

# **The Influence of Technology**

## **on the**

# **Land Surveying Profession**

by

**Brian John Coutts**

A thesis  
presented to the University of Otago  
in fulfillment of the  
thesis requirement for the degree of  
Doctor of Philosophy  
in  
Surveying

Otago, Dunedin, New Zealand, 2017

© Brian J Coutts 2017





## **Abstract**

Land surveying has grown from a technical occupation into a profession. This study traces the rise of professions and the criteria that defines the requirements for an occupation to be granted such status. It then recognises the origins and importance of accurate measurement in antiquity before following the developments in land surveying that changed the occupation in late medieval England from that of an estate manager or overseer to one of an expert in land measurement. The research identifies this period as a paradigm shift, the first, making the following period the 2<sup>nd</sup> paradigm in land surveying. There follows a comparison between the present institutional arrangements for surveying and the criteria established for the status of a profession. It concludes that land surveying in its current form meets the requirements of a profession.

Following a discussion on the nature of modern surveying, consideration is given to the changes that have taken place in the last 60 years. The challenges faced as a result of technological change, through first the electronic age and then the digital age, are identified. The question of whether these challenges and their resultant developments have fundamentally changed the profession, heralding a 3<sup>rd</sup> paradigm, is then addressed. The views of land surveying academics, practitioners, senior government employees and staff of professional institutions are addressed through exploring their views, by in-person interviews, of what sits at the core of land surveying today. Specifically they are asked to address the changes that have taken place by considering what has been abandoned as obsolete in degree programmes and in practice, and what has taken its place. It is concluded that land surveying remains a profession with unique expertise in the management of all aspects of measurement data, its gathering, its analysis, its presentation and its storage. No new paradigm is identified.

Using grounded theory methodology, the research identified related issues for the profession. The first was the belief that land surveying, as a profession, had a poor public image and was identified with only the field aspects of the profession. It was apparent that the poor public image was linked to a poor self-image by surveyors themselves. Attempts to change that image by the adoption of a new term, geomatics, in the late 20th century had not delivered the anticipated improvements, and dissatisfaction with the term was identified in all of the jurisdictions visited. In the meantime it was apparent that the term “geospatial” was gaining popular use and was replacing, by stealth, references to geomatics.



## Acknowledgements

I wish to acknowledge the contributions made by the following people who contributed in their various ways to the initiation and success of this research thesis:

Dr Brent Hall, former Dean of the National School of Surveying at the University of Otago, now Director of Education and Research at the Environment Systems Research Institute (ESRI), Canada, my original principal supervisor, without whose encouragement, facilitation and mentoring this research project would never have begun;

Dr Don Grant, former Surveyor General of New Zealand, Associate Professor at the Royal Melbourne Institute of Technology University, colleague of more than 35 years, thesis advisor from 1 May 2011 and co-principal supervisor from June 2014, whose perceptive questioning, debating, general critical thinking and frustrating attention to detail have assisted in directing this thesis to a productive conclusion;

Dr Mick Strack, Senior Lecturer at the National School of Surveying, University of Otago, co-supervisor through the whole period of study, who has answered all of the trivial question and proofread in detail every word, as well as relieving my teaching load to make concentrated time available to me for this research;

Professor Christina Hulbe, Dean of the School of Surveying, University of Otago and co-principal supervisor from June 2014 without whose considerable support, comments and advice this thesis would have taken much longer and would have been of lesser quality;

All of those willing participants without whose availability, patience and valuable time made the collection of the data for this research possible, practical and enjoyable;

Valerie and David Spiller of Edinburgh, Scotland, Brian and the late Kate Waldy of London, England and Malcolm and Noreen McCoy of Melbourne, Australia for their nurturing, hospitality, grounding and encouragement.



## Preface

**The nature of our intelligence is such that,  
it is stimulated far less by the will to know  
than the will to understand**

*Marc Bloch*

For some time now, as a result of my international professional connections, I have been aware that the National School of Surveying at the University of Otago was extraordinary. It is not only extraordinary for its uniqueness in New Zealand, but also for its success in attracting students and providing desirable graduates to the local and international markets. In other countries surveying courses were disappearing, mostly by absorption into schools of engineering. Even in our closest neighbour, geographically but also culturally, this phenomenon was apparent, if not rampant.

The genesis of the aspiration to carry out this research was a desire to understand why this should be. While the thesis that follows does not directly address this question it does touch on some of the issues that relate to the surveying profession and especially the perceived public image, but more importantly of the self-image of surveyors. The importance of that understanding is to ensure that, as Otago's course evolves, it does not "kill the goose that lays the golden egg" by any changes it makes. As much as anything I believe these issues of professional image impact on the ability of the profession, internationally, to attract new and young potential members.

Past attempts to redefine the profession by changing its name have not been helpful - probably the reverse. Nevertheless, the term "surveying" does need qualification to distinguish what has been land surveying from other forms of surveying. If a qualifying word were to be adopted, for example "geospatial" it could only be expected to be successful if it were accompanied by a major and comprehensive promotional strategy, and on the basis of international adoption.

I believe I now understand the nature of Otago's success, at least to my own satisfaction.

*Brian J Coutts*



## Table of Contents

<b>Abstract.....</b>	<b>iv</b>
<b>Acknowledgements .....</b>	<b>vi</b>
<b>Preface.....</b>	<b>viii</b>
<b>Table of Contents .....</b>	<b>x</b>
<b>List of Tables .....</b>	<b>xiv</b>
<b>Chapter 1 Introduction.....</b>	<b>1</b>
1.1 The Research need and purpose.....	4
1.2 Research objectives.....	5
1.3 Research strategy .....	6
1.4 Research approach .....	7
1.4.1 Research methodology principles .....	7
1.4.2 Grounded Theory .....	9
1.5 Thesis structure .....	14
<b>Chapter 2 What is a profession?.....</b>	<b>17</b>
2.1 Vernacular use of “Professional” and “Professionalism” .....	17
2.2 The historical origins of professions.....	19
2.2.1 The professions in history .....	20
2.2.2 The universities .....	23
2.3 The development of “new” professions .....	25
2.4 Criteria for the status of a modern profession.....	29
2.5 Professionalisation .....	35
2.6 Summary .....	39
<b>Chapter 3 Is Land Surveying a Profession? .....</b>	<b>41</b>
3.1 Defining Land Surveying.....	41
3.2 Is Land Surveying a Profession?.....	44
3.2.1 An intellectually complex activity .....	44
3.2.2 A body of knowledge.....	46

3.2.3 Self-governing professional bodies.....	49
3.2.4 Application to practical problems .....	56
3.3 Summary .....	58
<b>Chapter 4 Paradigms in Land Surveying .....</b>	<b>61</b>
4.1 Land surveying in antiquity .....	62
4.1.1 The Egyptians .....	63
4.1.2 The Greeks.....	64
4.1.3 The Romans .....	64
4.1.4 Cartography.....	66
4.2 Through the Middle Ages .....	67
4.2.1 Beyond Europe.....	67
4.2.2 Cadastral surveying.....	68
4.2.3 The first paradigm.....	70
4.3 A new paradigm .....	71
4.3.1 The new concept of property .....	71
4.3.2 Angular measurement .....	72
4.3.3 Linear measurement.....	74
4.3.4 Developments in mathematics .....	77
4.3.5 The (European) Age of Discovery .....	78
4.3.6 Colonisation .....	79
4.3.7 The nature of a 2 <sup>nd</sup> paradigm?.....	81
4.4 Summary .....	83
<b>Chapter 5 Pressures on the Second Paradigm .....</b>	<b>85</b>
5.1 Land Surveying from the Air .....	86
5.2 Linear Measurement .....	88
5.3 Computers .....	91
5.4 Geodetic surveying .....	92
5.5 Digital Mapping .....	94
5.6 Combined technologies.....	97
5.7 Summary .....	98

<b>Chapter 6 Changes in the Surveying Body of Knowledge.....</b>	<b>101</b>
6.1 The Research Approach.....	101
6.1.1 Methodology considerations .....	102
6.1.2 The nature of the interview .....	103
6.1.3 Selection of universities .....	105
6.1.4 Interview Metrics .....	109
6.2 The development of surveying as a unique university discipline .....	111
6.2.1 The United Kingdom .....	111
6.2.2 Ireland .....	114
6.2.3 Canada.....	114
6.2.4 Australia.....	117
6.2.5 Summary .....	118
6.3 Degrees offered by the Institutions visited .....	119
6.4 Subjects no longer taught.....	123
6.4.1 Results.....	124
6.4.2 Discussion.....	126
6.5 Subjects introduced to courses.....	128
6.5.1 Results.....	128
6.5.2 Discussion.....	130
6.6 Changes to the BoK .....	133
6.7 Summary .....	135
<b>Chapter 7 Defining the Core Competencies of Surveying.....</b>	<b>137</b>
7.1 The Core Competencies .....	138
7.1.1 Results.....	139
7.1.2 Discussion .....	140
7.2 Summary .....	143
<b>Chapter 8 Geoma(n)tics .....</b>	<b>147</b>
8.1 Geo-everything .....	148
8.2 Geomatics in Ireland and the United Kingdom.....	149
8.2.1 Comments by those interviewed .....	149
8.2.2 Discussion .....	155

8.3 Geomatics in Canada .....	156
8.3.1 Comments by those interviewed .....	156
8.3.2 Discussion.....	167
8.4 Geomatics in Australia.....	168
8.4.1 Comments by those interviewed .....	168
8.4.2 Discussion.....	174
8.5 Summary .....	175
<b>Chapter 9 The origin and spread of ‘Geomatics’ .....</b>	<b>177</b>
9.1 The myths.....	177
9.2 The facts.....	179
9.3 A move across the Pacific to Australia .....	184
9.4 A move across the Atlantic to the UK .....	187
9.5 Other jurisdictions .....	191
9.6 Summary .....	192
<b>Chapter 10 Discussion and Conclusions .....</b>	<b>197</b>
10.1 Is surveying a profession?.....	197
10.2 Paradigms in surveying.....	198
10.3 The core of land surveying.....	201
10.4 The name game .....	203
10.5 Final words.....	207
<b>References.....</b>	<b>211</b>
Wikipedia citings .....	224
Other readings.....	225
<b>Appendix 1 .....</b>	<b>233</b>

## **List of Tables**

Table 2:1 The process of professionalisation.....	36
Table 6.1 Sector and age of interviewees .....	110
Table 6.2 Relevant degrees offered by universities visited. ....	120
Table 6.3 University subjects reduced or eliminated.....	125
Table 6.4 Summary of subjects reduced or eliminated.....	126
Table 6.5 New topics in courses or professional practice.....	129
Table 6.6 Summary of new topics .....	130
Table 7.1 The Core competencies of surveying.....	138
Table 7.2 Summary of Core competencies .....	139





# **Chapter 1**

## **Introduction**

Land surveying as a human activity is old. It is very old. Its fundamental principles were known, understood and utilised by ancient civilisations. People with advanced technical knowledge and training laid out the Egyptian pyramids. By today's definition they would be surveyors. Surveyors laid out Roman roads across Europe. They laid out garrison camps every night when soldiers were on the march. They controlled the building of aqueducts. They laid out heating and drainage systems in urban areas. Little changed in the art and science of surveying for millennia.

The Renaissance, the Rise of Science, the Age of Discovery and the Industrial Revolution brought new knowledge to most aspects of human life. New knowledge brought more complicated tools and new techniques to most workplaces. As a consequence, in the 19<sup>th</sup> and 20<sup>th</sup> centuries, new professions began to emerge and join the traditional ones of the law, the church and medicine. The practice of surveying was caught up in these developments as were many other forms of employment.

The migration of large numbers of people to the New World, particularly from Great Britain to its numerous colonies, and especially as part of resettlement schemes promoted by private companies, created a need for navigators, explorers, mapping and charting experts and surveyors. Such migrations began in the 1600s with the colonisation of what would become the United States of America and continued into the 19<sup>th</sup> century, concluding with New Zealand. Surveyors were needed to explore and map these regions newly discovered, at least by Europeans. On being "opened up" for settlement, surveyors were then needed to mark out areas of land bought by the settlement companies for on-sale to their migrant clients. In the

absence of other professions with appropriate expertise, some land surveyors developed other skills including those used in town planning and municipal engineering.

More recently, with the advent of computerisation and digitisation, land surveying has undergone extraordinary change and development, as has the balance of society. The rate of change is ever-increasing in modern society and tools unimaginable 50 years ago are now in everyday use. The tools now available, their capabilities, their portability and their immense storage and computing power have revolutionised the surveying practice of centuries. The change in the equipment that surveyors use on a daily basis is clearly visible. What is less clear is whether the change in the technology has brought about a change in what the land surveying profession contributes to contemporary society.

An evolution in the practice of land surveying was experienced by those who practiced it. This occurred in virtually all British colonies during their development from colonies to nations in the 17<sup>th</sup>, 18<sup>th</sup> and 19<sup>th</sup> centuries, but especially in Australia, Canada, New Zealand and South Africa. This evolution and development occurred in isolation from educational and professional bodies. To some extent, though not driven by migration, similar trends can be identified in currently emerging countries, most notably in former British colonies in Africa, where the British Directorate of Overseas Survey (now Ordnance Survey) played a dominant role up until the second half of the 20<sup>th</sup> century. Some of that influence continues through a private expatriate British presence.

There is no universally accepted definition of what a land surveyor is, or what is included in the range of tasks that a professional land surveyor should be reasonably expected to perform. Further, there is no absolute acceptance of the inclusiveness of the term “professional” when describing the occupation of land surveying. To complicate this definitional imprecision, the work of land surveyors has developed with different emphases as it evolved to meet the needs of the communities that land surveyors have served. This trend has been exacerbated in the post-1980 digital era.

The digitisation of an almost limitless collection and variety of land-based spatial data, and the ubiquity of digital devices, such as mobile phones and tablets that require no specialised education or training in their use, have also had significant current impacts and will continue

to do so. That they do not necessitate any understanding of the accuracy, precision and implications of their output data for position finding may be a threat to some traditional land surveying activities, as well as posing potential dangers to their users.

The impact of “cloud” computing and crowd-sourcing of information also have particular relevance to land surveying both in terms of its practice and for the education of professional land surveyors. The implications of these developments are profound and may be the harbingers of fundamental changes to the identity of the occupation and the types of skills required to become a practicing professional land surveyor. There are also implications for those whom the discipline would seek to attract, and those who might not be otherwise attracted to it.

The added complexity of some of the wider aspects of contemporary land surveying, which require considerable depth of understanding, have worked to narrow the field of expertise of some individual practitioners. This has served to compartmentalise surveying further into sometimes fractured and disconnected sub-disciplines. In some cases the depth of required knowledge can be achieved without having obtained the breadth of education and training or professional attributes that would normally be required to meet the past or present definitions of the practice of land surveying, as identified by professional institutions. While specialists with adequate qualifications, experience and practice are usually accepted by many learned societies, it is likely that there will be increasing pressure on the land surveying community to recognise individuals from the broader geospatial community who have narrower but deeper levels of disciplinary expertise. Not doing this will risk further fragmentation in the field of land surveying, or at worst, obsolescence of the current status that land surveying has created for itself.

All of this raises the question of whether the sum of these influences of the last 60 years have changed the land surveying profession into something other than what it has historically been. It also raises the question of whether or not there has been a shift of paradigmatic proportions in the nature of the profession. It is these questions that this thesis explores.

## **1.1 The Research need and purpose**

Over time, new professions have formed, technology has changed beyond imagination, and the needs of modern society continue to evolve with respect to land development and its management. Practitioners and researchers within the field of land development and management have recently identified actual or potential skill shortages in land surveying practice and its sub-disciplines (see for example Blanchfield, 2005; Hannah, 2006; Mahoney et al., 2007; Hannah et al., 2009). The most commonly cited causes of the current and projected skill shortages are the anticipated retirements of the baby boomer generation of land surveyors, who are now approaching or have reached retirement age, combined with the lack of subsequent generations taking up tertiary studies in land surveying (Blanchfield, 2005; Hannah, 2006; Hannah, 2009; Fairlie et al., 2010).

This phenomenon has impacted especially on the Australian market, such that already some commentators have identified skill shortages in the workforce. As a result, graduate surveyors from all over the world are migrating to Australia, either on fixed-term contracts or as permanent residents, including increasing numbers of New Zealand surveying graduates. These surveyors are needed to meet commercial (mining in particular) and other development needs (urban expansion) that the supply of a diminishing number of Australian graduate surveyors cannot satisfy (Interview 21Ap; McCoy, 2012). The same generally is true in Canada, although there is no ready supply of graduates from abroad to fill the vacancies left by retirements of the Canadian baby boomer generation of surveyors (Horwood and Hall, 2012).

The lack of young people taking up a career in land surveying is a problem that is much greater than the trend in evidence in Australia. The difficulties being experienced may include issues symptomatic of fundamental changes in the nature and practice of land surveying itself. A common theme cited in the academic and professional literature suggests that land surveying suffers currently from both a branding and an identity crisis (Hannah, 2009; Fairlie et al., 2010; Hall, 2011; Horwood and Hall, 2012). It is asserted that the general public does not know what a land surveyor does, nor do they understand the range, complexity or importance of the land surveyor's contribution to the solutions to contemporary land development pressures.

In addition, it is claimed that the public is largely uninformed on the centrally important economic relationship between the land itself, its tenure, and capital development, and the essential role that land surveyors broadly play in land-based transactions and developments. Thus, if land surveying is to be a sustainable field of professional practice, and be marketed as a viable and interesting career for young people, the vocation needs clarity and precision in the characteristics that define it. This quest to establish a clear definition and to address the current identity of the land surveying profession circumscribes the overall goal of this thesis. *Therefore the research question is - has technology fundamentally changed the land surveying profession?*

## **1.2 Research objectives**

The difficulties, perceived or real, that confront the land surveying profession as it moves further into the 21<sup>st</sup> century will impact on its practice, the form and function of its relevant professional bodies, its educational requirements, and how and to whom it markets itself as a vocation and as a profession that serves society. Achieving the objectives of this thesis will provide guidance as to whether or not the field of land surveying will, within the context of its regional identities, remain as the uniquely identifiable entity in the future that it has been in the past. Critical to these issues is the need to affirm, or otherwise, the professional standing of land surveying and identify the core of the body of knowledge that defines it. The results of this investigation will be of significance to the surveying profession in general and to international surveyor education in the immediate and medium-term future.

Flowing from the goal of achieving a sound and systematic understanding of the discipline of land surveying from its origins and through its evolution to its contemporary state, this thesis seeks to answer several specific research objectives, namely to:

1. establish if the occupation of land surveying meets the criteria for being classified as a profession;
2. examine and establish the paradigm that defined the practice of land surveying and its core body of knowledge c.1960;
3. establish the recent pressures of change on land surveying practice, and their sources;

4. identify the changes that have been made to the land surveying core body of knowledge in response to the changes as a result of the technological revolution that has occurred in the preceding 60 years;
5. identify what core knowledge or skills distinguish the land surveying profession from any other profession;
6. identify and consider the relevance of the term geomatics to the land surveying profession.

### **1.3 Research strategy**

Relative to objective 1, literature is reviewed relating to the criteria for an occupation to legitimately claim the status of and be regarded as a profession. A generic and etymological definition of land surveying is established and an overview of the land surveying discipline, in the context of its English origins and colonial development, is undertaken to determine, generally, whether or not professional status is appropriate for the field of land surveying.

Relative to objective 2, the literature pertaining to the development of the practice and principles of land surveying is reviewed through history until c.1960. Significant events and developments are identified and brought together to establish the paradigm prevailing through the preceding three centuries. To achieve objective 3 a review is undertaken that identifies the relevant major technological changes that have taken place since about 1960 and the area of land surveying practice on which they have had an impact.

Objective 4 is met by interviewing land surveying academics, and surveyors in a variety of countries and sectors of the profession (private practice, government service and surveying professional institutions). The purpose of the interviews is to identify those aspects of land surveying that have become obsolete or irrelevant in the past 60 years and those areas that have been introduced, are new, or are developing. In the process of these interviews a consensus is established as to what it is that is at the core of land surveying, that contains the essential knowledge required to be a professional surveyor and that makes it a unique activity and therefore satisfies objective 5. Objective 6 is considered in response to the wide-spread use of the term geomatics in a vernacular sense, the need to clarify its original meaning and its usefulness to the land surveying profession.

## **1.4 Research approach**

This section explains the overall research philosophy adopted in order to answer the research question. In addition Chapter 6 contains a detailed explanation of the implementation of this philosophical approach as it applies in this circumstance. The research approach is an open one. That is, it does not propose a hypothesis and then gather data in a quest to either prove or disprove that initial proposition. Given the qualitative nature of the research, the absence of a hypothesis assists in avoiding bias in the approach of the author to the formation of the questions asked, and the need for those interviewed to express a view on the validity of the hypothesis. While the research question itself is a closed one, it permits an answer to develop from the data gathered that is free from any preconceived position, or the appearance or perception of such a position.

The research question is posed because over the nearly 50 year career of the author something has happened to, or within, the land surveying profession. It is a cliché to observe that the profession has been massively impacted by technological advancement. The research question asks whether technological advancement has caused a change that is of a fundamental nature and, by implication, if there are other relevant factors. The alternative is that the change has been processes of gradual adoption of new science and resulting technology and the refinement and refitting to new tools, as has happened within other professions and the balance of society generally. Finding an answer to this question requires observational data and the aim of the thesis is to provide that answer to that question. The philosophical approach to the research question is based in “grounded theory”, which is particularly suited to providing an answer to a research question or developing a theory based on observed data rather than proving or disproving a hypothesis (Leedy & Ormond, 2010).

### **1.4.1 Research methodology principles**

The nature of the research being undertaken in this thesis is a study based in social science rather than of a physical, experimental or empirical nature. It requires the use of qualitative data gathering and analysis rather than being based on experimental procedures. In this case the research is inductive in that it aims to document and explain what has occurred rather than being deductive or retroductive and seek to explain why these things might have happened. The “why” is explained in the thesis title, that is, that technological changes have taken place

over time. The question examined in the thesis is then whether these changes have altered the nature of the profession.

The nature of the research is twofold. The first section of the thesis deals with the historic development of professions and the surveying profession in particular by way of a literature review. The second section is also in two parts. The overall approach is inductive reasoning as described in Leedy & Ormond (2010. p.32). The first section involves the gathering of factual data from the research participants in which the researcher adopts an “empathetic” position, knowledgeable but impartial, and focuses on the reality of what has changed over time as explained in interviews. The second is that of a faithful reporter, in which it is necessary to have some knowledge of the topic and the professional language, but to allow the participants to speak for themselves and explore the opinions expressed (Blaikie, 2010. p.51). Impartiality, however, on the part of the interviewer is maintained through avoiding specific questioning of the subjects but rather by raising topics.

In this way the research paradigm becomes that of positive philosophy or Positivism as derived from Comte (Babbi, 2013. p.59-60). It is an attempt to map the reality as observed by the research participants that is derived from their experience, preferably over an extended period whenever possible. The thesis looks for consistency in the responses, particularly within geographical regions, as the nature of the profession is such that it has differing functions, practices and attitudes from country to country.

In the introduction to their book on grounded theory, editors Antony Bryant and Kathy Charmaz comment “Grounded Theory Method (GTM) comprises a systematic, inductive, and comparative approach for conducting inquiry for the purpose of constructing theory.” A definition of grounded theory is provided in the glossary to their book as follows: “Grounded theory: a method of conducting qualitative research that focuses on creating conceptual frameworks or theories through building inductive analysis from the data. Hence the analytic categories are ‘grounded’ in the data.” It continues: “This method is distinguished from others since it involves the researcher in the data analysis while collecting the data – we use this data to inform and shape further data collection, thus the sharp distinction between data collection and analysis phases of traditional research is intentionally blurred in grounded theory studies” (Bryant and Charmaz, 2007. pp.1-28). For this reason grounded theory is

particularly suited as the basis of a philosophical approach to the questions embodied by this research.

### **1.4.2 Grounded Theory**

Grounded theory was originally developed by two sociologists, Barney Glaser and Anselm Strauss, and first published in 1967 (Birks & Mills, 2015). Subsequently Glaser and Strauss went their separate ways and published individually (Strauss and Corbin, 1998). They followed different tracks and generated divergent views on the philosophical development of grounded theory. Rumours on their “split” are refuted by Birks & Mills (2015. pp.3-4) who maintain that the intellectual and personal relationship endured until Glaser’s death in 1996. It can be concluded, therefore, that their separation was a philosophical one within the bounds of grounded theory itself, and neither profoundly epistemological nor personal. Across the decades that followed its development, grounded theory has further evolved, characterised and expounded through what Birks & Mills describe as “generations” (Birks & Mills, 2015). Detailed discussions of the developments of grounded theory are not necessary here as the principles provided by its basic constructs are adequate for the task in hand.

The first step in grounded theory is to establish *a personal philosophical position* Birks & Mills (2015). This author was university educated and government trained as a professional registered land surveyor. Following several years of professional central government practice, retraining (or specialisation) as a protected natural area planner was offered. This led to professional land management practice in the high country, bushlands and mountains of the South Island of New Zealand. A short period as a private practicing land surveyor and consulting land planner followed. Finally an academic position in the School of Surveying at the University of Otago was offered and accepted. That position continued throughout the preparation of this thesis.

During the period in academia, teaching the principles and practice of land use planning, a close connection with the broad range of land surveying activity has been maintained. This activity has not merely been as an observer, but as a highly active institutional participant. Those institutions and activities include:

- teaching at the University of Otago National School of Surveying for 25 years, 5 years as Deputy Head of the School and chair of various committees, including the Undergraduate Committee;
- 12 years as a member of the Council of the New Zealand Institute of Surveyors (NZIS) including 2 years as President;
- 7 years as a Ministerial appointed member and Chair of the Cadastral Surveying Licensing Board of New Zealand (CSLB) since its inception in 2002;
- 10 years as member of the Management Board, including 4 years as President, of the Commonwealth Association of Surveying and Land Economy (CASLE); and
- over 20 years involvement with the International Federation of Surveyors (FIG) as a commission delegate, often Head of the New Zealand delegation, and at present being a Commission Chair (Professional Practice and Standards), and an *ex officio* observer at the FIG Council for 2 years (2015/16).

As a result, the author is well qualified to observe, comment on and evaluate the changes that have taken place in the profession of *land surveying*, as the profession is understood in New Zealand over the period of his involvement. (Note: discussion on terminological descriptions of the profession will arise in the body of the thesis). Absence from direct activity as a practicing surveyor, but active engagement in its administration and governance provides a sound position as an objective researcher yet a very involved member of the profession. While a dispassionate observer of the development of the profession, the author remains a committed adherent of the profession of (land) surveying, locally, regionally and internationally, as demonstrated by consistent commitment to its governance. These experiences provide the basis of his personal philosophical approach to the research question.

The following observations are offered based on the above experience and represent the author's personal philosophical position. Without question, there has been a continual change in land surveying technology over the previous six decades. There has also been a rapidly changing environment in which the practice of land surveying is conducted. One approach to the assessment of this question is to ask, in the sense of the use of "paradigm" as popularised by Thomas Kuhn (Kuhn, 1962), does the land surveying profession now work under a new paradigm?

As will be discussed and maintained in Chapter 4, a paradigm shift occurred c.1600. Has there been another one? Is there a new theoretical foundation to the role of the land surveying profession in modern society? Has there been a sufficiently significant change to warrant being referred to as a paradigm shift? The approach to these questions is an open one, and no hypothesis is offered as to what the answer to the questions may be. If there did exist a new paradigm for the land surveying profession, the task of defining an appropriately testable hypothesis, *a priori*, is beyond the scope of a single thesis. Avoiding the question of whether identification of a new paradigm is practicable, the risk of pursuing hypotheses that were capable of being disproved would be great, and the probability of identifying a provable one would be slight.

The second requirement of grounded theory is to develop ***a methodology***, a way of thinking about how to study the topic. The methodology selected for this study was to gather qualitative data from reliable sources. These sources are principally academic, but also include representatives of professional institutions, private practitioners and graduates of academic programmes. Academic institutions well known as providing qualifications in the surveying field are often linked by accreditation process to professional institutions. First contact was made by email with individuals either from personal networks, acquaintances, and recommendations of associates or names obtained from websites. The aim of the study was explained and a request to visit and conduct interviews made. Occasionally “cold calling” was necessary.

The principal factor in selecting academic institutions in the United Kingdom and in Ireland was their provision of surveying qualifications of high standing and international reputation. These were chosen as a priority. In Canada, the University of New Brunswick is considered as the home of surveying, and to have spawned the surveying (geomatics / geomatics engineering) programme at the University of Calgary. In Ontario, the lower international profile but relevant programmes at York and Ryerson Universities in Toronto were recommended by the author’s initial supervisor. In hindsight, the author may have included Laval University in Quebec in the survey, but was unaware of its influence. Its Francophone orientation is likely to be partly responsible for this. Sufficient information was gathered from the four universities visited, and the influence of Laval in a new issue that arose during

the research, use of the term geomatics, was very well covered by available documentary evidence.

In Australia, the original plan included all of the states with the exception of Tasmania. Cost dictated the deletion of the University of New South Wales and circumstances beyond the control of the author intervened to make the trips to South Australia and Queensland unproductive in terms of the academic sector. In both cases senior government employees and private practitioners made themselves available at short notice. Generally, it was left to the institutions themselves, academic, institutional and professional, to decide who specifically they provided to the author to be interviewed. Sometimes the interviewees are already known to the author, but for the most part they were not.

Grounded theory requires that the interview data be **coded** in a systematic way so that it can be organised and interpreted. Codes present themselves by repeated appearance in the responses of the interview subjects. The interviews themselves were informal or at most semi-structured. It was critical that through the interview, each subject was given the maximum opportunity to expand and extend the topic in whatever direction they felt significant to them. It was also anticipated that as the interview programme developed, new questions may arise from the data (that is from the responses of those interviewed) as it was being gathered. The interviewer had to be alert to any new directions that the data, or the interviewee, headed so that they could be followed up with subsequent questions.

Having decided on a methodology, the next task is to develop **methods** of data gathering. The principal method of gathering data employed in this research study is by recorded interview. When the interview programme was complete, the interviews were transcribed for close scrutiny and analysis. A portion of the interviews were transcribed by a transcription expert (approximately 48%), and the balance by the author.

All interviews were anonymous and had the written consent of the subject. Ethical approval was obtained from the appropriate University of Otago authority for the study, as described, to proceed. Only the principal researcher had access to the raw data and the recordings and transcriptions will be destroyed on completion of the project. An undertaking was given to

subjects that if the interviewer wished to quote them and attribute the quotation to them, their approval would be sought before publication.

Some mental coding of the data took place as the interview process proceeded. When necessary, ***memo writing*** also occurred to assist future detailed coding and interpretation. Initial coding was undertaken during transcription. Those interviews that were professionally transcribed were checked in detail for accuracy, as challenges arising from technical terminology were compounded by the wide range of accents of the Irish, Scottish, several English, Canadian, Chinese, Greek, South African and Australian participants. While initial coding took place as this checking and correcting was carried out, only once transcription of all interviews was complete did concentrated and detailed coding take place. That having been completed, a full and thorough analysis of the coded data was undertaken.

Analysis in the first instance was by the creation of three spreadsheets tabulating the coded responses to the topics raised by the interviewer with the subjects, and the topics raised by the subjects themselves. The number and extent of those spreadsheets was determined by the nature and quantity of the data acquired. The spreadsheets themselves are not presented herein, but are converted into a tabular form for easier interpretation. Once the spreadsheets were completed, the analysis of the interviews was written up and any conclusions drawn.

The interviews raised issues that went beyond the scope of the original objectives of the study, and to an extent, led into an area that had been intentionally left out of the scope of this research. However, the issue of what the discipline and the profession are called was raised in the very first interview and it quickly became apparent that this issue would be entangled with professional identity and the question of fundamental change. The term “geomatics” had been introduced into the language in the 1980s and had been adopted in some countries to be more inclusive of developing technologies and to label land surveying in a more modern way. This new term arose in the first interview in Ireland and persisted throughout the United Kingdom and Canada. It was especially popular within academia and often included in the name of university surveying programmes. It was less obvious but still present in Australia. The question of nomenclature therefore became impossible to avoid. The issue defies codification in the same manner as those issues dealt with in Chapters 6 and 7, and it is discussed in Chapters 8 and 9.

A more detailed description of the method used is contained in Chapter 6. Using grounded theory has provided a very clear and definitive answer to the research question. It has also led to an area that is topical in the surveying profession, and that is the name of the profession and the disciplines that it now encompasses. It is a matter that has been extant for nearly 30 years, has generated retrofitted explanations of its origins, gathered a mythology of its own and, debatably, not delivered what some of its proponents expected. Thus the research, and the use of grounded theory, has not only answered the research question asked, but lead to, and answered, other related questions.

## **1.5 Thesis structure**

Chapter 2 begins with an examination of the literature that discusses accepted definitions of what distinguishes a profession from any other form of occupation such as a vocation, a trade, a craft or a skill. From a review of these definitions the important points of difference that distinguish one from another are extracted and the proposition made that land surveying qualifies, against all agreed criteria, as a profession. Chapter 3 builds on the definition of a profession by examining the nature of the activity of land surveying as it is structured and practiced in the Australia, Canada, Ireland and United Kingdom (UK). In reviewing the literature on professions, it recognises the emergence of a host of new professions alongside the development of modern science. It concludes that in terms of the criteria established through the literature on professions and professional status, land surveying is a profession.

Chapter 4 extends this discussion to explore the historical context of the occupation of land surveying through time. It considers firstly the evidence of early civilisations and their knowledge and use of surveying practices to assist them design, lay out and construct significant engineering works. It also identifies the use of land surveyors in the identification of the location, size and productive value of areas of land for taxation purposes as well as the surveyors' knowledge of land law. From the literature, Chapter 4 then identifies a series of developments that were the product of the Renaissance, the Age of Discovery, the Rise of Science and the Industrial Revolution that brought about the emergence of the land surveying profession as it was by the early 20<sup>th</sup> century. Chapter 4 concludes that the technological and philosophical advances that occurred in the period between c.1550 and c.1650 established a new paradigm for the land surveyor.

Chapter 5 reviews the technological changes that have impacted on those developments and their applications that were established in Chapter 4. These have occurred mainly in the second half of the 20<sup>th</sup> century and flow largely from the creation of the electronic computer and the development of rocket science that enables satellites to be launched, maintained and operated. It is then questioned whether these factors have had a fundamental impact on the land surveying profession such that another fundamental shift has occurred.

Chapter 6 processes and analyses the responses gathered from a selection of people intimately involved with the education of surveyors and the practice of surveying in Australia, Canada, Ireland and the UK. The particular issues analysed are the topics that can be identified as no longer being taught or used in the land surveying and that have been dropped from curricula and from practice. It also considers what new areas of teaching and practice have been adopted or developed, or it is intended to introduce into the competencies of the professional land surveyor. Following this Chapter 7 similarly analyses the opinions of those interviewed in order to identify what it is that are the essential competencies that identify a member of the surveying profession as distinct from any other profession.

In the course of the interview process a further question was identified. That is that in some places the term geomatics has been introduced, and that it bears some relationship to land surveying. Chapter 8 explores, in the view of those who use the term, the origin, development and meaning of geomatics, how it relates to the profession of land surveying and the reasons that its use became widespread. This chapter also identifies how wide and varied the use of the term is among those who use it.

As a consequence of the variations in the use and the opinions expressed in Chapter 8, Chapter 9 explores the literature relating to geomatics, establishes its true origins and charts its spread through the countries under study in previous chapters. It examines the reasons given at the time for the adoption of this new term by those who advocated for its use, and comments on the success or otherwise of the expressed objectives.

The thesis is concluded in Chapter 10 with a discussion of the conclusions that can be drawn from the preceding chapters and expresses an answer to the broad research question that was originally proposed and the subsequent questions that emerged from the interviews.



## **Chapter 2**

### **What is a profession?**

This chapter discusses the origin and development of “the professions” and examines historical and contemporary thinking on what distinguishes a “profession” from any other form of occupation or activity. The discussion first explores the original meaning of the term profession. Second, it reviews the manner in which the number of occupations claiming professional status expanded. Third, literature is examined that proposes definitions or lists of criteria that an occupation should meet in order to qualify for professional status in the present day context. From this discussion, the chapter identifies current criteria that apply only to professions.

#### **2.1 Vernacular use of “Professional” and “Professionalism”**

The literature on the definition, meaning and attributes of a profession is extensive. There is reasonable agreement on the main two criteria that define a profession, namely the application of a complex body of knowledge to address practical problems in the service of society, and the need for a professional practitioner to strive for impartiality in providing professional services. However, the words “professional” and “professionalism” have crept into common usage, and have clouded, if not diverted, discussions about which occupations may correctly be considered professions and which may not. Often the words are used to describe the behaviour of individuals and are not intended necessarily to convey the view that the individual is, claims to be, is being credited with, or is in fact, a member of an occupation that rightly can be classified as a profession.

To define “professional” and “professionalism” in the modern context is not a particular objective of this thesis, although the definition of a “profession” is a necessary starting point. It is, therefore, important to note that the use of these words is not confined to references to members of a profession, and generally refer to individual behaviours rather than membership of anything. In the most commonly used context, recognised in the early 20<sup>th</sup>

century, the term “professional” could simply mean the opposite of “amateur” (Flexner, 1915). That is, it is used to distinguish those who practice some activity as a means of livelihood or for payment, from those who merely carry out an activity on a part-time basis, for recreation, for philanthropic reasons, or for motives of social conscience. In this respect at least, the distinction between amateur and professional, it is proposed, is generally widely understood. Further, while it is not used in reference only to members of professions, it may be used in this context as well.

However, the current meaning of “professionalism” is less clear. It does suggest that an individual has adopted some of the attributes of members of professions extensively described in the literature over the preceding 100 years, and more particularly in the influential contributions of Flexner (1915), Carr-Saunders and Wilson (1933) and Wilensky (1964). It is therefore necessary to distinguish the attributes expected of a member of a profession from the notion of the profession itself, so that the two can be objectively considered. At the same time, it is recognised that the words “profession”, “professional” and “professionalism”, while having the same etymological derivation, are not synonymous nor as directly related as may at first appear. That is, the latter two terms do not imply that a person who has demonstrated professional behaviour, that is professionalism, is necessarily a member of a profession by virtue of such behaviour. The status of the occupation therefore finds expression in the individual, but the behaviour in itself does not result in an occupation attaining the status of a profession.

It is expected that members of a learned or recognised profession will act professionally, and that they will exhibit professionalism in all that they do. Parsons (1939) observed that in the life of a professional person, the boundary between the practice of their chosen profession and the balance of their lives becomes blurred. If one of the fundamental principles of membership of a profession is observance of an ethical code, then those ethics cannot be left at the door of a practitioner’s workplace. By their very nature, those codes of conduct must pervade all that a person of professional status undertakes. Hence, ethical positions cannot be taken up and put down at will. Wilensky (1964) alluded to the same interpretation.

Meanwhile, Cogan (1955) asks whether an individual can be a member of a profession without being a member of a professional body, or is such status necessarily and, in fact, the

product of such membership? It would seem that both cases may be possible in this context. Cruess, Johnston and Cruess (2005. p.76) note “that rights and privileges [of professional status] are not inherent, but are granted by society in return for certain behaviours and skills”. Hence, becoming a member of any profession is first a matter of having proven the acquisition of the requisite body of knowledge for that profession and the ability to apply it, followed by the adoption of the professional culture, or as identified by Bledstein (1976) and referred to in Friedson (1988-89), as a particular “state of mind”.

The public demonstration of these attributes is typically reflected by membership of a professional body that has defined entry criteria and espouses and enforces an explicit code of practice. Public acceptance of a specific practitioner, who is not a member of any such learned society as a member of a profession, would require the individual to build a reputation for competence, trustworthiness and professional behaviour. Given an individual’s freedom from the sanctions of a professional body, remedies for indiscretions only being available under the law for illegal practice and not for acting unprofessionally, such status may be only granted grudgingly or unwittingly by society. In the professions of antiquity, namely the clergy, law and medicine, such status was and is protected by law in most countries.

Before addressing the question of what currently provides a basis for any occupation to make a valid claim for the status of a profession, it is important to examine where the concept of professions originated and what factors have caused the upsurge in claims for professional status. This takes, as a starting point, a current dictionary definition, and then explores the historical evolution of the concept through time, outlining the separation of particular occupations from the domination of the Church and the development of secular educational systems that underpin modern professional status.

## **2.2 The historical origins of professions**

As suggested above, the word “profession” is commonly used in modern parlance to describe a multitude of activities and occupations. Hence, definitions differ depending on the nature of the use of the word. For example, the Oxford English Dictionary defines a profession as “an occupation in which a professed knowledge of some subject, field, or science is applied; a vocation or career, especially one that involves prolonged training and a formal qualification.

In early use applied specifically to the professions of law, the Church, and medicine, and sometimes extended also to the military profession” (Oxford English Dictionary, 2011).

However, this definition is of little help in establishing in detail whether any occupation can be considered, or claim to be, a profession. The words “professional” and “professionalism” have crept into common usage to the extent that they have lost some of their original significance, and they are now used loosely in a variety of contexts beyond a strict reference to those who are members of “professions”. In order to understand the nature of professions in modern society and the significant features that distinguish professions from other occupations, the following sections examine the development of the concept of a profession from its origins to the present day. This examination provides the conceptual foundations upon which the status of land surveying can be scrutinised.

### **2.2.1 The professions in history**

In its original context, the word “professional” meant one who professes, that is, one who had taken the vows of a religious order (Armstrong, 1994; Dyer, 1985; La Vopa, 1982). In some cases, it also implied that the candidate for inclusion in a profession had not simply chosen their occupation, but had been called by, and had a responsibility to, their God. Hence their calling was one to devote their lives to the service of their God and their congregation in a specialised field (O’Day, 2000).

The concept of the professions being a calling remains relevant to this day, and it is the norm for those entering a profession to remain engaged in that vocation for their entire working life. However, this is likely to have more to do with the time, effort and cost involved in entry to a profession. It might be interpreted to be a spiritual call rather than a religious one. Carr-Saunders and Wilson (1933) expanded this definition and identified the 11<sup>th</sup> century, the period when Europe began to emerge from the Dark Ages, as the era in which associations began to form around a variety of aspects of society, including the development of trade or craft bodies that represented the specialisation of occupations. As noted by Lyte (1886) these societies were exclusive to their occupation and were the beginnings of the guilds, which are a style of organisation that still thrives in England. Guilds involved themselves in controlling the recruitment of members to their occupation, setting requirements for the education and training for new members and limiting the numbers of new entrants to their trade.

In England, this period also saw the founding of the earliest universities, and while they were not ecclesiastical in their origins, they did come under the dominion of the Church in time (Carr-Saunders and Wilson, 1933; Unwin, 1908). Tout (1916) observes that generally education had been the preserve of men of the Church, and novices entered the Church as students, prior to their advancement through the Church hierarchy. All records, communications and accounts were kept in Latin, though not only for religious orders, as this was the written language of the day. Those who might be thought to be members of a profession then, notably teachers, lawyers, physicians and civil servants, were initially members of the clergy, and who had developed particular skills that allowed them to fill specialised roles. It is further maintained that “maintenance and preferment within the professions was also by way of ecclesiastical preferment” (Carr-Saunders and Wilson, 1933. p.290). This explains why it has become common practice to refer to the original professions as the church, law and medicine, and how the term profession might have evolved into common use.

The first requirement of a profession was to profess vows, followed by a clerical education leading to a specialisation such as the law or medicine “Physic, together with theology and civil and canon law, were studied in the superior faculties” (Carr-Saunders and Wilson. 1933. p.66). The literature also gives implicit support for including teaching as historically being considered a profession in itself. However, this is not discussed explicitly (see, for example, Carr-Saunders and Wilson, 1933 and O’Day, 2000). The civil service is also alluded to in this early context, but it appears to be regarded as a form of service simply using the existing clerical education, especially reading and writing in Latin, without the requirement for additional study, but might have required the inclusion of additional skills in administration.

With reference to the law and in addition to canon and statute law, the common law, that is, law developed through practice, precedent and tradition, evolved over an extensive period. This precipitated the development of privately practicing lawyers. Carr-Saunders and Wilson (1933) suggest that the practice of law as a calling involved a separation of the vocation from the clerics, and that this had occurred by the middle of the 13<sup>th</sup> century. Further, by the 14<sup>th</sup> century, the Inns of Court in London had been created as an alternative route to a career as a lawyer and were well established by the 15<sup>th</sup> century. These institutions were completely separated from the Church and so placed the operation of common law into the hands of

those who had been trained or educated in the law by a system that sat between the guilds and the universities. Hence, the Church at this time was beginning to lose the direct control that it once enjoyed in matters of the law with the emergence of an independent legal profession (Carr-Saunders and Wilson, 1933).

At the most senior level of the civil service, the appointment from 1529 to 1532 of Sir Thomas More as Lord Chancellor, the most senior member of the judiciary, to the Court of Henry VIII was the first occasion upon which that position was held by a person from outside the Church. Since 1559 there has been only laymen appointed to that office. As a result, Carr-Saunders and Wilson (1933. p.293) noted that “. . . in the sixteenth century the already secularised common lawyers came to represent almost the whole body of lawyers”. Additionally, the last ecclesiastic to hold the office of Lord High Treasurer was William Juxton, who held the position from 1636-41 (Carr-Saunders and Wilson, 1933).

The influence of the Church diminished as secular society took over influential offices of State, and displaced the clergy from the higher callings that were to be associated with the professions. This transition was largely completed by the middle of the 16<sup>th</sup> century (Carr-Saunders and Wilson, 1933). Effectively, the taking of holy orders was no longer a prerequisite for entry into the established and learned professions. Additionally, the dispute with the Catholic Church under the reign of Henry VIII, and the dissolution of the monasteries, encouraged and accelerated the declining place of the Church in the administrative affairs of the State.

Carr-Saunders and Wilson (1933) do not cover the origins of medicine in the same detail as other occupations, but they do distinguish between the practice of surgeons and physicians. Surgeons, who were aligned with barbers and apothecaries as distinct from physicians, had formed themselves by the 14<sup>th</sup> century into trading guilds, along with grocers, scriveners or scribes, and notaries. The surgeons, unlike the physicians, developed outside the sphere of control or influence of the Church, and did not emerge from the clerical orders.

In contrast to the law, the relationship between the church and medicine, that is physicians (who were clerics) but not surgeons (who were not), had been close but differed on several grounds (Carr-Saunders and Wilson, 1933). Not only were there non-clerical physicians

working in England from as early as the 7<sup>th</sup> century, but they had also been accepted by the Church and were consulted by prominent members of the clergy (Singer, 1928).

Nevertheless, medicine is considered to be amongst the oldest professions, despite its origins being, at least in part, outside of the professed adherents to the Church.

If a professional *body* was deemed to exist at this time, it would be the Church itself, the members of the profession being the clerics, having professed their vows then used their competencies in the service of the Church's adherents. From these origins, additional criteria for the status of a profession include honesty and integrity, from the profession of faith; education, from the teachings of the specialist knowledge within the church; and service to society, given that the purpose of the additional competencies was to serve some particular need of society outside the realm of divinity.

As Europe emerged from the Dark Ages (c. 400-1000AD) the Christian values inherited from the Church were broadly established and accepted. Moreover, the classical literature of the Hebrews, Greeks and Romans was rediscovered and an instinct for organisation beyond local associations became apparent (Pederson, 1997; Whitehead, 1933). In place of the educational roles undertaken by the Church, new institutions of learning were starting to emerge. Their foundation was in the rediscovery of classical studies and the liberal arts, and they provided the basis of an education system that would, in the following centuries, take its graduates into the realms not only of the established professions but also into those that were to develop.

## 2.2.2 The universities

Pedersen (1997) observes that settled urban centres were a necessary pre-condition for what would be considered an accepted school in today's terms. The schools of Ptolemy, Plato, Aristotle, Socrates, Euclid and Pythagoras attest to the existence of formal institutions of learning well before the Common Era (BCE) and during the centuries of the dominance of Greek culture. The origins of modern schools of higher learning can now be traced back to pre-historical times, with the tradition of learning and teaching traceable at least in the pre-Grecian cultures of the Middle East (Pederson, 1997). The dominance of the Catholic Church through Europe in the period of the Dark Ages focussed the source of learning in the monasteries. These were to dominate and confine the spread of literacy and education to the

privileged, “where the Bible was the starting point of every kind of intellectual activity” (Pederson, 1997, p.66).

The late medieval period was one of significant social, economic and technological change that created an increased demand for both practical and theoretical training. However, as the monasteries strove to isolate themselves from the distractions of daily life, they were less able to meet these needs than had been the case. Monastic reforms further isolated them from the demands of daily life. At the same time, population growth and urbanisation, along with the devolution of centralised government to local corporations occurred. This encouraged the development of self-educated and business-controlling activities among the merchants and trade guilds in order to meet the technical needs of the growth of trade. However, the guilds limited the education of their prospective members to the specialised training required for their particular craft, and handed down their techniques, or trade secrets, through apprenticeship. Their form of education was not made available to the wider population, but only to those who would, in time, replace the current guild members (Pederson, 1997).

While the influence of the church diminished, and the need for the crafts and trades to develop their guilds’ teachings expanded, there was a general absence of centres of higher learning. The University of Oxford, the first university in the English-speaking world, began to form about this time, with teaching being recorded there in 1096 (University of Oxford, n.d.). The University of Cambridge was established early in the 13<sup>th</sup> century. Historically the town of Cambridge had been the location of a number of ecclesiastical establishments. It developed, almost as a reaction to the University of Oxford, where there had been troubles between the townsfolk and the students, with the students taking refuge in Cambridge (University of Cambridge, n.d.). Cambridge’s existing ecclesiastical tradition and the arrival of a nucleus of aspiring students provided the basis for a new institution of learning.

In the 13<sup>th</sup> and 14<sup>th</sup> centuries the university movement consolidated as a place of higher learning, growing as described in detail by Pederson (1997). Their teaching was in Latin, and their products were scholars and teachers. As they developed they gained independence from the State and from the Church. They gradually emerged from teaching the liberal arts to being institutions of higher learning in general, as they provided an alternative to a clerical education.

Secularisation was further enhanced with the dissolution of the monasteries and monastic teaching during the reign of Henry VIII in the 16<sup>th</sup> century. In time, the universities embraced the Rise of Science that followed the Reformation and the Renaissance. In particular they responded to the overwhelming changes brought about by the Industrial Revolution of the late 18<sup>th</sup> and early 19<sup>th</sup> centuries. These advances demanded the application of scientific method in the explanation and discovery of new technologies as well as in the explanation of natural phenomena, or the “Laws of Nature”.

