RMA & The Human Factor:

A Seat at the Table for Canadian Defence R&D

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Introduction

The fora in which the Canadian government has decided to deploy its military forces in the last century could not have been predicted. There is no reason to believe that the predictability will be better in the 21st century. Far more predictable is the axiom that a significant proportion of military research and development (R & D) activities currently underway will generate technologies exploited for future warfare applications. In other words, some of today's R &D will result in tomorrow's weapons and/or the technologies required to defend against those weapons.

In late 1998, experts from the military, industrial, scientific and political communities gathered in Ottawa to discuss the implications for the Canadian Forces of the Revolution in Military Affairs (RMA), the technology-driven tidal wave that has been embraced by the US and other traditional Canadian allies. At that gathering the Minister of National Defence stated that even though the 1994 White Paper on Defence did not mention the RMA, a key premise in that document was interoperability; for that reason alone, he stated, "Canada has no choice but to get on board."[1] VAdm Garnett, Vice Chief of the Canadian Defence Staff, challenged Department of National Defence (DND) strategic and scientific staff to develop a Canadian perspective on the RMA. He questioned publicly whether Canada can afford the fiscal commitment demanded by jumping on the RMA bandwagon "given the need to respond to floods, ice storms and offshore challenges."[2] In this regard the most recent iteration of the vision for the future Canadian Forces (CF) advocates accepting the technology challenge of RMA, primarily

[1] Hobson, Sharon. "Canada seeks vision of a military future." Jane's Defence Weekly 01 Dec. 1997: 5.

in order to facilitate coalition or combined operations with the United States.[3] Therefore this paper will not argue whether or not Canada should embrace the RMA; the public declarations of high ranking DND/CF officials that we must do so are accepted at face value.

A key issue then becomes the identification of the future contribution that Canada can make to operationalizing the promise of RMA technologies. No strategic direction in this regard has yet been publicly identified by the CF. This vacuum is disconcerting because, as in other areas of collaborative defence activities, it is likely that the ticket price for passage through the gate accessing US-driven RMA technologies will include expectations of a contribution to the collaboration. The progressively downward sloping trend in both the absolute Canadian defence dollars spent on research and development (R&D), as well as the relative proportion of the defence budget spent on R&D, does not augur well for Canada's ability to pass through that gate.

The main thrust of this paper is that Canada should not pretend to be able to engage independently in the myriad of defence R&D areas required to fully exploit RMA. It will be argued that DND/CF should therefore follow a "niche area" strategy by focusing its R&D resources. To that end this paper will review some of the sobering considerations that are currently moderating the enthusiasm with which RMA was initially received. Some attention will be given to arguments against the presumption that

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[2] Garnett, Gary. "Canadian Defence Beyond 2010." (slide #7). Symposium on DND and CF Beyond 2010. Dept. of National Defence. Ottawa. 30 Nov. 1998.
[3] Canadian Defence Beyond 2010. The Way Ahead. (Draft Copy). (1999, 26 February).Ottawa: Dept. of National Defence Management Committee Concept Paper.

the technologies underlying the RMA will "lubricate" Clauswitzian friction and lift the "fog of war." It is this aspect which suggests a candidate niche area in a R&D technology area that has been relatively neglected, and which is coincidentally an area where Canadian defence R&D capabilities excel, are respected, and frequently sought by US military R&D establishments. The reference is to "human factors," i.e. those human cognitive, behavioral, and physical characteristics and capabilities that should be the basis for delimiting and defining the means by which RMA technologies can be integrated with the "human system."

RMA Primer

> *"A Revolution in Military Affairs is a major change in the nature of warfare, brought about by the innovative application of new technologies which combined with dramatic changes in military doctrine and operational and organizational concepts, fundamentally alters the character and conduct of war. The Revolution in Military Affairs consists of four new warfare areas: Information Warfare, Precision Strike, Dominating Maneuver, and Space Warfare."*[4]

This paper will not enter into a detailed description of the core technologies purported to comprise the RMA, nor whether the applications of these technologies to warfare and defence do indeed represent a "revolution." Much ink has already been devoted to such discussions and the interested reader is referred elsewhere for detailed descriptions of RMA concepts and the underlying technologies.[5,6,7,8,9] Suffice it to state

