Attributes of Surveying Degrees: Australia and New Zealand

A report into the appropriate content and other attributes of land surveying degrees which are recognised by the organisations affiliated with the Council of Reciprocating Surveyors Boards of Australia and New Zealand

John Fryer
Harvey Mitchell

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by

John Fryer
BSurv, PhD
Emeritus Professor of Photogrammetry
University of Newcastle

and

Harvey Mitchell
BSurv, PhD
Conjoint Senior Lecturer
University of Newcastle

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Preface

The Council of Reciprocating Surveyors Boards of Australia & New Zealand (CRSBANZ) offers guidance for mutual recognition between individual jurisdictional Boards of Australia and New Zealand. This report establishes the prerequisite level of qualification to enable assessment and registration of land / cadastral surveyors. CRSBANZ acknowledges that this report has been prepared essentially for the use of its respective members and considers that by publishing this document “Attributes of a Surveying Degree, Australia and New Zealand” that guidance on degree content is provided to the surveying profession, academic institutions and the wider community.

For the past 20 years the guide of equivalence in respect to content of a surveying degree has been a publication known as the "Brown Book" which was developed by the land surveying profession essentially as a statement of the competencies that should be expected of a land / cadastral surveyor. Clearly, with the passage of time, CRSBANZ considered the emergence of significant changes in technology, computational capability, advances in global navigation satellite systems, as well as geographic information systems, and other advances, necessitated a review of minimum degree qualification content. The review ensures that CRSBANZ members’ prerequisite qualification for registration will be adequate to both protect and maintain the confidence of the public in the professional standard of registered land / cadastral surveyors.

CRSBANZ also recognised that to best assess the overseas qualifications from the increasing number of persons seeking registration a guiding statement was essential. It was also necessary to address the increasingly complex issue whereby persons may have completed one or more courses of study as a means of asserting equivalence with the degree benchmark.

This CRSBANZ document consists of two parts. Part A is a description of the content considered mandatory, described as inner and outer core content, that needs to be studied to meet the equivalent degree qualification for registration purposes. Part B is a statement of observations by the authors on trends and influences, which were taken into account in the development of Part A, and, as such, is for background purposes only. CRSBANZ will undertake ongoing review of Part A at appropriate time intervals to maintain the relevance and standard of content.

CRSBANZ will use the essential degree content in Part A of the document as one of the bases for deciding on the acceptability of prescribed university degrees for registration purposes. CRSBANZ recognises and accepts the importance of universities diversity and independence. However, by publication of Part A, CRSBANZ considers that transparency is provided to Australian and New Zealand universities on the surveying degree content required for land / cadastral surveyor registration purposes.

P Sippel
Chair
CRSBANZ

Summary

To seek registration as a cadastrally endorsed land surveyor in Australian states and territories or in New Zealand, a surveyor must have a degree in surveying and then enrol with one of the Boards which is associated with the Council of Reciprocating Surveyors Boards of Australia and New Zealand (CRSBANZ). The approved surveying degrees are prescribed by the Boards.

The primary purpose of this report is to offer Boards an up-to-date specification of the core content of those surveying degrees, especially in the light of the rapid rate of change of surveying technology. This undertaking occupies Part A, intended to be the more important part of the report. The background to the matter of specifying degree content is discussed in Section 1. Section 2 then explains the adopted approach to selecting the core degree content. Core educational material is seen as that which is crucial to enable the surveyor to carry out those surveying tasks which are expected of surveyors. Following from that, it is seen as useful to recognise two distinct categories within the core. An inner core group comprises matters which are widely acknowledged as being the province of surveying, and which are almost unique to surveying. Their selection has been based on a perceived list of tasks which, generally, only surveyors execute. The second group, the outer core topics, are not unique to surveying but knowledge of them contributes to appropriate execution of the tasks of the surveyor. Both the inner and outer core topics were perceived as mandatory. Various other useful but unessential topics in the surveyor's education are also enumerated - but are classified as non-core. A detailed catalogue of proposed core material, is provided in Section 3.

Part B of the report contains some wider opinions of the authors on some current issues surrounding tertiary education in surveying. The issue of the requirements of the degree programmes is viewed in the light of the requirements of industry in general (Section 4); the interaction between the universities and the TAFE sector is touched upon in Section 5; and the viability of surveying degree programmes across Australasia, but particularly Australia alone, is looked at in Section 6, by observing that a number of matters complicate the issue in the modern era. Overall, the viability of surveying degrees seems to remain problematic.

Recommendations

It is recommended that CRSBANZ:

1. *note the principles and processes which have been adopted during the preparation of the list of core topics;*

2. *reflect on and endorse the suggested essential content for land surveying degrees;*

3. *consider recommending to individual Boards that the suggested essential degree content becomes one of the bases for deciding on the acceptability of prescribed university degrees;*

4. *implement a programme of reviewing the suggested essential content for surveying degrees from time to time;*

5. *note the changing trends in university education, and, from time to time, seek updates on those trends, especially in relation to online courses;*

6. *continue to seek active involvement with relevant universities through regular meetings with staff and advisory committees.*

Part A: The Core Content of Land Surveying Degrees

1 Introduction

1.1 Background to the report

CRSBANZ instructions: This report derives from instructions to the writers from the Council of Reciprocating Surveyors Boards of Australia and New Zealand (CRSBANZ). One of the principal roles of the nine statutory Boards which are affiliated with CRSBANZ is to register (or license) land surveyors. Registration with a Board (or even with more than one Board) gives land surveyors the legal authority to carry out land boundary definition surveys within the relevant Board's (or Boards') jurisdiction. (Registration in mine surveying is a separate issue.) The Boards accept as candidates for their registration process those surveyors who have prescribed degrees in surveying from certain universities which lie within the Boards' jurisdictional areas. This report concerns primarily the desirable content of those prescribed degrees. Instructions from CRSBANZ asked the writers specifically to recommend the current crucial content - the core elements - of the accepted university degree courses in surveying in Australia and New Zealand. In addition to the Boards' needs which are specifically cadastral, consideration was to be given to the surveying and mapping industry's more general needs. Further, the writers were to note educational issues arising from the existence of the TAFE sector and the possibility of universities' cooperation to produce coherent courses and degree programmes. In short, the aim has been to consider and identify the current educational model for an Australasian surveyor, and especially a cadastral surveyor as registered by a Board which is party to CRSBANZ. In more specific terms, the stated purpose was to consider the following matters:

1. **The CORE elements for a surveying degree or equivalent qualification:** There is a need to define the core elements that are vital to enable graduates to operate as land surveyors, so that CRSBANZ member organisations can decide whether the programmes offered in their jurisdiction meet the baseline of core elements.

2. **Cadastral Surveying:** Additional modules, such as such as Land Law and Professional Practice, may be required to enable graduates to undertake a cadastral training programme leading from graduation to registration with CRSBANZ member organisations.

3. **Industry needs:** It was seen as valuable to also consider whether the current graduates meet the needs of the industry defined by surveying and mapping and its allied fields, and whether the proposed "core" elements will allow this to continue into the future.

4. **TAFE sector:** Including an investigation of or reference to TAFE course content was also seen as useful, especially as students from the TAFE sector frequently seek articulation into university degree programmes.

5. **Sustainability of the courses:** The future continuation of any of the current university degree programmes in surveying cannot be automatically assumed. The existence of any programme may depend not on community or industry demand so much as on its financial viability within its University. University degree programmes are influenced greatly by tight budgets depending in turn on student intake numbers and even on the availability of qualified academic staff, none of which can be taken for granted.

Of the five points listed above, the first two have been seen as by far the most important.

1.2 A benefit of defining core surveying degree content

Specifying Board degree requirements: Providing the Boards which are affiliated with CRSBANZ with a proposal for up-to-date core undergraduate content requirements of land surveying degrees is intended to assist the Boards' mechanisms for assessing degrees. Boards may not necessarily have in place transparent and recognised mechanisms for confirming whether the current degrees have the attributes which meet their requirements. A documented list of core content would presumably be beneficial, especially as both the surveying industry and the degree programmes undergo rapid and extensive change. It is also foreseeable that at some time Boards could face queries, or argument, perhaps even legal challenges, as to why they do not accept certain degrees (perhaps degrees in allied areas such as geography or spatial information), or even, on the other hand, why they do accept certain degrees. Universities cannot assume their degrees will be automatically acceptable to Boards, and they would reasonably benefit by knowing what programmes will satisfy the Boards when contemplating minor or major course changes. Boards may have representation on university programme advisory panels, but this may not guarantee that programmes meet all of the Boards' wishes. It is emphasised that the proposed list is intended for use by Boards who wish to assess whether graduates with certain degrees have an education which allows Boards to register them, and the suggested list is not intended for other purposes. The intention is not to specify the entire content of any surveying degree, but to specify the minimum essential content of a degree, if it is to be approved for candidate registration by a Board affiliated with CRSBANZ. **It should be noted that the writers do not see that the proposed core content of surveying degrees must necessarily be ground-breaking or revolutionary**; it is merely intended to provide a useful tool, in the form of a listing of the crucial contemporary content of surveying degrees. The entire core content is perceived as mandatory.

> *"…the expression of the core content of surveying degrees is not intended to be ground-breaking or revolutionary; it is merely intended to provide a useful tool, in the form of a listing of the crucial contemporary content of surveying degrees."*

Overseas qualifications: The case of surveyors with overseas qualification is informative. Surveyors from outside the Australasian jurisdiction are accepted if their qualifications are evaluated to be equivalent to a prescribed programme. For this purpose, Boards have sought advice from an organisation which they established in 1992, namely the Bureau for the Assessment of Overseas Qualifications (BAOQ). The BAOQ has introduced some uniformity into the acceptance (or otherwise) of overseas academic qualifications. Over 400 applications have been processed, with a 60% acceptance rate. The main criteria used relate to the specification of surveying degrees detailed in the so-called "Brown Book" (Institution of Surveyors, Australia, 1996), which is explained below. The weakness with this system is that Australasian degrees, which change in content from time to time, have not been scrutinised and, after nearly 20 years, many topics in the Brown Book are out-dated and new techniques have emerged. This report aims to address concerns such as these by providing what might be called a new checklist of programme attributes.

The "Brown Book": Between 1992 and 1996, the competency standards required of surveyors (not only graduates, but surveyors at all levels of seniority) were evaluated in a report by a consortium of surveyors based around what was then the Institution of Surveyors Australia. That report, the National Competency Standard for Professional Surveyors, often known as the "Brown Book" (a name which is maintained here), was prepared in recognition of the "*significance of having available a comprehensive set of competency standards which can be used to assess the performance of professional surveyors*" (page 3, our underline). It refers to the qualifications and experiences of land surveyors at various levels of seniority, so its coverage was much broader than the more limited university course requirements which dominate this report. Competency, at its simplest level, implies a maturity to undertake a task, to the satisfaction of a client and a legislative authority. The contents of the Brown Book did not appear to be binding on Boards. Part A of this new report is intended to be a useful and necessary update of those parts of that earlier book that relate to the demands of undergraduate education.

Repercussions from a prescribed list: Some repercussions from the compilation of a list of crucial degree content can be foreseen:

- The content of a checklist, if evaluated, may be shown to be equivalent to a workload which can be covered in less time than the length of some degrees. This might be seen to imply that a degree which is shorter than the current requirement is acceptable. However, it must be realised that the checklist being offered here concerns the crucial items, and the length of the period of education is a separate issue, which is touched on again later. Boards or other parties interested in the surveying profession would reasonably argue that there is a benefit from a degree of a certain length, for educational and maturity reasons, and that the extra time can allow elective or other material to be included.

- In the same vein, there is a danger that a checklist may be seen to encourage or support a modular attitude to teaching and assessment, leading to a situation in which graduates have extensive learning, but they cannot relate one problem to another, instead seeing the issues in isolation rather than having a broad view. Again, the writers advise that there must be a more extensive educational experience that allows students to assemble an overall picture, achievable through a degree which is longer than the minimum, and which provides broader experiences.

- A checklist would seem to encourage any students who had covered the material at different institutions - perhaps even by studying online without a formally recognised degree! - to claim that they deserved candidature for registration. This report draws Boards' attention to that possibility, without concluding whether or not this argument is valid. It may be an issue that Boards and other interested parties should consider.

- Listed core topics are regarded as "crucial". However, it has to be recognised that it is a fact of student assessment that a student may pass a course while not necessarily achieving a high level of understanding in all topics. The writers submit that their checklist advises graduates of the matters which he/she is expected to know about, as a professional surveyor or as a candidate for registration. Accordingly, the checklist provides advice to students and candidates for registration, as much as it advises educational institutions and Boards.

- Providing a checklist does not ensure the capability of any educational institution to teach, or even more importantly, to assess the material.

- The material needs to be described in whatever detail is necessary to enable Boards to assess the courses offered by any institutions.

1.3 Definitions

This report is devoted solely to that professional group known as “surveyors” or “land surveyors”. The terms “surveyor” and “land surveyor”, and “surveying” and “land surveying”, are regarded as generally interchangeable. Land surveyors must be distinguished from some other groups with whom they may at times be confused, namely: “quantity surveyors”, “building surveyors” and “marine surveyors”, with whom they have little in common technically, and who are not typically called “surveyors” by the layperson.

The statutory boards which affiliated with the Council of Reciprocating Surveyors Boards of Australia and New Zealand are involved in licensing (or registering) land surveyors, giving them an endorsement which allows them, legally, to undertake cadastral surveys. In the discussion below, it is at times unnecessary to distinguish between the registered and unregistered surveyor, and the distinction is then not made.

References to “surveying degrees” are intended to include any and all those undergraduate degrees majoring in land surveying and which are now automatically accepted for registration with Boards associated with CRSBANZ. Those degrees or the programmes may not necessarily be entitled “surveying” and may use words such as “engineering”, “geomatics”, “spatial” and so on. In this regards, the words “surveying” and “surveyor” are used for convenience and without any prejudice. “Graduate” will mean a graduate of an undergraduate degree programme.

It may also be pointed out that some groups of surveyors, notably “hydrographic surveyors” and “engineering surveyors”, are in fact sub-groups of the overall profession of surveyor. Land surveyors are very closely allied to “mine surveyors” (or “mining surveyors”), and some surveyors may be do the work of both. The land and mining surveying groups may be regarded as slight variations on the same measurement theme, having much in common technically and professionally, and may have the same tertiary qualifications. Some Boards affiliated with the Council of Reciprocating Surveyors Boards of Australia and New Zealand are involved in licensing both land surveyors and mine surveyors, but this report is not specifically related to the mine surveyor group, even though much of the content could be applied to both.