### **2.3 The development of “new” professions**

Following the Industrial Revolution and throughout the 19th century, the professions were regarded as occupations only suited for “gentlemen”. The term “gentleman” is not defined here but it is inferred from the context that it refers to male members of the nobility or their descendants who chose to have an occupation rather than be content with membership of the leisured class (Carr-Saunders and Wilson, 1933). That is, it includes those who chose to work, but did not need to work in order to live. It was not expected, that “common people” could rise to the ranks of members of the professions, as upward mobility was a rare phenomenon in society at this time in history. The participation of women in such activities was also rarely in evidence.

It took more than one specialised individual to form a profession, and required, as a minimum, an association of individuals with a common calling. That is, in forming a representative body, practitioners drew attention to the fact that there was some entity and greater good than the individual, and its members shared some common attributes. If aspiring members of a profession did not form an association, they could not truly be considered to have formed a profession. This indicates, at least in the view of Carr-Saunders and Wilson (1933), that one important criterion for professional status is the formation of a body or association for the individual professional to be admitted to, and that the profession becomes identified as the body of members who profess their competence in a vocation and receive the recognition of others who claim the same status.

Armstrong (1994, p38) confirms that “By the 17<sup>th</sup> century, “profession” came to mean the occupation in which one professed to be skilled, and still the term was applied specifically to the three learned professions - divinity, law and medicine”. This denotes a change, a

diminution, or at least a modification, of the original intent for the necessity to profess in the religious sense in order to be a member of the profession. The inclusion of the term “learned” with reference to professions is less clear, and Flexner (1915) raised the question as to whether there might exist “unlearned” professions. He concluded there were not and that the word “learned” added nothing to the meaning of the concept of a profession, implying therefore that it was merely a tautology. It does, however, suggest, by implication, that one requirement for an occupation to be granted the status of a profession is for the occupation to be “learned” in some way. That is, a key component of a profession is a requirement for advanced learning or education.

As the influence of the church declined over time, the universities grew in importance, and society demanded a greater number of specialised advisers in a greater variety of learned activities. Concurrently, the practitioners of numerous vocations wishing to achieve professional status grew in number, nature and importance. This growth began in the 18<sup>th</sup> century, and burgeoned in the 19<sup>th</sup> century as professions followed the significant changes taking place in European society. As noted earlier, these changes included the decline of the influence and control of the Church, the Reformation, the Renaissance, the Rise of Science, and the Industrial Revolution. The latter event, in particular, led to a redistribution of wealth, from the traditional aristocratic landed classes to the new industrialists. As a result of this shift, and renewed population growth from better food production, there was extensive urbanisation as factories created a demand for labour and thus new centres of industrial production appeared.

Hence, the Industrial Revolution created new work opportunities for the rural poor, who moved in large numbers to create new towns and cities. In England urbanisation increased threefold between 1800 and 1890. The population of London alone grew from 950,000 in 1800 to approximately 2,000,000 by 1850 while other major industrialised cities experienced similar population growth (Jones, 1964). However, as mechanisation, industrialisation and urbanisation brought an environment of economic growth, it also created new demands for services beyond those provided by manual labourers.

The Industrial Revolution was one outcome of, as well as being a contributor to, further and extensive societal changes that began with the Reformation and the Renaissance, and which

saw the rebirth of interest in the arts, science, religion and politics. In particular, the Rise of Science brought new inventions that could be put to practical uses for the benefit of society, especially in the context of machinery and mechanical process. As Whitehead (1933. p.76) observed “These were the centuries [the 18<sup>th</sup> and 19<sup>th</sup>] in which science triumphed, and science is universal . . . Again the advance of scholarship, and of natural science, transformed the professions. It intellectualised them far beyond their stage of advance in earlier times”.

Whitehead (1933) also observed that while tradition or custom was the foundation of the professions prior to this, they were becoming more based on theoretical principles. The professions founded in this period became the setting, and provided the over-sight, of the professional standards of their practicing members. He further suggests that “. . . foresight based on theory, and theory based upon understanding of the nature of things, are essential to a profession” and that “. . . the practice of a profession cannot be disjoined from its theoretical understanding and *vice versa*” (Whitehead, 1933. p.72).

This point is extended and focused on by Carr-Saunders and Wilson when they attributed the origin of this transformation in the professions to engineers in particular, who made possible large scale industrial organisation as a result of their scientific approach. They further noted that such organisation generated the need for a variety of other new and supporting vocations including accountants, secretaries, banking and insurance. The landscape of England was undergoing significant change as urban land uses spread across the countryside, requiring other vocations to rise in importance such as surveyors, auctioneers and estate agents. Similarly, other professions including applied chemistry in the 19<sup>th</sup> century, applied physics in the early 19<sup>th</sup> century”, and veterinary surgeons and dentists, grew in occupational status (Carr-Saunders and Wilson, 1933).

As these new vocations grew in relevance and importance, associations were formed, beginning the trend of the transformation of vocations into professions. From the reference above to specific disciplines of science producing a group of individuals who were “professional” coincides with criteria being developed for professions. The use of “applied” may indicate that there were chemists and physicists who earned their living from their

scientific discipline. It is likely, however, that they were later embraced as specialised engineers.

In the United Kingdom, the Institution of Civil Engineers (ICE) was founded in 1818 and was granted a royal charter in 1828. Its stated aim was “to foster and promote the art and science of civil engineering” (ICE, n.d.). Similarly, the Royal Institute of British Architects (RIBA) was founded in 1834 for “. . . the general advancement of Civil Architecture, and for promoting and facilitating the acquirement of the knowledge of the various arts and sciences connected therewith . . .” (RIBA, n.d.). This organisation received a royal charter in 1837. The Royal Institution of Chartered Surveyors (RICS) was founded in 1868, although it can trace its history back to the Surveyors Club of 1792 (RICS, n.d.). Further afield in Australia, the Institution of Surveyors Victoria (ISV) was founded in 1874 (ISV, n.d), the Institution of Surveyors New South Wales (ISNSW) in 1884 (ISNSW, n.d.). The Institution of Surveyors Australia (ISA), a federation of the state-based bodies, was not formed until 1952 (ISA, n.d.).

Members of these vocations, during the 19<sup>th</sup> century, voluntarily formed themselves into associations to provide for the needs of the practitioners of their various disciplines, and so fulfilled one of the key criteria of a profession, as identified by Flexner (1915). Specifically, their association allowed members to describe themselves as representing a formal body, “as public recognition can hardly be accorded to a group that has not discovered itself” (Carr-Saunders and Wilson, 1933. p.295). These organisations exemplify the emergence of new occupations, gathering practitioners of their craft together, and that developed over time, other attributes such as admission criteria, codes of ethics, rules of professional practice and methods of disciplining errant members. Even at this stage they distinguished themselves, and possibly distanced themselves, at least in name, from the trade guilds and associations of the past.

There have been a significant number of publications since the pioneering and innovative work by Flexner (1915) on the nature or characteristics of professions. Many of these have been particularly focussed on examining whether any specified occupations meet the specific criteria being established, to be considered a profession in 20<sup>th</sup> century society. These contributions begin with Flexner (1915) on social work, and include Pound (1944) and Bowie (1988) on the law, Dyer (1985), Calman (1994), Torstendahl (2005) and Cruess et al. (2005)

on medicine, Wright (1959) on accountancy, Anonymous (1968) on physical education, and Routledge (2011) on design.

These contributions generally start by identifying the broad requirements that are largely extensions of Flexner's approach, before examining their own cases, to bring the discussion of the nature of the professions into the present era. They demonstrate that even the long-established and universally accepted professions of law and medicine should re-examine or question their status as a profession from time to time. They also indicate that new occupations interested in acquiring the status of a profession, even if the ideals of professions may have been tarnished and are considered by some to be anachronistic, require thorough self-examination to determine whether they fulfil the requirements of a profession.

In the following section the literature on the criteria for defining a profession is examined, beginning with the work of Flexner (1915). This examination leads to a set of criteria against which to evaluate any occupation for the purpose of establishing whether or not it can attain professional status in current society. These criteria are then applied to the practice of land surveying in order to establish the validity of its professional status.

## **2.4 Criteria for the status of a modern profession**

Flexner's (1915) address to the National Conference of Charities and Corrections made an initial, original, significant and influential contribution to the subsequent literature on professions. As his original contribution was a speech, only published later, his points are not succinctly stated but require paraphrasing into a manageable list. Specifically, he suggested that the words “profession” or “professional” can be used either loosely or strictly. In its broadest sense the word professional is simply an antonym for the word “amateur”.

More specifically, he noted that “The term profession, strictly used, as opposed to a business or handicraft, is a title of peculiar distinction, coveted by many activities” (Flexner, 1915. p.152). The distinction between a profession and any other form of activity is as important today as it was at the time of his address. Simply stated, the claim for any activity to be a profession is an appeal for recognition and status in the society within which it exists. In conferring this status, there is an expectation of certain rights amongst the members of the profession, as well as the expectation of significant responsibilities, by the society it serves.

In addressing the question “Is Social Work a Profession?”, Flexner (1915) established six criteria that could be used to bestow the status of a profession on any form of activity or occupation. He also noted, with respect to the definition of a profession, that anything agreed upon in his time, would need to be revisited in the future in order for it to remain relevant. This provides a further reason for investigating the nature of the professions in the present, based on earlier perceptions and subsequent developments over time.

Flexner’s criteria, which form an important basis upon which to assess whether or not individual or group activities can legitimately be classified as a profession, are paraphrased as follows:

- (a) the understanding of specialised and complex problems by the application of intelligence unfettered by personal bias;
- (b) the application of the specialised and complex theoretical knowledge for the solution of practical problems;
- (c) a theory and practice that are educationally communicable;
- (d) the necessity to demonstrate competency in the relevant theoretical knowledge and its applications for admission to the recognised body of practitioners. That is by the profession, who themselves are recognised as being competent, having ethical standards and are largely self-regulating; and that
- (e) the practitioners place their client’s interest as well as the public interest ahead of any personal advantage.

This set of the criteria can be distilled further, whereby the occupation must be intellectual, interpretive, practical, transferable through education, self-regulating and, at least in part, altruistic. Bowie (1988) adds to these requirements that they must include a need to add to and improve upon the profession’s store of knowledge. While this is an admirable aspiration, if not a requirement, of a profession, it is doubtful that it can be claimed as a criterion, as it may be anticipated that any group of vocational practitioners, whether forming a craft, trade or service association, would expect the same of their qualified members.

Consistent with the historical perspective discussed earlier in this chapter, Friedson (1988-89) argues that the professions are further distinguished by the nature of their work, and more specifically that this requires the exercise of discretionary judgement. That is, in order to be

different from a trade or a craft, the members of a profession must be expected to formulate new solutions to problems based on the specific characteristics of the problem. This approach contrasts with the application of already defined methodologies to the tasks or the problems practitioners confront, be the problems traditional or novel. Again, while this is an admirable trait and expected of members of a profession, it is embedded in the fourth criteria listed. It is not the sole prerogative of the members of a profession, since it is the degree of complexity that the practitioners encounter and are expected to cope with that distinguishes a member of a profession from other types and levels of service providers.

Greenwood (1957) proposes five attributes that are fundamental to give credibility to claims of professional status. These are characterised as (a) a systematic theory or body of knowledge (b) authority (c) community sanction (d) an ethical code and (e) a culture. The attributes of a defined body of knowledge and of the presence of an ethical code are consistent with the principles identified earlier by Flexner (1915). However, the others do more to cloud the issues clearly enunciated by Flexner than to elucidate them. Further, they are heavily criticised in Roth (1974), who cites other authors who have attempted to create, in his view unsuccessfully, such augmented lists of attributes, for example, Slocum (1966), Pavelco (1971), Gross (1958), Perrucci and Gerstl (1969), as well as Evans and Levin (1966) and Gross (1966), who develop lists of between four and eight attributes. Routledge (2011), in the context of the design profession (which in itself is not defined by Routledge), has also constructed a list of 10 fundamental characteristics he considers necessary for a profession.

While Roth (1974) is critical of the attributes or characteristics approach to defining the professions, his arguments are principally based on a seemingly cynical perspective only of attempted upward mobility by specific occupations, and he offers no alternative methodology to replace the approaches which he criticised. Hence, despite its shortcomings, more recent alternatives created by others, and the criticism from Roth (1974), Flexner's (1915) approach retains its credibility and its usefulness

Dyer (1985) suggests that the requirement that a profession requires complex knowledge and the requirement to apply this knowledge in the practical service of society. This view places the professions somewhere between being a branch of science and a trade. He argues that professions have common ground with both of these needs, but are also different from each.

He further comments that technical expertise alone is not sufficient for a profession, but that it must be extended by an ethical application of the knowledge required to solve relevant problems (Dyer, 1985).

Embodied in the ethical dimension is the requirement that the members of a profession can acquire the confidence or trust of their clients and that they will act in a principled manner. While these characteristics conform to the final two requirements of Flexner's (1915) definition, namely self-regulation and altruism, trustworthiness might imply something further than was intended by Flexner (1915) in the fifth of his criteria. Whether trustworthiness is pivotal, already included but worded differently, or an additional requirement, it is undoubtedly a significant component of professional status that characterises activities not necessarily and inherently aligned with professions.

Wilensky (1964) provided a compelling argument that there are only two attributes that characterise a profession. The specific criteria he proposed are: "(1) the job of the professional is *technical* – based on a systematic knowledge or doctrine acquired only through long prescribed training, and (2) The professional man adheres to a set of *professional norms*" (Wilensky, 1964. p.138). While significantly reducing the criteria to be considered, the requirements do not conflict with the ideas of Flexner (1915) and may be interpreted as encompassing the same principles, but in a more succinct manner. However, in achieving this level of concinnity, the views of Wilensky require further explanation. When expanding Wilensky's criteria by explanation, they again resemble the thoughts of Flexner (1915) and so lose their minimalistic approach. Additionally, by use of the term "professional norms" the definition becomes self referential and circular.

Use of the term "technical" in the first criterion, did not intend that it be equated necessarily to scientific technicalities, but that the required knowledge is complex, and in its totality it is beyond the comprehension of a layperson. Hence, it is exclusive to the profession and the complexity and exclusiveness need to be accepted by society in general. Within the need to attain such complex knowledge in order to achieve professional status, is the embodiment of the principle of standards, both in *training and education* and implicitly in continuing competence (Wilensky, 1964. Emphasis added). It can be inferred also that the period of training in the discipline will be lengthy. Furthermore, it is essential for the full achievement

of the status of a profession, which ultimately is granted and respected by society at large, that “the public must be convinced that its services are uniquely trustworthy” (Wilensky, 1964. p.138). Thus, in one criterion Wilensky (1964) incorporates several of those proposed by Flexner (1915).

The second criterion defined by Wilensky (1964) refers to adherence to professional norms. He defined these as embodying the principle of service to the client. This included not just a service for payment, but a service that put the client’s interests before commercial gain and, if necessary, before the interests of the practitioner him or herself, should these come into conflict. At least part of the justification for this position is that the client is in a weaker position with respect to the service provided than the practitioner. This weakness exists because the client has a need that requires the assistance of the member of a profession and because he/she does not have the complex knowledge and training required to help themselves. Extending the principle of service antithetically, the member of the profession is personally accountable for the accuracy and quality of the service given, with all of the legal implications that this carries.

These professional norms also include the requirement that the service given to the client should be impersonal, impartial and objective (Wilensky, 1964). This suggests that all professional advice given to a client will be the same, irrespective of any personal sentiments held by the practitioner, in much the same way that an expert witness provides impartial assistance to the courts in matters of their established and accepted area of expertise. Hughes (1963) describes this as detachment. This is a point also made by Parsons (1939) who used the term “disinterestedness” or impersonal values to convey the same principle. Finally Wilensky (1964) advocated that an additional norm denoting a profession is that of the practitioner being aware of the limits of their own expertise, and being prepared to refer clients on to other professions or specialities when the need requires it.

Norms, expected standards of professional competence, ethics and general behaviour for any given profession are of the same nature as those expressed in Flexner’s (1915) fifth criterion. While not referring to any specific requirement for a professional body to be established, Wilensky’s (1964) attributes include: standards of achievement; continuance in the maintenance of high levels of complex knowledge; and the creation, maintenance and

monitoring of the profession's norms. It is suggested that these are imposed either by statute or by the profession itself. In order for the latter to be possible requires that there exists a body of existing practitioners who have achieved the status in the form of a professional society or association. This requirement is common to most other proposed lists of professional criteria.

Hence, comparing the five attributes defined by Flexner (1915) with those of Wilensky (1964) reveals little disagreement. While the number of requirements is reduced to two by Wilensky (1964) from the five offered by Flexner (1915), there is little fundamental difference in the content when the detail is examined. Calman (1994) also confirmed the soundness of Flexner's identification of fundamental criteria.

Despite attempts in the literature to expand the list of criteria necessary for an occupation to be considered a profession, Flexner's (1915) contribution remains robust despite the passage of time. Clarity in discussing any specific calling with respect to its status as a profession, or otherwise, can be simplified by identifying only the necessary and sufficient criteria that need to be met. While increasingly extensive lists of requirements can be useful in assessing specific activities to determine their status as a profession, or otherwise, they tend to blur the issues when discussing the general question, conceptually and in general, of what a true profession actually entails.

Flexner (1915) responded to the request of social workers to inform them in a rigorous and forthright manner as to whether collectively they had achieved the status of a profession. Since then there have been similar examinations of various professions, including those of antiquity, namely law and medicine, as the services required to maintain a modern society increase in both variety and complexity. As vocations respond to deliver required services they are compelled increasingly to formalise their knowledge and to adopt practices that assure society of their members' competence to perform their work in a transparently knowledgeable, fair and ethical manner. In so doing, many vocations now approach the criteria necessary to achieve the status of a profession.

In the final analysis, what distinguishes one profession from another is the body of specific and complex knowledge required for entry and continued membership in an appropriate

professional society. While codes of conduct, methods of attaining the necessary skills, means of applying specialised skills, and the nature of any professional association or associations will differ, a specific profession will be defined by the breadth and depth of the knowledge that is required to become a recognised member of it.

## **2.5 Professionalisation**

Having examined the literature on what defines a profession, the question arises as to why divergent views have arisen as to the basic requirements for recognition as a profession? Since at least the 18<sup>th</sup> century many occupations have attempted to claim the status of a profession. Wilensky (1964) produced an analysis, shown in Table 2.1, that summarises the development of numerous occupations through a sequence of events that he suggests indicate the process of professionalisation of particular fields of endeavour. His research was limited to eighteen occupations for which there was adequate information available, and was confined to events in the United States of America (USA). The earliest dates are in the 17<sup>th</sup> century (medicine and school teaching), while the latest occurs in 1948 (city planning). It is assumed that a similar contemporary table would produce many more recent additions to those identified up to 1964. However, the table does not claim, nor indicate, when such status was achieved according to this process.

Based on this analysis, Wilensky (1964. p.142) asked the question “Is there an invariant progression of events, a path along which they have all travelled to the promised professional land?”. He suggested that there is a general trend towards seeking professional status, and he asserted that, at his time of writing, “. . . no more than thirty or forty occupations are fully commercialised”. In addressing his research question he identified a number of steps that generally apply in the evolution of an occupation into a profession.

	Became Full-Time Occupation	First Training School	First University School	First Local Professional Association	First National Professional Association	First State License Law	Formal Code of Ethics	No. of Errors	No. of Ties	Per Cent Error, by Groups†
Established:										
Accounting (CPA).....	19th cent.	<i>1881‡</i>	<i>1881‡</i>	1882	1887	1896	1917	0	1	
Architecture.....	18th cent.	1865	1868	1815	1857	1897	1909	2	0	
Civil engineering.....	18th cent.	1819	1847	1848	1852	1908	<i>ca.</i> 1910	0	0	
Dentistry.....	18th cent.	1840§	1867	1844	1840§	1868	1866	3	1	
Law.....	17th cent.	1784	1817	1802	1878	1732	1908	2	0	
Medicine.....	<i>ca.</i> 1700	1765	1779	1735	1847	Before 1780	1912	2	0	21
Others in process, some marginal:										
Librarianship.....	1732	1887	1897	1885	1876	Before 1917	1938	2	0	
Nursing.....	17th cent.	1861	1909	1885	1896	1903	1950	1	0	
Optometry.....		1892	1910	1896	1897	1901	<i>ca.</i> 1935	1	0	
Pharmacy.....	1646	1821§	1868	1821§	1852	1874	<i>ca.</i> 1850	2	1	
School teaching.....	17th cent.	1823	1879	1794	1857	1781	1929	3	0	
Social work.....	1898(?)	1898	1904	1918	1874	1940	1948	1	0	
Veterinary medicine.....	1803	1852	1879	1854	1863	1886	1866	3	0	27
New:										
City management.....	1912	1921	1948	After 1914	1914	None	1924	2	0	
City planning.....	19th cent.	<i>1900‡</i>	<i>1900‡</i>	1947	1917	1963	1948	2	1	
Hospital administration ..	19th cent.	<i>1920‡</i>	<i>1920‡</i>	.....	1933	1957	1939	2	1	29
Doubtful:										
Advertising.....	1841	<i>1900(?)#</i>	<i>1909(?)#</i>	1894	1917	None	1924	1	0	
Funeral direction.....	19th cent.	<i>ca.</i> 1870	1914	1864	1882	1894	1884	3	0	29
							Total errors...	32		25

\* Dates concern only events in the United States. Among the sources: *Occupational Licensing in the States* (Chicago: The Council of State Governments, 1952); *Encyclopedia of Associations* (3rd ed., Metuchen, N.J.: The Free Press, 1954); *Encyclopedia of American Industries* (Washington, D.C.: Government Printing Office, 1955); *Encyclopedia of the Social Sciences* and other encyclopedias; J. W. Kane, *Famous First Facts* (New York: H. W. Wilson Co., 1950); professional association journals, newsletters, and yearbooks; and specialized histories, official or not. In cases of disagreement, precedence was given to a competent history—e.g., R. W. Habenstein and W. M. Lamers, *The History of American Funeral Direction* (Milwaukee, Wis.: Bulfin Printers, 1955)—or to a date supplied by a professional association cross-checked by one other independent source. I am grateful to Anne Mooney, Ted Cooper, and the headquarters of the dominant professional associations for assistance.

† The total number of dates out of order in group divided by total possible entries in group. The errors for the whole table are 25 per cent of possible entries.

‡ Dates in italics in the same row designate the same event.

§ Two dates in the same row marked with a section mark (\$) designate associated events.

|| Only three or four physicians are known to have resided in the Colonies prior to 1700. From 1607 to 1730 Colonial medical practice was relatively primitive (R. H. Shryock, *Medicine and Society in America: 1660-1860* [Ithaca, N.Y.: Cornell University Press, 1962], pp. 7, 18).

# “(?)” designates best inference from available information.

Table 2:1 The process of professionalisation

Source: Wilensky (1964, p.143)

The first step in Wilensky's progression was for an occupation to become a full time form of employment. Having become a “job”, the second step was that recruits to the occupation required training in the requisite theoretical aspects of their work, leading to the need for and establishment of a training school. Wilensky suggested that if training courses were not started in universities, the requirements of professional standing would lead them to being delivered by universities. This progression would lead to higher standards of education, as a theoretical approach to the vocation replaced a practical one and developed into an academic discipline. This would, in turn, result in longer and more detailed courses. In the third step the higher standards would lead to the evolution of more rigorous education as the requirements for entry to the occupation. The standardisation of required training courses would then lead to the establishment of a professional body, if one was not already in existence. Wilensky (1964) suggested that in the more established professions, the university programmes would appear first followed by the formation of a professional body, whereas in the less established professions the reverse would be true.

If not already formed, national associations would be established around the occupation, and the requirements for entry to the profession would be gradually constrained to include only those individuals prepared to undertake the training prescribed by the professional body. The

process could be given greater authority if, in claiming jurisdiction over a specified field, pressure could be brought to bear on legislators to give some form of legal protection to the use of specific titles relating to the occupation. These would then be used to distinguish between those who are adjudged to meet the required competency standards of the profession. The process is completed by the adoption of principles of service to the public by those who had taken up the vocation, and these principles would be formalised into a code of ethics (Wilensky, 1964).

Wilensky (1964) further proposed that during the process of gaining higher educational standards and the formation of professional associations there would be a further redefinition of the core tasks. There would be some emphasis placed on defining the essential professional tasks of the occupation, as distinct from those that may be performed by nonprofessionally qualified affiliates. Wilensky (1964) uses the example of the medical profession in which a doctor would delegate less complex tasks to nurses, who would delegate lesser tasks to nurse assistants, who would, in time, allocate some chores to ward helpers. Thus, a hierarchy is established with those of professional status at the top, descending through those who aspire to the status of a profession or para-professionals, to minimally or unqualified assistants. Such examples can be found in contemporary society in many recognised professions such as law, civil engineering and dentistry, as well as in land surveying.

One modern issue that can compromise the claim for professional standing by an individual is that many members of professions are now employed in large organisations, and therefore do not offer their specialised knowledge to the public in a direct way. As employees, their claim to professional status is compromised by the fact that they are responsible to managers or employers who are not necessarily members of their profession, yet are superior in the hierarchy of the organisation. While the structure of a multi-disciplinary professional firm will accommodate this, there will be cases where this is not so.

A useful example of how the structure described above operates, which appears to be reasonably widespread, is that of public hospitals. Medical practitioners and specialists are responsible to senior administrators, often qualified in business administration rather than medicine. They may also be answerable to elected or appointed boards of management that

can include members of the general public (Wilensky, 1964; Freidson, 1988-89; Bowie, 1988). Such lines of responsibility may lead to some loss of autonomy in professional decision making, and hence the exercise of their professional judgement. In extreme cases this hierarchical management can lead to conflict and confrontation when the interests of the client or patient and those of the organisation are at odds. In such situations, the presence of a strong professional body, with an explicit code of ethics, can add strength to the professionalism of the individual confronted with such a situation.

Another area of potential compromise happens when a member of a profession enters into business in order to practice their profession. This can occur when, for example, a medical practitioner takes ownership, in part or in whole, of a private hospital or clinic, or when an engineer becomes the owner of a construction company. A prime motivation behind each of these instances is business-driven, that is, it is profit-motivated. As a result the consultant, in effect, becomes their own client, unless they contract those professional services of other members of their profession and rely on their advice in matters of professional and non-conflicted decision-making, and themselves act only as business managers. As the objective of a business is to make a profit, the societal responsibilities of the member of the profession, and the ability to give impartial advice, are confronted by a conflict of interest. At this point the member of the profession is at risk of compromising the ethics of disinterestedness, impartiality and objectiveness, which are central to the conferment and maintenance of professional status (Flexner, 1915).

It is clear from the examination of the literature that the process of “professionalising” occupations that began in the 17<sup>th</sup> century, accelerated through the 18<sup>th</sup> and 19<sup>th</sup> centuries, continues. The demands of urban living in the 21<sup>st</sup> century have increased considerably in complexity, and more occupations have evolved into professions. Flexner (1915) developed the approach of defining criteria that should identify whether or not an occupation is a profession, and much of the subsequent literature has used his work as a starting point to examine the professional status of specific occupations. Those that have expanded on Flexner’s (1915) definition have tended to focus on the nature of professional behaviour rather than the defining aspects of what makes an occupation a profession. Hence, they have produced lengthening lists of “criteria”, which, while relevant to “professionalism”, tend to cloud the issue of defining what a profession is.

As noted earlier, Wilensky (1964) attempted to encapsulate Flexner's (1915) criteria into two "streams", namely education and service. However, these are too narrow in themselves to provide a basis for close evaluation of any particular occupation for the status of a profession. While Flexner's (1915) approach provides rigour to the evaluation of an occupation, its construction as a speech rather than a written paper leaves it open to some divergent interpretation. It may also be criticised for its antiquity, given that the occupational environment has changed dramatically over the last century, and continues to evolve, as have societal mores, views on morality, definitions of what is considered to be ethical behaviour, and the respect and authority afforded the established professions.

As a counter to these potential weaknesses, the United Kingdom Inter-Professional Group (UKIPG) provides an up-to-date and succinct definition that has been accepted, at least in the United Kingdom, by a variety of established professions, and which encapsulates all of the essential principles of a profession according to Flexner's original criteria. The UKIPG membership includes professional bodies of accountants, architects, bankers, chiropractors, dentists, engineers, lawyers, medical practitioners, optometrists, osteopaths, patent attorneys, pharmacists, psychologists, surveyors and veterinary surgeons, among others (UKIPGa, n.d.).

The UKIPG definition is entirely consistent with the sentiments expressed by Flexner (1915) and Wilensky (1964) in positing that a profession is "an occupation in which an individual uses an intellectual skill based on an established body of knowledge and practice to provide a specialised service in a defined area, exercising independent judgement in accordance with a code of ethics, and in the public interest" (UKIPGb, n.d.). This demonstrates that a broad variety of occupations view themselves, and each other as professions, and that they accept an encompassing definition of a profession. It also confirms that there is a significant group of people who do consider that the concept of the occupational status of a profession, or not, remains relevant in 21<sup>st</sup> century society.

## 2.6 Summary

This chapter has examined the origins of the concept of occupations as professions. The church, law and medicine (not including surgery) are generally accepted as the original professions. The common element is that religious vows had to have been "professed" within the clerical establishment of the Church system before an individual progressed to the further

education or training to become a specialist in those disciplines (law and medicine). This also explains why the professions are also referred to as a “calling” rather than a job.

The formation and rise of universities in the 12<sup>th</sup> century provided a ready home for the secularisation of the original professions, and for those new professions based on science and new technologies. The period known as the Reformation, when combined with the Enlightenment, the Renaissance and the Age of Reason, led to the events of the Industrial Revolution and the establishment of the concept of learned societies. The Industrial Revolution brought a paradigmatic shift in the way of life as society moved from its historic rural agrarian style to an urbanised industrial one. The specialisation of intellectual skills, developed out of the crafts and guilds, and that arose in the 18<sup>th</sup> and 19<sup>th</sup> centuries, led to the notion of professional bodies as collectives of members of a profession, sometimes referred to as the learned professions.

The number of occupations aspiring to professional status continued to expand. By 1915 discussion had begun on what criteria were necessary for a vocation to claim professional status. The work of Flexner (1915) in particular was shown to have withstood a century of scrutiny. While other writers have provided expanded or contracted versions of Flexner’s criteria, these contributions have confirmed and validated his work. The concept of professions, and the general criteria by which professions are set aside from other occupations, is verified by the existence of the United Kingdom Inter-Professional Group and the current definition it provides for occupations adjudged to be professions as evidenced by its membership.

Given the continued relevance of the standing of professions in contemporary society, and a set of criteria with which to evaluate occupations against when considering their status as professions, Chapter 3 examines the occupation and discipline of land surveying with respect to these criteria. Following a very general definition of land surveying, each of the criteria that have been discussed and identified above, are addressed with respect to it.

## **Chapter 3**

### **Is Land Surveying a Profession?**

Having established criteria to compare occupations against in deciding which may be professions, this chapter begins by providing a broad definition for the occupation of land surveying. This is then compared against the criteria that have been derived from the literature in Chapter 2. On the weight of evidence presented this chapter concludes that the vocation of land surveying meets the criteria for recognition as a profession.

#### **3.1 Defining Land Surveying**

Before considering the question of whether or not the occupation of land surveying as an occupation meets the criteria for being a profession, it is important to consider the vocation of land surveying itself, and how it might be defined. In order to address the question “Is Land Surveying a Profession?”, it is necessary first to place some boundaries around the activity under scrutiny. While there are dictionary definitions of land surveying, they are too succinct to be useful as they define the words rather than the occupation *per se*. There are also definitions of “land surveying” created by various professional bodies for the benefit of their members and for those members of the public who may want to know the functions the occupation encompasses.

Hence, a definition of the occupation is needed that is more than the few words of a dictionary definition so that a comparison can be made with the established criteria for a profession. However, a robust definition also needs to be more succinct than those provided by professional societies while still remaining broadly encompassing. The FIG has a definition for the “Functions of Surveyor” but not land *surveying*, or the land *surveyor*, and its definition embraces other professions of a surveying nature beyond land surveying such as quantity surveying. It is therefore of limited assistance for this purpose (FIG, 2017).

The possibility of forming a definition of land surveying that will satisfy all members of the international surveying community is unlikely, given the process by which land surveying has evolved in some countries. However, it is possible to identify the core components of the field that make it different from any other discipline or from any other body of knowledge. It has been suggested that the core of land surveying is measurement or measurement science (see for example Fryer and Mitchell, 2013. p.16). Is this justifiable and can it sustain contrary arguments? Measurement is used widely in a broad range of disciplines and for a myriad of purposes so a robust and encompassing definition of land surveying must be about more than measurement alone.

The beginnings of a workable definition may lie in the term “surveying” itself, before “land” is used to qualify the practice. The Free Online Dictionary (FOD) defines surveying as “The measurement of dimensional relationships, as of horizontal distances, elevations, directions, and angles, on the earth’s surface especially for use in locating property boundaries, construction layout and mapmaking” (FOD, n.d.). This appears to be specifically related to *land* surveying. Similarly, Wikipedia starts its definition of surveying with the qualification: “Surveying or land surveying is . . . ” (<http://en.wikipedia.org/wiki/Surveying>). Hence, at least these two sources see “surveying” as simply a contraction of, or synonymous with, the more definitive term “land surveying”.

One of the words used most frequently in the context of surveying practice is “position”. Some prefer to use the term “location”. The Concise Oxford English Dictionary (COED, 2004. p.1119), under *position*, yields “a place where someone or something is located . . .”. For *location* the COED (2004. p.836) provides “a particular place or position”. At first this mutual cross referencing appears to lead to a circular and semantic end only. However, both definitions have in common the word “place”. The COED further explains in the definition of *survey* “1. look carefully and thoroughly at”, which clearly provides the basis for a definition much broader than that of land surveying provided above, but it is a worthwhile start. The second definition given under *survey* is, “2. examine and record the area and features of (an area of land) so as to construct a map, plan, or description” COED (2004. p.1451). This second definition contains a parenthetic reference to land that is consistent with the numerous definitions that make an implicit connection between “surveying” and “land surveying”, as if the two are synonymous, which is supported by common usage.

If the parts of these definitions are combined, the following non-contextual definition of surveying can be achieved, that is “to look carefully and thoroughly at . . . and examine and record . . . features . . . so as to construct a . . . description”. Within this definition it is possible to derive the context of “land”, by inserting the appropriate words into the spaces utilising the common term “place” rather than either of “location” or “position”. Hence, the definition of land surveying then becomes *“to look carefully and thoroughly at a place in order to examine and record its features so as to construct a representation or description of it”*. The words “location” or “position” could be used to replace “place” if preferred, and the “description” could be interpreted to be a written description, a plan, a map, a computer-generated visualisation, or in another context, a digital dataset.

This definition is deliberately broad in order to be as embracing and as timeless as possible, while remaining applicable despite changes in technology, education, society or developments within the professional environment. Thus, it should be equally applicable to the past, the present or any future description of the practice of land surveying. However, it is recognised that to address the comprehensive nature of the activity of land surveying, an expanded and detailed definition is required when addressing, for example, curriculum matters for education and training courses in academic and practical land surveying degree, diploma and certificate programmes. The questions that arise from potential semantic ambiguity can then be related to the role the fully qualified land surveyor plays in the practice of field surveying. Further, what is the “professional” role, if indeed land surveying is a profession, relative to the roles of others who operate in the occupation.

A definition of land surveying, such as that provided in italics above, is required to answer the fundamental question this chapter addresses, that is, “is land surveying a profession?” Having extracted a set of criteria for examining an occupation with respect to its status as a profession, the above definition gives a dimension to the activity of land surveying and a context for its comparison to the criteria established for professional status. The following section brings together the criteria for a profession and the evidence needed to make a judgment with respect to the professional status of land surveying.

### **3.2 Is Land Surveying a Profession?**

As noted earlier, there is considerable consistency between Flexner's (1915) criteria and the definition of a profession currently displayed on the UKIPG website. In order to evaluate whether or not the occupation of land surveying satisfies these criteria, it is necessary to distil a set of necessary and sufficient criteria against which the status of land surveying, or indeed any other occupation, can be assessed. Hence, the following criteria are recast from the Flexner and UKIPG definitions discussed in Chapter 2, using their terminology as much as possible. They are listed as follows in a hierarchy that facilitates logical and systematic analysis with respect to land surveying.

To qualify as a profession an occupation must:

- (a) be specialised and intellectually complex;
- (b) have an educational base of theory and practice or body of knowledge;
- (c) have a body of practitioners (the profession) who are recognised as competent, trustworthy, largely self-regulating and have a code of ethics;
- (d) require the demonstration of competency in the application of the body of knowledge to practical problems for admission to the recognised body of practitioners (the profession); and
- (e) require the application of independent judgement, without personal bias, within the ambit of the specialisation for the solution of complex practical problems.

These are now considered in turn for land surveying.

#### **3.2.1 An intellectually complex activity**

Land surveying, by its very nature, has always required the acquisition of data about the land. However, the gathering of data is a technical function carried out in the past by manual methods of measurement. In particular, land surveyors measured distances and angles in order to define the location and the dimensions and shapes of units of the landscape. They also took measurements of objects such as buildings or other "improvements", for the use or benefit of a "client". Clients could include individuals, groups of individuals, business corporations or government agencies. Hence, gathering data is the first activity in the sequence of events of conducting a survey that leads to information being conveyed to the client in a way that is intelligible and useful to that client.

While requiring a degree of dexterity in the use of measuring instruments, as well as the knowledge of how to operate the devices, it would not qualify on that basis, in and of itself, as an intellectual activity. However, the knowledge required to determine what data to gather, that is measurement design, for the requisite purpose, i.e. that are “fit for purpose”, does require the exercise of judgement, and therefore qualifies as an intellectual activity. The ability to convert the data gathered meaningfully and with relevance to the purpose, and then to communicate that to a client requires further intellectual activity.

The Data, Information, Knowledge, Wisdom (DIKW) hierarchy was first hinted at by T. S. Eliot (1934) in his poem “The Rock”. According to Hey (2004) it first appeared in structured form in an article by Cleveland (1982). This model suggests that the conversion of data into useful information requires the application of organisation and selection. The DIKW hierarchy has been modified since and extended from its original form, downwards to include data and upwards with the addition of a variety of further classifications. It is beyond the scope of this thesis to examine such potential extensions or to debate their value, but in its basic and extended forms the DIKW hierarchy is widely used, indicating acceptance of it in principle and in practice.

Historically, the field collection of data was carried out by the professional land surveyor, but in recent times this aspect of the occupation is more often delegated to a junior or technician surveyor. More recently such tasks have been carried out through automated processes embedded in data collection devices. Since data gathering is an essential starting activity, and does involve the application of intellect to order the data, the level of intellectual application is not of a high level, nor is it significantly theoretical. As Wilensky (1964) pointed out, the handing down of simpler or mechanical tasks is recognised as part of the process of professionalisation, and the rise of the technician surveyor within the ranks of practising land surveyors conforms to this interpretation.

While information is itself a useful product of the endeavours of land surveyors, such information must be converted to knowledge so that it can be transmitted to and used for decision-making. The information may be transformed, therefore, into graphical products such as maps or models, or into textual products such as reports. Traditionally, the conversion of information into knowledge was carried out by the land surveyor who gathered

the data in the first instance. However, as in the case of the data collection, its conversion may also now be delegated, at least in part, to competent technicians. Such individuals may not be the same technicians who were employed in the data gathering. Nevertheless, the oversight of the conversion process requires intellectual input on the part of the land surveyor to ensure that the product meets the client's needs, that it is technically and practically sound, is consistent with accepted standards, and conforms to relevant aspects of the law.

An experienced land surveyor will carry this process further and transform the knowledge provided into enlightenment for the client. In this case, the term enlightenment is substituted for the more common "wisdom" referred to in the standard DIKW model as being more appropriate in this context. The provision of this enlightenment is likely to require some form of translation or explanation to render it understandable in lay terms. This transformation involves intellectual activities that require experience and an understanding of the principles behind the creation of the information and its conversion process. These principles in turn require knowledge of the body of theory of which the practical application is an extension. Thus the professional surveyor adds value to the work that may be within the capabilities of the purely technician surveyor.

Hence, land surveying at all levels beyond the physical gathering of data requires intellectual activities of varying complexity. As such it meets the first requirement of professional status, that of requiring intellectual input, and an understanding of theory, principles and practice in order to deliver its final outputs. The theory, which defines the nature of the proposed profession, is increasingly referred to in the literature on professions as the specific profession's associated "body of knowledge" (BoK).

### **3.2.2 A body of knowledge**

There is a long-standing history of specialised knowledge and techniques that must be acquired in order to carry out a survey of land at a level beyond the purely technical function of gathering data. As in the trades of the 18<sup>th</sup>, 19<sup>th</sup> and 20<sup>th</sup> centuries, and in the guilds before them, this type of specialised land surveying knowledge was traditionally handed down through apprenticeship or articled cadetship from skilled practitioners to trainees prior to and during the early 20<sup>th</sup> century. In more recent times, and particularly since about 1950, specialised land surveying knowledge has increasingly been transferred through the medium

of university-based academic study and more training and practically-focussed polytechnic courses, depending on the level of theoretical knowledge required by, or expected of, the student or trainee.

As a result of the movement of land surveying education into tertiary institutions during the 20<sup>th</sup> century, the specialised knowledge and techniques taught to student surveyors have developed into a codified BoK. Greenfeld (2012), for example, has done considerable and very specific work identifying the land surveying BoK in the context of the United States of America, as have Bethel (2011), Pavia (2011), Walthrop & Lucas (2011) and Walthrop (2011). The textbook by Clarke (1923) may also be considered as a comprehensive treatise on the BoK of surveying measurement, which formed the basis of undergraduate teaching of the basic principles of measurement aspects of land surveying for many decades. In Australia the Institution of Surveyors Australia (1996) published “the Brown Book”, a comprehensive documentation of the competency standards of professional land surveyors in that country in order to provide a basis for educational programmes at that time. A more recent unpublished report by Fryer and Mitchell (2013) has addressed the question of a required BoK for land surveyors in Australia, although their focus was on cadastral surveying in particular.

In 1987 the International Association of Geodesy (IAG), with the assistance of a number of other international surveying and mapping agencies, published a catalogue of undergraduate surveying programmes that were in existence around the world at that time. The publication analysed the content of sixty-one programmes in twenty four countries in Asia, Australasia, Europe, Scandinavia, and North and South America (Krakiwsky, et al., 1987).

Similarly, in 1992 the Commonwealth Association of Surveying and Land Economy (CASLE) published a guide to courses that were available within Commonwealth countries (Keith, 1992). This included a broader consideration than eligible land surveying courses, given the wider ambit of CASLE, which includes the disciplines of building surveying, quantity surveying, valuation and estate management, amongst others. Eighteen Commonwealth countries were included and qualifications ranging from national diplomas to doctorates were identified. Keith (1992) cited more than 50 university land surveying courses at the undergraduate level and over thirty postgraduate diplomas, masters and

doctoral degrees on offer within the British Commonwealth countries contributing to the guide.

The academic database of the International Federation of Surveyors currently lists over 90 academic institutions that offer surveying courses in over 50 countries around the world, and that are academic members of the Federation (FIG, n.d.). That there are a multitude of courses, and their wide distribution provides evidence that in these countries at least, academic courses exist supplying a BoK to aspiring professional surveyors. Because of the wide-ranging nature of the FIG definition of a surveyor (FIG, 2017), the list of institutions is not confined to land surveying, but also includes those that offer courses in land administration, quantity surveying, and construction economics, amongst others.

From these catalogues and databases it is clear that the academic discipline of land surveying is embedded in tertiary institutions throughout the world, and has been so for some time, up to six decades in some cases. While none of these sources indicate when their courses began, nor what is currently taught, it is clear from the curricula and the advanced qualifications of the academic staff of the institutions, that a BoK for the profession exists and is taught at university undergraduate level, and beyond. It is also noticeable that academic courses have existed for at least a generation, and in some cases in the order of 50 years. Hence, the number and extent of tertiary education and training courses available throughout the world for surveying in general, and for land surveying in particular, demonstrate that a recognised and formal BoK has existed and has been communicated to students in educational institutions for at least half a century.

Although the knowledge of the theory and practice of land surveying is widely distributed throughout the nations of the world, there is no reason to believe that the knowledge held within and communicated by these higher educational institutions conforms to any universally agreed set of criteria. It is more likely that it has evolved within any given institution to suit the needs of the particular community the profession and the institutions serve through the production of useful and practical graduates in land surveying, and as the occupation itself has evolved in that area.

In order to define a BoK for any given academic discipline, there must be some group of individuals or an organisation that has the ability to identify what should be contained within that knowledge base. Such an association must have some common interest in the occupation and be in broad agreement as to what its relevant BoK might contain. In order to define the nature of the BoK, such an association must of necessity contain members who themselves are individual or collective repositories of such knowledge. It must also be sufficiently organised and held in such regard that the institutions of those who teach the discipline will accept, respect and trust its advice. This task falls to the members of the learned societies or professional bodies who already have been admitted through proof of their competence in the recognised BoK and who maintain their current competence. In conformity with the criteria established at the beginning of Section 3.2, the professional bodies relevant to the practice of surveying are now considered.

### **3.2.3 Self-governing professional bodies**

The Royal Society (of London) claims to be “the oldest scientific academy in continuous existence” (Royal Society, n.d.). It was founded in 1660 by a small group of scientists as “a Colledge for the Promoting of Physico-Mathematicall Experimental Learning” (Royal Society, 2013). As such, the Royal Society is the first “learned society” created for the purpose of advancing and promoting bodies of knowledge. The professional bodies that were established during the period of the creation and development of the new and emerging professions formed their own respective societies of a similar nature with respect to their particular domains of knowledge. It is now appropriate to examine the origins and development of professional bodies in the countries which will be the focus of study in Chapter 4 and beyond. These are, respectively, the United Kingdom, Canada and Australia.

#### **3.2.3.1 The United Kingdom**

Given that the rise of the professions is a phenomenon that occurred particularly following the Industrial Revolution, the beginning of the development of professional institutions dates from the late 18<sup>th</sup> century, but is more obvious from the mid-19<sup>th</sup> century onwards. As noted in Section 2.3, professional bodies began with engineers in the United Kingdom in 1818 with the founding of the Institution of Civil Engineers, which “ . . . strives to promote and progress civil engineering . . . [and that civil engineers are involved in ] . . . delivering sustainable

development through knowledge, skills and professional expertise” (ICE, n.d.). It also claims to be a body for recognising civil engineering qualifications, “ . . . to act as a repository and market for specialist knowledge and to provide resources to encourage innovation and excellence in the profession worldwide”. It is registered as a charity also in England and Scotland (ICE, n.d.).

The Royal Institute of British Architects, formed in 1834, has as its stated purpose that it exists “ . . . for the general advancement of Civil Architecture, and for promoting and facilitating the acquirement of the knowledge of the various arts and sciences connected therewith . . . ” (RIBA,n.d.).

While the Surveyors Club began in London in 1792, the Royal Institution of Chartered Surveyors (RICS) did not take its current form as a professional body until 1868. Today it claims to be “a global property professional body which aims to regulate and promote the profession, maintain the highest educational and professional standards, protect clients and consumers through a strict code of ethics, provide impartial advice, analysis and guidance” (RICS, n.d.). As a statement of objectives this comes very close to the definition of a profession as stated by both Flexner (1915) and the UKIPG.

These examples exemplify that during the 19<sup>th</sup> century in the United Kingdom, along with the vocations of engineering and architecture, land surveyors were seeking to form an association of members into a professional body for their respective occupations beyond that of training and the limiting the numbers of recruits to their vocations, as had the trade guilds of the past. Collectively these bodies indicated in their public statements that they sought to promote greater altruistic values amongst their members for the protection of society from unqualified and unscrupulous practitioners. These values closely related to those that will be discussed later in this chapter.

### **3.2.3.2 Canada**

The first professional body of surveyors in Canada was the Association of Manitoba Land Surveyors (AMLS), which was formed in 1881. According to its website the AMLS “ . . . is a professional, self-governing body . . . which regulates the practice of land surveying for the

protection of the public . . . sets the standards of practice, continuing education, conduct of members and investigates complaints from the public" (AMLS, n.d.).

Each of the other provinces of Canada has its own professional body. The Ordres des Arpenteurs-Geométrés du Quebec (OAGQ) was formed in 1882 (OAGQ, n.d.), the Association of Ontario Land Surveyors in 1892 (AOLS, n.d.), the Association of British Columbia Land Surveyors in 1905 (ABCLS, n.d.), the Alberta Land Surveyors Association in 1909 (ALSA, n.d.), the Saskatchewan Land Surveyors Association in 1910 (SLSA, n.d.) the Association of Prince Edward Island Land Surveyors in 1968 (APEILS, n.d.), the Association of Newfoundland (including Labrador) in 1953 (ANFLS, n.d.), and lastly the Association of New Brunswick Land Surveyors (ANBLS, n.d.) in 1954.

Generally they are established and have responsibilities under provincial statutes. Although specific details of the manner in which each of the provinces administers its responsibilities are not available, an inspection of the website home pages of each of these bodies indicates that all require tertiary educational qualifications followed by post graduation training and other entry criteria, has a stated code of ethics, and a clearly stated objective or policy of protecting the public interest. Every one of these bodies would therefore meet the requirements of a professional body. It is significant that all of these institutions make specific reference to being exclusively for *land* surveyors.

Additionally there is the Association of Canada Lands Surveyors (ACLS), a national licensing body for surveyors who work in the three Canadian territories, in the Federal parks, on Aboriginal reserves, as well as on and under the surface of Canada's ocean territories. They hold the exclusive title of Canada Lands Surveyors (CLS). Of all the Canadian surveyors associations, the ACLS has the largest jurisdiction. Entry requirements include being a member of a provincial association or holding a Certificate of Completion from the Canadian Board of Examiners for Professional Surveyors (CBEPS). The ACLS Strategic Plan confirms that the ACLS also meets all the requirements necessary to be considered a professional body including education, continuing competence, ethical and disciplinary powers, and concern for the public interest (ACLS, n.d.).

### **3.2.3.3 Australia**

The first surveying institution established in Australia was the Institution of Surveyors Victoria (ISV) founded in 1874. The ISV states that it “. . . services the professional needs of surveyors by conducting seminars and workshops, and circulating technical and other information . . . provides input into the educational standards for surveyors, and into the legislation affecting the activities of surveyors . . . [and] provides government and the community with the collective professional opinion of the surveying profession” (ISV, n.d.). These aspirations include most of those included in the criteria established by Flexner (1915).