[4] Mazar, Michael et al. Military Technical Revolution. Washington, D.C.: Center for Strategic and International Studies, 1993.
[5] Joint Forces Quarterly. (1997, Spring). 6-49. Special edition which includes several articles on RMA, all of which list related references.
[6] Owens, William. "The American Revolution in Military Affairs." Joint Forces Quarterly 10. Winter (1995-96): 37.

that it is the integration of such technologies that really characterizes the RMA. This integration was conceptualized in the mid 1990s by US Admiral William Owens, then vice chairman of the US Joint Chiefs of Staff, who developed the idea of an integrated "system of systems" that will enable a military user to employ sensors (e.g., satellites, shipborne radar, remote acoustic devices), global positioning sensors, and precision guidance munitions in concert to not only locate, fix, and "kill" military targets, but to also do so from afar. [10]

American military technological superiority is uncontested currently, but Americans themselves question their ability to sustain this superiority without substantial input from allies. [11] Yet all G7 countries have reduced their military R&D budgets over the last five years and only France and the USA are attempting to engage in R&D across a broad range of systems.[12] Such a trend suggests that Canada and her allies will become increasingly dependent on US technology and intervention, when required, in the future. Our allies are taking steps to facilitate interoperability with the USA by undertaking selected aspects of the US-led RMA and appear to have identified niche areas for their

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[7] Odom, William. America's Military Revolution: Strategy and Structure after the Cold War. Lanham, MD: American University Press, 1993.
[8] Blaker, James. "The American RMA Force: An Alternative to the QDR." Strategic Review 25.3. Summer (1997): 21-30.
[9] Kagan, Frederick. "Wishful Thinking on War." Weekly Standard. 15 Dec 1997: 27-29.
[10] The US Joint Warfighting Science and Technology Plan can be consulted for more detail about the myriad of strategic concepts which they have deemed to be key to the implementation of RMA technologies: concepts such as "information superiority," "precision force," "dominant manoeuver", "full dimensional protection," "combat identification." http://www.dtic.mil/dstp/98_docs/jwstp/jwstp.htm as of 05 April 99
[11] Blank, Stephen J. "Preparing for the next war: reflections on the revolution in military affairs." Athena's Camp: Preparing for Conflict in the Information Age. Ed. J. Arquilla and D. Ronfeldt. Washington: Rand Corporation Report MR-880-OS/RC, 1997. 62.
[12] SIPRI Yearbook 1998: Armaments, Disarmament and International Security. New York: Oxford University Press, 1998, 265-289.

involvement [13,14] For example, the UK's Strategic Defence Review (SDR) of July 1998 indicates that their future defence R&D will focus on intelligence, surveillance and reconnaissance, and C^3 technologies.[15] They will invest in unmanned aerial vehicles (UAVs) for surveillance, as well as airborne radar aircraft. For command and control, their SDR is focusing on technologies that enable it to work effectively in multinational operations. A review of the public government defence planning documents of other allies such as France, Australia, Germany, Netherlands indicates that they plan to focus on very similar areas of R&D investment, also with the justification of keeping pace with the RMA.

Canadian Defence R&D Realities

From a Canadian perspective, DND/CF acknowledged that the fact that our most important ally is fully engaged in the pursuit of the RMA means that we have little choice other than to join that pursuit in some manner in order to ensure continued interoperability.[16] Optimists have suggested that this can be achieved with a Canadian government/industry partnership adapted to meet the technological demands of joining

[13] Hewmish, M and Pengelley, R. "Future soldier systems - Looking for the payoff from modernization programs." Jane's International Defense Review 31.12 (28 Nov. 1998): 54.
[14] The Technical Cooperation Program) (TTCP) is an organizational for collaborative non-atomic military R&D (NAMRAD) among the governments of the Australia, Canada, New Zealand, UK, USA. The minutes of the 33rd meeting of the NAMRAD Principals includes instructions to one of the organizations groups, i.e. the Joint Systems and Analysis Group, to address the RMA. The Chief of the Dept. of National Defence Research & Development Branch is the coordinating authority for Canada's representation in TTCP. The Technical Cooperation Program. Minutes of the 33rd Meeting of the NAMRAD Principals. 27 Oct – 03 Nov. Halifax and Ottawa: 1998.
[15] See UK Defence White Paper and the Strategic Defence Review at http://www.mod.uk/policy/sdr. Chapter 5 (The Future Shape of our Forces) and Chapter 7 (Equipping the Forces) are of direct relevance.
[16] Canadian Defence Beyond 2010. The Way Ahead. (Draft Copy). (1999, 26 February). Ottawa: Dept. of National Defence Management Committee Concept Paper.

