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Post-Graduate Program in Optics & Photonics

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Abstract

An optics and photonics post-graduate degree program is described that was organized, offered, and presented, at the Royal Military College of Canada between the years of 1976 to the present. While the author retired in 1998, one or more of the courses: Fundamentals of Photonics, Fourier Spectroscopy and Fourier Optics, Electro-Optical Systems, Radiation Heat Transfer, and/or Advanced Instrumentation, continued to be offered/given in the Division of Graduate Studies and Research. The most recent PhD thesis was completed this past year. The history, together with the problems and successes associated with the program at RMC are described. Recommendations are made.

Introduction

Arriving at RMC, Department of Mechanical Engineering, ME, in the in the Fall of 1976, after 14 years in optics and photonics^(1,2), it seemed unlikely that an opportunity for optics and photonics research would be possible. To propose nothing would achieve nothing; there was little time available for networking, an application for a grant to develop liquid-crystal, LC, light valves was made to CRAD, Chief Research and Development, Department of National Defense, DND. It had potential since one of the contracts while working in industry had involved LC's. CRAD was the only possible source of research funds for RMC engineering and science faculty unless a connection had been established with one or more colleagues at a civilian university. In the latter case, NRC, MRC, or private sources, could be addressed, the other colleague(s) could then "farm out" aspects of a successful proposal to RMC.

By the time the LC work had been completed, a satellite experiment was being considered. A reservation that used a Get Away Special, GAS, package carried on the Space Shuttle was obtained in 1979⁽³⁾. My experience with ISIS B⁽²⁾ and high altitude spectroscopic measurements⁽⁴⁾ were references. (The satellites: Alouette and ISIS B had been built down the hall from my laboratory). It turned out that the venue had minimal value for PG research—each shuttle flight was to spend only a few days in orbit as well as being problematic for the launch—and costs were significant. No other faculty members were interested to participate. The GAS did have value for undergraduate projects. Nine engineering projects in different departments stretched over several student generations between 1979 – 835⁽⁵⁾. NASA had requirements that had to be satisfied, the most stringent being "space-qualifying" an observation window. DIT was not interested in providing a minimum \$125K that was needed to move ahead, the efforts were dropped. The reservation was relinquished, but visibility had been achieved. Telesat Canada donated space-qualified lithium batteries together with the two surplus traveling wave amplifiers from Anik C⁽⁶⁾.

It took two years before a PG student was found. The graduate student, Capt(then) Paul Allen, was courtesy of Dr. D. Rogers, Physics Department. The suggestion had been made that an engineering thesis would have greater interest for the DND sponsor. Demand and supply determined a change in direction. Here was the premier and still greatest hurdle (see below) for research at RMC; the interest of the sponsor is paramount, not the desire of the student, nor the interests of the supervisor.

Organization & History

PG uniformed students come to RMC via a sponsor, the sponsor is the commanding officer of the unit to which a "posting" is directed. An SBQR, a requirement designation, is established within National Defense Headquarters; NDHQ, a search is undertaken to try to satisfy the requirement with a PG program. The sponsor opens a "window" of 22 months to complete that program; keeps the post open, and administers the salary. When the time is "up", the participant must report to the post.

Time extensions, when necessary, have to be negotiated with the sponsor. RMC being part of DND can mitigate this by extending the stay, but the sponsor ultimately controls.

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An incomplete thesis at the end of the 22 months sometimes results in the PG student making several short return visits to complete the thesis rather than have a direct extension of time.

Potential PG students for optics and photonics were drawn from graduates with bachelor's degrees in: electrical engineering, physics, engineering physics, chemistry, science applied, or engineering management. In the main, they were posted to RMC after two or three years work in their first job after graduation. RMC maintains its minimum acceptance level to any program. The PG students who entered the optics and photonics program were registered in different departments. Sponsors can insist that their candidate be registered in a given department. Depending on marks, a PG student from a different background may be asked by RMC to take several undergraduate courses in the new department. Created by the sponsor, this situation adds a year to the degree program; because of the time restriction, the result is often that the student goes elsewhere for the optics and photonics degree.

As much as desired, there was never an attempt made to organize this program as a distinct discipline⁽⁷⁾. From time to time, the Dean of Engineering was apprised of the movements within the professional societies: OSA, IEEE, and SPIE, towards making optics and photonics a distinct discipline, but such a delineation was never given serious consideration at RMC. After all, Engineering Physics and Engineering Management were dropped in 1993 because their populations were small. The critical mass for optics and photonics was never going to be achieved. RMC, until recently, draws its PG students exclusively from uniformed graduates. The supply is limited.

