

Colloque S&T Symposium 2010

Agility and Resilience: Preparing the Military for the Unpredictable
Résilience et agilité: Préparer les militaires à faire face à
l'imprévisible

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Defence R&D Canada – Corporate

Technical Report
DRDC Corporate TR TR-2010-010
September 2010

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Abstract

Defence S&T Symposium 2010 explored the Canadian Forces (CF) readiness in facing the inevitable disruptions that come with the globalization of S&T. The symposium featured sessions exploring the nature and cause of technology-enabled disruptions, approaches and best practices for their mitigation and exploitation, and solutions toward achieving greater organizational resilience and agility. Participants from the Department of National Defence, the CF, other government departments, academia and Canada's allies were invited to share their experiences, discuss the global dynamic environment of S&T and probe how to prepare the military for a world of uncertainty and technological surprises.

Résumé

Le Colloque S et T pour la défense 2010 portait sur la préparation des Forces canadiennes (FC) face aux inévitables bouleversements découlant de la mondialisation de la S et T. Plus précisément, on explorait dans ses séances la nature et les causes des bouleversements entraînés par la technologie, les approches et les meilleures pratiques visant l'atténuation et l'exploitation des effets de ces bouleversements, et enfin, les solutions visant à accroître la résilience et l'agilité. Des participants provenant du ministère de la Défense nationale, des FC, d'autres ministères, du milieu universitaire et d'organisations alliées du Canada ont été invités à faire part de leur expérience, à traiter du domaine mondial en constante évolution qu'est celui de la science et de la technologie et à sonder la façon de préparer les militaires à affronter un monde incertain et caractérisé par des imprévus technologiques.

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Executive summary

Colloque S&T Symposium 2010: Agility and Resilience: Preparing the Military for the Unpredictable Résilience et agilité: Préparer les militaires à faire face à l'imprévisible

**Hubbard, P.; Staples, B.; Breton, R.; Myers, V.; Ducharme, M.; DRDC Corporate
TR TR-2010-010; Defence R&D Canada – Corporate; September 2010.**

Approximately 200 participants took part in the Defence S&T Symposium 2010 held in Ottawa on 27-29 April, 2010. This was the tenth Symposium, and the fourth co-sponsored by the DND's Chief of Forces Development and Defence R&D Canada. Defence S&T Symposium 2010 explored the readiness of the defence and security and S&T communities to face inevitable disruptions that come with a complex, dynamic, evolving world. Resilience and agility are respectively defensive and offensive qualities of this readiness. Agility is the ability to adapt to take advantage of changes in context or environment by recognizing when to shift strategy and shifting quickly and easily. Resilience is the ability to recover quickly to unforeseen disruptions or damage while remaining functional.

The Department of National Defence needs both operational agility and strategic agility. Operational agility ensures that the Canadian Forces, enabled by their doctrine, training and materiel, can adapt in order to operate in a wide range of contexts to accomplish the full range of missions mandated by the Canadian government. Strategic agility ensures that DND, as an organization or institution, can learn and evolve, i.e. that the processes, refreshes and self-assessments are in place that enable the organization as a whole to adapt. One presenter at this year's symposium used the words of the previous CEO of General Electric, Jack Welch, to capture this point: "When the rate of change outside your organization exceeds that within your organization, the end is near."

DND has established planning processes based on developing capabilities. These were presented at the symposium by the co-sponsoring organization, CFD, represented by BGen Perry Matte. The challenge facing CFD is to use all available information, which includes projections of the future security environment and S&T developments, to generate the right requirements to inject at the front end of force generation, then adjust these as necessary as the force is generated to produce the most appropriate and effective force. Dr. Robert Walker, ADM (S&T) and CEO of DRDC echoed the need for the S&T community to work closely with force developers, to inform the multi-dimensional defence and security response that is required in a quickly changing world.

One aspect of this changing world, climate change, was emphasized in this year's Ingar Moen Memorial Lecture. This year's recipient of the award, Ms. Margaret Purdy from the University of British Columbia, provided a lecture on the security implications of climate change. Ms. Purdy argued that Canada needs to be more active in exploring, understanding and taking action regarding the security implications of climate change if it is to be prepared for the host of inevitable changes associated with global warming.

The symposium generated a host of insights on the role of S&T in providing agility and resilience. Among them are:

- **Foresight and organizational speed** are powerful enablers for agility and resilience. Foresight, or the perception of the nature and significance of possible events before they occur, requires active scanning for new technologies and for early signals of new usages of old technologies. These new technologies or applications can literally emerge overnight, especially with non-state adversaries that may emphasize short-term tactical innovation. Organizational speed enables the development of capabilities sufficiently quickly to outpace adversaries' innovation.
- **In stable times, optimization is the key to survival. In unstable times, agility is the key to survival.** Linear thinking and incremental improvements are artefacts of the symmetric mindset adopted during the Cold War. It may be dangerous to plan the military forces of tomorrow starting from expected adversaries through threats and through capabilities to boots-on-the-ground and to equipment, without exploring external drivers that disrupt this linear logic.
- **Persistent scanning** is already commonplace in commercial foresight and business planning; some exploit social networking as a means to gather small insights from many contributors. Subsequent to active scanning, the assessment of potential disruptions requires analytical rigor and imagination. Approaches such as interactive table-top war-gaming and red teaming can enable the merging of military assessment and technological expertise, and promote out-of-the-box thinking and imagination in the anticipation of and response to technology-enabled disruptions.
- **The world is in the midst of a global technology revolution** leading to accelerating advances in biotechnology, nanotechnology, materials technology and cyber technology. These advances bring about radical changes in all dimensions of life – social, economic and military – and enable new capabilities and growth while displacing whole national industries. A short list of those discussed in this symposium include high-power lasers, network-enabled jewelry, smart yoghurt, internet-based influence societies, murmurations generated from multi-agent systems and cyborg mind-control chips.
- The third session of the symposium, entitled simply Applications, revealed **two different approaches to ensuring agility** and preparing for the future. One approach could be termed traditional planning and is the more systematic. It exploits so-called point-scenarios and derives appropriate capabilities and investments, essentially attempting to optimize agility. Proponents of the approach claim it is pragmatic, and legitimizes investment in a complex decision environment. The second approach is built on the beliefs that (a) the future is fundamentally unpredictable and any forecasts for planning purposes are only illusions, and (b) that the creative process will bring into question even the most fundamental assumptions that are made in any systematic planning process. Hence, this approach advocates a liberal education, rewarding creativity, investing in exploring identity and values in place of contingency, and the appropriate framing of questions in order not to limit the possible answers to avoid colonizing the future with today's preconceptions.

Significance and Future Plans

Military forces around the world already find that they are called upon to operate in a wider range of missions and respond to un-anticipated usage of old and new technologies. In the future, military forces that can grasp this new reality and change their operational paradigm will be in a much better position to develop and respond to technological surprise.

Sommaire

Colloque S&T Symposium 2010: Agility and Resilience: Preparing the Military for the Unpredictable Résilience et agilité: Préparer les militaires à faire face à l'imprévisible

Hubbard, P.; Staples, B.; Breton, R.; Myers, V.; Ducharme, M.; DRDC Corporate TR TR-2010-010; R & D pour la défense Canada – Corporate; Septembre 2010.

Environ 200 participants se sont réunis à Ottawa du 27 au 29 avril 2010 dans le cadre du Colloque S et T pour la Défense 2010. Il s'agissait du 10^e Colloque, mais de la 4^e édition promue conjointement par le Chef – Développement des Forces (CDF) du MDN et R & D pour la défense Canada. Cet événement concernait le degré de préparation des secteurs de la défense, de la sécurité et de la S et T face aux incontournables bouleversements qu'entraîne un monde complexe, dynamique et en constante évolution. La résilience et l'agilité sont des qualités respectivement défensive et offensive de cet état de préparation. En effet, l'agilité est la capacité de s'adapter afin de profiter des changements contextuels ou environnementaux en sachant quand changer de stratégie et en étant en mesure de le faire rapidement et facilement, tandis que la résilience est la capacité de se rétablir promptement d'un bouleversement imprévu tout en restant fonctionnel.

Le ministère de la Défense nationale a besoin d'une agilité à la fois opérationnelle et stratégique. D'une part, l'agilité opérationnelle permet d'assurer que les Forces canadiennes, fortes de leur doctrine, de leur entraînement et de leur matériel, peuvent s'adapter à un éventail de contextes afin d'honorer toute la gamme de missions que lui confie le gouvernement canadien. D'autre part, l'agilité stratégique permet d'assurer que le MDN, à titre d'organisation ou d'institution, peut apprendre et évoluer, c.-à-d. qu'il dispose des processus, des mises à jour et des autoévaluations nécessaires pour s'adapter. L'un des conférenciers du Colloque de cette année a cité l'ancien président-directeur général de General Electric, Jack Welch, pour illustrer cette notion : « Lorsque le rythme de changement à l'extérieur de votre organisation est supérieur à celui de l'organisation, la fin est proche ».

Le MDN a établi des processus de planification fondés sur le développement des capacités. Ces processus ont été présentés lors du Colloque par l'un des promoteurs de l'événement, le CDF, représenté par le Bgén Perry Matte. Le défi que doit relever le CDF est d'utiliser toute l'information disponible, y compris des prévisions sur le futur contexte de la sécurité et les percées en S et T, pour définir les exigences précises à prioriser dans la mise sur pied de la force, puis pour adapter ces exigences au fur et à mesure afin d'obtenir la force la plus appropriée et la plus efficace qui soit. M. Robert Walker, SMA(S & T) et CDir de RDDC, a réitéré la nécessité pour le monde de la S et T de collaborer étroitement avec les responsables de la mise sur pied de la force dans le but de façonner l'adaptation multidimensionnelle sur le plan de la défense et de la sécurité qui s'impose dans un monde en évolution accélérée.

L'un des aspects de ce monde en évolution, les changements climatiques, a été mis de l'avant dans le discours de cette année en souvenir d'Ingar Moen. La lauréate de cet honneur annuel, Mme Margaret Purdy de l'Université de la Colombie-Britannique, a livré un exposé à propos de

l'incidence des changements climatiques sur la sécurité. Elle a avancé que le Canada doit être plus actif pour explorer ce phénomène, le comprendre et y réagir si le pays souhaite se préparer aux changements inévitables qu'entraîne le réchauffement de la planète.