the military technological revolution.[17] This writer is not so optimistic, primarily because of the picture depicted in the Table below which shows the lack of willingness to commit significant defence dollars to R&D, including support of related industrial/commercial R&D capabilities. Moreover, the recent US revocation of Canada's favoured status as a defence and aerospace trading partner has very severe implications for the long term economic viability and survival of Canada's military industrial base.[18]

Table 1. Financial Investment in Defence R&D.[19]

	Total Defence Spending ≈$000	Defence R&D ≈% of defence budget
Canada in Y1947 C$	240,000	5
Canada in Y1999 C$	10,000,000	2
UK in 1996 C$	47,2000,000	9.5
Australia in 1996 C$	10,600,000	2.0
Netherlands in 1996 C$	9,800,000	1.3
France in 1995 US$	45,000,000	11.0
Germany in 1995 US$	40,000,000	5.5
Sweden in 1996 C$	7,000,000	10.0
USA in Y2000 US$	267,000,000	13

Presuming that financial investment reflects commitment, Table 1 shows extensive erosion of support to Canadian defence R&D over the last half-century. Although it seems intuitive that the most appropriate time to be innovative and invest in military R&D is during relatively calm periods, so as to be adequately prepared to exploit that R&D in the future, there appears to have been another (hidden) logic at play within

[17] Latham, Andrew. "Military-Technical Revolution: implications for the defence industry." Canadian Defence Quarterly June (1995): 18-22.
[18] Morton, Peter. "U.S. Move Threatens Canadian Defence Industry." National Post 17 April 1999.

the CF and DND. The purpose of showing in the above table the corresponding figures for United States defence spending is not to highlight the obvious; no country spends as much in absolute dollars on defence or related R&D. What is noteworthy, however, is the proportion of the defence budget that is spent on R&D. Canada's status in that regard indicates the relatively low priority that is placed by the CF/DND on R&D in comparison with allies. The US have acknowledged the requirement to invest heavily in R&D in order to achieve their high technology objectives and this is manifested in the relative proportion of their defence budget which is so dedicated.[20] Moreover, next year about US$2 billion or 6% of the US defense R&D budget, is to be allocated to its high risk Defense Advanced Research Projects Agency (DARPA).[21] DARPA epitomizes the risks that are associated with a desire to be innovative in R&D; the DARPA is satisfied if even only a very small proportion of the funded projects are successful (Canadian defence scientists drool at the thought). This type of commitment demonstrates the resources that are needed to keep pace with technology development and the exploitation of such technologies for the RMA.

What is the insurance premium to be paid by the DND/CF to ensure that we will continue to remain abreast and have access to RMA. There is little doubt that we will remain a desired future coalition partner with our traditional allies, if not for the quantitative significance of the actual military contribution then perhaps for the political significance. "A coalition of the willing...may be a good start, but it should also be a

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[19] All budgetary figures were obtained from official federal government defence or defense department internet websites and from SIPRI Yearbook 1998: Armaments, Disarmament and International Security. New York: Oxford University Press, 1998.

[20] http://www.defenselink.mil/news/Feb1999/b02011999_bt032-99.html

coalition of the ready and able."[22] This statement is particularly applicable in light of the speed of conversion of RMA strategy into doctrine and operations. In order to avoid becoming militarily irrelevant and a burden in future coalition operations, Canada must therefore buy its seat at the RMA table. It does not seem prudent to advocate an investment of the limited R&D dollars across a wide range of technologies. Thus, the proposal in this paper is that Canada should identify and declare its focus on a niche technology. Such a strategy would be much akin to the entry price Canada paid for access to NASA's space programme: the Canada Space Arm. Significant federal government R&D grants and subsidies to the commercial sector which developed the arm, bought entry for the Canadian Space Agency that would probably otherwise not have been available. Canada must find a RMA technology niche; we cannot afford anything more...nor anything less. The alternative is to be excluded from future US-led coalition operations precisely because "willingness" is not synonymous with "readiness."