2 Selecting Core Content

2.1 The process of selecting core topics

Process: The aim in the Section is to define core degree content, seen as that material which is crucial to the education of land surveyors to degree level, to enable them to carry out the tasks which surveyors, and generally only surveyors, carry out. That crucial, or mandatory, degree content is defined here by a set of topics, which may comprise what the educational institutions call courses or subjects, or they may be components of courses or subjects, or they may extend over a number of similar courses or subjects. It is assumed that the topics generate knowledge, capabilities or skills, which enable surveyors to carry out their required tasks. Conversely, by firstly identifying the tasks required of surveyors, it may be possible to deduce the required skills and knowledge, and from them finally enumerate the educational topics required for the student. That path is followed here: the tasks which can be executed by any surveyor are nominated in Section 2.4, leading to a brief listing of skills in Section 2.5, and then to an outline of core topics in Section 2.6, with a more detailed listing in Section 3. Prior to that, consideration is given in Sections 2.2 and 2.3 to the criteria for deciding what is crucial, or core.

Other designations: The phrase "body of knowledge" has often used by overseas academics in relation to the required education of professionals. The Brown Book uses concepts of "*distinguishing qualities and characteristics of professional surveyors*" (Institution of Surveyors Australia, 1996, page 25) and *"core units of competency"* (page 28), while "graduate attributes" are used by some universities. These concepts are noted, but are not seen to be the same as specifying degree topics, related to specific surveying tasks, and are simply not adopted here.

Specifying the criteria: The process of selecting core topics must be logical - and even defensible in front of the wider community. The selection criteria for topics must be clear. **The writers have tried to develop a topic selection process which is sensible, robust and well-defined. It is hoped that, even if CRSBANZ chooses not to ratify the checklist provided in Section 3, the logic behind the selection of core tasks, skills and topics, may be a useful concept, usable in some way to assess whether degrees can be rationally accepted by Boards for registration of surveyors.**

The goal is a minimum list: A list of core topics must be carefully selected: a checklist which includes topics which are not really necessary could lead to a situation in which satisfactory degrees do not get CRSBANZ approval. On the other hand, a list which excludes crucial topics could lead to CRSBANZ approval of courses which are deficient in the education of surveyors. The **core material must therefore comprise a set of crucial and necessary, non-optional, mandatory topics** – enough to provide the minimum educational requirements of the graduate. It is obvious that an undergraduate may study a wide range of diverse and useful topics which are candidates for incorporation into a degree. But the challenge of enumerating core topics is to cull a long list, by excluding the unnecessary while leaving the necessary. The core topics will provide the bare essentials, leaving necessary and sufficient coverage. It would be easy to list topics which are simply seen as desirable, important or useful, but not necessarily essential or crucial, to surveyors. **The writers envisage that the core elements are those which could**

It is proposed that the core elements would comprise an acceptable degree in a situation which required land surveyors to be educated in minimum time or at lowest

comprise an ideal degree in a hypothetical situation in which useful land surveyors were to be educated in minimum time or at lowest cost.

Multi-skilling: One of the complications in defining what is necessary is that most professions are multi-skilled: few tasks are exclusive to any one profession. A surveyor knows how to do things which are done by non-surveyors, and non-surveyors know how to do things which are done by surveyors. For example, surveyors may do some engineering design, which is usually done by engineers; environmental engineers may be able to use a total station. Even with clear criteria, there will be "grey areas" whose classification is in the balance. Some disagreement with the suggested topics must also be anticipated, especially from those who see the list as too brief and/or excluding their area of interest, and it may be necessary to forestall that criticism with a clear expression of the logic used. In subsequent sections of this report, the selection of the obligatory degree content is assisted by observing that the mandatory core content is of two different types: in the first group is knowledge which is the province of surveyors (see Sections 2.2), and in the second is knowledge which supports the first group (see Sections 2.3).

…the mandatory core content are of two different types: in the first group is knowledge which is the province of surveyors, and in the second is knowledge which supports the first group.

Sources of information: It is not entirely appropriate for the selection of core content to be based on the writers' own suggestions. Input to the selection has been sought from various publications, including the Brown Book, but also presentations at recent conferences of the International Federation of Surveyors (e.g., Greenfeld, 2012; Roy, 2012; Goodhead, 2012; Mangione and Romanelli, 2012; Roberts, 2012; Bačić, 2012). The conference presentations provide useful concepts and general opinions, but they rarely provide the detail topic selection which is sought for this report in the context of local CRSBANZ needs. Ultimately, therefore, many of the decisions about core content have been influenced substantially by the writers' own experiences and opinions, which fortunately is at least based on a total of over seventy years of academic involvement.

2.2 Inner core topics: the province of surveyors

"Inner core" tasks and skills: It is useful to realise that there is a large number of skills which are regarded - by the knowledgeable community perhaps - as the province of the surveyor. They are skills which are almost unique to the surveyor. Only surveyors are assumed to have these skills, and all surveyors are assumed to have these skills. When the community seeks these skills, they expect that it is surveyors who are the experts who provide them. And if surveyors are not available, the source of the execution of that task is not readily apparent! (While they may be used occasionally by some members of another profession, they are not typical of members of another profession). **Such skills are categorized here as inner core skills**. **They correspond to inner core topics in degree programmes**. **It is found that these inner core topics are normally taught in universities by academics with a surveying background. Students would be expected to achieve an excellent understanding of inner core topics**. Astronomical positioning is a classic example of what is here called an inner core task: only surveyors have been able to determine their position to single second accuracy from the stars.

"Precise astronomical positioning is a classic example of a recognisable inner core surveying skill: non-surveyors cannot locate themselves to single second accuracy from the stars."

That point is crucial to the compilation of the checklist. Another example of an inner core task is the use of total stations: all surveyors can be expected to use a total station; (some engineers can use a total station, but not all engineers can do so).

2.3 Outer core topics: support for inner core topics

"Outer core" tasks and skills: In order to acquire or use the inner core skills, surveyors need some related knowledge – whether some fundamentals of general mathematics and sciences, or knowledge that enable surveyors to work with other surveyors and/or with other professionals, clients or colleagues. They are regarded here as **outer core** skills. They are not seen as the sole province of the surveyor. Outer core topics include some awareness of the allied professions, notably engineering, and communications skills and business management, which enable surveyors to execute their inner core tasks. Not only surveyors have these skills. When the community seeks these skills, it is not necessarily expected that it is surveyors who provide them. **The outer core material is necessary for surveyors to enable them to carry out inner core tasks. Outer core topics are <u>not inferior</u> to the inner core skills, but they may not typify the surveyor.** Outer core topics are normally taught in universities by academics with a background other than surveying. Graduates with a degree other than surveying will rarely have covered the inner core material - but they may have covered some or all of the outer core material. **Students may not be expected to gain the level of detailed understanding of the outer core topics that would be expected for inner core topics.**

An example of an outer core topic is English (grammar and expression), because it is not unique to surveyors but it is required to enable the surveyor to execute an inner core task: that of reporting survey outcomes to colleagues and clients. Mathematics and sciences are also crucial to surveyors, and are core, but they are not exclusive to surveyors, so they are <u>outer</u> core. Outer core topics are still mandatory in the context of this report.

2.4 The tasks of a land surveyor

Fairly clearly, the selection of a set of core topics hinges on a characterisation of what a surveyor is, or does, or is seen by the community to do, and the process followed here is to identify the surveyor's core tasks, and then to use the tasks to identify the required crucial topics. Indeed, the most difficult part of the entire core topic selection process is to define the surveyor, and more specifically to define the limits to what a typical surveyor does.

CRSBANZ definition of the surveyor: The CRSBANZ website (Council of Reciprocating Surveyors Boards of Australia and New Zealand, 2013) refers to the "international definition of a surveyor" provided by the International Federation of Surveyors, and is reproduced in Figure 1. The bulk of the descriptions relate to the "functions" or "activities" of the surveyor, an explanation of the surveyor's expertise which does not help home in on specific tasks. A more succinct definition from CRSBANZ is that,

> *"A land surveyor means a person carrying out professional surveying work, the adequate discharge of which work requires possession of the following qualifications:*
> *(i) they have a qualification that will admit them to a Degree of Bachelor of Surveying at an Australian or New Zealand's Otago University;*
> *(ii) they hold a licence or registration as a Surveyor in an Australian State or Territory or in New Zealand,*

and it then explains what surveying is:

"Land surveying is the definition of land boundaries by the application of survey procedures and exercise of judgement in accordance with precedent and statute law. It includes surveys for the layout of cities, sections, roads and streets; the disposition, subdivision, alienation, resumption, amendment of title and other dealings in land and interests in land. It also includes the collections of material facts and the giving of evidence for courts of law in cases of damage, title boundary disputes, the rectification of titles, etc., the preparation and giving of professional opinions, and interpretation of descriptions and other documents pertaining to land and interests therein.
Land surveying is regulated by the laws (Acts and Regulations) of the various States and Territories of Australia and of New Zealand, relating to land dealings".

The definition adds: *"however there are many other surveying disciplines, the more common forms are described below. …,"* and refers to and describes other types of surveying: geodetic surveying, topographic surveying, engineering surveying, hydrographic surveying, and mining surveying.

Definition by Institution of Surveyors NSW: The outline by the Institution of Surveyors New South Wales Inc. (ISNSW) may suggest how surveyors see themselves:

"Surveyors carry out measurements both above and below ground and water, surveying by varying means to establish relative position and size of both natural and man-made objects", (Institution of Surveyors New South Wales, 2013*).*

The adopted definition: The definition is seen to be influenced by the following three aspects of the surveyor.

1) **The surveyor as measurer:** The writers observe that the functions of the surveyor given by International Federation of Surveyors are broader than the specific definitions of surveying and a surveyor given by CRSBANZ (which is obviously pertinent to this report) and ISNSW. A definition which says what the community would expect all surveyors to be able to do, and only surveyors to be able to do, is more likely to be in line with the latter two definitions. This report seeks a minimal list of core tasks, concentrating on what work is necessarily executed by surveyors, in line with the concept of recognising the surveyor's crucial skills. The distinctive attribute of a professional surveyor in Australasia, (not necessarily a registered surveyor at this stage of the discussion) may then be seen to be those of **a professional measurer, who is able to undertake precise spatial positioning in a way that no other professional can, knowing the precision of the positioning and whether it suits the purposes of the survey.** That surveyor is regarded as being involved in:-

"The distinctive attribute of a surveyor … may be one who is able to undertake precise spatial positioning in a way that nobody else can."

- **establishing a widespread network of precise control points in three-dimensions**, which are used to support
- **measuring, using competently a wide variety of techniques, the general topographic surface of the earth, along with natural and constructed or cultural features on it, such as roads and buildings, and also measuring a range of other objects, which may be from a few metres to some kilometres in size, particularly**
    - **industrial objects,**

  - **buildings and various other engineering structures, whether completed or under construction,**
  - **the earth's surface underwater** and any natural and manufactured features thereon,
- while operating in a wide variety of situations, including underground, on industrial sites and on the water, and
- **setting-out points which define the location of objects to be constructed**,
- to **as high a precision as is required**, (and notably to a level which is higher than non-surveyors might), and
- **converting the measurement data to spatial information of high accuracy**,
- **calculating in three dimensions and/or taking into account the curvature of the earth** if and when and as necessary,
- **while knowing, generally or specifically, as necessary, the accuracy of the information being provided**, and
- **presenting proficiently the results of the measurement as spatial information** in a form required by and/or useful to a second party (client, colleague, supervisor, and so on), noting the expanding use of digital information which is geo-referenced,
- **utilising a sufficient working knowledge of related professions** such as town planning and engineering design which facilitates the measurement and set-out tasks mentioned above,
- **while working safely**, and
- **communicating professionally** with colleagues, clients and the public.

2) **Surveyors and the land:** The writers observe that the functions of the surveyor given by International Federation of Surveyors makes repeated references to the land and geography. Historically, surveyors certainly had a distinctive role connected with the land. During the era of the Europeans' exploration of Australia and New Zealand, many explorers were surveyors. In subsequent eras, surveyors continued to be involved in mapping, and were out and about on the land well before most other professions. Arthur Streeton's painting, "Surveyor's Camp", depicting a site near Richmond, NSW, in 1896, reveals how the surveyor was mapping, in the field, on the land, before perhaps any other professional worker. This connection with the land continued of course with the surveyor's crucial role in rural and urban land developments and the construction of all manner of infra-structure. This has given surveyors a close affinity with the land and its geography, for mapping and land development. This may not be immediately recognised in the topic lists above. For that reason, the outer core (and non-core) listings <u>also</u> include references to land-related studies, such as land development, and land use, and/or geography.

3) **Registered/Licensed surveyors:** The definition above of an Australasian surveyor is not necessarily one who is registered via CRSBANZ. In addition, therefore, a registered/licensed surveyor is a professional measurer as defined above, but who <u>additionally</u> is involved in:-

- **legally delineating property boundaries, whether rural or urban,** knowing relevant boundary law, and using those field, calculation and presentation techniques which are especially applicable to boundary surveys,
- **practising professionally** as a registered/licensed surveyor.

2.5 The core skills of a surveyor

Considering the core tasks of a surveyor at Section 2.4, the core skills required of the surveyor, who is viewed as a professional with a close affinity to land and its geography, have been deduced as being:

1) **able to undertake measurement for positioning in general**, but notably for defining topographic, urban, engineering and industrial objects, involving field techniques and detailed usage of all survey instruments, including levels, total stations, global navigation satellite systems (GNSS), laser scanners, and imaging systems from close-range or aeroplanes;

2) **familiar with a variety of more specialised types of survey**, including control surveys, engineering surveys for building construction or for road and railway construction, underground surveys for mining and tunnelling, industrial surveys, and photogrammetric surveys;

3) **able to define boundaries by executing cadastral surveys;**

4) **able to process measurement data to convert it into spatial information;**

5) **able to present the spatial information** in a format suited to colleagues, clients, and/or the public;

6) **able to communicate and discuss survey matters with colleagues, clients, and/or the public;**

7) **able to work professionally, ethically, and safely.**

The essential surveyor: The above definitions of the surveyor provides objective assessments of a surveyor, without distilling any essential characteristic of a surveyor, and that can lead to an equally clinical listing of core topics of a surveying degree. In that light, it is worthwhile reflecting on the characteristics of surveyors and surveying to consider whether an education based on the core topics is in fact sufficient to fashion surveyors. The surveyor does seem to be different from other professionals. It is even arguable that surveyors generally see themselves as different from other professions, and guard the distinctions jealously. Apart from anything else, surveyors have to work to far higher absolute and relative accuracies than almost all other professions, both now and in the past. It may also be that the surveyors' requirement, especially the cadastral surveyors' requirement, to continually refer to past survey records to locate survey marks, instils in them a historical perspective on the work and role of the surveyor. More than that, this discussion relates to various other references in this report on the length and breadth of education, and shows how the degree must not only cover the dispassionate list of core topics, it should inspire students with the broader aspects of the surveying profession.

