of NATO mission. The ARW was supported by NATO–Emerging Security Challenges division of Science for Peace and Security program.

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