

SUMMARY: RMC STRATEGIC RESEARCH PLAN

1. RMC HISTORY AND MISSION

Founded in 1876, the Royal Military College of Canada is the only federal institution with degree granting powers. Originally oriented towards science and engineering, since WWII it has broadened to cover a wide range of disciplines. Its extraordinary learning environment has provided Canada with leaders in the military, education, industry and public service in a proportion far higher than its size would predict. During the past quarter century, the increased emphasis upon graduate studies and research at RMC has resulted in significant leadership in these domains as well. RMC now produces approximately one graduate degree for every 2 undergraduate degrees awarded, and the average civilian faculty member at RMC attracts over \$120,000 per annum of extramural research funding. The foundations laid by RMC in creating this environment for learning and scholarship are reflected in its academic mission statement: *RMC will build on its strengths to rank among the best of national and international universities recognised for (a) the outstanding quality of undergraduate and postgraduate students and programs in arts, engineering, science and the military profession; (b) the intellectual value of scholarship and research by faculty and students; (c) the outstanding service of Canada's only "national university" and its graduates to the building of the nation.* While RMC is a component of the Department of National Defence, its research activity is not confined to work that is of interest to the Canadian Forces or the defence community. The faculty at RMC are guaranteed academic freedom in their collective agreement with the Crown.

2. PRINCIPLES AND PRIORITIES

The teaching, learning and research environment at the RMC are mutually supportive and complementary. This is put into effect through a framework of comprehensive planning that applies to all aspects of life at the university.

A. Planning Principles: The basic principles for planning at RMC are to promote quality, to challenge traditional assumptions and ways of doing business, to enhance flexibility and respond to opportunities, to promote military-civilian interaction, to focus and build on strengths, to capitalise on synergies, and to develop a spectrum of opportunities compatible with resources.

B. Priorities: The three priorities for the development of research at RMC are the building of high quality, world-class research programmes in selected areas of importance to Canada, the encouragement of national and international collaborations and partnerships, and the promotion of interdisciplinary co-operation to exploit synergies to the maximum.

3. THEMATIC AREAS OF THE RESEARCH PLAN

Because RMC was originally focussed primarily on technology, there is a long tradition of cutting edge research in science and engineering. It is our intention that this should persist. While some topic areas will be focussed on those of high priority for the Department of National Defence, others are of broader interest. The emphasis remains on quality. It is, however, a small institution, and not all fields can be covered; the limited resources will be directed to achieve maximum results through interdisciplinary collaboration and cooperation. Substantial involvement in research in the humanities, social sciences and pure and applied social sciences is more recent. Nonetheless, for more than twenty years the Faculty of Arts at RMC has built its research on its recognized strengths, also unique in Canada. It aims to increase our understanding of security, defence and society by utilizing a multidisciplinary approach. These strengths flow from its national and international reputation as a centre of excellence in military history and political studies as they relate to issues of international security, governance and the economics of defense. More recently, the Departments of Military Psychology and Leadership and of Business Administration have added depth to the faculty by providing unique expertise in military psychology, organization, leadership and management. Culture and media research in the French and English departments greatly extend the scope of our understanding of civil and military societies. The following are the principal areas of research at RMC:

- *Information Technology, Communications, Microelectronics, Chip Technology and Physical Computational Modelling*
- *Environment and Climate*

- *Advanced Materials*
- *Space Mission and Planetary Sciences and Remote Sensing*
- *Energy and Alternate Energy Sources*
- *Geo-technical Engineering*
- *Fluid Mechanics and Engineering*
- *Mathematics and Statistics*
- *Security: Domestic and International*
- *Armed Forces: Military and Peace Operations, Economy of Defence, Management, Military Law, Organization, Psychology*

- *Information Technology, Communications, Microelectronics, Chip Technology and Physical Computational Modelling*

World-class high performance computing resources are in place for RMC researchers through RMC's membership in the Eastern Ontario High Performance Computing Consortium that provides access to the High Performance Computing Virtual Laboratory (HPCVL). The consortium includes RMC, Ottawa, Ryerson, Carleton and Queen's. These infrastructures serve to enhance the research programs of a number of different groups at RMC.