International Definition of a Surveyor

A surveyor is a professional person with the academic qualifications and technical expertise to practise the science of measurement; to assemble and assess land and geographic related information; to use that information for the purpose of planning and implementing the efficient administration of the land, the sea and structures thereon; and to instigate the advancement and development of such practices.

A professional surveyor will practise surveying for the benefit of society. The practice of surveying may involve, but is not limited to, one or more of the following activities which may occur either on, above or below the surface of the land or the sea and may be carried out in association with other professionals.

1) Acquiring, interpreting and manipulating geodetic data to determine the shape and size of the earth and its surface.
2) Designing, establishing and managing the spatial infrastructure and fundamental data sets needed to support economic development and environmental management at a local, regional, state or national level.
3) Maintaining a spatial infrastructure, as required, to support an effective cadastre and efficient land tenure systems that meet real estate market requirements.
4) Determining, locating and defining the boundaries of public and private land (including national boundaries), interpreting anomalies in the cadastre, and arbitrating on disputes over boundary location.
5) Designing, establishing and managing spatial reference systems to provide a homogeneous framework for geographic and land information systems.
6) Collecting, analysing and managing geographic data and designing, establishing and administering land and geographic information systems.
7) Measuring, controlling and monitoring the shape, size and location of physical features, structures, machines and engineering works and determining their spatial relationships.
8) Measuring and mapping seabeds, lakes and waterways; measuring tidal movements and current flows; providing information for navigation and maritime developments.
9) Providing information and advice, pertinent to property and its environment, to assist in determining the best sustainable land use and development.
10) Assessing the potential benefits or disadvantages that could accrue from property development and advising clients and government accordingly.
11) Contributing to the development and management of urban and rural properties by planning, advising, negotiating, and implementing procedures.
12) Planning, estimating, designing, measuring, and implementing projects such as construction works, mineral exploration, and mining; and applying prudent financial control and sound project management principles.
13) Producing for clients, plans, maps, files, data bases, models, charts and reports.
14) Advancing the science of measurement; the management and administration of land and land information; the effectiveness of surveying; and the assessment, management, and introduction of new concepts such as geomatics and geoinfomatics.

In application of the foregoing activities, surveyors take into account the relevant ethical, legal, financial, environmental and social aspects affecting each project.

Figure 1: International definition of a surveyor quoted by CRSBANZ

2.6 Outline of core topics

Outline of topics: From an analysis of the above definition of the tasks and skills of a surveyor, the following core educational topics have been derived and allocated to broad groups discussed below. Figure 2 represents the concept graphically. For some purposes, this outline may be more useful than the detailed listing in Section 3. **It is emphasised that core topics would be mandatory for courses approved by Boards; the extent of the coverage is specified in Section 3. Inner core topics differ from outer core topics by the exclusiveness to surveying.**

Inner core topics:

1) **Measurement, or raw data collection in general:**
   a) Crucial principles of surveying, including field-note taking, the need to avoid errors and the need for checking.
   b) Surveying concepts: working precisely, in three dimensions, horizontal and vertical components, spherical and ellipsoidal earth shapes, Cartesian and spherical coordinates.
   c) Taking measurements, notably of topographic, urban, engineering and industrial objects: field techniques and detailed usage, including calibration and testing, of all survey instruments, including levels, total stations, GNSS.
   d) Introduction to laser scanners and imaging systems from close-range or aeroplanes,
   e) Sources of instrument errors and measurement errors (including refraction and earth curvature) and corrections; typical accuracies.
   f) Reductions of field measurements for known errors and for calibration.

2) **Processing measurement data to convert it into spatial information:**
   a) Survey computations: plane coordinates and heights, reading plans to derive spatial and dimensional information; the theory behind all routine surveying calculations.
   b) Typical errors in calculations; significant figures, and accuracies of computed quantities; assorted numerical skills; procedures for check calculations.
   c) Engineering set-out calculations.
   d) Contouring, including accuracy and errors in contouring; areas and volumes from coordinates, accuracy of area and volumes from coordinates.
   e) Spherical and ellipsoidal earth models, Cartesian, spherical, ellipsoidal and geoidal coordinates; geodetic effects, curvature of the earth; geodetic datums; map projections in detail; map grids and their characteristics.
   f) Error propagation/variance propagation; adjustment by least squares; *a priori* survey design; assessment of accuracy of computed quantities.

3) **Basic presentation of spatial information to colleagues, clients, and/or public:**
   a) Survey software packages.
   b) Report preparation.

4) **Control Surveys:**
   a) Instrumentation; network design.
   b) Accuracy specifications and relevant regulations.

5) **Survey Specialisations:**
   a) Engineering surveys for building construction, for road and railway construction, etc.
   b) Underground surveys for mining and tunnelling.
   c) Industrial surveys.
   d) Photogrammetric surveys.
   e) Laser scanning.
   f) Hydrographic Surveys.

6) **Cadastral surveying (crucial to registered surveyors but not to non-registered surveyors):**
   a) Land boundary and cadastral law to a high level.
   b) Field techniques applicable to boundary surveys.
   c) Professional practices as a cadastral surveyor.

Outer core topics:

7) **Fundamentals of mathematics and sciences:**
   a) Basic sciences, especially physics, earth sciences and geology.
   b) Basic mathematics and statistics.

8) **Specialised presentation of spatial information for colleagues, clients, and/or public:**
   a) GIS, computer graphics/CAD, and city modelling.

9) **Communication with colleagues, clients, and/or public:**
   a) Communication, report writing, English expression.

10) **A working knowledge of applications of surveying in allied professions, to facilitate discussion of surveys with colleagues and clients:**
   a) Introduction to land administration, land development, economics, land usage.
   b) Basic engineering: hydrologic, hydraulic, geotechnical; road and railway design, transportation.
   c) Introduction to mining practices.
   d) Basic town planning.
   e) Basic property valuation.
   f) Basic remote sensing.

11) **Working professionally, ethically, safely:**
   a) Business management and business practice.
   b) Work health and safety.
   c) Ethical matters, social issues.

Comment on cadastral surveying: Surveyors' involvement with cadastral surveying has an interesting peculiarity. By being able to legally specify where a boundary is, the registered surveyor has a responsibility and capability which seems to deviate from a pure measurement role defined above. The legal responsibility of deciding where a boundary lies would seem to be the province of the lawyer, and, as such, the topics associated with cadastral law would seem to the uninitiated to be core to a law degree, not to a surveying degree. It has to be recognised that the surveyors in the states of Australia, the Australian Capital Territory, the Northern Territory, and New Zealand all have an act of parliament which is centred on them, their surveying and their Boards of Surveying or equivalent. The registration and recognition of cadastral surveyors enshrines their additional legal power. No other professionals seem to have this dual character, in this case an additional legal power which seems to be beyond their normal field of measurement expertise, and that needs to be jealously guarded in the specification of degree content. The right of the surveyor to legally define a boundary

> *The states and territories of Australia and New Zealand have an act of parliament which is centred on … surveying… No other professionals seem to have this…*

means that some legal matters must be inner core, even though they do not appear to be ultimately related to measurement.

Other approaches: The approach of selecting core topics from a theme of surveyors' tasks, as followed here, may seem to be obvious. However, Greenfeld, in a search for the surveying body of knowledge (but not for Australia), groups his body of knowledge into five distinct core sub-sets of knowledge (positioning, imagery, GIS, law, and land development) plus a knowledge base in mathematics and so on, (Greenfeld, 2012). His subdivision of the body of knowledge therefore tends to be into work types. What is notable is how different his listing of degree content is from that presented here.

2.7 Outline of non-core topics

Non-core items: There are clearly matters which many surveyors may want to know about but which another professional may routinely undertake or provide under normal circumstances. These are not crucial for surveyors to know. The matters are not core by the definition used here. Excluding these topics leaves those which are sufficient. **The non-core items are optional and discretionary, AND Boards would not mandate them. But they are recommended as general educational material outside the core, or as priorities for electives. Educational institutions would even be expected to teach these matters to make their programmes attractive to students.**

> *"The non-core items are recommended as general education outside the core, or as priorities for electives"*

Non-core topics would cover the following sorts of material:

- **Specialised sciences:**
  Earth sciences: geophysics, geology.
  Geography.
  Tides.
  Elective mathematics.
  Elective statistics.
  Computing skills, including programming with a low-level or high-level language.

- **Allied professions:**
  Land administration, land development, economics, land usage.
  Specialised spatial information systems and more detailed aspects of GIS.
  Specialised remote sensing.
  Engineering design relating to subdivisions and land development generally: hydrological, hydraulic, geotechnical.
  Engineering transportation, structures, road and railway design.
  Mining engineering.
  Local government policies, finance and law.
  Indigenous studies, especially related to the law.

- **Other surveying**
  Aspects of positional astronomy theory and practice.
  Higher geodetic surveying and geodetic science.
  Higher photogrammetry.

2.8 Education considerations

The writers are keen to emphasise an argument given in section 1.2: that university courses are concerned with education, and are not aimed at "training", and that, although the core topics are presented here as a "checklist", it is still expected that surveyors should have a good comprehension of all matters. It is important that graduates have a grounding which ensures that they can continue over their career to adapt to new developments, presumed to grow at an ever faster pace, while remaining true to a founding requirement of being involved in precise spatial positioning. In that regard, the writers have tried to maintain an awareness of those fundamental matters which might contribute to enabling graduates to stay on top of precise positioning problems in the future. This is taken up again in Section 4.

2.9 Length of a land surveying degree programme

For the past three decades, all approved land surveying degree programmes in Australasia have been of four years duration. This report provides an opportunity to re-visit the length of the degree programme. A simple consideration would suggest that all engineering-based degree programmes in Australasia are a minimum of four years in length. For surveyors to maintain a long-considered parity with engineers, and acknowledging that there is much common material amongst several engineering degrees and land surveying, and that the entry levels within most Engineering Faculties are similar, then four years seems appropriate.

It is worth noting that for the last decade, countries inside Europe have moved to the five year model of a basic Bachelors degree of three years duration followed by a two year specialist Masters degree. The University of Melbourne embarked on this model five years ago, but to date it has not been well accepted by students in its Engineering Faculty. The concept of providing a specialist Masters degree which would be attractive to European students has merit, but at this time (2013) it could be argued that external factors including the highly valued Australian dollar and the Global Financial Crisis have thwarted its appeal.

An independent way of assessing what is considered to be the necessary, or appropriate, length of a land surveying degree is to examine the degree programmes approved and accredited by the Royal Institute of Chartered Surveyors (RICS) as appropriate for membership of their Geomatics Division. With only one or two exceptions, they are all of four or five years in length. The odd exception is three and a half years in length BUT with three terms per year rather the Australian model of two semesters.

The RICS criteria include the number of contact hours as well as the research output and teaching quality of the staff, the entrance criteria for students (cut-off scores, etc.) and some assessment of the quality and industry acceptance of graduates. In the last 15 years, Australian universities have reduced their semesters to 12 teaching weeks, the number of subjects per semester to four and the number of hours per subject to four per week (some with practical work components may be longer). This can be compared with the period up to the 1980s, when Australian Universities had teaching years of up to 30 weeks with between 24 and 30 hours per week of staff-student contact. The Australasian degrees presently have near to the minimum acceptable number of staff-student contact hours for RICS accreditation. RICS has closely examined and accredited only a few Australasian degree programmes, but it is obvious that any reduction from four years would make graduates with (shorter) Australasian degrees ineligible to seek RICS membership. Note that such membership is essential in parts of the world before obtaining government contracts.

Another way of examining the dilemma of deciding the proper length for a surveying degree is to consider the experiences of some senior university lecturers. Most will admit that the essential elements of a land surveying degree could be crammed into a three year period, but all will suggest that in order for a student to mature and fully assimilate with the surveying information presented, that four years is essential. It is only in the fourth and final year that the individual strands of surveying can be tied together in meaningful major projects, often termed ‘capstone projects’, and appreciated as options which could be used to solve multi-faceted problems.

Boards of Surveyors try to test ‘competencies’ and set candidates practical assignments which allow them to demonstrate their competency. Once a student has graduated they should possess and understand the basic tools of surveying, but it is maturity which allows the graduate to express that tool as a competency. After three years of university, given the Australian semester system, there simply has not been enough time to assimilate all the necessary information and maturely understand it.

The writers of this report would support four years as still the desirable minimum length for a land surveying degree in the current Australasian university system.

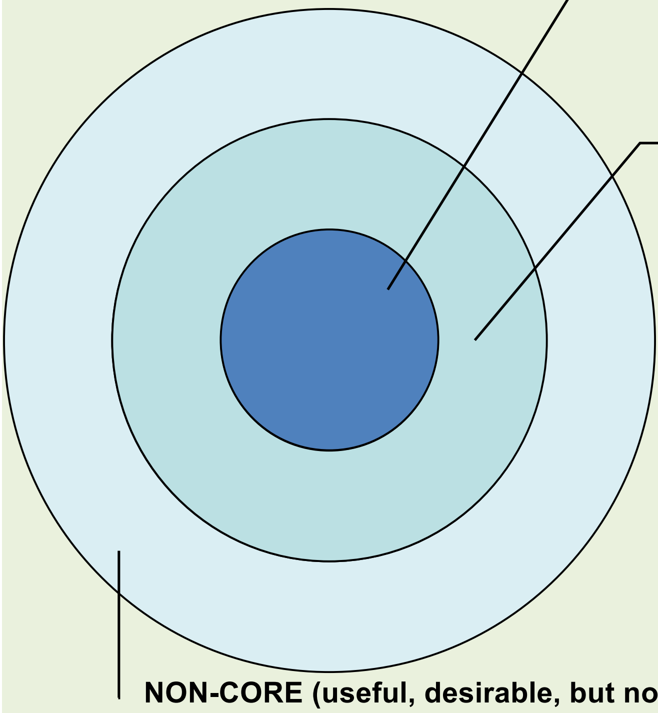

Figure 2: An outline of constituents of programmes in terms of proposed mandatory core topics (inner and outer) and non-core topics.

