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## Educational Programmes for Spatial Information Sciences in the Technological University of Dublin

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## EDUCATIONAL PROGRAMMES FOR SPATIAL INFORMATION SCIENCES IN THE DUBLIN INSTITUTE OF TECHNOLOGY

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### Abstract

The ever increasing spatial information needs of society, the rapid development of new surveying technologies, and the global demand for appropriately qualified surveyors, have triggered a radical re-evaluation of geomatics education worldwide. Significant enhancements have been made to the educational programmes in the spatial information science discipline in the Dublin Institute of Technology's (DIT) during the last decade including the provision of a BSc in Geomatics and various masters' programmes to cater for the increasingly specialised needs of the Geographic Information sector in Ireland.

### Historical Background

DIT introduced a 4 year diploma in Geo-surveying in 1968 from which 24 students graduated between 1972 and 1977. Viability issues due to low student numbers gave rise to a programme review which resulted in a programme change to a 2 year certificate with an optional additional one year for a diploma in Geo-surveying. The programme ran in this format from 1977 to 2002 from which 104 students graduated with Certificates and 369 students graduated with Diplomas. These certificate and diploma programmes predominantly focussed on the traditional areas of geodetic surveying, topographic surveying, photogrammetry, etc., now collectively known as measurement science or spatial data acquisition.

There was a perception among some diploma graduates that the diploma level qualification was hindering their career progression because a four year honours degree was the accepted norm for professional appointments, especially in the public sector in Ireland. A substantial number of diploma graduates opted to study abroad during the 1990s for an extra year either in Glamorgan University in south Wales or in the Fachhochschule Oldenburg in Germany. Additionally, access on to master degree programmes in Ireland normally requires a second class honours on a four year honours degree, so many diploma graduates considered that their academic and professional advancement was restricted.

The Bologna Agreement in 1999 (a joint declaration of the European Ministers of Education) promoted a rationalisation of third level education in Europe, consisting of 3 year bachelor degrees followed by an additional 2 years for a master degrees (many variants of this format existed). A five year master degree was the accepted norm in many European countries at that time for professional appointments, but in the UK the norm was a three year bachelor degree. In the last 15 years the situation in Europe has remained and the norm in the UK and Ireland seems to be moving towards the acceptance of masters degrees for professional appointments.

### Undergraduate Programmes

These factors led to the redevelopment of the diploma in Geo-surveying into a BSc in Geomatics (DT112) which was introduced in 1999. The redevelopment was performed from first principles where the technical and professional skills required in the Geographic Information

sector in Ireland were identified through discussions with industry partners both public and private. Additionally most surveying equipment was now electronic and surveyors were daily processing digital data into electronic products and increasingly analysing digital information using various software packages including geographic information systems.

It was fortunate that at this time the Council of European Geodetic Surveyors (CLGE) and the International Federation of Surveyors (FIG) separately established sub-committees to investigate the education of surveyors. These two groups combined their resources and funded research of existing programmes in Europe to inform their discussions. The joint report (Enemark & Prendergast, 2001) promoted an educational profile for the future education of surveyors (figure 1). This profile proposed three areas of competence, the traditional land surveying skills under measurement science, expanded skills of land governance including land registration/cadastré under a new area of land management and data processing and analysis skills for digital spatial information under spatial information management.

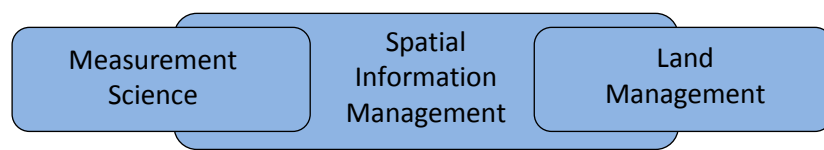


Figure 1 - Educational profile for surveyors of the future promoted by CLGE & FIG (Enemark, 2001).