The suggestion for concentrating work in a niche R&D area, with the specific objective of making a meaningful contribution to the RMA, is a radical departure from the current plans of the DND branch responsible for defence, the Defence Research and Development Branch (DRDB). To its credit, the DRDB has acknowledged that available resources will not enable it to continue the status quo in terms of the number of R&D areas in which it is currently active. They have recently identified those technologies which they anticipate nurturing "in-house", those which will be addressed in partnership with the civilian sector, and those which will involve complete reliance on adopting

[21] http://www.arpa.mil/budget.html

civilian developments.[23] Although it is not the purpose of this paper to discuss the various technologies, they will simply be listed here for reference purposes. The following technologies fall into the first class mentioned above, i.e. those that will receive future increases in R&D investment geared at improving the DRDB's own capabilities for independent R&D: "smart materials, embedded sensors, novel energetic materials, autonomous intelligent systems, human systems interaction, biomolecular engineering, knowledge management, modeling and simulation, artificial intelligence." Those R&D areas falling into the second class described above are: "laser technology, structural materials, high-resolution imagery, human performance and capabilities, wide-bandwidth communications and networks." In the third class of R&D areas, i.e. those that the DRDB has declared, *a priori*, future dependency on civilian developments, are the following: "microelectronic materials and components, nanotechnology and microminiaturization, massive computing, power sources, software engineering."

This proposal does not advocate the wholesale dismantling of R&D in all other areas except a niche. Canada has expertise across a broad spectrum of the military R&D areas described above, and the DRDB has clustered these areas into three general spheres: Combat Systems, Sensors and Information Technology, and Human Systems.[24] An R&D "niche focus" could be achieved by de-emphasizing either the "Research" or

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[22] Freedman, Lawrence. The Revolution in Strategic Affairs. Adelphi Paper 318. New York: Oxford University Press, 1998, p. 37.
[23] Looking Forward, Staying Ahead. (1998, September). Ottawa: Defence Research and Development Branch.
[24] Roy, Roger L. (Ed.) A Technology Investment Strategy for the Defence R&D Branch. Ottawa: Defence Research and Development Branch. April 1998.

the "Development" in one or more of the spheres or by further reducing the scope of the spheres over and above that discussed in the preceding paragraph.

The proposal presented here is that DND declare to its allies that its contribution to RMA will be in the area of Human Factors R&D, and then focus its resources accordingly. Are Human Factors likely to be a confounding variable in future warfare? In rationalizing the requirement for Human Factors R&D, it is somewhat ironic that this paper now turns to Clausewitz, the 19th century Prussian military strategist, to support the significance of human factors limitations in future warfare. The following section outlines some of the arguments against wholesale dependency on the promise of technology alone as a guarantee of victory in future warfare,.

RMA as a Lubricator and De-fogger

Rather than turn into a sadistic exercise what was for this writer a masochistic one, the reader will be spared a physiologist's interpretation of Clausewitz's convoluted labyrinth "On War."[25] Hopefully it will suffice to direct to the primary source those who wish to study and parse the original related text. A brief mention of the key concept of "friction", however, is merited as it relates to RMA technologies. In Book One chapters four through eight, Clausewitz describes the degrading effects of battle stresses on what behavioral scientists would today classify as cognitive performance, individual affect, and the accuracy of decision-making. "Linear, predictable relationships are hard to come

by (in war)."[26] This is one of the clearer, if perhaps simplistic, explanations of the concept of "friction" repeatedly referred to by Clausewitz as one of the key elements that impedes progress during war in a chaotic fashion.

From his interpretation of "On War", Watts listed the following causes of "friction" on the battlefield that were identified by Clausewitz as being endemic to the 19th century battlefield.[27] Watts, at least, concludes that these factors will be equally applicable to future warfare "regardless of technological changes in the means of combat."[28] The reader is invited to consider how many of these factors will be rectified by the promise of RMA technologies and how many of them will confound technological advances because of the "human factor."