3 Catalogue of Proposed Core Surveying Degree Content in Detail

The suggested core surveying degree content is listed in Sections 3.1 and 3.2. The tables should be read with an awareness of the following:

- The topics given in the first row of the tables are intended to indicate the connection with those given in Section 2.6.
- The goals in the second row are intended to be just as instructive as the subsequent rows indicating specific content.
- The amount of detail which is provided in the tables is intended to be greater for those topics for which the content is less obvious, or which are seen as more controversial or more difficult to select.
- It has been seen to be valid to suggest at times that content be "at the discretion of the educational institution", assuming that familiar, competent and reputable institutions in Australasia are being assessed.

Prerequisites: It is assumed that all students entering university programmes in surveying have completed the highest school level in Australia or New Zealand, with a high level of mathematics and physics experience, or the equivalent of such qualifications. It should be noted that universities do not necessarily require that students have that entry qualification.

Changes to the role of a surveyor since the Brown Book: Some difficulty is caused by deciding whether the role of the surveyor - and hence the definition of the surveyor – has changed over the last 20 years. There been a growth in the use of GIS, remote sensing, laser scanners (of various sorts), GNSS of various accuracies, online mapping resources, digital spatial data sets from a variety of sources, and so on. It was foreseen that these may impact on surveying, by introducing new options for surveyors or, conversely, by allowing non-surveying professionals or even lay-persons to undertake work normally done by surveyors. However, the opinion of the writers is that impact has been less than expected. As Greenfeld says, *"…sometimes, new technologies can give us a false belief that we can do things that we really can't. Just because we have easy access to tools it does not mean that we can do the job as well as a professional person,"* (Greenfeld, 2012, page 2). Precise three-dimensional positioning still requires an understanding of what instrument output means and when errors are occurring: spatial information systems and remote sensing, low accuracy GNSS and low accuracy scanning have not altered these challenges. Even though technological changes have made many tasks <u>appear</u> simpler to execute, that has not turned out to be true. Despite forecasts that surveying would be killed off by GNSS or "Google maps" or laser scanners, engineers needing precise three-dimensional positioning still call upon the professional surveyor. The existence of satellite navigation systems in cars seems to have spread the impression that its use is simple. However, knowing of satellite navigation does not mean knowing about it, and the means to achieve the high accuracy positioning required by a surveyor from satellites has added to the knowledge base required of the surveyor, not reduced it. Despite the prevalence of precise GNSS, the person in the street does not carry out engineering set-outs: given scale factors and grid convergence, it still requires a surveyor to interpret MGA coordinates!

3.1 Inner core (Mandatory material)

(1)	Introduction to surveying and to crucial concepts in surveying
Goals	To convey the nature, characteristics, concepts, fundamentals and some history of surveying, and distinguish it from other professions. To convey crucial concepts in positioning.
Content	Crucial principles of surveying, but including: • the essential need for accuracy and to avoid mistakes; checking and re-checking, the need to take all necessary measurements in the field; • field notes, including sketch plan drawing. Positioning concepts such as working in horizontal and/or vertical, angles and bearings, plane, spherical and ellipsoidal earth shapes, Cartesian and spherical coordinates, cartographic principles and plan reading. Use of control points and bench marks to commence surveys.
Superseded material	Detailed cover of historical instruments and techniques.
Pre-requisites	High school mathematics at a level which is sufficient to undertake a technical degree at university, or university equivalent.

(2)	Data Collection: field measurement techniques
Goals	To engender competent use of the full variety of field equipment types which are normally encountered by surveyors; to convey an understanding of error sources, means of overcoming errors, calibration processes for all equipment; to provide awareness of the varieties and capabilities of equipment available on the market; to provide adequate practical experience to permit the surveyor to be a competent user soon after graduation.
Content	Full details of the following: • levels: practical use; error sources; accuracies, testing, standard booking practice; bench marks; • total stations, including EDM: error sources, accuracies, testing, calibration, and including reflectorless and robotic instruments, data recording options; • GNSS field options available to surveyors to obtain low, medium and highest possible accuracies, in three-dimensions, using diverse real-time and post-processing techniques, predominantly using differential methods with nearby base station or external signal corrections; introduction to commercially available equipment. Crucial aspects of measurement with: • steel bands; • echo-sounders, including multi-beam versions.
Superseded material	Steel band measurement in detail. Barometric levelling, and use of barometers for other purposes.
Pre-requisites	High school physics at a level which is sufficient to undertake a technical degree at university, or university equivalent. Physics: rotational motion, wave motion, basic electricity/electronics: see Topic (19).

(3)	**Processing measurement data to convert it into spatial information: field reductions**
Goals	To enable the surveyor to correct field measurements for known sources of error.
Content	Instrument errors. Refraction models. Applying calibration parameters. Full details of GNSS theory and processing options available to surveyors to obtain low, medium and highest possible accuracies, in three-dimensions, using diverse real-time and post-processing techniques, predominantly using differential methods with nearby base station or external signal corrections; introduction to commercially available software. (See also geodetic considerations.)
Superseded material	-
Pre-requisites	High school mathematics at a level which is sufficient to undertake a technical degree at university, or university equivalent.

(4)	**Processing measurement data to convert it into spatial information: surveying computations**
Goals	To enable the surveyor to convert field measurements into useful information, whose accuracy and other characteristics are estimated.
Content	2D computations, including: • angle computations; • plane coordinate computations, especially from bearings and distances; • traverse computations, simple adjustment of traverses; • subdivision calculations; • intersection and resection; • extensive examples from practice. Heighting: trigonometric levelling. 3D computations: 3D geometry, examples from practice. Numerical skills: orders of magnitudes, significant figures. Options for checking calculations.
Superseded material	Intersection and resection using approximate methods. Computations involving approximated and/or series solutions which facilitate manual computations.
Pre-requisites	Computing: spread-sheets. Mathematics: spherical trigonometry: see Topic (19).

(5)	**Processing measurement data to obtain spatial information: computing skills**
Goals	To provide the surveyor with the technical skills to undertake calculations.
Content	Computing skills, spread-sheet capabilities.
Superseded material	Detailed instruction on how computers and peripherals work.
Pre-requisites	-

(6)	**Processing measurement data to convert it into spatial information: geodetic considerations**
Goals	To enable surveyors to convert measurements to ellipsoidal spatial data when earth curvature is relevant, knowing enough geodesy to carry out geodetic surveys, i.e. those surveys affected by the shape of earth, including competent use of a map grid.
Content	Basics: latitudes, longitudes and heights on earth; latitudes and longitudes on ellipsoidal geodetic datum; eastings and northings on map projections; the relationship between these systems and the effects on surveys. Introduction: the relevance of gravity and the earth's shape to contemporary surveys. The concept of level surfaces and the geoid; relationship with MSL; sources of geoid information; corrections to field observations, e.g. deflection of vertical, etc. Ellipsoidal datums: Approximation of geoid by ellipsoid - satisfactory for most surveying; shape and size of optimum ellipsoid; ellipsoidal latitude and longitude coordinates; azimuth; equivalent Cartesian coordinates; local geodetic datum and its characteristics (e.g., parallelism of ellipsoid and earth's rotational axes), fundamental stations and extended control networks. Map projections: concept of different projections with different properties; UTM in detail: conformality - relevance to surveying; scale factor; grid convergence, meridian convergence, true north and bearings, calculations with grid coordinates; map grids and characteristics; limited coverage of conversion between ellipsoid and grid. Background to positional astronomy: astronomical coordinates based on the vertical; basis of astronomical positioning and azimuth determination by the stars and sun.
Superseded material	Physical geodesy: determination of geoid by various methods, gravimetric, astro-geodetic and satellite (including GNSS). Detailed mathematics of the ellipsoid, and calculations with coordinates on it (e.g. distances from latitude and longitude). Detailed formulae for conversions between ellipsoid and map grid. Positional astronomy: sidereal time systems; star coordinate systems; means of calculating latitude, longitude and azimuth from stars.
Pre-requisites	Mathematics: spherical trigonometry: see Topic (19).

(7)	**Processing measurement data to convert it into spatial information: errors in measurements and error propagation**
Goals	To enable surveyors to estimate and quote the accuracy and/or precision of surveys, and to recognise when errors may be occurring, in order to ensure the validity of information conveyed to clients, colleagues, etc.
Content	Types of errors, and their properties. Accuracy and precision. Propagation of variances; software packages for real-world control surveys. Statistical testing of calculated quantities.
Superseded material	Approximate adjustment methods, e.g. braced quadrilateral adjustments.
Pre-requisites	Mathematics: partial differentiation: see Topic (19).

(8)	Processing measurement data to convert it into spatial information: adjustment of observations
Goals	To appreciate the theory behind adjustment to be able to examine output from adjustment software, understand and interpret it and to recognise problems and errors, and to be able to contribute to analytical survey design.
Content	Purpose of adjustment, concept of least squares method, distinguishing observations/measurements and unknown quantities; observation equations; weighting by expected precision; solutions for parameters and corrected observations; precisions of parameters and observations. Statistical testing of adjustment results. Characteristics of least squares solutions: influence of errors/blunders. Network design and analysis. Familiarity through experience with simple adjustments.
Superseded material	Detail of condition method and its solutions. Approximate solutions.
Pre-requisites	Mathematics: matrices; solutions of linear equations: see Topic (19).

(9)	Presentation of survey information
Goals	To enable the surveyor to present survey information effectively and according to conventions.
Content	Map and plan concepts and conventions. Contouring, including its accuracy, errors in contouring; areas and volumes from coordinates, accuracy of area and volumes from coordinates. DTM, DEM and geo-referenced spatial data. CAD software usage. Concepts of 3D graphics presentation.
Superseded material	Manual cartography methods.
Pre-requisites	-

(10)	Control surveys
Goals	To enable surveyors to be able to plan and execute a survey which will establish a system of control points around a project area.
Content	A revision of equipment types and the advantages/disadvantages of selecting certain types of equipment depending on topographic or other constraints. Expected accuracies of different techniques and the accuracy requirements and specifications of local and national authorities.
Superseded material	-
Pre-requisites	Topics (1) to (9).

(11)	**Survey specialisation: engineering surveys for building construction**
Goals	To give surveyors the opportunity to be involved in planning, calculating, executing and managing surveys involving small, medium and high-rise building construction, working cooperatively in a team with other professionals on larger projects. Competency in medium to high-rise construction is not expected of new graduates.
Content	As a survey specialisation, coverage may range from an introduction to full details of types of building set-out requirements ranging from domestic buildings to strata units to high-rise; management matters.
Superseded material	-
Pre-requisites	Topics (1) to (9).

(12)	**Survey specialisation: engineering surveys for road and rail construction**
Goals	To give surveyors the opportunity to be involved in planning, calculating, executing and managing surveys involving road and rail construction, and to work cooperatively in a team with other professionals on larger projects.
Content	As a survey specialisation, coverage may range from an introduction to full details of engineering set-out practice, including roads and railways. Computations: • cut and fill, cross sections, long sections; • horizontal curves, including tangent points, lengths etc.; • basic transition curves • vertical curves.
Superseded material	Detailed derivations of multiple types of esoteric spiral and transition curves.
Pre-requisites	Mathematics and physics generally: see Topics (18) and (19). Topics (1) to (9).

(13)	**Surveying specialisation: industrial measurement**
Goals	To give surveyors the opportunity to be involved in industrial surveys by provide an awareness of the special difficulties faced and special techniques used in industrial surveys; to provide an awareness of options in industrial measurement, to facilitate selecting solutions, and provide a knowledge base which can be built on later if desired. Full professional competence enabling graduates to work without supervision at graduation is not expected.
Content	As a survey specialisation, coverage may range from an introduction to full details of raw data collection and converting measurements to spatial data, in the special case of measurement for industrial purposes. Theory and practical options for precise determination of flatness, verticality, levelness (including high precision levelling), straightness, squareness, deformation, shape. Case studies.
Superseded material	-
Pre-requisites	Topics (1) to (9).

(14)	Surveying specialisation: underground surveys
Goals	To give surveyors the opportunity to be involved in surveys underground, by providing a knowledge of the special difficulties faced and the special techniques used in working underground for tunnelling and mining; to provide an awareness of options and possibilities in underground working, to facilitate selecting solutions from options, and to provide a knowledge base which can be built on later if desired.
Content	As a survey specialisation, coverage may range from an introduction to full details of raw data collection and converting measurements to spatial data, in the special case of measurement underground. Theory and practice for underground mining and tunnelling, including transfer of control, guidance and monitoring, and volume determinations. Gyro-theodolites.
Superseded material	-
Pre-requisites	Topics (1) to (9).

(15)	Surveying specialisation: photogrammetric imaging and processing
Goals	To give surveyors the opportunity to • appreciate the capabilities of close-range photogrammetry, and be able to assess the viability of photogrammetric approaches to tasks using packaged software if required, and • to work competently in the field of mapping from aerial or space imagery, under supervision on graduation.
Content	As a survey specialisation, coverage may range from an introduction to full details of raw data collection and converting measurements to spatial data, in the special case of measurement using imagery, with coverage as follows: Stereoscopic viewing of pairs of images. Concepts of intersection and resection of rays; solutions of intersections and 3D resections of rays (including weaknesses in solutions). Camera optics in brief; properties of lenses, sensors, film and images, sources of error, calibration. Commercial software and hardware for non-aerial use. Analogue methods. Digital methods, including target recognition. Examples from practice. Application to high accuracy mapping from near-vertical aerial and satellite imagery. Practicalities of flight planning, survey organisation, control, camera usage; practical aspects of use of aeroplanes. Unmanned aerial vehicles' use. Properties of aerial and space imagery. Radar techniques with 3D capability.
Superseded material	Detailed concepts of parallax, analogue and analytical machines and methods, plotting equipment involving operators, perhaps relative and absolute orientation; most reference to film usage at close-range.
Pre-requisites	Topics (1) to (9).

(16)	Surveying specialisation: laser scanning – terrestrial and aerial
Goals	To give surveyors the opportunity to be involved in laser scanning, by enabling the surveyor to understand the theory and practical use of terrestrial and aerial laser scanning, and their capabilities for survey applications.
Content	As a survey specialisation, coverage may range from an introduction to full details of raw data collection and converting measurements to spatial data, in the special case of measurement using imagery, sources of error and levels of accuracy, examples.
Superseded material	Nil: basically a new topic area.
Pre-requisites	Topics (1) to (9).