Rather than proposing a harmonisation of existing educational programmes in Europe into a common core syllabus, the report stated that diversification was good, and that programmes should be able to adopt different percentages of these three areas of competence. The new BSc in Geomatics in DIT was the first programme in Europe to formally adopt this new model. The original format of the BSc in Geomatics was reviewed in 2007 and semesterisation and modularisation was also introduced at this stage. The programme now contains six semesters of teaching, a work placement semester and a dissertation semester (figure 2).

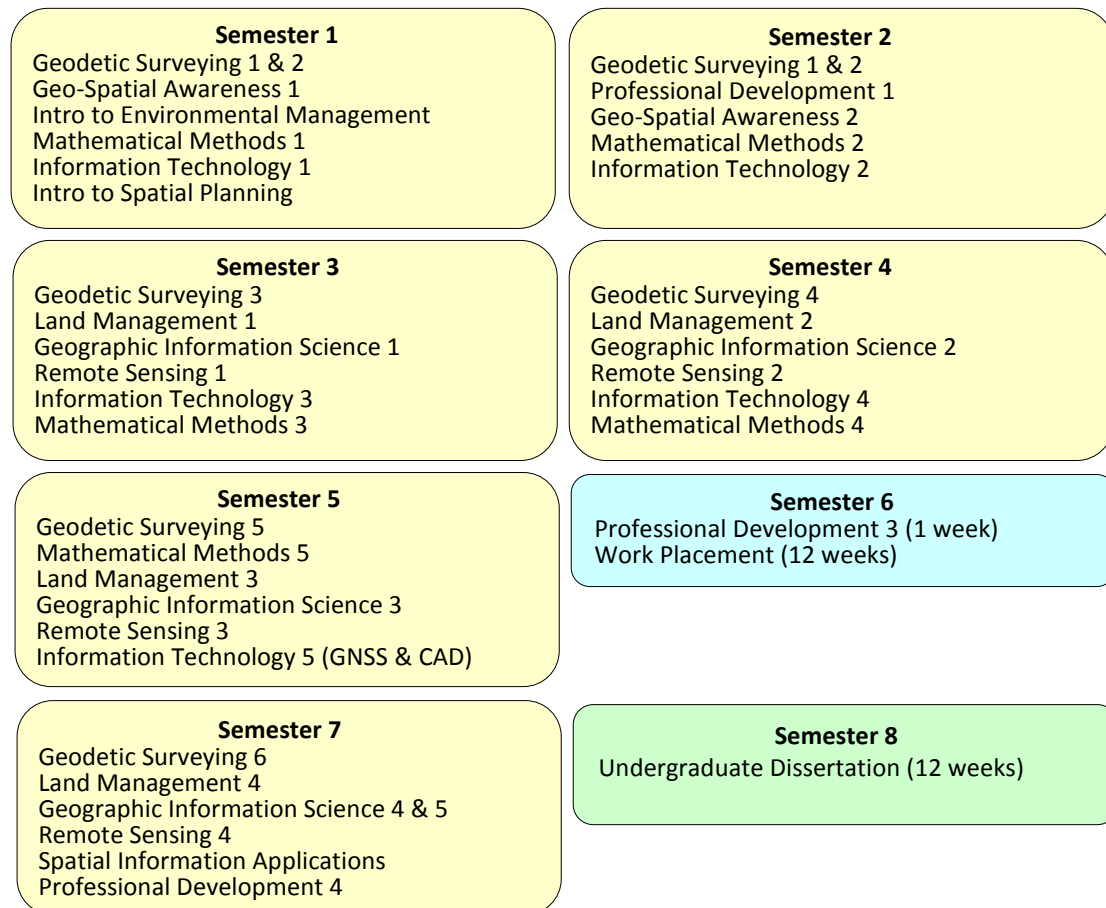


Figure 2 – Current format of the DIT BSc in Geomatics undergraduate programme.

The programme includes five modules on Geographic Information Science and many more modules are of particular relevance to GIS so geomatics graduates are well versed in creating, processing and using geographic information.

