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A NEW UNIVERSITY CENTRE OF SURVEYING IN CANADA

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ABSTRACT

The establishment of a new surveying engineering programme at The University of Calgary represents a major milestone in the history of the surveying profession in Canada. It is the first such university centre west of Ontario and the establishment of the programme required two decades of dedicated work by the profession in Western Canada. This programme includes an undergraduate component, graduate studies, research activities and continuing education. The Division of Surveying Engineering started in September, 1979, with two full-time professors, five sessional lecturers and some 22 undergraduate students. Three additional full-time professors have joined the Division for the second semester and about 10 graduate students have already applied for graduate programmes. When fully operational (circa 1981), Surveying Engineering will have about 12 full-time teaching members and will occupy some 900 m^2 of newly renovated floor space in The University of Calgary Engineering complex.

0. - Preamble

During the past two decades, the surveying profession in Western Canada has been extensively involved in the establishment of a university level programme in surveying. Their Brief of 1977 clearly indicated the need for such a programme and thereby called for proposals from the educational institutions in Western Canada. It was the proposal of The University of Calgary which gained eventual approval of the Alberta Department of Advanced Education and Manpower. Subsequently on July 7, 1979, The University of Calgary Board of Governors gave official sanction of the venture and a 2.6 million dollar operating and capital budget was allotted for its development over a four-year period. In September 1979, 22 students were enrolled in the undergraduate programme.

Essentially three factors accounted for the successful establishment of this programme:

(a) the undisputed need in industry for surveying engineering graduates,

(b) the full cooperation and support of The University of Calgary, and

(c) the general support of the surveying profession in Western Canada, notably, the four provincial land surveying associations (CBCLS, ALSA, SLSA, MLSA), the Association of Professional Engineers, Geophysicists and Geologists of Alberta (APEGGA).

In addition, at the national level, the Canadian Institute of Surveying (CIS) also gave unconditional support to The University of Calgary proposal.

1. - Justification for the Programme

The Surveying Engineering Programme at The University of Calgary has been established to fulfill the basic educational requirements of three sets of professional surveying statutes. These are:

(a) the various provincial land surveying acts (e.g., The Surveys Act (Alberta), 1970),

(b) the different professional engineering acts (e.g., The Engineering and Related Professions Act (Alberta) 1977), and

(c) the Canada Lands Surveys Act (1979)

This means that The University of Calgary surveying engineering graduate will have fulfilled the basic technical subject requirements of these professional associations. However, before such a graduate can be registered as a Professional (Provincial) Land Surveyor and/or a Professional Engineer and/or a Professional Canada Lands Surveyor, additional examinations must be completed with the respective associations covering the acts themselves and practice under these acts.

Furthermore, the surveying profession has identified the requirement for surveyors educated at the masters and doctorate levels. Their reasoning is to the effect that such highly qualified people are needed to investigate, develop and implement new instrumentation, techniques and procedures

so that the surveying profession may remain efficient and competitive in serving society. It is for this reason that the Surveying Engineering Division has already begun to admit graduate students on a limited basis while the complete programme of graduate studies is being developed and implemented.

The surveying profession also recognizes the need for a continuing education programme at The University of Calgary. Numerous short courses, seminars and workshops have been held over the years in Western Canada and more specifically at The University of Calgary. The future plans are for a greater involvement of The University of Calgary with regard to this service to the surveying profession.

2. - The Undergraduate Programme

One of the principal objectives of the undergraduate programme is to provide the students with a broad analytical engineering education so that they can adapt more easily to the changing technology and professional requirements. The undergraduate studies constitute the academic foundations on which professional development grows.

The engineering undergraduate programme at The University of Calgary covers four years with the first two in common with other disciplines in the engineering faculty. The third and fourth years are then devoted mainly to specialization in surveying engineering subjects. A number of elective technical courses also permit emphasis in geodesy, photogrammetry, and in other engineering subjects, applied mathematics or computer science. The liberal studies electives allow secondary emphasis in such areas as law, geography, planning and economics.