(17)	Surveying specialisation: hydrographic surveying
Goals	To enable the surveyor to participate in hydrographic surveys, by providing a knowledge of the special difficulties faced and the special techniques used in mapping bodies of water, having various sizes and depths.
Content	As a survey specialisation, coverage may range from an introduction to full details of raw data collection by sounding and positioning systems, instrument calibration, corrections for tides, sea, swell, etc., and converting measurements to spatial data.
Superseded material	Hydrographic positioning other than by GNSS.
Pre-requisites	Topics (1) to (9).

(18)	Land boundary law and cadastral surveying
Goals	To enable surveyors to carry out a full range of boundary definition surveys within the jurisdiction of the relevant Board.
Content	Essentially, a detailed coverage of matters which enable the above goals to be met, along the following lines: A full introduction to the legal system as appropriate to cadastral matters, depending on the jurisdiction. Concepts of the cadastre, historical review. Extensive land boundary law: all acts of parliament within that jurisdiction relating to surveyors and boundaries, types of titles. Role of the surveyor, plans, detailed examination of easements, covenants, roads, and so on. Survey practices relating to boundary definition, surveyor's reports. Survey practice regulations. Examples and field experience.
Superseded material	-
Pre-requisites	Topics (1) to (9).

3.2 Outer core (Mandatory material)

(19)	Basic sciences
Goals	To provide a basic knowledge of theory relating to concepts used in the core topics.
Content	At the discretion of the institution but at least the following: • 3D mechanics; • electricity and electronics; • simple harmonic motion; wave propagation; antennae characteristics; • optics of lenses; optical principles of telescopes and cameras; • rotational motion: precession, gyroscopes, gyrocompasses.
Superseded material	Detailed optics, including thick lenses.
Pre-requisites	High school physics at a level which is sufficient to undertake a technical degree at university, or university equivalent.

(20)	Basic mathematics
Goals	To provide a basic knowledge of theory relating to concepts used in the core topics.
Content	At the discretion of the institution, but at least the following: • differentiation, including partial differentiation; • integration: single, double and triple integrals; • matrices; • spherical trigonometry; • solutions of linear equations; • Fourier analysis / series; • complex numbers (mention only).
Superseded material	-
Pre-requisites	High school mathematics at a level which is sufficient to undertake a technical degree at university, or university equivalent.

(21)	Basic statistics
Goals	To provide a basic knowledge of theory relating to concepts used in the core topics.
Content	At the discretion of the institution but at least the following: • normal distribution of errors and standard deviation; • F, t and chi square (χ^2) distributions.
Superseded material	-
Pre-requisites	High school mathematics at a level which is sufficient to undertake a technical degree at university, or university equivalent.

(22)	Professional presentation of survey information
Goals	To enable the surveyor to present survey information in a sophisticated manner.
Content	Extensive CAD software. 3D presentation software.
Superseded material	Manual cartography methods.
Pre-requisites	-

(23)	Communication and discussion of surveys: communication essentials
Goals	To enable the surveyor to communicate with colleagues and clients in an effective and professional manner, following recognised conventions and practices.
Content	At the discretion of the institution, but including • English expression, • report writing: conventions, options.
Superseded topics	-
Pre-requisites	-

(24)	Communication and discussion of surveys: introduction to land development
Goals	To enable the surveyor to communicate with colleagues and clients in land development, in order to be able to cooperate effectively on related work.
Content	Details at the discretion of the institution, to achieve the desired goals, but including coverage of land administration, land development procedures, economics of land development, land usage.
Superseded topics	-
Pre-requisites	-

(25)	Communication and discussion of surveys: introduction to engineering
Goals	To enable the surveyor to communicate with colleagues and clients in engineering, in order to be able to cooperate effectively on related work.
Content	Details at the discretion of the institution, to achieve the desired goals, but including extensive coverage of: • water engineering: basic hydraulics, basic hydrology; • geotechnical engineering: basic ground engineering, foundation practices. and concepts of structural engineering.
Superseded topics	-
Pre-requisites	-

(26)	Communication and discussion of surveys: mining practices
Goals	To enable the surveyor to communicate with colleagues and clients in mining, in order to be able to cooperate effectively on related work.
Content	At the discretion of the institution, to achieve the desired goals.
Superseded topics	-
Pre-requisites	-

(27)	Communication and discussion of surveys: town planning
Goals	To enable the surveyor to communicate effectively with town planning professionals in order to appreciate survey requirements in subdivision set-out.
Content	At the discretion of the institution, to achieve the desired goals.
Superseded topics	-
Pre-requisites	-

(28)	Communication and discussion of surveys: land and property valuation
Goals	To enable the surveyor to communicate effectively with valuation professionals in order to appreciate matters of professional and/or cadastral relevance.
Content	At the discretion of the institution, to achieve the desired goals.
Superseded topics	-
Pre-requisites	-

(29)	Communication and discussion of surveys: remote sensing
Goals	To enable the surveyor to appreciate the extent, capabilities, limitations and difficulties of remote sensing methods, primarily from space, for the determination of two-dimensional earth cover, land use and other information.
Content	At the discretion of the institution, to achieve the desired goals.
Superseded topics	-
Pre-requisites	-

(30)	Communication and discussion of surveys: GIS
Goals	To enable the surveyor to appreciate the extent, capabilities, limitations and difficulties of GIS.
Content	At the discretion of the institution, to achieve the desired goals, but including a solid foundation into geo-referenced data sets, their availability, limitations, accuracy, precision, metadata and usefulness as their digital availability increases their importance in a spatially enabled society.
Superseded topics	-
Pre-requisites	-

(31)	Working professionally, ethically and safely
Goals	To enable the surveyor to work professionally, ethically and safely.
Content	Details at the discretion of the institution, to achieve the desired goals, but including: • Social, ethical, moral issues. • Standard business practices and management. • Basic economics. • Work health and safety.
Superseded topics	-
Pre-requisites	-

3.3 Comments on included and excluded material

A list of what has been omitted can be almost as informative as a list of what is included. Material has been omitted if it is seen to be superseded, not relevant to university courses aimed at undergraduates who are at the early stage of their surveying career, or not core by the definitions above. Disagreement with the suggested topics must be anticipated, especially by those who see the list as too brief and/or excluding their area of interest. However, the core list must not be excessive, lest the checklist be a barrier to degrees whose graduates are able to carry out surveys satisfactorily.

Graduate level: The writers emphasise that topics are for graduates and not for senior members of the profession, who may, for example, wish to expand their technical or business horizons. For that reason, there is limited reference to higher level projects and business management, communications and philosophical matters. The emphasis here on graduates rather than senior members of the profession differentiates it from much of the substance of the Brown Book.

Superseded instrumentation: Technological development has seen a number of changes in the 20 years since the Brown Book was conceived:

- Positioning by satellite has become so reliable and precise that it has entirely replaced long-range EDM measurement for both geodetic control and for hydrographic positioning, heighting techniques using barometers, satellite positioning by Doppler

"Positioning by satellite has entirely replaced … astronomical positioning (unfortunately, as it was a distinguishing feature of surveying)."

techniques (largely superseded in a previous generation) and astronomical positioning (unfortunately, as it was a distinguishing feature of surveying).

- Digital imaging has reformed photogrammetry and also enabled the introduction of the digital level, which seems to have reduced the demand for a special case of levelling called precise levelling.

- Other developments in instrument technology have enabled the creation of scanners, including short-range indoor scanners (less common in surveying), terrestrial and aerial devices.

- Improvements in total stations have led to robotic instruments which have revolutionised the content of survey parties: one person surveying is now a feasible option, including for certain types of cadastral surveys. The consequence has been a change from traditional field techniques using theodolites.

- Theodolites, i.e. optical-mechanical angle measuring instruments without any inbuilt EDM capability, are seen to offer educational benefits by allowing students to see not simply their structure but the effects of errors. The theodolites can still occasionally find use in unusual situations. However it would seem to be excessive to regard their teaching as core.

Superseded theory: Clearly, change has also been facilitated by the spread of the micro-chip. It has enabled inbuilt programmes to carry out many surveying calculations within instruments, while greater computer power has revised computational procedures in the office. The impact has been that the practising surveyor need not be familiar with computational steps within algorithms. Even so, it is argued that basic computational algorithms need to be covered in enough detail to enable surveyors to notice, detect and cope with errors in their computations. Graphic and semi-graphic processing, and formulae based on approximations which reduce hand calculations, were probably departing the education scene a generation ago. Deciding whether some theory has been superseded has made selection of core theory difficult.

Land development: For many Australasian surveyors, involvement in the many and varied aspects of land development represents a considerable proportion of their work and a considerable component of their income. Hannah argues that, "*The professional surveyor in New Zealand is a specialist in measurement science, land development (including subdivisional planning and engineering design) and cadastral studies,"* (Hannah, 2012). For this report however, the problem lies in deciding how much of the topics related to land development should be included in the core, and therefore mandatory. The depth and breadth of the coverage of this topic varies widely across Australasian universities. Our omission of subdivision project management and detailed engineering design, from the inner core definition is probably controversial, and has not been taken lightly. While design matters, including urban planning and engineering design, have been included in a number of surveying degrees, economic and business aspects of land development have not necessarily been a substantial part of all surveying degrees. Not all surveyors are involved in land development. Overall, land development subjects are still seen as filling an important role in the development of a surveying graduate and an introduction to these subjects is regarded as mandatory in the outer core, but the detailed components have been placed in the non-core, and are thus recommended. These detailed subjects are often a distinguishing feature of some university programmes and taught by invited specialist lecturers from the profession.

Spatial information and GIS: Spatial Information and GIS create an interesting case as they were once expected to have significant impacts on surveying. The Brown Book refers to:

> *"… tertiary institutions where surveying courses are constantly under review to incorporate new technology … particularly in regards to geographic information systems and the management of spatial data",* (Institution of Surveyors, Australia, 1996, page 5).

Hannah has also observed that the surveyor, *"… will also require a good working knowledge of GIS systems and technology"*, (Hannah, 2012). Specifying that an introduction to GIS/SIS is outer core may therefore generate some controversy. However, spatial information and GIS have not created the revolution that may have been predicted. Quite simply, rightly or wrongly, spatial information studies are not being dominated by surveyors. Horwood and Hall are not convinced that GIS is crucial:

> *"Some professional surveying associations cognisant of this trend have capitalised on it by embracing not only GIS but also the more broadly defined knowledge base and skills that are centred in the spatial sciences. For example, the Association of Ontario Land Surveyors (AOLS) added in 2001 the Geographic Information Management (GIM) branch and currently has about 60 members with this designation. However, the AOLS is still struggling with articulating what this designation means, whether members with GIM credentials should be licensed, how a GIM relates to cadastral surveying, how the GIM value proposition can be best articulated to the large cadre of students exposed to GIS in higher education, or what benefits exist for current GIMs that will encourage them to renew their designation. The question of the relationship between GIS and surveying therefore remains substantially unanswered, as does the possibility that the surveying profession should or may be able to capitalise on the growth and popularity of GIS without sacrificing any of the professional integrity associated with the surveying brand, "* (Horwood and Hall, 2012).

What is clear, however, is that many geo-referenced data sets are now digitally available and accessed by surveyors in their routine operations. This trend will surely continue and GIS has been listed as a mandatory topic in the outer core. The 'revolution' that surveyors would become GIS specialists may not have occurred as predicted 20 years ago, but spatially enabled data sets are now a ubiquitous tool for surveyors.

Remote sensing: Remote sensing has been an important component of some surveying degree programmes, but, despite predictions a couple of decades ago that it would become a major element of surveying and mapping, remote sensing is not yet routinely carried out by surveyors in practice, and it is not exclusive to surveying, rightly or wrongly. An awareness of it is sufficient and this is classed as outer core.

Geodesy: The coverage of geodesy is intended to provide all the geodesy which is needed by surveyors. That coverage recognises that all geodesy is not surveying and surveying is not the same as geodesy; similarly, all geodesists are not surveyors, and surveyors are not geodesists.

Positional astronomy: The exclusion of positional astronomy from the inner core is probably sad more than anything else. The ability to determine position and azimuth very precisely from celestial objects has always been the

> *"The exclusion of positional astronomy from the inner core is sad more than anything else. The ability to determine position and azimuth very precisely from celestial objects has always been the province of surveyors."*

province of surveyors, even more than for navigators because of the precision achieved by surveyors. The transit of Venus in 2012 was seen to strike a chord with many surveyors. Unfortunately, this topic's continuation simply cannot be justified.

Mathematics and sciences: It is realised that the topics nominated in the tables above may not be exactly what educational institutions provide in their courses which are aimed at a broad spectrum of students.

Computer basics: An interesting side effect of technological change occurs in the use of computers. There may have been a time when teaching basic computer use, including word processing, would have been seen as an essential part of a tertiary programme in the technologies, but it is now assumed that all incoming students are competent with a PC, with word processing and so on.

Harder or easier programmes? Technological changes clearly continue to make tasks easier to execute. It invites the question whether the extent of the core topics is growing or diminishing – whether degrees are getting easier. Roy warns that "*geomatics programmes must integrate new contents, without unduly extending in length*", (Roy, 2012, page 1). The writers of this report would argue that courses are, at least, not harder. GNSS has been introduced, but astronomy has virtually gone. Students are expected to have computing skills which will enable them to prepare information for clients electronically, using software for CAD, electronic plan submission, and so on, but they save enormous amounts of time and effort by avoiding hand calculations and hand drawing. There have also been improvements in educational approaches. As Roy (page 5) reminds readers,

> "*The era of the blackboard for strictly recopying notes, contents and equations should be over… (The blackboard) should be used to explain theoretical concepts, to show examples of empirical applications, to analyse case study, to express critical reasoning, to animate discussion and to answer to questions. Pedagogy must be dynamic and facilitating knowledge appropriation by working on contents (and not merely presenting contents)*"

Students are now frequently provided with course notes in hardcopy or electronic format, and can easily be provided with other material including tutorial exercises and their solutions. This trend may continue: McMillen notes that, "*open educational resources and game-based learning were at the top of the list of what students wished their teachers used more*", (McMillen, 2012) (our underline)!