The Institution of Surveyors New South Wales (ISNSW), founded in 1884, includes in its mission reference to representing land, engineering and mining surveying professionals and providing professional education and accreditation of university surveying courses. Its stated roles include to “. . . progress . . . the science of surveying, endorse and promulgate professional and ethical conduct, foster . . . ongoing learn[ing] . . . promote excellence in surveying and spatial sciences” (ISNSW, n.d.). Again, these aspirations and roles generally cover the criteria required for a profession as defined earlier, and therefore indicate the existence of a professional body of land surveyors. Other Australian state bodies were established in due course.

In 1952 six state surveying Institutes formed a federation called the Institution of Surveyors, Australia (ISA) (ISA, n.d.). Each state institution (New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia) became a Division of the federated body. Further divisions were established for the Australian Capital Territory (ACT) and the Northern Territory and one designated “Foreign”. “The primary objective of the Institution is to empower its members to strive for excellence in the application of the science and practice of surveying for the benefit of society” (National Library of Australia, 2014). This Federation continued until it merged with four other Australian organisations to form the Spatial Sciences Institute (SSI) in 2003.

The SSI added Surveying into its title in 2009 and became the Surveying and Spatial Sciences Institute (SSSI) following years of dissent and discord from its members who were professional surveyors. The SSSI has several levels of membership and has professional streams within its structure. One of those streams is the Land Surveying Commission, which

meets the criteria for consideration as a professional body, including requirements for tertiary qualifications, continuing professional development (CPD) and has a code of ethics (SSSI, 2012). While the SSSI itself may not be a professional body, that question remains open, it appears to incorporate within its structure Commissions that could qualify as professional bodies. However, ISNSW and ISV continue to operate independently under their original constitutions and the ISA (South Australia) and ISA (Western Australia) continue to exercise land surveyor licensing legislation.

### **3.2.3.4 Summation**

While an exhaustive examination has not been made of the world-wide professional bodies or learned societies, it is clear from the above discussion, that within the discipline of land surveying there do exist, and in particular in the countries under examination (Australia, Canada and the United Kingdom) a range of organisations that, by their titles and mission statements, represent a profession. In some cases they were established by statute, while in other cases they were formed as privately organised, self-governing bodies. It is also apparent that in some areas membership of the bodies was compulsory in order to practice as a land surveyor, while in others it is voluntary, as in Australia. Based on the membership of the FIG, by its constitution a federation of bodies dedicated to the surveying profession, similar bodies also exist beyond the range of these countries. They are widely dispersed around the world, if not in all countries.

In June 2013 the FIG included 103 member associations from 87 countries (FIG, n.d.). The membership database does not distinguish between land surveyors and other branches of surveying that are included under the broad definition that the Federation has adopted (FIG, n.d.) for the wider discipline of surveying. Many of the member organisations have names in their own language, hence it is not practical to identify which and how many of these represent land surveyors.

Despite this, from an examination of the names of the member associations of the FIG, forty-eight can be identified as specifically including land surveying, by the use of terms such as cadastral surveying, engineering surveying, geodetic surveying, topographical surveying or use of the French term “géomètre” in their names. Others simply use the term “surveyors” which may or may not include land surveyors (although based on the author’s personal

knowledge, a significant number of these do). Only six member associations identify themselves specifically as valuers, estate managers or quantity surveyors. Within the international community, therefore, there is a significant number of national associations related to land surveying that are deemed to be professional bodies.

As defined by the criteria derived from Flexner (1915), one of the significant functions of any professional body is to ensure that its members conform to high standards with respect to their relationships with clients and with the public at large. This normally includes the power to exercise discipline over members who are in breach of such standards and the ability to impose sanctions, sometimes as severe as removing membership. Standards may include technical as well as moral or ethical considerations. These standards of professional behaviour are customarily codified either within the constitution of the organisation, in the form of a separate code of ethics, or may be embedded in legislation where the professional bodies have statutory authority, functions or responsibilities.

A recurring theme in the review of professional bodies above is the issue of the protection of the public. While this is dealt with, in part, by the assurances given by professional bodies about the qualifications and competence of their members, it also relates to the way in which members deal with their clients. The former tends to be one of theoretical, technical and practical knowledge, while the latter relates to the behavioural and moral tenets to which professional land surveyors aspire, and the nature of the performance that clients should expect from all members of a professional society.

In all of the examples cited, the professional associations take positions in defence of the public interest and in most cases specifically refer to codes of practice, codes of conduct or codes of ethics. They also indicate that they have in place, and are prepared to exercise, disciplinary powers over members who are found to be in breach of technical or ethical standards. Such disciplinary powers are more universally effective when membership is compulsory than when it is voluntary. However, potential members may be more encouraged to join professional associations with clearly stated standards to use as part of marketing themselves with a point of difference from their non-member land surveying business competitors.

There are jurisdictions, such as Quebec in Canada, in which it is compulsory to be a member of a professional body in order to practise as a land surveyor. There will be differences also in the applicability of codes of conduct and to whom and how they are applied, depending on the nature of an individual's employment. Whether a practising surveyor is privately offering consulting services to the public, is employed by a company that offers consulting services, is employed by a local or central government agency, or works in academia will affect the applicability of parts of any ethical code. While the applications may be different, the spirit or ethic behind the conduct is just as important relative to the achievement of professional status.

In 1998 the FIG produced a "Statement of Ethical Principles and Moral Code of Professional Conduct" for the guidance of member associations. The Statement begins with a set of ethical principles followed by a definition of "the public interest". It is completed by a model code of professional conduct. It recommends the model be adopted as the minimum standard of behaviour expected of a professional land surveyor. It explains in the preface to the Statement that "One consequence of globalisation and the opening up of markets to foreign participation is the need for professional and ethical standards that apply to all . . . to ensure fair competition, to build and retain the confidence of clients, to protect the environment within which we all live, and to respect the interests of third parties" (FIG, 1998). Hence, FIG believes that although cultural practices will vary from country to country, there are fundamental principles that should apply to all practitioners. Each member body should then be responsible for the interpretation and application of these principles within its own jurisdiction (FIG, 1998).

Thus, with respect to land surveying, there are organisations within the countries that are the focus of this thesis that promote to, and enforce, codes of conduct or ethical standards on their members. There are also statements of the principles that are expected of a surveyor who aspires to claim the status of a professional land surveyor and that are accepted and adopted by the international community of surveyors (including, but not restricted to, land surveyors). These principles encompass the ethical and moral standards of the behaviour of surveyors with respect to clients, colleagues, the environment and the public at large. There is an implicit expectation that the world-wide community of professional associations that choose to join the FIG will have in place, or will be intending to adopt, some form of

professional ethical code. The criteria the FIG identify, yet again, reflect those of Flexner (1915) and add further weight to the contention that not only have these criteria withstood the test of time, they are applicable around the world and across cultures.

The final criterion for professional status is the requirement to apply professional knowledge, skill and judgment to real-life problems. There is no need for professional services if there are no clients with practical and complex issues for which they need the assistance of an individual with an understanding of the theory and experience in the practice of the particular domain of knowledge. In general, in order to be regarded as a profession, a body of practitioners must exist and be publicly or privately available for engagement as consultants to give appropriate advice and provide the means of supplying the necessary practical solution.

### **3.2.4 Application to practical problems**

Several prerequisites are required to apply the practice of land surveying to practical problems. These include the existence of a clientele, which may include corporate or government bodies and a range of practical applications that the clientele have a need to access. There needs to be a set of applications sufficiently technical or intellectual that the clients are unable to carry them out for themselves, or that the law requires the use of particular accredited practitioners. Finally the needs of the client must be of such urgency that they are prepared to purchase the services of a person qualified in the practice of land surveying in order to have their problem solved.

Some of the members of the professional land surveying bodies are employed by local or central government and a small proportion are employed in academia. However, most practitioners are employed by or have ownership in land surveying companies. These companies range from single service firms of sizes varying from single owner-operators through multi-partnered companies to multi-disciplinary practices providing services such as architecture, engineering, planning as well as surveying. The range also includes services related to the surveying of the sub-marine landforms of the seabed.

The evidence for the provision of such applications of land surveying to serve the needs of the general public can be deduced from the existence of the land surveying professional

bodies noted earlier, some of which specifically include sub-bodies of practitioners. In Australia there is the Consulting Surveyors National (CSN) “. . . which represents the private sector of the land surveying profession in Australia” (CSN, n.d.). There is also the Spatial Industry Business Association (SIBA), an independent body that claims to be “. . . the voice of the private sector of the spatial industries”. Their self-defined ambit extends “. . . from surveying and mapping to geographic information systems (GIS) and location based services” (SIBA, n.d.). These organisations specifically identify with the provision of consulting services to the public in land surveying and the provision of advice to government.

Evidence of the application of theoretical knowledge and practical skill to real-life problems can also be deduced from the commission structure of the FIG. This structure includes commissions for the analysis and discussion of issues relating to standards, i.e. Commission 1, Professional Practice and Standards , but also dealing with specific technical fields such as: Spatial Information Management (Commission 3); Hydrography (Commission 4); Positioning and Measurement (Commission 5); Engineering Surveying (Commission 6); Cadastre and Land Management (Commission 7); and Spatial Planning and Development (Commission 8). All of these sub-disciplinary activities are suggestive of a body of individuals who consult to the private and public sectors.

The indicators that suggest the application of land surveying to practical problems experienced by those in need of specialised advice is supported further. In the last decade there have been claims of existing or potential skill shortages in the provision of land surveying services. Warning is given of a looming crisis that will occur unless corrective action is taken in the short term (Blanchfield, 2005; Hannah, 2006; Mahoney, et al., 2007; Hannah et al., 2009; Fairlie et al., 2010). Claims of an impending crisis, either real or perceived, predict that development will be constrained through the lack of a sufficient body of practitioners to service the market. This, in itself, is evidence of the existence of a demand by society for land surveyors. However, the global financial crisis may have forestalled the arrival of the skill shortage, as it is noted that with one exception these writers published their views in advance of the financial down-turn.

### **3.3 Summary**

It is concluded from the above examination, analysis, evaluation and discussion that land surveying, since the development of the new professions, has established itself as a profession in accordance with the criteria distilled by Flexner (1915). The continued relevance of land surveying is confirmed by those criteria defined by the UKIPG and the inclusion of surveyors in the group. In so doing land surveying has developed a wide-spread body of practitioners trained in the discipline that has developed along with its professionalisation, and is represented by a significant number of learned societies widely distributed around the world.

In making a comparison between the criteria deduced from Flexner (1915), the UKIPG and the discipline in both local and international contexts, land surveying is shown to meet all criteria to make a legitimate claim that it is a profession within the currently accepted definition of the word. The broad extent to which universities teach and extend defined bodies of land surveying knowledge, the existence of a world-wide network of internationally recognised professional bodies that examine, accredit and monitor the technical competence of practitioners, the proliferation of qualified land surveyors providing services to government agencies, corporate and individual clients, and the existence of published codes of professional conduct for land surveyors all provide substantial ratification of the claim to professional status. Predicted skill shortages add weight to its continued relevance to society.

That which distinguishes one profession from another is the body of knowledge that its practitioners must acquire. The BoK required in any specific region will be defined by the needs of the society that the profession serves. The profession, the professional body and the educational providers will have evolved to meet those specific needs. However, it is anticipated that there will be a common core of knowledge which all land surveyors share and that distinguishes them from not only other professions, but from colleagues in the discipline who have not met the criteria for admission to the professional body.

In further examining the profession of surveying and the degree to which it has changed in recent years, the nature and development of the core body of land surveying knowledge for land surveying is a critical factor. It is important to distinguish what is core or essential to land surveying as a profession, and what is peripheral or of local or regional significance

only. Chapter 4 examines the historical development of this body of knowledge of the profession of land surveying and the way in which it developed to define the modern practice of land surveying.



## **Chapter 4**

### **Paradigms in Land Surveying**

This chapter develops the discussion of land surveying as a profession and focuses on the development of the knowledge, skills and operations inherent in its practice as an occupation through time. In particular, in contrast to the other attributes required to meet the criteria of a profession generally, as discussed in Chapter 3, this chapter identifies the attributes of the land surveying profession as distinct from any other.

An historical perspective is established that traces the purpose and functions of land surveyors and the principal developments that contributed to its establishment as an occupation and as a profession. It begins with recognition of an original paradigm. It then speculates about the existence of a second paradigm appearing about the 17<sup>th</sup> century. It proposes that this paradigm existed until the 1960s, and identifies its principal components. Identifying the extent of the traditional occupation of land surveying will provide a platform for the examination of any changes in the content or direction that are occurring in the profession during the second half of the 20<sup>th</sup> century and as the 21<sup>st</sup> century advances.

Land surveying is an occupation for which records go back to antiquity. Current evidence of surveying field records and calculations of areas of allotment shapes and sizes from the times of the Sumerians (c.2150 BCE) have been discovered Cooper (2009). As an aspect of work and study land surveying has developed incrementally through time and has been influenced by many and diverse factors. In its early development these were focussed on the gradual improvement in measuring equipment, but increased in pace as science, and particularly mathematics and physics, progressed. It also extended its ambit as the world was explored and new explanations were offered for the extent and nature of the world of human habitation. New skills were added to meet the demands of the exploration and the expansion of colonial empires.

#### **4.1 Land surveying in antiquity**

The practice of land surveying and practicing land surveyors existed in early settled societies. The control of domesticated plants and animals produced the concept of ownership of the means of food production and became a major source of wealth and power. The control of food supplies brought about through the Agricultural Revolution c.10,000 BCE, particularly domestication of plants and animals and the invention of the plough, allowed mobile hunter-gatherer tribes to evolve stationary and stable settlements. In turn, with surpluses of food, early societies developed sophisticated means of communication, and writing, mathematics, theology and philosophy evolved. Scribes were able to record their history in writing rather than relying simply on oral tradition. The surpluses also permitted the evolution of a class system that allowed labour specialisation, freeing some of the population from the necessity of spending a major part of their time finding food (Shultis, 1991).

Ownership of resources became a matter of importance within or between neighbouring tribes. However, with the emergence of ownership as a social concept, disputes could arise over which area of cultivation belonged to which individual, family or community. This was important because as civilisation developed, claims to ownership of resources could indicate the amount of tax that a citizen might owe to their rulers. Taxes were often related to the amount of land “owned”, grain produced or beasts farmed (Cooper, 2009). The control of such resources was essential for survival and stability. Additionally, ownership led to wealth, and wealth in a community could free individuals from the need to spend their time in the daily pursuit of sustenance, and so freed them to devote themselves to intellectual pursuits (Shultis, 1991).

The demarcation of the limits of land, in the form of boundary markers, was a matter of central importance to land owners as well as to governments. It was important since the calculation of land areas for estimates of production, volumes for quantities of harvested grain and the value of land for exchange purposes were of economic significance (Cooper, 2009). In the Babylonian and Egyptian eras the land measurers were government officials and boundary marks were highly regarded. In some cases they were protected by religious proscription – “Cursed be he that removeth his neighbour’s landmark. And all the people shall say Amen” (King James Bible, 1611).

Mariners had been navigating the seas for thousands of years, and were established as traders in the Mediterranean by c.2800 BCE (Columbia Encyclopaedia, n.d.). The earliest European navigators, when out of sight of land, found their way by making astronomical observations in the northern hemisphere with its advantage of a “north” or pole star, Polaris, which remained relatively fixed. Its earliest use is attributed to the Phoenicians (Gascoigne, 2001). The finding of direction by the use of stellar observations, both on land and sea is, therefore, a long established tradition by those seeking their own precise location as well as those wishing to travel to some other known place, or to explore to unknown places. Thus location in both the local and the global context, as a result of measurement, is significant at the dawn of human history.

#### **4.1.1 The Egyptians**

The accuracy with which the Egyptian surveyors laid out the Great Pyramid, and the pyramids generally, attests to their competency in geometry, angular and linear measurement as well as some understanding of astrological or astronomical alignments. They achieved accuracies of 20 cm over a horizontal distance of 230 metres and 6mm to 14 mm in vertical difference or level. They aligned their structure within 5½ minutes of arc of true cardinal directions, indicating that they also had some understanding of geodesy (Dilke, 1971).

As a result of the regular flooding of their alluvial plains by the River Nile they also developed a system of replacing ownership boundaries after these had been destroyed by the flooding of the river, an early form of cadastral surveying redefinition. The Egyptian authorities were interested particularly in crop yields as this formed the basis of their taxation system. They also developed systems of irrigation to utilise their available water to best advantage in the process of food production. However there is little written confirmation or detail of this as it is thought to be a matter of local interest only (Kemp, 2006) although such land management techniques were necessary as Egypt had suffered severe famines as a result of drought in the past (Hassan, 1997).

Other implications of the measurement of land for the production of topographical maps essential to the Egyptian farmers involved establishing gradients that would allow water to flow for irrigation, calculation of the quantities to be removed for channels or canals, and computing the number of bricks or blocks needed for a building (Cooper, 2009). The

important status of the Egyptian surveyor is observed in their appearance in hieroglyphics where the surveyor is depicted with his rod of office, supervising his workers as they use their knotted rope to make measurements (Brock, 2013).

#### **4.1.2 The Greeks**

The Greek surveyors, who understood the importance of the relocation of boundaries from the regular River Nile floods of Egypt, “as Herodotus shows, thought of themselves as having learnt the principles of surveying from the Egyptians” (Dilke, 1971). They were also competent in tunnelling and in the laying out of towns in accordance with the plans of those such as the architect and planner Hippodamus. Additionally, the understanding of geodesy allowed Dicaearchus to establish a line of latitude from the Himalayas to Gibraltar in the 4<sup>th</sup> century BCE. This was based on work done by those such as Pytheas of Marseilles in circumnavigating Britain and the description of the Ganges valley by Megasthenes. In the 3<sup>rd</sup> century BCE Eratosthenes was able to make a remarkably accurate estimate of the Earth’s circumference, against the prevailing flat-earth beliefs of the time (Dilke, 1971). The true size of the planet, as well as its relationship with the sun and with the other planets, remained a matter of interest to Greek philosophers and mathematicians until the time of Ptolemy c.150 AD (Encyclopaedia Britannica, n.d.).

#### **4.1.3 The Romans**

In the era of Roman dominance the *agrimensores* or “measurers of the land” (Dilke, 1971) were recognised as professionals who received special education and training (Cooper, 2009). Roman land surveyors were trained and educated in cosmology, astronomy, geometry, orientation, sighting and levelling. In addition, they were knowledgeable in land law, centuriation, the legal status of land, the allocation of land as well as the mapping and recording of land (Dilke, 1971). Their status was high in the Roman bureaucracy as they had “. . . expertise in land law and . . . advise judges in disputes over land ownership . . .”. The *agrimensores* were held in high esteem generally (Cooper, 2009 p.4).

During the establishment of the Roman Empire, the *agrimensors* fulfilled other tasks. As the empire spread it required both a network of roads for communication purposes and for the speedy deployment of troops to maintain order within the expanding territories. The

agrimensors were also required for the setting out of the rectangular-patterned garrison settlements across the vast Roman Empire, which needed to be controlled by suppression of the local inhabitants. Additionally the land surveyors were necessary for the laying out of roads, aqueducts, bridges and drains (Cooper, 2009).

The Romans had standardised plans for settlements, or castra, depending on the size of the garrison that was to be maintained in any specific area (Lyon, n.d.; British Museum, n.d.). Specifically, plans were prepared for garrisons of 200, 500 and 800 troops. The site of a temporary or permanent garrison establishment had to be selected depending on slope, aspect, climate and strategic position. The grid street system was laid out and the defence system of palisades and trenches put in place, often on a daily basis, as troops travelled throughout the Empire. Thus, the agrimensors were involved in all of these aspects of planning, setting out and building of garrison-based communities. The Roman land surveyors had important practical functions in the expansion of the Roman Empire, beyond the demarcation of land boundaries and the establishment of early cadastral records.

Greek and Roman surveyors developed a number of specialised instruments to assist them in their work. These included the groma, for surveying straight lines and turning right angles, measuring rods of various lengths, the chorobates and the dioptra for levelling, and the hodometer (possibly the first odometer) a mechanism attached to a wheel for measuring longer distances (Dilke, 1971).

The work of these early land surveyors was principally measurement and sometimes its particular application to land boundaries, with logical connections to the law relating to land, and the location, orientation and dimensions of structures. At times they also became involved in town and rural planning as the officials who laid out on the ground the towns and rural subdivisions planned by the architects and military commanders of the Roman Empire.

From Egyptian times the position of the land surveyors was one of authority and status, and the educated and trained surveyors supervised other less qualified assistants to carry out their measurements. Their abilities and competencies remain obvious with such monuments as the Great Pyramids, the Roman roads of Europe and the aqueducts that can still be seen and marvelled at, as well as the patterns of settlement that can be seen in European landscapes

several millennia later. The micro level of land measurement was important to transportation and urban and rural development. However, the surveyor's influence also involved an interest in surveying at the macro scale when they extended their mathematics and philosophy to attempting to measure the size of the planet and to explain the movement and relationship of the heavenly bodies.

The collapse of the Roman Empire during the early part of the first millennium BCE brought the Western world into what is now commonly referred to as the Dark Ages, a time of famine, pestilence and conflicts between neighbours as well as invaders attempting to establish territorial dominance that spread throughout Europe (Shultis, 1991). One outcome of the pursuit of territorial acquisition was the need to fund wars through the taxation of land owners or tenants. This in time would lead to the creation of cadastral records, as monarchs attempted to assess the territory, and consequent wealth, they had accumulated through conquest.

#### **4.1.4 Cartography**

In addition to the application of surveying to matters of land area definition and the alignment of significant structures, measurement was also being used by the Greeks in early recorded history for a larger purpose, that of interpreting the known world, its dimensions and its position in space. Eratosthenes of Cyrene (276 – 194 BCE), third librarian at Alexandria, was able to calculate the circumference of the Earth to within 100 miles (160 km), though the known inhabited world he portrayed in a map is confined to Europe, Africa and part of Asia (including India). He is alleged to be the first to coin the term “geography”. The word derives from the Greek “geo” meaning “Earth” and “graphien” meaning “written” (Garfield, 2012).

Eratosthenes also was one of the first scholars to render the written word into an illustration, thus founding the art of cartography (Garfield, 2012). There is a written account of the (then known) world, Strabo's 17 volume *Geographica*, but there is no existing map that relates to his text (Garfield, 2012). Strabo lived between 62 BCE and 24 AD, and his *Geographica* was a life's work. The inhabited world is rendered flat, although Pythagoras had proven that it was a sphere as early as 194 BCE. Cartographic progress appears to have “fallen into the

cartographic dark ages for about a thousand years” (Garfield, 2012 p.39). Maps such as the Mappa Mundi, the Psalter Map, did not start appearing until around the 13<sup>th</sup> century.

Early examples of cartography, however, appear to be the pictorial representation of descriptions of routes, locations and places, rather than accurate representations of the relative positions of the places shown. That is, they were for illustrative purposes, and while they might indicate how long it may take to travel from one place on the map to another, they did not contain, nor were they based on, measurements taken by the people now known as land surveyors. This was to come at a much later date as standards of measurement were adopted, equipment and techniques of calculation were developed, and greater knowledge of the size and shape of the planet Earth were understood.

## **4.2 Through the Middle Ages**

There is no evidence of specific advances in the practice of land surveying through the medieval period in Europe (Wolf, 2002), though this ignores the developments in mathematics outside of Europe. While Europe had descended into what later became known as the Dark Ages, the Islamic world pursued the development of mathematics and science specifically in China, India and the Hellenistic world. In the view of at least one author (Joseph, 1987) the role of the Arab scholars in this period was crucial. They pursued and developed mathematical knowledge from Jundishapur in South-east Persia, “. . . moving through Baghdad, Cairo and finally, to Toledo and Cordoba in Spain” (Joseph, 1987).

### **4.2.1 Beyond Europe**

The adoption of the Hindu number system and the Arabic numerical notation, along with developments in algebra and basic trigonometry, also occurred during this extended period and from the same source. Europe remained largely in the state of the scientific knowledge reached by the Greek and Roman schools. The adoption of the Hindu number system allowed for simplified means of calculation and algebra was developed by the Arab scholar Mohamed ibn-Musa Al-Khwarimi (c.825 AD). Al-Khwarimi’s work was taken up by other Arab mathematicians and continued into the 13<sup>th</sup> century (Joseph, 1987). As European scholars travelled in the pursuit of knowledge and as the Middle Ages gave way to the Renaissance, Robert of Chester translated Al-Khwarimi’s book on algebra into Latin in the

12<sup>th</sup> century, and Euclid's "Elements" was translated by Adelard of Bath, Herman of Carinthia and Gerard of Cremona. Fibonacci (c.1170 – c.1250A D), the son of an Italian merchant or diplomat, and who was educated in North Africa, marked the first European contribution to mathematics since Eratosthenes and introduced the Hindu-Arabic numerals (Usvat, 2013).

While the principles of trigonometry appear to have been understood by the Egyptians and the Babylonians with respect to the mathematics of astronomy and based on chords of circles, its origins are lost in prehistory. Greek writers, such as Hipparchus and Ptolomy, acknowledge that they gained early knowledge about astronomy, mathematics and surveying from the Egyptians (Joseph, 1987). It is speculated that Pythagoras may have travelled to India as his theorem was known by Babylonians (1800 BCE) and Chinese (500 BCE) (Joseph, 1987, footnote p.17). The melting pot of Alexandria provided a centre for the movement of knowledge from India, China, Greece and Persia by Arabic scholars and through Baghdad to Cairo and on to Toledo and Cordoba (Joseph, 1987). This knowledge then became available to the rest of Europe through Robert, Adelard and Herman (Usvat, 2013).

Trigonometry emerged in Europe in the 16<sup>th</sup> century as spherical trigonometry and based on the mathematical relationships of sides and angles in triangles, from which its modern name is derived. The term trigonometry was first introduced by the German mathematician Bartholomaeus Pitiscus in 1595. It consists principally of the ability to solve triangles from one linear measurement and then measuring angles (Adamek, Penkalski & Valentine, 2005). It is therefore integral to the practice of land surveying, along with other contemporary developments, as it emerged in Europe during the Renaissance period.

#### **4.2.2 Cadastral surveying**

A cadastre is a comprehensive register of land holdings and of the rights that attach to the land or its owner. It may be supported by a cadastral survey or cadastral map. A cadastre commonly includes details of the land such as the ownership, the types and conditions of tenure, the precise location, the external dimensions and the area, and may include the attendant rights in property. It also may include, but not necessarily, the actual or permissible land use, such as crops or pasture types in the case of rural areas, and the value of individual parcels of land (<http://en.wikipedia.org/wiki/Cadastre>. Accessed 6 November, 2013).

The earliest extant cadastral survey of England is the Domesday Book, prepared for King William I (the Conqueror) in 1086 (King, 2007). The purpose was to establish what lands were held by his subjects in what was then England. This register recorded the extent of land that individuals held, the value of the land, the stock maintained on it, and the taxes that had been paid or were due. The register did not involve the recording of the physical boundaries of properties, but it did record the quantity and valuation of the assets held by King William's subjects (BBCb, n.d.). Hence, it is believed that the Domesday Book is the oldest general cadastral record still in existence. It is held, and is on view, at the British National Archives in Kew, London, and can be accessed on-line at [www.doomsdaybook.co.uk](http://www.doomsdaybook.co.uk). While not directly attributable to land surveyors as the profession would be defined today, it marks the beginning of an activity that was later to become of central importance to land surveyors, as well as surveyors of different types, such as valuation surveyors and estate managers.

Little is known about what measurements might have been taken, if any, in compiling the Domesday record. Information was gathered by "commissioners", who were men of high rank such as members of the nobility and high churchmen. They questioned local "juries" made up of the sheriffs, reeves and as many as six peasants. A standard set of questions were asked and the responses recorded by clerks (King, 2007; Anonymous, 1999-2003; BBCa, n.d.). The accumulated information from across the country was written up by a single scribe. While King (2007) describes the exercise as a survey, it is not a survey in terms of what a land or cadastral survey would entail in contemporary terms. Neither would the information gatherers be termed land surveyors in modern contexts, though surveyors they clearly were in the broadest sense. That is, that they gathered, or oversaw the gathering of, data for the purposes of making it into a land information record.

The true purpose of the Domesday Book is unknown though there is some agreement about the principal reasons for its preparation (King, 2007). King William was introducing a more rigid form of feudalism to England and wished to know who owned what in his new kingdom. It is also known that he maintained a large standing army to defend against other claimants of his new realm. It is speculated that in order to pay for that army he had to tax those who held land under him. In order to do that he needed to know the nature of their wealth and their ability to pay taxes. The areas of land were defined in terms such as virgates and hides. A virgate was enough land to support an individual, whereas a hide was enough to

support a family. The physical area, therefore, depended to some extent on the fertility of the soil. Hence areas did not have measured dimensions, which only appeared much later (Linklater, 2002).

In a later era Napoleon Bonaparte established the foundation for the European cadastral system. In 1807 he ordered maps and cadastral records to be created over some 100 million parcels throughout his empire. The purpose was the same as that of William the Conqueror in England, namely to raise taxes from landowners (Williamson, et al., 2010).

#### **4.2.3 The first paradigm**

The period immediately prior to the Renaissance and the Rise of Science represents the end of the first era in the development of the land surveying profession. Land surveyors had been held in high regard during the classical period, but nothing is known of their formal education or training. It is evident, however, that they did have knowledge of mathematics and of astronomy. As Vice President Rudolf Staiger of the FIG states “The Archaic phase lasted thousands of years and ended in 1590 with the invention of the telescope” (Staiger, 2009). While Staiger suggests that there was an Archaic period, which is not doubted, the proposition that its ending was brought about by the invention of the telescope overestimates its significance, though it did play an important part in the shift.

The development of the concept of land as private property changed the role of the land surveyor. Additionally, and partly as a result of this, the standardisation of measurements, the arrival of new forms of mathematics and advances in angular measurement based on the invention of and modifications to the telescope were to provide such change that the shift in practice was revolutionary. The following sections expose the significant changes that led to the development of scientific methodologies and the use of increasingly more sophisticated equipment to define the dimensions and location of parcels of land. These advances also led to the land surveyor’s ability to identify the accurate location on the planet of any objects, places or persons, aided navigation, and assisted in the opening up the world to European colonisation following the Age of Discovery.

## **4.3 A new paradigm**

William the Conqueror brought a more exacting form of feudalism to England and quantified the land in his new kingdom through the construction of the Domesday Book. Measurement at that time was defined by anatomical terms for smaller measures, such as thumbs, fingers, palms, feet or the length of a forearm (a cubit). The need for the standardisation of measurement affected trade in all manner of commodities, from farm produce to manufactured goods, so that fair and consistent values could be attached to quantities for the purpose of exchange, either by barter or coin. Larger land areas were defined mostly by how long an area would take to plough or how many people a given allotment of land could support. Thus, an acre of fertile land was smaller than an acre of less productive soil (Maitland, 1897). Other weights and measures for produce and for manufactured items such as cloth were equally based in approximated anatomical dimensions.

### **4.3.1 The new concept of property**

According to Linklater (2002), land management practice was undergoing change in England as well. As a result of inflation during this period, land owners attempted to maximise the production from their lands. To facilitate this, the process of “enclosure” was underway. Tenant farmers had managed their lands in strips or rigs and were under pressure to consolidate areas and separate them with hedges so that crops would not be trampled. In the publication “The Boke named the Governour” Sir Thomas Elyot, giving advice to land owners on how to run their estates, advised that the first essential step was to “draw a map or ‘figure’” of the estate so that the governor knows of what it consists,” (Linklater, 2002. p.3). Linklater asserts that by drawing maps of their holdings, land owners were asserting ownership, and that this is the foundation in England of “land as private property” (Linklater, 2002. p.5).

While Linklater clearly identifies a potential change in the nature of rights in land, or the way in which they are asserted, it signifies only a change in perception. In the English land registration system, as in the future British colonies, the Crown (or the State) retains the right to “resume” any title to itself, with the appropriate level of compensation, irrespective of the bundle of rights that it may have allocated to a land title holder in a modern land title system.

Linklater (2002. p.6) further asserts that “the “greatest real-estate sale in England’s history” occurred when Henry VIII dissolved some 400 monasteries in the 1530s and their lands reverted to the Crown. Henry’s need of cash meant that, rather than allocating his regained estates in the feudal manner that had predominated until then, he choose to sell the land. Thus instead of having the feudal rights of the service of his tenants, he was able to sell the land for cash, principally to pay for the defence of his realm. This new type of rights in land required that those purchasing land needed to know exactly what they had acquired. It was no longer adequate to define land areas by how many people it could support. Areas had to be defined by measurement – by measuring the sides of regular and irregular figures and calculating the area therefrom (Linklater, 2002). That is, by defining boundaries in the way in the manner of land surveyors.

At about this time (the 16<sup>th</sup> century) a number of important discoveries were being made and inventions developed. These included more accurate angular measurement, standardised linear measurement, the adoption of standard units for distance and areas, and the development of the telescope. In addition, computational methods were being adopted that would ease the calculations required of the land surveyor, including the adoption of Arabic numerals, the decimal system and logarithms.

#### **4.3.2 Angular measurement**

It is pointed out by Turner (1991) that surveying textbooks of the early 16<sup>th</sup> century dealt mostly with methods for conducting audits and valuations and were only just beginning to consider issues of actual land measurement. Bennett (1991. p.345) observes that in the 16<sup>th</sup> century the surveyor’s symbol of office was a pole, but also that the surveyor’s work involved “other kinds of measurement” and valuations, and that linear measurement was still accomplished using poles and ropes. He further asserts that the developments in mathematics, specifically geometry and arithmetic, had proved so successful in navigation that the advocates of the mathematical sciences found surveying their next target.

In 1570 a work appeared by an English surveyor, Leonard Digges (or Diggs), entitled “Pantometria”, which was added to and published posthumously by his son Thomas (Bennett, 1991). It was a book on surveying which describes an instrument called a “theodolitus” that was used in topographical surveying and incorporated a graduated horizontal circular disc of

12–14 inches in diameter and divided into 360 degrees (Wolf, 2002). It is claimed that it is from this instrument that the modern theodolite developed. It included a vertical semi-circle and a magnetic needle (presumably for compass bearings) and could be used for the determination of heights and distances (Wallis, 2005). At some point the new instrument moved from being mounted on a pole to the more stable tripod support, possibly first referred to by Joshua Habermel (<http://en.wikipedia.org/wiki/Theodolite>. Accessed 14 May 2014). Following the invention or improvements in telescope design by Galileo and its addition to the prototype theodolite, the utility and accuracy of the device was improved (Wolf, 2002).

The evolution of this new instrument continued with the addition of Vernier scales, following their development by Pierre Vernier, and described in his Brussels publication in 1631, *La construction, l'usage, et les propriétés du quadrant nouveau de mathématiqu,. This allowed for the more precise reading of the graduated circle to achieve more accurate results, though they did not become universally used until the 18<sup>th</sup> century. A better sighting mechanism was developed using telescopic sights, modifying the original astronomical instruments by William Gascoigne, possibly c.1644 (Hacking, 1989). A further refinement by Jean Picard was to add crosshairs to the telescope of the theodolite and the introduction of a “level bubble” by Melchisedech Thevenot in 1666 (Wolf, 2002). This further improved the ability of the theodolite to provide accurate readings.*

The final major refinement to the basic design of theodolites was the mechanical division of the 360° circle to improve further the accuracy of readings obtained from it. This was developed by Jesse Ramsden in 1770 and provided for “. . . significantly improving their accuracy”(Wolf, 2002. p.82 ), although Ramsden’s invention has also been dated as being in 1773 (Wallis, 2005). Having been rewarded for his efforts by the Board of Longitude, Ramsden was required to publish details of his invention. Subsequent improvements were made to his dividing engine by significant surveying instrument manufacturers such as Edward Troughton in 1793 and William Sims in 1843 (Cox, 1986).

Little changed in the concept of the first theodolite from the time of Digges though refinements continued through the 16<sup>th</sup> century, and improvements in the quality of the various components continued through the 17<sup>th</sup> and 18<sup>th</sup> centuries. The final improvements to this level of technology came in the 20<sup>th</sup> century when Heindrich Wild improved the internal

focusing of the telescope in 1908 (Cox, 1986) and glass graduated circles replaced metal ones about 1920 (Staiger, 2009).

Staiger (2009) maintains that what he refers to as the “optical era” reached its peak with the work of the Swiss theodolite designer Heindrich Wild and the arrival of the first completely enclosed and glass-circled modern theodolites. The theodolites designed by Wild included a range from instruments that could give readings of horizontal and vertical angles to 1 minute of arc, as in the Wild T0, or to 0.2 of a second of arc, as in the Wild T3 (Trutman, n.d.). These instruments were designed for land surveyors whose measurements were, per force, required to be made on the ground. Such accuracy as the T3 could attain was particularly applicable to increasing the accuracy of ground-based trigonometrical networks by triangulation.

The developments in angular measurement brought greater accuracy to the measurement aspects of the 16<sup>th</sup> century land surveyors and their successors through the following 300 years. In parallel there were equally important developments in the associated requirements for more precise linear measurement. These were required to enable the surveyor accurately and consistently to define and re-define the boundaries of specific tracts of land and calculate their areas for the new classification of land ownership. Such accuracy was also required in order to establish equitable valuations for both the levying of taxes by the Crown or the government and for exchange in the land market.

#### **4.3.3 Linear measurement**

Until the 16<sup>th</sup> century linear measurements were arbitrarily defined and there were no consistent definitions on which to base calibrations. Weights and measures had been introduced in Europe by the Romans. These were largely defined in relation to parts of the human body such as thumbs, palms and feet. In order to achieve fair trade, in land as well as other commodities, standardisation was necessary. It was in this period of the rising volume of trade, both local and international, that there was much interest in establishing agreed standards of measurement, both linear and volumetric. Nations began to legislate for their own standards, and to proscribe the use of one set of standards for selling and another for buying commodities. This was a widespread practice alluded to as long ago as biblical times. With the emergence of the new land market following the redistribution of land after the

dissolution of the monasteries by King Henry VIII, land areas could no longer fluctuate according to such variables as fertility. The new land owners required exactness of their surveyors (Linklater, 2002).

As has already been described, areas were usually related to the time needed to work a plot of land or the number of people that it might support. Linear measurement of land was traditionally based on the rod, pole or perch, varying names for the same unit of length. It is asserted that the origin of the pole lies with the stick used by ploughmen to control their oxen as they worked the land. The stick needed to be long enough to reach from the back of the plough (the position of the ploughman) to the nose of the furthest oxen (Anonymous, n.d.). Whatever the true origins of the name and the selection of its dimension, the standardised unit became the rod or pole, and its length was standardised at 16.5 feet (Linklater, 2002).

In this system four rods made a chain. A field of an acre, sufficient to support one family, was deemed to be a furlong deep (40 poles or 220 yards) by 22 yards wide. The standard measurement of 22 yards is also the length of a “chain”, a measure used as the basis of plane land surveying in many countries, and that persisted well into the 20<sup>th</sup> century in many places. This unit of linear measurement is still in use in parts of the United States of America. The standardisation in the time of Henry VIII, and which was legislated by his daughter Queen Elizabeth I in 1588, was an integrated system that defined relationships between lengths (inches, feet, yards, poles, chains, furlongs, and miles) and areas (acres, roods, perches and square miles). In 1601, in order to standardise the measurements for the country, a brass yardstick of 36 inches (one yard) was constructed (Linklater, 2002). These measures formed the basis of the Imperial System for several hundred years. It was only superseded by the extensive adoption of the metric system in the 20<sup>th</sup> century, though remains in use in a few places in the modern world.

It was against this background that Edmund Gunter, born in Wales in 1581 and educated at Oxford University, had his influence. He was later to become Professor of Astronomy at Gresham’s College, London in 1619. Gunter was educated for the church but had a passion for mathematics, and in particular ratios and proportion. This had enabled him to design and construct a variety of instruments, including an early slide rule. He was also familiar with decimals, logarithms and trigonometry (Linklater, 2002). His development of a measuring

device that was of a useful construction, a practical length, and a chain in physical reality, was to cement his name in the annals of surveying history. The Gunter's chain was used for centuries following its invention and was only replaced in the late 1800s by the continuous steel band. However the measurement principles embodied in its invention remained the same.

Gunter's chain was made up of 100 physical links each of 7.92 inches and made of quite heavy steel wire. The links had loops at each end enabling them to be joined together. It also had brass markers at every tenth link for "reading" or counting purposes, and was easy and flexible to use. In the view of Linklater, this was "... a brilliant synthesis of two otherwise incompatible systems; the traditional English land measurements, which were based on the number four, and the then newly introduced system of decimals, based on the number ten" (Linklater, 2002. p.12). That is, four rods equalled one chain, which in turn equalled 100 links. Thus it was that the formerly variable units of rods, acres and miles became fixed in the 16<sup>th</sup> century.

In this way, Linklater attributes to Gunter the means of making privately owned land a market commodity. By enabling the precise measurement of boundaries and areas that did not alter with the nature of the soils, the land could become a commodity and a true and fair market could be established (Linklater, 2002). As a result comparable land values could be established by factoring in the given area and the productive quality of the land. While property had been a private good previously, what the standardised measurement did fulfil was the ability to define, and accurately redefine, the boundaries of any particular allotment.

Although the development of surveying measuring equipment was a critical development at a fortuitous time of change, the arrival of new concepts in mathematics also contributed to the rising importance of the surveying of land. In particular the calculation of areas and the ability to calculate distances from angular measurement using a single measured linear baseline became standard land surveying practice – facilitated by the adoption and use of geometry and triangulation.

#### **4.3.4 Developments in mathematics**

The computation of areas using the newly standardised system was achieved by relatively simple arithmetic using the dual systems based on the traditional base of four and the new decimal system based on ten. These early surveying devices relied heavily on the physical measurement of distances in order to define the land and to enable the drawing of scale maps or plans of the areas they had surveyed. “Angle measurement and trigonometry presented much greater challenges. It was here that a struggle was developing for the proper practice of surveying and the legitimate image of the professional surveyor” (Bennett, 1991. p.346).

In this respect, surveying was closely affected by the developments in astronomy and navigation, both utilising similar instruments of observation and the same principles of geometry. The inducement for surveyors to take up geometrical principles was that of trigonometry. Being able to solve unknown dimensions of triangles, that is the unmeasured sides and angles, and to calculate areas. This could be achieved by measuring one baseline and then merely observing distant points from either end of it. There was no longer any need to physically measure all distances, especially longer ones. They could, instead, be calculated using trigonometric formulae. This technique became known as triangulation, and was explained in 1533 in the Gemma Frisius edition of “Cosmographia” by Apianus (Bennett, 1991).

In this way, the invention and development of the theodolite changed the principal practice of surveying from one based on linear measurement, but which retained considerable importance, to the combination of angular and linear measurement enabled by the use of trigonometry for triangulation. The introduction of the use of Arabic numerals (Turner, 1991), the decimal notation in a paper by Steven Stevin in 1585, and logarithms by John Napier (who also worked to improve Stiven’s decimals) in the early 1600s were of great computational value to the land surveyors of the time (Linklater, 2002). They were in a period of transition from the simple arithmetic required of them previously, to the mathematics needed to calculate distances using geometry and trigonometry (Bennett, 1991).

The uses of these new developments in mathematics, and the instruments developed for measurement purposes, were not confined to land surveying. The renewed interest in astronomy as a result of the development of the telescope and the dependence of navigation

on stellar and solar observation also were closely related to the advances for land surveying. The need for greater accuracy in navigation in the period when Europe was discovering the rest of the world and developing maritime trade and commerce meant that all of these advances were of keen interest to a much larger audience.

#### **4.3.5 The (European) Age of Discovery**

The great European navigators during the era of world exploration during the Age of Discovery (c.15<sup>th</sup> to 17<sup>th</sup> centuries) were able to navigate around the globe. They also were able to prepare maps of the lands they discovered. Additionally they produced charts of the waters surrounding their discoveries and maps of the waters through which they travelled.

The invention of a precise mechanism that could carry accurate time on a pitching and rolling ship became a prized ambition. Early attempts at such devices can be observed in the Royal Observatory at Greenwich, London, England (Rosenberg, n.d.). Navigation was significantly improved when it became possible to carry on board ship a chronometer that could be relied upon to keep accurate time while a vessel was constantly changing direction in all three dimensions. This improvement in navigation, until then based on observations of the sun and the stars, was due to the invention of a stable maritime clock by John Harrison in 1764. Harrison's chronometer allowed much improved accuracy in the calculation of latitude (Orchiston, 1998; Taylor & Wolfendale, 2007). This was especially so in the Southern Hemisphere where the pole star or any equivalent, so critical in navigation in the Northern Hemisphere, was unavailable.

The improvement in navigation allowed much greater accuracy in charting and mapping of newly discovered lands and their surrounding seas than the previously relied upon astronomical observation. As instruments and mathematics developed it became possible to fix accurate positions using observations on the sun and the stars while knowing the precise time. James Cook, explorer, navigator and cartographer, was amongst the earliest to use this new technology in his voyages to the South Seas in the 1770s. It is noteworthy that Beaglehole refers to Cook as a surveyor and notes that "It is the surveyor as well as the seaman in [Cook] that denounces the publishers of faulty charts. It is something beyond the surveyor, but still the surveyor, who exalts 'the improvements Navigation has received from the Astronomers of this Age' and the credit 'that is due to the Mathematical instrument

makers for the improvement and accuracy with which they make their Instruments'" (Cook, Journal II, 78-79, as quoted in Beaglehole, 1992. p.702).

The 17<sup>th</sup> century saw renewed interest in establishing the precise size and shape of the globe, a standard for the measurement of length and a need to establish a common basis for the measurement of time for global navigational purposes. To assist this, meridians were measured in a number of places with a view to extrapolating these into an estimate of the Earth's dimensions. Despite their relatively primitive equipment, these meridional measurements provided a good degree of accuracy for the consequent calculations. The adoption of the Greenwich Meridian as an origin of longitude may be considered as the beginnings of internationally agreed astronomical position fixing and modern geodesy and geodetic surveying.

Exploration was carried out from natural curiosity, to map and explore trade routes to parts of the world generally unknown to western society, but more importantly, to expand trade through the import of raw materials and exotic products, and the export of finished goods. Competition between the maritime nations and the desire to create and dominate empires led to the colonisation of newly discovered lands. Overcrowding in the unpleasant environments of Britain's urban areas and the need to maximise food production for a burgeoning population encouraged migration not just from the urban areas, but from the nation as a whole. This led to an increasing need to establish new areas for food production and settlement, and to provide a new life for the urban and rural poor and the dispossessed.

#### **4.3.6 Colonisation**

The European "Age of Discovery" was the prelude to colonial expansion by the major European powers of the time, namely; Spain, Portugal, the Netherlands, France, Great Britain, and to a lesser extent Belgium and Germany, that spread across the entire globe. The colonial period lasted for four hundred years, from the Treaty of Tordesillas in 1494 until the independence of India in 1947. Britain became the supreme colonial power following Spain's alliance with France and their defeat in the Seven Years (or Franco-Indian) War, confirmed by the Treaty of Paris in 1763 (Stuchtey, 2011). While this was a North American conflict it had broader implications for the nature of European colonialism and was a precursor to increased British expansionism and domination.

Accurate measurement and its related mathematics had become an important element in navigating the world. Equally, with standardisation and Gunter's chain, accurate measurement had become of critical importance to the new land-owning class of England. This importance, along with the modern development of land as a commodity, became highly relevant as migrants from Europe, and especially England and the other parts of Great Britain, spread through the newly developing colonies. This occurred first in North America, where royal patents entitled the Governors of colonies to assume exclusive ownership and to enclose areas of land, as had happened earlier in England. This newly acquired attitude to land as property (Linklater, 2002) placed further significance on the knowledge and practice of land surveyors.

“Since the native Americans had nothing to show that they owned the land, the new Americans could take it freely, and New England, like the old, would belong to those who could measure and enclose it” (Linklater, 2002. p.23). Such an attitude to indigenous peoples and their rights to land would characterise the following spread of the British colonies across the globe. In America the frontier pushed west from the original French, British and Spanish colonies (Linklater, 2002); in South Africa the Dutch were progressively replaced by the British (Stuchtey, 2011); and in Australia and New Zealand only minor opposition was encountered from other colonial powers as the British colonised the east coast of Australia and signed the Treaty of Waitangi with the Maori tribes of New Zealand.

The 18<sup>th</sup> and 19<sup>th</sup> centuries saw planned emigration and settlement by the British government of what are now its former colonies. This included Canada beginning in the early 1600s (University of Ottawa, n.d.), Australia from 1788 (Australian Government, n.d.), South Africa in the early 1800s following the Dutch who had settled in the mid 1600s (Middleton, 2002). Finally New Zealand was added after the signing of the Treaty of Waitangi in 1840, though there were prior occupations at whaling and sealing bases, and by missionaries. Surveyors often accompanied or preceded the settlers and were required for the laying out of allotment boundaries as the settlers took up ownership of the “new” land. The surveyors, as experts in measurement and mathematics were also needed for the laying out of canals, roads, railroads and other infrastructure projects as colonies developed and settlements grew. In many cases this necessitated the application of known surveying methodologies for the

measurement of land to other needs, for the construction of such utilities as irrigation and hydro electric dams, railways, roads and tunnels.

#### **4.3.7 The nature of a 2<sup>nd</sup> paradigm?**

As discussed above, land surveying underwent a revolution during the late 16<sup>th</sup> century and early 17<sup>th</sup> century. The revolution was spurred by the development of a market as land became an item of private property. The economic forces of the time demanded maximisation of the economic returns from agricultural land in particular. The developing market required that boundaries be clearly delineated and areas calculated for purchase, production and taxation purposes. The nature of measuring land up to this time had changed little since the times of classical antiquity.

The revolution that took place in land surveying was brought about by three principal factors. The first and underlying factor was the arrival of geometry and trigonometry, acquired from Arabian scholarship and originating in China and India. Reaching the universities in Spain through the conquest of the Iberian Peninsula by the Moors, they were brought to the northern European countries by travelling scholars. The introduction of the decimal system and the invention of logarithms further enhanced the ease of calculation for the new type of land surveyor.