The addition of a work placement module in 2007 is considered to be very positive both by employers who can evaluate students over a 12 week period, and by students who can more easily find employment after graduation, but also by an increasing cohort of mature students who are attracted to the programme by it. The downside however is the loss of a teaching semester, which further compresses content into the six remaining teaching semesters.

Another difficulty being experienced is the speed of development of new surveying technologies which puts pressure on resources available to provide new equipment and to make space in the programme for inclusion of new ideas and techniques. Topcon relieved some of this pressure via their Educational Partnership Programme when they donated €250,000 worth of new surveying equipment to DIT in 2013 (Topcon, 2014) for which the spatial information sciences staff in DIT are sincerely grateful.

Geomatics surveyors also have a crisis of identity worldwide, in that the terms “land surveyor” and “geomatics surveyor” are not well understood by the general public. This results in less first preference CAO applications for the programme than warranted by full employment of graduates and the wide range of sectors they are employed in. To combat this lack of understanding of what geomatics surveyors do, the spatial information science group in DIT commissioned a short media video for social networking sites such as YouTube™, Facebook™, etc., to better inform students and parents of the role played by BSc in Geomatics graduates

(Murray, 2011). This initiative received many plaudits from professional associations and academics in Europe and beyond.

The average intake for the BSc Geomatics in first year is 30 to 35 students from which approximately 25 graduate per year. This intake number has been falling steadily since 2007 to a low of 17 in 2013, but is back up to 25 students in 2014. During the boom years up to 2007 the programme was producing approximately 25 graduates per year, but the market need was for 50, so many non-nationals were employed in Ireland at this time. Since the crash of the financial and construction markets in 2007, the market need in Ireland has reduced to circa 10 graduates per year, and only now in 2014 is that situation beginning to improve. Notwithstanding this reduced market in Ireland, there is a global shortage of professional geomatics surveyors, so much so that even during the difficult years of 2007 to 2014 the BSc in Geomatics programme had full employment of all its graduates in the UK, and Europe but most notably so in Australia and Canada.

The BSc Geomatics at DIT is the only undergraduate programme offered in spatial information science on the island of Ireland and it provides a level 8 qualification in the national framework of qualifications and attracts 240 European Credit Transfer points (ECTS). The number of disciplines encountered by the student, over the 4 year programme, has grown significantly in the last decade to include advanced geodetic surveying techniques, photogrammetry, GIS, land management and mathematical methods. Consequently, the availability of sufficient time for effective student learning is constantly under threat.

### **Post-graduate Programmes**

As well as developing the BSc in Geomatics to remove a perceived blockage to career progression for graduates of the old Diploma in geo-surveying, there was also a need to provide post-graduate programmes to encourage higher degrees and enhancing skills in the sector.

### **Admission**

For admission to all these post-graduate programmes students require a minimum of a 2.2 in an honours degree (level 8 NQAI) or equivalent, and prior work experience is not a pre-requisite for entry on to the course. Applications may be considered from candidates who do not have the minimum academic requirements but who do have significant relevant industry experience.

Non EU applicants must have documentary proof of Irish residency or an Irish work permit to be eligible to apply for the programme and a minimum English proficiency (6.0 in IELTS) is required for overseas applicants.

### **Awards & Accreditation**

Completion of all taught modules on these programmes entitles students to the relevant post-graduate diploma (not in the case of the MSc in Geospatial Engineering) if a master's dissertation is not completed or a higher degree as a master of science if the dissertation is successfully completed.

Accreditation for all post-graduate programmes is available or in the process of being sought from the following professional bodies; the Irish Institution of Surveyors (IIS); the Society of Chartered Surveyors Ireland (SCSI), Engineers Ireland (EI), and the Chartered Institution of Civil Engineering Surveyors (CICES).

### **Post-graduate diploma and MSc in Spatial Information Management (DT113)**

The first programme developed was the post-graduate diploma and MSc in Spatial Information Management introduced in 2007. Other post-graduate programmes at this time in this discipline in Ireland tended to focus on the technology of geographic information systems (GIS) and remote sensing (table 1). Consequently it was decided that the new DIT programme would focus

on management issues relating to the spatial information, i.e. the management of large national spatial databases.

