

# III

## An Optics & Photonics Program: Buried

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### Abstract

Buried in the Land Forces Technical Staff Program, a one-year program within Applied Military Science, AMS, at the Royal Military College of Canada, is a set of 27 lectures in optics and photonics. The lectures, spread over 1½ months, are organized and presented to 22 participants each year, Captains and Majors, to give an appreciation of: thermal imagers, image intensifiers, laser designators, atmospheric characteristics, and many of the basic concepts associated with the detection, identification, and recognition, of targets. Discussion is provided of the difficulties associated with this program.

### Introduction & History

The Land Forces Technical Staff Program, LFTSP, was organized within the AMS Department at RMC to repatriate a program for CF personnel, previously offered at the Royal Military College of Science, RMCS, Shrivenham, UK. RMCS offers many programs of interest to participants from the UK as well as other countries. One of these courses offers instruction on: armaments, artillery, explosives, “fire control” equipment, data and characteristics of different vehicles and their operating technique and tactical use.. There are two ‘streams’ or Divisions—one for degree granting purposes, the other much shorter program, is non-degree granting.

The LFTSP, within AMS, is a one year program organized to prepare officers for new roles in the Canadian Forces, CF. It is a clone of the RMCS course, but emphasizes equipment that is used by CF land elements. The course provides the opportunity to obtain a master’s degree in Applied Military Science. The participants come as senior Captains or Majors; their average age is about 28; most are married with families; many have had experience serving in hostile environments.

Since there are many weapons and vehicles that make use of optics and photonics systems, lecture time was made available for this subject. The Electro-Optics Short Course had been presented by me many times at RMC<sup>(1)</sup>; it was natural to volunteer to modify it for a shorter series of lectures in 1994.

There were similarities between the two programs:

- i) The lectures and demonstrations were designed to bring the participants from a limited (or forgotten) background in optics and photonics to an overview of electro-optical systems that operated actively or passively in the ultra-violet, visible, and infrared.
- ii) There was a night session about ½ way through the program to demonstrate and contrast: binoculars, telescopes, aiming devices, image intensifiers, and thermal imagers, under atmospheric conditions that included scattering from smoke. There was one two-hour afternoon session to demonstrate laboratory equipment: polarizers, lasers, LDA, Bragg modulation, detectors, and spectrometers.
- iii) Like the Short Course<sup>(1)</sup>, it was a rare year that there were one or two who had a science or engineering degree. Lectures had to avoid reliance on mathematics. The lectures had to show “why” rather than “how”. Power capture was the crux<sup>(1)</sup> to appreciate the developments.

There were also differences:

- a) The main difference was that there were only a limited number of periods available for optics and photonics. That number originally was 29, scattered within the LFTSP; the number were reduced over vigorous objection to 27 after the first year.
- b) The participants had a defined purpose in the LFTSP, a focus on land-element equipment.

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The participants in The Electro-Optics Short Course had a general purpose; they were drawn from all elements; land, maritime, and air<sup>(1)</sup>. Examples illustrating optics and photonics that were not associated with the defined purpose of the LFTSP were deemed less important and by inference less interesting.

c) The LFTSP is built on the RMCS model that organizes participants into syndicates or groups. Each syndicate works together as a unit; co-ordination is through a syndicate director. The optics and photonics instruction had to include an assignment for each syndicate. Three assignments were developed: one for thermal imaging, one for an image intensifier, and one that varied from year to year that was either a directed weapon scenario or a different thermal imager to operate at a different spectral wavelength.

d) The LFTSP has a requirement for year-long projects for teams of two or three. Participants choose projects (with sponsor<sup>(2)</sup> input?) at the start of the program. Most projects are overly sophisticated, inappropriate in my view for any of the syndicates.

e) Marks were required for the projects based on a team written report and oral presentation, for the team assignments, and for exercises to be done by individuals that were added (see below).

Course notes: The Electro-Optics Short Course Notes<sup>(3)</sup>, were provided to each participant.