Le Colloque a généré une multitude d'idées sur la façon dont la S et T peut nous aider à acquérir de l'agilité et de la résilience. En voici quelques exemples :

- **La capacité de prévision et la rapidité de réaction des organisations** sont de puissants moteurs d'agilité et de résilience. La capacité de prévision, autrement dit l'appréhension de la nature et de la portée d'événements éventuels avant qu'ils ne surviennent, requiert un examen continu des nouvelles technologies et des signes précurseurs de tout nouvel usage de technologies anciennes. Ces nouvelles technologies ou ces nouveaux usages peuvent littéralement surgir du jour au lendemain, surtout en présence d'adversaires non étatiques qui mettent l'accent sur l'innovation tactique à court terme. La rapidité de réaction des organisations permet de développer des capacités assez promptement pour devancer l'innovation des adversaires.
- **En période de stabilité, l'optimisation est la clé de la survie, mais en période d'instabilité, c'est plutôt l'agilité.** La pensée linéaire et l'amélioration progressive sont des vestiges de la mentalité symétrique adoptée au cours de la guerre froide. Il peut être dangereux de planifier les forces militaires de demain en prenant comme point de départ des adversaires hypothétiques au chapitre des menaces et des capacités et de se fonder sur ces prévisions pour planifier des opérations et de l'équipement, et ce, sans tenir compte de facteurs externes étrangers à cette logique linéaire.
- **L'examen continu** est un outil couramment employé pour la prévision commerciale et la planification organisationnelle; le réseautage social est parfois utilisé pour chercher à mettre à contribution un grand nombre d'intervenants. Après cet examen, l'évaluation de possibles bouleversements doit se fonder sur une analyse rigoureuse dans laquelle l'imagination joue un rôle prépondérant. Des approches telles que les jeux de simulation de guerre et la méthode des « équipes rouges » permettent de combiner l'évaluation militaire et l'expertise technologique et aussi favorisent la mise à profit de la réflexion hors des sentiers battus et de l'imagination dans le cadre des activités de prévision et d'intervention face aux bouleversements entraînés par les technologies.
- **Le monde vit une révolution technologique qui dépasse les frontières** et mène à des percées rapides en biotechnologie, nanotechnologie, technologie des matériaux et cybertechnologie. Ces progrès entraînent des changements radicaux influençant toutes les dimensions de la vie (sociale, économique, militaire) et jettent les bases d'une capacité et d'une croissance nouvelles tout en supplantant les industries nationales. En voici quelques exemples qui ont fait l'objet du Colloque : « lasers haute puissance », « bijoux réseautés », « yogourt intelligent », « sociétés d'influence virtuelles », « nouveaux comportements engendrés par des systèmes multi agents » et « puces de contrôle de l'esprit androïdes ».
- La troisième séance du Colloque, intitulée tout simplement Applications, traitait de **deux approches différentes visant à assurer l'agilité** et à préparer l'avenir. La plus systématique de ces approches pourrait être qualifiée de planification traditionnelle. Elle

exploite ce que l'on appelle des scénarios par points pour en tirer des capacités et des investissements essentiellement dans le but d'optimiser l'agilité. Les promoteurs de cette approche soutiennent qu'elle est pragmatique et qu'elle permet de légitimer l'investissement dans un environnement décisionnel complexe. La seconde approche repose sur la croyance que (a) le futur est fondamentalement imprévisible et toute prévision utilisée dans un objectif de planification est illusoire et que (b) le processus créatif remet en question les présomptions, aussi fondamentales soient-elles, qui découlent d'un processus de planification systématique. Cette approche préconise donc des études libérales, la valorisation de la créativité, l'investissement dans l'exploration de l'identité et des valeurs au lieu de la contingence ainsi que la formulation appropriée des questions afin de ne pas limiter les réponses possibles et d'éviter d'envisager le futur à travers les préconceptions d'aujourd'hui.

Portée et recherches futures

Des forces militaires de partout dans le monde ont déjà constaté qu'elles sont appelées à opérer dans le cadre de missions plus diversifiées et à faire face à des utilisations imprévues de technologies anciennes et nouvelles. À l'avenir, les forces militaires qui comprendront cette réalité nouvelle et modifieront leur paradigme opérationnel en conséquence seront plus à même de se développer et de prendre les mesures adéquates face aux utilisations imprévisibles de la technologie.

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1 The Ingar Moen Memorial Lecture: Climate Change at the Global Security Nexus, Ms. Margaret Purdy

Dr. Ingar Moen was one of DRDC's most influential scientists and the key driver of the S&T Policy directorate; he was the original thought leader that drove the first and future S&T Symposia since 2000. He chaired the Disruptive Technology Working Group that became the generator of ideas for many areas of science policy at DRDC, including the annual symposium. Ingar was key to the development of many strategic documents and activities including the Technology Investment Strategy (TIS) and "Looking Forward, Staying Ahead". After his passing in June 2006, the first 2007 S&T Symposium keynote lecture was dedicated to Ingar's memory/legacy. It was determined to make this an annual award entitled the 'Ingar Moen Memorial Lecture.'

2010 Recipient of the Ingar Moen Memorial Award: Ms. Margaret Purdy

Ms. Purdy is a Research Associate with the Centre of International Relations at the University of British Columbia and the Principal of Margaret Purdy Consulting, a firm providing strategic advice on national security, public safety and emergency management. During her 28 years with Canada's federal public service, Ms. Purdy held a wide range of policy, operational and senior management positions. Most of her work had a counter-terrorism focus, but she also provided leadership on transportation security, cyber security, emergency management, critical infrastructure protection, intelligence assessments and protective policing. Her assignments included Deputy Secretary to the Cabinet for Security and Intelligence and Associate Deputy Minister of National Defence. Ms. Purdy has published articles on the root causes of terrorism, the security of trade and transportation gateways, the role of diasporas in countering terrorism, and Canada's counter-terrorism policy. Her current research and writing focus on the implications of climate change for Canada's security interests. Her team is the only one of its kind to be dedicated to exploring the full range of implications for climate change for Canada.

In her presentation, Ms. Purdy argued that Canada needs to be more active in exploring, understanding and taking action regarding the security implications of climate change. Her thesis is that there is an attention deficit in Canada at the nexus of security and climate change (with the possible exception of the Arctic), and that this must change quickly if Canada is to be prepared for the host of changes associated with global warming.

Ms. Purdy argues that the security implications of climate change are blatantly obvious; increases in average global temperature, precipitation patterns, sea level and extreme weather will stretch the public safety and national and international capacities, including those of the Canadian Forces. Ms. Purdy agrees that climate change will be the defining national security challenge of the century, with novel and unexpected consequences (see *Climate Conflict* by Jeffrey Mazo, Institute of Strategic Studies).

She began by reviewing the current status internationally and within Canada. There are research institutes and think-tanks in many countries around the world include the USA, Germany, Singapore, New Zealand and the UK that have issued reports, held conferences, and raised

awareness on this topic in decision-makers. Climate change figures prominently in strategic documents of our closest allies, including the UK National Security Strategy, 2010 US Quadrennial Defence Review, and US Quadrennial Homeland Security Review. The US CIA now has a centre on Climate Change and National Security. In contrast, the topic of climate change is absent from the agendas of government ministers in Canada, and basically ignored by academia, newspapers and thinktank community. There have been, however, scientific assessments of the effects of climate change from the National Research Council, on the impact from region to region in Canada, and from Health Canada on the effect of climate change on human health, though paradoxically, security organizations have not leveraged these scientific assessments. Some activities have occurred in Canada – a recent workshop (see the LIU at UBC website), and the Future Security Environment from co-sponsoring organization CFD, may be the only government document in the public domain that tackles climate change as a significant security issue.

Ms. Purdy argues that the solution to filling this gap within Canada is for climate change to be integrated into the intelligence, public safety, emergency management, critical infrastructure owners, public health and other organizations with security responsibilities. She argues that this requires a sustained and vocal alliance between S&T and security communities in Canada, and she outlined a seven step approach to create a collaborative effort on climate change.

Build trust. Get comfortable working together and build relationships. DRDC can play lead role in this regard. There is ignorance on both sides of the science and policy interface in this area.

Fill the information gaps Security players need a different kind of information from that provided to environment Canada, Natural Resources Canada, Finance, or Foreign Affairs, for example research linking physical impacts and human domains or specific information on international locations of strategic interest to Canada. Both scientists and security policy makers have to commit to a two-way flow of information to fill these gaps.

Assess the risks. Discussions in Canada on climate change tend to be vague, anecdotal, or focused exclusively on the arctic. More serious, comprehensive and systematic assessments are long overdue.

Examine the obvious and non-obvious ways climate change contributes to insecurity. Sometimes climate change is the obvious sole cause, e.g. forced migration due to sea level rise. However, in other cases, the causal link is indirect, for example how it exacerbates existing conflicts through food shortages or has subtle causal links to extremism and terrorism. (see *Global Warring*, Cleo Paskal, 2010)

Take multi-disciplinary approach. Stovepipes exist within government. Climate issues are coupled with economic, demographic, environmental, social and geo-political issues. Assessments require an inter-disciplinary science that brings together the natural, physical and social sciences as well as integrated government machinery that does not currently exist.

Tell it the way it is. The time has come for blunt language backed up by sophisticated and reliable assessments to inform and influence public dialogue in Canada around climate change. Importantly, Ms. Purdy points out that we can learn from other governments in this regard, on how to capture the attention of both senior bureaucrats and the Canadian public.

Help DMs understand that uncertainty is no excuse for procrastination. While high-impact consequences are almost guaranteed, the complexities in climate science make it hard to predict timing, exact magnitude and duration with precision. Unknowns should not halt action. Indeed, uncertainty should make the need for action stronger, not weaker. The traditional approach in the face of uncertainty and complexity - to analyze, understand and mitigate risk while preparing for unavoidable consequences - remains the obvious appropriate approach in this context.

DND and the CF will be increasingly and dramatically impacted by climate change in terms of domestic and international deployments, planning for equipment and physical infrastructure and personnel, and relationships with other militaries around the world.