The second influence was the standardisation of measurements. Moving away from the measurement of areas that were defined by fertility and distances that were defined by parts of the human anatomy, standards were set for linear measurement. Additionally, Edmund Gunter produced the chain that bears his name to this day, and enabled those carrying out measurements to produce consistent results and records, which could be repeated, to an accuracy that satisfied the needs of the time. This chain was used for the following four centuries, and was only replaced in very recent times by the spring steel band. This measuring tool, however was merely a development of the original Gunter's chain into a more accurate, manageable and flexible form.

The third factor was the burst of developments that took place with respect to optics and angular measurement, though driven largely by the advances made principally for astronomical and navigational purposes. The telescope, the compass, Vernier scales,

instruments on levelled tripods, and mechanical engraving of circular protractors evolved into plane tables and theodolites that provided the basis of surveying instrumentation that was to last well into the 20<sup>th</sup> century.

The adaption of optical instruments for land surveying purposes provided a major advance to measurement. When combined with the new branches of mathematics and the standardisation of linear measurement, these defined new methodologies for land surveyors as their profession developed to meet the local demands, and those of exploration and colonisation. While each of these areas evolved, the principles established as a result of their adoption or creation in the 16<sup>th</sup> century, having once adopted them the nature of land surveying changed little over four centuries. There were only minor variations in the mathematics and steel measuring bands and optical theodolites were still being used to teach the students of land surveying in New Zealand in the 1980s (Neaves, 2014; Hemi, 2014.).

This second paradigm of land surveying persisted through centuries and was only impinged upon in the latter part of the 20<sup>th</sup> century. The developments that were to impact on the traditional practice of land surveying are those that have come to affect every aspect of modern society. The arrival of electronics and miniaturisation technology has brought into being instruments that have had an impact on the very nature of the practice of land surveying.

The invention and exponential expansion of the power of computers, along with the diminution of their physical size, have changed work practices. They have also enabled a new dimension in the visualisation of the outputs of the land surveyor's work. Further, the change from finding position by the stars and astronomically derived observations, broken down into terrestrially observed networks, to the use of satellite systems and their ubiquitous applications, not only by land surveyors but by the public at large, places considerable strain on the accepted definition of the role of the land surveyor in modern society. It challenges the 2<sup>nd</sup> paradigm in the evolution of the land surveying profession.

The arrival, development and influence of each of these developments is examined and discussed in detail in Chapter 5. The capabilities of the land surveyor and the land surveying profession to analyse, adopt, adapt and apply these technologies to the services they provide

are critical factors in the future definition of the land surveying profession. It affects how it is perceived by its clients and the public and also may be indicative of new educational requirements of the land surveyor of the future.

#### **4.4 Summary**

This chapter began with a description of the origins and functions of the land surveyor in classical antiquity. During this period surveyors were educated, respected and important functionaries in the Egyptian, Greek and Roman societies in which they lived. This may be considered the 1<sup>st</sup> paradigm of land surveying. Little development occurred in most of Europe in what is commonly referred to as the Dark or Middle Ages. During the Renaissance and particularly during the period of 50 years either side of 1600, a number of advances occurred that changed the means by which land surveyors undertook their work and the nature of it.

Arabic numerals were introduced, as was the decimal system, logarithms were invented, and geometry and trigonometry arrived through the incursion of the Moors into Spain, from the east. Lenses were developed, telescopes invented and angular measurement became increasingly more accurate. Additionally, standards were developed for linear measurement (amongst many others), which translated into mathematically definable areas for the identification of parcels of land and records developed to record their owners and a land market was established. Gunter's chain played a significant role in this regard. As European colonisation expanded to cover the globe so the idea of land ownership and land markets spread to those colonies. The methods developed in the early 17<sup>th</sup> century spread with the colonists. Those same methods were being taught to land surveyors in the 1980s, with the addition of photogrammetry. These elements define the 2<sup>nd</sup> paradigm of land surveying.

Chapter 5 extends the discussion of what defines the modern profession of land surveying and examines the elements of development in science and technology that have had an impact on the manner in which land surveyors carry out their work. It discusses the changes that have taken place from the middle of the 20<sup>th</sup> century, specifically the disparate developments since approximately 1950, on the nature of the work of the land surveyor. These include electronic distance measurement, computerised angular measurement, the use of satellite survey control in place of the traditional triangulation networks, the miniaturisation and

exponential increase in the power of computers for calculations, and the development of geographic information systems. While these impact directly on the work of the land surveyor, they have also contributed to an unparalleled shift in society at large.

## **Chapter 5**

### **Pressures on the Second Paradigm**

This chapter considers the pressures on the 2<sup>nd</sup> paradigm of land surveying, as identified in Chapter 4, in the late 20<sup>th</sup> century and the early 21<sup>st</sup> century. The advent of high speed electronic computing and digitisation has accelerated the changes in technology available to land surveyors. This chapter provides a review of the significant and relevant threads that, when woven together, influence the fields of interest that now characterise the modern discipline and practice of land surveying. Identifying the extent of the traditional occupation of land surveying in Chapter 4 has provided a platform for the identification of changes in the content or direction that have occurred, or are occurring, in the profession of land surveying as a result of these developments as the 21<sup>st</sup> century advances.

Since approximately 1950 technological change has been exponential. While it has had an impact on all facets of life, the equipment used by land surveyors has undergone revolutionary change over a short period, and change continues. Additionally, educational systems have evolved from on-the-job training supplemented by formal examinations, to university based education followed by post graduation technical and professional development.

As discussed previously in this thesis, for several thousand years of human development there had been a relatively stable idea of what a land surveyor was and what he or she might be reliably capable of doing. Change was incremental and reflected advances in the equipment used and the needs of the clients requiring land surveying services. While there were, and are still, variations from country to country, there was a common core of activity that could be used to define the nature of the profession. It was largely focussed around land, the measurement of land areas and features, the location of terrestrial features in relation to other terrestrial features, and the representation of those features in two dimensional maps or

plans. These could be interpreted by the surveyor, the surveyor's clients and in some cases, the public at large. Client expectations might be extended to include those features on the bed of the sea. Then it became possible for people to leave the ground and observe and measure the planet, or parts of it, from above the surface of the earth.

### **5.1 Land Surveying from the Air**

Land surveying from the air ranks as the first challenge to the traditional ground-based land surveyor (Staiger, 2009). The introduction of human flight in balloons and later powered flight in aeroplanes changed the world of information gathering about the land. When combined with the development of photography, it brought the ability, through the ingenuity of individuals, to interpret photographs of the land taken firstly from the relatively static platforms of balloons and then from moving aircraft. This activity could be considered a survey, and the result could be perceived as a form of map. In 1858 the first photographs were taken from a captive balloon and in Moscow in 1900 cameras were attached to kites. As is often the case, the taking of photographs from the air, and the making of maps from them, was given impetus by the growing awareness of their use for military purposes (Kilford, 1970).

Photography was invented in 1839 following the work of Niépce, Daguerre and others (Ghosh, 1979). Photogrammetry, the science of making measurements from photographs and converting them into maps, is attributed to Colonel A. Laussedat between 1851 and 1859 when he produced the first suitable cameras and operating procedures for this purpose. Ground photography for land surveying applications was in limited use before 1914. In 1901, the development of the stereocomparator, a means of looking at two aerial photographs taken from different places along a flight path, brought accurate photogrammetric mapping a step closer (Kilford, 1970).

Surveying for mapping purposes from aerial photographs became more practical with the increased use of aircraft for military purposes between 1914 and 1918. While not achieving accuracies required for non-military purposes, these aerial surveys were sufficiently accurate for the immediate wartime needs of the time (Hart, 1940). Following the First World War (1914-1918) aerial cameras were perfected and stereoscopes were connected to planimeters or semi-automated contour drawing machines. From this it became practical to produce maps

from stereoscopic pairs of aerial photographs quickly and accurately. From 1930 onwards photogrammetry was accepted as a discipline and a number of universities took up the training of photogrammetrists. Scientific journals devoted to the discipline were established as well (Kilford, 1970). The application of calculus and trigonometry to photogrammetry grew in importance in order to make the necessary adjustments and corrections, for the matters such as the tilt, swing and yaw of the aircraft while taking the photographs, and to facilitate accurate modelling, as is demonstrated in Kilford's textbook published in 1970.

Since then photogrammetry has continued to develop the use of stereo images and has used such techniques as colour film and infra-red emulsions to increase the applications to which its technology can be applied. Optical double projection principles were introduced by Theodor Scheimpflug and developed by Max Gasser (Schwidefsky, 1959). These developments led to the multiple optical projection (Multiplex) plotters, using the anaglyph technique, whereby strips of multiple aerial photographic transparencies could be projected onto a flat white table. Following appropriate adjustments and corrections, and using red-green glasses, a three dimensional model of the land and objects on it, such as buildings, could then be viewed. However photogrammetry remained reliant on land survey ground control throughout this period of development (Kilford, 1970). This type of modelling of the landscape was the forerunner of the computer-generated three dimensional (3D) digital terrain models that were to appear much later.

Aerial photograph interpretation and photogrammetry remain in wide use and are still taught in geography and land surveying courses, although they have uses in many other disciplines such as facial reconstruction surgery in medicine. Photogrammetry has also made many recent advances with global positioning systems (GPS) running in aircraft and recording the position of the aircraft while the aerial photography is in progress. The requirement for ground control on which to base photogrammetric measurements has not been reduced but has changed.

On this basis, photogrammetry is the first new “discipline” or specialisation to be added to the profession of land surveying in over 300 years. In this way it represents the first symptom of a change in the nature of the work carried out by land surveyors. It takes the land surveyor's feet off the ground, where they have been firmly planted for several

millennia. Thus it introduces a whole new area of methodology, application, and specialisation. It also requires a greater and different application of calculus and analytical triangulation which, while not of the nature of a fundamental threat by itself, it began to change some of the demands on the education and training of land surveyors through the first half of the 20<sup>th</sup> century.

While photogrammetry appeared as a new area of land measurement, little else changed in the broader profession of surveying in the early part of the 20<sup>th</sup> century. However, as the many technological advances made during the Second World War emerged into the private domain in the 1950s, other significant changes were about to impact on the science and art of land surveying. The first of these involved the technology related to linear measurement.

## **5.2 Linear Measurement**

Linear measurement by terrestrial methods using an updated version of Gunter's chain, the steel band, was used by land surveyors well into the second half of the 20<sup>th</sup> century. The conversion from chains and links to metres occurred on 1 January 1973 in New Zealand and the steel bands were updated to metric lengths. However, the steel band was still generally referred to as "the chain". The techniques necessary for accurate use of "the chain" were still being taught to students at the National School of Surveying in New Zealand, and used in professional practice, in the late 1980s (Hemi, 2014). In particular, they were using the Bolt and Sutherland steel band in conjunction with optical theodolites. The continuous steel bands came in standard lengths of 5 chains (100 metres) and 10 chains (200 metres) with the first chain, or "reader", calibrated in links with annotated markers every 10 links. Metric bands had readers of 10 metres with 20cm calibration marks (Neaves, 2014). Intermediate lengths could be obtained from manufacturers and an engineer's version also, which was calibrated in feet. Metric bands were still being used in the Pacific Islands in the early 21<sup>st</sup> century (Neaves, 2014).

Developments that led to the departure from manual techniques of distance measurement began as early as the 1930s. The Swedish scientist Dr Erik Bergstrand used his knowledge of the speed of light to devise an instrument that could emit light pulses, that when the pulse was returned and received by the emitting device and knowing the speed of light, could provide data from which the distance travelled could be calculated. In 1947 Bergstrand produced

high accuracy measurements (accuracy in the order of 1 in 100,000) over a 7 kilometre line and by 1953 had produced the first Geodetic Distance Meter, later to be the well known brand – the Geodimeter. These were manufactured by Svenska Aktiebolaget Gasaccumulator, more commonly known world-wide by the brand name AGA, a Swedish chemicals manufacturer (Cheves, 1999; Reuger, 1978).

During the same period Radio Detection and Ranging (radar) was developed and **High Intensity Radar Aids to Navigation** (hiran) and **Short Range Navigation** (shoran) emerged. However, while practical for navigation, these were not sufficiently accurate for land surveying purposes. More recently multibeam sonar technology has enhanced the work of the hydrographers and hydrographic surveyors in the specialist area of bathymetry. In 1955 the Council of Scientific and Industrial Research (CSIR) in Johannesburg commissioned Trevor Wadley to investigate a measurement system that was portable, worked by line of sight and gave high resolution measurements. Wadley is known to have made measurements using radio waves by June 1955 (Sturman and Wright, 2008). His invention was marketed as the Tellurometer by 1957, and had a longer range than the Geodimeter of the same vintage (Reuger, 1978). These early instruments were specifically designed for the measurement of longer range geodetic distances (Finn, 1983).

The internationally known companies such as AGA, Tellurometer, Zeiss, Wild Heerbrugg and Hewlett Packard, amongst others that became household names in the land surveying profession, have continued to develop measurement instruments using electromagnetic waves, radio waves, micro waves, visible light and infra-red radiation since those early times (Burnside, 1971). The development and application of such instruments continues and has led, almost, to the abandonment of the traditional manual form of measurement by land surveyors in the developed world.

While the earliest development work on electronic measurement occurred in the 1930s, it was not until the 1970s that electronic distance measurement (EDM) became generally available. Instruments such as the Wild DI-10 in 1968 (Reuger, 1978) and the HP9800B in 1969 using infra-red light (NOAA, 2007), were designed for short range measurement of up to 3 kilometres (University of New South Wales, n.d.). In 1973 the author was using one of the two HP3800B purchased by the New Zealand Department of Lands and Survey, and which

were circulated around the land district offices on demand, and the Wild DI-10 of the New Zealand Forest Service. These were amongst the first regularly used EDM devices in New Zealand. At the same time the author was involved in the testing of a Geodimeter Model 8 for geodetic measurement purposes in New Zealand.

Early EDM devices were still relatively large and cumbersome compared with later developments. Although they were initially a small tripod-mounted box, or in the case of the Wild DI-10 a set of optics mounted over a theodolite, they quickly reduced in size until they were able to fit inside the angle measurement equipment (the theodolite). This combined instrument became known as the “total station”. Trimble, the present owner of the Geodimeter brand, claims the first total station was available in 1971 (Trimble, 2013). According to Cheves (1999), AGA introduced automated electronic angle measurement in 1981 with the Geodimeter 140. However, Cheves appears to retract this later (Cheves, 2003) and agrees that both AGA (Geodimeter 700) and Zeiss (Reg Elta) introduced total stations at the same exhibition in 1971.

Combining the optical theodolite with small EDM devices allowed electronic measurement to replace the more traditional means. About the same time, glass angular measuring scales in theodolites were replaced by bar code readers. This allowed angular measurement to be made by the instrument itself, and was displayed in a liquid crystal diode format, or other medium, as a read-out. This replaced the requirement of the operator to “read” the glass circles through the optics of the theodolite. Furthermore Trimble introduced the first electronically levelled rotating laser in 1975, the first electronic level in 1981 and in 1985 added robotic instruments to its range (Trimble, 2013).

The integration of calculation into the electronics of the total station enabled the direct read-out of angles and “reduced” measurements (those to which such reductions as atmospheric or slope corrections had been applied already) giving horizontal and vertical (height difference) distances. This led quite naturally to the electronic data recorder, replacing the requirement for the land surveyor to record observations of angles and distances manually in field books which had then formed part of the survey records. These steps in development changed the routine nature of survey or positional measurement, but did not alter the requirements or its outputs in any profound way. However, they did change the nature of the work involved.

The latest developments in technology have brought the laser scanner into regular and growing wide-spread use, with significant applications to surveying and to land surveyors. The laser scanner is capable of collecting large quantities of measurement data that can be converted into 3-dimensional models using complex computer software. In this way, laser scanning is an extension of the discipline of measurement in combination with computerised modelling. Laser scanning can be used both indoors and outdoors. As such, while not a traditional role for surveyors, it can be compared in some respects to photogrammetric modelling as it combines many of the skills that land surveyors have acquired with the advent of digital technology. It does, however, place them in an innovative environment. Notwithstanding, the design of a data collection project, and the understanding of the measurements gathered, requires the traditional understanding of accuracies and error analysis that is largely the preserve of the professional land surveyor.

The development of EDM devices has changed profoundly the way in which land surveyors undertake linear measurements. It has also simplified the way in which angular measurements are made, although the changes are less significant as these measurements have always been made by some form of technology, however simple. These changes would not have been conceivable without the parallel development of electronic computers.

### **5.3 Computers**

In the period of classical antiquity land surveyors used geometric algebra and recorded their results on cuneiform tablets (Cooper, 2009). In the second period of the development of the profession Arabic numerals, decimals, logarithms and natural trigonometrical functions were developed. Mechanical devices were invented in the 19<sup>th</sup> century. One of the most notable was the development of the Original Odhner, a pinwheel arithmometer, by Willgodt Theophil Odhner (1845-1905), a Swedish mechanic working in Russia at Ludwig Noble's mechanical factory.

It is estimated that this machine, the first of its sort, was available in 1890, having taken since 1874 to develop (Leipala, 2003). Later models of this calculation aid, but with only minor modifications, were in use when the author sat computing examinations in the Department of Surveying at the University of Otago in 1972. They were used for office-based calculations as well as in the field for on-site and immediate computations. Other manufacturers such as

Monroe, Marchant and Facit had produced similar machines by this time, including one that was small enough to be held in the palm of a hand. Later still these calculators could be electrified to remove the hand-mechanical aspects of carrying out calculations, at least in the office setting.

Miniaturisation, exemplified first to the public by the transistor radio, also brought electronic calculators that would quickly replace natural and logarithmic tables. Extended battery life allowed them quickly to replace mechanical calculators and printed books of natural trigonometric functions and logarithmic tables, especially useful for calculations carried out during field work. The author was using Hewlett Packard-developed hand held calculators for in-field computations in 1973. Shortly after this larger punch-card- fed computers were replacing the need for much of the time spent doing lengthy office-bound computations by mechanical methods.

Punch cards were then replaced through the late 1970s and early 1980s by magnetic strips carrying “programmed” instructions, further simplifying the process. Continued advances in miniaturisation made sizeable desk-top computers obsolete quite quickly, as hand-held calculators increased in power and capacity, as well as reducing in price. As software developed and the power of hand-held calculators increased, complex mathematical problems that once took days of painstaking work with the use of natural trigonometric functions and logarithmic tables could be completed with accuracy and confidence in minutes. The ability to carry out complex calculations in small computers has continued to expand.

#### **5.4 Geodetic surveying**

Geodesy, or geodetic surveying, as defined by F. R. Helmert, is the “science of the measurement and mapping of the earth’s surface” (Torge, 1991. p.1). “It is that branch of the art of surveying which deals with such great areas that it becomes necessary to make systematic adjustment for the earth’s curvature” (Hosmer, 1919). However geodesy goes beyond land measurement and includes the surface of the sea floor as well as variations in the Earth’s gravity field. As such it has been of interest to humanity at least since the time of Erathosthenes, who may be regarded as its founder. Although interest lapsed in the European Middle Ages fresh impetus is found at the start of the modern age. This was especially so

following the developments in astronomy, particularly the telescope with the addition of cross hairs, as used by Abbé Picard in 1669/70 (Torge, 1991).

Advances had also occurred in the field of global positioning, for more practical rather than philosophical reasons, following the development of a reliable ships' chronometer for navigational purposes. In particular, this was driven firstly by the needs of the circumnavigators of the Earth, and then by the desire by European countries to map and then to colonise the "new" lands that were discovered as a consequence.

Since the 1600s, with the invention of the telescope, angular measurement technology and the principles of triangulation, considerable interest was rekindled in defining the shape of the Earth and defining or identifying positions on its surface. This was further aided by the work of the Frenchmen Delambre and Méchain in the 1790s with their efforts to measure a meridian of the Earth. They were also attempting to derive an international standard unit of linear measurement (the metre) to which all other measurements could be compared (Alder, 2002. p.3). Arc measurement and the art of triangulation played a significant role in the pursuit of earth measurement. With respect to the role of the land surveyor in geodesy, triangulation using the most accurate angular (precise theodolites) and linear (high accuracy long distance EDM) measurement remained the principal methodology until the advent of global navigational satellite systems (GNSS).

The Space Age began in 1957 with the launch of Sputnik 1. The "TRANSIT" submarine-positioning two dimensional project of the USA Defence Department, commissioned in 1958 and declared operational in 1964, was released for public use in 1967. In 1973 the Navstar Global Positioning System (GPS) project was formed. In 1983 the GPS constellation was made available for civilian use for the first time by the United States government. This, however, was only capable of allowing relative positioning, being deliberately degraded by Selective Availability (SA). That is, it gave the user a position only in relation to an already known position. It was not until 1996 that SA was discontinued and the military and civilian uses of GPS were separated. Since the first development of global navigational systems other countries or regions have developed or are developing their own satellite navigational systems. These include GLONASS (Russia), Galileo (the European Union), CNSS (China), QZSS (Japan) and GAGAN (India) (Bonnor, 2012).

While GPS technology was originally developed for the positioning of military transport and weapon aiming purposes, it has spread widely in civilian use. Among those uses is the measurement or positioning purposes of land surveyors (Bonnor, 2012). The land surveying community has been supplied with devices by its equipment suppliers and has widely adopted the ever-developing technology for the solution of measurement problems. However, it represents a fundamental change in the nature of data gathering regarding locating any place, object or feature on the Earth's surface. It must therefore have had some impact on the practice of land surveying. This impact goes well beyond the narrow range of interests of the geodetic surveyor, but has impacted on other specialised aspects of the land surveyor's work, including cadastral, engineering and hydrographic surveying. Within geodesy, and for the geodetic surveyor or geodesist, satellite systems have very specific advantages over former methodologies. For example they may provide platforms for satellite assistance in the determination of the exact shape of the Earth; satellite altimetry may be used in the determination of sea level and more particularly sea level changes.

Along with the advances made in the gathering of data for land surveying, there has been a parallel advance in the storage, recording and presentation of the information extracted from the data. The traditional form for this has been physical plans and maps often, but not always, compiled and drawn by specialised draughting personnel or by the land surveyor. Since the development of high capacity computers from the 1970s until the present, the nature of the storage of data and information has revolutionised the preparation, distribution and use of maps. This has had implications for not only the land surveying profession but the public at large.

## **5.5 Digital Mapping**

The conceptual origins of Geographical Information System (GIS) date back to an earlier period when Charles Picquet used spatial analysis and maps to chart the location of individual cases during an outbreak of cholera in Paris in 1832 (Land System Research (Australia), 2012; Morias, 2014). The medical practitioner John Snow is also well known for his identification, in 1854, of a London water pump as the source of an outbreak of cholera in Soho. Using crude draughting, mapping and statistical data Snow, with the help of the Reverend Henry Whitehead, was able to identify the offending utility by mapping the location of individual cases cholera (Aguirre, n.d.).

The credit for the creation of the first computerised GIS, and the first system to be termed as such, is attributed to Roger Tomlinson, a Canadian based English geographer (1933-2014) and resulted from a conversation he had in 1962 with Lee Platt a government official and head of the Canada Land Inventory. The resulting development is “responsible for the staggering shift in the way we conceptualise spatial information . . . GIS is everywhere” (Aguirre, 2014).

The landscape architect and urban designer Ian McHarg (1920-1981) has also been credited by some as the “father of GIS” (University of Minnesota (Rochester), n.d.), although it may be more appropriate to designate him the “father of overlays”. McHarg’s overlays were a form of mapping development for the site selection and design of projects. They foreshadowed the use of computers and digital mapping for this purpose. McHarg pioneered the use of transparent overlays superimposed on base maps, for the purpose of mapping the physical areas of a variety of environmental parameters that might constrain the location of a particular project. McHarg used one overlay for each parameter, which might be used, for example, to identify the need for the protection of environmental values, or for the avoidance of natural hazards or unsuitable areas. This was explained in his book *Design With Nature* where he says “. . . let us map physiographic features . . . Let us make them transparent. When superimposed . . .” (McHarg, 1971. p.34). These were of particular and practical use in the development of environmental impact assessment and reporting (Foster, 1993).

Since 1962 there have been immense changes in GIS but “the history of the development is little more than anecdotal” (Coppock and Rhind, 1991. p.21). The development of GIS from the 1960s is haphazard, and was a series of “. . . failures, set-backs, diversions and success”. Less is known about the failures but the notable successes relate to the work of Fisher at the Harvard Laboratory for Computer Graphics, Roger Tomlinson in the Canada Geographic Information System (CGIS), Jack Dangermond in the Environmental Systems Research Institute (ESRI) and Brickmore at the Experimental Cartographic Unit (ECU) in the United Kingdom (Coppock and Rhind, 1991, p.3).

In an attempt to discuss the history of GIS, Coppock and Rhind (1991) identify four overlapping phases of development. They refer to the first as the “research frontier”, dominated by the United States and the United Kingdom. The second phase is one of formal

research and government funding, lasting from about 1973 to the early 1980s. The “commercial phase” replaced this from about 1982 and has since rapidly become the “user phase”. In the latter two phases GIS has moved from the individual and isolated operator to inter-connected and integrated networks. It has also involved the integration of non-spatial databases (Coppock and Rhind, 1991).

Miniaturisation and the exponential expansion in the capacity of computers has characterised the information technology (IT) industry since Cooper and Rhind’s comments were made in 1991. This has enabled mobile telephones and other devices, through the design of applications (apps), to use GIS such that they have become ubiquitous. Unknowingly the population at large is constantly using GIS when they connect to Google Earth, Google Maps or similar proprietary products. Their movements may also be tracked in relation to maps using the GPS capabilities of their mobile phones.

GIS are constructed by computer engineers and computer systems architects who are specialists in their field. With front-end applications everyone is capable of using the products that are produced. Given that land surveyors have traditionally, since the origins of their profession, produced maps and plans for their clients, what place do they now have in the business of geographic information collection and management?

Particularly, land surveyors should be capable of interpreting the needs of their clients and converting these into specifications for the practical outcomes desired by their client. This requires that the land surveyors have sufficient familiarity with the capability of GIS, and the abilities of their IT builders, in order that appropriate design specifications can be prepared to meet the particular needs or desires of their clients. However, they may also have access to, and an understanding of, proprietary software or applications that can be purchased to meet any specific business need. If so, the practicing land surveyor will also require to have, or to employ, the necessary operating expertise to utilise these products.

In the public sector, some jurisdictions’ governments are utilising custom-designed GIS to maintain their land title and land surveying records. These systems have been developing since the late 1990s. They allow access to the national database by suitably qualified practitioners (for example, by way of a “license”) who constantly add to the system. While

these systems have been built in the first instance as a cadastral record, they are now being developed to be multi-purpose, survey accurate, object oriented, 3D/4D, real time, global and organic (Grant, 2014). Land surveyors have been at the forefront of this strategic approach to the development of a very specific GIS that has become one of wide use, as well as enabling for its community.

According to Enemark (2007) only 25-30 countries currently have cadastres that satisfy his definition of a good property system. His definition includes such factors as the ability of the general public to participate easily in the property market, widespread ownership, open access, the ability to make registerable transactions, and the provision of an infrastructure that allows for simple, fast, cheap, reliable and corruption-free transactions. It must also provide safety for housing and business, leading to investment and the formation and accumulation of capital.

## **5.6 Combined technologies**

In some instances new technologies have combined to produce completely new ways of working, new applications or new disciplines. These are not necessarily areas of application that are owned exclusively by the land surveying profession. These include laser scanning, building information modeling (BIM) and remote sensing.

The applications of laser scanning has opened up a capability to gather large quantities of data (point clouds) and in so doing made it possible to “map” both indoor and outdoor areas with high accuracy because of the redundant measurements included in the scanning process. An example of this is the ability to produce highly accurate representations of building façades especially useful in building preservation and restoration. It is also applicable in monitoring the movement of building structures. When combined with or turned into a GIS, 3-dimensional computer models can be generated. This is particularly useful in the construction industry as BIMs can be produced as a structure is built and later used to locate services through the buildings life and to accurately map interiors of floors for rejuvenation or office subdivision purposes.

Remote sensing is the ability to gather measurement data without being physically present. It is a combination of aerial photography, photographs taken from space (satellite imagery), photogrammetry, and the use of newly developed sensors. It has led to a resurgence in the interest in photogrammetry and has also spawned the use of unmanned aerial vehicles (UAVs or drones) now known as remotely piloted aerial systems (RPAS). Interest in drones has not been confined to the land surveying profession, but is popular amongst hobbyists also.

## **5.7 Summary**

Technology has had an impact at an accelerating pace over the last 100 years on every aspect of modern living. The first significant change to the skills of the land surveyor for over 300 years occurred with the application of photography to land measurement and analysis, and particularly with the development of stereoscope plotters for the interpretation of those photographs taken from moving platforms embedded within aircraft.

While the development of measurement, first linear and later angular, had a slow beginning in the middle of the 20<sup>th</sup> century, advances progressed rapidly once the fundamental technology was developed. This in itself has been embraced by the surveying profession, but did not bring about fundamental change to the land surveyor's work or underlying methodologies. It has increased dramatically the rate at which measurement data could be gathered and recorded, and removing much of the manual labour required for these tasks previously. Electronic calculators and computers added to the speed with which land surveying data could be processed and converted into the products required by clients.

The development of global navigational satellite systems from the combination of space science, remote sensing by specialised cameras and electronic measurement has led to fundamental change in the way in which position is established on the surface of the planet, particularly on land, though just as profoundly on the sea bed or its surface. No longer is it necessary to establish and maintain ground-based positional control systems of a high order, with origins in astronomical observations, in order to create and maintain high accuracy position identification. Satellite systems have rendered such systems obsolete and changed the methods by which accurate positioning is achieved.

Finally, the impact of Information Technology on the storage, management and manipulation of location data in GIS has made possible a range of new products, unimaginable half a century ago. However, many of these, and the ability to manipulate and manage the data, are not the sole prerogative of the land surveyor. Information technologists, geographers, architects and engineers, amongst many others, are capable of using the information provided by GIS. How long will the spatial data gathering expertise of the land surveyor be a necessary component in the creation of maps and other spatial data representations?

With respect to the land surveying profession specifically, does the combination of these advances that have occurred in the last 100 years threaten the 2<sup>nd</sup> paradigm as defined in Chapter 4? Is it such that a fundamental shift is about to occur, is in the process of occurring, or has already occurred? Chapter 6 examines the influences that the developments since the 1950s have had on the profession through discussion with educators and researchers in academic institutions with internationally significant academic surveying programmes. In addition, professional surveyor organisations and private practicing surveyors are interviewed to ascertain their perceptions. Specifically, the purpose is to identify if what they perceive to have taken place in the profession reflects a paradigmatic shift. This addresses the relevant aspects of their professional lives as they have responded to the new tools, new demands and new environment in which they work and provide their professional services.



## **Chapter 6**

### **Changes in the Surveying Body of Knowledge**

This chapter identifies the changes that have taken place in the surveying profession as a result of the changes in technology and the associated forces of modernisation described in Chapter 5. This is achieved by discussion with stakeholders in Great Britain and Ireland, Canada and Australia. These stakeholders include particularly academics, but also representatives of professional associations, government agencies (specifically Surveyors General) and individual private practitioners. Their views and opinions were gathered on the nature of changes to the profession of land surveying as demonstrated by subjects taught in recognised courses and by activities undertaken by those surveyors currently or recently practicing.

The specific regions chosen for information gathering were selected so that an assessment could be undertaken across an international community of similar practice, culture and language. The issues that are identified through interviews with those representatives are collated to establish a basis for considering their magnitude and impact on the profession. These are considered against the pressures on the profession already identified, with respect to their cumulative effect. This provides a basis for an evaluation, in Chapter 7, of whether or not collectively they indicate a sufficiently significant impact on the second paradigm identified in Chapter 4 to warrant the consideration of them as indicating a further shift of paradigmatic proportions for the surveying profession.

#### **6.1 The Research Approach**

In order to establish what changes had occurred in the activities that the modern land surveyor was trained to undertake, a methodology consistent with and based in grounded theory has been applied. This allows a hypothesis to emerge from the data that were

collected. In this case the approach involves interviewing mainly long-standing staff of academic institutions that traditionally have high standing in the surveying community. The objective is to establish changes in their academic curricula over the period of interest. Confirmation of change in the practice of land surveying also is sought by interviewing mature practicing land surveyors, as they could be located and were available, who had witnessed the changes in the education, training and the practice of the profession from their personal and professional experience and over an extended period of time.

### **6.1.1 Methodology considerations**

It is important for this research that the information gathered for this section is free of personal biases of the researcher, either intentional or unintentional. Since the author has had a long and deep association with the surveying profession, both nationally and internationally, a research methodology was required that, as much as possible, removed that potential for bias, and also had sources and relevance beyond New Zealand. The first decision regarding methodology, from the classification of social research provided by Blaikie (2010), was to opt for a comparative national case study over time. That is, to compare what had occurred by way of change in the countries selected for the case study. Furthermore, in order to minimise bias or the influence of preconceptions developed over a long career, sources independent of the researcher were essential.

Second, and for the above reason, it was considered appropriate not to develop an hypothesis or research approach that posed a question. Having a specific question could indicate an underlying view held by the researcher and this was considered to be at risk of encouraging data sources (interview subjects) to seek to agree with or react to the hypothesis, or to be less than frank in expressing their own opinions for fear of offending or entering into conflict with the researcher.

Third, universities that run surveying courses were considered to be the primary source. This was because of their need to be responsive to changes in the profession in a timely way if they were to meet societal needs for professional surveyors who are conversant and competent with modern developments. It was also useful that there are a limited number of universities that have such courses. This gave the further advantage that it could be possible

to achieve a high percentage response rate, but without amassing an unmanageable quantity of data.

The first source of data considered was that of using online sources. This was quickly dismissed. The principal disadvantage of using websites is that they record only the current state or curriculum of a programme and not past versions. As a consequence they do not indicate changes that have taken place over time, which is the focus of the research. The second source considered was a journal content approach. However there are few high level professional journals in the surveying profession, and those that do exist focus specifically on highly technical issues of practical surveying rather than curriculum, body of professional knowledge or graduate attribute issues. Nor do they deal greatly with professional issues, which may have been useful.

Given the relatively small numbers of sources, the limitations on budget and time, it was practical to visit the universities with leading surveying programmes in each of the countries. This would allow personal contact and interviews that could allow the researcher to explore past and present curriculum issues generally with members of the university community who had been in place for medium to long term tenures. They should therefore be able to respond knowledgably to questions of changing circumstances in the education of potential professional level surveyors. Similar opinions could be sought from local practitioners, as and when practicable to confirm, or otherwise, the views of academics.

An advantage of this approach was that the researcher already knew of the important institutions by reputation, and in many cases had an initial acquaintance with a faculty member who could assist in identifying the most appropriate academics and practitioners in their area to interview. As such grounded theory became the best fit as a methodological approach to the research topic. In this way no hypothesis or indicative question was required to be developed and no preconceptions of the researcher would be conveyed to the interview subjects.

### **6.1.2 The nature of the interview**

The general approach was to interview each subject with a set of open questions or topics compiled in a only semi-structured way, so that responses were spontaneous and original, as

much as could be managed. It was important for the integrity of the process that interviewees were not led by any preconceptions conveyed through “leading” questions or pre-formed opinions or ideas of the interviewer. It would also allow the discussions to follow the interviewee as much as possible, rather than being led by the interviewer, other than in the most light-handed way necessary to keep within the subject area. In addition, it would encourage them to share their experience with spontaneous reactions, rather than risk directing their responses to narrow areas or giving responses of a “closed” nature.

The interview was informal and did not have a set structure. A questionnaire was not used. The interview was more akin to a discussion between colleagues, but with the “interviewer” having an agenda or areas of necessary discussion. There were a set number of topics to be covered, some of only a very general nature in order to begin and conclude the interview. In some cases the subject did not need to be asked about the agenda items as they arose naturally in the discussion. The agenda was as follows:

1. The discussion was opened with an explanation of the nature and purpose of the study and an explanation of the background of the interviewer. Very general questions related to the origins, age, history, number of students, mergers that the surveying establishment had gone through, what degrees were offered. The purpose of these was to establish a comfortable relationship with the subject, who in most cases was not previously known.
2. Following the general opening two major topics were indicated. Specifically these were: what topics have been deleted from the course over time and for what reason, and what topics had been introduced into the course in their place. The purpose of these questions was to attempt to establish what extant changes had been made over time and why they had occurred.
3. This was followed by asking if there were any topics or areas of interest that the interviewee could foresee or would like to introduce into their programme.
4. The fourth major topic was what the subject considered to be the core of surveying. What was it that had to be included as a core competency for an individual to be considered, or to consider themselves, a (land) surveyor?
5. In order to evaluate the nature of surveying in the locality, a question was asked about the research that was being carried out by the subject and what motivated it, the

profession, the department or school, industry or some other factor. The purpose of this question was to attempt to confirm the response to the previous topics.

6. The interviewee was asked about their institutions programme's relationship with professional associations. That is, were they accredited by anyone and did they consider accreditation an important issue.

7. Finally the subject was asked if there were any other comments that he or she would like to make regarding any questions that had been asked or if they thought anything had been overlooked.

8. While those were the original topics, as indicated elsewhere, reference had been made by respondents to the questions in terms of "geomatics" when it had been introduced in terms of surveying. As a result, before the final question was put, subjects were asked about their views on the relationship between the terms geomatics and land surveying.

These interviews were recorded for later transcription into hard copy for full and detailed analysis. Each interviewee was provided with an information sheet to read prior to the interview and a consent form to fill in and to sign if they agreed to participate. No requests for participation were declined although one interviewee declined to be recorded. The discussion framework itself was approved by the principal thesis supervisor, Professor Hulbe. The methodology was given Category B approval by the University of Otago Human Ethics Committee.

### **6.1.3 Selection of universities**

The next decision in the process of selecting who to interview was constrained by the time available and the cost of travelling to the destinations dictated by the selection. As the home of the surveying system known to the author, the United Kingdom (UK) was a logical place to start. Additionally there were some pre-existing contacts within the university system, academic staff and the institutions of the UK that could prove useful. One of those contacts, the Director of the Land Group of the Royal Institution of Chartered Surveyors (RICS), recommended that the Dublin Institute of Technology (DIT) was a significant player in the education field in the region and that many of their graduates were active around the world. He suggested that they should be added to the itinerary, and his suggestion was adopted.

The other countries selected were Canada and Australia. South Africa was desirable but proved impractical mainly for financial reasons but also due to a lack of initial contacts. Canada was chosen because of the historical significance and reputation of two of its surveying departments, specifically the University of New Brunswick in Fredericton, New Brunswick and the University of Calgary in the province of Alberta. In hindsight it may have been useful to visit Laval University, Quebec, whose significance to the research only became clear much later in the process when a further issue emerged, that of terminology for the name of the profession. However, the influence of Laval University was later identified and evaluated through a literature search and the publications of several of its staff.

Australia was selected because of its proximity to New Zealand and the number of existing connections the author had with members of the academic community, with private practicing surveyors and government employees in all of the states and territories of that country. Additionally, both of these countries had been settled by British colonists, were developed countries and had well developed surveying educational facilities and surveying systems.

The second task was to identify which establishments to target for visits and whom among the academic staff to identify as the principal people to interview, or at least in the first instance, to contact. In most cases, the advice and assistance of the selected academics was sought in finding local contacts in other agencies or private practice with whom to conduct interviews. In particular, the higher profile and longer standing universities known for their surveying programmes would be the focus of the investigation.

The following establishments were selected because of their pre-eminence in offering surveying programmes. They are listed here by country, along with the principal contacts. The initial contact persons were asked to recommend appropriate interviewees in their university as well as within their region, based on a description of the thesis research, an explanation of which they were given. In all, 52 potential interviewees were identified. The establishments, along with the contacts, are as follows:

United Kingdom:

University College London (UCL), Senior Lecturer Dr John Illiffe;

University of East London (UEL), Principal Lecturer Dr Brian Whiting;

University of Glasgow, Senior Lecturer Dr Jane Drummond;

University of Newcastle-upon-Tyne, Senior Lecturer Dr Stuart Edwards;

University of Nottingham; Professor Gethin Roberts;

and on the recommendation of the RICS Director of the Land Group, James Kavanagh, in Ireland, added to the list was:—

Dublin Institute of Technology, Senior Lecturer Dr Paddy Prendergast.

In Canada the following universities, with contacts, were selected:

University of New Brunswick (UNB), Professor David Coleman; and

University of Calgary, Professor Michael Barry.

On the recommendation of Professor Brent Hall (principal supervisor at the time) visits were also arranged at:—

Ryerson University (Toronto), Professor Songian Li;

York University (Toronto); Professor Costas Armenakis.

York University was in the process of further developing a land surveying programme with the assistance of the Association of Ontario Land Surveyors, while Ryerson University was in the process of abandoning its land surveying programme, or at least merging remnants of it with its civil engineering programme.

In Australia the following universities, with contacts, were selected:

Curtin University, Western Australia, Senior Lecturer Mr Tony Snow;

Royal Melbourne Institute of Technology University (RMIT), Professor Nick Chrisman;

University of Melbourne, specific academic contact unknown in the first instance;

University of New South Wales, Sydney, Professor Chris Rizos;

University of South Australia, Associate Professor Dr David Bruce;

University of South Queensland (USQ), Toowoomba, Dr Albert Chong.

These contacts are not necessarily, and in many cases were not, the people who were actually interviewed.

As a result of budgetary and time constraints, as well as the existence of a thorough history of its School of Surveying by Robert Loeffel (2007), the University of New South Wales was removed from the programme. The visit to the University of South Australia did not occur

due to tight constraints on the time of Dr Bruce and ill health on the part of the author while in Adelaide. However, a senior and a junior surveyor in private practice were interviewed, as was the Surveyor General of South Australia. Professor Chrisman of RMIT had resigned from his position in the university by the time detailed arrangements came to be made and the visit to that institution was facilitated by Associate Professor Don Grant (by then a thesis co-supervisor). At the last minute, that is, during the week before the planned visit, the proposed interviewees at USQ in Toowoomba all proved to be unavailable, despite prior arrangements having been made many weeks before. Alternative arrangements had to be made in Brisbane at short notice through other contacts in the private and government sectors, but academic interviewees proved to be unreachable, probably due to the approach of the summer vacation.

The original intention was to travel to Australia first, in June 2014, to carry out the interviews and return to Dunedin. This was to be in the nature of a pilot programme, in part because many of the people involved were generally known to the author, and in part because the location was closest. It would allow for any refinements to be made to the process if these were found necessary or appropriate, and in the worst case, it would be economical to return if this was found to be necessary. The plan was then to proceed through Canada from west to east and then on to the United Kingdom to complete the interviews.

It became clear, as a result of thesis and other academic commitments, and as the year progressed, that it would not be possible to arrange a departure from New Zealand before August. Therefore, if the above itinerary were followed the travel programme would run extensively into the northern hemisphere winter. This could put at risk the ability to travel and therefore keep to the proposed itinerary, and in turn to maintain the pre-arranged meetings programme with the interviewees. The decision was therefore taken to run the original programme in reverse. That is, to start with the United Kingdom, cross the Atlantic to Canada and generally head from east to west, concluding in Calgary. Later, Edmonton was added to the itinerary as the offices of the Surveyor General of Canada and the Alberta Association of Land Surveyors were located there.

One week was allowed at each centre, with the exception of London and Toronto where there were two universities. Two weeks, therefore, were allowed in each of those. Travel between centres was undertaken during weekends. The first journey began with the departure from

Dunedin in August 2014 and returning to New Zealand in October 2014, having completed the interviews in Great Britain, Ireland and Canada. Allowing a short time for recovery and consolidation, the field work was then completed with the tour of Australia, beginning in Perth in mid November 2014 and concluding in Brisbane in early December 2014. Of all the contacts that the author sought, and all those that were recommended to be contacted with a request to conduct an interview, not one declined, although one declined to be recorded. All of the participants were cooperative and willingly signed the *Participants Consent Form* provided, (the original of which can be found at Appendix 1) having first read the information sheet.

#### **6.1.4 Interview Metrics**

The interview programme accumulated 45 recorded interviews and 7 conversations or discussions that were not recorded. The unrecorded conversations occurred for a variety of unrelated reasons. They were either in inappropriate places, for example in a noisy bar or cafeteria, over lunch in a public place, in the presence of a self-invited “participant”, or the person simply did not want to be recorded. On one occasion, early in the study tour, the author underestimated the potential significance of an interview, which had begun only as a discussion with a colleague, and as a result neglected to record it. However, notes of these unrecorded conversations were written up at the earliest opportunity, but often that was some time later and after other interviews or events. Their value for subsequent analysis was therefore, and unfortunately, considerably diminished, depending largely on the recall of the interviewer.

Apart from those with whom prior arrangements had been made through email appointments, other long-standing university faculty available during the week of the visit to a particular city were interviewed if they were agreeable and a mutually suitable time could be made available. Recommendations were sought from all of these individuals for other surveyors outside the workplace who might be available and willing to participate. This was more successful in some places than others. It being the summer holiday period in the United Kingdom made it particularly difficult to find other contacts. It was also notable that (a) university staff members generally were not well connected to their graduates and (b) most graduates from all over the United Kingdom seem to have headed into the hydrographic area and were working off-shore.

In all 55 subjects were interviewed including (a) 45 recorded interviews with 48 individuals, 3 interviews being with 2 interviewees at the same time. Seven interviews were not recorded. Of the 45 recorded, 17 were from the United Kingdom, 15 from Canada and 13 from Australia. Of the 48 recorded interviewees, 26 were academics, 12 were from private practice and 10 were from government agencies or professional institutions. Of those not recorded, 3 were academics, 2 private practitioners, 1 professional institution officer, and 1 a government official. With respect to gender, 11 of the interviewees were females, being 7 from academia, 3 from the private practicing sector and 1 from a professional institution. Women were represented in all of the age groups. Table 6.1 shows the distribution of sectors in which the interviewees worked and by age.

	20-30 yrs	30-40 yrs	40-50 yrs	50-60 yrs	60+	Total
Academic	—	5	4	11	9	29
Practice	3	4	2	—	6	15
Government	—	—	1	3	1	5
Administrative	—	—	1	4	1	6
<b>Total</b>	<b>3</b>	<b>9</b>	<b>8</b>	<b>17</b>	<b>18</b>	<b>55</b>

**Table 6.1 Sector and age of interviewees**

In total the 45 recorded interviews provided 23 hours and 27 minutes of discussion hence the average length of an interview was approximately 53 minutes, the longest being 1 hour and 58 minutes and the shortest 16 minutes. All of the recorded interviews have been transcribed into hard copy for detailed analysis. Transcription of the interviews provided 625 pages of text containing 316,550 words. These transcriptions, and the audio files, will be destroyed on completion of the project.

The transcriptions were subsequently coded to protect the identity of the interviewees when reference is made to their comments in later chapters of this thesis. The principle behind the code was to first put the transcriptions into an alphabetical order based on one of the parameters (e.g. a forename) and then number them consecutively. They were then allocated an uppercase letter to indicate their country of origin: G for Great Britain and Ireland; C for Canada; and A for Australia. Finally they were allocated a lowercase letter signifying which segment of the profession they belonged to: “a” for academic; “p” for private practice; “g”

for the government sector; and “i” for professional institutions. For example, the code 35Ca would signify that a quotation had come from a Canadian academic, while the code 27Gi would indicate a quotation from the interview of someone from Great Britain or Ireland who worked for a professional institution. Unless there is a compelling need to identify the author of any quote from an interview, the reported quotes are anonymous and only identified using this code.

## **6.2 The development of surveying as a unique university discipline**

While the art and science of land surveying is ancient in its origins, as discussed in Chapter 4, its establishment as a university discipline is relatively recent and usually development has been incremental. For this reason, at least in part, there is little written history about the development of the university discipline. The history is therefore largely anecdotal although three written histories of university surveying programmes were found, namely the UEL (formerly well known as the North East London Polytechnic), the University of Melbourne and UNSW, and consulted during the research.

### **6.2.1 The United Kingdom**

From the interviews conducted at the various universities it is apparent that surveying has been taught in the United Kingdom for over 100 years (Interview 33Ga). However, in these early years it was taught in the first instance as a service to other programmes within the universities, in particular geography and civil engineering, but also to mathematicians, archaeologists, and physicists (Interviews 16Ga, 29Ga, 33Ga, 36Ga). There is general agreement that the move towards an independent university discipline followed the Second World War and as early as 1949 (Rogers, c.1999), but more widely during the 1950s and the 1960s (Interviews 16Ga, 29Ga, 33Ga, 36Ga). It is also suggested strongly (Interviews 16Ga, 29Ga; Rogers, c.1999) that the military, specifically in the person of the Director of Colonial Surveys of the Ordnance Survey (a civilian organisation since 1974) played a leading role in its establishment.

South West Essex Technical College, after several name iterations to become the present UEL, through its Department of Architecture and Building, began offering courses and examinations in land surveying in 1949. The specific objective of these courses was to

prepare candidates for entry into the Land Surveying Section of the RICS as Professional Associates. The original course tutor was “a geodesist of high repute”, Mr Michalski, formerly a major in the Polish Army (Rogers, c.1999). This is construed, at this formative stage, to be a service to the profession rather than the establishment of surveying as an independent university discipline. The first reference to a degree is to a Bachelor of Science in Land Surveying Sciences being approved in 1968 (Rogers c.1999. p7).

Under the leadership of Gordon Petrie, the University of Glasgow had begun to offer a degree in Topographical Science, believed to be in 1962 or the mid-1960s (Interviews 16Ga, 29Ga). Given the source of the information, the 1962 date is likely to be more reliable. It can be noted from a connection through the University of Glasgow website that Professor Petrie gained a Post-graduate Diploma in Surveying from UCL in 1952-53 following a Masters degree in Geography from the University of Aberdeen from 1948-52 (University of Glasgow, n.d.). Rogers (c.1999. p.2/3) noted that UCL had established a Chair in Surveying and Photogrammetry in 1946, but commented that UCL “taught only undergraduates in related subjects” (author’s emphasis), implying there was no department but only an appointment to cover these nominated topics in support of its engineering programmes. This is presumed to be a reference to earlier comments made regarding civil engineering and geography students in particular (Interviews 33Ga, 36Ga). Again, this is identified as providing some surveying knowledge to graduates in other fields, rather than the establishment of an independent university discipline in surveying.

However, interviewee 33Ga refers to a diploma established in 1950-51 at UCL that later became an MSc in Surveying. This may be a reference to the same post-graduate diploma taken by Petrie. However, Glasgow’s reference to Petrie’s qualification does confirm that there existed at UCL as early as the early 1950s, a postgraduate qualification specifically in surveying. It is also suggested by interviewee 33Ga that much of the drive came from the British Government Directorate of Overseas Surveys, and that the objective was to “improve the mapping infrastructure of British overseas colonies”.