1. Danger
2. Physical exertion
3. Uncertainties and imperfections in the information on which action in war is based
4. Friction in the narrow sense of the resistance within one's own forces
5. Chance events that cannot be readily foreseen
6. Physical and political limits to the use of military force
7. Unpredictability stemming from interaction with the enemy

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[25] Von Clausewitz, Carl. On War. Ed. and Trans. Michael Howard and Peter Paret. Princeton: Princeton University Press, 1976.
[26] Beyerchan, Alan D. "Clausewitz, nonlinearity and the unpredictability of war." International Security 17.3 (1992): 59-90.
[27] Watts, Barry *Op. cit*., Clausewitzian Friction and Future War. McNair Paper 52. Washington, D.C.: National Defense University, 1996, p. 32.
[28] Watts, Barry *Op. cit*., p. 131.

8. Disconnects between ends and means in war.

Although he apparently never used the term directly, among the effects of "friction" is embedded the "fog of war", caused by the inadequacies and inaccuracies of situational awareness. It is the lif is the lif69.612 0 0 12 208.59573 o Tm(is the lif82w 1236 0 12 208.59573

there are those who speculate that the Desert Storm demonstration of RMA efficacy will mean that it is highly unlikely that warfare on that scale will be waged again.[31] From a strategic perspective, it is tempting to speculate that high technology dependency makes it increasingly unlikely that those who are so dependent will willingly enter wars that do not have technological solutions. Conversely, is it not more probable that future potential enemies, well aware of their technological inferiority, will choose to exploit warfare strategies that are geared to avoiding at all costs technological confrontations.

An example of the potential futility of technological superiority in such situations is found in the October 1993 operation of the US Army Special Forces in Somalia. They were on a mission to capture key members of the entourage of the Somali warlord Aidid. There are few branches of the US military that possess more advanced technology at their disposal than Special Forces. A planned half-hour "snatch-and grab" mission became a 15-hour battle with horrendous consequences for the US personnel involved, consequences that should dispel the presumed invincibility of technological superiority in such scenarios once "friction" complicates operations .[32]

Consider those RMA technologies that are purported to result in improved "information superiority." The quantity and quality of information available at much lower levels of command than has been traditional, will likely result an increased "empowerment" for those lower levels of command. The command structure will likely become flattened as a result. One wonders whether the strategic implications of the rapid

[31] *Ibid*.
[32] Bowden, Mark. Black Hawk Down: A Story of Modern War. New York: Atlantic Monthly, 1999.

flow of information have been fully considered. Echevarria discusses the implications for decision makers of rapid flow of battlespace information, be they not only lower down in the command hierarchy, but also members of government, warlords, criminals, or terrorists.[33] It is likely that the rate of technology advances is currently far ahead of considerations of the human limitations to information processing and the organizational changes that the information flow will demand.

Together with the increased flow of information to/from the battlefield, it is reasonable to speculate that the pressure to make decisions more rapidly will also be increased in order to reduce "decision cycle times" to durations that are shorter than the enemy's. The implications of wrong or bad decisions, however, given the expected latitude for decision-making have the potential to be much more severe than historically. Although many analysts and pundits have attributed the overwhelming US-led victory in the Desert Storm campaign to technology, a strong case is made by Press to the effect that the victory could be just as much attributed to superior training and skill, i.e. human factors, as to superior technology.[34] One cannot help but wonder if sufficient resources are currently being dedicated to R&D about training, leadership, and command and control issues, not only those required to fully exploit the technological promise of RMA, but also in order to establish the "back-up" in the event of technology failure.

Clausewitz described in the 19th century in relatively clear terms some human factors limitations to the accuracy of information processing and decision-making caused

[33] Echevarria, Antulio J. "War, politics and RMA – the legacy of Clausewitz." Joint Forces Quarterly 10. Winter (1995-96): 76-80.

by arousal and emotion. Since that time the R&D about such topics has been relatively limited compared to that carried out in the engineering sciences. To bring the issue back to RMA, from personal experience, this author[35] is aware of the paucity of R&D currently ongoing or planned which targets the integration of the Human System, with its related human factors limitations, into the "system of systems" that is at the heart of RMA.