Future generations may look back on inaction on climate change as the biggest failure of our generation. Ms. Purdy ended her talk with a call to the Canadian S&T and security communities to take bold and innovative actions that could contribute to international security and provide a more secure future for Canada and Canadians.

2 **Setting the Scene and Introductory Presentations**

For the past decade, the defence S&T symposium has provided military and civilian leaders with a unique forum in Canada to come together and discuss the latest trends in emerging military concepts, technologies, applications and solutions in current and future defence and security environments.

The master of ceremonies for the symposium, Dr. Pierre Lavoie, Chief Scientist at DRDC, opened the symposium with a discussion of the themes - organizational foresight, resilience, agility and speed within the context of modern-day challenges and the possible solutions in the face of disruption.

The co-sponsors of this event, the assistant deputy minister for science and technology (ADM(S&T)), Dr. Bob Walker and the Chief of Force Development for DND, represented by BGen Perry Matte provided a welcome message in which they discussed the objectives of the symposium. These were to raise awareness of the requirement for agility and resilience, to raise awareness of types of S&T that are relevant, provide a wake-up call for S&T generated disruptions, and explore the thesis that in today's context, the investment in S&T requires a higher level of ambition.

Resilience and Agility: Preparing the Military for the Unpredictable

BGen Perry Matte, DG Integrated Force Development for Chief of Force Development

BGen Matte graduated from West Kings High School in 1977, and from Acadia University in 1980 under the Regular Officer Training Programme with a Bachelor of Science Degree majoring in Computer Science. He completed his Basic Air Navigator Course in June 1981 and was posted to CFB Greenwood. He has flown three operational tours on the CP140 Aurora, all with 405 MP Squadron, and has over 2,500 flying hours. His staff tours have included: the Aurora Software Development Unit (ASDU) as an Operational Liaison and Analysis Officer; Wright-Patterson AFB in Dayton, Ohio, on exchange as the senior avionics engineer on the USAF's ring-laser gyro and embedded GPS/INS programme; Maritime Air Group HQ in Halifax as the Director of Air Operations Atlantic and then as Chief of Staff and Director of Operations in the newly established Maritime Air Component (Atlantic); 1 Cdn Air Div/CANR HQ in Winnipeg as A3 Force Employment and then as A3 Force Generation and as a Director of Operations for CANR. BGen Matte is a graduate of the Aerospace Systems Course, the CF Command and Staff College and the National Security Studies Programme. BGen Matte was appointed as an Officer of the Order of Military Merit in June 2006. His command appointments include Commanding Officer 405 MP Squadron, 14 Wing Operations Officer and 14 Wing Commander. Following his tour as Wing Commander, BGen Matte served as the Special Advisor to the Chief of the Defence Staff, Gen Hillier. Promoted to his current rank in June 2008, BGen Matte is currently serving as the Director General

BGen Matte started his presentation with a discussion of the context in which we consider disruption - differentiating between true disruption and trends that are ignored - and the context in

which the department's force development activities contribute to resilience and agility. He also separated resilience and agility at the level of the soldier and at the level of the institution. At the level of the soldier, BGen Matte emphasized that the Canadian Forces are well prepared, well trained and exhibit all the hallmarks of adaptability - of which two are resilience and agility. At the institutional level, however, there are major challenges to ensuring resilience and agility. Perhaps the most important of these is the acquisition horizon in force generation. This challenge is by no means restricted to the Canadian department of national defence - all large organizations, including military forces around the world, face this challenge. The difficulty is that there are process timelines associated with transparent acquisition, physical manufacture of materiel, and recruitment and training of forces. Though these can be minimized, the challenge facing CFD is to use all available information, which includes projections of the future security environment and S&T developments, to generate the right requirements to inject at the front end of force generation, then adjust these as necessary as the force is generated to produce the most appropriate and effective force. He emphasizes the need to work with the S&T community between development and generation to account for changes while acquisition is ongoing.

As BGen Matte points out, this will only become more challenging as the world evolves, becomes more complex and interconnected, and the pace of change accelerates making it harder to understand the nature of future conflict. A guiding principle is to reduce the sphere of the unknown in order to minimize the realm of the truly unpredictable.

BGen Matte outlined the capability-based planning in the department of national defence. This is a deliberate, pro-active, well-informed process that translates strategic guidance to military objectives and then to force development plans while also reacting to requirements generated from operational personnel in the field and working within the constraints of fiscal reality. He also discussed other efforts within CFD, such as the Canadian Forces Experimentation Centre, that is exploiting an integrated test bed to trial new ideas and concepts.

BGen Matte ended his presentation with a summary of other challenges to agility and resilience in the department. These include several specific domains that will require significant change, such as Joint C4ISR, the Cyber environment, as well as understanding other elements of national power and their influence in the human domain. He also highlighted the challenges of decision-making on divestment versus investment, and the impact of budgetary deficits and economics on future defence agility and resilience.

The S&T Challenges of Preparing for the Unpredictable

Robert S. Walker, Ph. D. FCAE, Assistant Deputy Minister (Science and Technology), DND

Dr. Robert Walker is the Assistant Deputy Minister (Science and Technology) of the Department of National Defence and the Chief Executive Officer of Defence R&D Canada. In this capacity, he leads Defence R&D Canada, which consists of a national network of nine defence research centres with an annual budget of \$350 million and a staff of 1700 people in programs addressing a broad range of defence technologies. Defence R&D Canada provides national leadership in defence and security S&T, and provides scientific advice and products to the Canadian Forces and the Department of National Defence. The defence and security S&T network extends beyond

the Defence Research Centres to encompass partnerships with Canadian industry, universities, and allied defence S&T organizations. Dr. Walker was born in Nova Scotia and received his B.Sc (Honours Physics) from Acadia University in 1973. Dr. Walker also received a Master's degree (Engineering Physics, 1975) and a Ph.D. (Electrical Engineering, 1977) from McMaster University. His graduate studies were in the area of semiconductor material research. Dr. Walker is a graduate of the National Defence College (June 1992). Throughout his 30-year career at Defence R&D Canada, Dr. Walker has served in a number of senior appointments. From 1998 to 2005 as Director General Research and Development Programs, he was mandated to provide central coordination and strategic planning for the R&D Program through interface with DRDC's client groups in the Canadian Forces and with external partners, in addition to managing several key national and international programs. From 1995 to 1998, he was the Director General of Defence R&D Canada Valcartier and the Scientific Advisor Land for the Department of National Defence. Prior to this appointment, he spent one year as the Deputy Director General at DRDC Valcartier. From 1990 to 1994, Dr. Walker was responsible for the direction of development activities aimed at improving the Canadian Forces' exploitation of information technologies, terrestrial and space-based communications, space-based surveillance and command and control systems in his capacity as Director, R&D Communications and Space at DRDC Headquarters. In the earlier part of his DRDC career, Dr. Walker spent 13 years at Defence R&D Canada Atlantic. During this tenure, he conducted research in the general area of underwater acoustic signal processing and sonar system design for undersea warfare and served as Head of the Signal Processing Section. In his capacity as Assistant Deputy Minister (Science and Technology), Dr. Walker is the principal Canadian representative to The Technology Cooperation Program (TTCP) and was recently elected Chairman of the NATO Research and Technology Board (RTB) effective April 2009. He also provides departmental input to national issues in science and technology by sitting on a number of interdepartmental committees of assistant deputy ministers. Dr. Walker's achievements have been recognized by the Deputy Minister of National Defence in 2003 with a DM Commendation, by the international community in 2001 with a TTCP Personal Achievement Award and by DRDC in 2005 for the Agency Performance Excellence Award. Dr. Walker and his wife, Karen, reside in Ottawa and have three children.

The thesis of Dr. Walker's presentation had three elements: First, the world is changing; second, that this change requires a multi-dimensional defence and security response; and third, that this response must be informed (among others) by science and technology. He discussed each of these in turn.

The increased pace of change in the world can be explored by looking back on the previous decade. Dr. Walker provided anecdotal evidence for major change from the perspective of crises (e.g. 9/11 and major natural disasters), wars, multipliers (e.g. the globalization of S&T and climate change), threats, and technology. He also provided an analogous ten year retrospective for the Canadian department of national defence and discussed the major changes in policy (highlighted by the creation of the Canada First Defence Strategy), strategy, structure (highlighted by the creation of Public Safety Canada in 2003), governance, alliances, and doctrine.

A paradox in the changing world, argues Dr. Walker, is that while the world is increasingly interdependent due to global warming, critical infrastructure, population health and financial markets, it is also increasingly fractured by ideology, culture, values and wealth. The perspective

of security for Canada and Canadians in the 21st century can be viewed through three lenses: that of national/societal attributes such as sovereignty and cultural values, that of threats such as inter-state conflict or terrorism, and that of force multipliers such as energy security, climate change and financial crises. These three perspectives emphasize the complex challenges facing Canada through the range of conflicts, actors and interdependencies and the very unpredictability of the *complex* systems these interdependencies create.

A further dimension to this changing world is the globalization of S&T. Economic barriers to R&D are eroding, meaning that technological innovation is everywhere – not just everywhere in the senses of technological niches, but also everywhere globally. Dr. Walker discussed how positive S&T developments always have a downside (e.g. e-commerce vs. identity theft or improvements in healthcare vs. the threat of bio-terrorism), and how this dichotomy exists at the interface between the global S&T ecosystem, on one side, and defence and security ecosystem, on the other. Both ecosystems continue to evolve in parallel but are more and more interconnected. Dr. Walker emphasized that government has a critical role at the interface – it is expected to lead in providing security for its citizens and also in stimulating industry for S&T innovation.

The second component of Dr. Walker's argument is the need for a multi-dimensional defence and security response. He described four key security outcomes for Canada. First, Canada and its peoples, allies, institutions and socio-economic fabric must have a greater resilience to high-consequence public security events. Second, that Canada must have a secure and efficient flow of people, goods and services across its borders and ports of entry. Third, that a national emergency management and response system must be in place, providing an effective full-spectrum protection of people, responders and critical infrastructure from all-hazards. Fourth, the public must be confident that public security threats are being identified, assessed and addressed in a way that reflects Canadian values and maintains the integrity of the criminal justice and national security systems. A critical component of the defence and security response to these four desired outcomes is the Canada First Defence Strategy, which lists long-term objectives and provides a stable and predictable investment program for the department of national defence. The Canadian Forces response to the changing world is articulated in the CF Integrated Capstone Concept.