## Difficulties

There were(are) a good number of unique difficulties:

First. A Term at university has the courses presented with distinct identity, three periods per week until perhaps 11 or 12 weeks complete the program. Professors complain about compartmentalization, but isolation for optics and photonics would have been an asset with the LFTSP. University courses come with prerequisites; without the isolation identity, the implied prerequisite is the LFTSP itself, but there is nothing else of an optics and photonics nature in the program. Without the identity, the participants questioned the fit.

Second. Lectures were presented when time was available from “normal” LFTSP matters. Optics and photonics lectures commenced in the fifth month and ended in the sixth month. The lectures were spread: perhaps three in the first week, then four, then three in one day in the third week, then six, then two, then six, until completed. Because of other duties, presentation time was also constrained by my own availability. The impression was that of disorganization. Invariably discussions and questions brought concepts to the fore that needed far more time to explain than was available. The periods together were not lectures in the traditional university sense; they were more like instructions that became repetitive—returning many times to concepts associated with assignments.

Third. The participants who had chosen optics and photonics projects at the start of the LFTSP would show up early at my office asking for help. Enthusiasm and willingness were obvious, initiative needs to be rewarded, but a zero background causes much “spinning of wheels”.

Fourth. Optics and photonics lecturers from outside RMC could not be invited before the fundamental lectures had been given. Such visitors’ lectures<sup>(4)</sup> were not part of the 27.

Fifth. Occasionally, based on misinformation from outside the program, a participant would challenge me. Misinformation is difficult to dislodge. Such participants were the product of the classic: “someone who has just enough information to make him or her dangerous”! One participant believed that: “... optical fibres have to have mirror coatings along their length to reflect the *em* wave passage.” *TIR was a foreign concept*. Another asked: “... where do audio waves appear on the *em* spectral chart?” *A wave is a wave is a wave?* Others were overly concerned about laser reflections from the class-room pointer! *Lambert’s law and irradiance were not obvious*. Difficult concepts to isolate are the differences between diffraction and aberrations. Correcting misinformation is not easy within short time constraints and lack of background.

Sixth. The Notes<sup>(3)</sup> were organized for the presentation of data over 85 periods; most were made available to the EO Short Course participants to read ahead of time. Only parts were used in the 27 periods for the LFTSP participants; the participants had little time for advance reading. Furthermore they were used to having “hand-outs”, not used to take notes, or consult references. The lecture overheads were photocopied, but created confusion because there was little time to tie them to sections in the notes.

Seventh. The participants had no difficulty accepting that general input functions: the step, the ramp, the impulse, and the periodic, can be applied to transducers and “control boxes” in order to find their general response. There was difficulty in understanding that these functions could be combined to make any generalized polynomial input. Without mathematics, there was difficulty accepting the output responses to the inputs from the transfer function characterization of the devices and systems. The transfer functions used are either zero, first, or second order. The concepts of: time constant, rise time, decay constant, amplification and responsivity, were repeated, often using graphical depictions. The 27 periods did not allow time for review.

## **Conclusions & Recommendations**

It is expensive to educate personnel in optics and photonics; there are no short cuts. As with any discipline, without the education, the options are limited. The equipment is ‘thrown away’, to be replaced, or ‘sent back’ for repair<sup>(1)</sup>. Without the education, personnel become knob turners, panel openers and viewers, screw fasteners, or component replacers—the same as “fetchers of water and hewers of wood”. Until the proper education is achieved, the personnel remain at worst over-the-shoulder onlookers, and at best followers of action by rote.

Usage follows a recipe, understanding needs the background. Optics and photonics is a discipline that requires a lot of background for mastery. For example, one can train an individual how to use a laser, but understanding how it works requires considerable chemistry, physics, and engineering. To understand a laser’s limitations, detail is needed. There are many types of laser: gas, semi-conductor, solid, dye, DFBL, tunable, quantum dot, VCSEL, etc, not to mention LED’s. Each has unique characteristics. In addition, laser safety requires study of the physiology of the eye. The difference between cw and pulsed signals needs the understanding of the difference between energy and power. The differences between cw and pulse lasers need a firm understanding to appreciate eye protection.