The chronology therefore appears to be that surveying was taught first at UEL at an undergraduate level from 1949 but did not reach degree status until 1968. However, it was being taught at a post-graduate level to graduates in cognate subjects at UCL as early as

1950. The University of Nottingham taught surveying within its civil engineering department, beginning in the 1960s and referred to its discipline as Engineering Surveying (Interview 36Ga). The University of Newcastle-upon-Tyne first offered joint honours degrees 50/50 of surveying with geography, mathematics or physics from the time it separated from the University of Durham in 1963. It had offered service courses prior to that, but its separation from Durham and its employment of a former senior Ordnance Survey Officer (Lieutenant General Pat Carmody), a University of Cambridge graduate, were significant. Carmody, given a free hand, grew the programme into a surveying degree as a stream of the new University of Newcastle-upon-Tyne's civil engineering department (Interview 16Ga).

It is therefore claimed, legitimately judging by the consensus, that Newcastle had the first undergraduate surveying degree programme in the United Kingdom (Interview 16Ga). UEL was teaching surveying at a tertiary level (but not for degree purposes) for RICS professional membership earlier, and UCL was teaching surveying at a post-graduate level before them. Glasgow was teaching topographical science in these early days as well, but as ancillary to other programmes.

Whatever the technicalities of the claims, it is clear that following the Second World War there was a strong drive within the United Kingdom to formalise land surveying professional qualifications first through tertiary teaching, and then by establishing degree programmes throughout the area. These degree programmes were driven largely by the government, and more specifically by the British government's Ordnance Survey and its Directorate of Overseas Survey in particular.

Thus, there appears to have been a dual origin in the nature of the courses. The first was for mapping purposes, or to use the Glaswegian term topographical science, and therefore related to geography. The second was for infrastructure development, resulting in the attachment to, alongside of, or development within, existing departments of civil engineering. The two were not always completely separated and in some cases aspects have moved between the various departments within the one institution (Interview 33Ga).

Quite incidentally, and in a quite separate context during Interview 27Gi, the interviewee talked of the history of land surveying in the UK coming from the rural context of mapping for land management, large scale mapping, and boundaries and for land taxation purposes. He intimated that the engineering context of the land surveyor only emerged in the 1950s, 1960s and 1970s consequent on major infrastructural development in the UK such as motorways, power stations and high-rise buildings. This goes some way to explain the connection, with the exception of Scotland, of surveying departments with civil engineering faculties. The exception of Scotland may be further explained by the lesser importance of infrastructure development in Scotland during those years (Interview 27Gi). This suggests that engineering faculties, or the engineering profession, was becoming more aware of the expertise of the surveyor, and for the need for surveying expertise in large scale construction projects.

### **6.2.2 Ireland**

The Dublin Institute of Technology began its tertiary education programme with a 4 year diploma course in 1967, producing its first diplomates in 1971. After about 10 years this was reduced to a 3 year course due to lack of numbers. As this programme was not degree awarding, many of those who gained the diploma were going off-shore to complete a degree so that they could gain professional recognition or progress to a master's degree. To counter this, a BSc (Hons) in Geomatics was established in 1999. The use of the term geomatics is discussed in detail in Chapters 8 and 9. This indicates that while Ireland was conscious of the need for tertiary education in land surveying at approximately the same time as the developments in the UK, it did lag behind in developing a full undergraduate programme.

### **6.2.3 Canada**

The situation with the development of land surveying as a university discipline in Canada is considerably simpler and clearer than in the UK. As with other British Commonwealth countries it took place at a slightly later time, but not significantly so. The birthplace of surveying at a university level in Canada was the University of New Brunswick in Fredericton, New Brunswick. A series of events culminated in the establishment of a surveying course within the Department of Civil Engineering, a constituent of the Faculty of Engineering. These events involved the council of the Canadian Institute of Surveyors (CIS),

the New Brunswick Branch of the CIS, the UNB Faculty of Forestry and the Faculty of Engineering staff members and given the burgeoning urban development in Canada in the late 1950s. The core disciplines were geodesy, photogrammetry, cartography, land surveying, engineering surveying with hydrography being added later (Wells, 2010).

Classes started in the autumn of 1960 with four students. The first staff member was Dr Gottfried Konecny, a photogrammetrist. As it developed the UNB provided the first English-language land information systems programme and was a leader in developing courses in remote sensing and geographic information systems. In 1965 the Department of Surveying Engineering was established in its own right within the Engineering Faculty (Wells, 2010). In discussing the present place of the discipline within the Faculty of Engineering at the UNB, it was made clear that Surveying Engineering was regarded within the Faculty as an equal with the other engineering departments (Civil, Electrical, Mechanical and Chemical).

While it is no longer a sub discipline of civil engineering (Interview 42Ca), “At the Canadian universities, surveying education so far [2010] has been part of the Civil Engineering curriculum . . .” (Secord, 2010). “I wouldn’t call it a sub [discipline], I would call it one of the disciplines of engineering” (Interview 42Ca). So surveying, or more commonly geomatics or geomatics engineering, is quite clearly regarded as a component of engineering rather than a unique discipline. The department within which the land surveying programme is taught now is the Department of Geodesy and Geomatic Engineering, a department within the Engineering Faculty.

While the programme at the UNB was started in the early 1960s, it is apparent that it was the only degree programme that was servicing Canada’s 35,000,000 English-speaking population (Interview 38Ca). Edward Krakiwsky was a Doctor of Philosophy graduate from Ohio State University who had joined the UNB in 1968 (Wells, 2010. p28). In 1979 he resigned from the UNB to start a Geomatics Engineering Department at the University of Calgary (Wells, 2010. p60). That he was the first head of Geomatics Engineering at the University of Calgary was confirmed in Interview 38Ca.

The objective of creating a geomatics teaching department at Calgary was that the university would provide for the western provinces of Canada what the UNB was providing for the

maritime provinces (and elsewhere). It is a telling commentary to note that when questioned on the location of most graduates from the UNB programme in Interview 42Ca, it was stated that “the vast majority go out west. By out west I mean Alberta, British Columbia, Manitoba, driven by the oil industry” (Interview 42Ca). So while the purpose of setting up the Calgary programme had at least one specific objective, that institution was not, apparently, satisfying the demand of that segment of the national market for surveyors. One suggestion for the interest of graduates in going into that aspect of surveying, or geomatics engineering, was the level of student debt and the comparative level of salaries they could earn in that market.

In the 1960s in Ontario, Ryerson University in Toronto was a polytechnic. In 1966, encouraged by the Association of Ontario Land Surveyors (AOLS), it offered a 3 year diploma and a 4 year Bachelor of Technology degree in Surveying Engineering (Ryerson University, n.d.). Given the nature of the AOLS it is likely that the course had a very heavy emphasis on cadastral surveying. Current staff at Ryerson University, being from overseas and relatively recently arrived, know comparatively little about the history of their programme and were unable to supply much detail about the history of surveying at that institution. However, surveying (surveying engineering or geomatics) has now been removed as a specialist option from their curriculum (as of 2014) although all civil engineering students are required to take 6 geomatics courses within their degree (Interview 49Ca).

Meanwhile, York University, also in Toronto, has put in place a geomatics engineering programme in its Faculty of Earth Science. The York BEng Geomatics Engineering website states that “York is the only university in Ontario and only one of four in Canada offering this program!” (York University, n.d.). The page cites the UNB (twice) and Calgary, but does not cite the fourth, but it may be a reference to the Ryerson programme mentioned above, or possibly Laval University in Quebec. Again, the staff that were available at York were relatively recent appointments (within the last 10 years) and from overseas. The best estimate of the start of the programme at York was 2001 (Interview 22Ca).

However at the time of the interview at York (in late 2014) they had been working closely with the AOLS. This was so that the curriculum allowed graduates of the programme, among other things, to seek certification as Ontario Land Surveyors (OLS), a status that would allow them to undertake land title registration surveys (cadastral surveys). They might also become

an Ontario Land Information Professional (OLIP). While the AOLS does not accredit courses (Interview 8Ci) it is clear that York sees an association with AOLS as a strategic marketing point of difference. The AOLS has concerns about the age profile of its membership, 72% being over the age of 50 years, and made up mostly of those licensed to carry out land title surveys (Interview 8Ci). It is likely that the origins of this course, at least in part, lie in pressure from the provincial association to enlarge its pool of potential members.

University education for surveyors began in Canada only slightly later than in the United Kingdom. It appears from the staff names referred to in Wells (2010) that surveying education in Canada was heavily influenced in its origins by the continental European approach to surveying as a branch of engineering rather than as a separate and unique discipline. However, as in the United Kingdom, it was responding to the societal development needs of the immediate post war era for surveyors.

#### **6.2.4 Australia**

As part of its civil engineering staff, the University of Sydney had a full time surveying lecturer as early as 1890. The Institution of Surveyors New South Wales (ISNSW) was agitating for a full time university course in New South Wales as early as 1925. Surveying degrees were being offered by the University of Queensland in 1937 and in the University of Melbourne in 1949. The University of New South Wales (then the New South Wales University of Technology), established in 1949, enrolled its first students in a full time surveying degree course in 1957 (Loeffel, 2007).

The University of Western Australia taught surveying through the 1930s, 40s and 50s, but discontinued doing so in 1963 as it was no longer considered viable. It is not known when it started, but surveying was also taught at Perth College. Perth College became West Australia Institute of Technology (WAIT) in 1967, which in turn became Curtin University in 1987. WAIT was able to issue degrees and in particular a Bachelor of Science of Surveying (Interview 52Aa).

The Royal Melbourne Institute of Technology University (RMIT) has a similar history to that of Curtin. It is uncertain when the teaching of surveying began, but it is speculated that it is

over 100 years ago, and that it was as night school study to assist surveying “cadets” in their professional training. The date of surveying as a discipline in itself is somewhat uncertain also. There is correspondence signed by a “Head of Department” in the early 1960s, but it is thought that the first degree course started in 1968. While at this time officially a polytechnic institute, RMIT could not issue degrees in its own name, but was able to do so as a member of the Victorian Institute of Colleges (Interview 12Aa). RMIT achieved university and degree awarding status in 1992 (RMIT, n.d.).

While surveying appears to have been taught from an early date in tertiary institutions in Australia, it is likely that this was in support of the examination process common through Australia and New Zealand in the early days of colonisation. Surveyors were “articled” (similar to an apprenticeship) to “master” surveyors, that is, those already fully qualified. They learned their profession in practice under the tutelage of their master practitioner. Gradually Surveyors’ Boards were set up in each of the Australian jurisdictions. That is, each state or territory established its own system independently. The function of the Boards was to license or register surveyors for the purpose of land boundary definition and registration. The Boards collaborated by an agreement reached in 1892 in Melbourne, which included New Zealand, and took turns at setting examinations to test the theoretical knowledge of candidates for licensing. Each Board then carried out *viva voce* and practical examinations of their own jurisdiction’s candidates to complete the process.

As university degrees became universally available throughout the region, Boards discontinued their theoretical examinations in favour of recognising university diplomas and degrees. The practical law examination and the oral examination of projects portions of this historic system continues, and is conducted at an appropriate period after graduation for those who wish to carry out land title surveys (Coutts, 2010; Coutts, 2011). By 1964 almost every Australian state, was offering a surveying university degree (Loeffel, 2007).

### **6.2.5 Summary**

Land surveyors traditionally learned their profession at the feet of their masters, in the metaphorical sense but also almost in the real sense. When surveying professional bodies were set up in the 19<sup>th</sup> century, most established examination processes by which they tested whether candidates met the criteria that merited admission as professional members. These

included tests such as written examinations, field work tests, project work and individual oral examination. In many places most of these still exist.

It is clear that the surveying profession, in the countries examined in this research, recognised the need for university educated civil engineers to have some education in surveying as early as the late 1800s. However, surveying as a unique and self supporting academic discipline did not emerge until after World War II. In most cases, Scotland being the exceptions, these surveying degrees grew out of or were attached to existing engineering programmes.

Nevertheless, whatever the origins, the 1950s and 1960s saw surveying programmes start up in all of these countries within a quite short space of time, and apparently quite independently, as surveying sought to establish or maintain its status alongside other modern professions. The other significant influence, quite independently, was the acceleration in technology. Measurement technology in particular, as computerisation and miniaturisation took hold, required much greater understanding of the less than obvious internal operations of the new devices.

Over the little more than half a century since the introduction of specialised and independent surveying degrees, the variety, nomenclature and length of study to attain them has altered considerably. Additionally the content has changed, developing and adapting over time. Universities, being autonomous institutions, while often consulting professional institutions in the process, have named their degrees, and decided on their content. This has happened in accordance with the nature of the faculties in which they are housed and influenced by local custom and sometimes current fashion. The following section identifies the surveying and related degrees offered by the universities visited in the course of this study.

### **6.3 Degrees offered by the Institutions visited**

The 14 institutions visited in the course of this research were those that have supplied graduates to the profession of surveying in their local area and to the wider global profession, given that a proportion of their graduates chose to enter practice elsewhere. Some would pursue further study for higher degrees, specialisations or take up academic positions. This study is particularly concerned with those undergraduates being prepared for professional practice and what they are taught. Hence; it focuses on “first” degrees.

Institution	Degree(s)	Duration	Accreditation
DIT	BSc (Hons) Geomatics (Surveying and Mapping) MSc Geospatial Engineering <i>BSc (Hons) GIS</i> <i>MSc Spatial Information Management</i> <i>MSc Geographic Information Sciences</i>	4 years	SCSI/RICS/ICES/ISI SCSI/RICS/ICES/ISI
Glasgow	MSc GeoInformation Technology & Cartography MSc Geospatial & Mapping Sciences	12mths 12mths	RICS/ICES ICES
Newcastle	BSc (Hons) Surveying and Mapping Science BSc (Hons) GIS <i>MSc Civil Engineering Surveying</i>	3 yrs 3 yrs	RICS/ICES RICS/ICES
Nottingham	BEng (Hons) Civil Engineering (Full survey option) MEng (Hons) Civil and Enviro Eng (undergraduate)	4 yrs	RICS/ ICES/ICE RICS/ICES/ICE
UEL	BSc Surveying and Mapping Science BSc Civil Engineering and Surveying		RICS/ICES RICS/ICES
UCL	MSc Surveying MSc Geomatics for BIM <i>MSc Hydrography</i>	12mths 12mth 12mths	RICS RICS (pending 2014) IHO
Calgary	Bachelor of Geomatics Engineering	4yrs	CBEPS
Ryerson	Bachelor of Civil Engineering		CEAB
UNB	Bachelor of Geomatics Bachelor of Geomatics Engineering	3yrs 4yrs	ACLS APE/CBEPS
York	BEng (Geomatics Engineering)		CBEPS
Curtin	Bachelor of Surveying <i>BSc (Engineering and Mining Science)</i>	4yrs 3yrs	WASB (by inference)
RMIT	Bachelor of Applied Science (Surveying) (Hons) <i>Bachelor of Science (Geospatial Science)(Hons)</i>	4yrs 4yrs	SRBV/RICS RICS
Uni Melb	Bachelor of Environments + Master of Geomatics Eng <i>Master of Engineering (Spatial Systems)</i> <i>Master of Information Technology</i>	5yrs	SRBV/RICS
Uni Sth Aus	Bachelor's degree + Master of Surveying	4.5 years	SBSA

**Table 6.2 Relevant degrees offered by universities visited.**

**Key to abbreviations not already defined:**

SCSI: Society of Chartered Surveyors of Ireland;	ICES: Chartered Institute of Civil Engineering Surveyors;
ISI: Irish Surveyors Institute;	ICE: Institute of Civil Engineers;
IHO: International Hydrographic Institute;	CBEPS: Canadian Board of Examiners for Professional Surveyors;
CEAB: Canadian Engineers Accreditation Board	APE: Association of Professional Engineers;
SBWA Surveyors Board of Western Australia;	SBSA: Surveyors Board of South Australia;
SBV: Surveyors Registration Board of Victoria;	

Table 6.2 shows the names of the universities, the names of the surveying-related degrees offered by them, and includes whether the programme is accredited, and if so, by whom. The table includes, in addition to the regular undergraduate programmes offered, those that are

available in other closely related disciplines within the same department and in particular, degrees in geographic information systems (GIS). These are shown in italics. The relationship between land surveying and GIS will be discussed in a later chapter.

In addition to the programme itself, a question was asked as to whether the course had any accreditation. Accreditations are available from professional bodies, and in some countries, especially those with Torrens type cadastral systems, from licensing bodies. The degree of importance placed on accreditations varies from country to country. The level of influence that the accrediting body has on the curriculum of the institutions also varies quite significantly between countries.

Most of these courses began their existence following the Second World War first as global recovery and then global prosperity, at least in the western hemisphere, took hold. It appears purely coincidental that just as the first of these university programmes was beginning to appear, so were developments beginning that would reshape the way in which land surveying was carried out. In particular, the technology that had brought new developments and inventions for that conflict found new markets during the taut peace of the Cold War. These accelerated slowly at first, but with increasing rapidity as the decades passed. Their influence on society in general was broad, from transistor radios to satellite defence systems. However, they had a profound impact on the land surveying profession. The advances in electronics were of particular relevance to the art, but more particularly the science of measurement.

Some of the advances simply meant that time consuming tasks could be conducted more quickly. For example, a hand-held calculator could save the time of looking up six-figure natural trigonometrical tables in order to carry out both simple and more complicated surveying computations. This could speed up both field and office work. However, as time passed, new instruments appeared that required new techniques and skills, and rendered others obsolete. New topics had to be introduced into curricula.

It may also be noted for future discussion how many times the term “surveying” does not appear in the title of these qualifications compared with “geomatics” and “engineering”. It does occur in the name of almost all of the accrediting bodies. Many universities place considerable emphasis on having accreditation from professional bodies. In some cases this

is used prominently in their advertising. However, in other cases, particularly in Canada, the surveying curriculum is heavily influenced by an external professional examining and standard setting body such as the Canadian Board of Examiners of Professional Surveyors (CBEPS).

Table 6.2 demonstrates the variability of the names, duration and locations of the most prestigious and well known programmes in land surveying in the countries that are the subject of this research. Starting from small beginnings following the Second World War, surveying as a university discipline has spread through the mainstream universities of these countries. The undergraduate programmes range from 3 to 5 years in duration with a tendency towards a 4 year degree programme. Only two universities in the whole of England now offer undergraduate land surveying courses (Newcastle and UEL).

Two universities in the UK teach only at the post graduate level, offering only masters degrees (UCL and Glasgow). Entry to these courses is by way of a first degree in a cognate subject. In Glasgow these are often attended by day-release part-time students and the scheduling of classes is organised to facilitate this (Interview codes withheld for anonymity). Canadian land surveying courses are all designated “Geomatics Engineering”. These are within engineering schools, and geomatics is an option selected from a variety of engineering disciplines. At the UNB geomatics is in the Faculty of Engineering and students select which branch of engineering they wish to study from the 4-year programmes. In choosing geomatics engineering they graduate as engineers. If they choose a particular set of courses they may also seek a licence as an Ontario Land Surveyor. Additionally, should they wish only to progress to being a land surveyor they can choose to complete the 3 year Bachelor of Geomatics.

At Calgary students are required to select which branch of engineering they wish to enter, expressing their choice as a list of preferences, when they enrol for the first time. Predominantly geomatics is the third choice of students after chemical (due to the oil industry) and civil engineering (Interview code withheld for anonymity). The university then allocates students to programmes based on their first year academic performance and their expressed priority.

The University of Melbourne is unique in that it requires a specific undergraduate degree (Bachelor of Environments) and the surveying course competes for students to elect surveying as their major for a Masters degree (Master of Geomatics Engineering). Competition for students comes principally from other professional disciplines such as architecture, engineering and planning. If candidates then wish to proceed to a cadastral licence they are required, by the Surveyors Registration Board of Victoria, to pass specified subjects (Interview 11Ap). This extends the university education of land surveyors in Victoria to 5 years. The University of South Australia also has a 5 year programme (Interview 39Ag).

Professional institutions will use the accredited academic qualification as the basic educational standard for membership of their organisation and as a prerequisite for further examination of professional standards. This occurs after an appropriate period of post-graduation practical experience of candidates (generally referred to as “articles”). In almost all cases, the accrediting body undertakes routine audits of the courses it accredits, commonly at 5 yearly intervals. Accreditation was occasionally referred to as a “protection” measure within the institution against loss of staff and amalgamation with other departments within a faculty, notably civil engineering. As surveying courses in universities attempted to cope with these new instruments and new techniques in their already full programmes, it became clear that something had to be reduced in order to make room for the new material. The following section explores this aspect of university curricula by asking what areas of teaching had been dropped out of degree programmes in order to make room for new material.

#### **6.4 Subjects no longer taught**

Having warmed the interviewees to the discussion, they were then informed that the core of the research had been reached. In order to indicate whether there had been a fundamental shift in the profession, an assessment of what changes had been made to university curricula was sought. This was a question approached in two parts. First, what had been dropped from their curriculum over time to make way for new material; and second, what new material had been introduced into the programme?

In order to assist with getting started if interviewees were hesitant, the example of astronomy was given. While in most cases it was confirmed that astronomy had been dropped, there

were two examples in which the interviewees disagreed with the suggestion. This proved useful as confirmation that while providing an example to work from, the prompting did not function as a leading question that would predetermine responses. However, in some cases, staff had insufficient background in their establishment to be able to make comment on what had been but was no longer taught in the degrees for which they were now responsible. In the case of one university the programme itself was too new to provide a relevant response.

#### **6.4.1 Results**

In general, interviewees were hard pressed to identify topics that had been completely eliminated. In some cases the staff available were unable to answer the question with full certainty as the totality of their programme was outside their area of expertise. Much more commonly they would admit to compressing aspects so that they were dealt with in much less detail. Occasionally, however, subjects had been dropped because a staff member with particular area of expertise had left, usually retired, and had not been replaced. Many of the institutions visited were also suffering from diminishing staff resources, with consequential impacts on what they were able to offer students by way of course content.

The results of the question about items dropped from curricula are presented in Table 6.3. This table shows the topics identified by the interviewees; the interview in which they arose, whether the topic was eliminated, or reduced. Of particular interest is the explanation or comment interviewees made in relation to the topics they identify. In this table the results have been presented by topic in alphabetical order in a detailed format showing which interviewees identified specific subjects supported by any comment that was made regarding that topic.

These results are then summarised for easier interpretation in Table 6.4. Table 6.4 shows quite clearly the predominance of the first three topics, as well as the random nature of others that were commented upon. This reflects, to some extent, the variable nature of curricula, as well as the predominance of technology-based subjects.

<b>Topic</b>	<b>Interview Code</b>	<b>Status</b>	<b>Comments</b>
Astronomy	4Aa	gone	
	9Ga	not taught	maybe should be able to do sun shots at sea?
	12Aa	gone	completely. Last to go was sun obs 6/7 years ago
	13Ca	never taught	
	19Ga	not taught	no one has time
	32Ag		replaced by satellite technology
	33Ga	gone	
	36Ga	gone	went a long time ago
	37Ag	reduced	everyone assumes GPS is going to be there.
	38Ca	gone	(but students do a sun shot)
	40Ga	not sure	will only be a little since retirement of expertise
	41Ga	gone	
	42Ca	small amount	in space geodesy as intro to GNSS. Relevant to coordinate systems.
Cadastre	46Ga	reduced	
Cartography	28Ca	much reduced	not so relevant in the UK
	40Ga	much reduced	and combined with projections
Chains/tapes	36Ga	not used	now "geospatial awareness"
Descriptive Geometry	28Ca	gone	
Engineering survey	4Aa	gone	replaced by CAD
	33Ga	gone	an application of 1 <sup>st</sup> principles
Formulae derivation	4Aa	not taught	
	33Ga	not taught	
	38Ca	not expected	
	39Ag		not enough 1 <sup>st</sup> principles taught
	52Aa	not taught	less time on the mathematics behind transformatns
Geodesy	12Aa	reduced	dropped some material
	42Ca	reduced	from 3 papers to 2 papers
GIS	36Ga	not taught	GIS is part of Geography Not surv/eng.
	46Ga	gone	gone to a separate course
Horizontal & vertical tachymetry	34Ga	gone	
	46Ga	gone	
Hydrography	51Ca	dropped	to a large degree. Retirement of staff.
Land info mgmt	46Ga	reduced	
Land Administration	51Ca	gone	staff retirement
Longhand computations	33Ga	gone	
Mathematical geodesy	4Aa	reduced	an application of 1 <sup>st</sup> principles
Map projections	12Aa	reduced	
Optical Theodolites	34Ga	gone	don't have them now
	36Ga	gone	seen but not used
	41Ga	gone	
Planning	46Ga	reduced	
Plane tabling	9Ga	gone	would like to. Not enough time.
	19Ga	not taught	no time
	40Ga	gone	went a long time ago
Photogrammetry	19Ga	not taught	nobody is going to earn money from it.
	28Ca	morphed	into remote sensing
	29Ga	reduced	traditional photogrammetry
	33Ga	not taught	but surveyors were never into that stuff anyway
	36Ga	gone	still do close range.
	41Ga	only 2 lectures	all done on computers now
	42Ca	gone	
	46Ga	gone	
Spherical Trigonometry	51Ca	changed	all analogue photogrammetry
	4Aa	gone	to digital
	12Aa	reduced	an application of 1 <sup>st</sup> principles
	33Ga	gone	
Remote Sensing	36Ga	not taught	because it is all automated
Road design	4Aa	gone	because it is part of Geography. Not surv/eng
			an application of 1 <sup>st</sup> principles

**Table 6.3 University subjects reduced or eliminated**

<b>Topic</b>	<b>UK</b>	<b>Canada</b>	<b>Australia</b>	<b>Total</b>
<b>Astronomy</b>	6	3	4	<b>13</b>
<b>Photogrammetry</b>	6	3		<b>9</b>
<b>Formula derivation</b>	1	1	3	<b>5</b>
<b>Optical theodolites</b>	3			<b>3</b>
<b>Plane tabling</b>	3			<b>3</b>
<b>Spherical trigonometry</b>	1		2	3
<b>Eng surveying</b>	1		1	<b>2</b>
<b>Geodesy</b>		1	1	<b>2</b>
<b>GIS</b>	2			<b>2</b>
<b>Tachymetry</b>	2			<b>2</b>
<b>Chain/tapes</b>	1			<b>1</b>
<b>Descriptive Geometry</b>		1		<b>1</b>
<b>Hydrography</b>		1		<b>1</b>
<b>Land Info mgmt</b>	1			<b>1</b>
<b>Land Administration</b>		1		<b>1</b>
<b>Longhand comps</b>	1			<b>1</b>
<b>Mathematical geodesy</b>			1	<b>1</b>
<b>Map projections</b>			1	<b>1</b>
<b>Planning</b>	1			<b>1</b>
<b>Remote sensing</b>	1			<b>1</b>
<b>Road design</b>			1	<b>1</b>

**Table 6.4 Summary of subjects reduced or eliminated**

#### **6.4.2 Discussion**

There are three areas that stand out clearly from the rest. The first is astronomy. To many it seemed that no explanation was necessary for its abandonment. The reason given, when an explanation seemed applicable, was that GPS, or Global Navigational Satellite Systems (GNSS), had rendered the need for surveyors to have any knowledge or understanding of astronomy obsolete. There were, however, some who questioned that. Two interviewees mentioned the ability to carry out sun observations as a useful skill for a surveyor (Interviews 9Ga, 38Ca). One indicated that he thought it still had some relevance in space geodesy (Interview 42Ca). A final, and quite telling comment, was a suggestion that being taught astronomy had assisted him in “the understanding of orbits, reference frames, and celestial versus terrestrial”. He mused further that maybe not all surveyors need astronomy but only one out of every class (Interview 37Ag). However, it is quite clear that university

programmes have seen fit to replace the teaching of astronomy with techniques in GPS, and most admit that they now no longer have staff capable of teaching the subject.

The other topic that is clearly identified is photogrammetry. However, it is in quite a different category from astronomy. The old analogue form of photogrammetry, the use of large stereoplotters, has declined and disappeared. More recently it has been resurrected in the form of digital photogrammetry and commonly has merged with remote sensing. This is not always the case as in one example (Interview 33Ga) photogrammetry was not considered to be a part of surveying anyway. That particular department, which had explicitly included photogrammetry in the past but in a separate and distinct degree, had lost the ability to teach the subject through the retirement of its expert in the field. In a further example (Interview 29Ga) the interviewee considered that on their retirement it was unlikely that the university would consider a replacement by someone with an interest in, or a skill set that included photogrammetry. That is, if they were replaced at all. A resurgence of photogrammetry is related to the arrival of new technology such as drones or Unmanned Aerial Vehicles (UAVs), now more correctly referred to as Remotely Piloted Aircraft Systems (RPAS), and laser scanning. RPAS was not a term that was used by any of the interviewees in 2014.

The third subject that arose significantly was that which has been generally defined as formula derivation. If longhand computations, mathematical geodesy and spherical trigonometry is added to this, it becomes clear that the use of computers, be they hand held, desktop or programmable, has allowed so many of the more tedious exercises required in the teaching of surveying to be transferred to these electronic means. The teaching of mathematic principles generally has been simplified and much of the tedium removed through the use of computers.

Most of the other topics raised simply reflect changes in technology. The abandonment of analogue photogrammetric plotters, cartography, descriptive geometry, optical theodolites, plane tables, steel chains and cloth tapes, and tachymetry have all been replaced by more modern instruments that carry out the same or similar functions. In some cases, in particular optical theodolites and steel tapes, old technology is still used to teach students measurement practices from first principles in some institutions. This is justified by the rationale that

students should understand what the “black box” instruments are doing within their circuitry, and not be capable just of pressing the buttons in the correct order. However, the deletions otherwise appear random and are dependent on previous course content.

## **6.5 Subjects introduced to courses**

New technology requires new techniques and methodologies, and sometimes renders old course content obsolete. New subjects introduced to curricula are shown in Table 6.5 and Table 6.6. Also they require some training in the use of the latest instruments for gathering the information required to provide the answers to the surveying problems they are addressing. In order to make space for new material, old material either has to be condensed or eliminated. The author’s experience is that this is an iterative process and that it starts with material becoming compacted and greater reliance placed on reference to texts for additional reading. Then only reference is made to the texts for wider reading, and finally, unless historically important, the old material is dropped in favour of the new.

The corollary of asking what had been dropped from the university programmes was to enquire what new developments had been necessary to include that made these exclusions necessary. Interviewees were also asked if there were any topics that they would like to add but had not been able to because of time constraints, and if there were any new technologies that they were anticipating it would become necessary to accommodate. Table 6.5 shows, in alphabetical order, the list of subjects or topics that interviewees identified as having been introduced into the curricula of their degree programmes, and the interview in which the topic is identified, particularly to show the country in which this has occurred. Again, it is of significant interest what comments are attached to the topic.

### **6.5.1 Results**

In Table 6.5 it is noteworthy that as the interview programme developed, interviewees sometimes needed to prompted, more than in the question of what had been dropped, with topics that had been indicated by others or that the interviewer was aware of with respect to recent developments in technology. Building Information Modelling and UAVs were cases in point. As can be seen in the comments column of Table 6.5, the adoption of some of these latest developments was either of no interest to the designers of the programmes, or had been tried and had not been taken up in curricula developments.

Topic	Interview Code	Interviewee Comments
Big data Building Info Modelling	51Ca 4Aa 9Ga 13Ca 16Ga 21Ap, 22Ca, 27Gi, 31Ap, 33Ga 38Ca 41Ga	yes, just the way you use database information in there, but it is just a 3D GIS not yet, maybe soon. Opportunity for surveyors been developing, now spatial modelling in BIM  new. New specialist degree in it no, don't need to teach explicitly. Can learn if needed should be used right through the life of the project. Uses traditional surveying skills
Data mgmt/analytics Digital photogrammetry GIS and mapping	44Ap, 45Gp 48Ca 49Ca 16Ga, 21Ap, 22Ca, 39Ag, 44Ap, 45Ga 28Ca, 36Ga, 44Ap, 52Aa 4Aa, 5Ga, 9Ga, 13Ca	no. Don't even talk about no. Don't seem to be interested  not specifically mentioned, referred to with BIM
GPS / GNSS Ground penetrating radar	21Ap, 27Gi, 28Ca, 31Ap, 32Ag, 33Ga, 38Ca 4Aa, 5Ga, 10Ci, 12Aa, 13Ca, 32Ag, 34Ga, 36Ga, 38Ca, 42Ca, 46Ga, 52Aa, 9Ga, 45Gp, 48Ca	not specifically mentioned, referred to with BIM
Indoor mapping Land management Laser alignment Laser scanning/3D model	16Ga 22Ca 24Ga 48Ca 6Ap 21Ap 25Ga 36Ga, 45Gp 9Ga 13Ca, 36Ga	new. Response to EU. Mapping for environmental mgmt  been doing for 10 years a fight between the professions everyone wants a slice  not yet. Working on bringing forward. Demonstrate.
Laser scanning /Mobile Laser Scanning/ Terrestrial	5Ga, 6Ap, 9Ga, 22Ca, 25Ga, 32Ag, 36Ga 38Ca 39Ag 42Ca 44Ap, 52Aa	not yet. Will come in  but do not do BIM. Might do?
LiDAR Programming Project management Remote Sensing Risk management Statutory planning UAVs	10Ci, 16Ga, 28Ca, 45Gp 13Ca 24Ga 16Ga, 27Gi, 28Ca, 42Ca, 44Ap 24Ga 32Ag 3Cp 5Ga 9Ga 10Ci, 16Ga, 23Cp, 27Gi 19Ga 21Ap 31Ap 36Ga 39Ag, 52Aa 48Ca	new  new (an aberration) surveyors can add value that no one else can have one but it has never flown. Broke on the first day. not yet, but coming. Proximity to an airport a problem  only seminars. Privacy and legal issues. impacts on the trad aerial survey market. We have UAV no, not at this stage. To many regulations damaged vehicles (3). Problems with regulations.  not yet, but a growing area. Need to keep up.

**Table 6.5 New topics in courses or professional practice**

It is further noted that most of the topics shown in Table 6.5 are relatively recent. Many academic interviewees, when considering their course, did not appear to reach as far back in their recollections of new introductions as for those items that had been dropped. For

example, while the passing of optical theodolites and steel and fabric tapes was commonly mentioned, many did not mention the introduction of GPS or GNSS. It is doubtful that there was a single institution that was not teaching its students the intricacies of satellite positioning. It is suggested that this was because GNSS has now been embedded for so long that it is taken for granted by most, and is no longer considered new. Table 6.5 has been simplified and re-presented as Table 6.6. This table assists in interpreting the frequency of each of the new topics identified.

Topic	UK	Canada	Australia	Total
<b>BIM</b>	6	5	4	15
<b>UAVs</b>	6	4	4	14
<b>GIS and mapping</b>	5	3	4	12
<b>GPS / GNSS</b>	4	4	4	12
<b>Terrestrial laser scanning</b>	4	3	5	12
<b>Data management</b>	2	1	3	6
<b>Digital photogram</b>	2	1	2	5
<b>Remote sensing</b>	2	2	1	5
<b>LiDAR</b>	2	2		4
<b>Ground penetrating radar</b>	2	1		3
<b>Mobile Laser scanning</b>	2	1		3
<b>Big Data</b>		1		1
<b>Indoor mapping</b>		1		1
<b>Land Management</b>	1			1
<b>Laser alignment</b>		1		1
<b>Programming</b>		1		1
<b>Project management</b>	1			1
<b>Risk management</b>	1			1
<b>Stat planning</b>			1	1

**Table 6.6 Summary of new topics**

### 6.5.2 Discussion

The more common items, the top seven in the list, are evenly spread through the countries involved. This indicates that for these major new technologies, the land surveying profession has been relatively uniformly impacted. Other topics, while all related to land surveying as defined in a particular region, for example land management, may indicate the differing nature of the profession in some places. In some cases, for example ground penetrating radar, it may indicate the earliest introduction of a new topic that will spread to other places in the future.

What did show up quite clearly, in some instances, was that there were differing perceptions of what land surveying may or may not include. For instance, in one case it was stated explicitly that surveyors did not do photogrammetry (Interview 33Ga). Elsewhere both GIS and remote sensing were considered to be aspects of geography, and as such were not taught to surveying students, nor were they taught within the department in which surveying courses were located (Interviews 29Ga, 36Ga).

The issue of Building Information Modelling (BIM) supplied the most varied set of responses. University College London indicated that it was introducing an MSc degree in 2014/15 (UCL, n.d.) in Geoinformatics specifically focussing on BIM. This was conveyed in the interview as a future event (but only one month ahead). Reference is not given here to protect the interviewee's anonymity, but the existence of the course is confirmed by the web reference above, details of which are found in the Reference section of this thesis. In another UK university the topic of Geoinformatics was also identified as a separate department in the same greater faculty (Interview 9Ga).

Elsewhere it was indicated that there was no interest in having BIM in their surveying programme (Interview 48Ca, 49Ca), yet others saw it as an opportunity for the surveying profession, but who considered that the surveying profession had not yet recognised its potential. In yet other places, it was felt that BIM was simply the application of the already existing skill set of the modern land surveyor (Interviews 13Ca, 38Ca, 41Ga). On that basis it did not need to be addressed specifically in academic programmes. Outside academia, especially in Australia, it was apparent that BIM was seen as a particular application of laser scanning and had been embraced in practice some years earlier and was therefore not new (Interview 21Ap, 31Ap, 44Ap).

The other item that arose consistently, and often controversially, was that of UAVs or drones. Several academic departments had had bad experiences with their attempts to venture into the use of UAVs. One university was still negotiating with the supplier for repairs to be carried out after damage subsequent to crash landing on its first flight (Interview 29Ga). Another had three damaged UAVs in its workshop and was not progressing its interest in that line of work (Interview 36Ga). One private practitioner in Australia (Interview 31Ap) considered the complications of the civil aviation regulations as being a limiting factor, while another

that historically had been in the business of aerial mapping was very active in the commercial use of UAVs (Interview 21Ap). While the general goal of this thesis is questioning whether there has been a paradigm shift in the profession, Interviewee 31Ap was the first to suggest that in the context of civil aviation regulations there was, in fact, “paradigm drag”! The issue of paradigm drag was raised again later, quite independently and by another interviewee in a quite different context.

The various aspects of laser scanning were widely recognised as a new and productive aspect of land surveying. Again, though not raised by all, having been in place and adopted in some cases more than a decade ago, it did not always spring to mind immediately as a recent introduction. It had introduced surveyors to 3D modelling, could be combined with GIS, and was being used in the stationary terrestrial format as well as for mobile mapping. While stationary scanning was common, mobile mapping applications were rare. It is interpreted that the cost of “tooling up” for this application was a limiting factor in its development in academia. One of the universities with this capability had gained it for research purposes rather than teaching (Interview 36Ga). As an application, it was also mentioned by a practitioner as something that did not need to be taught but that the skills could be acquired by using existing surveying techniques, and indeed had been. (Interview 26Gp)

It was surprising how little mention was made of GIS. However, as with remote sensing and photogrammetry, in many institutions only basic GIS is taught. This was explained by some as being because GIS was seen to be a separate discipline and is therefore either in a department or a section of a department on its own. In many cases it is not regarded as a part of land surveying so it was maintained that land surveyors need only a basic understanding of GIS for their professional needs.

Ground penetrating radar for the location of underground services came up three times. Locating these services in the past has been facilitated, at least in part, by the use of metal detectors. However, the increasing use of non-ferrous conduits has rendered this method at least limited, and it was becoming obsolete. Both in the United Kingdom and in Canada, this appeared to be an issue of potential growth for the land surveying practitioner, especially where they were involved in urban development. Yet again, it is possible that some see this as an application of traditional skills using a different form of technology rather than

requiring anything new to be added to course prescriptions. Consequently they did not see a need to teach it specifically, or saw it is an application of methodologies already taught, the only variation being the tool used, and hence not worth a mention.

## 6.6 Changes to the BoK

Grounded theory requires that the data sets speak for themselves and that any hypothesis be developed from what the data have provided. In this case, 45 years experience in the profession of land surveying had led the author to suspect that something had happened to the surveying profession in the intervening period between his entering the profession and his imminent departure from practicing within it. This change was not something that was minor or trivial, but something significant. The question, therefore, was the degree of magnitude of the change and whether it could be construed as being sufficient to warrant being defined as a fundamental or paradigm shift. In the course of the literature search a paradigm shift had been detected c.1600. Had there been another one?

Examining Table 6.3 closely, it is clear that what have dropped out of land surveying courses is the old technologies. Such old technologies are largely the updated versions of what came into being for the 2<sup>nd</sup> paradigm that appeared between 1550 AD and 1650 AD. In particular, those are the theodolite, updated to the optical model, the steel tape adaptation of the Gunter's chain, the natural trigonometrical and logarithmic tables, and the more recent mechanical calculating machine.

The need for the dexterity that only came through years of practice in handling some of this equipment is also no longer a requirement. Extended field camps are therefore also a thing of the past in land surveying education, though aspects of field work remain an integral part of most programmes. The more recent development of GNSS has obviated the need for dependence on the application of ground control to the same extent and the need for triangulation both plane and spherical.

The advent of the computer has taken the tedium out of much of the mathematics and so the need to understand the derivation of complex formulae and the ability to work painstakingly and patiently through lengthy computations has been eliminated. This has meant that the time taken to teach the fundamental principles of geodesy, in most cases, has been reduced.

With respect to photogrammetry, the large stereo-plotting machines or multiplex platens that filled a room have disappeared. While photogrammetry also has been a disappearing art form, computerised plotters, aided by new technologies, have seen its resurgence but in a different form.

In a few isolated cases it appears that some subjects, while being dropped from land surveying courses have not vanished, but have developed into specialities in their own right. In some areas photogrammetry falls into this category, as does remote sensing. The most notable example, however, is that of GIS. In some locations there are professional territorial jealousies between these areas of specialism and the more general profession of land surveying.

In a very few cases material has fallen out of courses because of staff retirements and reducing budgets. Staff members have left and not been replaced because of budget cuts, and they have taken their expertise with them. How this affects the local profession, and how they have reacted to the closing off of this area of expertise is not an issue explored in this thesis, but remains an issue for the profession in that location.

But what of the new? From a day-to-day perspective, the combination instrument, the total station that measures both angles and distances, has replaced all of the old “technologies” and procedures. It can carry out reductions and corrections, download these to a data recorder or upload them to the cloud, simplifying field and office tasks. It is also easily mastered as it requires fewer of the manual skills and dexterity required of the old instruments and equipment. For longer range work, GNSS use makes geodetic measurement a relatively simple task also. Carrying out measurements, or collecting data, has never been simpler or quicker or provided data in such quantity. Whereas in the past it could require a 3-person field party, now in many cases it can be, and very often is, carried out by one person. Extended to laser scanning, data can be gathered at such speed and in such quantity that surplus measurements exceed those that are required for the specifications of the job by orders of magnitude.

UAVs remain a controversial topic. All can see the potential but there are pitfalls. The machines take manual skills to manoeuvre. The quality of the data returned depends on the

knowledge and skill of the operator and the quality of the camera employed. The quality of the camera is dictated by the cost. There are a variety of issues that arise from public safety concerns from potential harm from a drone crashing, through interference with commercial aviation, to invasion of privacy issues for individual property owners. While they are clearly a useful tool for land surveyors, as for others, their full utilisation appears a matter for the future.

## 6.7 Summary

The data discussed above are possibly open to closer scrutiny to reveal greater detail about the *minor* variations between countries and between institutions. However, the detail of the picture is not what is sought. The objective of the study is to consider the question of the magnitude and significance of change that has occurred in the land surveying profession. Had the data been more variable, then closer scrutiny, examination and consideration could have been required. The data are consistent through the countries and conform to the New Zealand-based experience of the author. Further study of the data would not lead to a greater understanding of the “big picture” required of a shift of fundamental or paradigmatic proportions. Rather the closer study of questions that were prompted by the responses of the interviewees will reveal answers to more important questions facing the profession of land surveying.

In examining Table 6.5, the focus of the new material in programmes clearly remains with measurement. Table 6.3 indicates that it is old and obsolete material that has dropped out of programmes and which was generally replaced with new ways of carrying out old tasks. There are new tasks that can be achieved with the equipment that was developed from and replaced the old instruments. In many of the interviews conducted, this was explicitly stated by the interviewees. Measurement data are gathered rapidly and in large quantities. Hence, the challenge for land surveyors is how much data to gather, at what level of accuracy, and how then to process the accumulated data set to meet the needs of the client. This remains the specific and specialised role of the land surveyor, and alludes to the discussion that follows in Chapter 7.

Hence, answering the question “has technology fundamentally changed the profession?” the answer must be an unequivocal no! However, something has happened in the last 60 years.

If it had not, then the question would not have arisen. During the interview programme, that the answer may be a negative one was quickly sensed. The subsequent question that followed the enquiries as to programme content sought an opinion from interviewees as to what they thought was now at the core of surveying? What made a surveyor a surveyor as opposed a member of some other profession, or what made a surveyor a professional surveyor rather than *just* a surveyor? Chapter 7 examines and discusses the answers to these important questions.

## **Chapter 7**

### **Defining the Core Competencies of Surveying**

This chapter aims to clarify what is at the core of the surveying profession in the opinion of those who teach its skills and those who practice them. Chapter 6 indicates that although technology has impacted heavily on the profession in the period since the Second World War, as it has on the rest of the world, it also clarifies that the essence of surveying has not changed. Some interviewees went as far as to say, in casual conversation, that if there had been a fundamental shift within the land surveying profession, then it was to the technology used by land surveyors, rather than to the profession itself.

Chapter 6 demonstrates that contemporary practice, and the teaching thereof, has followed the development of technologies. The old has been replaced with the new as the new has arrived on the scene. It has also been suggested, off the record, that land surveyors are, in fact, technology “hungry”, and that they adapt to new technology quickly. It is likely at the moment that the developers and manufacturers of the latest technologies are leading the profession rather than the reverse. New science finds new applications, and new applications create new opportunities. With land surveyors the uptake of the new technology is rapid.

However, as indicated throughout the interview process, the new applications generally do not require fundamentally new skills or disciplines. What appears to have happened is that the new instruments and new applications have required the deepening of the understanding of the old knowledge in order to be able to apply the new instruments to new opportunities. In order to gauge a better understanding of this, interviewees were asked to identify what they considered to be the *core* skill or skills required to be able to call oneself a professional surveyor in the current environment.

## 7.1 The Core Competencies

When asked what the central feature of land surveying was, the stock answer was, and has always been, “measurement”, usually with little further elaboration. For the purposes of this study, such a closed response was not adequate. It was necessary to explore this somewhat clichéd answer by pressing the interviewees further. However, in this case no leading examples were offered as had been with the question of what topics might have been dropped from degree programmes in order to get the conversation started.

<b>Component of Measurement</b>	<b>Interviewee</b>
Measurement science	3Cp, 4Aa, 7Aa, 8Ci, 11Ap, 12Aa, 17Ap, 21Ap, 22Ca, 24Ga, 27Gi, 28Ca, 32Ag, 34Ga, 36Ga, 37Ag, 38Ca, 39Ag, 42Ca, 52Aa.
Accuracy	3Cp, 4Aa, 7Aa, 11Ap, 14Cp, 17Ap, 22Ca, 25Ga, 27Gi, 28Ca, 29Ga, 31Ap, 32Ag, 34Ga, 39Ag, 42Ca, 45Gp, 46Ga, 48Ca, 49Ca, 52Aa.
Precision	3Cp, 7Aa, 13Ca, 16Ga, 22Ca, 28Ca, 29Ga, 38Ca, 42Ca, 46Ga.
Errors (propagation/uncertainty)	5Ga, 7Aa, 8Ci, 9Ga, 12Aa, 13Ca, 16Ga, 21Ap, 22Ca, 27Gi, 28Ca, 31Ap, 32Ag, 33Ga, 34Ga, 36Ga, 37Ag, 38Ca, 39Ag, 41Ga, 49Ca 42Ca, 44Ap, 45Gp, 49Ca, 52Aa.
Least squares	4Aa, 9Ga, 12Aa, 13Ca, 14Cp, 22Ca, 25Ga, 29Ga, 33Ga, 34Ga, 36Ga, 38Ca.
Statistics/probability/correlation	13Ca, 22Ca, 28Ca, 29Ga, 33Ga, 36Ga, 38Ca, 44Ap, 45Gp, 52Aa.
Confidence limits	14Cp, 37Ag, 44Ap, 45Gp, 52Aa.
Adjustments	4Aa, 5Ga, 9Ga, 13Ca, 14Cp, 21Ap, 22Ca, 29Ga, 33Ga, 52Aa.
Calibration	9Ga, 19Ga, 52Aa.
Tolerances	16Ga, 36Ga, 46Ga.
Risk	3Cp, 24Ga, 37Ag, 45Gp.
Limitations of equipment	16Ga.
Geodesy	4Aa, 8Ci, 11Ap, 19Ga, 22Ca, 27Gi, 28Ca, 31Ap, 32Ag, 34Ga, 35Ca, 37Ag, 38Ca, 42Ca, 44Ap, 49Ca, 52Aa.
Coordinate systems including 3D	4Aa, 9Ga, 12Aa, 13Ca, 16Ga, 22Ca, 23Cp, 25Ga, 28Ca, 33Ga, 34Ga, 42Ca, 45Gp, 46Ga, 49Ca, 52Aa.
Coordinate transformations	4Aa, 9Ga, 14Cp, 33Ga, 43Ga, 46Ga, 48Ca, 52Aa.
Projections	3Cp, 4Aa, 8Ci, 12Aa, 14Cp, 19Ga, 22Ca, 27Gi, 29Ga, 33Ga, 34Ga.
Datums	3Cp, 4Aa, 12Aa, 29Ga, 32Ag, 33Ga.
Data analysis	9Ga, 24Ga, 32Ag, 36Ga, 38Ca, 46Ga.
Managing data sets	21Ap, 31Ap, 33Ga, 39Ag, 44Ap, 45Gp, 46Ga, 51Ca, 52Aa.
Relative quality/integrate different data	4Aa, 8Ci, 21Ap, 27Gi, 33Ga, 38Ca, 52Aa.
Quality of data gathered	3Cp, 4Aa, 17Ap, 19Ga, 34Ga, 37Aa, 46Ga, 49Ca.
Three dimensions	8Ci, 9Ga, 27Ga, 31Ap, 41Ga, 46Ga.
Presentation	24Ga, 46Ga.
Visualisation	8Ci, 24Ga, 38Ca.
Fit for purpose	7Aa, 9Ga, 10Ga, 46Ga, 49Ca.