The table of courses (Table 1) shows the requirements for the eight semester terms. The fact that the first four terms are common to all engineering students is an important aspect of the curriculum. An engineering student does not have to commit himself to one engineering discipline before registration time for the fifth term. Also, an out-of-town student can complete the first two years at his home institution before coming to The University of Calgary for the remaining two years of the engineering programme.

Furthermore, students transferring from surveying technology programmes usually require three additional years at The University of Calgary to complete the surveying engineering programme. Those students are given credits for some of the courses in the first six terms, depending on the individual technology programmes. Such credits and special course substitutions seldom add up to more than the equivalent of two terms or one year out of the four-year engineering programme.

The fifth term includes introductory courses in geodesy, photogrammetry, surveying instrumentation, data processing and surveying law. The sixth term includes courses in geodetic and photogrammetric positioning, numerical methods, error analysis and map projections. In addition, the students are required to take one liberal study elective course per term.

A field survey camp will be organized for a three-week period prior to the beginning of the seventh term that is, just before the fall session of the

fourth-year programme. The field work will consist of basic surveying, geodetic and photogrammetric operations, measurements and computations in the field. This survey camp will be held at the Fortress Mountain Centre and the field operations will make use of the Kananaskis calibration and test network. The students will collect their own data sets which they will then use in the various laboratories throughout the fourth year.

The seventh term includes courses in optimization, gravity field and surveying networks. In addition, one elective course in surveying engineering, (see List A), one elective course in engineering and related subjects (see List B) and one liberal study elective course must be taken to complete the seventh term.

The eighth term includes courses in cadastre, mapping and surveying project. In addition, one elective course in surveying engineering, (see List A), and one other technical elective (see List C). Again one liberal study elective course must be taken to complete the eighth term and allows students to add a law or planning or geography or other emphasis to their studies.

3. - Research and Development Areas

The principal areas for research and development work have been identified to be the following:

a) Positioning Methodology: One of the primary objectives of surveying engineering is unquestionably the development of methods and techniques to establish accurate positions on land, at sea or in space near the surface of the Earth. The advent of modern space and inertial technology has greatly emphasized and enlarged the scope of positioning methodologies in recent years. In fact, geodesists and photogrammetrists have recently inherited the task of transferring and adapting their methods and techniques to the lunar and other planetary environments, and of using extra-terrestrial techniques, such as radio interferometry, for the positioning of terrestrial points.

b) Geodetic and Photogrammetric Networks: A set of points (or stations) whose coordinates are referred to a common reference system is called a network. Such networks are called geodetic when using geodetic methods and photogrammetric when using photogrammetric methods. The fields of network design, analysis, solvability and adjustment have become critical with the multitude of positioning methods used by surveying engineers, particularly in the context of the North American redefinition projects.

c) Gravity Field Applications: The gravity field of the Earth affects the geometry of space in which surveying operations are carried out. For instance, geodetic vertical reference systems are classically defined in terms of gravity equipotential surfaces with heights explicitly related to geopotential differences. The implications, which are generally more critical in mountainous areas, have to be considered in all kinds of applications, ranging from the alignment of a theodolite to inertial navigation systems used in geodetic and photogrammetric positioning. For these applications, global and local approximations of the Earth's gravity field are required.

d) Distortion Analysis: Distortion problems are very common in surveying engineering but their treatments are just about as different as the areas in which they occur. A unified approach to the description and analysis of distortion problems is clearly required in order to facilitate any further in-depth studies and investigations. The discrete deformations of surveying networks and engineering structures have to be considered in parallel with the continuous photogrammetric image distortions and the local gravity field irregularities. Monitoring horizontal displacement due to slippage along slopes is another area which naturally complements this type of analysis.

e) Standards and Specifications: Engineering applications of positioning technology require comprehensive standards and specifications for station monumentation, instrumentation, observation procedures, data processing, error analysis, and so on. In particular, the development of calibration and testing procedures for the various types of surveying instrumentation and operations has a high priority in view of rapidly changing technology. The users of surveying information demand this standardization and calibration of instrumentation and procedures as guarantees of accuracy and reliability of the information.