As a segue to the role of S&T in the multi-disciplinary response, Dr. Walker discussed the greater national, public outcomes for the department to which the S&T dimension can contribute. These include building a state of the art military, ensuring strong partnership with industry and strengthening Canada's security posture. Indeed, Dr. Walker's thesis is that S&T has a role to increase the likelihood of the department achieving these outcomes. In this context, he discussed positioning the S&T investment so that is brought to bear on technology drivers, to understand security implications as societies adapt and contribute to the readiness of the defence and security forces. The first component in particular – bringing S&T to bear on drivers - is a key motivator for the 2010 S&T Symposium, in which we are exploring foresight processes, structured gaming for assessing technology disruptions, and calibrating on global trends by inviting international participation.

Dr. Walker ended his presentation with the key message that the S&T community is seeking to raise the level of ambition for the S&T investments. Indeed, he presented specific roles for S&T (as integral advisor, knowledge integrator, risk mitigator and open innovator) as well as why and how these roles increase the likelihood of our defence and security partners achieving their outcomes.

3 Sources of Disruption

This session, chaired by Mr. Richard Morchat, defence scientist at Defence R&D Canada, explored the sources of disruption – emphasizing those from S&T, over those from political, social or environmental – and the way policy and future investment is framed in North America. The session included a high-level presentation on the future of S&T investment within the USA, with themes paralleling closely those previously presented for Canada by ADM(S&T). A second presentation explored the myriad of potential technological and societal disruptions that we can expect in the coming decades. The third and final presentation explored a methodology to identify likely sources of disruption and the relevance of foresight in the Canadian context.

The U.S. Department of Defence S&T Program: Sources of Disruption and the Need for Innovation, Speed and Agility

Mr. Al Shaffer, Principal Deputy Director, Defence Research and Engineering, USA

In his current position, Mr. Shaffer is responsible for formulating, planning, and reviewing the DoD Research, Development, Test, and Evaluation (RDT&E) programs, plans, strategy, priorities, and execution of the DoD RDT&E budget. Specifically, this position reviews the maturity of technology as part of the acquisition cycle, as well as develops options to reduce the overall technology development risk to DoD programs. Prior to entering the federal government, Mr. Shaffer served a 24-year United States Air Force career with assignments in weather, intelligence, science and technology management, acquisition oversight, and programming. His career included deployment to Honduras in support of Joint Task Force Bravo in the mid-1980s and direct support of the United States Army 3rd Armored Division at Hanau, Germany. During Operation DESERT STORM, he was responsible for deployment of the 500-person theatre weather force. Other assignments included Wing Weather Officer supporting the 320th Bombardment Wing (Heavy) at Mather AFB, California; Intelligence Officer at Foreign Technology Division, Wright Patterson AFB, OH; Deputy Director of Weather for Air Combat Command, Langley AFB, VA, numerous staff assignments in the Air Staff and Office of the Secretary of Defense, in the Pentagon; and finally, the Air Force Weather Agency, Offutt AFB, Nebraska. Upon retirement from the United States Air Force in 2000, Mr. Shaffer was appointed to the Senior Executive Service as the Director, Multi-disciplinary Systems, Office of the Deputy Under Secretary of Defense for Science and Technology. In 2001, he assumed the position as Director, Plans and Programs, Defense Research and Engineering. Mr. Shaffer continues to serve as the Director while serving as the Principal Deputy. As the Director for Plans and Programs, Mr. Shaffer is responsible for the oversight of the Department of Defense science and technology portfolio totaling over \$10.5 billion. Mr. Shaffer has served as the Executive Director for several senior Task Forces. These included the Technical Joint Cross Service Group during the Base Realignment and Closure activity; DoD Energy Security Task Force in 2007 and most recently the Executive Director of the Mine Resistant Ambush Protection Task Force. In addition he serves as the tri-chair to the Department of Defense Modeling and Simulation Steering Committee. Mr. Shaffer earned a Bachelor of Science Degree in Mathematics from the University of Vermont in 1976. He earned a second Bachelor of Science in Meteorology from the University of Utah, a Master of Science in Meteorology from the Naval Postgraduate School, and a Master

of Science in National Resource Strategy from the Industrial College of the Armed Forces. He has been awarded the Distinguished Executive Presidential Rank Award in 2007 and the Meritorious Executive Presidential Rank Award in 2004.

The topic of Mr. Shaffer's presentation was the future of defence S&T investment in the U.S.A., how this investment is being conceived at senior levels, and how the investment plans are impacted by current global trends such as S&T globalization or the increased pace of technology. An idea that permeated his presentation is that the three dimensions for measuring S&T are now *innovation* (how far can one move the bar), *speed* (how quickly can one do it) and *agility* (how quickly one can respond to a contextual change).

Mr. Shaffer started by emphasizing that senior executive levels within the U.S.A. understand the importance of S&T. He quoted President Obama (Speech at the National Academies of Science, April 27, 2009) who stated, "At such a difficult moment, there are those who say we cannot afford to invest in science, that support for research is somehow a luxury at moments defined by necessities. I fundamentally disagree. Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been before." The difficulty remains translating this to actions that can be taken to support the war fighter.

From this, Mr. Shaffer then discussed the over-arching strategic concepts and documents in the U.S.A. He began with 2010 Quadrennial Review (similar in level and content to the Canadian Canada First Defence Strategy). In particular, he noted the review objective of rebalancing the military from a kinetic platform-centric focus to a focus on broader national security threats and challenges. He then translated these objectives to imperatives for the Department of Defence Research and Engineering, which included accelerating delivery of technical capabilities (i.e. speed), preparing for an uncertain future (i.e. agility) and developing a world class S&T workforce (i.e. innovation). This last item he raised as a critical consideration moving forward in the context of other countries such as India and China increasing their output of highly trained S&T workers.

Mr. Shaffer then discussed the global dimensions affecting S&T, and presented themes that closely matched those presented by Dr. Walker. He highlighted the *Pace of Technology* through a discussion of how the number of years from invention to 80% adoption has drastically changed from the cold war (measured in years) to counter-insurgency warfare (measured in weeks or days). He highlighted the *Technology Commercialization* and with examples of the use of commercial-off-the-shelf products and public sources such as Google maps for terrorist planning. He highlighted the *Rise of the Commons* with examples of operational arenas that are not owned by anyone, such as cyberspace, the open ocean and the electro-magnetic spectrum. He also discussed the shift in emphasis from the physical (i.e. platforms and weapons systems) to sociological and anthropological, sometimes called the *human terrain* (or analogously the *human domain* in Canada), with examples of social networking and crowd-sourcing.

Mr. Shaffer finished his presentation with some examples of ongoing investment changes programs that have resulted from a decomposing of the objectives in the QDR. The investment changes are reflected in the last three budgets, with increases in such topics as cyber protection and security, anti-tamper technology, large data handling and sociology research to shape the battlefield. However, Mr. Shaffer emphasised that alongside the preparations for an uncertain

future it is imperative to field capabilities quickly to troops on the ground. In this context he provided additional detail on several ongoing activities relevant to current operations such as the management of water and energy in forward-deployed arenas, data mining (data to decisions), helicopter survivability, persistent ground surveillance.

Major Societal Issues & Emerging Warfare Revolutions

Mr. Dennis M. Bushnell, Chief Scientist, NASA Langley Research Center

Mr. Bushnell is responsible for program formulation for a major NASA Research Center with technical emphasis in the areas of Atmospheric Sciences and Structures, Materials, Acoustics, Flight Electronics/Control/Software, Instruments, Aerodynamics, Aerothermodynamics, Hypersonic Airbreathing Propulsion, Computational Sciences and Systems Optimization for Aeronautics, Spacecraft, Exploration and Space Access. Mr. Bushnell has 46 years experience as Research Scientist, Section Head, Branch Head, Associate Division Chief and Chief Scientist. Mr. Bushnell is the author of 252 publications/major presentations and 310 invited lectures/seminars, a member of National Academy of Engineering, Selected as Fellow of ASME, AIAA and the Royal Aeronautical Society, has 6 patents, AIAA Sperry and Fluid and Plasma Dynamics Awards, AIAA Dryden Lectureship, Royal Aeronautical Society Lanchester, Swire and Wilber and Orville Wright Lectures, ICAS Guggenheim Lecture, Israel Von Karman Lecture, USAF/NASP Gene Zara Award, NASA Exceptional Scientific Achievement and Outstanding Leadership Medals and Distinguished Research Scientist Award, ST Presidential Rank Award, 9 NASA Special Achievement and 10 Group Achievement Awards, University of Connecticut Outstanding Engineering Alumni, Academy of Engineers, Pi Tau Sigma and Hamilton Awards, Univ. of Va. Engineering Achievement Award, service on numerous National and International Technical Panels and Committees and consultant to National and International organizations. Mr. Bushnell has a B.S. in Mechanical Engineering from University of Connecticut with Highest Honors, Distinction, University Scholar (1963), M.S. degree in mechanical engineering from University of Virginia (1967).

In his presentation, Mr. Bushnell provided a stimulating, fast-paced window into the future of warfare and insights into societal trends (i.e. “where is it all going?”) by presenting a broad overview of an emerging technologies and threats. In so doing, he provided a wake-up call to the symposium attendees on the variety and lethality of many emerging technologies and their implied vulnerabilities.

He began his presentation with a brief historical perspective from the hunter-gatherer age, to the agricultural age, industrial age, IT/Nano/Bio age and the coming so-called ‘virtual age’. He returned to this description a second time later in his presentation when describing the sources of wealth of the U.S.A. While the U.S.A. was blessed with wealth in the first three of these ages, its dominant position is not guaranteed in the latter two without an increased emphasis on domestic technical education.