Queen's University and RMC had earlier organized reciprocal arrangements, put in place because RMC had (has?) no mechanism to charge fees. Uniformed students did(do) not have sponsor's funds for tuition. RMC PG students were accepted freely into given courses at Queen's and qualified Queen's PG students were accepted in kind into given courses at RMC.

A specific problem was that the optics and photonics program was "hidden" inside ME. Cautious sponsors tend to follow a traditional path as they know it. An optics and photonics program buried inside ME may be "normal" for an Asian or European university, but not for North America. Optics and photonics is seen as necessarily attached to EE or Physics Departments.

Curriculum

PG students for a master's degree in science and engineering take five courses of three periods per week, plus a thesis. The course work is spread over two Terms. The initial courses⁽⁸⁾ for optics and photonics were: Radiometry, and Remote Sensing. Although the title was meant to be generic, the Remote Sensing course did include satellite content. Eventually, the core of the program was refined to three courses⁽⁹⁾ :

ME581, Fundamentals of Photonics: radiometry, reflection & refraction, electro-magnetic wave theory, photons, detectors—thermal & quantum, atmospheric transmittance, coherent & incoherent sources—natural, artificial, laser, FOV, FOR, optical crystals

ME583, Fourier Spectroscopy & Fourier Optics: spectroscopy review, diffraction, prism & grating instruments, Fourier Transform review, correlation, convolution, central limit theorem, Michelson interferometer, Fabry-Perot interferometer, imaging, filtering

ME587, Electro-Optical Systems: information control—chopping, reticles, phase sensitive techniques, spectral filters, scanning, detector arrays, figures of merit—D* & NETD, IFOV, image intensifiers, contrast, OTF, thermal imaging systems, low-light level TV, satellite observation, hyperspectral systems, synthetic apertures, MAWS, laser designators, laser aiming

These courses attracted students from Queen's as well as from other RMC departments and DND locations. Their average number was 2 per course. Occasionally, this meant that lectures had to be given one night per week per Term to accommodate out-of-town participants. An unexpected need was the time for the Queen's students to commute the four km distance between campuses; the institutions were out of step by ½ hour in their timetables. Two-hour slots had to be set aside for one period. In 1995, ME581 was presented via a video link between CFB Kingston and NDHQ, Ottawa.

An Electro-Optics Short Course⁽¹⁰⁾ was voluntarily developed for people who lacked a fundamental understanding of optics and photonics. A course variation, ME580, soon became necessary⁽¹¹⁾, it was an amalgam

of ME581 and ME587 for individuals who had participated in the Short Course who wanted academic credit. It added mathematical rigor and assignments. ME580 was given on demand, about 15 extra periods, depending on the routine for individuals who commuted from distant locations.

ME589, Advanced Instrumentation⁽¹²⁾, was voluntarily developed, originally for ME students, but it became useful for the optics and photonics program for students who lacked background in measurement techniques. It included some electronics and sensor theory, signal processing, A/D and D/A techniques, electronic filters, and displays. A significant part of the content included fibre-optic sensing. Remaining courses needed for degree requirements were chosen from the EE Department, Computer Science, Mathematics, or Physics Department, either at Queen's University or from a different department at RMC.

One may ask, given my background in detector and semi-conductors⁽²⁾, why a distinct detector course was not included. There is some detector analysis included in ME581. The answer is given through the experience of one PG student with a different supervisor; a thesis topic in new detector materials was chosen. The sponsor declared the officer to be "useless" on return to the "post"; this despite a satisfactory thesis! The operative content obviously had to be electro-optic systems.

Summary

The degrees awarded at RMC for the PG candidates in optics and photonics were from the disciplines in which they were registered: EE (4), Phys (2), and ME (7); one withdrew after a month into the program, and one did not complete the thesis nor all the course work. All theses resulted in publications.

There were 14 males and one female. There was one civilian, of the 14 uniformed participants—one was from the land element, one maritime, the remainder were air. Six remain in the CF, five continue to do optics and photonics work (only 3 within the CF); unfortunately information about four has been lost. Eight arrived married, two were with children, there was one divorce, and one birth, during their programs.

Among the thesis topics are: spectroscopic UV measurements on a rocket-motor exhaust (1), laser anemometry studies at $\lambda 514$ & $\lambda 488$ [nm] (1), diffractive element design and blur measurements at $\lambda 10.6$, and $\lambda 1.064$ [μm] (7), passive ranging using a diode array (1), detector fabrication studies (1), resolution capability of a fibre optic integrated spectrometer⁽¹³⁾ at $\lambda 4.7$ [μm] (1), and phase diversity astronomic studies in the visible (1).