f) Optimization of Surveying Operations: Any surveying project lends itself to engineering systems modelling and analysis for optimal results. The optimization can be formulated in terms of allocation of resources and decision problems which require solutions in accordance with the accuracy specifications and the economics of the situation. The actual design and planning of a large surveying project requires expertise of a comprehensive nature and the different strategies have to be carefully analyzed in view of the objectives of the project. General engineering systems techniques, such as, linear and quadratic programming, critical path analysis, and Bayesian optimization can be used within this context.

g) Position-Related Information Systems: Surveying engineering applications involve the generation of large amounts of position-related information, such as topographical and geophysical data, cadastral information, locations of natural and other man-made features. Graphical and numerical information systems are, therefore, intrinsically connected to surveying engineering, and with modern computer technology, this area has become one of intensive research and development in recent years. The optimization of positional and position-related information systems is a complex problem of operations research.

4. - Graduate Programme

The objectives of the graduate programme are to educate a person with in-depth knowledge and expertise in the different areas of surveying engineering, especially those of current interest to industry. The graduate courses offered by the Surveying Engineering Division will provide the necessary support for graduate studies in those areas elaborated upon in the previous section.

The requirements for the Masters of Science degree in Engineering are:

(a) a minimum residency requirement of two four-month terms (i.e., one academic year);

(b) the following three courses:

- Surveying Project Management,
- One graduate level course in mathematics, physics or computer science,
- Advanced Least Squares and Statistical Testing;

(c) at least three courses from the following:

- Advanced Cadastral Studies,
- Geopotential by Satellite Techniques,
- Least-Squares Collocation,
- Inertial Positioning,
- Reference Systems and Differential Geodesy,
- Geodetic Boundary Value Problems,
- Mathematical Distortion Analysis,
- Mathematical Estimation and Error Analysis,
- Operations Research in Surveying Engineering,
- Advanced Space Positioning,
- Advanced Photogrammetric Systems,
- Advanced Photogrammetric Methods,
- Advanced Engineering Surveys, and

(d) a masters thesis.

A Masters of Engineering degree comprises the previous requirements (a), (b) and at least five courses out of those listed under (c).

A Ph.D. degree programme consists of the following requirements:

(a) a minimum of three academic years of full-time study and research after a Bachelorate or Engineering degree,
or a minimum of two academic years of full-time study and research after a Masters of Science or Masters of Engineering degree,

(b) the course requirements for the Masters of Science degree, if not already satisfied,

(c) five additional graduate courses with at least three from the above list under (c) and the other two from other university departments,and

(d) a doctoral thesis.

The University of Calgary Faculty of Graduate Studies also has general requirements, (e.g., a language requirement) for all graduate studies and degrees which must be satisfied by all graduate students.

5. - Continuing Education

Continuing education is a reality within the surveying profession. The first semester actually started with a two-day geodetic seminar on The Impact of Redefinition and New Technology on the Surveying Profession held on the university campus. About 120 attendants came from industry, provincial and federal governments departments and agencies. This seminar proved to be a very successful opening venture of the Division of

Surveying Engineering.

There are two main reasons for an increase in continuing education programmes offered by The University of Calgary. They are:

(a) given the commitment of the surveying profession to raise the level of formal education for the new surveyors, it then becomes imperative to do likewise for the others in offering them the opportunity of learning about new methods, techniques and instrumentation, and

(b) the new surveyors which are university graduates also require refresher courses to keep up-to-date with changing technology and related information.

In these days of rapid evolution in science and technology, short courses and seminars on specialized topics provide one of the best avenues for keeping the profession at large aware of current trends and developments. Research and development projects usually require the support and sponsorship by a large number of people who require technical information. Continuing education programmes can contribute greatly to this endeavour.