Most of Mr. Bushnell’s talk concentrated on technology, their variety and the speed with which they are emerging. However, he took the time to explore five societal issues before launching into the technologies. The first trend is the so-called *rise of the machines*, and is categorized by the emergence of artificial intelligence and robotics, potential crises for unemployment of human

the population (and implied friction from idleness), the possibility of a global brain and human brain augmentation and integration with machinery. The second trend is *climate change and energy*, in which he discussed the positive feedback associated with global warming process, and the clear signals from our models and conservative predictions, that our science is not complete – we do not know what is going on. He also noted that the five major renewable sources of energy (drilled geothermal, seawater irrigated biomass on wastelands, solar photo-voltaic, solar thermal and wind) do, in fact, have the potential to solve our energy needs. The third trend is that of *econometrics*, characterized by a massive, unsustainable U.S.A. domestic and foreign debt. A disheartening implication from this trend is a likely drastic reduction in the standard of living (i.e. the so-called bursting of the standard-of-living bubble). Another implication is that the U.S.A. can expect to have more peer competitors, at least from an economic standpoint, in the future. The fourth societal trend is *tele-everything* - a hallmark of the virtual age characterized by tele-presence for work, socially and culturally and driven by emergence of virtual reality environments that stimulate all 5 senses, and holographic projection. The fifth and last societal issue is *the death of privacy*. With the emergence of a global sensor grid and a host of sensor technologies (RF/ID tags, acoustic sensors, bio emission sensors, optical, RF radiometry magnetic change sensors, etc.), it will become nearly impossible to protect your location, status or perhaps even intent.

This last societal trend, i.e. that it is now potentially possible to identify intent at the granularity of the individual leads to one of the Mr. Bushnell's key theses. Many emerging technologies are empowering individual to such an extent that they can cause catastrophic, or even species-ending, damage. His thesis is then that the only practical defence to the hyper-empowered individual terrorist is to exploit all sensors and data available to intuit intent at the granularity of the individual, and then take preventative measures.

A large portion of the remainder of Mr. Bushnell's presentation dealt with specific emerging and potentially disruptive technologies and how these present vulnerabilities and opportunities to the Western world. These include low-energy nuclear reactions, immersive realities, bio-enhancements that increase lifespan, machine intelligence and augmented intelligence, non-nuclear explosives with extremely high yield, unmanned systems and robotics, neural sciences, electro-magnetic pulse weapons, incapacitating weapons (e.g. weapons that attack the blood-brain barrier), and the threat from foreign-sourced microprocessors with intentional or unintentional flaws. He also highlighted a host of emerging trends. These include the trend towards advanced research moving outside of the USA (particularly for nano-technology research), the trend for warfare to be increasingly robotic, the appearance of synergies between IT, bio, nano and quantum technologies, an increase in life span, and a change in the nature of warfare from explosives-based to anti-electron and on to the targeting of brains (both human and machine).

Mr. Bushnell ended on a positive note, highlighting several ways forward that include web-based education that can improve education world-wide, research on all-threat immune boosters, work on optics rather than electronics, and the potential for the threat of climate change to bring all of humanity to face a common enemy for survival. One particular approach he espouses is the investigation of operational surprise instead of technical surprise. In this context, he discussed the *Mad Scientist* series of workshops at the US Army Training and Doctrine Command. These workshops bring together thirty to fifty leading scientists with good knowledge of vulnerabilities and the ability to think diabolically, to brainstorm how to destroy the United States in the 2030

timeframe. These have proved very effective in informing defence S&T investment. Mr. Bushnell strongly recommends this approach to Canada.

Building Resilience & Foresight Capacity to Anticipate Disruption and Strategic Surprise

Mr. Jack Smith, Director, Proteus Canada Institute Inc. and Adjunct Professor, Telfer Management School, University of Ottawa and Co-Director of the Telfer Foresight Leaders Forum.

In March 2010, Mr. Smith completed 33 years of federal government service spanning several departments and agencies. From 2008-2010 he served as Senior Advisor to the Chief of Staff Defence R&D Canada, focused on federal S&T foresight development. From 2004-2008 he served as Director of Science & Technology Foresight for the Office of the National Science Advisor, Government of Canada. From 1989-2003 he was Leader of the NRC Corporate Office of Technology Foresight, Senior Corporate Strategist and Manager Planning and Assessment for the National Research Council of Canada. Mr. Smith brings over 20 years of federal government policy, technology and innovation program development experience to his futures and foresight work. Since founding the Office of Technology Foresight at the NRC in 2002, he has led or been an advisor to collaborative foresight projects in several emerging S&T domains such as: bio-systemics; nano-bio-info convergence; bio-products; future fuels for APEC economies; animal health; bio-health innovation and stewardship, and future professional readiness for physicians and veterinarians. Mr. Smith is Chair of the Foresight Synergy Network (FSN) of Canada, a member of the International Advisory Board for the APEC Centre for Technology Foresight in Bangkok and a member of the Technical Committee for the European Commission's Future Technology Assessment Conference. He has a BA Hon. from Queen's University and a Masters Sc. from Cornell University. He also is or has been a member of: the Canadian Association for the Club of Rome, the Association of Professional Futurists, the International Institute of Forecasters (IIF), the Society of Competitive Intelligence Professionals (SCIP) and the Canadian Association of Business Economists (CABE), and he is the author of articles for Frontline, R&D Management, Foresight, Futures, Science and Public Policy, Policy Options, Technology Forecasting and Social Change and the Innovation Journal on technology futures, security and strategic management.

Mr. Smith provided a presentation on foresight and its relevance to institutions such as DRDC and the government of Canada. He also described a gaming platform, named Proteus, which enables players to learn collaboratively about contingent actions and generate fundamental insights about the future. Mr. Smith began with an overview of resilience and how foresight can contribute to resilience through the monitoring of weak signals and horizon scanning. Resilience is recognizing that there really are unknown unknowns. Foresight requires a balancing of the probable and possible with the plausible and contingent. Unfortunately, many organizations are inward-looking and do not exploit foresight sufficiently to avoid institutional surprise. He then presented some context for the discussion of avoiding S&T disruption through foresight. He offered a categorization of the sources of disruption, including linear mind sets, new societal models of behaviour, self-deluding narratives as well as unavoidable such as natural disasters, and unthinkable doomsday events. He then offered lists of areas of S&T that enable disruptions – quantum computing, cyber agents, nano-robotics and smart organics to name but a few, and areas where foresight has indicated future investment is needed, such as neuro-cognitive science, human system and personality modeling (again, only naming only a few from a longer list).

Mr. Smith then described how the Proteus foresight toolset uses collaborative learning to increase resilience by enabling players to enter the mindset that would result from a true disruption. An alternative description of this subtle mindset shift is to replace “what if?” analysis, which remains hypothetical, to a “what then?” analysis, which requires participants to assume an event or disruption has occurred, place themselves in the situation, and look for solutions. This is the foundation of the Proteon methodology - exploring how organizations can restore order after shocks.

The output of the Proteus approach is a set of insights, currently in the context of the year 2020. These include insights on how today’s technologies and methods tend to focus on events that have already occurred (so-called *starlight*), how it is possible to hide discrete events and trends despite ever increasing globalization and connectivity (so called *sanctuary*), how truth and authenticity becomes elusive, sometimes irrelevant in a future complex, interconnected, and fast-paced world (*veracity*), how people and groups, their ideas, beliefs, loyalties and affinities can have highly correlated dynamics (*herds*), and how the organisational agility to create new partnerships, customers and relationships becomes critical as the pace of change increases (*bedfellows*).

Each of these insights can be further explored – and Mr. Smith offered further detail on *starlight* and *veracity* in particular – but the bottom line is mechanism to generate and explore these insights is key foresight tool for increasing resilience.

4 Approaches to Resilience and Agility

This session, chaired by Mr Paul Comeau, Director Science and Technology Integrated Capability, focused on approaches required by organizations to reach agility and resilience. In order to be prepared for unexpected events, agility and resilience are two critical characteristics that organizations are looking for. The three speakers in this session presented perspectives on approaches that would lead organizations to reach agility and resilience. The three approaches included (a) modeling including dimensions or optimizing behaviours; approaches centered on the creation of networks that provide the first responders the ability to decide and act; and the importance of S&T and the critical linkages between scientific communities.

Organizational Agility

Dr Philip S. E. Farrell, Defence Scientist, Defence R&D Canada

In his current position, Dr. Philip S. E. Farrell works as a Thrust Coordinator within the Directorate S&T Integrated Capability. Dr. Farrell holds three degrees from the University of Toronto including a Ph.D. in mechanical engineering specializing in fluid dynamics and control theory. Dr. Farrell's current expertise is in the area of Human Factors and in particularly human systems design and multiple agent interaction. This has helped him explore a variety of research topics with his international colleagues including the Human Factors of Uninhabited Military Vehicles, effects-based thinking, comprehensive approach and interacting organizations, and most recently C2 Agility and Requisite Maturity.

This presentation was offered in replacement for Dr David Alberts, who works with Dr Farrell on a NATO panel SAS-065 addressing specifically the problem of agility in organizations. To define Organizational Agility, Dr Farrell proposed 6 dimensions to agility: Robustness, Resilience, Responsiveness, Flexibility, Innovation and Adaptation. Agility is the ability to recognize a change in a situation complexity, and therefore the need to transition between C2 approaches. Such Governance and Management (GM) approaches can transit from conflicted, de-conflicted, coordinated, collaborative and edge states. Dr Farrell presented an interesting 3D model including three axes, one referring to the Distribution of the Information among team members, another referring to the Distribution of the Decision Rights among team members and finally, the other one related to the Pattern of Interaction among team members. Levels on these axes define the type of GM approaches. Dr Farrell suggested in his presentation that changing the GM approach over time with compensatory and adaptive methods would lead to more agile organizations while changing it with only compensatory methods would lead to less agile ones.

Dr Farrell concluded by proposing four other dimensions or optimizing behaviours to reach agility, including adaptation, compensation, anticipation and learning. Organizational agility can be reached by the organization's inherent ability to optimize its own attributes using those behaviours.