Practical experience: Surveying is a profession which involves data gathering, and hence field work. Familiarity with the data gathering stage of surveying (involving both technical techniques and team-work) is a fundamental part of surveying, and it needs to be experienced by the student of surveying. For this report, it is assumed to be a normal integral component, time consuming perhaps, of the teaching of those topics which have a practical component. Whether this field experience comprises residential field courses is the province of the educational institution, which has a responsibility to provide whatever experience achieves the educational goals. Experiencing field work of a general nature by, for example, obtaining work experience with a practising surveyor, is seen as highly desirable for educational reasons, but it does not seem to be possible to specify an exact amount, on the basis that quality and type of experience can vary so widely. Boards would recognise this quality assurance requirement.

Student projects: Student research-type projects are a typical component of university studies. Their inclusion here does not tie with the concept of core tasks, and is not specified. Presumably Boards assessing degrees would recognise the education benefits of such projects.

A conservative list? The listings provided above may seem to be conservative, even old-fashioned, ignoring a lot of newer material. A lack of coverage of newer topics, such as higher levels of GIS and remote sensing has been explained. The real driver has been to give emphasis to basic knowledge which will allow surveyors to cope with novel surveying situations or new technology, while retaining an ability to position accurately in three-dimensions.

Part B: Discussion of Some Matters affecting the Tertiary Education of Surveyors: Some Views from the Authors

In the preparation of this report, some opinions on the education of surveyors in Australasia in 2013 were gathered by Fryer and Mitchell. These opinions are expressed in this part of the report. It is recognised that while informative of the current educational process, these opinions may be more transient than the substantive documentation in the first part of this report.

4 Requirements of Industry

It was seen by CRSBANZ as valuable to consider whether current graduates meet the needs of the industry, as defined by surveying and mapping and its allied fields, and whether the proposed "core" elements will help this to continue into the future.

Graduate numbers: It is not intended to delve into the long-standing issue of the adequacy of current graduate numbers for industry. The writers of this report are aware that recently there have been a Surveying and Spatial Information Skills Demand Study commissioned by Consulting Surveyors National and undertaken by BIS Shrapnel into the requirements of the surveying profession/industry and a (related) study for the Surveying and Spatial Sciences Industry in Queensland into workforce requirements, (Lyons *et al*., 2010). One of the writers has been in close liaison with Dr. Lyons in the gathering of enrolment, graduate and other data for his studies. It did not seem to be the role of this project to duplicate the efforts contained in these well documented studies, but instead it seemed to be more appropriate and constructive to offer some insights into the more general aspects of the matter. This is taken to involve a consideration of whether the core content recommendations have an impact on industry requirements, now or in the future.

Will the core topics meet the needs of industry? As far as the writers are aware, there has not been any groundswell of dissatisfaction with the typical surveying graduate in Australasia. This may be partly attributed to the close contact between the surveying profession and individual staff members, who have often been members of professional institutions. The writers do not see the recommendations of this report changing that situation! Whether industry will be accepting of the proposals outlined in this report would seem to depend whether industry understands the goals of the work. This report was prepared principally in consideration of the requirements of cadastrally endorsed surveyors. Some industry groups may oppose the suggestions to not necessarily include all aspects of land development, detailed subdivision design, project management and spatial/geographic information (but they may even welcome the exclusion of remote sensing). But the report recognises that the proposed core material will not occupy the full length degree which is necessary to produce an accomplished graduate. Considerable opportunity exists, as it always has existed, to insert into degree programmes those non-core topics which are seen as desirable, advantageous or attractive but not crucial. It may be that different components of the industry can see different things as essential. What is crucial to surveyors involved in commercial land development is not what is crucial to surveyors working for a traffic authority. In the end, most institutions themselves have had programme advisory committees which have helped guide programme content.

Future needs: The question whether the core requirements for a surveying degree will meet the future needs of the profession emphasises a crucial point: as suggested in section 2.9, graduates must have a grounding which ensures that they can continue over their career to adapt to new developments, presumed to grow at an even faster rate, while remaining true to a foundation requirement of being involved in precise spatial positioning. To put this question into perspective, it is useful to reflect that over the past few decades, surveying has not failed to adapt to changing technology. When the Brown Book was conceived, for example, there was no thought of laser scanning. It has moved quickly from a speciality air-borne technique used to gather three-dimensional information along a narrow strip of terrain to almost universal acceptance in a range of surveying applications. Indeed, developments in this technique are still occurring and as recently as January 2013, Australia's CSIRO announced details of Zebedee, a hand-held, lightweight laser scanner for (initially) archaeological work (Geospatial PR, 2012, and Spatial Source, 2013). It allows in-door or underground 3-D mapping in areas where there is no GNSS access as the archaeologist or surveyor moves around. Presumably surveyors will cope with this continuing development. Twenty years ago, there were no special subjects on laser scanners being offered by universities to aid today's professional surveyors cope with this technique. What direction some of the future tasks surveyors will undertake is impossible to detail. A mere 10 years ago, who could have foreseen that 500,000 American workers would be employed in 'phone apps' and 'gaming'? The computer science courses did not exactly teach what they required, but obviously the fundamentals were taught, the students learnt how to seek out information for themselves and the graduates have adapted. Because surveying degree programmes have emphasised precise surveying or positioning in 3D, whether by topographic survey, geodetic applications, building and industrial set-outs or photogrammetry, the present-day professional has been able to rapidly adapt to laser scanning. Graduates will be able to embrace new technologies as long as the fundamentals of measuring and positioning are taught. The crucial topics are seen to be (1), (3), (4), (6), (7) and (8) in Section 3.1. These core topics may even be more important than the land development topics which may be sought by some industry groups.

Conclusions: While not doubting the inadequacy of current graduate numbers to meet industry requirements, the question of whether the core content recommendations have any impact on industry's requirements deserves two responses which would suggest the answer is no. The first response is that, regardless of the proposed core content for the express purpose of Boards, there are sufficient programme content options to enable industry groups to seek programmes that meet their requirements, and the second is that, when looking to the future, it is to be expected that university graduates must and will maintain a capacity to adapt to changes, a situation which can be assured by a good educational background. Boards and industry do need to ensure that degrees retain those core topics which are crucial to enabling educated surveyors to adapt the challenges of the future.

5 The Relevance of the TAFE Sector

The role of TAFE courses and their content has been seen by CRSBANZ to be worth contemplating (Chapter 1), especially as students from the TAFE sector commonly seek articulation into university degree programmes and thus supplement the numbers of professional surveyors. Indeed, for several decades, a TAFE qualification - a Diploma or Associate Diploma - in Surveying has been seen as a pathway for entry into a university degree in Surveying, normally receiving standing of up to one and a half years, depending on the university. The standing has been limited to those subjects directly related to basic surveying and the practical use of surveying instruments. TAFE courses have justifiably prided themselves on the well-drilled practical nature of their subjects and their graduates were what are now termed “shovel ready” to undertake standard surveying tasks. The theory behind the use of the regular practical surveying techniques has also been well-drilled, so universities have had no problems integrating ex-TAFE students into their programmes. Moreover, TAFE students had typically worked part-time, and they usually had a good grasp of surveying from practical experience, and, having made a decision to undertake university studies on the basis of the experiences in surveying, they were seen as motivated – and they generally completed degrees successfully. Many practising cadastral registered/licensed surveyors started in the TAFE system and to an extent, the pool of potential new cadastral surveyors has relied on some technician surveyors upgrading their qualifications to professional status. This report acknowledges the real-world skills of TAFE trained students and acknowledges their contribution to surveying numbers. However, the question to be faced here is whether anything can be done - by CRSBANZ and even the surveying profession in general - to facilitate the cultivation of this source of professional surveyors.

5.1 TAFE Teaching and Assessment

TAFE training: Despite the positive side to TAFE students’ articulation into universities, there has always been an awareness that TAFE approaches to teaching centred, appropriately, on training, as distinguished from education. For the articulating student, this was seen to be balanced by years spent in a university programme. If there are any concerns about TAFE students, it can lie in moves toward competency-based assessment and other new assessment methods, which could weaken the students’ good understanding of surveying, making it harder to justify their standing at university.

Competency based assessment and prior learning: Competency-based assessment was introduced as a new strategy for TAFE some years ago. “Recognition of prior learning and prior knowledge” are also being offered. According to this model, a practically-trained student who is seeking recognition of prior knowledge, not necessarily obtained at TAFE, can show such a competency and be given a ‘pass’ in that subject. By providing evidence of a competency, the student may gain recognition for all or part of a course at an Australian TAFE. The TAFE NSW website explains that credit for previous learning and experience may be sought by persons who have

> *“completed previous training at TAFE NSW*
> *qualifications from previous studies in Australia*
> *qualifications from previous studies overseas*
> *<u>relevant work or life experience</u>”,* (our underline)

where

> *“You may have gained skills through community or volunteer work, sports team management, domestic responsibilities or even your hobbies and leisure activities.*

> *These skills may be recognised if relevant to your course. This is an example of Recognition of Prior Learning (RPL),"* TAFE NSW (2013).

There is no suggestion that surveying assessors would be satisfied with unacceptable training, but the trends are worrying. Furthermore, it is informative that an interview with a former TAFE teacher has drawn attention to the introduction of a closely related development: "on-the-job, in-the-field" training, which can lead to an assessment but without TAFE educational input (Graham, 2012). The teacher meets with companies to assess whether their students are competent. If so, they are awarded a pass in a certain TAFE course.

The concern is that a competency based teaching approach introduces a modularisation or compartmentalisation of learning (referred to earlier, in Section 1.2), so that students do not see the relationships between the learned components, they do not see inter-connections between one matter and another, and they do not get the chance to build up a good overview of surveying. The TAFE teacher commented, "*I am really worried by the direction TAFE is taking. It is my pet hate subject. Students know how to press all the buttons to do a task, but they don't really understand why they are doing it. They don't have a basic understanding of how the instrument works and if the battery went flat, they couldn't do anything!*" In the case of on-the-job training, he is concerned that they can do what their employer wants, but that they do not really understand why they are doing it or how the equipment works. He believes the new competency-based assessment is not really building a workforce ready for work into the future. A further danger of course is that students could seek to enter university, be given standing for a TAFE course, which in turn has involved credit for on-the-job training or even "life experiences", without formal education. Any minor learning deficiencies may be carried over. Once a student has completed early surveying courses, the understanding of the need and process for focussing both the objective and eyepiece lenses of a telescope may never be touched on again. But it is a fundamental piece of the surveyor's knowledge.

> *"If the battery went flat, they couldn't do anything!"*

5.2 Conclusions

Despite the remarks above, it has to be recognised that TAFE surveying diplomas are still a mixture of traditional teaching and competency-based components. The majority of students still attend regular classes and do not undertake "on the job" training so there is a danger that the remarks above may overstate the current state of this problem. It must be recognised that the surveyors who have become TAFE teachers have served their profession well. But it must nevertheless be noted that TAFE teaching methodologies have changed and continue to change, and the direct entry pathway to university degree programmes may not be as simple in the future. Newer modes of learning now being adopted by the TAFE sector may require that the seamless integration of Diploma holders into degree programmes is reconsidered.

The problem of TAE students succeeding at university is really an admissions problem for the universities themselves. For CRSBANZ, the answer to the question - whether anything can be done to facilitate the cultivation of TAFEs as an indirect source of professional surveyors - may be that the situation will not be helped if the gap between TAFE and university graduates' analytical skills widens. It may be useful to watch whether the competency-based direction of TAFE leads to less successful transitions to university studies, as that will not assist the availability of cadastrally endorsed surveyors.

6 Viability of the University Programmes

The instructions for this report expressed concern about the sustainability of the current university degree programmes in surveying, declaring that the continued existence of the current programmes cannot be automatically assumed. It was recognised that the continued existence of any programme may depend, not on community or industry demand for it so much as on its financial viability within its University. University degree programmes are influenced greatly by tight budgets depending in turn on student intake numbers and even on the availability of qualified academic staff, none of which can be taken for granted.

Viability has long been a concern: The viability of surveying degree programmes across Australasia, but more particularly Australia, has been of concern to the surveying profession and industry for at least a quarter of a century. In that period, the number of students entering most of the surveying programmes has consistently been below the desired level – seen as too low to ensure the survival of university programmes as well as too low to provide the graduate numbers which would sustain the profession (as already mentioned in Section 4). Indeed, programmes at three Australian institutions, the University of Queensland, Queensland University of Technology and University of South Australia, have been discontinued in the last 30 years, although in the case of South Australia an alternative scheme has been implemented at the post-graduate level. Five of the nine operating Australasian programmes have probably felt threatened by low student numbers at some time in the last 25 years or so. Two previously independent schools and departments have forced into amalgamations with other disciplines in their engineering faculty in the last five years.

Industry efforts: The surveying profession finds it hard to unearth means of increasing student numbers. The issue of university programme viability has been faced in various forums over the last few decades, with discussion dominated by means of alerting students to the existence of surveying. Obtaining just a few extra students is worthwhile to make a difference to numbers. But attracting students into small surveying courses makes targeting prospective school leavers difficult. All university courses, whether surveying or anything else, which have a small student intake, must source it from a large base of prospective candidates, typically direct school leavers. In New South Wales, around 70,000 students sit for the Higher School Certificate each year; from that number the two surveying programmes would together be pleased to attract just one in a thousand, making it clear that simple but broad (and expensive) "scattergun" advertising is likely not to be cost effective, in which case highly focussed advertising seems to be necessary. Industry forums which seek to find ways to attract students into surveying degree programmes can easily lead to well-intended but ineffective "reinventions of the wheel" relating to publicity mechanisms. Some notable efforts to recruit school leavers have been made, including:

- the programme by the Joint Industry Promotion of Surveying Taskforce, "A Life without Limits", in Victoria (Institution of Surveyors Victoria, 2013), which is comprised of members nominated by seven Victorian industry and education organisations,
- the Destination Spatial study in Queensland (Queensland Government, 2013) aimed at supporting "the surveying and spatial industry by providing strategic direction to ensure the availability of a skilled workforce",
- the Surveying and Mapping Industry Days instigated by ACS NSW with four partners, and,
- the mathematics in surveying days for school students organised by the Institution of Surveyors NSW.

University structure: Any useful discussion about the viability of surveying programmes needs to include some recognition of the various conflicting attitudes and demands of stakeholders. In particular, universities do not necessarily operate in the way that the community imagines. Much of the community, not just the surveying sector, but school students who look to become university students, current university students, graduates and the community which takes up graduates, quite reasonably view the universities as educational institutions, whose dominant responsibility lies simply in teaching. Their mission is assumed to be to provide the community with educated graduates for the benefit of that community. However, universities may not see their role as being so straight-forward. They have the challenge of executing both teaching and research missions while coping with severe and complicated budgetary limitations.