Table 1 - List of post-graduate courses in Ireland in 2006 on Geographic Information Systems

Programme Title	Venue
Post-Grad Dip/MSc Geographic Information Systems	University of Ulster
MSc Geographic Information Systems MSc Coastal Management and Informatics with Geographic Information Systems	NUI Cork
Post-Grad Dip/MSc Applied Remote Sensing and Geographic Information Systems	NUI Maynooth

A second decision was that the programme would only be offered as part-time to specifically target mid-career professionals already employed in the sector who wish to enhance their skill set for career progression. The average age of students on this programme to date has been mid-thirties so they bring 10 to 20 years' experience which benefits lecture discussions and significantly raises the standard of analysis and presentation for assignments.

The initial programme format involved five semesters, but this was reduced to 4 semesters (figure 3) in 2011 to shorten the length and the cost of the programme.

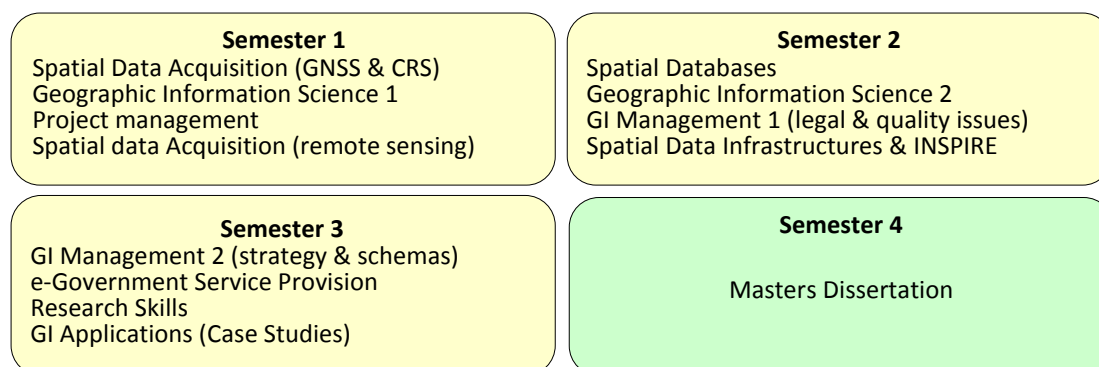


Figure 3 – Structure and modules included in the MSc Spatial Information Management

Two new master degree programmes were also introduced in September 2013, an MSc in Geospatial Engineering and an MSc in Geographic Information Science. These three masters programmes all contain some common modules.

### **MSc in Geospatial Engineering (DT9415/9416)**

This master's programme was developed to meet the changing needs of the geospatial sciences sector in Ireland and was also cognisant of the declining numbers of graduates from the BSc in Geomatics. This is a conversion programme to prepare graduates for employment in various domains, such as architecture engineering and construction (AEC), geospatial sciences including earth observation, and cultural and natural heritage.

The rapid development of spatial data acquisition and processing technologies such as new terrestrial (laser scanners), airborne (UAV/RPAs) and space borne sensors deliver rich data sets which need new processing pipelines to exploit their information content for service delivery. Cloud computing offers a solution and spatial information science graduates must be competent in this environment. Limitations in national data sets are being partially overcome with the

maturing of object-based data models compliant with internationally agreed specifications and standards, and the provision of national 3D data sets.

To complete the programme students must successfully complete 12 five-credit modules and the dissertation module thus achieving the 90 credits NFQ requirement. In DIT one ECTS credit equates to 20 learning hours, so individual 5 ECTS modules equate to a total of 100 learning hours, of which 20 - 35 % are direct contact hours either in class or remotely, the remaining learning hours are considered non-contact, self- or group-study hours.