**Table 7.1 The Core competencies of surveying**

### 7.1.1 Results

Table 7.1 summarises the responses to the question about the core competencies of the present profession of land surveying. The table was, at first, arranged alphabetically. On closer examination of the words used by respondents, it was apparent that some of the terminology referred to the same, similar or related matters.

	UK	Canada	Australia	Total
<b>Measurement Science</b>	4	6	10	20
<b>Geodesy</b>	3	7	7	17
<b>Management of data sets</b>	3	1	5	9
<b>Data analysis</b>	4	1	1	6
				<b>52</b>
<b>Errors</b>	9	8	9	26
<b>Accuracy</b>	6	7	8	21
<b>Least Squares</b>	6	4	2	12
<b>Precision</b>	3	6	1	10
<b>Adjustments</b>	4	3	3	10
<b>Calibration</b>	2		1	3
<b>Tolerances</b>	3			3
				<b>85</b>
<b>Coordinate systems</b>	7	6	3	16
<b>Projections</b>	5	4	2	11
<b>Co-ord transformations</b>	4	2	2	8
<b>Datums</b>	2	1	3	6
<b>3-dimensions</b>	4	1	1	6
				<b>49</b>
<b>Statistics</b>	4	4	2	10
<b>Confidence limits</b>	1	1	3	5
<b>Risk</b>	2	1	1	4
				<b>19</b>
<b>Quality of data</b>	3	2	3	8
<b>Relative quality</b>	2	2	3	7
<b>Equipment limits</b>	1			1
				<b>16</b>
<b>Visualisation</b>	1	2		3
<b>Presentation</b>	2			2
				<b>5</b>
<b>Fit for purpose</b>	3	1	1	5
				<b>5</b>

**Table 7.2 Summary of Core competencies**

Additionally, the topics have been rearranged in Table 7.2 in an order that better reflects the connections so that interpretation of the “big picture” is more obvious and their impact more

easily grasped. It should be noted that all of the topics are closely related, and have at their core an understanding of various branches of mathematics.

### 7.1.2 Discussion

In Table 7.2 measurement science is placed at the top of the list. It is not the most numerous of responses, but is such a common response that it is likely that some, if not many of the interviewees considered that it would be stating the obvious. Geodesy rates similarly. There were instances where the *impression* was given to the interviewer that it was assumed that the discussion was actually about geodesy, and the responses were in that context, even though the word itself was not used. In passing conversation the term space geodesy was occasionally used. Being pressed to expand on and explain what it was about measurement, particularly the science of measurement, that would demonstrate their expertise, further common details emerged from the discussions.

By far the largest response was devoted to the understanding of errors, often referred to as the Theory of Errors. However, the same concept was also expressed in a number of slightly different ways such as level of accuracy, degree of precision and levels of confidence. Table 7.2 has grouped together these closely related topics. Some interviewees suggested that discussing “errors” outside the professional context was ill-advised as it may lead to a misunderstanding by clients. That is, that the client may be led to believe that the land surveyor was discussing making mistakes, rather than dealing with inaccuracies within the context of systemic “errors” generated by instruments. These can be eliminated through making redundant measurements and discarding those that are aberrant. For this, the professional land surveyor is also required to understand the limitations of the instruments that are available for use on any specified job, and to be able to choose the most appropriate instrument to give the most fit-for-purpose result required by the client.

Along with the references to the Theory of Errors was reference to adjustments, and the increasing need for a sound understanding of the principles and practice of least squares adjustments in particular. That is, the maximisation of accuracy by minimising the squares of the residual differences of the individual readings from a determination of the best-mean-fit of all measurements. Such an understanding of least squares adjustments, by default, also required a close familiarity with correlation, probability theory, and levels of confidence. In

brief, a sound knowledge of mathematics and statistics is required as a core of the body of knowledge of the professional land surveyor.

As noted earlier, to some degree, it was surprising how few times reference was made specifically to geodesy, and it has been placed in the same box as measurement science in Table 7.2. In the words of one academic Head of Department “geodesy is the science that permeates everything” (Interview 35Ca). While not referred to explicitly as often as expected, this might have been because respondents attempted to answer the question with specifics rather than with such generalities, which in turn would have required further responses for clarification.

Nevertheless, general and essential aspects of geodesy arose quite frequently without using the word itself. In the previous chapter it was apparent that much of the tedium had been taken out of the practice (and therefore much of the teaching) of geodesy. In some cases the time spent on geodesy had been reduced for the detailed teaching of formulae derivation and hand calculations, and a number of specific geodetic topics arose (Interviews 4Aa, 29Ga, 42Ca). As demonstrated in Table 7.2, considerable emphasis was placed on the understanding of coordinates. Even those courses that started at postgraduate level where entry was gained through recognition of degrees in cognate subjects, considerable emphasis was placed on coordinate geometry (Interview 33Ga). Additionally, coordinate transformations and 3-dimensional coordinate systems were considered to be of high importance.

A sound understanding of datums and map projections also appeared regularly enough to be significant. Related to this, and in a more generalised form, some mention was made by interviewees of the necessity of being able, not only to manage, but to integrate data of differing accuracy or from different datums or projections. This particular ability was recognised by many as not only being essential to the land surveying profession, but as a unique characteristic of the profession. Some went as far as to suggest that it was *the essential point of difference from all other professions* or disciplines using geospatial data. There were suggestions that some of those disciplines that used data of mixed origins had got themselves into trouble on projects and on more than one occasion had to be rescued by surveyors (Interviews 21Ap, 31Ap, 44Ap). It was considered by some to be the most

undersold aspect of the competencies of the modern professional land surveyor (Interviews 31Ap, 44Ap, 47Gp).

Beyond understanding the varying quality of data and the ability to integrate data from multiple sources, was the requirement to understand the capabilities of instruments. Modern land surveyors have available a wide variety of technologies with which to gather measurement data. In addition to being able to adjust the data output of their instruments, it was pointed out that there was a need to be able to understand the field information needed to be gathered for the instruments themselves. Table 7.2 suggests that, for example, it is essential to understand corrections for atmospheric conditions or altitude, to be able to ensure that instruments are correctly calibrated for their location, and to understand the tolerances within which their instruments are accurate. In this way, the professional land surveyor is able to select the correct instrument for the conditions, or any set of conditions, applicable to a particular measurement situation.

There were several references to “fit-for-purpose”. Fit-for-purpose was a theme for Teo Chee Hai during his tenure as President of the FIG from 2011 to 2015. It referred particularly to the development of cadastral systems in developing countries where highly technical, high cost western societal type cadastral systems could not be afforded. What was needed was to provide systems that met the need of the population for a purpose, and no more. In the context of this study it can be construed as referring to the art of land surveying. That is, designing measurement systems that provide the level of accuracy necessary to meet the client’s needs, and not necessarily to the highest accuracy that the practitioner’s instruments could attain without regard for need.

For example, it would not be necessary to use a laser scanner, gathering in excess of a million points per second into a point cloud, in order to define the footprint of a building on an allotment, simply because the surveyor happened to own a laser scanner. While this was mentioned only a few times, it does raise an interesting ethical question regarding potentiality rather than practicability in public practice. A professional practitioner in any field should be, at all times, cognisant of the needs of the client before their own ability to produce a result that is greater than the client requires or needs to pay for. It also highlights the fact that only

technical responses were given in the interviews and that no reference was made to matters of ethics.

Finally, Table 7.2 shows there were also brief mentions of visualisation and presentation. These arose surprisingly infrequently. Essentially, they refer to the ability to produce a visual representation of the outcome of the land surveyor's work for their client. Often the technical requirement is a dataset or a 3-dimensional model only visible by use of complex computer software. In the past, in some parts of the profession, the result would be a plan or a map. Some academics believed that professional surveyors should be able to present to their clients, wherever possible, some tangible form of their work beyond the bill for their services. A dataset or a computer model only visible within an expensive software product did not meet this requirement, and is therefore not a tangible result for the surveyor's client.

## 7.2 Summary

Those interviewed had a remarkably common, but also a remarkably narrow view of what defined the core of the professional land surveyor's body of knowledge. It is critical that this is seen in context. In this part of the interview, the interviewees were not asked to define the broad roles a professional land surveying practice might fulfil. Neither were they asked to define what they thought was the *extent* of the body of knowledge that a professional land surveyor should attain in order to meet the requirements to be considered a member of that profession. Furthermore, they were not asked to consider where the professional land surveyor might extend the core skills obtained in establishing and maintaining a practice from which to make a reasonable living, let alone run a profitable business. The question was very specifically to define what was at the *core* of the land surveying profession. That the respondents were so disciplined as to remain on target is gratifying.

The professional land surveyor is a measurer – at and to the core. If no longer physically taking the measurements personally, the surveyor has to understand the art and science of measurement. In order to succeed in business, the professional land surveyor needs to apply those measurement skills in a variety of innovative ways as new tools develop. However, historically, this surveyor may have had to add some other related disciplines to the professional toolkit in order to run and stay in business.

In some instances, such as during the early development of Australia, the surveyors could also apply their measuring skills to defining land boundaries. In doing so they could extend that skill to include an understanding of the law related to the boundaries and land within them, and the rights and responsibilities that went with ownership. Additionally, they included municipal engineering (suburban roading, stormwater drainage and foul sewerage systems, water supply) as well as town planning. This was easy to do, and necessary, as both of these professions were either in short supply or did not exist at the time.

However, in adding these areas of expertise to their professional knowledge, this acquisition did not make these forms of supplementary expertise part of the core competencies of the land surveying profession. Neither did it make them engineers nor planners. It simply made these areas of expertise part of the range of skills that the local land surveyors could provide to clients, and from which they could develop a sustainable business. The core of that business remained their ability to measure, to understand the qualities of their measurements, and to apply them for the benefit of their clients and for the benefit of society at large.

Having extracted from the interviews what the interviewees considered to be the core of the profession of land surveying, a further topic arose that was not one of the original considerations for this research or the interviews. This topic was known of prior to the survey being undertaken, and a conscious decision had been taken not to include it as it appeared to raise a question that likely would have no consistent or satisfactory answer. Nor was it perceived to have a relationship with the original research objectives. However, from the second interview onwards, the first with an academic, the term “geomatics” began to appear without prompting in the discussions. Having then looked ahead specifically at the programmes offered by the universities, it became clear from the earliest interviews that addressing the question of the introduction of the term geomatics would become unavoidable. Having experienced it in the second interview it quickly became a direct question in its own right.

The interviews were intended to establish the changes in the profession of land surveying relative to prevailing paradigms in pedagogy and practice. In this context it was clear that few of the universities surveyed were offering programmes specifically in “land surveying”. Out of the profusion of names that institutions had chosen for their programmes (see Table

6.2) only a small number used the word “surveying”, and only in one case out of fourteen did it stand alone at the undergraduate level. During the interviews, the term “surveying” seldom arose in the vocabulary of the interviewees, though the context of the interview was the profession of surveying and was used by the interviewer in the discussion. Despite this, many of those interviewed admitted regarding themselves as surveyors. Some even proudly carried the designation Chartered Land Surveyor, Registered Surveyor or Licensed Surveyor (depending on the country of origin) among their professional qualifications.

The most common reference to describe aspects of programmes during the interviews was to “geomatics”. However, through the course of the survey, this term was supplemented by references to geomatics engineering, geospatial engineering and geoinformatics. In response to this, interviewees were asked directly what they thought geomatics was or what it meant to them. The variety of responses were such that the interviewer was left to wonder if there was a real meaning to the term, and if there was, what impact was it having on the standing and on the image of the land surveying profession. Chapters 8 and 9 discuss the responses given by interviewees to the question on the meaning of geomatics, examine the origins of the term and dispel some of the myths and retro-fitted explanations that surround this controversial term.



## **Chapter 8**

### **Geoma(n)tics**

This Chapter discusses the terminology used to describe the surveying profession that, up until this point, has been referred to - quite specifically and with intention in this study - as *land* surveying. In the course of the survey of professional and academic surveyors, while questions were always in terms of *land surveying*, or just surveying, responses were couched around the term *geomatics*. There had not appeared to be a connection between the development of this terminology in the 1990s and the influence of technology on the land surveying profession prior to beginning the interviews. However, specific questioning evolved in the interviews as to what interviewees thought the word “geomatics” meant to them.

The responses of interviewees are presented in the order they were gathered and are presented by country. This is important, as was pointed out in Chapter 3, the land surveying profession takes subtly different forms in different societies. The origins of the profession as it now coincide with the colonial expansion of European nations. Given their isolation in those early days, the land surveyors adapted their skills to the needs of their emerging society. While there is much in common, there are also different cultures within the profession in different countries.

As the topic was novel to the research, and developed as the interview programme progressed, the words of the interviewees are used to precisely demonstrate their views as expressed by them. It also illustrates the way in which it became necessary to explore the terminology, its origins, and its influence on the land surveying profession. The responses were as enlightening as they were varied, as precise as they were vague and as meaningful as they were meaningless. This chapter exposes and discusses the views of those interviewed on the origins and use of the term geomatics, and explores their interpretations of the term.

## **8.1 Geo-everything**

The term ‘geo’ has become used as a prefix to a significant number of words in common use, and its application is continually increasing. In a less than one-page article alone, by a professor of cartography, the terms geocommunity, geodata, geovisualisation, geodisplay and georelief all appear (Buchroithner, 2016). GeoBusiness is used as the name of an event in London, in the UK (Groom, 2014). The British Ordnance Survey has a GeoVation Hub, Fugro has GeoServices (Anon, 2016) and GeoSystems is a company in New Zealand. Geo-referencing and geospatial can be easily added to the list as they have been in the common vernacular for some time.

In recent years the development of information technology (IT), when combined with the introduction of satellite navigation and remote sensing, has encouraged society to be more aware of the importance of location. It has enabled an unprecedented ease with which absolute position on the planet, or geolocation, can be established for virtually all phenomena. In particular, the widespread use of smart mobile phones can not only track the geolocation of the owner but also be used to locate other phenomena. The precision and accuracy of geolocation continues to improve, and new applications that use geopositioning continue to appear. Hence, geolocation is likely to continue to grow in importance. Also, it has been at the core of land surveying practices since long before modern technology made it ubiquitous.

Geomatics has been in the lexicon of the surveying profession for at least 30 years. The views that have been expressed on the origins of the term are varied and have almost reached mythical status such is the level of mis-information. However, its origins and meaning are well documented. Despite this, the reasons for its adoption beyond the country of its origin are relatively consistent, which will be discussed in Chapter 9. The success or otherwise of its adoption in relation to the stated reason for it, are of particular interest. Despite the fact that it has been in use for decades in and around the surveying profession, the surveying profession remains the surveying profession, not the geomatics profession, as demonstrated by the names of almost all relevant professional societies discussed in Chapter 3.

The term Geomatics was controversial when introduced and remains controversial in some quarters. The true origins and development of the term, and its controversial nature, are

discussed in Chapter 9, but at this point it is important to demonstrate the wide and varied use of the term as indicated by the interviewees in this study.

## **8.2 Geomatics in Ireland and the United Kingdom**

In one of the early interviews a comment was made about geomatics and GIS being two different things (Interview 40Ga). This was one of the first references to geomatics and in the first instance did not appear to warrant special attention. Further, in another of the early interviews the comment was made: –

*Although I don't like the term Geomatics Surveyor, I don't think Land Surveyor possibly encapsulates what we do anymore* (Interview 24Ga).

This comment was made without any prompting regarding the use of the term geomatics. It was not followed up with any further questioning as it had not been included in the topics to be explored. However it did attract the attention of the interviewer on reflection subsequent to the interview, and drew attention to the fact that geomatics had been used regularly throughout the discussion. However, it was not clear at this early stage how it related to the influence of technology on the profession.

### **8.2.1 Comments by those interviewed**

In the particular establishment in which this comment was made the staff were particularly targeting and attracting students interested in geography to join the surveying programme. In fact, they were “selling” their programme as being one of applied geography in order to recruit more students than they had been. In this case it was also stated that “GIS was firmly embedded in Geomatics” (Interview 24Ga). This was the first clear signal, very early in the interview process, that the use and interpretation of the term “geomatics” was going to be an issue.

Another university offered degrees in Geospatial and Mapping Sciences and in Geospatial Technology and Cartography (at postgraduate level) through its Department of Geographical & Earth Sciences. The programme’s origins are in geography and at one time the Department was named “Geography and Geomatics” before joining with geology and

adopting its present name (Interview 29Ga). With respect to land surveying, the programme originated in 1958 under the name of “Topographic Science”: –

*we never really used the word surveying in our title.” “Never ever. . . so geomatics has never been a problem for us (Interview 29Ga).*

It is significant that neither the word “surveying” nor “geomatics” appear in either of the formal degree titles. The course prescriptions are described in detail in their handbook “Postgraduate Programmes in Geomatics”. Both degrees have accreditation from the RICS Geomatics Professional Group Board (GPGB). The degree in geospatial and mapping sciences includes modules in both the “Principles and Practice of Land Surveying” and in the “Fundamentals of Geomatics”. This is a clear signal that the terms are not interchangeable, that is that one is not a replacement for or modernisation of the other. Land surveying and geomatics are different in this university.

Earlier in an interview at the same institution, when asked about the range of subjects taught, the picture is made even less clear in the interviewee’s response: –

*I would say the conventional spread of geomatics subjects in that we teach GIS and topographic mapping. We teach land surveying, engineering surveying, hydrographic surveying and we teach what we call the fundamentals of geomatics which is co-ordinate systems, map projections adjustment. . . and photogrammetry, remote sensing, I don’t know if I mentioned that, and topographic . . . (Interview 29Ga).*

The interviewee describes, in this response, topics that were identified by other interviewees in Chapter 6 as core to surveying, that is, co-ordinate systems and map projections adjustment, as the “fundamentals of geomatics”. Also included are topics clearly identified as part of land surveying in some other jurisdictions, such as photogrammetry and engineering surveying, at least, if not hydrographic surveying as well. It seems clear that here there is no clearly articulated distinction between “geomatics” and “surveying”, other than that there *is* a distinction. It is noted that geomatics here is taken to include GIS, though to specialise in GIS the student undertakes the second of the above named master’s programmes.

At a different university, during Interview 16Ga, the point was made that land surveying was not well understood in the UK. This general theme recurs, and in Interview 25Ga, at the same establishment, it was extended to say that this university cannot attract students to its

programme because neither geomatics nor surveying was well known. These are telling points when it comes to a distinguishing between surveying and geomatics, if such a distinction exists.

This university claims to offer the only undergraduate geomatics degree left in the UK. For this claim, to be upheld there must be a distinction between surveying and geomatics since, as may be noted in Table 6.2, UEL offers a degree an undergraduate degree in Surveying and Mapping Science. This appears to draw a distinction between surveying and mapping (UEL) and geomatics at this institution. Additionally, it is considered that those who study GIS are geographers and not surveyors (or geomaticians?) although it is possible to graduate from this university in Geography without any GIS component (Interview 16Ga). This confuses the situation when considered against the first example cited above.

At the same time, in Interview 16Ga, it is acknowledged that the MSc in GIS at the University of Edinburgh (not visited as part of this study) has RICS accreditation. However, it is also noted that they do not teach any surveying in the Edinburgh course, but that it has *geomatics* accreditation from the RICS GPGB. What is the implication of that? It has already been noted above that the GIS masters at the previous university also has such accreditation. Hence, it is clear that at least in these cases within academia, and within a reasonably confined physical region, questions appear with respect to the consistent use and interpretation of these terms.

What, if any, are the differences between surveying and geomatics? Is GIS a part of either or neither? Is GIS geography? Or is it something else again? However, this university offers BSc (Hons) degrees in Surveying and Mapping Science and in Geographic Information Science through its Department of Civil Engineering and Geosciences, though Interviewee16Ga has already indicated GIS is geography. These questions are those which led to the extension of the interviews to ensure the inclusion of geomatics as a topic following this visit.

A further potential issue that arises from these three discussions is the academic connection between surveying and geography and between surveying and engineering, particularly civil engineering. This evokes the question of whether surveying is a branch or discipline within

engineering or is it applied geography? Interesting as this question may be, it was not considered to fall within the scope of this thesis.

According to Interviewee 36Ga, having moved to another institution whose particular university course in surveying was firmly based in the School of Civil Engineering, GIS and remote sensing were not taught within the School but, again, are dealt with in their Geography Department. This university dealt specifically with engineering surveying and with geodesy and did not refer to terms such as land surveying or to geomatics. However it had introduced the term “geospatial” into a research facility, (the Geospatial Institute Research Group), referring to geospatial science or geospatial engineering and has used that term to bridge the gap between engineering and geography (Interview 26Ga). In this way, and in this case, the university has avoided the geomatics controversy. It might be noted that the university has retained the use of the word “surveying” in some of its course descriptions. However its graduates are engineers (BEng or MEng) with engineering accreditations, and are not surveyors in any traditional sense.

In the next interview the respondent did not once use the word geomatics. However, as noted earlier, it had occurred so often in responses that it had been added as a specific topic. It was later discovered that in the debate that occurred when the word arrived in the UK, this particular establishment was the home of one of the most outspoken opponents of the term. This was only discovered in later research, and is expanded upon in Chapter 9. The programmes here each have surveying in their name. Geomatics, however, is used in some of their promotional material, especially on-line. It was explained that the reason for this was to capture potential students using search engines and who had managed to become familiar with the term, possibly from other websites. It is a term that is also used in the UK’s University Central Admissions System (UCAS), a national database used by prospective students, under which this university has a listing.

The comment was made: –

*But I don't think it is a term that certainly school leavers, and people at that level, will ever understand. I know other people have said "but it gives you the opportunity to explain it", but you've got to actually have that opportunity. If they've just dismissed it completely out of hand, then you don't even get that opportunity, so it goes there. So I suppose we haven't been brave enough (Interview 9Ga).*

In this institution GIS was not included in the department teaching surveying. GIS does, however, exist as a stand-alone unit in the greater collection of departments comprising the School in which surveying is taught. It uses the term Geoinformatics in its name and exists purely and specifically as a research unit.

In a further interview in the same establishment the comment was made: –

*In an (open) conversation I would say that I am a land surveyor. And then when you get a blank expression you don't have to try to explain what a land surveyor is. But I would never describe myself as a geomatician or a geospatial engineer. Even though there may be a place for those words and for those descriptions, I am a land surveyor. . . You could take almost any other profession, you could say you are a civil engineer, you could say you are an electrical engineer, you could say you are a doctor, you're a lawyer, an accountant, and all of those immediately mean something to people. In this country saying you are a land surveyor means absolutely nothing to somebody. And I think that is a problem that we have. It is a problem that has not been solved by new terms.*

*I think that one of the interesting areas is how have other professions changed and adopted their change or gone with their change. Yes, really how have other professions taken on to those changes. . . They have all taken on technological and fundamental changes in the way they go about their work but not many of them have struggled necessarily for an identity, and I think it is that identity struggle that we are looking at (Interview 46Ga).*

These final comments introduce the idea that the land surveying profession, or land surveyors, have an identity problem in the UK. They further suggest that other professions have adapted to new technology without the need to redefine their occupational identity with a new name. Furthermore, they reinforce the point that individuals will still call themselves surveyors, and are not comfortable using a derivative of geomatics, e.g. geomatician, to describe themselves or their profession to others.

In the final university interview of the series in the UK, in an institution that uses the term geomatics in the title of postgraduate degree offerings, when asked what geomatics meant to him responded: –

*I suppose I could apply what somebody said, something like Alice in Wonderland and say it means whatever I want it to mean. . . The danger with "surveying" is that it means whatever the listener has understood it to mean. Therefore if you say I am in the Department of Surveying, you sell houses or something, particularly in this*

*country with a very broad definition of surveying and so on. So as an extreme you are looking at quantity surveying or price of houses or these sorts of things* (Interview 33Ga).

This interviewee deflects the question, first by asserting geomatics can have any meaning he wants to apply to it, then by digressing to indicate a lack of clarity of the meaning of surveyor in the public mind. That geomatics is ill-defined among academics in the UK is becoming apparent. The latter comment is a recurring issue within the UK. That is, that the term surveyor generally connotes a valuer or property surveyor, and that a land surveyor is generally perceived to be a person associated with civil engineering, as first mentioned in Interview 24Ga. In Interview 30Gp, an expatriate New Zealander who works in human resource recruiting in the surveying field, it was suggested that a land surveyor was perceived in the UK as someone who carried out topographical surveys and monitoring surveys. Whatever the truth of the matter, it is becoming clear that the image of the land surveyor in the United Kingdom is confused with other types of surveyors.

The following comments and views were expressed from within the Royal Institution of Chartered Surveyors (RICS). To include them without naming the Institution is impractical, but at this stage the identity of the interviewee, as much as can be, is protected. The history of some of its development is relevant at this point. As noted in Chapter 3, the RICS was founded in 1868 by land surveyors and maintained a Division of that name. It later was expanded to include hydrography, becoming the Land and Hydrographic Surveying Division (LHS). However, it is reflected by an interviewee: –

*... but then there was also the engineering surveying. And geodesy didn't quite sit within that traditional mapping, Ordnance Survey, national mapping industry types of stuff. So I think it was seen in the 90s with geomatics, with the advent of GIS and the other new technologies like remote sensing becoming more available, would enable us to use an umbrella term to cover all these technologies* (Interview 27Gi).

Given that there was some controversy when the term geomatics was introduced to the UK, the interviewee added: –

*The great Peter Dale of course always said he saw geomatics as being a subset of land surveying, which a lot of people in the audience I think gave him a standing ovation when he said that. It was actually quite a difficult process for us to accept that term. It [geomatics] doesn't make much sense in English* (Interview 27Gi).

By way of explanation, Professor Peter Dale, at the time of the debate in the 1990s, was Head of the School of Surveying at the University of East London (or North East London Polytechnic (NELP) as it was at the time), was President of the RICS LHS Division, and later became the 21st President of the International Federation of Surveyors (FIG) in the period 1996-99. His standing in the profession at the time was, therefore, considerable.

Furthermore, the RICS interviewee added: –

*I think that is the problem . . . I think geomatics has now taken on the mantle of being predominantly instrument and measurement orientated. So the other softer skill sets are not called in, like legal knowledge, like cadastral knowledge, like land management knowledge, like valuation knowledge are all left to the side (Interview 27Gi).*

In conclusion on this topic in the UK, the same interviewee added: –

*I'll be honest with you. I don't think the RICS, corporately, likes the term geomatics in the first place. Don't forget that a lot of our members from the old Land Survey Division resigned when we changed the name to geomatics in outrage, because why throw away 2000 years of history (Interview 27Gi).*

### **8.2.2 Discussion**

The term geomatics was controversial even in its introduction to the UK. While it has been adopted among the universities at varying levels, there does not appear to be any commonly shared definition amongst them of what the term means or what the discipline, if discipline it be, encompasses. Geomatics and surveying are said to be different, and one may or may not be a subset of the other. Further, it may or may not include GIS. For some it includes only the “hard” skills of measurement technology, thereby associating itself more recently with the civil engineering profession. Elsewhere it is part of geography. For others again, it would seem, it is believed that geomatics can have whatever meaning an individual wishes to attach to it for their own purposes.

Many are critical of its adoption and continued use. Many of those interviewed, if not most, continue to identify themselves, when asked, as surveyors. They accept the need to explain just what kind of surveyor they are within the UK system and what they do, because there are many varieties of surveyor. Furthermore, the term geomatics has not been generally adopted

into the names of practices nor is it, according to a number of interviewees, known or understood by the general public. Some conclude that it never will be.

At this point the study programme moved to Canada, the reputed origin of the word geomatics. By this time, reference to the meaning and use of the word was embedded in the standard interview approach, and was raised with all of the individuals interviewed. It likewise produced an interesting variety of views and opinions.

### **8.3 Geomatics in Canada**

Canada is of special importance in this discussion as it is reputed to be the home of the originators of the term geomatics. A range of academic staff members from universities are interviewed as well as some who practice in the private sector along with administrators. Federal Canada is divided into provinces and the opportunity was taken to interview several administrators of provincial association. Two public officials were also included in the programme.

#### **8.3.1 Comments by those interviewed**

The first interview in Canada was with an academic of foreign origin, who explicitly claimed not to be a surveyor, but a GIS specialist. Nevertheless, the interviewee is the Director of the university's undergraduate programme that includes teaching those who wish to become land surveyors (as that term is used in Canada – that is, cadastral surveyors). The programme of which the interviewee is the Director is in the Faculty of Earth Science. The comments regarding the use of the word geomatics are placed here without editing and were stated as follows: –

*The photogrammetry and the remote sensing, like the geodesy, is part of the surveying. But this is not enough for explaining what we are doing here. We are considering people who see geomatics as a discipline of land surveying. So it is part of it . . .*

*So yes, land surveying is very clear, but geomatics is very confusing – even to me!*

*As the newcomers to geomatics, the faculty members, the questions that you have are my questions. So I am very happy if you can publicise what you collected* (Interview22Ca).

The notable aspect of this quotation is what the interviewee includes as part of surveying, namely geodesy (as generally expected) but also photogrammetry and remote sensing. This is not a unanimously held view, and at times the very existence of these subjects is used to justify the need for a new term that includes them. This new term, of course, is “geomatics”.

At the same university the comment from another member of the faculty, again of foreign origin but having been in the faculty for some time, is telling. The comment is as follows: –

*To me Geomatics encompasses all the known areas of what we used to call surveying and mapping. However some people even now, many people do not know what exactly Geomatics means, and also there is many people that when we talk about geomatics they think it is only GIS, remote sensing and cartography.*

*So that means surveying, geodesy, photogrammetry is not part of the Geomatics. So if you're saying I'm doing geomatics, ah, you're doing GIS work. The way that the term we use here is in the form of Geomatics is where it encompasses all the disciplines and this starts from the basics – data position, data storage, data processing, managing, modelling, analyses and of course your presentation of data. That includes as well your positioning, navigation etc etc.*

*But the main issue is some people really do not know exactly what Geomatics is. There is some change in the last few years because the course has been introduced in the high schools, it's called Geomatics. So at least students they have heard about this term. However most of the times when I say I'm a Geomatics Engineer people say - what? What do you do? So we have to explain to them . . . ” (Interview 13Ca).*

The indication here is that, even within the same department of the same university, there is not a clearly understood agreement on what geomatics encompasses. It also introduces the popular designation in Canada, namely that of geomatics engineer. This is something else again, but is only a peripheral issue compared to that of the distinction between land surveying and geomatics. However it is not entirely unrelated as it impacts on the land surveying profession in Canada.

At a different university, but again interviewing a faculty member who is of foreign origin but did postgraduate study (PhD) in England, a different perspective again was evident on the use of geomatics as an alternative to land surveying. The comments are verbatim. When asked for a personal view of the use of geomatics, the response was as follows: –

*Personally, I like this new term for the profession because it reflects the revolution in the field, right? Because we used to be getting this traditional surveying under that*

*surveying engineering term without taking into consideration the information technology side. So personally I think geomatics is better than even geoinformatics, because geoinformatics makes people think more about information technology and forget about other traditional surveying. So my personal opinion is that geomatics is a better term to reflect this quickly changed field.*

*But the problem with geomatics is, we have been talking about this identity issue for so many years already, it has caused a problem. I am not sure how much it actually impact on the enrolment of the geomatics programme. We have been talking to the people around, and many agree that this is probably an issue and many people do not really know what is geomatics. Even if you go onto the streets, grab any people and ask “have you heard about geomatics?”. “What is it?” So that is not common* (Interview 49Ca).

For the same interviewee, in response to the question *What would be the term the public would understand in Canada?* The response was: –

*I guess for this field they are still familiar with surveying. Geoinformatics is not really popular here. I think geoinformatics is more popular in Europe.*

*Might be that you cross with people who confuse the words. But I guess, relatively speaking, surveying is much more clearer than geomatics for the ordinary people. Geomatics is a new term and many many would not really have any clue* (Interview 49Ca).

In this interview there is an allusion to problems of recruitment. The interpretation, however, is that there is a problem with the perception of the traditional role of the land surveyor, and that geomatics might bring about an improvement. It is also opined that while geomatics is a better term, it is not understood. It is suggested that the term is “new”, although it was first used in Canada over 25 years ago. When does a new term stop being new? If it is not understood after a generation of use, how valuable is it as an addition to the language of surveying, or to having an impact on the perception of the profession?

Moving to another university, the following series of comments emanate from a variety of faculty within the same department, and as usual, are identified only by the codes generated for the purposes of anonymity. The following comments were made: –

*I would say that land surveying is part of geomatics. Geomatics includes surveying, it includes remote sensing, it includes laser scanning, it includes cadastral systems, it includes ocean mapping and geodesy. All of those, in our definition, are all part of*

*geomatics. So surveying, we define as part of geomatics. Some people might say it is not* (Interview 42Ca).

In response to a question as to whether land surveying and geomatics meant the same thing, or if there were subtle differences the following response from another faculty member was forthcoming: –

*I would see there are subtle differences. My take on the name change was the fact that initially surveying was a part of civil engineering, and there was a recognition by a number of people - not necessarily within the university, a number of people within the Province and also nationally - that there was enough to do with surveying that it should be a separate engineering discipline as it is in Europe. So in 1960 there was a separate surveying engineering programme, and it eventually became a separate department a couple of years later.*

*So I think from that point of view I can understand how the word surveying maybe doesn't convey the enormity of the activity as geomatics would. But unfortunately it also opens up the opportunity for people to use geomatics and call it geomatics. So somebody who uses the data and does geography is also geomatics.*

*But then using land surveying and cadastral surveying, there are some people who recognise a definite difference between the two and others who say there is not really any difference at all. But I can see the logic now if we try to say why it is geomatics and not surveying? I think there is a definite recognition that there is a difference between the two . . .* (Interview 28Ca).

The significant issues in these statements include an unequivocal claim that surveying was initially a part of civil engineering. It is also stated that land surveying and geomatics are “subtly different”. There is no suggestion that one lies within the other, but an implication that they are two separate and distinct disciplines but that geomatics is the larger.

Still working within the same university but another faculty member, on being asked to differentiate between land surveying and geomatics made the following comment: –

*To me land surveying is part of geomatics where the land surveying is concerned with the property rights and boundaries related to natural resources, both in the oceans and on land. (Interviewer: And geomatics includes . . . ?) The information technology. Geospatial information technology* (Interview 51Ca).

When it was suggested that other academics had difficulty promoting their courses because the public did not understand the term geomatics the following response was offered: –

*But they know what surveying was, because surveying and surveying engineering meant that you could get a job with the Department of Transportation and on the side of the road with your yellow hat on all summer. And that was what the term geomatics was trying to overcome. It was a recruitment tool. (Interviewer: Did it succeed? ) Yes, it has worked (Interview 51Ca).*

This is the first unequivocal acknowledgement by an academic that the change in terminology from land surveying to geomatics was for the purpose of recruiting students. This is the first (and only) suggestion that the change was, or has been, successful. Given that several statements have been made that the public do not understand what geomatics is, this appears as a contrasting opinion to others already interviewed. Furthermore the initial reference to the nature of land surveying is one which defines it in the Canadian context. Internationally such a definition would not hold universally.

Finally in this university, in discussing the specific name of the department, the following comment was made regarding geomatics: –

*Now we used to have our degree in engineering, it was called surveying engineering then it moved to geomatics engineering, which is a name that doesn't exist. Geomatics, it is created by the French after some wine I think. And what happens is that to indicate something different, wider, than just survey engineer because people think of the guy who just measures along the road.*

*To decide to change from surveying into geomatics, that was a big struggle in itself because first of all geomatics was a new term (again a term that means nothing) because I remember the discussion. We had lots of Greek students here and they say "geomatics is not Greek, geo is Greek, matics is not". So it is a term that means absolutely nothing.*

*And in Europe, most of our faculty members at that time were Europeans, and they say that in Europe people are looking into geoinformatics. So there was a fight for the name, because there was also another group who said if we just go to the catchy new word we may be missing the foundation (Interview 35Ca).*

Again there is reference to using the new name in an attempt to create a new image for the purpose of attracting students, and a suggestion that geomatics is something greater than just surveying. This is echoed by a comment from the final interviewee in this university stating that: –

*And I think that the surveying community itself, in Canada, is often perceived by other people in geomatics and so on, I talked about the traditional surveying community, as*

*being fairly rigid and stuck in its ways, and I think the sort of cultural shifts that they have to happen there as well as the technology change - we are talking about keeping abreast of* (Interview 48Ca).

Here is a further reference to the idea that the image of land surveying, or land surveyors, is lacking, and does not encourage potential students to take an interest in surveying. This was also alluded to in interviews in the UK. It is implied that the introduction of this new term was deemed necessary to show that this discipline (now geomatics) is not only a modern one, but one that is larger and more technical than its predecessor, land surveying.

The final academic interview in Canada, at a different university, was with a faculty member who, again, was not of Canadian origin and education. He had lived and taught at the university long enough to have gained a commission as a Canada Lands Surveyor, and is the only surveyor on the staff. His comments with respect to geomatics are as follows: –

*I think geomatics is a term that has been accepted in Canada. Quite a few surveying firms have changed their names to geomatics from land surveying.*

*The name geomatics . . . the name land surveying doesn't sit very comfortably with a lot of people who are not really land surveyors. So geomatics for them is starting to take shape as an identity, but it is still a very difficult identity to communicate* (Interview 38Ca).

When asked if the word geomatics was getting traction, did that mean that the public had an understanding of what geomatics might be, his response was an emphatic “No!” In response to a question about the relationship with GIS, he indicated that his university did run a master’s programme in GIS, but that was in the Geography Department and had a “quite different emphasis”. This is the first indication in any country so far, that companies providing surveying services have adopted geomatics within their names (Interview 38Ca).

Outside academia, interviews were conducted with staff of three provincial associations of land surveyors. The first was with two members of a provincial association, one of whom was its Registrar, and made the following comment: –

*. . . so I have seen a huge, huge change not just in the technology of responding to the question of where is my lot corner or where is my boundary line, or how big is my piece of ground, but to all of those other areas of expertise that require an understanding of the science of measurement but had migrated into that magic world called geomatics* (Interview 23Ci).

However, along with his colleague, he would not be drawn further on the topic. They were both land surveyors in the Canadian sense, that is, cadastral surveyors, and the comment made suggests the interviewee had some scepticism about geomatics.

In another province, and again a joint interview with two senior staff of the provincial association, both of whom were land surveyors also, in discussing the terminology the conversation went as follows: –

*Interviewee 1: We have an identity crisis?*

*Interviewee 2: Nobody knows what geomatics is.*

*Interviewee 1: We have had a lot of discussions around that. It is a word, I remember when it was coined, I didn't like it. . . . I can recall the beginning of its use for surveyors. But it has become part of my vocabulary. When I used it, it was without thought. It just came out.*

Interviewer: I wonder if this is part of the issue? It is certainly confused in the UK because the term surveyor means something else on the street there. But here, if you talk about a surveyor, people will understand roughly . . .

*Interviewee 1: They have an idea. They don't have an idea about geomatics. In fact we were at a conference in Ottawa, maybe 4 months ago, and there was a video played asking people on the street if they knew what geomatics – have you seen that on YouTube? It is the funniest thing. People were really scratching their heads as to what the heck it meant. There is confusion. It is not an easy sell.*

Interviewer: And you have no intentions of it becoming the Association of [province] Geomaticians?

*Interviewee 1: I think I would have trouble making that one fly! No, no intention whatsoever* (Interview 8Ci).

There are two particular recurring themes that appear in these comments. The first is that these land surveyors dislike the term geomatics. The second is that they believe the public, while having limited knowledge of (land) surveying, they do not have any knowledge or understanding of geomatics at all. There is also reference at the start of this passage that land surveying has an identity crisis. This final point will also be discussed further in Chapter 9.

In interviewing the director of a third provincial association, in response to a question, not just about geomatics, but about other terms including geoinformatics, geospatial engineering and geomatics engineering being unhelpful in promoting land surveying, the following comment was offered: –

*In Canada, we generally have settled on geomatics, but even then that is a difficult term for the average person to understand. They don't know what geomatics is. They*

*do understand what land surveying is. I think there are really two schools of thought on that. There are some people who say yes, I want to use geomatics or a term like that to represent, or brand ourselves, that we are a modern organisation and it sounds more high-tec and therefore you must be a high-tech organisation. I know what a land surveyor is. He is that person behind the instrument that is not very high-tech at all. It creates that bit of an image.*

*At the same time, the other school of thought would be our technical school here in [the city name is deleted to protect the identity of the interviewee] had used the term geomatics for a number of years and they have gone to using “surveying and geomatics” now because students who maybe wanted to go into a surveying programme couldn’t find it anywhere, and they could not relate that geomatics was somehow related to surveying. So for them, they have gone back and are using both terms. They want to make sure that the term surveying is in there so that people know that its I’m looking for surveying, I want to become a surveying technologist, well now you can find that (Interview 10Ci).*

For the professional associations the theme is clear. Land surveying suggests something old-fashioned but the public has some understanding of it, or maybe at least of its importance. Geomatics suggests something more sophisticated, modern and high-tec, but the public do not know what it is. The importance of the term geomatics lies in the ability to attract young people into the profession, whatever it may be called, and there has been a resumption of the use of surveying to ensure that prospective students, and therefore prospective professional practitioners, can find what they are looking for. Again, there are strong indications of a dislike for, or a reluctance to use the term geomatics.

In addition to the universities and the professional institutions, two surveyors in private practice were interviewed. The first is the owner of a large private company with a multi-million dollar annual turnover. Without prompting on the issue he said: –

*... and also, I’m going to jump ahead to this thing that they are calling geomatics in Canada and we’ve been struggling with it since the late 80s when the term was coined to define what it is. But Peter Sullivan, who is the current Surveyor General [for Canada] and I were brain storming one day about what it all meant and I think that he best defined it by saying that Surveying is the aspect of Geomatics that requires you to be in the field (Interview 3Cp).*

When asked, as a follow-on to this statement, if remotely sensed information was surveying he had this to add: –

*Its geomatics, that's the challenge we're having – what is geomatics – geomatics is the art and science of collecting and managing geographic information and measuring it. So the third component of that, there's really three components to it – there's surveying where I have to be on the ground, there is the remote sensing where I collect, and surveying can be either picking up information or laying out information.*

*The third component of it, which is where all the growth is taking place, is in the actual storing and organising that information into an information system that people can make decisions from, and that's GIS (Interview 3Cp).*

Here we have a new concept, not raised or implied up to this point. Surveying is what the surveyor does in the field, either collecting data or laying it out. This is at variance with what has been defined in Chapter 7 as the core of land surveying. That is, land surveying is the art and science of measurement, at no time alluding to who physically collects that measurement data, and goes beyond the field aspect of the work. The core of surveying is defined in Chapter 7 as being about the understanding and manipulation of measurement data, not the collection of it, although that may be included.

Neither is this view supported by the wide-ranging FIG definition of the functions of a surveyor (FIG, 2017). However, it is reminiscent of comments made by Professor Dale in the UK (in Booth, 1996, p17) about geomatics when it was being introduced into the UK, as well as Interviewee 29Ga. Many academics and professional surveyors would not agree that they had no part to play other than the gathering of data by personally being present during the field operations, and that they had no data processing function (2Gp, 45Gp). Remotely sensed data, in this comment, is not the result of surveying and neither is GIS. GIS, remote sensing and photogrammetry are, however, subsets of geomatics.

Nevertheless, in further comments he added: –

*In Canada here they've got this term geomatics that they're trying to get traction on and among the public it's got no traction, you're a surveyor, you're an aerial photographer . . .*

*- when you spend 25 years trying to build a brand and you've got no work - give it up.*

*I see absolutely nothing wrong with calling a spade a spade, a surveyor is a surveyor, an aerial photographer is an aerial photographer, a geographer is a*

*geographer and these are terms that have survived for centuries, and just because we are using a bunch of new instruments and we've got new ways of seeing, it doesn't mean we need to change our name. A doctor's been a doctor and a physician for several thousand years and they're not changing their name into healthmatician.*

*- surveying didn't exactly cover photogrammetry, hydrography and cadastral sort of stuff. So I just think the term geomatics was a bad choice of name and I can't really give you a better term* (Interview 3Cp).

In this case there is not only an attempt to define geomatics but also surveying. It is likely that some would debate whether the last statement is universally true. The profession of surveying in some countries would consider it included some or all of photogrammetry, hydrography and cadastral surveying (16Ga, 46Ga). The RICS Land and Hydrographic Surveying Division (as it was once known) would be a case in point. However, this is Canada and it is becoming clear that the perception of what a land surveyor is, or does, differs from the interviewees from other countries in that land surveying and cadastral surveying are synonymous.

The second private sector interviewee is a freelance contractor and comes from a surveying family. That is, his father had a practice as a professional surveyor. He calls himself a surveyor because he is a member of his provincial association of land surveyors. However he is a GIS specialist. His first comment was that: –

*. . . surveyors, in my opinion, are reaching an existential . . . They're not sure what they are, what their role is in society and what they should be doing. They know what they have done for a lot of years* (Interview 14Cp).

Without prompting on the question of geomatics the interviewee followed with the following sequence of comments: –

*there is a lot of talk about this term geomatics and I hate the term. I've asked pretty much everybody that I know, university professors, does it mean anything to you – no.*

*. . . we use that to kind of expand upon what a geographic information surveyor would be. But they call all of the programmes geomatics and then geomatics also blends into engineering, because engineering also claims the geomatics terms as well.*

*. . . it's something like a GI surveyor, we were trying to come up with terms for this, because surveying to me means something, to me it means you go out and with a critical eye, examine the real world, to me that's what surveying means. Surveying*

*means something, Geomatics doesn't actually mean anything. I can't determine the root of it. I know it is a concocted word, doesn't really mean anything. GEO means earth – MATICS may mean – I think they're trying to think like Mathematics – geomatics right, but the root of mathematics is matheba not matic. Matic isn't the suffix. So geomatics is not geomathematics so geomatics is really earth acting like automatic and that doesn't mean anything, it doesn't have the compelling – its nebulous as a term.*

Interviewer: Someone has suggested that the -matics means measurement . . .

*Yeah I know, but they can say that, but the closest root would be automatic – which is self acting, right. So by consequence it would be earth acting if you wanted to go to the Latin which – the other thing that they say it comes from but it's one of these words that everybody claims to have invented, but I can't really get down to it. There's one company in Manitoba that claims to have invented the term.*

Interviewer: I thought it came from Calgary?

*It didn't, no (Interview 14Cp).*

And further: –

*Geomatics has not resonated with the public, it hasn't resonated with students, it hasn't resonated in the industry, so I'd give it up . . .*

*You Google engineering and you get a billion hits, you Google surveying you get a couple of hundred million, you Google geomatics across the internet and you maybe get one or two million. All of them are the schools trying to promote this term that nobody is buying and in the end it doesn't inform as to what the job of a surveyor is and it doesn't help them (Interview 14Cp).*

The final interview is one with a member of another provincial association of land surveyors. In this case he is not a surveyor. He works in an arm of government dealing with the land record, but has surveying field experience. He made the following comment: –

*You say you work in health care, people probably get that you are a doctor, a nurse, you are a pharmacist or something, you know, people can kind of understand that. But I think if you work in geomatics or you work in the land information sector, they really don't have a clue what that is.*

*. . . if you want to define geomatics, surveyors are certainly in there.*

*. . . everybody I know that works in surveying or GIS, is working in geomatics in some ways, so I think of it as the broadest terminology of all the things that take place.*

*There is a lot of debate whether we should get rid of it.*

*I think it is partly because of the communication of the identity is so important for the future, and so you need the terminology, and you need those reading or listening, to know what those words mean* (Interview 1Cp).

Again, there is a suggestion that geomatics is a term that includes land surveying and it also includes GIS. There is a further comment regarding other professions and that their adoption of new technology has not required them to create a new name for the profession they belong to. This was a comment also specifically made in the UK. However, this is yet another suggestion that in Canada the use of the term geomatics should be abandoned.

### **8.3.2 Discussion**

Anecdotally, the term geomatics did originate in Canada, and some had identified the University of Calgary as the source. In an unrecorded and informal meeting with the Head of the Geomatics Faculty at Calgary the assertion that Calgary was the origin of geomatics was denied (Litchi, 2014), though it is noted that he was not working at Calgary when the term first appeared or when it began its spread through the Canadian community.

For the Canadian surveying profession the position appears to be no clearer than in the UK. Most academics confirm that the term has not “caught on” with the public and that marketing geomatics courses is difficult, compounding an issue of shortage of students in surveying programmes. Many of the academics themselves admit to not understanding the term geomatics and some go as far as expressing their dislike. Others have their own interpretation of what geomatics includes and how it relates to land surveying.

There is also a lack of knowledge as to the origins of the term. It may have originated in Calgary but this is by no means certain. Calgary staff denied any responsibility for creating the term geomatics while not being able to explain where it did come from. Given that it first gained popularity in the 1980s, the present staff may not know the true origins or the part that the University of Calgary played, if any, in its dissemination in the English language.

Many academics in Canada have a clear idea of its meaning and application within their institution. Others have no knowledge of what is meant by the term geomatics, but appear to

be aware that it does have a specific meaning. As in the UK, although not as marked, it is apparent that over time the original need for and meaning of geomatics has been lost and sometimes it has been adapted to suit individual needs. A specific detail that is confused is whether or not GIS falls within the geomatics ambit. For some it does include GIS yet for most it does not.

## 8.4 Geomatics in Australia

To conclude the survey the study moved to Australia, another jurisdiction, or set of jurisdictions, where the term geomatics has been adopted and has been in common use, particularly in academia. It is however one of several new terms used in Australia. In examining the Australian perceptions of geomatics, academic opinions are examined first. These are followed by surveyors employed in state government officials and finally surveyors in private practice.

### 8.4.1 Comments by those interviewed

When asked about the profusion of terminology around surveying, such as geomatics, geospatial engineering and geoinformatics the first response given was as follows: –

*No, look I'd like to think that Spatial Sciences encompasses everything regarding information, in terms of the surface of the earth or whatever. So in other words the GIS people are an important part of Spatial Sciences, but the photogrammetry side, the hydrographers, land surveyors, engineering surveyors, mine surveyors, so that whole group sits under, and I'm quite comfortable with Spatial Sciences. However when I identify myself from a professional point of view I am a Surveyor first and I've always have been a Surveyor.*

*I mean the trouble is geomatics doesn't mean anything. I mean, I know what the definition is but to most people a surveyor is a surveyor and they have a very rudimentary idea of what a surveyor does and they comfortable with it. Whereas geomatics is like - you know - no idea at all! I'm obviously a traditionalist so I like to stick to things I know and I'm comfortable with. A surveyor is a nice name. It describes exactly what I do and it fits nicely (Interview 52Aa).*

As has proved common in the other countries visited, the observation made here again reflects that geomatics is said to be a term that is meaningless to the public. In this case, however, the interviewee is aware that there is a definition of geomatics and what it is. It

would have been useful here if that known definition was explained, but the interview moved on quickly.