Given that the problem of surveying's sustainability has been a widespread concern for some years, it does seem unlikely to be able to offer novel solutions here. Instead, it is intended to raise some issues, which have an impact on the question of the viability of surveying programmes and about which most surveyors are unlikely to be aware, and which may inform debate.

6.1 Issues

1. **Industry image:** The problem has frequently been seen in terms of the low profile and poor esteem of the surveying industry itself, and publicity campaign resources are often aimed at rectifying the broader industry image problem. The lack of awareness of surveying appears to be world-wide: Lemmens, reflecting that the only remaining Bachelor of Science in Geomatics in the Netherlands at the Delft University of Technology was closed in 2005, after which only a Master of Science programme remained, contends that the surveying profession is not visible. It produces data and information but he states that at the end of a day making observations at a construction site, they leave and *"…perhaps some nails have been hammered into the asphalt. How can a profession be promoted without impressive products and appealing icons?"* (Lemmens, 2012).

   "…perhaps some nails have been hammered into the asphalt. How can a profession be promoted without impressive products and appealing icons?"

   Even so, the writers' experiences with students have suggested that direct contact with surveying is valuable to spark interest. Most students' interest in surveying seems to be aroused by seeing surveyors working, or by having work experience, or as a result of a discussion with friends or relatives who knew about surveying. It is therefore interesting to note that authors Musungu and Motala from South Arica stated that,

   > "*In order to assess the factors that attract students to South African universities, interviews were held with current undergraduate students at CPUT to find out what drew them to a qualification in Surveying or GIS. … 57% of the total number of students enrolled for the qualifications by observing surveyors working in their neighbourhoods … Also, 20% of the students stated that they had been influenced by discussions with a friend or relative. It is noteworthy that the availability of funding only attracted 11% of the current students",* (Musungu and Motala, 2012).

Another tack is suggested by the fact that the surveying programme at the University of Otago in New Zealand has been successful. John Hannah observes,

> *"In order to achieve competitive entry, the School has worked consistently and diligently on marketing a career in surveying to high schools throughout New Zealand. In this regard, it has been greatly assisted both by Otago University's high school's liaison officers and by the [New Zealand Institute of Surveyors]. One of my primary goals as Head of Department was to ensure, firstly, that the School had excellent relationships with the liaison officers; secondly, that at least two pieces of new marketing information crossed the desk of every high schools career advisor each year and thirdly, that I would visit at least 5 –10 high schools each year, typically to take a senior mathematics class. The results speak for themselves – we know of no other surveying degree program in Australasia, the UK or North America that has the level of competitive entry found at Otago,"* (Hannah, 2012).

Clearly a decision has been made at university-level in that case to support this considerable investment of time by academic staff. There is little evidence such a process has been routinely endorsed in Australia.

While the decline in undergraduate numbers in Surveying degrees in Australia has been well-documented over the last decade, and there has been similar documentation decrying the demise of surveying programmes in USA, similar problems have also occurred in Europe, perhaps with less publicity in Australasia. The European solutions to local problems may deserve to be considered. The Netherlands case cited above is instructive, (Lemmens, 2012). Lemmens stated that one cause of the poor influx of undergraduates can be pinpointed: high school students across Europe from 1990 chose not to study technical subjects but concentrated their efforts in business studies. After the Global Financial Crisis, a slow reversal of that trend has been observed. It is claimed in Lemmens' article that a minimum annual influx of 20 students is required in order to keep a Masters programme sustainable. There is no reason to doubt that a similar figure is required to keep like programmes financially viable in Australasia.

It can be concluded that in the foreseeable future the profession will continue to assist the move to improve student numbers, but it will not discover a "silver bullet" that brings noticeably more students into surveying.

2. **University branding:** As is well known, university departments themselves have sought over the past couple of decades, to appeal to students who have not been attracted by the conventional surveying career path, by adopting names in addition to or instead of surveying. Horwood and Hall argued the issues thus:

> *University departments have sought to attract more students by adopting names in addition to or instead of surveying. The profession and industry has generally tended not to follow the same path.*

> *"In this context, the surveying profession did itself a significant disservice in the 1990s in several countries by replacing the surveying brand with the different and previously unknown, and some might suggest, unknowable alternative of "geomatics". As a result, the geomatics label was enthusiastically adopted during the 1990s by the surveying profession worldwide. However, this term had and has no resonance with the public, it is divorced from the well-known brand*

of land surveying, and it blurs the divisions of labour that differentiate the field of surveying from other professions and trades. Nevertheless, surveying programs in educational institutions throughout the world during the 1990s and into the 2000s undertook a rebranding, and department names were replaced with contrived labels such as geomatics, geoinformatics and geomatics engineering.

The word geomatics itself is nebulous and ambiguous in interpretation, both implying all forms of study related to the earth or all forms of activity on the earth. Perhaps in response to this, some tertiary institutes in Australia recently opted to re-evaluate how they position and name their surveying programmes. The renaming of the field to "modernize" it and attract students seems to have failed and the surveying brand might be returning to favour, as it more accurately articulates what surveyors do day-to-day in their work. In this context, we would suggest that the act of surveying is to observe critically and measure the real world and to form a professional opinion. Our view is that these attributes are where the brand should be promoted in order to realise its prominence and investments in practice both in the past and in the future," (Horwood and Hall, 2012).

Not all name changes have been maintained. **An interesting point is that the profession and industry has generally tended not to follow the same path**. The moves may have enabled programmes to survive by slowing a leak in student intake numbers, but it cannot be suggested that their programme viability has been substantially improved.

3. **Entry scores:** One of the concerns about low demand is that it leads to a lower entry score requirement. Entry requirements are usually selected to control student numbers. What is dangerous for surveying is that universities may fiddle entry scores to juggle total faculty enrolment numbers rather than the numbers in single programmes, and surveying may be affected. But low entry scores have another repercussion which is often unrecognised: prospective students assume incorrectly that entry scores are based on academic assessment of course difficulty, so a low entry score equates to an easy course, which in turn implies a low status course. Many students want to do a degree with a high cut-off, possibly because it gives the course higher prestige, or perhaps because they expect it relates to a high income! A lowering of the score can thus create a spiral of decreasing demand. The most important point may well be that the surveying academics may have no influence on choosing the cut-off score which is set by any university: such decisions may well be made at a level which is above even programme heads. Overall, the entry score problem is not as simple as it may seem. The profession is probably beholden to universities who will do what they will, without Boards being able to influence programme viability. Boards may be in a position to communicate with universities at a higher level, should it be seen as necessary.

   > *"…prospective students assume incorrectly that entry scores are based on an assessment of course difficulty."*

4. **The number of surveying programmes:** With only the most populous two states of Australia currently having more than one surveying programme, it is suggested that there is <u>not</u> an excessive number of courses. A concern about the number of universities offering surveying degrees may be generated by a belief that having a large number of courses spreads the small number of interested surveying students too thinly amongst the programmes on offer. This assumes that students choose a

desired degree and then travel to the most attractive university offering such a programme. However, there is evidence that prospective students do not necessarily follow such a pattern. Students – especially those who live in a city which has one or more university – typically choose the university which they wish to attend, because of its convenience or prestige, and then select a preferred course from those offered by that university. If so, the best approach to seeking surveying students at a certain university is to attract them away from other programmes. There is anecdotal evidence that some students do migrate away from their home cities to other cities with universities, but they seek out prestigious programmes, such as medicine, paramedical professions and law, and again the number of surveying programmes seems to be irrelevant.

5. **Financial viability distorts decision making:** It is now widely recognised that, under current university funding models, the institutions' biggest challenge and priority is to maintain a business plan, and this can be at the expense of some educational considerations. Financial considerations mean, among other things, managing total student numbers or, moreover, class sizes. To attract increasing numbers of students, universities now advertise in a way they once never did, aiming to draw students not only from what may have once been their traditional region, but from interstate and, preferably, from overseas. Scrutiny is put on specialist subjects with limited numbers, and pressures are exerted onto academics to find ways to combine or eliminate small classes. The universities' 'end game' is to close some programmes in order to survive and expand others where student demand is high even though there may not be a strong societal need (for example the recent rapid expansion of tourism and recreation degrees). The surveying profession is slowly becoming aware that societal need for a programme may not be a sufficient argument for a programme's continuation, if made at the university level. The matter does not help the viability of small programmes such as surveying.

6. Research and programme viability: The universities' attitude to research is often misunderstood. For universities – which, unlike schools and TAFE colleges, do not close down outside teaching periods – research is a very significant activity. Although sometimes seen as a pursuit that academics follow in their spare time, universities actually support research activity intensively. It is a means of generating income through research grants and, perhaps more importantly, it is seen to generate reputation and prestige, which may attract students (and moreover the better students), yield community esteem and even bring forth willing benefactors. Academic staff can regard research as both their preferred and approved work activity, being the dominant means of achieving promotion. Teaching can be seen as simply a base level activity, of little interest to the university, and shunned by the more successful academics who become full time researchers (or, in some cases, administrators). Research thus complicates attitudes. The profession may regard surveying lecturers as surveyors, who are participants in the surveying profession and who often retain membership of their professional surveying societies, and the lecturers may have the same attitude. But universities can regard the same staff primarily as academics, who are required to classify themselves as university lecturers on their tax returns! Staff procurement may be affected by universities which are less concerned about a candidate's teaching or practical experience as much as their field of research and their research success, often measured by publications (not necessarily in journals read by practising members of the profession) and by their ability to secure research grants. Whatever the forces, there has been in the last decade, an enormous drive amongst all universities for research excellence with the establishment of 'research league tables' to which federal funds are linked. Surveying, however, is often seen as the 'poor relation' relative to other branches of Engineering in this research scenario. Low staff numbers, a consequence of low student enrolments, have meant that surveying staff have more courses to teach per staff member, reducing available time for research. Overall, the viability of some undergraduate surveying programmes may be as much influenced by research profiles as by actual undergraduate numbers. (The solution to this dilemma is complicated as some universities are starting to regard certain programmes (and staff) in their portfolio as teaching, rather than research, intensive.) The point is that the surveying profession can regard esoteric research as a distraction from surveying educational needs, but the lack of research in surveying can actually hamper programme viability. **It may be beneficial to accept that research in certain useful and specified directions should be encouraged.**

7. **Availability of staff:** The concern that programme viability may depend on the availability of qualified and interested academic staff is endorsed. Sourcing academic staff has consistently disclosed a deficiency of interested and qualified candidates in Australasia, an outcome usually attributed to an unwillingness of surveying graduates to leave the current high-paying surveying jobs to return to further study. Sourcing staff from overseas has not been effective either. The effect is especially destabilising if staff are needed at the leadership level or to cover particular areas of teaching or research specialisation. Even if this shortage is not as big a risk to programmes as student numbers are, it can lead to disruptions due to a lack of leadership or even to adjustments of subject content to accommodate the capabilities of available staff. The surveying profession may find that encouraging research flows on to encourage graduates to consider teaching and research. This is easily said. In reality, in the short term, the staffing problem cannot help endear surveying to university administrators, and cannot help the viability of surveying.

8. **The relevance of student satisfaction is resurgent**: Despite the assertions made above that teaching concerns can take second priority to financial management and research success, there is evidence - in the form of a growing number of irritating student questionnaires - that an increasing importance is being attached by funding agencies, and hence in turn the universities, to student satisfaction. The Tertiary Education Quality and Standards Agency (TEQSA) website advises that,

   "From January 2012, TEQSA will register and evaluate the performance of higher education providers against the new Higher Education Standards Framework. The Standards Framework comprises five domains: Provider Standards, Qualification Standards, Teaching and Learning Standards, Information Standards and Research Standards. The Provider Standards and Qualifications Standards are collectively the Threshold Standards which all providers must meet in order to enter and remain within Australia's higher education system.

   TEQSA will undertake both compliance assessments and quality assessments. Compliance assessments involve auditing a particular provider's compliance against the Threshold Standards for registration as a higher education provider. Quality assessments can either be an assessment of the quality of an individual provider or a review of an issue across a number of providers (a thematic review)," (Tertiary Education Quality and Standards Agency, 2013).

"…priorities of student surveys may relate to education technique and student contentment rather than to ensuring that students learn surveying."

The implication is that teaching may be regaining some priority, and this may balance the dominance of research and strictly budgetary priorities. However, from the surveying industry's point of view, there must be concerns that priorities of student surveys may relate to education technique and student satisfaction - even student pampering – rather than to ensuring that students learn surveying. In that regard, the profession may still need to rely on having influence via professional-based programme advisory committees and procedures for professional accreditation. The effect of such policies on programme viability is hard to forecast, but Boards may want to monitor whether educational quality assurance does not interfere with effective surveying teaching.

9. **Cross-institutional study for individual students**: A scheme known as cross-institutional study now exists amongst Australian universities and may apply in New Zealand as an approved study for an exchange student. In essence, the following steps are involved:

   i) The degree programme coordinator certifies that a subject at another (away) university is equivalent to a subject in the surveying degree at his/her (home) university.

   ii) The administrative division at the home university agrees to the transfer of HECS or other government payment.

   iii) Staff at the away university agree to a delivery and assessment method.

   For example, a student may only have one or two subjects outstanding in order to complete a degree and he/she obtains employment in another city or state. The student finds equivalent subject/s in their new location and thereby completes the degree. Such a scheme should make surveying more attractive. Overall, it probably makes no real difference to the total pool of students, and so far it has only been applied in a small way to a very small percentage of, usually, final year students. The writers are unaware of any attempt for an entire class at one university to be directed (and permitted) to undertake a surveying subject at another university, so there appears to be no significant contribution to assuring programme viability.

10. **Resource sharing:** It has been suggested that academic surveying groups could make valuable savings by sharing teaching resources, which is especially attractive in an era of electronic media. Consideration deserves to be given to reducing course presentation costs – whether to assist institutions with long-term or short-term staff shortages, or to generally help surveying programmes survive. It seems reasonable that educational institutions could share course material, especially for first year material which is relative commonly accepted and quite straight-forward. However, it does not seem to work. The availability of text-books has never lead to educational institutions reducing their course costs. Past attempts to share course materials or computer programmes or exercises have so far not been effectual. Face-to-face lectures which provide a distillation of more long-winded content of other resources, are needed by students. Lectures also inform students which specific material is to be the basis for their assessments! But more than anything else, the provision of course material can represent one of the cheaper components of the cost of running a subject. More time consuming and labour intensive are the provision of tutorial and practical work, and their assessment (the setting of assignments and examinations, and the marking of both). Subject administration is another matter which cannot realistically be shared. Presentation of a subject requires expensive staff who know not only the theoretical and practical material, but

who are able to make other judgments about teaching. Even when teaching staff are not available, it is usually more economical to hire a local professional to provide a subject (that is, the government teaching benefit for a class full of students will be greater than the part-time lecturer cost), and this is more effective than instigating a temporary cooperative educational arrangement between institutions. Improved programme viability does not appear to be on offer.