An Agile Force for a Resilient World – How to be prepared to be surprised

Professor Mihaela Ulieru, University of New Brunswick

Professor Mihaela Ulieru holds the NSERC Canada Research Chair in Adaptive Information Infrastructures for the eSociety since 2005 when she also established at the University of New Brunswick (with Canada Foundation for Innovation funding) the Adaptive Risk Management Laboratory (ARM Lab). Her areas of research include complex networks as a control paradigm for complex systems and the vulnerabilities arising from the interplay between social organization factors and interdependent physical infrastructures, targeting the increase in effectiveness of public safety and security operations through the deployment of digital ecosystems. Professor Ulieru obtained her PhD (1995) in computational intelligence applied to systems diagnostics at Darmstadt University of Technology, Germany. Professor Ulieru is an expert in distributed intelligent systems, topic on which she is a frequent keynote and Tutorial speaker as well as distinguished visiting professor internationally.

For Professor Ulieru, risk and uncertainty are integral parts and can not be eliminated from systems-level thinking about large organizations and society as a whole. Rather, peoples need to learn to embrace risk and uncertainty as they consider national security. Her thesis is that the full societal *system* needs to be strengthened in order to create a more resilient world.

For Professor Ulieru, a step toward this objective is the creation of *Self-Organizing Security (SOS) Networks*. The rationale for this approach is to infuse agility in the joint first responder forces by enabling the power of decision to be vested with the lowest level elements – those at the edge, away from the power centers. With such a conception, it was not surprising to hear Professor Ulieru claiming the importance of social science to reach social resilience. She suggested a shift toward a new society that stimulates participation by rewarding initiative and courage to take creative action; that ensures that there are sufficient “safety nets” (SOS networks) that can absorb the recovery from catastrophic surprise; and ensures that these “safety nets” can be easily deployed.

Her approach opens the possibility of implementing an agile organization that “self-organizes” around the needs of an evolving crisis through emerging leadership that creates operational units as the situation demands. With such SOS networks, communication and coordination between these networks are critical elements. Professor Ulieru made an interesting analogy between these SOS networks and the human nervous system. To ease the communication among participants in an SOS network, and the rapid implementation of such SOS network, Professor Ulieru suggested that linking partners in the SOS network should be on the basis of linking processes while allowing individual execution according to those processes.

Professor Ulieru presented agent-based modelling and simulation efforts that support the SOS Network concept. These models and simulations enabled her team to quantify how manageable a “meta-organization” is; to evaluate the sustainability of the “meta-organizational” architecture model; to diagnose and monitor the process flows; to check if the process is critically complex; to evaluate holistic risk-exposure measures; to establish the general state of health of an organization; and to simplify the process flows.

According to Professor Ulieru, the biggest challenge in the development and implementation of SOS network approach to security systems dynamics is the need to balance the “top-down” command and control with the “bottom-up” emergent collective behaviour. She stated the importance of optimizing sharing of information, teamwork and a collaborative working environment to overcome the challenge.

Covering the Full Spectrum of Risk – Foresight for Cataclysmic Threats and Planetary Resilience

Dr Shane Roberts

Dr Shane Roberts has been working as a futurist on problems in long-range risk-assessment for the federal department of Public Safety Canada, first in the Strategic Policy Division and now in the Science and Technology Division of the Emergency Management and National Security Branch. His focus is on emergency preparedness for catastrophic risks posed by natural disasters and asymmetric warfare. In addition to substantive issues in major global and North American trends, potential surprises and risks (covering human-made and natural threats/hazards and vulnerabilities), Shane is working with colleagues in the Canadian and allied governments on qualitative and quantitative analytical challenges in futures, forecasting and "foresight" studies, and the theory and methodology of risk assessment.

In his presentation, Dr Roberts exposed situations with extremely low level of probability but extremely high consequences (those that comprise planetary history) in order to illustrate the importance of being prepared and resilient to these events. Dr Roberts stated that understanding these risks is being pursued on the frontiers of science, and the means of responding to them being chased in visions for the technology of tomorrow. Frontiers of Science include five spaces: Deep Space; Outer Space; Near Space; Sub Space and Inner Space. This talk focused on the Outer and Near Spaces. Risks in the Near Space are related to volcanoes eruptions, Earthquakes and other natural disasters. For the Outer Space, asteroids and comets striking the Earth were presented. He also talked about six scientific publications from which he extracted some important contributions. First, he raised the importance of understanding the meaning of “low probability”. These events are rare, but they are happening. Second, he stressed the importance of looking at risks with potential impacts of a planetary scale and the need for global systems across the “pillars” of Emergency Management (EM). Third, he suggested the use of Science & Technology (S&T) as a means to understand risk, its continual evolution, and as a source of solutions. Dr Roberts also presented steps taken towards planetary preparedness for these types of events. Among them, there is growing support to EM from Earth Observation (multilateral partnerships of governments and S&T communities. For Dr Roberts, extreme S&T are required for extreme emergencies. He listed some S&T such as SILT (Sensor, Identifier, Locational Technologies (GPS, GIS, etc), Internet-enabled collaboration, Artificial Intelligence, Robotics, and Biomimicry & Stigmergy. He also raised the importance of harnessing e-collaboration and cybernetic surge-capacity, the creation of virtual operations centre and human first responders. Dr Roberts suggested that the planetary preparedness for EM must be made from evolution and transformation that would lead to the development of new relationships for new capabilities. Innovations from S&T must be the driving force. To steer developments, dynamic partnerships are required among S&T, the military and EM communities.

5 Agility and Resilience - Applications

This session, chaired by Dr. Craig Maskell, Director S&T Intelligence examined potential approaches to agility and preparing for the future. Two basic yet different approaches were explored: The first can be seen as more systematic and based on traditional planning methodologies, while the second approach is built on the belief of the fundamental unpredictability of the future.

How to Ride Black Swans: Strategic Security Planning under Deep Uncertainty

Mr. Stephan de Spiegeleire, the Hague Centre for Strategic Studie

Stephan de Spiegeleire studied Slavic Philology (B.A., K.U. Leuven, 1984) and International Affairs (Master's degrees from the Graduate Institute for International Studies, Geneva 1986; and the School for International and Public Affairs of Columbia University, New York 1987). Mr. de Spiegeleire's academic career got sidetracked by a professional career which he started at the RAND Corporation in 1989 as a Sovietologist, where he stayed in various capacities for 10 years. His work at RAND was interrupted by stints at the Stiftung Wissenschaft und Politik (Ebenhausen, Germany, 1993-96); and the Western European Union's Institute for Security Studies (Paris, France, 1996-99). Currently, Mr. de Spiegeleire is Senior Scientist at the The Hague Centre for Strategic Studies. He also teaches at Webster University in Leiden and at a number of military academies throughout Europe. Mr. D de Spiegeleire has published widely in many fields, but is currently most actively in the application of new ideas such as adaptive planning, security resilience, network-centrism, capabilities-based planning, and meta-foresight for national and European security policy planning in the broader sense (homeland security and external action). His two recent books are a Planning Guide for Defence and Security Benchmarking, which has now been validated by the Dutch MoD and is used for all major MoD policy and acquisition decisions; and Closing The Loop - Towards Strategic Defence Management, a benchmark study of defence planning in a number of different countries. He was the Lead Subject Matter Expert for NATO Allied Command Transformation's Multiple Futures project; and is currently providing analytical support to the project team of the Netherlands' major bottom-up defence review ('Verkenningen').

Mr. de Spiegeleire presented results from the Dutch government's Future Policy Survey, which was an examination of options for the future of defence efforts in the Netherlands. Part of the strategic function of the armed forces is anticipating and preparing for unforeseen developments, so-called "unknown unknowns" or "black swans". This kind of anticipation has changed from the Cold War era, where the future threat was generally thought to be well-known. However, following the end of the Cold War, new scenarios were generated which covered the spectrum of anticipated threats, albeit lacking a quantifiable notion of uncertainty associated with them. To better incorporate uncertainty, nations are building in branches around these scenarios to parameterize them.

The Netherlands is now implementing the concept of meta-foresight (a summary of a collection of other foresight exercises), sidesight (incorporating practices from other defence and non-

defence organizations), and hindsight. The methodology for capturing, analyzing and displaying this meta-foresight was also presented, including risk and impact assessments, as well as the need to use foresight as the basis of strategic planning. Mr. de Spiegeleire made the point that agility has so far been seen as operational and not strategic. Strategic agility is what is required, since otherwise making irreversible choices are the equivalent of placing large bets on the future which can be very costly and difficult to recover from. The ultimate goal of this project is to create a strategically agile organization.

Agility and Time, Resilience and Death: Distinguishing Tactics from Strategy – An Opportunity for Leadership?

Riel Miller, XparadoX

Riel Miller is a specialist in long-run strategic thinking and the design of advanced foresight processes. For over twenty-five years he has assisted senior decision makers to assess and direct the potential for socioeconomic transformation in both the private and public sectors. His extensive publications address a range of issues, from futures methodology and the design of scenario processes for strategic decision making to the future of money, education, the internet, the knowledge society, the public sector, etc.. He is one of the world's leading practitioners of scenario methods and now designs cutting-edge "hybrid strategic scenarios" processes for a wide range of international clients. Dr. Miller started his career as a professional economist in the early 1980s at the Organisation for Economic Cooperation and Development's Economics and Statistics Directorate. From the mid 1980s up until 1994 he worked in four different areas of the Ontario Government: the Legislature, the Ministry of Colleges and Universities, the Ministry of Finance, and the Ministry of Economic Development and Trade. At the beginning of 1995 he returned full-time to the OECD as a Principal Administrator in the International Futures Programme. In 2005 he left the OECD to establish an independent consultancy, xperidox: futures consulting, Paris. His current and recent client list includes public and private sector organizations in more than twenty-five countries. He has taught courses at undergraduate, graduate and professional continuing education levels at institutions around the world. He is currently a member of the Board of the Association of Professional Futurists; a faculty member at the Masters in Public Affairs, Institut de Sciences Politique (Sciences-Po), Paris, France; and a Fellow of the World Future Studies Federation. Born in Canada in 1957, he holds a Ph.D. in Economics from the New School for Social Research in New York, MA from York University, Toronto and a BA from Carleton University, Ottawa.

The main focus of Dr. Miller's presentation was how to relate the future to the choices that are made today. His thesis is that the nature of decision-making is changing and the military is in a pivotal position to change the decision making processes in society.