This programme contains 10 mandatory modules and two optional modules are chosen from the suite available (Digital Elevation Models from airborne sources, Visualisation and Delivery of Geospatial Information, Geographic Information Science 1, Spatial Data for 3D Urban Models, National Landscape and Land Cover Models, and Masters Work Placement). The part time mode consists of 4 semesters (figure 4), and students on the full-time mode complete modules listed for semesters 1 and 3 during the first semester and modules from semesters 2 and 4 during the second semester. The master's dissertation is completed from January to September in both modes.

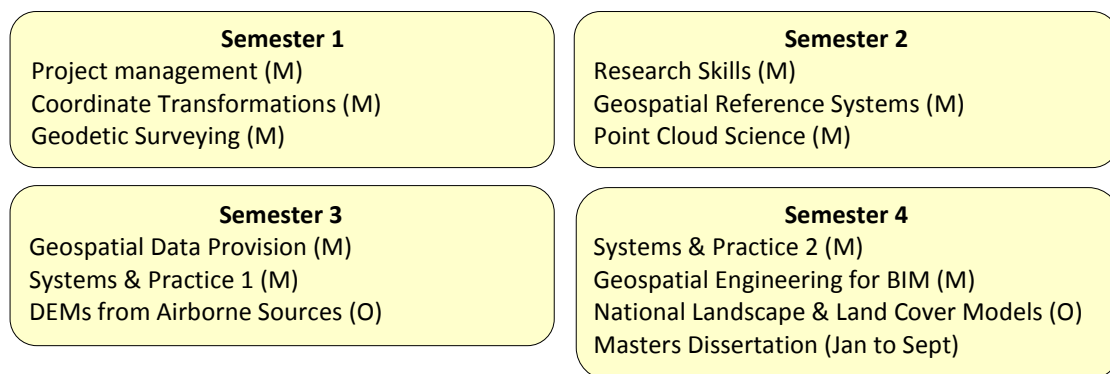


Figure 4 - Structure and modules included in the MSc in Geospatial Engineering. (M) denotes mandatory modules and (O) denotes optional modules

The profile of the first student cohort in September 2013 for the MSc in Geospatial Engineering programme includes architectural professionals wanting to specialise in modern point cloud manipulation for urban modelling, mining surveyors with requirements for up-skilling in recent point positioning technologies and engineering graduates with a need to develop competencies in geodetic surveying principles. In addition, the full-time option attracted international survey practitioners required to obtain academic qualifications at MSc level for promotion within their national government agencies. This student variability bodes well for the future.

### **MSc in Geographic Information Science (DT9419/9420)**

The programme goal is to produce highly-educated, technically-competent and marketable graduates for the geospatial sciences sector. This is also a conversion programme to enable graduates of related disciplines (geomatics, geography, geology, planning, archaeology, forestry, agriculture, computer science, engineering, environmental sciences, etc.) to acquire a qualification in Geographic Information Science.

Competency in both geomatics and information technology has consistently been identified as a critical need in the geospatial industry in Ireland. The programme has been designed specifically to address the needs of the geospatial industry and it is delivered in both part time and full time modes. The part time mode consists of 4 semesters (figure 5), and in fulltime mode the modules listed for semesters 1 and 3 below are completed in semester 1 and the modules from semesters



2 and 4 are completed in semester 2. The master's dissertation is completed during the final semester from January to September in both modes.



Figure 5 - Structure and modules included in the MSc Geographic Information Science

This master's programme is totally focussed on the GIS technology and its use to optimise delivery of enterprise and web-based GIS solutions.

### **MSc in Applied Building Information Modelling and Management (DT9876)**

Building Information Modelling (BIM) is the process of designing, constructing and managing buildings, structures, and infrastructures using one coherent intelligent system of 3D virtual models. It offers significant savings in cost and time, greater accuracy in estimation, and the avoidance of error, alterations and rework due to information loss. To achieve these benefits surveyors, architects, engineers, constructors and others engaged in the process must work collaboratively. In response, third level educational programmes need to adapt traditional, isolated and un-collaborative modules to a more interdisciplinary approach.