RMC has built a strong team in software design and engineering, management, operation and security, with emphasis on Command and Control and parallel computing. The internal collaboration between the Department of Electrical and Computer Engineering and the Department of Mathematics and Computer Science is complemented by outside partnerships with a number of groups including the Department of National Defence and Queen's University. RMC has developed an international reputation in electromagnetic engineering that encompasses the specialties of communications and data fusion, radar, microwaves, wireless communication, under water acoustics, signal processing and coding. This area finds its strength in the collaboration among RMC's Departments of Electrical & Computer Engineering, Physics and Electrical & Computer Engineering at Queen's. It is also supported by contracts with a number of Defence Research Establishments. Professor Y. Antar (Electrical & Computer Engineering), who is a world leader in this area, is RMC's Canada Research Chair (Tier I) in Electromagnetic Engineering.

RMC has established a Centre for Smart Materials and Structures that has collaborations with the Canadian Smart Materials and Structures Group and is conducting fundamental, experimental as well as simulation research on structural health monitoring and smart technologies for civilian and military applications. RMC also has a strong research programme in oceanographic numerical modelling and developing programmes to study both the coastal ocean and large ocean basins. This research is supported by agencies such as NSERC, CFCAS, MITACS and the Department of National Defence. In collaboration with the Centre for Space Research, RMC has also developed research programmes in Ionospheric-Thermospheric-Magnetospheric modelling, including projects in support of Defence Research Development Canada and the Canadian Space Agency, involving collaborations with a large number of Canadian and American universities, Natural Resources Canada as well as international research laboratories such as the Laboratory of Physics and Chemistry of the Environment.

- *Environment and Climate*

Significant steps have been taken by RMC to build a strong foundation for research, training, and education in environmental sciences and engineering. A number of groups including Environmental Sciences, Analytical Services and RMC's Green Team support numerous projects. The interdisciplinary programme in Environmental Sciences and Engineering was developed in 1999 linking important elements of the Departments of Chemistry & Chemical Engineering, Civil Engineering and Politics & Economics. The environmental foci include biotechnology, bio-analytical chemistry, bioremediation, and ecological site risk and remediation assessment. RMC has partnerships with Environment Canada, Canadian Coast Guard, Geological Survey of Canada, Queen's University and the Canadian Forces. It is the centre point for the largest environmental remediation project in Canada, which is to restore the former DEW (Distant

Early Warning) sites in the arctic. RMC operates one of Canada's leading accredited analytical environmental laboratories. RMC allocated one of its Tier II Canada Research Chairs in environmental science to a world leading researcher in this area, Dr. Barbara Zeeb. Recent faculty recruits have allowed expansion to include microbiological remediation and the effects of toxins on biological organisms.

- *Advanced Materials*

RMC has built a strong expertise in surface science and catalysts that places it on a par with a very small number of leaders in this area in the world. The group has developed innovative catalysts and other new materials to support the efficient production of alternate energy sources, especially applied to fuel cells and pollution abatement. Partners include the Canadian, US, UK and Australian National Defence. RMC has also developed research in non-destructive evaluation (NDE) with capabilities in eddy current, ultrasonic and magnetic testing, neutron radiography, corrosion resistance in metals, and infrared thermography, with unique research facilities including a SLOWPOKE-2 nuclear reactor for neutron radiography and a triple axis scanner for eddy current and ultrasonic examination of materials. The research carried out in Physics, Chemistry and Chemical Engineering and Mechanical Engineering includes support from the Canadian Forces (CF), CF Aerospace and Telecommunications Engineering Support Squadron (ATESS) and NRC.

Research is strong in the area of materials and manufacturing to encompass polymeric, piezoelectrics, thin films, fast-ion conductors, corrosion, knowledge based systems, optically responsive polymers for electro-optic devices and their applications. There is strong interdisciplinary cooperation among the RMC Departments of Chemistry and Chemical Engineering, of Mechanical Engineering, and of Physics. This strength of the Faculty has resulted in partnership with Queen's University and the Centre for Advanced Materials and Manufacturing and funding support from the Ontario Research and Development Challenge Fund, Canada Foundation for Innovation and NSERC. In this area, RMC has a world leader in the field. Dr. Phil Bates (Chemistry and Chemical Engineering) is RMC's Canada Research Chair (Tier II) in 'Polymer Processing and Joining'. Other strengths in the area include the recruitment of new faculty notably a number of strong researchers focused on using innovative chemical and physical (including nanotechnology) approaches in the development of novel materials. RMC is a Canadian leader in the application of advanced materials for civil engineering structures. Work in the strengthening of structures and the development of temporary lightweight structures has been a focus of research since 1992. Collaborations with the Canadian Network of Centre of Excellence, ISIS, and its partners are particularly strong. The group has had major input for new construction and repair using advanced materials in the latest edition of the Canadian Standards Association's Canadian Highway Bridge Design Code.