Recommendations & Conclusions

Professionals often say that their "current work" is far removed from their original degree program. Any degree is less an indication of utility and more a measure of capability. Too often, sponsor and student look only at immediacy. They need to look beyond the department residence of a program, beyond the program detail to judge its utility. It is education that must be the goal, not training for a particular "slot". Education paves the way to greater understanding.

There is a reluctance, or perhaps an inability, to understand the effort and the hours spent in developing such courses and research, as well as in administrative and organizational matters associated with the PG programs. One has to be willing to work long hours to bring about any PG program when there is minimal recognition of the commitments. RMC gave (gives?) no credit or bonus to its faculty for time spent preparing and presenting graduate courses. Setting up the optics and photonics program was an exclusive volunteer responsibility. In the words of one department head: "It's like shooting yourself in the foot." All faculty members present two undergraduate courses as a minimum, three or more periods per week, per Term, as well as supervising undergraduate laboratories, and projects. Each PG course adds a commitment of a further three periods per week per Term. Credit for time spent preparing PG courses must be given to encourage the effort. Individual department heads are keen to see the effort, but have to balance the undergraduate work loads.

All uniformed PG students are paid to attend class. They also have military duties. There are no teaching or laboratory assistants; these duties were handled by the RMC faculty.

This added a further two to three hours per week for each faculty member. This had to change; the Dean of Engineering, Dr WC Moffat, negotiated the use of PG students for these tasks with potential sponsors, but it took several years until 1991 to achieve.

A research program must be carried out by the thesis supervisor to gain credibility. Credibility means the chance to expand. The research, funded through CRAD, may not necessarily be in the direction that a PG-student and sponsor would like. A “Catch-22” arises. The sponsor is willing to support the PG student, but has no financial support for the research; CRAD finances the proposed research, but the sponsor is not particularly interested in its direction. If the research is widely divergent from the sponsor’s interest, the faculty member never gets a PG student. As a consequence, the research activity is not freely chosen.

By 1997, Dean R. Weir, Graduate Studies and Research, had negotiated accessibility to NSERC. This was no small task since RMC, being a part of DND, had always been denied this access by the Treasury Board; access was deemed to create a precedent allowing for the transfer of budgeted funds between government departments. With the change, research at RMC at last could attempt to find funding in directions that: could become independent of a sponsor’s interests, could have more peer visibility, could give the possibility to hire research associates on long term contracts, and could generate a healthy competition with all universities. The sponsor still had (has) to be “sold” on the utility of the potential graduate—but the research became independent.

The 22-month arrangement between sponsor and supervisor gives RMC a slight advantage over a civilian university. Being part of DND, the detachment has a bit more flexibility if delayed for the time may be marginally extended. Geographically, RMC is close to NDHQ, a commute is feasible for short work periods.

The hurdle in getting uniformed PG students to RMC has always been the struggle between sponsor and supervisor. There is also the normal struggle between departments for more graduate students at any university. When a separate discipline is not identified, the result can be a greater struggle. The RMC program within ME had visibility only through the trickle of graduates, through the sponsor who had familiarity, through the RMC PG Calendar listing of courses, and through word of mouth. A wide ranging PR effort was missing.

Given a choice, the sponsors would like a course-only master’s program. This is identified as having a fixed time. The interest seems to be to have the degree, not necessarily an independent thinker. RMC did (does?) not have the resources for such a program. There were several efforts to nudge RMC to offer a course only degree; it was faculty resources that prevented it. Today, a nine-course master’s program with no thesis is offered in some departments. When the argument was presented that a thesis forces the candidate to use initiative to learn more, there was disbelief.

The individual efforts have been successful, the program has not been. Because RMC is a university that comes under the “training umbrella” of DND, there is a struggle between the academic requirements and the sponsor’s requirements. The sponsor wants the candidate to be immediately useful on his or her return, “to hit the ground running”, pronounced “full”, ready to go. There is disinterest from the sponsor in the research; the focus is on the waiting job that has been kept open.

It is clear that the formal optics and photonics program will not revive. Of course there will be individual optics and photonics theses, but not a focused program. The author was not asked, nor able to steer a successor into the department to carry on work in optics and photonics. The circumstances that brought optics and photonics to the RMC ME Department were unique, but the condition did not have to be abandoned.

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