Recognising the growing importance of BIM, and the opportunity that existed through having all of the disciplines immediately relevant to BIM in the one physical and administrative location in then College of Engineering & Built Environment in DIT, a part-time two and half year MSc was designed in Applied Building Information Modelling and Management. The Programme is aimed at AEC (Architecture, Engineering, and Construction) professionals seeking to up-skill in BIM process and technologies.

Exit awards at Postgraduate Certificate in BIM Technologies (1 year) and Postgraduate Diploma in Collaborative BIM (2 years) are embedded within the programme. The structure of the programme, including its disciplinary streams, is shown in Figure 6. Students are only separated by domain during the first semester (12 weeks) during which they become competent in the use of one or more BIM technologies as appropriate to their professional knowledge. All subsequent collaborative or elective modules are offered to all students in a multidisciplinary environment.

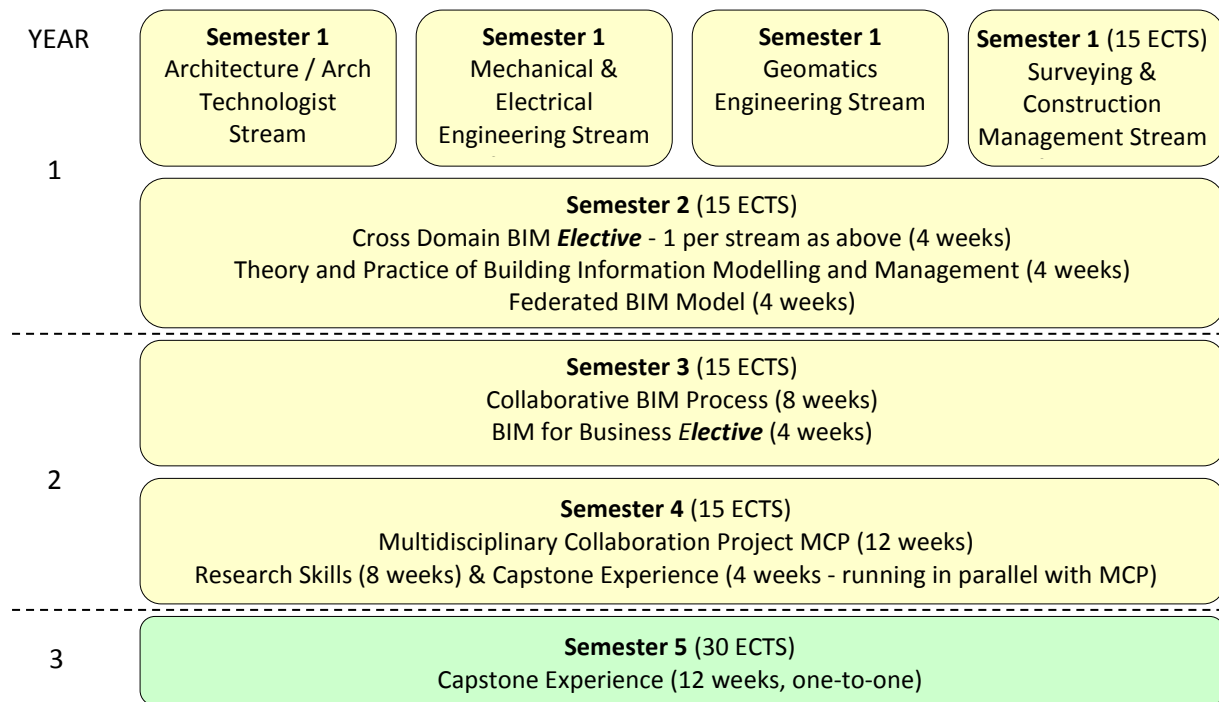


Figure 6 - Structure and modules included in the MSc in Applied BIM and Management.