- *Space Mission and Planetary Sciences and Remote Sensing*

This research theme has two major components that are carried out by researchers in Physics, Chemistry and Chemical Engineering, Mathematics and Computer Science and Electrical and Computer Engineering. Space Mission and Planetary Sciences: RMC's Space Surveillance Research and Analysis Laboratory (SSRAL) have been developing hardware and software dedicated to the optical ground-based tracking of Resident Space Objects such as satellites. This has resulted in the construction of a prototype optical ground based satellite surveillance system that became the equipment baseline for the Department of National Defence Concept Demonstrator surveillance network constructed by Defence Research Development Canada. This network is currently being used by both RMC and DRDC in the investigation into data acquisition and analysis, networking issues and information transfer issues. Results from this investigation are used to establish the data handling capabilities and to ensure procedures are in place prior to the launch of Project SAPPHERE, the first surveillance of space from space satellite by the Department of National Defence. These data are intended for use by the US Air Force Space Surveillance Network and will augment current NORAD aerospace surveillance capabilities. Other more academic research projects such as the study of structure and evolution of nearby galaxies are also major projects in this theme.

Remote Sensing: There is a long history of RMC Physics research into applications of space borne synthetic aperture radar. From the early 1990's, with participation in Ocean Wave Spectrum

Calibration/Validation studies for the European Space Agency's ERS-1 and ERS-2 satellites, through initial evaluation of the Canadian Satellite Radarsat-1 for target detection and for logistic support for Canadian Forces operations in Africa, into the current work on identification and delineation of prairie landscapes in preparation for the launch of Radarsat-2. Partners in these projects have included NASA, the European Space Agency, the Applied Physics Laboratory of Johns Hopkins University, DND and the Canadian Space Agency. This work is continuing with approved projects from the Canadian Space Agency to examine Radarsat-2 imagery over Canadian Forces Base Shilo and Petawawa. Environmental assessment using satellite imagery in the visible and near-infrared atmospheric windows is a continuing research thrust of RMC's Departments of Chemistry and Chemical Engineering and of Physics.

- *Energy and Alternate Energy Sources*

A strong research programme has been built at RMC in alternate energy sources, including fuel cells and nuclear. The fundamental work on the fuel processing of hydrocarbons to produce a hydrogen rich gas capable of being fed to fuel cells has made it unique in Canada for the expertise in power production for fuel cell systems. RMC acts as the Scientific Authority to oversee the next generation of fuel-cell research for the Canadian Navy. Collaborations and partnerships are in place for the main portable power systems and small portable engines with the Ministry of Defence in the U.K. and the Department of Defence in the U.S.A. The applications of these developments in power production are developed by collaboration with the RMC Departments of Chemistry and Chemical Engineering and of Electrical & Computer Engineering. A joint Queen's University- RMC Fuel Cell Research Centre has been established supported by a joint multi-million grant from the Ontario Research Foundation and support from the Canada Foundation for Innovation. The nuclear research encompasses nuclear fuel and fission product release behaviour, thermodynamics of nuclear materials, as well as nuclear fuel management and fuel cycle optimisation. This research is supported with funding from NSERC, the CANDU Owners Group (COG) and the Director General of Nuclear Safety. Recent recruits focus on other novel approaches including the exploitation of the vast amount of energy that is trapped in the form of gas hydrates in Canada's north.

- *Geotechnical Engineering*

RMC has developed a strong research group in the area of geotechnical engineering with special expertise in the areas of geo-synthetic engineering, earthquake engineering and unsaturated soil mechanics. The group has a large-scale indoor test facility that is unique in the world and is used to construct and test full-scale earth structures to failure and the largest shaking table apparatus in Canada used to investigate the response of earth structures to earthquake. Numerous national and international awards have been received for this work on reinforced soil retaining walls. Research funding has come from NSERC, CFI, Department of National Defence, Ministry of Transportation of Ontario and departments of transportation in eleven of the states of the USA. The group has collaborations with researchers and agencies in five countries.