Because the optics and photonics lectures are buried without identification or “highlighting”, the impression is given that they are “fill in”. The lecture pattern leaves the impression that their content is peripheral, yet the systems carried by soldiers and on military vehicles are crucial to the success of the operations. The participants appear to have little faith that their goals are kept in focus. It is a strong visibility for optics and photonics inside LFTSP that is lacking.

There was bitterness about the assignments because of the inordinate amount of time required (in the opinion) of the participants. The assignments were difficult for those who had little interest in simple mathematics understanding. The concepts of radiance, emittance, power, and intensity, gave difficulty. Group work was done within each syndicate which made it difficult to identify individuals having trouble understanding. Only once in seven years was help asked.

With reference to marks: in the first year, there was a debacle at presentation time, a public event with visitors from NDHQ. Presenters had not submitted their efforts ahead and too many fundamental errors were noted! Later years saw previews before the “official” presentation. Because there were only one or two projects in optics and photonics, it was awkward to be harsh in judgments, even though harsh might be deserved. Marks were listed in “order of merit”. Marks meetings degenerated into positioning candidates according to the opinions of the syndicate directors.

An impression was given that the projects were related to future postings of the participants; that both the participants and the sponsors were looking for “a leg up”, perhaps some free advice, on their coming work within NDHQ. The guests invited to the presentations were from some industries, as well as from NDHQ. Were they invited because of an interest in the projects or because of a general interest in the program? Their presence and contributions were unclear.

Because of the marks requirement, and the group mark only being available for optics and photonics, two or three problem sets were added to be responded individually. This was unpopular, but it was the only way to get a clear distinction between participants.

Generating a proper understanding of optics and photonics in those with little or no background is an impossible task. The best that can be hoped is a rudimentary appreciation rather than understanding.

In my view, treating these lectures as education is incorrect, a waste of effort and time. The short number of lectures on optics and photonics buried in the LFTSP should emphasize training on specific systems. Training does not require a PhD. The conclusion must be made that the PhD lecturer was used for “window dressing” perhaps for credibility for the program? These periods should make use of manuals, brochures, and catalogues<sup>(5, 6)</sup>. It is obvious that the participants look on the lectures on optics and photonics as an inconvenient truth that has to be endured. The CF understand training, use and need training for specific equipment and machines, and for tactics and strategy. The CF requirements are for now, not for the future. There is little patience for research. This is understandable given the required tasks.

Given the optics and photonics lectures, they need to be spread over six to eight months for a proper education. There is no time during the lecture interval for “reflection time” or a “soak time”. It is a disservice to the participants who choose their project in optics and photonics to have to wait for over ½ the elapsed time of the LFTSP before to receive lectures in their subject.

If one takes the LFTSP lectures as being 8 months (remaining time being establishment visits) of 25 periods per week, the result is about 800 hours of instruction. A course-only master’s degree of nine courses spread over two Terms (each university level course being 4 hours per week) is about 400 hours. There is more than enough time for a course-only program. If such is to be the case, care has to be exercised to establish that such a program is still education, not training, if it remains at RMC.

Because the purpose of the LFTSP is to study military vehicles, artillery, and weapons, the optics and photonics lecturer becomes the last to know about changes to the schedule organization and time table. Visiting lecturers deserve notice also that fundamental material has already been presented. There was repetition of a number of concepts by visitors. The visitors are invited to discuss special equipment, perhaps classified, or unique in some way, and should not have to discuss or repeat fundamentals. There was little or no direction for visitors; significant time is lost in repeating basic concepts already discussed.

The optics and photonics lectures for the LFTSP were a volunteer activity within RMC. Because of my personal commitments to the under-graduate<sup>(7)</sup>, graduate<sup>(2, 8)</sup> (also volunteer) and the Electro-Optics Short Course<sup>(1)</sup> (also volunteer) programs, the LFTSP did not get all the attention it might have needed. When I retired, a modest stipend was paid for the last three offerings of mine, until 2002. Optics and photonics lectures continue to be presented as a part of the LFTSP by several others, using, I believe, “The Electro-Optics Short Course Notes”<sup>(2)</sup>. I hope that optics and photonics within LFTSP gets its proper attention.

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