Human Factors R&D

There are no unmanned weapon systems. At the very least, humans are involved in setting a weapon system in motion and interpreting the results of using the weapon. What follows are specific examples of human factors R&D that could comprise the niche area advocated above. Each one of these areas is the focus of current expertise within the DRDB, and space does not permit anything other than a cursory listing. The key point to keep in mind is that Canada could almost immediately declare its desire and capability to make one or more of these areas its specific contribution to improving abilities to fully exploit RMA technologies.

- Translating information on human capabilities and limitations into engineering terms for use in the design, integration and evaluation of systems and equipment, with an emphasis on modeling and simulation; includes

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[34] Press, Daryl G. "Lessons from ground combat in the Gulf. International Security 22.2 (1997):137-146.
[35] The author is currently the Chief Scien

research on appropriate functions to be performed by humans in complex systems, and the design of error-tolerant systems.

- Advances in computing, data fusion and sensor technologies will result in the collection of immense data sets. Human-computer interaction, and information processing R&D will be required to ensure that collected data/signals are processed in a useful and useable manner.
- Cognitive performance and measures of performance and effectiveness that span the psychological skills necessary in C^2 and "Decision-making" as it relates to the influence of team structure and communication protocols on overall team efficiency.
- Integration technologies to support the fielding of affordable, effective equipment needed for future military operations by advancing the state of the art in human system design tools, performance requirements estimation, performance metrics, crew-station integration, operational logistics, and acquisition logistics.
- Individual protection and sustainment R&D to support mission capabilities through personal protection, escape/crash safety, survival and rescue, individual and unit systems modeling, food and nutrition.
- Improving sensory perception, and physical and cognitive performance via exploitation of engineering or pharmacological advances.
- Stress and human performance; strategies to cope with military stresses such as information uncertainty, information overload and dynamically changing operational scenarios.

- Modeling the threshold, onset and course of individual and unit fatigue to objectively determine when unacceptable levels threaten mission safety or success.
- Develop and promote biomedical contributions to operational readiness.
- Provide the bases for scientifically sound doctrine for optimizing recovery following stress.
- Quantify the combined effects of multiple diverse stressors in support of improved operational concepts, tactics, and doctrine.

The following listing attempts to put into military operational terms the output of engaging in the type of R&D listed above.

- Reductions in physical, perceptual, and cognitive workload.
- Reduction in average crew size.
- Reductions in weight of personal equipment.
- Reduction in development costs. More rapid prototyping with use of computerized human engineering tools; reduction in total life-cycle costs.
- Improved mission performance through more effective information displays and decision support systems.
- Force multiplication by enhancement of individual cognitive, physical and psychological performance.
- Improved individual protection technologies to counter expected new weapons technologies.

- Improved use of, and defence against, psychological operations.
- Improved interoperability with allies during combined operations.
- Improved gender integration within military forces.
- Improved mobility; envisaged continued requirement to operate anywhere on the planet will pose human performance challenges related to transmeridian and transhemispheric travel; better logistics and unit sustainment technologies.

Conclusion

There is political will for Canada to join its traditional allies and be an active participant in the development, and application of the advanced integrated technologies that will be the result of the RMA. The alternative is to become militarily irrelevant because of inability to participate in future coalition operations. To keep a seat at the RMA table and reap the rewards of investment by our key allies, Canada must contribute significantly to the technology development process. The available R&D dollars preclude the possibility for Canada to sustain an independent defence R&D capability across the vast array of strategic technologies purported to underlie the RMA. Canada has a historic niche in human factors R&D which is exemplified by the development of the first operational anti-G suit for fighter pilots during WWII; that niche continues to this day with the development, at the request of the US, of a new generation anti-G suit considered to be the most effective currently available. This is only one example of a myriad of human factors R&D successes which have contributed significantly to the

respected reputation which is accorded Canada's DRDB.[36] In colloquial terms Canada punches well above its weight class, frequently initiating and leading international collaborative R&D groups in human factors R&D within the Technical Cooperation Program and the NATO Research and Technology Organization. There are human factors considerations that have not yet been adequately addressed by RMA technology development and such Human Factors R&D could constitute a significant and affordable niche technology contribution by DND, one which would contribute to our allies in a manner that is likely to facilitate retaining a seat at the feast of developing RMA technologies.

[36] Defence Research and Development. 50 Years of Excellence. (1997). Ottawa: Minister of Public Works and Government Services.

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