The interviewee was personally comfortable describing himself as a surveyor. Furthermore, the umbrella term that was preferred is “spatial science”, which presumably is intended in this context to perform a similar function as some believe geomatics does. That is, to embrace a number of disciplines or sub-disciplines, including land surveying under a more modern and all-embracing title. In this case the staff member is part of a Department of Spatial Sciences. This introduces into the mix yet another term.

At another Australian university, the question of how the university distinguished between surveying, geomatics and geospatial engineering was asked. The first response was that they use the term “geospatial science”. In this case, the School included geospatial science in its name. In responding to the larger question, the following comment was offered: –

*We, with the surveying programme, we certainly spend much more time on very descriptive learning activities that we think a surveyor should know, and there's obviously this common foundation. But the geomatics or the geospatial science people tend to cover a broader range of more related areas. So more computer science, more application domains, like remote sensing, and less of what I would call them the more metric sciences. It's not a hard and fast definition and I don't think there is one. Generally the geomatics or the geospatial sciences people have more freedom in sort of choosing where they'll specialise. The surveyors are essentially told that if they are doing the surveying programme - they are specialising in surveying* (Interview 12Aa).

This response indicates that at this university geomatics is not generally used and the interviewee replaces the reference to geomatics with the term geospatial science. This appears as a variation on the previous example where spatial science is the terminology of choice, and yet another new expression. In this case it is identified that surveying and geospatial science are separate programmes, and that geospatial science is the broader discipline. Unfortunately it was not clear from the interview whether or not surveying forms part of geospatial science.

At a third university, the first interviewee was a retired government surveyor, but who was currently working in the university as a research fellow. He had also been on the department’s Advisory Board at the time that it changed its name from surveying to

geomatics. In response to being questioned on his “take” on the change from surveying to geomatics in this university the response was as follows: –

*It started here and it was all to do with marketing the course. Trying to find, as they continue to do, they struggle to attract students into the course to do surveying. Surveying said it didn't have its marketing. They couldn't market us, as surveying didn't make the New Age type of thing, I would call it. So it was decided that it was really the marketing might try and make it this more, give it an appearance of a broad thing – that people had this perception of surveying as very narrow. And I think geomatics was too. Geomatics covers surveying; it covers mapping, it covers this whole . . . that was how it was marketed. I think it is fair to say that it didn't really change the numbers. The numbers didn't spike up or anything like that.*

*So when they changed to geomatics I don't think it had a significant effect apart from probably upsetting a lot of people in the profession. The surveying profession.*

*. . . but I think the major effect it had was to, in some ways, to alienate the university from the profession in some ways. Because a lot of the profession wouldn't buy this name of geomatics. I think that has continued right on (Interview 11Ap).*

This interview raised again the public image of the land surveying profession that has been referred to in each of the countries in the survey. It also is indicative of the difficulty many programmes were having in attracting sufficient students to remain viable. There is no reference here, however, to the *meaning* of geomatics, only its use as a tool to change the public face of the profession and thereby to attract new entrants in sustainable numbers. It also makes clear that those practicing surveying in this region at the time rejected the term geomatics and, so it seems, still do.

The final academic interview was with a much younger faculty member of the same university as the previous interviewee. In this case the question of the use of geomatics did not need to be raised. In response to a question of what she called herself the reply was given that she was a surveyor. In expanding the explanation for this, the response was as follows: –

*Mainly because, and I've argued this with myself, it's a profession that I identify with, even though I know I am very loosely connected to it in lots of ways. It's the only profession that I connect with in any way. There are many other things I think I could call myself but they don't seem to be real professions. I can say I'm a spatial scientist or a geomatics engineer or maybe a geodesist, but that to me is just a surveyor anyway, they're not things that I know what they mean. If you asked me what a spatial scientist did I'm not sure - I could give you examples of things I might do, but I couldn't define it as a profession (Interview 4Aa).*

When asked directly about her views on the various terminologies and whether they had any influence on external perceptions of surveyors, she had this to say: –

*We can't describe ourselves. How can we expect other people to! Of course it does, I think it is one of the biggest problems that we have today, that if you go around any one of these Schools, and you probably did that in the UK and Canada, if you ask anybody what their Department name means, they're probably going to give you a different answer.*

*We cannot get a consensus on what it is that we do! I mean I'm sitting here going "I don't know", I guess I call myself a surveyor, but I'm not really a surveyor am I? But I'm not a spatial scientist, because I don't know what they do either. You don't know either? It's a big problem, I see this as one of the biggest problems we face, is that we can't collectively agree on an umbrella term for what we do (Interview 4Aa).*

The above is a very frank and honest representation of the interviewee's opinions. They crystallise much of what has been said already both in Australia and in the other countries visited, especially in the academic context.

To widen the scope of the opinions, several senior government surveyors were interviewed. One of them, when asked whether he thought there was a difference between geomatics, geoinformatics, geospatial engineering and land surveying or if they were all different names for the same thing, he responded: –

*Yes, I think they are. If you talk about paradigm shifts, what do we actually do? We still do surveying and mapping. The mapping might be in digits, but it is still surveying and mapping. And I think we have confused the bugger out of the people in between with the profusion of names. But just like if I go out to people and say that I manage a number of spatial data sets as part of my role, they have got no idea what I am talking about. If I say, look I am involved in mapping they understand it.*

*I think in wanting to give ourselves titles we have forgotten about the community and the community need to understand it. It is critical that the community understand what we are about. I know they really don't know what a surveyor does, but fundamentally if you say you are a surveyor they immediately think of one of the guys out there with a yellow tripod and a machine on it, and if you talk about mapping, they all know Google Maps or topographical maps (Interview 39Ag).*

When then asked if this had something to do with getting students to take up the land surveying profession, he responded: –

*I think there is no doubt the sexiness of an industry is in the back of the mind of a seventeen year old. And surveying and mapping doesn't fit that category.*

*The smallness of our industry is a great penalty to us. I think the other penalty that has come in over the last decade is the general winding-down of the sciences and maths through the school education and in the general community. You know, the level of mathematics in the community is quite appalling, I think* (Interview 39Ag).

Finally several surveyors from the private sector across Australia were interviewed. One was retired, one the owner of a substantial surveying company, three were managers in a significantly large company in different cities, and one a junior surveyor in a significant company. One survey manager, when asked about the relationship with GIS and whether it was a surveying discipline of responded: –

*I think GIS is a discipline of surveying, because there are a lot of GIS operators out there that can analyse the data. I guess that's where you have to look at where is the GIS profession today, so the true professionals understand where all their data comes from or the accuracies associated with the different data sets and they set up the cataloguing correct so they know what they are interpreting at the right time . . .*

*I think the biggest problem you have is that a lot of the surveying professionals have forgotten that there are a lot of GIS professionals that were surveyors or have studied specific postgraduate degrees in GIS. And yes we do cross more paths with people that sit down the other end of the spectrum, that don't understand where the data came from, don't understand datums and grids* (Interview 21Ap).

While these comments do not relate so transparently to geomatics, they do bear on the same issue with respect to what is, or is not, land surveying and what may or may not be included in geomatics. The more common term in Australia is spatial science rather than geomatics, further compounding the definitions. There are tensions across Australia between the surveying practitioners and those who operate in the GIS field. However, this particular company clearly operates across the spectrum.

The retired surveyor responded to the question about the new terminology that includes geomatics, geoinformatics and geospatial engineering with the following comment: –

*I am a lot more comfortable with those words than the spatial sciences, which - I don't know where it came from. Boy, but did they latch on to it.  
Geo itself has a spatial feel about it* (Interview 44Ap).

Unfortunately the interview veered away from pursuing the issue of geomatics, but the first comment has a particular relevance to the terminological issues in Australia.

Asking the same of a young graduate surveyor, though including spatial science and land surveying in the terms asked about, he responded: –

*There are plenty of different words, and I think it can become confusing, really, for the young people who want to get into it.*

*Lack of identity in my mind is one of the biggest problems we face. Surveying is a respected profession and has been since Colonel Light – everyone, pretty well everyone knows who he is. What did he do? He founded Adelaide didn't he?*

Interviewer: He laid it out?

*Yea that is right, and they may know he was the Surveyor General. Well they might. But they know who he is and he is a famous surveyor. Ask people what a surveyor is – they don't know.*

*I think engineers, doctors, lawyers, everyone knows what they do. I believe we are a profession that needs to work on raising our identity which would help, this doesn't go into so much of what you are talking about, but if we can raise our profile and we can raise our interest, to get more people in (Interview 6Ap).*

In this case the use of multiple terms, he believes, has led to a lack of clear identity for the surveying profession in the public mind. There is a clear reference that this is an impediment to recruiting young people into the surveying profession. He also points to the image of the profession being an impediment. With the identical question put to the owner of this significant company, the response was: –

*If we could get some consistency it would be good. We have got them [the terms]. They are always going to be there. We have gone for flavours of the month everywhere, this year or that year. But fundamentally the general public don't even know what a surveyor is. When you go and put 20 other terms there and they get a bit of an inkling, (Interview 31Ap).*

Again, there is concern for the public perception of the surveying profession which appears, to the public, to refer to itself in a variety of different and confusing ways.

The final interview is with the manager of a branch office of a very large surveying company, but not in Melbourne although he had studied surveying there. The issue of terminology was initiated very early in session but by the interviewee before any question could be directed at this topic. His comments were as follows: –

*... I know they [University of Melbourne] changed their name, to attract more people to get away from the idea that surveying is not just someone standing on the road, but I think that has exacerbated the problem. I think something like GIS, I'm in the*

*industry, I don't even know what it means. It's far too wide. It's a nebulous term. Anyone with coloured crayons in the corner to hard core geodesy, can be called Geographic Information. So it gets back to my premise before, that making up a new term like GIS or Geomatics it doesn't define what we do and I don't know what they do nowadays so I'm sure the young seventeen year old at school wouldn't know what we do.*

*I would call it all surveying if it was me, I would call it all surveying. And GIS, Land Information, something like geodesy is a subset of surveying, but to me the overall arching one thing is that I would get rid of GIS, I would get rid of Land Information, which has obviously gone by the way side anyway, certainly geomatics. We had one surveyor in Australia who called himself a geomatician, so he changed his card to be a geomatician. . . . In my mind, talking semantics, I think I would go back to basics, it's all surveying and there's subsets, like you know photogrammetry is just a form of surveying. Geodesy is a form of surveying.*

*. . . I remember having discussion when Melbourne University first changed its name and went to Land Information . . . I remember at the time he changed the name then, because Land Information was the buzz word it was pulling the research dollars and I thought then it was an odd thing to do . . . I think it is a good example because that was Land Information Systems you know they renamed the LIS Lab. I remember they crossed out photogrammetry and it became the LIS Lab, same room of course. That was geared towards, because that was the buzz term and I'm sure there was research money there and prestige and perhaps a few grants . . . But I suspect that was a short-term gain for a profession that is floundering for identity, because of that obviously it is a part of a bigger picture* (Interview 17Ap).

This interviewee had clear and strongly held views on the issue of terminology, though does not particularly pick on geomatics. However, he does see surveying as the umbrella term for the profession, as it has been historically. This includes the area of GIS, which has been in question from the very beginning of the interview programme. He considers the issue of fiddling with the terminology that defines the surveying profession as merely the following of fashions or trends. He also makes reference to the complementary issue of attempts to attract young people into the “industry” and the confusion that a profusion of names might create for those exploring educational options and potential careers.

#### **8.4.2 Discussion**

According to those interviewed the issue of the use of the term geomatics in Australia shows every indication of having dissipated. It is said to have been controversial when it was

introduced and it is suggested that the main purpose of its introduction was to boost flagging numbers in universities running land surveying programmes. Behind the concern for diminishing student numbers is the claimed poor public image of the surveying profession. It may be noted that it is academics who say that the image of the profession is one that is reflecting on the profession as a whole and therefore discouraging student uptake. This may not have been helpful in convincing their colleagues in practice that a name change was necessary.

However, in Australia there was little current interest shown in geomatics, its use or its definition. The term generally had given way to “spatial science” for which there was no specific definition. Even that term was being superseded by reference to “geospatial science”, or the “geospatial sciences”. These give the appearance of being general terms rather than specific, and there was no reference given to any definition.

## **8.5 Summary**

Despite being in the language for several decades, there is no agreement on the current meaning or definition of geomatics. Amongst those interviewed there is a high level of dislike for the term, and few of those interviewed argue in favour of it. In the country that reputedly spawned the term, many of those interviewed would go as far as abandoning it altogether.

Many of the respondents indicated that the introduction of the term was an attempt to enhance the recruitment of students into surveying or related programmes. The rationale for this was that the profession of land surveying had a poor image. That image was one of individuals standing beside tripods on roads, would therefore generally be in outdoor clothing, and consequently not be of professional status. The new term was intended to convey a message that suggested a higher level of sophistication and allusion is made to the adoption of modern technology.

This perception is compromised somewhat by the additional view held by many that those parts of the discipline that were using sophisticated, modern and computerised technology in fact were not part of land surveying. This view further complicates the original intention, if

intention it was, to improve the image of the land surveyor. It takes the process one step further and suggests that maybe geomatics is, in fact, a new profession alongside that of surveying. In some cases land surveying is perceived as a part of this new profession.

This attempt to improve the image of the land surveyor then appears to be driven by academia and a desire to recruit students. Practitioners, and even many academics, though embracing the term geomatics continue to call themselves surveyors, or land surveyors, when they discuss what they do with the public. In Canada and the UK, and where the academic component of geomatics is attached to an engineering school, universities have compounded the terminology by introducing the term geomatics engineer. In some of these cases the graduates then style themselves as engineers rather than surveyors, and are able to become members of the engineering profession.

In Australia, while geomatics was adopted at the time it became popular elsewhere in the English speaking world, they have mostly superseded geomatics with the use of the term spatial science or the spatial sciences. Those interviewed, however, do not know what spatial science is and what it might include. It is assumed that it covers land surveying, in the same way as most assume geomatics does. However, there are indications that the term “geospatial” is gathering greater acceptance and is becoming more widely used in the UK and in Australia. Canadians, however, despite the strongly stated disquiet amongst those interviewed, gave no serious indication that geomatics would be abandoned, two maintaining that it was gaining in public acceptance.

Most commonly and of great interest, is that those that practice in this area, and including a number in academia, when asked to describe themselves, maintain they are surveyors. Others, especially those in schools of engineering, define themselves as geomatic engineers. In some cases, in Canada, a geomatics engineer can also be a licensed land surveyor.

The picture of geomatics is thus one of confusion. It is confused among sectors of the profession within countries, and there is no consistency between the countries in this study. Given the confusion over the definition and use of the term geomatics, the following chapter will trace the origins of the term to its starting point, and examine how and why it migrated from its point of origin to other parts of the English speaking world.

## **Chapter 9**

### **The origin and spread of ‘Geomatics’**

The term geomatics, used in some way to relate to land surveying, has spread through the English-speaking international surveying community. There are a variety of origins and meanings attached to the term as clearly demonstrated in Chapter 8. A mythology has grown up around its origins, with numerous anecdotes about where the term came from and who first coined it. *A posteriori* constructions have also been attempted to explain the origin and meaning of geomatics. A profusion of meanings have been attached to the word by individuals for their own convenience. Some of the people interviewed for this thesis are of the opinion that they can attach whatever meaning they choose to define the term geomatics, while others have adopted what they understand to be a common definition. This chapter explores the origins and definition of geomatics, and tracks the adoption and use of the term through Canada, the UK and Australia.

#### **9.1 The myths**

It is possible that the term geomatics was first coined in the 1960s and there is anecdotal support for this view (Foster, pers. comm. 2016). This period is also referred to by Young (2013). However, Young bases his comment on Potůcková (2006), who in turn references Wikipedia as the origin of this statement. Current reference in Wikipedia is to the introduction of the term by Michel Paradis in 1981 (<https://en.wikipedia.org/wiki/Geomatics> n.d.), a French-Canadian surveyor. Potůcková (2006) also suggests that: –

*The terms ‘geomatics’ and ‘geoinformatics’ are used interchangeably in some university programmes (Potůcková, 2006. p.35).*

While this may be so, no examples are given and this statement does not clarify geomatics as a discipline. Moreover, in some universities both geomatics and geoinformatics are in use

(e.g. University of East London, University of Glasgow) where they are used to identify separate and distinct areas of work.

According to Ballantyne (1996) geomatics is a contraction of géographie and informatique. He further states that: –

*... translation of géomatique to geomatics has been accepted by the International Standards Association (ISO), by the Banque de Terminologie de Québec, and by various university departments, government agencies and surveyors (Ballantyne, 1996. p.4).*

The ISO definition is given in Bervoets, Ogleby and Smith (1999) as: –

*A field of activity which, using a systematic approach, integrates all means used to acquire and manage spatial data required as part of scientific, administrative, legal and technical operations involved in the process of production and management of spatial information. These activities include, but are not limited to: cartography, control surveying, digital mapping, geodesy, geographic information systems, land surveying, mining surveying, photogrammetry and remote sensing (Bervoets, Ogleby and Smith, 1999. p.33).*

Young (2013) refers to a paradigm shift in surveying that is being recognised by practitioners and educators, and suggests that the widening scope of the profession is indicative of the shift. He identifies the widening scope as a ‘geomatics paradigm’, and uses the term in later parts of his thesis. However, he provides no analysis of the profession to substantiate the claim of paradigmatic shift, and appears to use the term ‘paradigm’ in a vernacular sense rather than in the context of a Kuhnian definition (Kuhn, 1962). It is likely that no technical profession has been immune from the spectacular advances in technology, and while there may have been a paradigm shift in technology, there is no evidence presented that, as a result, the surveying profession itself has undergone a paradigm shift. That is, the practice of land surveying, at its essence is still basically the same as it has been from the start of its history as we know it.

Who first coined the term geomatics would appear to have been lost in the mists of time. However there is sound evidence that the term had received official recognition, at least in the French language, by 1975. Clearly, such is the limited nature of the understanding of the origins and meaning of geomatics, as identified in Chapter 8, that greater exploration is required.

## 9.2 The facts

In 1975 Bernard Dubuisson, a French photogrammetrist and geodesist, refers to “a new discipline which is called GEOMATIQUE. And thus a geomatic standing committee has been formed within the framework of the Central Committee of French Geographical Activities”. Geomatique is translated as geomatics. He further states that: –

*... two essential disciplines that are intermingled today: photogrammetry and one that an official neologism has recently referred to as geomatics.*

Other than the reference to the new word, Dubuisson does not give an indication of its meaning, except for mentioning geographical location and computerisation. He also refers to the possibility of another neologism, photogeomatics (Dubuisson, 1975). Furthermore the entry in Wikipedia for geomatics, at the date of writing, refers to hydrogeomatics (<https://en.wikipedia.org/wiki/Geomatics>). Neither photogeomatics nor hydrogeomatics seem to have caught the imagination of those who may identify with these fields.

Gagnon and Coleman (1990) also source the introduction of the term geomatics in France at the end of the 1960s but they do not cite the source of their information. They confirm that Dubuisson: –

*“... was the first to use the term in a scientific work [Dubuisson 1975]” and that “It was recognised by the Comité international de la langue française by 1977” (Gagnon and Coleman, 1990. p.378).*

They add that the *Grande dictionnaire encyclopédique Larousse* supplied a definition of geomatics in its 1983 edition (Gagnon and Coleman, 1990). Bédard (2007) states that: –

*... the word “geomatics” first appeared in the early 1970s at the Department of Equipment and Housing. At that time, Geomatics only referred to computer assisted mapping activities similar to the word photogeomatique . . . Since the new words had a narrow meaning . . . they did not catch on (Bédard, 2007. p.269).*

He continues that “the term *géomatique* was re-invented” in Quebec City, Canada, and that its re-inventor had not heard of its earlier use in France. That re-inventor was Michel Paradis: –

*... a Quebec land surveyor working for the Quebec Department of Natural Resources created the term “géomatique” as an umbrella term encompassing every method and tool from data acquisition to distribution. This time . . . it spread worldwide . . . (Bédard, 2007. p.269).*

Given that Bédard (2007) references a personal interview with Michel Paradis, this account has substance and veracity.

Michel Paradis takes the etymology of the word a stage further than prior users, according to Ballantyne (1996). Ballantyne identifies three components used in constructing géomatique. These are *terr* (land), *information* and *automatique* (automatic) (Ballantyne, 1996. p.4).

While the reference to *terr* (as in *terra*) and *information* are clearly and simply understood, it must be assumed that the inclusion of “automatic” is a reference to the computerisation of the management of data. In the abstract for his article, however, Paradis (1981) does not use the word geomatics. He refers to the new approach as being “Geodata”, and defines it as the integration of data capture, manipulation, storage and diffusion. He further observes that the land surveyor is “naturally predisposed to geodata” (Paradis, 1981).

Following its appearance in Quebec other organisations in Canada were taking up the use of geomatics in formal titles. The Canadian Institute of Surveying and Mapping became the Canadian Institute of Geomatics (CIG) in 1992 (CIG. n.d.). Furthermore, the Department of Geodetic Sciences at Laval University in Quebec, in a revision of the curriculum, offered a Bachelor of Geomatics in 1986, (<https://en.wikipedia.org/wiki/Geomatics>) the first in the world to do so. A name change of the department itself then included geomatics as part of its title (Bédard, 2007). Furthermore: –

*... the ‘Association canadienne des sciences géodésiques et cartographiques’ changed first in French to the Association canadienne des sciences géomatiques. Such a name demonstrated that “geomatics” was used as an umbrella, and that it did not replace the existing disciplines of surveying, mapping, geodesy and photogrammetry. By using the plural form explicitly, it indicated that these sciences continued to exist on their own while sharing a common vision, and that they shared common issues resulting from the new digital era* (Bédard, 2007. p.270).

Bédard goes on to clarify an issue that arose, particularly in the UK, about the relationship of geomatics with GIS. He states: –

*Although it is still common to see non-specialists confusing GIS and geomatics, it is not, and never has been, intended in this way. GIS is only one component that may contribute to a geospatial data workflow. Geomatics is the “science of selecting and chaining different Geospatial Information Technologies in the most efficient manner . . . ”* (Bédard, 2007. p.271).

Finally, in the words of Bédard (2007): –

*. . . it is widely recognised that the modern geomatics paradigm originated from Canada, and more specifically from Quebec; and that Michel Paradis is the father of the term, while its mother is Laval University (the Department of Geomatics Sciences). The Canadian Institute of Geomatics played a key role in disseminating this new paradigm* (Bédard, 2007. p.271).

The use of the term “geomatics paradigm” is not germane to this study and so will not be pursued. Nevertheless, the origin of the term geomatics is quite clear and undisputed. Laval University took up geomatics, and it was adopted by a Canada-wide professional body for surveying and mapping. It is no surprise, therefore, that its use spread eastward to the UNB and then westward to the University of Calgary, whose geomatics programme was initiated by former UNB staff. Other Canadian university programmes (York, Ryerson) have conformed to the use of this terminology and the University of Waterloo introduced a specialist stream in Geomatiques in 2008 that integrated its strengths in GIS and remote sensing (Hall, 2017).

In contrast to the universities, the Canadian provincial land surveying associations have not subscribed to the use of the geomatics in their titles, and have strong feelings about its use with respect to surveying, as discussed in Chapter 8. It is further observed that the use of an umbrella term to cover the variety of disciplines specified by Canadian authors may have been a peculiarly Canadian issue. Ballantyne (1996) notes the unique position of Canada as a bilingual country, and suggests this also was an influence on the uptake of new terminology. Gagnon and Coleman (1990) describe surveying in Canada as historically concerned with land title or cadastral surveying. According to the associations visited, and the staff interviewed for this research (Interviews 3Cp, 8Ci, 10Ci), this remains predominantly true.

The Canadian experience is not universal. The profession of land surveying in other countries, for example New Zealand, embraces most of the disciplines cited above. New methods and technologies have been absorbed by the surveying profession as they developed and incorporated into the land surveying educational curriculum over time without the requirement of adopting a new term to embrace them. That these broader disciplines were simply not considered a part of surveying in Canada may be an anomaly. As Ballantyne (1996) comments “the mere fact that geomatics is promoted in Canada is no reason to adopt it in place of surveying”.

Ballantyne, however, may be oversimplifying. As has been pointed out repeatedly in the literature of the history of geomatics, the intention was not to replace surveying with geomatics, but to include surveying under the umbrella of geomatics, along with other disciplines. Those other topics referred to by the originators of geomatics, such as geodesy and photogrammetry, are not professions in themselves with respect to the criteria discussed in Chapter 3, but sciences or disciplines. At least a part of the problem in absorbing these new disciplines may have been the conservative nature and narrow focus of the surveying profession in Canada.

Gagnon and Coleman (1990) give three reasons for the need to adopt the new name, geomatics. They are: technical change, the development of specialisations, and social changes that have created a greater requirement for both quantitative and qualitative data. They suggest that Paradis (1981) “casts light on the enlarged horizons for surveying and mapping” (Gagnon and Coleman, 1990. p.379) and quote Paradis as saying: –

*“It is evident that geomatics has widened the field of application of surveying. Why should the surveyor be limited to the drawing up of a cadastre . . .”*

(Paradis, 1981. p.379. Translation quoted in Gagnon and Coleman, 1990).

Clearly, the limited view of the range of the surveyor’s work applies particularly to Canada. But the assertion above confuses rather than clarifies how the relationship between surveying and geomatics should be understood as it is clearly stating that geomatics widens surveying, implying that geomatics is simply an enlargement of the competencies of the surveying profession. This does nothing to help the understanding of what the inventor of the term intended to be the relationship of surveying and geomatics. It is uncommon, if not unique, for the technological advances in a profession to require that the profession change its name (Interviews 3Cp,14Cp, 46Ga).

The paper of Gagnon and Coleman (1990) was written as an explanation, to the membership of the Canadian Institute of Survey and Mapping, of a motion to be put to its next Annual General Meeting to change the French name of that body to the *Association canadienne des sciences géomatiques*. By way of explanation they express the desire of some members –

*“to (1) have an Association which now extends beyond the traditional fields of surveying and mapping; and (2) provide the organisation with a title which much better identifies the roles and activities of its members”*

(Gagnon and Coleman, 1990. p.378).

It would seem that the motion to change the name only referred to the French language version, and does not refer to the English equivalent. The Association did, as noted, become the Canadian Institute of Geomatics during 1992 and its professional publication, the Canadian Journal of Surveying and Mapping, became Geomatica from Volume 47, in the spring of 1993.

What is more, in this same paper the authors provide a definition of geomatics, though this differs from, and is more succinct than, the definition adopted by the International Standards Organisation (ISO). This definition is: –

*Geomatics is a field of scientific and technical activities which, using a systematic approach, integrates all the means used to acquire and manage spatially referenced data as part of the process of producing and managing spatially based information”* (Gagnon and Coleman, 1990. p.378).

Despite claims to the contrary made by individuals, as recorded in Chapter 8, geomatics has a clear meaning at its point of introduction to the Canadian surveying and mapping profession. The meaning is not open to speculation or modification to suit an individual’s preferences.

The authors go on to say: –

*Geomatics is not a new field. Rather, it represents the evolution of our existing range of activities within a system-based approach or vision. Geomatics emphasises the interrelationships between traditional surveying and mapping disciplines – geodesy, photogrammetry, remote sensing, topometry, hydrography and cartography – which deal with the production of spatial information.* (Their italics replaced by underlining. Gagnon and Coleman, 1990. p.378.)

Geomatics then, at its source, was an attempt to bring together disciplines that were already seen as “belonging to” surveying and mapping. It is therefore merely a collective noun for a set of disciplines already in existence. The inclusion of the listed disciplines as part of surveying and mapping implies that the collective term merely replaces “surveying and mapping” but is required to emphasise their interconnectedness. This explanation labels “surveying and mapping” as a group of sub-disciplines, suggesting that the collective noun is needed more for academic coherence than for the practice of the profession of surveying.

The issue of the term geomatics arises directly from the structure of the surveying profession in Canada and the narrow view of the profession, as identified in the interviews conducted for Chapter 6. The ambit of land surveying arises in other countries, for example in the UK,

where it is somewhat confused but broad, and in Australia where it is more consistent but diverse.

Reviewing the proceedings of the XIVth North American Surveying and Mapping Teachers Conference of 1993, Smith (1995) reports on that organisation's plea for an umbrella term for the profession. He refers to a paper by James Crossfield of California State University citing the public perception of the profession as the greatest hurdle in attracting students. In a paper from the same conference Donald Bender comments on an "identity crisis" and calls for a less masculine term . . . *to provide the missing sex appeal, and incorporating the word engineering or geography or mathematics but not surveying* (Smith, 1995. p.37). This is the first and only reference to a gender issue in attracting students to surveying programmes. However, it demonstrates that the profession in the United States of America (USA) was experiencing similar problems with the definition of the profession of land surveying, as well as difficulty in attracting students to surveying programmes.

While there are sound reasons for adopting the terminology and definition of geomatics in Canada, it is less clear why it should have then have been adopted in other countries. Specifically, why did geomatics join the lexicon in countries that were not bilingual, where the definition of land surveying had greater breadth and where the surveying profession had already absorbed the new technologies, as they developed, into their existing traditional profession in an evolutionary manner? Australian universities were relatively quick to pick up the new word, making their reasoning of particular interest.

### **9.3 A move across the Pacific to Australia**

The use of geomatics in Australia was advocated by John Trinder and Clive Fraser in 1994. They were respectively staff of the School of Surveying, University of New South Wales and the Department of Surveying and Land Information, University of Melbourne. They give as the primary reason for the need for a name change that "surveying" portrays a limited range of activities and assert that this is true both locally and internationally. However, no supporting evidence is supplied to justify this claim. It is therefore presumed to be anecdotal, or merely the personal opinions of two senior Australian academics.

In the same paragraph, conversely, Trinder and Fraser claim that the graduates of their programmes become involved in: –

*a much broader range of activities than those associated with surveying and mapping alone, with many engaged in pursuits such as resource and environmental management, remote sensing and GIS” (Trinder and Fraser, 1994, p.88).*

This comment appears to contradict their former statement about the narrow perception of surveying, that while these representatives of their institutions view the profession as narrow, their graduates secure employment involving a broad range of professional activities with surveying qualifications, well beyond these narrow confines and, apparently, in spite of it.

Nevertheless the authors use this argument to call for an “umbrella” term to cover the “new” activities. Supporting their argument is a claim that “the surveying profession is apparently not held in high esteem in the general community” (Trinder and Fraser, 1994. p.88). Again, no evidence is offered to substantiate this claim. Going even further afield from the content of the profession, Trinder and Fraser assert that the students entering their programmes are of “low quality” compared to those taking up engineering and science. They claim it is not only an Australia-wide issue, but that it also exists elsewhere. They seek the support of the surveying profession by suggesting that addressing this issue is important for the future standing and leadership of the profession. Their proposed solution to all of these problems is the use of the term geomatics, which they argue is a step towards changing the image of surveying.

In examining the other seven surveying programmes in Australian universities in 1995, with the exception of the University of Tasmania, Fraser and Trinder found little interest and much caution among the practicing land surveyors in adopting geomatics into the names of their surveying programmes (Fraser and Trinder, 1995). A year later Fraser was identified as the Head, Department of Geomatics at the University of Melbourne and Trinder as the Head, School of Geomatic Engineering of The University of New South Wales in the UK publication *Surveying World* (Fraser and Trinder, 1995). Between June 1994 (the publication date of their first paper) and September 1995 both of their universities had gone ahead with a name change, dropping the reference to surveying and including geomatics or geomatic engineering in their titles.

While using the argument of adopting an umbrella term that included a broader range of activities, Trinder and Fraser (1994) acknowledge that surveying graduates were already finding post graduation positions in a variety of related occupations to which their surveying skills could be adapted. The principal motivation in seeking a name change from surveying to geomatics, however, appears to be to attract higher quality students into surveying programmes through marketing, which they explicitly refer to in their paper. This view was supported in Interviews 11Ap and 17Ap.

There were immediate effects on the number and quality of enrolments in the University of Melbourne programme, but improvement was short-lived. The change in the downward trend matched the intensity of marketing, but the intense promotion could not be sustained (Interview 11Ap). Additionally, the new term was not popular with practicing surveyors and in some instances caused acrimony between its academic proponents and the profession at large (Fraser and Trinder, 1995). In some cases it caused there to be alienation between the two arms of the profession (Interview 11Ap). The conversion to geomatics was so unsuccessful at the University of New South Wales that Baker (1999), only 4 years after the name change, described the situation at its School of Geomatic Engineering as a crisis: –

*It [the School] has an enviable international undergraduate and research reputation, but it is fighting for its life in its present form* (Baker, 1999, p.13).

While acknowledging the considerable breadth of the FIG definition of surveying, Trinder and Fraser (1994) and Fraser and Trinder (1995) make a direct comparison of geomatics with cadastral surveying in their publications. They attribute the poor image of the professional surveyor in Australia to this particular and constrained aspect of *land* surveying. This is an inadequate comparison because land surveying firms in Australia, in general, provide services well beyond those which maintain the integrity of the land title system with accurate, highly regulated, land boundary surveys. The author's experience suggests that any inadequacy in the image of professional surveyors, or surveying, is a lack of self-image and under-valuation of their skills and contribution. It is not helped by such criticisms by academics, especially when not supported by any empirical evidence.

In more recent times, and with the assistance of the newly formed professional body, the Surveying and Spatial Sciences Institute (SSSI), the terminology debate has mostly moved on. The use of the designation “spatial science(s)” has taken over from geomatics as the term

in more common use in Australia. This is despite the fact that it has not been taken up amongst the international community and remains a term with no specific definition either in the singular or in the plural form. The term geomatics in Australia has been unpopular within the surveying profession, was in declining use over a lengthy period in favour of spatial science, and more recently, as noted in Chapter 8, geospatial science has been growing in common use.

In 1999 the University of New South Wales School of Geomatic Engineering adopted the new name of the School of Surveying and Spatial Information Systems (Leoffel, 2007). In 2012 it changed its name again, on this occasion to the School of Surveying and Geospatial Engineering (SAGE). In 2013 SAGE was disestablished and merged with the School of Civil and Environmental Engineering (UNSW, 2017). Several changes of name have not aided survival.

At the University of Melbourne the Department of Geomatics has been absorbed into the Department of Infrastructure Engineering in the School of Engineering (Interview 4Aa). For a period it sent its students wishing to become licensed cadastral surveyors to the RMIT University, also in Melbourne, for a part of their programme (Interview 11Ap). More recent information indicates that this is no longer the case (Grant, 2017). The University of Melbourne has moved away from the incorporation of land surveying amongst its offerings towards the field of information science (Interview 4Aa) but retains its accreditation with the Surveyors Registration Board of Victoria (SRBV) (SRBV, n.d.).

The UK has also followed the Canadian and Australian examples of adopting the new term geomatics for many of its former surveying programmes. As in Australia, there was much debate about its adoption, and its implementation was controversial and contentious.

#### **9.4 A move across the Atlantic to the UK**

The debate over the geomatics name took place in the UK during the period 1996 to 1997, after the Australian initiative, and is recorded in the RICS publication *Surveying World*. The publication became *Geomatics World* in 2001 (Kavanagh, 2016a). While the first suggestion of adopting geomatics is not recorded, it was “well argued” at a meeting of the Divisional Council of the LHS Division of the RICS on 10 October 1996. This suggests that at the very

least there was some level of awareness of geomatics among the members of the RICS prior to this, and that it had been debated at some earlier date. The result of the October 1996 debate was that the president of the LHS was authorised to approach the members of the division about changing its name to the Geomatics Division (Coulson, 1996a).

In an Editorial advocating for the change of name, Coulson states that: – “we can make it mean what we want it to mean” (Coulson, 1996a, p.1). He appears to be unaware that a definition already existed and was approved by the ISO, and had been for more than a decade. He advocated for its use as an “umbrella term” (not the first time this phrase has been used) to include and tie together the various branches of measurement surveying (civil engineering, land, hydrographic) and also extended it to include GIS practitioners who at this time were looking for a professional home. He considered the name change a matter of urgency or “. . . we will be washed aside by the momentum of the geospatial revolution”.

Curiously, he also stated that: –

*“. . . the external market will continue to see us as surveyors. But the other professions and our internal market for members will quite quickly accept a new name . . .”.*

He relied on the Canadian experience in making this claim (Coulson, 1996a. p.1).

At the LHS Divisional Conference during 6-8 September 1996, Coulson reported that the well-attended discussion concluded that a new name was required to reflect the greater breadth of the Division and –

*Although geomatics was not universally liked, there seemed to be no viable alternative . . . and that . . . A new name could be brought into common usage at once, but incorporation on the statute books would probably take at least three years . . .*  
(Coulson 1996b. p.15).

Booth (1996) noted that the University of Newcastle-upon-Tyne had been the first in the UK to incorporate geomatics when the Department of Surveying was renamed the Department of Geomatics. He commented that the university believed that the name change would remove the confusion between different types of surveyors.

In the same issue of *Surveying World*, Draper (1996) sounded a warning. He asked in his regular column “Undercurrents”, if the new word had been market tested and if the

introduction would be supported by a multi-million pound advertising campaign. He suggested that: –

*... the move does not seem to have been thought through properly. If we were being seriously commercial about it . . . we would take advice from marketing experts, carry out tests on market awareness and do the 101 other things business does before risking the launch of a new brand* (Draper, 1996. p.6).

He also surmised that it: –

*... is a word dreamt up by academics . . . so as to encourage more students to sign up for courses in something that sounds a tad more exciting than surveying* (Draper, 1996. p.6).

Professor Peter Dale also voiced a warning about introducing the new term. Dale is reported in Booth (1996) as saying: –

*Geomatics is a dead end, since it will ultimately be automated, Robots will monitor the earth. If you want to be a robot, be a geomatician* (in Booth, 1996. p.17).

The original circumstance of this comment is not given. While Dale's was a particularly pessimistic view of geomatics, it was also a reflection on the future of surveying, given the historic emphasis on data gathering, by the surveying profession. Dale's own view of the profession emphasises professional services for clients over technological aspects of surveying. In an interview in 1996 with the professional magazine GIM, he said: –

*It is about providing a service to society . . . we shall win [status] through meeting the needs of the community rather than through the sophistication of computers and the technology that we play with* (Dale, 1996. p.66).

This view is echoed in the comments of van Gysen (1996) of the University of Natal referred to in Section 9.5. Dale further comments that: –

*Geomatics relates to surveying and mapping but these are only a subset of the activities of the surveyor as defined by FIG. Land management, spatial planning, land and property valuation and construction economics or quantity surveying are not regarded by many people as geomatics but they are part of the work of FIG* (Dale, 1996. p.66).

Dale appears in this discussion as a lone voice advocating that surveying is not a subset of geomatics, which is the common view, but the reverse and that it cannot be a substitute name for surveying.

In *Surveying World* later in 1997, UCL was recognised as the second university in the UK to adopt geomatics, at the expense of surveying, as part of its name. Adding further to the ambiguity regarding names, Professor Paul Cross discussed “geomatic engineering”, a term used frequently in Canada. This usage raises a related question, which is whether surveying is an engineering discipline (as claimed explicitly in Leoffel, 1997), or whether it might be more correctly defined as applied geography, as noted earlier. Cross went on to explain a rationale for the connection to engineering, not the least of which is the fact that his department (the Department of Geomatic Engineering) is housed within the Faculty of Engineering at UCL (Cross, 1997).

Cross (1997) also cites personal experience, commenting that in calling himself a surveyor he always had to give a full explanation of what a surveyor does. The implication is that if he used the term geomatics or described himself as a geomatician this problem would not exist. He further made the prophetic statement that: –

*A profession that cannot even agree a name is unlikely to be taken seriously*  
(Cross, 1997, p.15).

Lack of clarity regarding the meaning of surveyor is a particular feature of the UK, but replacing it with geomatics has not met with universal agreement there (or in Australia or Canada). Cross did make the point that he saw geomatics as “meaning much more than traditional surveying” which could not previously have included managing GIS, quality controlling industrial processes and carrying out environmental impact analysis (Cross, 1997). While this may have been a reasonable position in the UK at that time, many people interviewed for this thesis would disagree.

In his advocacy of geomatics Cross makes the further point that describing himself as a geomatic engineer gives him the opportunity to explain the term, presumably because people will not know what that means. However, when he calls himself a surveyor, –

*“nobody asked because they thought they knew the answer (although they were probably wrong!)”* (Cross, 1997, p.15).

The real issue emerging is that the meaning of the term surveyor is more ambiguous in the UK than elsewhere (already referred to in Chapter 8.2.1) because of the host of related disciplines that claim the term “surveyor”. These include quantity surveyors, valuers and

estate managers, who have very different training and competencies, yet who can become, and are, Chartered members of the Royal Institute of Chartered Surveyors. Such professionals can use titles such as Chartered Valuation Surveyor.

Jon Maynard, as president of the LHS Division of the RICS, advocated to his members that they vote in a referendum as to whether they wanted to change the name to the Geomatics Division. He argued for the expanded definition that would include land and hydrographic surveyors and claims inclusion of geographic information specialists. He added that the term had the support of academia, that it was a “modern looking word” and that there would be an opportunity to “establish a meaning for it” Maynard (1997). Again there appears to be either an assumption that the term can be redefined to suit local circumstances or ignorance that geomatics already has an official meaning.

Maynard later reports that the result of the referendum was that it passed by 113 votes to 93, but that the voting turnout had only been 13% of the membership. He considers this a statistically reliable result. Nevertheless, his Divisional Council still had a lengthy debate over the matter and had not decided to take it forward for the RICS General Council approval at that point (Maynard, 1998a).

The Divisional Council later voted by postal ballot to change the name to the Geomatics Division by 19 for and 6 against and 6 abstentions. Maynard reported that the new name would then be put to the Institution’s General Council (Maynard, 1998b). In the July/August issue of *Surveying World*, Steve Shipman was by-lined as the President of the Geomatics Division of the RICS. The RICS Interview conducted for this research reveals that a large number of members resigned from the RICS as a result of this change of name (Interview 27Gi). The voting numbers, and the balance of the voting, do not give confidence that the members of the LHS Division had significant enthusiasm for the change.

## **9.5 Other jurisdictions**

Booth (1996) records that early in 1996 the University of Natal, South Africa, used geomatics to define its first year surveying course. The University of Natal was absorbed into the University of KwaZulu-Natal (UKZ) in 2004 and today maintains a School of Land Surveying and Property Management. The School’s website states that “Land Surveying

deals with the field of Geomatics” and goes on to define correctly the origin of the word as “geo” (earth) and “matics” as a derivative of informatics. It explains the need for the term as a consequence of the “digital revolution”. It then defines Geomatics by stating: –

*Geomatics therefore is a discipline with focus on acquisition, processing, management, presentation and dissemination of information about the earth and features with a fixed location on the earth surface (UKZ, 2106).*

This definition is consistent with original meaning given to geomatics. It is noteworthy, however, that the School within UKZ has retained land surveying in its title, and has not changed to geomatics. Like UEL, UKZ recognises the newer term, but uses it only in subtext rather than in a title. This may reflect the desire for geomatics to be recognised by search engines in the same manner and for the same reasoning as UEL in the UK. Van Gysen, Head of the School at the then University of Natal, explained and expanded on the meaning and use of geomatics (van Gysen, 1996).

Booth (1996) also refers to a change of name in the American Society of Civil Engineers of its Surveying Engineering Division to that of the Geomatics Division, but notes that the American Congress of Surveying and Mapping (ACSM) “. . . is not quite ready for such a leap of faith”. ACSM more recently merged into the National Society of Professional Surveyors, and has still not made the leap of faith referred to by Booth. Booth further reports that the University of the West Indies had adopted geomatics into its name for what had previously been surveying (Booth, 1997. p.5).

Booth (1996) makes mention of the adoption of geomatics in Australia, and that it was yet to make an impact in New Zealand (Booth, 1996. p.17). While adopted in some parts of Australia but superseded, as discussed above, geomatics still has not been accepted either by practitioners or academics in New Zealand and continues not to be a topic of discussion.

## **9.6 Summary**

The term geomatics spread in the Anglophone surveying community after its creation and spread in bilingual Canada. It was adopted by some bodies in the USA, Australia, South Africa and the UK. While its absorption into academia appears to have occurred without

much debate, its adoption by the premier land surveying professional body in the UK, the RICS, was not without controversy or cost in membership.

The reasons for the adoption of the term are threefold. First is a desire to embrace “other” disciplines under the umbrella of geomatics that were not traditionally included as aspects of surveying in these jurisdictions, particularly photogrammetry, remote sensing and GIS. This is especially a UK and Canadian issue, and while it occurs elsewhere, it is not universal. There are other countries where most of those disciplines were already considered to be part of land surveying.

The second reason is related to the image of the profession of land surveying and of land surveyors. The image, as portrayed by academics in particular, is old fashioned, field-based, and generally of low status among other professions. This is important as it relates to the recruitment of students into academic programmes, and in the longer term, into the profession. However in each of the counties considered in this research, these are comments made by academics about the public image of land surveying practitioners. As yet no evidence has been discovered to support this assertion.

The third reason is regeneration and originality. The word is “invented” and therefore is perceived by some to have no definition. It can therefore be defined in any way those who choose to use it, and as a result, used to create a more attractive image. The catch in the last rationale is that in order to change the image, the new term would have to be widely and consistently used as part of a coordinated and agreed promotional campaign. It has not been so used or promoted.

Contrary to popular belief outside Canada, the word geomatics, from the time it was introduced into the English language at Laval University, had an internationally approved definition. The new term was believed to be required in Canada because the land surveyor was generally considered to be narrowly constrained to cadastral surveying. This was at a time when the digital revolution was just beginning to have an impact on the land surveying profession. The introduction and use of geomatics was intended, and defined, to include diverse means of gathering and managing measurement data about the spatial relationship of the physical and built environment. Its introduction in Canada, therefore, was a legitimate

attempt to provide an umbrella term that would include cadastral or land surveying among the emerging other disciplines of GIS, photogrammetry and remote sensing. The bilingual nature of Canada was also an important influence in the need for and creation of the term.

Canadian academics and surveyors hoped that the new term would improve the general image of the land surveyor by associating the profession with other sophisticated technological advances that were taking place in society. It was not intended as a new name for the surveying profession, but instead to recognise that some graduates with geomatic skills would become professional land surveyors. This situation continues, and is particularly noticeable at the University of New Brunswick. The reasoning, however, is dependent on the equating of Canadian land surveying to cadastral surveying. More than thirty years on, the term geomatics remains controversial and disliked by some of the profession surveyors in Canada and is not clearly understood by contemporary academics. Notwithstanding, professional land surveyors continue to call themselves surveyors.

Geomatics in Australia has a similar provenance to Canada. Again, the first issue referred to was the need for a broad term that embraced more than traditional land surveying. The new term, explicitly, was not intended to rename the profession but to incorporate the impacts of the digital revolution into its activities. However, that reasoning was less important than the decline in student numbers in university surveying programmes. The adoption and marketing of a new name was seen to be the solution to that problem as outlined by Trinder and Fraser (1994) and Fraser and Trinder (1995). Subsequent to the initial drive to change the nomenclature to geomatics, Australia has moved to the term spatial sciences, and more recently geospatial sciences, is taking hold. Both are attempts to add breadth.

The relationship between the terminology of universities and that of professional surveyors is not clear, as demonstrated by Australia's premier professional body in this field, the Surveying and Spatial Sciences Institute. At face value this title implies that surveying is not included amongst the undefined spatial sciences, but lies outside although alongside them. This is further supported by the fact that the Spatial Sciences Institute, formed in 2003, chose to add Surveying to its name in 2009.

The reasoning in the UK is much the same. It is primarily maintained that geomatics suggests a larger, wider and more contemporary discipline. Nevertheless, the decline in student numbers, the perceived poor image of land surveyors and the surveying profession generally, appear to be of greater importance. However, the term is not universally liked or accepted. Some university programmes retain surveying in their title but accept that geomatics is useful to have in search engines. If connected to an engineering school, geomatics engineering is preferred, as in Canada, although the University of Nottingham uses neither geomatics nor surveying. It does, however, provide graduates with a degree in engineering. Ireland uses geomatics but Scotland uses neither surveying nor geomatics in the name of its qualifications, but teaches both in its courses. There is, therefore, no consistency of approach in the UK and Ireland.

Gordon Johnston, present Chair of the Geomatics Professional Group Board (GPGB) of the RICS, the rebranded LHS Division, has reported that the GPGB has called on its members to offer an opinion and comment on the Division's name. He referred to geomatics as being ascribed by some as a "fashion or trend rather than a long term title". While the GPGB had not received sufficient returns to enable a name change as yet, the term geomatics, at least as a controversial issue within the RICS, is alive and well (Johnston, 2016).

The one country that resisted adoption of the term geomatics, although it was seriously discussed by the professional institution and the academic body, was New Zealand. The breadth of the educational programme at the University of Otago, which is home to New Zealand's only professional surveying programme, is considerable. It has absorbed GNSS, GIS and remote sensing into its programme as they developed and has always included photogrammetry. The continued over-subscription of students wanting to study surveying, and the standing of the profession in New Zealand, provided compelling arguments against change. The strong cooperative and combined marketing by the New Zealand Institute of Surveyors and the National School of Surveying at University of Otago contributed to the view that there was no need for change (Hannah, Ballantyne and Khan, 2000).

Hence, wherever geomatics has been adopted it has been controversial. It has been used indiscriminately by the academic community. It has also been redefined at will. It has alienated some members of professional bodies and it is disliked by others. It was intended

to provide an umbrella term for a number of disciplines that included surveying where those were not already included. While recruitment to the profession has been a significant reason for its adoption, evidence suggests that it has failed to do this. After over 25 years it remains contentious wherever it is used and there are both murmurings and actions afoot to replace it.

## **Chapter 10**

### **Discussion and Conclusions**

This study began as an investigation into the nature and magnitude of changes that had taken place in the land surveying profession since the advent of the electronic and digital environments, approximately 60 years ago. The primary issue was to determine if the technological changes were of such a magnitude that the fundamental role of the surveyor had changed. This was accomplished by first clarifying the meaning of “fundamental” and then considering whether such a change could be described as a paradigm shift.