11. **Student expectations for online material:** It is suggested that there is pressure for an escalation for the provision of online materials by staff. Electronic resources relating to surveying are already extensively available. An internet search via online encyclopaedias, e.g., for "deformation monitoring", reveals substantial amounts of useful, informative and logical descriptions of deformation surveys. The web pages of equipment manufacturers have for many years yielded information about the variety, capabilities and applications of equipment from those sources. Online text books can even be discovered. Students' familiarity with online teaching material follows routine provision of video copies of lectures and copies of associated audio/visual presentations, such as "PowerPoint" presentations and "You-Tube" short demonstration video clips. The modern student generation is so familiar with electronic media, that it has a reasonable expectation of online educational material. However, the greatest impetus is likely to come from the fact that on-line course materials allow students to change their daily timetable. It is arguable - not always with strong written evidence – that for the current student generation, owning a motor car may not be as much a priority as an electronic social media device. It has already been noticeable that students spend less and less time on campus than in the past, their lives revolving more often around part-time work and their own social networks. Attendance at university is seen to be a less important part of their daily routine. Online material helps save extensive amounts of travel time and even the hassles of car parking. A wider variety of resources can be expected by students. But more importantly, remoteness from university and from staff contact may detract from the learning experience, which is especially important in the case of practically oriented surveying. Boards may want to monitor whether online material impacts on surveying education.

> *"…routine provision of video copies of lectures and copies of associated audio/visual presentations, such as "PowerPoint" presentations and "You-Tube" short demonstration video clips"*

12. **New modes of online cooperation:** Universities themselves are now viewing large-scale online education in a new light. For universities, remote learning may contribute to resource saving in teaching and in the not-insignificant capital cost of lecture theatres, and other infrastructure, even car parking. While online learning is not completely new, it is becoming more widespread; e.g., Charles Darwin University is the first Australian university to offer Bachelor and Masters level programmes in chemical engineering online, (Charles Darwin University, 2013). What is important is that the universities are now looking to engage in online large-scale educational schemes <u>with other cooperative institutions</u> as a means of both growth and survival, and this may have an impact on the nature of courses. This new education (or perhaps business) model has been considered closely by Professor Caroline McMillen, Vice-Chancellor of the University of Newcastle, who, in a lengthy article on the specific subject in the Newcastle Herald promoted the concept of offering course material online,

> *"…massive open online courses emerged on the international landscape as the Massachusetts Institute of Technology and Harvard joined forces to launch 'edX', which offers courses to both on-campus students and also free to millions of people around the world,"* (McMillen, 2012).

It is crucial to recognise that great novelty lies in the fact that the material would be offered free, but a student must enrol (and pay a fee) for any assessment. McMillen observes that,

> *"One of the first offerings, 'Circuits and Electronics', from MITx, attracted a staggering 154,763 enrolments, with 7157 students making it to the end and passing the course"*, (our underline).

This is a distinctly new education model. Readers can see the edX website, (edX, 2013). Coursera is a company which emanated from Stanford University, and now comprises 33 universities, including Johns Hopkins University, Ohio State University, Princeton University and the University of Melbourne, offering over 200 courses, (Coursera, 2013). Open Universities Australia is owned by seven leading Australian universities, (Curtin University, Griffith University, Macquarie University, Monash University, RMIT University, Swinburne University of Technology, University of South Australia) while the courses are provided by these institutions plus a number of other cooperating institutions, including TAFEs, according to its website, (Open Universities Australia, 2013).

Given that much surveying is carried out in regions which are remote from the cities where universities are to be found, it may be suited to such novel programme models. Perhaps the success of the University of Southern Queensland in attracting students is informative. Section 1.2 has already suggested that "a checklist would seem to encourage any students who had covered the material at different institutions - perhaps even by studying online without a formally recognised degree! - to claim that they deserved candidature for registration. This report draws Boards' attention to that possibility, without concluding whether or not this argument is valid. It could be an issue that Boards and other interested parties should consider." Boards could be ready to take up or encourage online cooperative degree options if they are being deliberated upon.

However, according to McMillen, "*free online courses will change universities*", (McMillen, 2012). So, among all the anticipation, what may be important is the possible impact on education. In an interview with Professor Bruce Downton, the recently appointed vice-chancellor of Macquarie University in Sydney, the reporter noted that, "*Many Australian academics, rattled by the enthusiastic take-up of massive open online courses, are suffering from existential angst. Some fear for their survival in an online era,*" (Armitage, 2013, our underline).

Boards may want to ponder whether there is any guarantee that surveying would be among the surviving programmes which have a conventional format. Surveying programme viability does not seem to be helped by such developments.

13. **University degree programme structures:** Simmons explains that some moves towards an education "based on two cycles, undergraduate and graduate" have arisen from the Bologna Declaration by the European Higher Education Area in 1999, (Simmons, 2012). The University of Melbourne and University of South Australia adopted the model, affecting surveying in both cases. The University of Tasmania has a three year surveying degree, followed by a one year diploma for those graduates seeking registration. Perhaps the selected entry into second year

at the University of Otago is worth noting too. Geomatics at the Delft University of Technology, which has been mentioned already, has introduced another novelty. The problem facing Delft in 2012 was that the minimum number of 20 students for their MSc Degree had never been achieved. Their solution to this dilemma has been to expand the range of basic qualifications that new Masters students may possess. Graduates with backgrounds in Information Technology, Civil Engineering or Geosciences (Geology, etc.) are encouraged to enrol. Delft claims it is centring its Masters programmes in surveying (geomatics) around the existing interests of these students, (Lemmens, 2012). In a similar vein, Professor Chris Rizos at the University of New South Wales, recently announced a new name for the School of Surveying and Geospatial Engineering. While referring to the problem of "*...anaemic undergraduate enrolments in fields such as surveying...*" over the last few decades, he believes the name change may better reflect the career opportunities and scope of work of graduates. But, further, he refers to the current four year Bachelor of Engineering degree,

> "*..a five-year concurrent degree leading to a Masters is also possible. This would allow students to earn a generic degree in one discipline and then specialise in another. A 'geospatial specialisation' could be offered to augment an undergraduate degree in electrical, civil, mechanical or computer engineering,*" (Rizos, 2012).

Clearly there is some commonality of thought and approach between these two recently published articles. The severe decline in the numbers of students wishing to undertake undergraduate surveying programmes has caused these (and other) universities to consider ways to maintain their viability. Expanding enrolments in Masters programmes by trying to attract graduates from Information Technology, Civil Engineering and the Geosciences is one approach to a solution. To some extent the University of Melbourne is already a couple of years along this pathway, having attracted as many students from outside their university into their (4th and 5th year) Geomatics and Spatial Information Masters programmes as they have from their 3-year first degree programmes.

So far, the new structures which have been introduced do not appear to have improved the programmes' viability. Boards may want to contemplate whether the trend of universities trying to maintain viability with a diversification of degree structures may distract providers from an emphasis on some of their traditional undergraduate surveying programmes, and whether, in that regard, such moves are worth noting, opposing or promoting.

6.2 Conclusions

Repercussions to Surveying: A point to be made in this Section is that university education is not as it once was. Boards may need to revise their expectations and their perceived actions in this new world. Overall, the situation is complicated and outcomes are unclear, but if anything there is little encouraging news. The viability of programmes can seem to be too big a problem for the profession to have any influence. It would be naïve of CRSBANZ to see any mechanism as a simple means to overcome any shortages of students, and hence graduates, but various useful observations can be made. It has to be remembered that educational institutions will always offer their degree structure in the manner they see fit, often constrained by other major degree programmes at their university with whose students they share subjects, such as engineering, physics and mathematics. Surveying departments do not have complete control over their own offerings. What may be important is that the surveying profession continues to keep in touch with universities, through involvement in advisory panels or by other means.

7 Conclusions and Recommendations

7.1 Conclusions

The primary goal of this report has been to respond to a request by CRSBANZ to suggest core content of current undergraduate surveying degrees. The purpose has been to aid those Boards which are affiliated with CRSBANZ in their process of confirming whether surveying degrees have the attributes which meet their requirements, and a documented list of core content is presumably beneficial. The list of suggested core content is not intended for other purposes, such as specifying the desirable complete content of a surveying degree.

It is recognised that a list of core topics which contains topics which are superfluous could result in deserving courses not gaining CRSBANZ approval; a list which excludes crucial topics could lead to CRSBANZ approving deficient courses. Accordingly, the section of core material is based on the assumption that the list must comprise a minimum set of crucial and necessary, non-optional, topics which fulfil the requirements of the graduate. Suggesting a wide range of possible topics for incorporation into a degree is not difficult; the challenge is to cull a long list, by excluding the unnecessary but leaving the necessary. The core elements are regarded as being those which could comprise an ideal degree in a hypothetical situation in which surveyors were to be educated in minimum time or cost.

This listing of the crucial contemporary content of surveying degrees is not intended to be ground-breaking or revolutionary; it is merely intended to provide a tool which is useful for Boards for the purposes described above. The specification may appear to be conservative, providing a restatement of the basic content of the current traditional programmes. However, it is intended to be radical only in its reversion to establishing and recognising that a surveying stronghold lies in precise three-dimensional measurement, which has not been taken over by anybody else despite predictions otherwise. Higher level topics in spatial information, GIS and remote sensing do not comply with the precise three-dimensional measurement notion and do not seem to have intruded into surveying, and they have been rejected from the core list. Of course, introductory GIS and the use and presentation of geo-referenced spatial data sets are now routine in surveying practice and seen as mandatory.

The desired degree content has been defined here by a set of topics. It is assumed that by firstly identifying the tasks required of surveyors, it has been possible to deduce the required skills and knowledge, and from them it has been possible to enumerate the educational topics required for the student. The writers believe that, even if CRSBANZ chooses not to ratify the provided checklist, the logic behind the nomination of inner core and outer core tasks, skills and topics, may nevertheless be a useful contribution, which will be usable again in the future to assess whether degrees can be rationally accepted by Boards for registration of surveyors.

There are many “grey areas” of possible programme content. Despite the explanation of the selection criteria, the decisions to include or exclude certain materials in a programme are not always easy: while there will be many topics whose selection is clear, there will always be a small number of topics whose classification is in the balance.

An enumeration of proposed inner core and outer core topics is provided. The inner core topics come from the large number of skills which are regarded as the province of the surveyor. They are skills which are almost unique to the surveyor, who can undertake precise spatial positioning in a way that nobody else can. The student is expected to gain a good understanding of inner core topics. They are distinguished by the fact that inner core topics are normally taught in universities by academics with a surveying background.

Outer core skills are the ones the surveyor needs to carry out the inner core tasks, to work with other surveyors and with professions, to carry out the surveys for them as clients or colleagues. These skills are not seen as the sole province of the surveyor. A person who has a degree other than surveying will generally not have covered the inner core material but may have covered some or all of the outer core material. The student is not expected to graduate with the detailed understanding of the outer core topics that would be expected for inner core topics. They are distinguished by the fact that outer core topics are not normally taught in universities by academics with a surveying background. Outer core topics are not inferior to the inner core skills, but they are less crucial to the definition of the surveyor.

The writers are keen to emphasise that, although the topics are presented as a “checklist”, university courses must impart an understanding of topics, and are not aimed at “training”. It is expected that surveyors should have a good comprehension of all matters. It is important that graduates have a grounding which ensures that they can continue over their career to adapt to new developments, presumed to grow at an even faster pace in future, while remaining true to a foundation requirement of being involved in precise spatial positioning. In that regard, the writers have tried to maintain an awareness of those fundamental matters which might contribute to enabling graduates to stay on top of precise positioning problems in future.

While not denying the inadequacy of current graduate numbers to meet industry requirements, the question of whether the core content recommendations have any impact on industry’s requirements elicits two responses. Regardless of the proposed core content for the express purpose of Boards, there are sufficient programme content options to enable industry groups to ensure that programmes meet their requirements. It is expected that university graduates will maintain into the future a capacity to adapt to changes, a situation which can be assured by a good educational background. Boards and industry do need to ensure that degrees retain those core topics which are crucial to enabling educated surveyors to adapt to the challenges of the future.

Many practising cadastral registered/licensed surveyors started in the TAFE system and the pool of potential new cadastral surveyors has relied on technician surveyors upgrading their qualifications to professional status. TAFE surveying diplomas are still a mixture of traditional teaching and competency-based components, but if TAFE teaching methodologies continue to change, the direct entry pathway to university degree programmes may be downgraded in the future. It may be necessary to watch whether the competency-based direction of TAFE leads to a less successful transition to university studies, as it will not assist supplying the demand for cadastrally endorsed surveyors.

The viability of surveying degree programmes across Australasia, but more particularly Australia alone, has been of concern to the surveying profession and industry for at least a quarter of a century. Overall, the situation is complicated and outcomes are unclear, but if anything there is little encouraging news. Boards can probably do little to turn around the lack of awareness of surveying in the community. Boards may be in a position to communicate with universities at a high level, should it be seen as necessary. The surveying profession is becoming aware that societal need for a programme may not be a sufficient argument for a programme’s continuation, if made only at the university level. The surveying profession may find that encouraging research flows on to encouraging staff. Boards may need to watch changes in education brought on by online learning and moves to different degree structures.

7.2 Recommendations

It is recommended that CRSBANZ:

1. *note the principles and processes which have been adopted during the preparation of the list of core topics;*

2. *reflect on and endorse the suggested essential content for land surveying degrees;*

3. *consider recommending to individual Boards that the suggested essential degree content becomes one of the bases for deciding on the acceptability of prescribed university degrees;*

4. *implement a programme of reviewing the suggested essential content for surveying degrees from time to time;*

5. *note the changing trends in university education, and, from time to time, seek updates on those trends, especially in relation to online courses;*

6. *continue to seek active involvement with relevant universities through regular meetings with staff and advisory committees.*

7.3 Acknowledgments

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