- *Fluid Mechanics and Engineering*

Production of Power in Flight: Research underway includes novel flight methods, instrumentation, the exploration of low speed or high altitude aerodynamics, aeroelasticity and the interaction of fluid with structures. This activity has led to extensive collaboration via the Canadian Space Agency, the Canadian Department of National Defence especially for unmanned air vehicles, The Technical Cooperation Programme with the USA, UK and Australia particularly for aircraft flutter and limit cycle oscillations.

Gas Turbines: This research involves the use of the jet cell at RMC and which is Canada's only such university located facility. There is a history of such work here, which has led to partnerships with the Canadian Air Force, Pratt & Whitney Canada Limited and with the Standard Aero Limited. Current developments in this area are providing important experimental data for prognostics and health monitoring. To complement and enhance RMC's experimental strengths, RMC has Dr. Wu (Department of Mechanical and Aerospace Engineering) as Canada Research Chair Tier II with world expertise in modelling the transitional and turbulent boundary layers and simulating numerically flow in turbo machinery.

- *Mathematics and Statistics*

Pure Mathematics: Researchers in the Department of Mathematics and Computer Science are making significant contributions in Analysis, Algebra, Discrete Mathematics, Multi-valued Logic, and Graph Theory. The group has developed considerable expertise in Optimization theory and promotes research and teaching in the domains of Conflict Analysis, and Multi-Criteria Optimization. Operations Research: RMC has assembled an interdisciplinary research team that applies advanced analytical methods to help make better decisions in a variety of areas of engineering, business, military operations, specifically in telecommunication systems, traffic flow, manufacturing processes, airport traffic and scheduling. Researchers in the departments of Mathematics and Computer Science, Business Administration and Politics & Economics have established collaborations with departments at Queen's University and carry out research in cooperation with the Department of National Defence and DRDC. More recent recruits are involved in different aspects of mathematical modelling of the human brain including artificial intelligence to study knowledge acquisition as well as learning algorithms used by neural networks.

- *Security: Domestic and International*

RMC is part of Canada's Security and Defence Forum, a network of Centres for International Relations at Canadian Universities and is a contributor to the NATO Partnership for Peace Consortium of Defence Academics and Institutes for Strategic Studies. Dr. Boulden who is a world renowned expert on NATO holds RMC Canada Research Chair in International Relations and Security Studies (Tier II). Her research focus is on peacekeeping through studies on comparative government, international relations and ethical conduct in conflict. Numerous other projects in this area, notably studies on Canadian foreign policy and the war on terror represent other areas of intense investigation with many of these funded by SSHRC.

A significant area of research involves the protection of personnel against Chemical Biological Radio Nuclear (CBRN) agents, both for civilian and military use, domestically and internationally. Specific activities include: development of the concept of operations in contaminated areas, response and readiness plans; developing and validating national and international requirements, standards, and test methods; understanding the implication of decontamination on personal protection; and understanding and designing new methods, materials, concepts and items for providing protection.

- *Armed Forces: Military and Peace Operations, Economy of Defence, Management, Military Law, Organization, Psychology, Tradition and Culture of the Military.*

In addition to conducting joint research projects with agencies such as the Directorate of History and Heritage and the Canadian War Museum, academics pursue collaborations with colleagues facilitated through international research networks. In support of this research focus, Dr. Tiessen is a CRC chair Tier II in Military Sociology.

- *Armed Forces and Society*

Here the focus is on Civil-Military relations, taken in the widest possible sense. The relationships between Armed Forces and civil society are studied, how militaries relate to the civilian leadership and what role the media play in informing the public about military matters. Our research draws upon our expertise in History, politics, economics and management. The important dimension of literature, art and culture is also part of this effort to understand military and civilian societies and how they relate to each other. RMC, Queen's and a broad consortium of Canadian Universities have developed the Canadian Military and Veteran Health Research (CMVHR) foundation that aims to research all academic disciplines associated with the health protection and care of Canada's serving and released military personnel, aid workers, police, diplomats, and other Canadians exposed to dangerous and hazardous environments in the service of their country. This includes the effects on physical, mental and social health from such service on those who serve and their families over the life course.