To keep up the tradition of The University of Calgary in continuing education in surveying and related fields a number of seminars are already planned for the near future in different centres of Western Canada.

6. - Human and Physical Resources

A formal commitment has been made by The University of Calgary and the provincial government of Alberta to provide the necessary human and physical resources to create and develop a centre of excellence in Surveying in Western Canada.

The undergraduate programme alone calls for the following human resources:

- nine full-time professors,
- two full-time teaching assistants,
- three full-time technicians/technologists, and
- three full-time secretaries.

When the graduate programme is fully implemented (circa 1981) the full-time teaching faculty will total about 12 professors.

Presently, the full-time teaching faculty includes:

Anderson, E.G.	B. Surv. (First Class Honours; Board of Surveyors Gold Medal), Ph.D. (University of New South Wales)
Blais, J.A.R.	B.Sc. (Honours; Silver Medal; Hamilton Award), M.A., Ph.D. (University of New Brunswick)
Krakiwsky, E.J.	Dipl. Land Surv., B.Sc. (Honors Roll), M.Sc. (Wild Heerbrugg Award), Ph.D. (Heiskanen Award; The Ohio State University)

Schwarz, K-P.	Dipl. Ing., M.Sc., Dr. Ing. (Summa Cum Laude; Technical University of Berlin), Habilitation (Technical University of Graz)
Teskey, W.F.	B.Sc. (Distinction), M.Sc. (University of New Brunswick)

Part-time teaching staff during the current academic year includes: J.R. Adams, T. Crago, W. Falkenberg, B. Langan, M. Mepham, M.L.J. Morin, D. Reid, A.D. Vander Vliet and R. Wade. It is also important to point out that most of the part-time teaching staff come from industry and hence can contribute much in terms of their daily working experience and often perform demonstrations with instrumentation from industry.

In addition to the equipment owned by industry, the students of the Surveying Engineering Division will shortly have access to over half a million dollars worth of modern equipment such as: theodolites, levels, satellite receiver, analytical plotter, conventional photogrammetric equipment, EDM instruments, a total station system and an interactive computer graphics system. In addition, the students already have access to the existing equipment in other departments such as a Zeiss Zoom Transfer Device, flatbed and drum plotters, a Honeywell DPS Level 2 (Multics) computer system, and an IBM 370/148 computer for administrative purposes.

The Surveying Engineering Division is presently establishing a calibration and test network in the Kananaskis Valley, a mountainous region, in south western Alberta about 100 km from Calgary. The facilities will make it possible to meaningfully test different instruments and procedures under controlled conditions and analyse the results in detail. The area which is traversed by a major highway, is characterized by large mountain formations with several access side roads and some geological faults in the adjoining areas on one side.

A great asset to the surveying engineering programme is The University of Calgary Library with over one million volumes of books, journals, documents and other print materials as well as a half million volumes in microforms. The Library also contains significant collections of maps, air photos and maintains subscriptions to over 12 000 periodical titles.

The presence of the Arctic Institute of North America on The University of Calgary campus opens up numerous possibilities for Arctic Surveying and related projects. The Library of the Institute also has an impressive collection of some 16 000 bound volumes, 20 000 reprints and 1 000 serials. This collection spans all disciplines and interests related to the knowledge of the North and the orderly development of the Arctic and Middle North.

Finally, the space allocation for the Surveying Engineering Division is another advantageous asset for future development plans. By 1981, Surveying Engineering will be moving into about 900 m^2 of renovated space of its own. This includes some 15 faculty offices, two undergraduate home (i.e., work) rooms, photogrammetric laboratories, interactive computer graphics laboratories and a geodetic observatory on the roof of the E block of the Engineering complex. The lecture rooms are outside of this area.

7. - Acknowledgements and Concluding Remarks

The Division of Surveying Engineering of The University of Calgary owes a sincere debt of gratitude to the numerous individuals who have contributed so much over the last two decades to make this venture a reality in Western Canada. Their documents and reports were used extensively in preparing this paper. Recognition and tribute are due especially to Alexander Hittel of Shell Canada, to David Usher, Consultant, to Professor M.A. Ward, Chairman of the Civil Engineering Department and to Dean T.H. Barton of the Faculty of Engineering at The University of Calgary.