Spatial information plays a central role in the BIM process, particularly in the context of creating a building model (especially of existing buildings), providing dimensional control during construction, asset management, and maintaining model currency over the life of a building. At DIT this central role was recognised during the design of the BIM programmes and geomatics skills were embedded in both discipline-specific (Architecture, Mechanical & Electrical Engineering, and Surveying & Construction Management) and collaborative modules. This level of integration of geomatics skills within streams aimed at other professionals in the BIM domain is hugely significant in terms of raising awareness of geomatics skills amongst peers. Indeed, as a reflection of the significance of geomatics within the BIM process, a separate stream known as Geomatics Engineering and focussing on point cloud usage, has been incorporated in the programme since 2013. This is a discipline-specific stream but is fully integrated within the collaborative modules and represents a significant development for the profession of geomatics in Ireland.

### Potential Masters Programmes

#### MSc in Land Management

A preliminary investigation was completed in 2012/2013 into the design of an MSc in Land Management. The aim of the programme was to focus on the operation and service delivery from the land administration systems dealing with land tenure, land use, land development and land value.

A draft syllabus was prepared and research was conducted to evaluate the market need for such a course. This research established that there was not a large need at this time in the Irish market, but that there was a significant need internationally especially from Africa, Latin America the East to support United Nations and World Bank initiatives to enhance land administrations systems on these continents. However, the cost of course fees and attendance would be expensive for non-EU students, so many of the modules would have to be delivered by distance learning to service this need. This was not considered possible at this time due to resource constraints.

### **MSc in Surveying & Mapping for Land Registration**

The Irish Institution of Surveyors published a Green Paper (Prendergast *et al*, 2008) which recommended the development of a third level course to enhance technical skills and professional competence of surveyors carrying out boundary surveys for registration purposes. The Inter-Professional Task Force on Property Boundaries, published a report (Brennan, de Buitléir & Prendergast, 2014) which recommended the development of a course at level 9 (masters or post-graduate diploma level) aimed at existing professional stakeholders (surveyors, engineers and architects) to enhance skills required for surveying and mapping of property boundaries.

Both of these reports identify a specific need in the Irish market for a third level course for surveying boundaries for legal mapping. Many of the modules required to deliver such a course are already available in the existing undergraduate and post-graduate courses provided by DIT, so the opportunity to develop and deliver such a course is quite appealing and should be considered by DIT.

### **Continuous Professional Development (CPD) Programmes**

#### **CPD Certificate in Geographical Information Systems (DT157)**

The Spatial Information Sciences Group also delivers a short CPD certificate course of 24 three hour sessions on one evening per week (normally Tuesday from 6 to 9 pm) in GIS. The aim is to provide students with the necessary technical, analytical and administrative expertise to beneficially employ this technology. A DIT CPD certificate of completion (10 ECTS credits) is awarded to successful participants.

The Spatial Information Sciences Group has in the past occasionally delivered specially designed short CPD courses for various national and local government agencies of a number of day's duration. These courses are specifically designed to enhance skills in a defined discipline or technology, or to provide a broad overview of modern geospatial technology and its application in the GI sector in Ireland.

Finally, due to the fact that all DIT courses were modularised in the mid noughties, it was possible to offer all of the MSc modules as individual CPD modules since September 2013. The fee for each module is €400 and if the assessments are successfully completed, these modules can be considered for exemptions if a student subsequently registers for any of the MSc programmes.

### **Conclusions**

During the last two decades the DIT spatial information sciences group has successfully developed a suite of undergraduate and post-graduate programmes to meet the needs of the geographical information sector in Ireland. DIT has not been alone in these developments and University College Cork, NUI Maynooth and University of Ulster have also diversified their programme offering for the geosciences during the same period. Perhaps there is potential to collaborate to improve the content quality and student experience in the future?

With the loss of two staff members in the last two years due to retirement and promotion without their replacement, the remaining seven members of the DIT spatial information sciences group are under significant pressure to continue the delivery of these programmes. This lack of resource will also limit the review and redesign of the undergraduate degree in geomatics, the design and provision of any industry specific CPD courses and the development of any other MSc courses. Additionally, the age profile of the remaining staff is such that half the group are due to retire in the next 6 years, so how these retirements are managed and replacement staff hired will be important for the survival of the group and their programmes into the future.

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