Creativity is inherently unpredictable, and it is therefore not possible to determine in advance what the creative/innovation process will produce in the future. As a consequence of this unpredictability, Dr. Miller claims, planning is an illusion. The decision-making process must embody not only hierarchical principles as it does now, but also heterarchical ones, i.e. coupled decision making bodies that are not subservient to one another. Dr. Miller used several examples to illustrate how processes produce unpredictable results, and in which decisions emerge,

including a biological example of a flock of starlings, which he termed a *murmuration* - a community with rapid birth, death and exit as individuals join the flock, and whose overall behaviour appears both coherent and chaotic.

The evolution in the quality of the picture of the future and the present decision-making capacity is approached in three ways. The first is through the use of *anticipatory systems* to define the future, which is composed of three dimensions: contingency (as coming from outside), optimization (the expected), exploration (the creative). An anticipatory system is able to exploit all three. A second approach is to *reframe the possibilities* in order to make one open to creativity and spontaneity, an economic example of which was a “learning intensive society”, where value is attributed to creativity, as opposed to the production of goods of the supply-and-demand model. Third, *challenging assumptions* is necessary to engender the change in the decision-making process which alters the basic beliefs we have about the future. Through futures literacy, he argued, it is possible to have a strategic approach to agility and resilience by embracing uncertainty, imagining changes in how change occurs, and formulate possibilities about the potential of the present.

RMA Redux: The Promise and Peril of Information and Communication Technologies

Paul Mitchell, Deputy Chair, DMPO, Canadian Forces College

Dr Mitchell holds a BA (Hons) from Wilfred Laurier University, a MA in War Studies from King’s College London, and a PhD from Queen’s University at Kingston. Following the completion of his doctoral studies, he worked as a post-doctoral fellow at Dalhousie University in Halifax in the Centre for Foreign Policy Studies, where he assisted with the production of the Canadian Navy’s “Adjusting Course” strategy. He also worked as Directing Staff at the Pearson Peacekeeping Centre on their Maritime Peacekeeping course in 1996 and 1997. He has worked at the Canadian Forces College since 1998, first as the Deputy Director Academics, and later as its first Director of Academics (DAcad). As DAcad, Dr Mitchell oversaw the development of the Master of Defence Studies degree following accreditation of the Command and Staff Course by the Ontario Council of Graduate Studies in 2001. Dr Mitchell was awarded the Literary Award by the United States Naval Institute and the Surface Naval Association for his paper on Network-Centric Warfare and Small Navies in 2003, the first non-American and the first civilian to be so recognised. He recently was published in the International Institute for Strategic Studies’ prestigious Adelphi Paper series with his Network-Centric Warfare: Coalition Operations in the Age of US Military Primacy. Dr Mitchell is continuing his research on the impact of networks on military operations, particularly with regard to coalition operations and will publish an expanded study with Routledge in the summer of 2008. He is also working on how modern technology is confounding traditional analyses of military power and on a text on the use of film to teach concepts of strategic studies.

Dr. Mitchell discussed the promise and false beliefs associated with information communication technology (ICT) as a cautionary tale about imagining the disruptive effects of emerging technology. Dr. Mitchell started by examining the beliefs that were held about the tactical use of nuclear weapons in the 1950s and how they affected military operations. He encouraged the audience to think critically about the notion that ICT would bring about the Revolution in

Military Affairs which has been heralded for some time. He examined the principles and implications of informationalism, as coined by Castells (*Informationalism, Networks, and the Network Society: A Theoretical Blueprint*, in *The Network Society: A Cross-Cultural Perspective*, Northampton, 2004) and what makes information different today than it was in the past. He argues that while ICT can allow the decentralized “power to the edge” it can also lead to a very centralized system created by total information awareness, in a big brother type of scenario. In addition, the use of technology to solve military problems is not generally suitable to address social problems. Dr. Mitchell reasons that rather than trying to predict and control ICT, it should be considered as a wave to be ridden, and that efforts, such as the educational effort at the Canadian Forces College, should be in teaching critical thinking rather than developing technology.

Panel discussion – Contrasting approaches to agility and resilience

Stephan de Spiegeleire, Riel Miller and Paul Mitchell

A lively panel discussion followed, where contrasting approaches -- the more systematic one suggested by Mr. de Spiegeleire (e.g. the use of point-scenarios) versus one built on the belief of the unpredictability of the future and the creative process and advocating a liberal education, as suggested by Dr. Miller and Dr. Mitchell – were hotly debated. During his talk, Dr. Miller warned against “colonizing the future”, meaning that the process of thinking about a possible future can and will affect how the future plays out, and that society needs to re-think how it thinks about the future. Framing the questions which are being asked is important, since these will limit the possible answers which in turn end up being critical decisions with great consequences for institutions such as those represented at the symposium. Perhaps a more sensible course of action is to create security now, rather than create it in the future.

Conversely, in the systematic use of point-scenarios suggested by Mr. de Spiegeleire, security is still seen as a legitimate investment and policy makers need to be able to make decisions that will maximize return on investment. As such, tools are required (of which there are very few) which can help guide policy makers as they make difficult choices. It is important to be able to consider “taboo” scenarios in order for these tools to have credibility – one such a scenario is the breakup of the European Union. In addition, it was acknowledged that uncertainty in these models is not understood or properly modeled or even fully acknowledged. The metaphor of an organizational Swiss-army knife was analyzed by the panel. First, it was used by Mr. De Spiegeleire as a description of the modern defence and security forces - capable of doing many things to varying degrees that result from the investment in capability. The same metaphor was analysed by Dr. Miller as an example how planning fails, i.e. while a Swiss-army knife is capable of doing many things, it does not excel at any particular function. The choice is to apply our collective effort to deciding who we are and what values we hold dear, or to deciding which tools we will need.

Finally, it was generally agreed that the humanities and social sciences should gain greater importance in a resilient and agile S&T organization.

6 Preparing the Canadian Forces and the Department of National Defence

This final session, chaired by Dr. Christian Carrier, Chief Scientist at DRDC Valcartier, focused on the implications and practical activities for the Canadian Forces and DND that can be taken immediately. The session included a presentation on horizon scanning and how to think about the future, a presentation on red-teaming and table-top gaming to assess the disruptive potential of technologies, and a presentation of the Chemical, Biological, Radiological and Nuclear capability development within Canada.

Adapting to rapidly changing technology

Dr. Ian Pearson, futurologist, Futurizon Inc.

Ian Pearson is a full time futurologist, tracking and predicting developments across a wide range of technology, business, society, politics and the environment. He is a Maths and Physics graduate and has worked in numerous branches of engineering, from aeronautics to cybernetics, sustainable transport to electronic cosmetics. His inventions include text messaging, the active contact lens, and active skin. He was BT's full-time futurologist from 1991 to 2007 but now works with Futurizon, a small futures institute. He writes, lectures and consults globally on all aspects of the technology-driven future. He has written several books and made over 450 TV and radio appearances. He is a Chartered Fellow of the British Computer Society, the World Academy of Art and Science, the Royal Society of Arts, the Institute of Nanotechnology and the World Innovation Foundation. In 2007 he was awarded a Doctor of Science degree by the University of Westminster.

Dr. Pearson began his presentation with a description of how to think about the future. He argues that by monitoring current trends, tracking science to spot future potential, then studying how political or economic advantage can be gained, it is plausible to have 85% correctness at the ten year horizon on technological predictions, and perhaps though 50-60% on the twenty year horizon.

Dr. Pearson then provided a key insight for the survival of organizations: *in an unstable, dynamic environment, agility is more important than optimization.* Over-optimization to a niche or market is dangerous because strategies become obsolete. Therefore, organizations need to be able to change fast to survive.

The rest of Dr. Pearson's presentation was dedicated to technological trends and how they will impact the rest of society. He argues that convergence and synergies between technologies and between components of society (so-called virtuous cycles) will lead to an acceleration of technological development. One synergy in particular is the convergence of nano-technology, bio-technology, information technology, and cognitive science (which may soon become a technology).

One of the significant trends Dr. Pearson discussed is the evolution of computer networking. In this context, he discusses the proliferation of very small networkable short-range devices (so called *electronic jewellery*) and the alternative internet and the surveillance challenges that these ad-hoc networks will engender. He also discusses the extension of denial-of-service attacks to more general correlated-traffic attacks, and the emergence of cyberspace communities that are able to wield political power through web-based pressure.

Another significant trend is the forecasted augmentation to the physical human. Enhancements could be cognitive -Dr. Pearson suggests that sensor membranes attached directly on the surface of the brain could be linked with future computing devices, perhaps fabricated by harnessing bacteria to replicate neurons. Enhancements could be physical - Dr. Pearson suggests that active skin could be developed that would not only contain processors, but would provide additional senses that measure magnetic fields, radiation, chemicals in the air or proximity of other people. They can also be display enhancements. Enhancements could be to the interface between the information and the human - Dr. Pearson predicts an evolution of traditional computer monitors to visors that project information directly on the retina, and then to active contact lenses, perhaps as early as 2020.

Dr. Pearson ended with a dire warning. While technology brings many positive aspects to humanity, we must be very careful – we are becoming more and more able, either by accident or intentionally, to eliminate our own species. Dr. Pearson suggests there will be hundreds of technologies that are capable of species extinction in the coming decades and that these will be increasingly easy to develop (the hyper-empowered individual also discussed by Mr. Bushnell), increasingly dangerous and increasingly difficult to police.

Gaming: A tool to identify/assess disruptions or a tool towards agility

Dr. Gitanjali, Adlhakha-Hutcheon, Defence Scientist, Defence Research & Development Canada

Gitanjali Adlakha-Hutcheon's academic qualifications include a Masters with a major in Biochemistry and a minor in Microbiology (India) and a PhD in Pharmacology and Therapeutics (University of British Columbia). Her doctoral dissertation focused on programmable delivery of anti-cancer formulations using nano-particles. Dr. Adlakha-Hutcheon has worked in the Canadian Food Inspection Agency (CFIA) as a Biotechnology Officer, at Environment Canada on the consequences of nanotechnology for the environment. She was awarded the Head of the Public Service Award for excellence in Service Delivery as well as the President of CFIA's commendation award for her role in managing the Mad Cow crisis of May, 2003. She joined DRDC in October 2007 as a Defence Scientist in the Office of the Chief Scientist, DRDC, where she has several roles including the science/policy interface interdepartmental approach on nanotechnology, the Canadian representative on a NATO panel developing methodologies to assess disruptive technologies. Her background combines rigorous academic training and several years of policy work experience in the areas of biotechnology, nanotechnology and sustainable development and more recently in the areas of red teaming for assessing disruptive technologies.