The University of Calgary Surveying Engineering Advisory Committee is also acknowledged for their valuable critique of the course content of this programme and the identification of pertinent research areas. Drs. Donald B. Thomson, Klaus-Peter Schwarz, Edward G. Anderson, and Messrs. William Teskey and Brian Langan also participated in the development of this programme. Messrs. W. Falkenberg and M. Mepham critiqued the manuscript of this paper. Mrs. P. Austin, Administrative Secretary in the Division, is acknowledged for her work in preparing this manuscript.

TERM 1 (Fall)	TERM 2 (Winter)	TERM 3 (Fall)	TERM 4 (Winter)	TERM 5 (Fall)	TERM 6 (Winter)		TERM 7 (Fall)	TERM 8 (Winter)
MATHEMATICS FOR ENGINEERS I	MATHEMATICS FOR ENGINEERS II	MATHEMATICS FOR ENGINEERS III	MATHEMATICS FOR ENGINEERS IV	SURVEYING LAW	MAP PROJECTIONS	FIELD SURVEY MEASUREMENTS (3 weeks prior to Term 7)	OPTIMIZATION IN SURVEYING	CADASTRAL STUDIES
LIGHT & SOUND	ELECTRICITY & MAGNETISM	ELECTRICITY CIRCUITS & MACHINES	ELECTRONIC SYSTEMS & INSTRUMENTS	SURVEYING SENSORS	NUMERICAL METHODS		ELECTIVE IN SURVEYING ENGINEERING (LIST A)	ELECTIVE IN SURVEYING ENGINEERING (LIST A)
PHYSICAL CHEMISTRY	PHYSICAL GEOLOGY	ORGANIC CHEMISTRY	STRENGTH OF MATERIALS	INTRODUCTION TO GEODESY	GEODETIC POSITIONING		SURVEYING NETWORKS	SURVEYING PROJECT
MECHANICS STATICS	MECHANICS DYNAMICS	THERMODYNAMICS	PROBABILITY & STATISTICS	ADJUSTMENT OF OBSERVATIONS	ANALYSIS OF SURVEYING RESULTS		ELECTIVE IN ENGINEERING (LIST B)	MAPPING IN SURVEYING
GRAPHICS & DESIGN	GASES, LIQUIDS	COMPUTERS & PROGRAMMING	FLUID MECHANICS & HEAT TRANSFER	BASIC PHOTO-GRAMMETRY	PHOTOGRAM-METRIC POSITIONING		GRAVITY FIELD & APPLICATIONS	OTHER TECHNICAL ELECTIVE (LIST B OR C)
		LSE #1	LSE #2*	LSE #3*	LSE #4*		LSE #5*	LSE #6*

* Liberal Study Elective

TABLE 1: UNDERGRADUATE CURRICULUM IN SURVEYING ENGINEERING

List A: Electives in Surveying Engineering

- Surveying Systems
- Space and Inertial Positioning
- Hydrographic Surveying
- Engineering and Mining Surveys
- Photogrammetric Engineering Systems
- Remote Sensing in Surveying
- Digital Terrain Modelling

List B: Electives in Engineering and Related Subjects

- Civil Engineering Materials
- Soil Mechanics
- Water Resources Engineering
- Basic Structural Design
- Mechanics of Materials
- Civil Engineering Systems
- Theory of Structures
- Design of Transportation Facilities
- Resources and Environmental Engineering

List C: Other Technical Electives

- Unconstrained Optimization
- Constrained Optimization
- Planetary Physics
- Archeo-Astronomy
- Computer Graphics
- Analytical Methods in Geography
- Computer Mapping
- Engineering Geology
- Exploration Geophysics
- Statistical Decision Theory
- Nonparametric Statistics
- Multivariate Analysis