Dr. Adlhaka-Hutcheon started her presentation with a discussion of the definition of disruption, which is generally accepted to be *an interruption or upset of orderly progression*. The NATO

group in which she participates chose to augment this definition in the context of technology, to be a technological development which significantly changes the rules or conduct of conflict within one or two generations and forces the planning process to adapt and to change long term goals.

The thesis for her presentation is that gaming that exploits red-teaming, because of it allows participants to take on adversarial roles, is an appropriate and effective tool for the assessment of the potential for disruption of a given technology. The notion of *red-teaming* is not new. Many organizations in industry and governments use this authorised, adversary-based critical thinking technique to challenge assumptions and explore outcomes. It is a risk mitigation technique as well as a planning tool.

The NATO System Analysis SAS-062 panel developed a table-top gaming methodology called the Disruptive Technology Assessment Game (DTAG), that uses red-blue teaming to categorize emerging technology as disruptive, revolutionary or evolutionary. These games, based usually in 2020 to 2030 are non-computerized, and have a structured process in which red and blue teams develop courses of action independently then meet in a red-on-blue encounter. To assess new technologies, the planning and encounter are then re-played, but in the context of new ideas-of-systems, or IoS, cards that capture the application of a new technology. One output from these games is a countermeasure tree that captures the red and blue counter-moves as the IoS cards are played. In Canada, Dr. Adhalka-Hutcheon is leading a team tailoring the DTAGs to the Canadian context and integrating it within the existing processing for identifying, assessing and scoping potentially disruptive technologies.

Dr. Adhalka-Hutcheon put particular emphasis on the role of these games in sensitizing and socializing ideas and new technologies. It is well documented that individuals and organizations often resist change and the complex dynamics in groups can lead to culturally-induced blinders. By gaming, participants can immerse themselves in the game and break-through the blinders to make objective assessments of the new technologies. This, claims Dr. Adhalka-Hutcheon, is the key to agility.

Resilience and Agility: Preparing the Military for the Unpredictable and The CBRN Defence Program in DND

LCol MacVicar, Director CBRN Defence, Canadian DND

Lieutenant-Colonel Ian MacVicar, a native of Glace Bay, Nova Scotia, transferred to the Regular Force in 1983 after six years in the Reserve Force. He completed the Land Forces Command and Staff Course in 1990. He received the Chief of Defence Staff (CDS) Commendation for his leadership in the implementation of the Chemical Weapons Convention in Canada. He was awarded the Deputy CDS Commendation for his leadership as the Commanding Officer of the first Disaster Assistance Response Team (DART) Company deployment in Honduras in 1998. He was appointed as the first Commanding Officer, from 2002-2005 of the Canadian Forces Joint NBC Defence Company. Upon promotion to Lieutenant-Colonel in 2005 he was employed as Chief Of Staff of 36 Canadian Brigade Group (36 CBG) and CO 36 CBG Headquarters, G5 of Land Force Atlantic Area where he developed emergency response plans for Joint Task Force Atlantic. In 2008, he was assigned as Senior Military Liaison Officer in the Joint Support

Coordination Mechanism with the United Nations- African Union Mission in Darfur. Lieutenant-Colonel MacVicar was assigned to NDHQ Ottawa/Chief of Force Development division on return from Africa in July 2009, holding the appointment of Director CBRN Defence. He holds a Bachelor of Arts (Honours) from Acadia University, a Master's of Arts in International Affairs (Conflict Analysis) from Carleton University, and a Master of Defence Studies from the Royal Military College of Canada.

In his presentation, LCol MacVicar described the inter-related nature of capability development and operations in the Chemical Biological, Radiation and Nuclear (CBRN) community in Canada. He identified the CBRN technologies as areas of great importance, due to the scale of the potential threats they pose, and also areas that require agility and resilience within the community to maintain awareness and countermeasures as these technologies evolve.

He began with a description of the omnibus project on capability development in which his directorate identifies gaps and performs options analysis to select the best CBRN defence for the Canadian Forces. He also described how the directorate develops the concept of operations for the response to domestic or international CBRN incidents – this includes the commanders' intent, the scheme of manoeuvre, the end-state and criteria for context, and identifies how the CF will structure itself to respond to incidents.

The CBRN defence program includes components on Detection, Identification and Monitoring, Warning and Reporting, Protection, Hazard Management, and Medical Countermeasures.

He emphasized how resilience and agility can only be achieved through a partnership between the Canadian Forces, the defence science community and industry to develop up-to-date relevant operational capability.

LCol MacVicar ended with a description of the recent Operation Podium which provided support to the 2010 Vancouver Olympics as an example of the major event planning required in CBRN defence. He highlighted the whole-of-government approach that included a science town that collected the relevant experts in one location and the structure of the organizations that provided S&T support to CBRN at the event.

7 Conclusion

Dr. René LaRose, COS (S&T), brought the symposium to a close with a short reflection on the key concepts, followed by a suggestion and solicitation for ideas for the Colloque S&T Symposium 2011.

While the 2010 symposium brought to the light many future trends and interesting technologies, it is interesting to note that in the end, everything returns to understanding the human, human society and the way humans and society interact with technology. A key insight from a survey of the presentations is that if predicting technology is hard, predicting the outcomes that results from the *interplay between society and technology* is harder. Technological uncertainties exist in the first place because humans invented the technology and use it in new ways. The humanities and human sciences have as big a role in anticipating the future as the technological sciences. Future symposium themes may further explore the interactions of society and technology with sessions that present technological futures alongside societal futures. Importantly this would require presentations from experts on both technology and humanity, in order to provide a holistic base to inform departmental and governmental decision-making.

Through the different facets of society, there is an exponential propagation of advances, only some of which are driven by technology. It is forums such as this symposium that will help prepare the Department of National Defence and the Canadian Forces (DND/CF) to act in a much more interconnected world where the ramifications of developments, S&T developments as an example, are so complex as to appear to be, and for all intents and purposes are, unpredictable. This unpredictability motivates the response – which is to be agile, in order to adapt to and capitalize to changes, and to be resilient, in order to recover *quickly* to disruptions.

However, the hard part is in the doing, i.e. applying what has been explored in this symposium within DND/CF, and setting up processes that can respond quickly. *Speed in innovation* in was noted by several speakers as a key enabler for both agility and resilience.

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Annex A Further Reading Suggested by Presenters and Organizers

The organizers recommend the following books and papers that were suggested in various presentations:

- Taleb, Nassim Nicholas, *The Black Swan: The Impact of the Highly Improbable*, Random House, 2007.
- Evans, Alex and Steven, David, *The Resilience Doctrine*, from the Global Dashboard, <http://www.globaldashboard.org/2009/07/09/the-resilience-doctrine/>, 2009.
- Kahan, J. H., Allen, A.C. and Goerge, J.K., *Concept Development: An Operational Framework for Resilience*, Homeland Security Studies and Analysis Institute, Berkeley Electronic Press, <http://www.bepress.com/jhsem/vol6/iss1/83/>, 2009.
- Economist Intelligence Unit, *Organisational Agility: How business can survive and thrive in turbulent times*, <http://www.emc.com/collateral/leadership/organisational-agility-230309.pdf>, 2009.
- Purdy, M. And Smythe, L. *From obscurity to action: Why Canada must tackle the security dimensions of climate change*, *International Journal*, Spring 2010.
- Mazo, Jeffrey, *Climate Conflict: How global warming threatens security and what to do about it*, *Institute for Strategic Studies*, 2010.
- Paskal, Cleo, *Global Warring: How Environmental, Economic, and Political Crises Will Redraw the World Map*, Palgrave Macmillan, 2010.
- Natural Resources Canada, *Climate Change Impacts and Adaptation: A Canadian Perspective*, http://adaptation.nrcan.gc.ca/perspective/index_e.php, 2010.
- Darilek, R. E., Pirnie, B.R., Drezner, S., Gordon, IV, J., Joe, L. and Perry, W.L. *Issues and Insights from the Army Technology Seminar Game*, RAND, 2001.
- Department of National Defence, *Canada First Defence Strategy*, <http://www.forces.gc.ca/site/pri/first-premier/index-eng.asp>.
- Department of National Defence, *Defence S&T Strategy*, available at Government of Canada Publications <http://publications.gc.ca/site/eng/302094/publication.html>, 2006.
- Department of Defence *Quadrennial Defence Review*, <http://www.defense.gov/qdr/>, 2010.
- Arthur, W. B. *The Nature of Technology: What it is and how it evolves*, Free Press, 2009.

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<p>3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title.)</p> <p style="text-align: center;">Colloque S&T Symposium 2010: Agility and Resilience: Preparing the Military for the Unpredictable Résilience et agilité: Préparer les militaires à faire face à l'imprévisible</p>		
<p>4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)</p> <p style="text-align: center;">Hubbard, P.; Staples, B.; Breton, R.; Myers, V.; Ducharme, M.</p>		
<p>5. DATE OF PUBLICATION (Month and year of publication of document.)</p> <p style="text-align: center;">September 2010</p>	<p>6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)</p> <p style="text-align: center;">49</p>	<p>6b. NO. OF REFS (Total cited in document.)</p> <p style="text-align: center;">0</p>
<p>7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)</p> <p style="text-align: center;">Technical Report</p>		
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Defence S&T Symposium 2010 explored the Canadian Forces (CF) readiness in facing the inevitable disruptions that come with the globalization of S&T. The symposium featured sessions exploring the nature and cause of technology-enabled disruptions, approaches and best practices for their mitigation and exploitation, and solutions toward achieving greater organizational resilience and agility. Participants from the Department of National Defence, the CF, other government departments, academia and Canada's allies were invited to share their experiences, discuss the global dynamic environment of S&T and probe how to prepare the military for a world of uncertainty and technological surprises.

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Resilience, Agility, Disruptive Technologies, Horizon Scanning, Capability-Based Planning, Force Development, S&T Investment