Studying the past 60 years of change required a baseline understanding of the past and present nature of the land surveying profession. This, in turn, required addressing the question of whether land surveying could be regarded as a profession. A review of the extensive literature on professions was therefore undertaken. The nature of change to the body of knowledge, passed on through the education system, was considered and the fundamental core of land surveying identified. Using grounded theory methodology as a guide, the nature of change was examined using interviews. This led to a further question regarding the name of the profession, and the developments that have taken place with respect to terminology within the study period. Answers to these questions are discussed in the following sections of this concluding chapter.

#### **10.1 Is surveying a profession?**

While the concept of professions has existed for centuries, only in the last 200 years has the definition extended beyond the original three, namely the law, medicine, and the church. As discussed in Chapter 2, entry into a profession was first by taking religious vows, that is “professing” faith, followed by clerical education and finally by education in the chosen

specialist field (Armstrong, 1994; Dyer, 1985; La Vopa, 1982). In recent times however, the number of occupations claiming the status of a profession has grown considerably.

The rise of the universities in the Middle Ages brought education without the necessity of a religious commitment as a prerequisite. However it was not until the 18<sup>th</sup> and 19<sup>th</sup> centuries that new professions began to emerge, principally as a result of the rise of institutional science and the Industrial Revolution. Surveying, as represented by a professional body in the UK, had its origins with the Surveyors Club, but really emerged as a fully-fledged professional body with the founding of the RICS in 1868 (RICS, n.d.).

Within the voluminous literature about the professions there is a general consensus on the basic requirements, as demonstrated in Chapter 3. Specifically, an occupation must be intellectual; the body of knowledge of the profession must be capable of being educationally transferred; the profession should be self-regulating; it must offer an altruistic service to society; and its members must act ethically. The requirement for ethical behaviour necessitates that there is a body that defines ethical behaviour and that it has mechanisms to enforce that behaviour, and sanctions in place to deal with those who transgress. It has been demonstrated that surveying, at least in the countries examined, meets all of these criteria and therefore can be deemed to be a profession.

## **10.2 Paradigms in surveying**

Land measurement has been practiced for at least 4000 years (Cooper, 2009). The pyramids are evidence of an understanding of measurement in early Egyptian culture and the ability to carry it out to a high degree of accuracy (Dilke, 1971). Egyptian surveyors were also important for the re-establishment of boundaries following the regular flooding of the River Nile (Kemp, 2006). There is evidence that, at least in Roman times, surveyors were also highly regarded in the field of the law relating to land. Their knowledge was also important for the laying out of garrison encampments for Roman troops, and the design and monitoring of major engineering works such as aqueducts (Cooper, 2009). This period of antiquity has been identified as the first paradigm of land surveying practice.

The predecessors of modern land surveyors in England were overseers or, to use the modern equivalent, estate managers for land owners. The dissolution of the monasteries and the

resumption of their lands by King Henry VIII, along with the sale of rights in land rather than imposition of feudal demands, changed the nature of the land market. The enclosure of land by new owners, the development of better tools for land measurement and imported developments in mathematics changed the function of land surveyors in the period from approximately 1550 through to about 1650, as detailed in Chapter 4. From being overseers of land management they became the measurers of land areas, the definers of boundaries of land entitlements, and therefore the identifiers of the physical limits of the rights in land.

This change signifies a move of paradigmatic proportions as the land surveyors of the time took up new technologies and adapted their occupation accordingly. Chapter 4 distinguishes between the 1<sup>st</sup> and the 2<sup>nd</sup> paradigms in the land surveying profession. While the new technologies evolved, albeit slowly, little changed in the methodologies or the practices of the land surveyor until the 20<sup>th</sup> century. It has been suggested that if a paradigm shift has occurred in the recent past it is in the technology that surveyors use as a result of firstly electronics and then digitisation.

In Chapter 5 it is demonstrated that there has also been a major shift from reliance on ground-based technology to aerial and orbital measurement platforms. In particular, for the likes of the cadastral surveyor, the move from triangulation-based survey control to GNSS has required the development of new practices and methods of thinking and working. It has also required a new way of thinking about how to apply the technology.

In the course of interviews conducted for this research, two interviewees mentioned the idea of paradigm drag. In both instances the reference was made with respect to the law. In the first case, it was a reference to the delay in legislation to keep up with the use of drones or UAVs. It was considered that both the regulations relating to the piloting of these “aircraft” and the health and safety requirements had not kept up with the advancing technology and its uses (Interview 31Ap). The second case was with reference to GNSS in relation to its use for control for cadastral surveys. It was opined that much greater use could be made of satellite technology in this respect, but that the legislators had not kept up with the capabilities of the technology (Interview 37Ag). Both of these suggestions came from Australian surveyors.

The move from surveyors drawing plans of their surveys, especially in the cadastral speciality, to producing “datasets” to be sent to the land registry directly from the surveyor’s desk, could be considered paradigmatic. In the more advanced jurisdictions this also included land title information and therefore also involved the legal profession. This change had occurred in some jurisdictions and was being developed in others (Interview 32Ag).

Again this is an observation from an Australian surveyor.

Moving from a paper-based system to a digital one was significant for many and traumatic for some practitioners. It required a considerable shift in work methods and in its earliest stages of transition was resisted, sometimes vehemently. However, its narrow range of impact, that is, only on the cadastral work of the surveyor in these jurisdictions, and only on one aspect of that work, argues against viewing this as a paradigm shift for the land surveying profession at large. As paradigm drag was identified by interviewees as only of particular applicability to legal issues, while an interesting concept, it is beyond the scope of this study.

The information generated through the interview process and presented in Chapter 6 does not support the claim that there has been a shift to a third paradigm for the land surveying profession. Technological advances have changed the tools and methods that land surveyors use to gather data. In some cases the new methods have changed how surveyors think about and plan their work, and how they interpret their data. Technology has also driven profound changes to the presentation of data for clients. Many systems do not easily lead to a printed plan or map as was once the case. ***Nevertheless, while technology has revolutionised traditional land surveying practices in many ways, it has not changed the activities at the core of the profession or the benefits that land surveyors provide to society.***

New technologies have not only provided new modes of geospatial data acquisition. They have opened up the potential for professional land surveying practices to apply the acquired data to new areas of enterprise from agriculture to movie sets. Data can be accumulated from equipment such as terrestrial laser scanners, drone-mounted high resolution cameras and satellite imagery. Data can be supplied at higher accuracies and greater reliability than ever before, can be applied in a greater variety of ways, and can open up a wider variety of potential projects for land surveyors. However, the understanding of the mathematics behind the technology, the ability to plan data gathering operations, and the ability to interpret and

understand the nature of the data being captured remain largely the same. The need to understand the principles behind this more complex technology is greater in depth but not significantly altered in breadth. It is this that defines the exclusive expertise of the professional land surveyor. Nevertheless, ***no new paradigm has been identified by this study.***

### **10.3 The core of land surveying**

The interviews undertaken in this research survey were unanimous in defining the core of land surveying as being “measurement”. Chapter 7 establishes that changes to the body of knowledge held by the profession have arisen in response to the advancement of technology and have taken place as new equipment has been developed. While the clichéd response that land surveying is about measurement was the norm, it is not adequate as a complete answer. Measurement is both a science and an art. The gathering of measurement data, more commonly referred to as spatial or geospatial data, has become largely automated.

One of the greatest challenges to assessing the core of land surveying is regional variation in the definition of “land surveying”. Topics such as photogrammetry, remote sensing and GIS that are seen as part of surveying in some places (e.g. New Zealand) are seen as separate disciplines or specialities in others. Despite these differences, ***there is remarkable agreement on the fundamental knowledge being related to measurement, being its accuracy and its precision.***

Changes in technology are reflected in changes that have taken place within surveying education curricula. As identified in Chapter 6, topics that have been eliminated from surveying programmes were no longer needed because they had become obsolete or redundant alongside the new developments. It is apparent that programmes are under constant review and that new methodologies and equipment are readily absorbed into teaching programmes. The programmes, therefore, evolve as the technology does. However, while teachers are responsive to new equipment they also find difficulty eliminating material from the courses within their programmes.

Land surveyors no longer need to go into the field personally in order to accumulate sufficient, accurate and reliable data. Professional land surveyors formerly spent a significant

proportion of their time personally gathering measurements and particular physical skills and techniques were required to gather reliable data. The tools now in common use are easily operated by technical staff with purely technician training and the manual dexterity of former times has been minimised.

The professional task of the surveyor has two main components. First, the quantity and nature of the data needed to meet a client's needs must be identified, the appropriate accuracies defined, and the field survey planned and designed. The second function is to confirm the reliability and accuracy of the data gathered with respect to the requirements of the output required. It may also be necessary to integrate the data by dealing with variable accuracies if it has been accumulated by more than one device. The data must then be managed or manipulated in such a way that it can be presented in a form that is appropriate for the client's needs, intelligible to the client, and suitably stored.

Altogether, *understanding the accuracy and precision of measurements and their implications for various applications, and the ability to translate that knowledge into appropriate programmes of work and appropriate products for clients, are the core functions of the professional land surveyor today*. This requires competence in problem definition and the mathematics related to the theory of errors, probability theory and least squares adjustment.

The practice of land surveying in a professional capacity requires managing the collection, organisation, analysis, storage, and the dissemination of the data in a form that will be finally useful to the client. It differs little from the original definition of geomatics. This requirement is regardless of the size of a project and should result in fit-for-purpose surveys. No higher level of accuracy than that needed to meet the client's needs, but sufficiently accurate to meet the project requirements with a high level of confidence and minimal risk, is the desired outcome. It is not necessary to maximise the capability of available equipment.

Land surveyors have always done these activities, but the quantity, quality, medium and nature of the data formats has changed. That does not demonstrate or suggest a fundamental shift in land surveying. It acknowledges a change in the technology of the collection and storage methods. It does require a variety of new knowledge and skills. At its essence it is a

rebalancing of the relationship between field operations and office activities. This clearly requires ***new education, knowledge and skills in the management of data***, the nature of which continues to change, but does not make land surveying something different to what it has been since the 17<sup>th</sup> century.

## **10.4 The name game**

Having established that the land surveying profession has not undergone a fundamental shift, but has evolved alongside the technology that supports it, a new question is raised. Why should there be concern over, or a need, to rename the profession? As Cross (1997) noted: –

*A profession that cannot even agree a name is unlikely to be taken seriously* (Cross, 1997. p.15).

The literature and the interview outcomes supply lines of reasoning. These reasons are consistent in the areas studied and where the term geomatics has been introduced, that is in Canada, the United Kingdom and Australia. Chapter 8 demonstrates the present degree and extent of lack of understanding of the original meaning of geomatics and its original purpose, especially outside Canada. Hence, it is used to mean different things by a variety of people.

Chapter 9 exposes that geomatics was originally coined as a translation from the French *geomatique* in bilingual Canada. The expressed need for it was that land surveying did not embrace within its definition the new technologies of photogrammetry, remote sensing and GIS. There was, it was felt, a need for a new term that did include these new and developing technologies. This remains true for Canada where the term land surveyor is restricted to meaning a cadastral surveyor.

Given the close association of geomatics education with engineering in that country, to the extent that it is mostly referred to as geomatics engineering, it is difficult to see how this can now be changed. Land surveying is viewed as a sub-set of geomatics engineering, and graduates of these programmes, should they select the appropriate courses, may become land surveyors as well as geomatics engineers. However, it was clearly stated at the time of its introduction that geomatics was not intended to be a new name for surveying. Geomatics was intended to embrace a collection of new technological disciplines, and it included land surveying within it.

The second and third reasons given for the need to adopt a new name by the creation of a new term are closely related. The second reason is expressed as the difficulty in recruiting sufficient numbers of students to land surveying programmes. This is important for the viability of the programmes in the competitive academic environment and to supply the surveying profession with adequate numbers to replace loss through the imminent retirement of the baby boomers.

The third reason is the alleged poor image of the land surveyor, to which the second is at least partially attributed, as claimed by academics. Geomatics, created in 1981, became popular in academia principally for the second reason above, and was a deliberate marketing strategy when adopted beyond Canada. The expectation was that a more exciting, more modern sounding word would be more attractive to prospective students than references to land surveying. Or so it was thought – and overtly stated.

In Canada, there was clear justification for the change and an awareness of the original intention. Elsewhere it is not so clear that it was anything other than rebranding and a marketing exercise to recruit greater numbers of “good” students (Trinder and Fraser, 1994; Fraser & Trinder, 1995) as discussed fully in Chapter 9. With respect to the University of Melbourne, one of the first to introduce the term in Australia, this interpretation is explicitly supported by a member of its Advisory Board at the time the new name was introduced (Interview 11Ap) and a former student (Interview 17Ap). The case in Australia for a new name because of the changing nature of the profession, that is to include the new technologies, is much less convincing. It is much more a rebranding of the land surveying professional programmes that were suffering from a lack of applicants, and quality applicants in particular. In Australia the members of the land surveying profession itself were less enthusiastic about any change.

In the UK the reasoning is only a little different than in Australia. While there is some recognition of the wish to expand the range of new technologies embraced by the wider profession, it is clearly claimed, incorrectly, that the word geomatics has no meaning (Interview 33Ga; Coulson, 1996b; Maynard, 1997). The proponents of geomatics claimed that it could therefore be taken up and used in a way that was defined by the user, in this case presumably, the land surveying profession.

Twenty years later there is still evidence that this is an extant belief, that geomatics is a meaningless word to which any meaning can be attached (Interviews 33Ga, 35Ca, 52Aa). While academia adopted the term widely, to a greater or lesser extent depending on the establishment, the practicing surveyors, as in Australia and the UK, were and are much less enthusiastic. Many members of the RICS left their professional body when it changed the name of their particular part of it (Kavanagh, 2016a). The use of the word geomatics remains a matter of concern such that it has been recently questioned. A survey of members of the Geomatics Division of the RICS has recently been conducted to invite suggestions for a new name. To date insufficient responses have been received to progress the issue (Johnstone, 2016).

Finally there is the issue of the image of the land surveying profession itself, and that of land surveyors. The time honoured image of the land surveyor is of someone standing by a tripod on which is mounted a technical device. The surveyor him or herself (though traditionally reference to or depiction of female surveyors is not common, but is changing) wearing boots and outdoor and safety clothing, is presumed to be not that of a person of professional status (Interviews 1Cp, 3Cp, 23Cp, 27Gi, 46Ga, 51Ca). The implication is that they are carrying out menial and manual tasks. Does not the dentist have to carry out manual tasks, the surgeon, the engineer? The picture of the land surveyor as only a technical operator seems to be one created and perpetuated within the profession itself, often supported by the literature used by universities to attract potential students. Insufficient exposure is given to the nature of the office work undertaken by the professional land surveyor, and the traditional image is one now more commonly of the surveying technician.

An extensive literature review uncovered no studies that have been undertaken to establish the true public perception of the land surveying profession or land surveyors. Instead, it may be surveyors themselves, and more particularly their academic colleagues, who create and perpetuate the notion that the image and status of the profession is less than it could or should be. The public image of the land surveyor is a matter that deserves more rigorous study than has been given to it in the past so that it may be better understood, and if found necessary, remedied.

At least one observer (Interview 46Ga) commented that surveyors generally did not value their own work and often gave it away. The poor professional image of the land surveyor, it is suggested, may be one of poor self-image, rather than poor public image, though one may follow the other. It is also suggested that surveyors have long under-valued the contribution their skills make to underpinning the confidence of other professions, especially those working in the built environment.

The term geomatics has proved to be controversial and of questionable benefit. Those who adopted it as a part of a marketing strategy have found that in the long term it has failed to provide the inflow of students that it was designed to encourage. In the UK all of the universities visited struggle to attract sufficient numbers to ensure their sustainability (Kavanagh, 2016b). The same can be said for Australia where the lack of student numbers is having a similar effect (Blanchfield, 2005). Schools of surveying of the past are being merged into larger departments or faculties and do not have a common basis to their surveying courses (Interview 39Ag). The land surveying profession itself is not, and has never been, an enthusiastic supporter of the term geomatics. ***Geomatics has almost disappeared in Australia, it is being questioned in the UK, and is no longer fully supported in Canada.***

At least a part of the problem for the land surveying profession is that the term “land surveying” does not have a common meaning in the countries visited. The Canadian land surveyor is a term restricted to cadastral or land title surveyors. In the UK, it is not clear exactly what a land surveyor does. Without the cadastral base of the former colonial countries, the suggestion is that they only do topographical surveys and monitoring surveys (Interview 30Gp). In Australia there is a common understanding of what a land surveyor was qualified to do and that it ranges far beyond land title surveys.

This would suggest that the term land surveyor is no longer useful in the international community. It conveys different messages in different countries. A term such as geomatics, while not universally understood either, as shown graphically in Chapter 8, could be adopted by everyone, and hence would be an advantage. The term geomatics might have proved beneficial. Unfortunately now, in part due to it not being properly understood when first introduced outside Canada, is too contaminated with misinterpretations and

misrepresentations to be that term. Could it be that a better term might supersede geomatics by stealth or simply by common usage rather than by revolution?

Already in Australia many institutions have shifted away from surveying through a sequence beginning with geomatics, moving to spatial science and have now moved on to geospatial science. The Chartered Institution of Civil Engineering Surveyors (ICES) in the UK has as its journal the Civil Engineering Surveyor with an annual supplement called the Geospatial Engineer. The RICS has most recently introduced a pathway to a new Associate level of membership and refers to it as “geospatial surveying”. If the land surveying profession needs rebranding, it is apparent that rebranding is taking place by itself and is likely to overtake the wishes of those involved. By such common use, rather than by statute or by declaration of professional bodies or academic institutions, the concept of the geospatial surveyor is asserting itself.

## **10.5 Final words.**

The profession of surveying has an extensive provenance. According to Cooper (2009) land measurements of agricultural fields of have been found on Armenian tablets from 4000 years ago. Egyptians left the evidence of their measurement expertise that remains today and the Romans had their agrimensores. Archaeological evidence suggests that the measurers were citizens of high standing (Brock, 2013).

The word surveyor in English is derived from the French words *sur* (over) and *veior* (to see) (Linklater, 2002; Ballantyne, 1996). Hence, the surveyor was an overseer. However, survey was first used as a verb in 1550 to mean “to determine the form, extent, and situation of the parts of a tract of ground, or any portion of the earth’s surface, by linear and angular measurements (Ballantyne, 1996). Those who practiced the art and science of surveying were held in high regard. The designation of surveying as a profession in that period is not appropriate as the term was defined by very narrow criteria and was confined to the church, medicine and the law.

As professions grew in number and diversity surveying grew as a distinct occupation that was more than a trade or skilled vocation. As its educational requirements developed from training by those who were already accomplished or learned in its pursuit through a form of

indentureship and formal examination to one of university education and training, true professional standing was achieved. This is a common sequence of development for the activities acquiring the status of a profession. Surveying has acquired all of the criteria necessary to be regarded as a modern profession by comparison to established benchmarks.

Technological developments in measurement science have revolutionised the way in which surveyors carry out their functions and the tools they use to accomplish them. However, the fundamental knowledge the surveyor requires has not lessened as a result. The automation of measurement has not diminished the need for an understanding of the mathematics of measurement. The growing need for reliance on an understanding of the accuracy and precision of location or spatial data by a greater array of other professions is as important as it has always been, if not more so. Information about accuracy is a critical activity, and information about accuracy reduces risk.

The reduction of risk is a fundamental aspect of all surveying. In the built environment surveying minimises the possibility of construction on the wrong area of land; in tunnelling surveying minimises the risk of not arriving at the target location; in hydrographic surveying it minimises the risk of shipping running aground or not reaching its designated destination; in cadastral surveying it minimises the risk of boundary disputes; in geodetic surveying it minimises the risk of erroneous maps or other representations of the planet on which we live; it minimises risks for air traffic navigation as well as providing a basis for all other types of surveying. Surveyors therefore play a critical role in the safe operation of modern society.

Any impediment to the recognition of the importance and potential status of the land surveying profession among other professions, and society in general is not what it is called. Rather, the greatest limitation of the profession is how its members view it. Land surveyors should identify themselves as members of a separate, distinct and important profession. Land surveying is not a branch of the engineering profession. Land surveying has everything to do with the certainty of location and place. Having absorbed and adopted every relevant new technology since the beginning of the electronic and digital ages, and as it continues to do so, it has every reason to perceive itself as a modern highly technological and intellectually demanding profession.

The grounded theory approach used in this thesis allowed the issue of self-perception in the surveying profession to emerge during the research but this theme was not investigated separately, becoming apparent only on reflection on the comments made in response to the question of its name. Little is known about the public perception of the land surveying profession. Some of those interviewed for this thesis and a number of articles in the professional literature, especially at the time of the introduction of the term geomatics, referred to the poor image of the profession, or more especially to the poor image of the surveyor. The image portrayed by those expressing concern focuses on the technical or technician aspects of the work of the surveyor. This image is grounded in the field practices of surveying, in as much as members of the surveying profession must first be proficient in the use and understanding of its relevant technology. However, as indicated in the interviews, this image is not representative of the land surveying profession as a whole.

Views expressed with respect to the public image of land surveying by interviewees in this research were those of academics in particular during the debates to introduce geomatics to Australia and the UK. They were perceptions rather than comments made based on any research that is referred to, and are not commented upon by practitioners at the time. However, it is clearly apparent that self-image as well as public image are issues for the profession. These matters are too important to be reliant on limited internal perceptions and demand more rigorous examination.

The controversy over terminology is compounded together with the issue of self-perception. The motivation for a new name to embrace the new technology within the discipline, but not the profession, was not universally required but had some attraction where it originated. While “geomatics” spread through the English speaking surveying community it was not widely accepted. The term has been superseded to a greater or lesser extent in some of those communities. Spatial science, for example was adopted in Australia but this too is waning in its use.

Land surveyors, by and large, have remained surveyors rather than become geomaticians. In all of the countries visited, professional land surveyors still refer to themselves as surveyors with few exceptions, and no attempt has been made to define geomatics as a profession. However, “surveying” by itself is inadequate to identify the contemporary profession of land

surveying. Occupations other than land surveying, including professions, legitimately use the term surveying in their definition of themselves. Any claim to be a surveyor needs a qualifier to identify the nature of the surveying being referred to.

“Geo” has become a prefix for a growing number of words. “Spatial”, with its connotations of location and place, is a useful identifier and is relevant to the land surveying profession. Already geospatial is in wide use to identify activities, institutions, publications and conferences and has wide acceptance and understanding as a term. Given the real and perceived connotations of “land surveying”, as evidenced in this research in Canada especially, but also in England, the combination “**geospatial surveyor**” meets the requirements of a rebranding. It is already happening by common and growing usage rather than by imposition.

Land surveying has not changed in any fundamental way in the last 60 years. It has evolved with changes in technology. The *art* of measurement in surveying remains but imposes new requirements, but the *science* of measurement has expanded and deepened. The demands of the applications to which surveying can be applied require even greater understanding of the mathematics behind the science of measurement than ever before. Understanding the capabilities of modern surveying instrumentation and their appropriate applications to risk management and mitigation is more important than ever. For this reason the descriptor *land* no longer serves to describe adequately the breadth and depth of the surveying profession.

Ω

## References

- Adamek, Tara., Penkalski, Kaitlyn., & Valentine, Gina. (2005). The History of Trigonometry. *History of Mathematics* (11 May), 18.
- Aguirre, Jessica Camille. (2014). The Unlikely History of the Origins of Modern Maps. Retrieved 14 May, 2014, from <http://www.smithsonianmag.com/history/unlikely-history-origins-modern-maps-180951617/>
- Alberta Land Surveyors Association. (n.d.). Retrieved 20 September, 2013, from <http://www.alsa.ab.ca/PublicInformation/AbouttheALSA.aspx>
- Alder, Ken. (2002). *The Measure of All Things*. New York: The Free Press.
- Anonymous. (1968). Education Profession. *Journal of Health, Physical Education, Recreation*, 39 (7), 4.
- Anonymous. (1999-2013). The Domesday Book Online. Retrieved 6 November, 2013, from <http://www.domesdaybook.co.uk/index.html>
- Anonymous. (2016, Sept/Oct). News. *Geomatics World*, 24, 3.
- Anonymous. (n.d.). Imperial Measures of Length. Retrieved 27 May, 2014, from <http://gwydir.demon.co.uk/jo/units/length.htm>
- Armstrong, M. B. (1994). What is a Profession. *Outlook*, 62(2), 38.
- Association of British Columbia Land Surveyors. (n.d.). Retrieved 20 September, 2013, from [ww.abcls.ca/](http://www.abcls.ca/)
- Association of Canada Land Surveyors. (n.d.). Retrieved 29 April, 2014, from <https://www.acls-aatc.ca/>
- Association of Manitoba Land Surveyors. (n.d.). Retrieved 20 September, 2013, from <http://www.amlsl.ca/>
- Association of New Brunswick Land Surveyors. (n.d.). Retrieved 20 September, 2013, from <http://www.anbls.nb.ca/>
- Association of New Brunswick Land Surveyors. (n.d.). Retrieved 20 September, 2013, from <http://www.anbls.nb.ca/>
- Association of Newfoundland Surveyors. (n.d.). Retrieved 20 September, 2013, from <https://www.anls.ca/about/history/>
- Association of Ontario Land Surveyors. (n.d.). Retrieved 20 September 2013 from <http://www.aols.org/single.asp?itemcode=AOLS-ABOUT>

Association of Prince Edward Island Land Surveyors. (n.d.). Retrieved 20 September, 2013, from <http://www.apeils.ca/>

Australian Government. (n.d.). European discovery and colonisation of Australia. Retrieved 12 June, 2014, from <http://australia.gov.au/about-australia/australian-story/european-discovery-and-colonisation>

Babbie, Earl. (2010). *The Practice of Social Research* (13th ed.). International Edition: Wadsworth CENGAGE Learning.

Baker, Hazel. (1999). Crisis in Surveying Education. *Measure and Map*.(2), 3.

Ballantyne, Brian. (1996, March). A polemic against 'geomatics': Buttering no parsnips. *Survey Quarterly*, 5.

BBCa. (n.d.). Retrieved 5 May, 2014, from [http://www.bbc.co.uk/history/british/normans/domesday\\_01.shtml](http://www.bbc.co.uk/history/british/normans/domesday_01.shtml)

BBCb. (n.d.). The Domesday Book. Retrieved 11 May, 2014, from [http://www.bbc.co.uk/history/british/normans/doomsday\\_01.shtml](http://www.bbc.co.uk/history/british/normans/doomsday_01.shtml)

Beaglehole, J. C. (1992). *The Life of Captain James Cook*. California, USA: Stanford University Press.

Bèdard, Yvan. (2007). "Geomatics": 26 years of history already. *Geomatica*, 61(3), 4.

Bennett, J. A. (1991). Geometry and surveying in early-seventeenth-century England. *Annals of Science*, 48(4), 9. doi: 10.1080/00033799100200331

Bervoets, Sjef., Ogleby, Cliff., & Smith, Jessica. (1999). *It Figures: The First 50 Years of the Department of Geomatics At the University of Melbourne*. Melbourne, Australia: The Department of Geomatics, University of Melbourne.

Bethel, J. (2011). Imaging Body of Knowledge for the Professional Surveyor. *Surveying and Land Information Science*, 71(3 & 4), 10.

Birks, Melanie., & Mills, Jane. (2015). *Grounded Theory: A Practical Guide* (J. Seaman Ed. 2nd ed.). London: Sage.

Blaikie, Norman. (2010). *Designing Social Research: The Logic of Anticipation* (2nd ed.). Cambridge, UK: Polity Press.

Blanchfield, Frank. (2005). *Registered Surveyors in the ACT and NSW. Will there be enough in 2025*. Council of Reciprocating Surveyors Boards of Australia and New Zealand. Unpublished.

Bledstein, Burton. (1976). *The Culture of Professionalism: The Middle Class and the Development of Higher Education in America*: W.W. Norton & Co.

- Bogle, A. H. (1957). Training and Recognition of Surveyors. *New Zealand Surveyor*, *XXII*(2), 3.
- Bonnor, Norman. (2012). A Brief History of Global Navigation Satellite Systems. *The Journal of Navigation*, *65*(1), 14. doi: 10.1017/S0373463311000506
- Booth, Stephen. (1996, Nov/Dec). A dead end with the robots or a new start? - the G-word debate. *Surveying World*, *5*, 2.
- Booth, Stephen. (1997, Jan/Feb). Editorial. *Surveying World*, *5*, 1.
- Bowie, Norman. (1988). The Law: From a Profession to a Business. *Vanderbilt Law Review*, *40*, 4.
- British Museum. (n.d.). Roman Britain. Retrieved 23 May 2013, from [http://www.britishmuseum.org/pdf/visit\\_roman\\_britain\\_ks2.pdf](http://www.britishmuseum.org/pdf/visit_roman_britain_ks2.pdf)
- Brock, John. (2013). *Boundary Stones of Tutankhamen's Father – Akhenaton's City of the Sun*. Paper presented at the FIG Working Week "Environment for Sustainability", Abuja, Nigeria. [http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2013/papers/ts04e/TS04\\_E\\_brock\\_6562.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2013/papers/ts04e/TS04_E_brock_6562.pdf)
- Bryant, Antony., & Charmaz, Kathy. (2007). Grounded Theory Research: Methods and Practices. In A. Bryant & K. Charmaz (Eds.), *The Sage handbook of Grounded Theory*. London: Sage.
- Buchroithner, Manfred. (2016, Feb). 3D Visualisation: Gimmick, Hype or Necessity? *GIM International*, *30*, 1.
- Burnside, C. D. (1971). *Electromagnetic distance measurement*. London: Crosby Lockwood & Son Ltd.
- Calman, Kenneth. (1994). The profession of medicine. *British Medical Journal* (309), 4.
- Canadian Institute of Geomatics. (n.d.). Retrieved from <http://www.cig-acsg.ca/history> 14 November 2016.
- Carr-Saunders, A. M., & Wilson., P. A. (1933). *The Professions*: Oxford at the Clarendon Press.
- Cheves, Marc. (1999). Geodimeter - The First Name in EDM. *Professional Surveyor*, *19*(2).
- Cheves, Marc. (2003). The First Total Station? *Professional Surveyor*, *23*(4).
- Clark, David. (1923). *Plane and Geodetic Surveying for Engineers* (Vol. 1). London: Constable & Company.
- Cleveland, H. (1982). Information as a Resource. *The Futurist* (December), 5.

- Cogan, Morris L. (1955). The Problem of Defining a Profession. *Annals of American Academy of Political Science* (297), 7.
- Columbia Encyclopedia. (2013). Phoenicia. *The Columbia Encyclopedia, 6th ed.* Retrieved 5 November, 2013, from <http://www.encyclopedia.com/doc/1E1-Phoenici.html>
- Concise Oxford English Dictionary. (Ed.) (2004) (11th ed.). Oxford, England: Oxford University Press.
- Consulting Surveyors National. (n.d.). Consulting Surveyors National. Retrieved 3 October, from <http://www.acsnational.com.au/content/2/about.aspx>
- Cooper, M. A. R. (2009). *Who did they think they were? or Land Surveyors in Society.* Christmas Lectures. Royal Institution of Chartered Surveyors.
- Coppock, J. Terry, & Rhind, David W. (1991). The history of GIS. *Geographical information systems: Principles and applications*, 1(1), 22.
- Coulson, Martin. (1996a, Nov/Dec). The Geomatics debate - a crucial point for surveyors. *Surveying World*, 5, 1.
- Coulson, Martin. (1996b, Nov/Dec). Geomatics: are you ready. Working sessions herald change for the profession. *Surveying World*, 5, 2.
- Coutts, B. J. (2010). *Disciplinary Principles for Cadastral Surveyors: A case study in Australia and New Zealand.* Paper presented at the XXIV FIG International Congress, Sydney, Australia. Retrieved 23 September 2013 from [http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2010/papers/ts06j/ts06j\\_coutts\\_3980.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts06j/ts06j_coutts_3980.pdf)
- Coutts, B. J. (2011). *The Trans Tasman Reciprocal Agreement for Cadastral Surveyors.* Paper presented at the Surveying and Spatial Science Conference, Wellington, New Zealand.
- Cox, R.C. (1986). The Development of Survey Instrumentation. *Survey Review*, 28(219), 21.
- Cross, Paul. (1997, Nov/Dec). Paul Cross - explaining geomatc engineering. *Surveying World*, 6, 3.
- Cruess, S. R., Johnston, Sharon., & Creuss, Richard L. (2005). "Profession": A Working Definition for Medical Educators. *Teaching and learning in Medicine: An International Journal*, 16(1), 3.
- Dale, Peter. (1996, Sept). Facing a Different Future. *GIM International*, 10, 3.
- Dempsey-Morias, Caitlin. (2014, May). History of GIS. *GIS Lounge.* from <http://www.gislounge.com/history-of-gis/>
- Dilke, O. A. W. (1971). *The Roman Land Surveyors: An Introduction to the Agrimensores.* Newton Abbot, Devon, UK: David & Charles.

- Draper, Malcolm. (1996, Nov/Dec). What's in a word? Will geomatics work anywhere? *Surveying World*, 5, 2.
- Dubuisson, Bernard. (1975). *Practique de la Photogrammetrie et des Moyens Cartographiques derives des Ordinateurs*. (K. J. Dennison, Trans.). Paris: Editions Eyrolles.
- Dyer, A. R. (1985). Ethics, advertising and the definition of a profession. *Journal of medical ethics*, 11, 7.
- Eliot, T. S. (1934). The Rock.
- Encyclopædia Britannica Online. (n.d.). Ptolemaic system. *Encyclopædia Britannica Online Academic Edition*. Retrieved 7 November, 2013, from <http://www.britannica.com/EBchecked/topic/482079/Ptolemaic-system>
- Enemark, Stig. (2007, June). Integrated land use management for sustainable development. *Survey Quarterly*, 5.
- Evans, W.M., & Levin, E. G. (1966). Status-set and role-set conflicts of the stockbroker: a problem in the sociology of the law. *Social Forces*, 45, 6.
- Fairlie, Kate., McAlister, Chris., Mottolini, Darren., & Kivilcim, Cemal Ozgur. (2010). *Identity Crisis: Challenges and Capacity Building for Next Generation Surveyors*. Paper presented at the FIG XXIV International Congress "Facing the Challenges - Building the Capacity", Sydney, Australia. Retrieved 5 September 2013 from [http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2010/papers/ts07h/ts07h\\_mcalister\\_fairlie\\_et\\_al\\_4435.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts07h/ts07h_mcalister_fairlie_et_al_4435.pdf)
- FIG. International Federation of Surveyors. (n.d.). List of members. Retrieved 26 April, 2013, from <http://www.fig.net/members/index.asp>
- FIG. International Federation of Surveyors. (2017). Definition of a surveyor. Retrieved 23 January, 2017, from <http://www.fig.net/about/general/definition/index.asp>
- FIG. International Federation of Surveyors. (1998). Statement of Ethical Principles and Moral Code of Professional Conduct. from <http://www.fig.net/pub/figpub/pub17/figpub17.htm>
- FIG. International Federation of Surveyors. (n.d.). International Federation of Surveyors (FIG) Academic Database. Retrieved 5 September 2013 from [http://www.fig.net/sedb/am\\_overview.htm](http://www.fig.net/sedb/am_overview.htm)
- Finn, P. B. (1983). *Electronic Distance Measurement*. Dunedin, New Zealand: Department of Surveying, University of Otago.
- Flexner, Abraham. (1915). *Is Social Work a Profession?* Paper presented at the National Conference of Charities and Corrections at the Forty-Second annual session, Baltimore, Maryland.

- Foster, Bob. (2016, 17 September). [Pers.comm.].
- Foster, Christine. (1993). Effects? What effects? Ideas for Implementing Assessments of Effects for Subdivision. *New Zealand Surveyor, XXXIII* (282), 21.
- Fraser, C.S., & Trinder, J.C. (1995, Nov/Dec). The Geomatics Debate and Australia's Universities. *Surveying World, 4*, 2.
- Free Online Dictionary. (n.d.). Surveying. Retrieved 23 September, 2013, from <http://www.thefreedictionary.com/surveying>
- Freidson, Eliot. (1988-89). Theory and the Professions. *Indiana Law Journal* (64), 10.
- Fryer, J., & Mitchell, H. (2013). *The Attributes of Surveying Degrees recognised by CRSBANZ*. Council of Reciprocating Surveyors Boards of Australia and New Zealand. Brisbane, Queensland.
- Gagnon, Pierre., & Coleman, David J. (1990). Geomatics: An integrated, systematic approach to meet the needs for spatial information. *Canadian Institute of Surveying and Mapping Journal, 44*(4), 6.
- Garfield, Simon. (2012). *On the Map: Why the world looks the way it does*. London: Profile Books Ltd.
- Gascoigne, Bamber. (2001). History of Exploration. *History World*. Retrieved 3 June 2013, from <http://www.historyworld.net/wrldhis/PlainTextHistories.asp?historyid=ab90>
- Ghosh, Sanjib K. (1979). *Analytical Photogrammetry*: Pergamon Press Inc.
- Grant, D. B. (2014). Cadastre 2034: A 10-20 year Strategy for developing the cadastral system (pp. 39). Wellington: Land Information New Zealand.
- Grant. D. B. (2017). [Pers.comm.].
- Greenfeld, J. (2012). *Components of the surveying body of knowledge*. Paper presented at the FIG Working Week "Knowing to Manage the territory, Protect the environment, Evaluate the cultural heritage", Rome, Italy.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2012/papers/ts04i/TS04I\\_greenfeld\\_5561.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2012/papers/ts04i/TS04I_greenfeld_5561.pdf)
- Greenwood, Ernest. (1957). Attributes of a Profession. *Social Work, 2*, 10.
- Groom, Richard. (2014, July/Aug). "Meet me at GeoBusiness!". *Geomatics World, 22*, 3.
- Gross, E. (1958). *Work and Society*. New York: Thomas Y Crowell.
- Gross, M. (1966). *The Doctors*. New York: Dell.
- Hacking, Ian. (1989). The life of Instruments. *Studies in History and Philosophy of Science, 20*(2), 5.

- Hall, G. Brent (2011, Sept). Surveying the Future. *Survey Quarterly*, 4.
- Hall, G. Brent (2017). [Pers.comm.].
- Hannah, John. (2006). *Australasia's Surveying Skills Crisis - Is it Marketing Failure*. Paper presented at the FIG XXIII Congress "Shaping the Change", Munich, Germany.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2006/papers/ts40/ts40\\_03\\_hannah\\_0287.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2006/papers/ts40/ts40_03_hannah_0287.pdf)
- Hannah, John. (2009, September). Surveying: In identity crisis. *Coordinates*, V 1.
- Hannah, John., Ballantyne, Brian., & Khan, M.K. (2000). Geomatics: Does the name make a difference? *Geomatica*, 54(2), 9.
- Hannah, J., Kavanagh, J., Mahoney, R., & Plimmer, F. (2009). Surveying: A Profession in Crisis? *Survey Review*, 41(313), 11.
- Hart, C. A. (1940). *Air Photography Applied to Surveying*: Longmans, Green and Co.
- Hassan, Fekri A. (1997). Nile Floods and Political Disorder in Egypt. In H. N. Dalfes, G. Kukia & H. Weiss (Eds.), *Third Millennium BC Climate Change and Old World Collapse* (pp. 23). Heidelberg: Springer-Verlag Berlin.
- Hemi, Richard. (2014, 2 July). [Pers.comm.].
- Hey, J. (2004). The Data, Information, Knowledge, Wisdom Chain: The Metaphorical link. Retrieved 22 August 2013, from J Hey - Intergovernmental Oceanographic Commission, 2004 - dataschemata.com
- Horwood, David M., & Hall, G. Brent. (2012, Dec). GIS and the future of surveying. *Survey Quarterly*, 4.
- Hosmer, George. (1919). *Geodesy* (2nd ed.). New York: John Wiley & Sons, Inc.
- Hughes, Everett C. (1963). Professions. *Daedalus*, 92(4), 13.
- Institute of Civil Engineers. (n.d.). Retrieved 26 April, 2013, from  
<http://www.ice.org.uk/About-ICE>
- Institution of Surveyors, Australia. (1996). *National Competency Standards for Professional Surveyors*.
- Institution of Surveyors Australia. (n.d.). Retrieved 29 April, 2014, from  
<http://www.isaust.org.au/about/backgrnd.htm#objects>
- Institution of Surveyors New South Wales. (n.d.). Retrieved 23 September 2013, from  
<http://www.surveyors.org.au/about/history-of-isnsw>

Institution of Surveyors Victoria. (n.d.). Retrieved 23 September 2013, from  
<http://www.surveying.org.au/>

Johnston, Gordon. (2016, Nov/Dec). Names, standards and a competition. *Geomatics World*, 25, 1.

Jones, Emrys. (1964). *Human Geography* (Fourth Impression, 1967 ed.). London: Chatto & Windus.

Joseph, George Ghevarughese. (1987). Foundations of Eurocentrism in mathematics. *Race and Class* (28), 15. doi: 10.1177/030639688702800302

Kavanagh, James. (2016a, 9 May). [Pers.comm.].

Kavanagh, James. (2016b, 9 December). [Pers.comm.].

Keith, Simon. (1992). *The CASLE guide to courses available in surveying and land economy*. London: Commonwealth Association of Surveying and Land Economy.

Kemp, Barry J. (2006). *Ancient Egypt: Anatomy of a civilisation* (2nd ed.). Oxford: Routledge.

Kilford, W. K. (1970). *Elementary Air Survey* (2nd ed.). London: Pitman Publishing.

King James Bible. (1611). *The King James authorised version. Deuteronomy 27:17*. The University Press, Cambridge: The British and Foreign Bible Society.

King, Victoria. (2007). The Domesday Book. *History Magazine*. Retrieved from  
<http://www.history-magazine.com/domesday.html>

Krakiwsky, Edward J., Rais, Jacob., White, Lawry., Welsch, Walter., Alpar, Gyula., Leick, Alfred., & Lugnani, Joao Bosco. (1987). *A Catalogue of Undergraduate Programmes in Surveying and Mapping in the World*: International Association of Geodesy.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions* (3rd ed.). Chicago: University of Chicago.

La Vopa, A. J. (1982). Humanism and professional education: historical background. In A. R. Dyer (Ed.), *The humanities and the profession of medicine*: Research Triangle Park, NC: National Humanities Centre.

Land System Research (Australia), Department of. (2012). History of GIS. Retrieved 14 July, 2014, from <http://dlsr.com.au/2012/06/gis-geographical-information-system/>

Leedy, Paul D & Ormond, Jeanne E (2001). *Practical Research: planning and design*. New Jersey USA: Pearson Education International.

Leipala, Timo. (2003). *Life and Works of W.T.Odhner*. Paper presented at the Greifswalder Symposium zur Entwicklung der Rechtentechnik, Greifswald University.  
[http://www.rechnerlexikon.de/en/artikel/Life\\_and\\_works\\_of\\_W.\\_T.\\_Odhner](http://www.rechnerlexikon.de/en/artikel/Life_and_works_of_W._T._Odhner)

- Linklater, Andro. (2002). *Measuring America*. London: Harper Collins.
- Litchi, Professor Derek. (2014, 15 October). [Head, Geomatics Engineering, University of Calgary. Pers.comm.].
- Loeffel, Robert. (2007). *The History of the UNSW School of Surveying and Spatial Information Systems 1949-2007*. Sydney: The University of New South Wales.
- Lyon, Robert. (n.d.). *The Influence of Roman Military Camps on Town Planning*. State University of New York at Potsdam. New York. Retrieved from dspace.sunyconnect.suny.edu/bitstream/1951/.../PRES03lyonrm190.pdf
- Lyte, H. C. Maxwell. (1886). *History of the University of Oxford: From Earliest Times to the Year 1530*. London: Macmillan and Company.
- Mahoney, Rob., Plimmer, Frances., Hannah, John., & Kavanagh, James. (2007). *Where are we Heading? The Crisis in Surveying Education and a Changing Profession*. Paper presented at the FIG XXX Working Week "Strategic Integration of Surveying Services", Hong Kong SAR, China.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2007/papers/ts\\_6e/ts06e\\_02\\_mahoney\\_etal\\_1381.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2007/papers/ts_6e/ts06e_02_mahoney_etal_1381.pdf)
- Maitland. Frederic William. (1897). *Domesday Book and Beyond: Three Essays in the Early History of England*. Cambridge: Cambridge University Press.
- Maynard, Jon. (1997, Nov/Dec). "Geomatics" - it's time to decide. *Surveying World*, 6, 1.
- Maynard, Jon. (1998a, Mar/Apr). Geomatics - your vote has been counted. *Surveying World*, 6, 1.
- Maynard, Jon. (1998b, May/June). End of term - reflections on a Presidential year. *Surveying World*, 6, 1.
- McCoy, M. J. (2012, August). [Pers.comm.].
- McHarg, Ian. (1971). *Design With Nature*. New York: John Wiley & Sons.
- McRae, J. A. (1989). *New Zealand Institute of Surveyors 1888-1988*. Wellington, New Zealand: New Zealand Institute of Surveyors.
- Middleton, John. (2002). *Africa: An Encyclopedia for Students*. New York: Charles Scribner's Sons.
- National Library of Australia. (n.d.). Retrieved 29 April, 2014, from  
<http://trove.nla.gov.au/people/473342?c=people>
- Neaves, Alistair. (2014, 3 July). [Pers.comm.].
- New Zealand Institute of Surveyors. (n.d.). New Zealand Institute of Surveyors. Retrieved 25 September 2013, from <http://www.surveyors.org.nz/about>

- Nicholls, Sue., & McLaughlan, John. (n.d.). *Resource Management: Towards a new educational agenda*. Unpublished.
- NOAA. (2007). Hewlett-Packard Model 3800B Distance Meter. Retrieved 4 July, 2014, from [http://celebrating200years.noaa.gov/distance\\_tools/hp3800b.html](http://celebrating200years.noaa.gov/distance_tools/hp3800b.html)
- O'Day, Rosemary. (2000). *The Professions in Early Modern England, 1450-1800: Servants of the Commonwealth*. Harlow, England: Longman. An imprint of Pearson Education.
- Orchiston, W. (1998). From the South Seas to the Sun: The Astronomy of Cook's Voyages. In M. Lincoln (Ed.), *Science and Exploration in the Pacific: European Voyages in the Southern Oceans in the Eighteenth Century* (pp. 17). Suffolk, UK: Boydell and Brewer.
- Ordres des Arpenteurs-Geométrés du Quebec. (n.d.). Ordres des Arpenteurs-Geométrés du Quebec. Retrieved 26 September, 2013, from <http://www.oagq.qc.ca/>
- Oxford English Dictionary. (2011). *Oxford English Dictionary Online*. Retrieved 15 March, 2011, from <http://www.oxforddictionaries.com/definition/english/profession>
- Paradis, Michel. (1981). De l'arpentage à la géomatique. *The Canadian Surveyor*, 35(3), 7.
- Parsons, Talcott. (1939). The Professions and Social Structure. *Social Forces*, 17(4), 10.
- Pavelco, R. M. (1971). *Sociology of Occupations and Professions*. Itasca, Illinois: F.E Peacock.
- Pavia, Joseph. (2011). Surveying Body of Knowledge for Positioning. *Surveying and Land Information Science*, 71 (3&4), 11.
- Pedersen, Olaf. (1997). *The First Universities* (Reprint ed.). Cambridge: Cambridge University Press.
- Perrucci, R., & Gerstl, J. E. [eds.]. (1969.). *The Engineers and the Social System*. New York: John Wiley.
- Potuckova, Marketa. (2006). Trends in Geoinformatics Education. *Geoinformatics FCE CTU* 1, 8.
- Pound, Roscoe. (1944). What is a Profession? The Rise of the Legal Profession in Antiquity. *Notre Dame Lawyer*, XIX(3), 41.
- Rogers, Dick. (c.1999). *50 Years of Land Surveying Education in North and East London*. School of Architecture, Computing and Engineering. University of East London. London.
- Rosenberg, Matt. (n.d.). Greenwich: A visit to the Royal Observatory at Greenwich. Retrieved 03 June, 2013, from <http://geography.about.com/od/timeandtimezones/a/greenwich.htm>

- Roth, J. A. (1974). Professionalism: The Sociologist's Decoy. *Work and Occupations*, 1, 17.
- Routledge, Andy. (2011). *Design Professionalism: the designer's guide to taking back your profession* Retrieved from <http://designprofessionalism.com/defining-design-professionalism>.
- Royal Institute of British Architects. (n.d.). Retrieved 26 April, 2013, from <http://www.architecture.com/TheRIBA/AboutUs/Ourhistory.aspx>
- Royal Institute of Technology University. (n.d.). Retrieved 18 January, 2017, from <https://www.rmit.edu.au/about/our-heritage/history-of-rmit>
- Royal Institution of Chartered Surveyors. (n.d.). Retrieved 19 July 2013 <http://www.rics.org/nz/about-rics/who-we-are/history-and-mandate/history/>
- Royal Society. (n.d.). The Royal Society. Retrieved 25 September, 2013, from <http://royalsociety.org/about-us/history/?from=welcome>
- Rueger, J, M. (1978). *Introduction to Electronic Distance Measurement* (2nd, 3rd Impression ed.). Sydney: School of Surveying, University of New South Wales.
- Ryerson University. (n.d.). Geomatics. Retrieved 8 August, 2016, from <http://www.ryerson.ca/civil/undergraduate/geomatics/>
- Saskatchewan Association of Land Surveyors. (n.d.). Retrieved 20 September, 2013, from [http://www.slsa.sk.ca/about\\_slsa.php](http://www.slsa.sk.ca/about_slsa.php)
- Schwidefsky, K. (1959). *An Outline of Photogrammetry* (J. Fosberry, Trans. 1st Ed.). London: Sir Isaac Pitman & Sons, Ltd.
- Secord, James. (2010). The Undergraduate Curriculum: Then and Now and In-Between. In W. Wells (Ed.), *By Any Measure* (pp. 235-272). Fredericton, New Brunswick, Canada: University of New Brunswick, Canada.
- Shultis, J. D. (1991). *Natural Environments, wilderness and protected areas: an analysis of historical Western attitudes and utilization, and their expression in contemporary New Zealand*. PhD thesis. Geography. University of Otago.
- Singer, C.J. (1928). *From Magic to Science: Essays on the Scientific Twilight*. London: Benn.
- Slocum, W. L. (1966). *Occupational Careers*. Chicago: Aldine.
- Smith, J.R. (1995, Jan). Marketing to the Student. *Surveying World*, 3, 1.
- Smith, J. R. (1998). The International Federation of Surveyors (FIG). *Survey Review*, 34(269), 4.
- Spatial Industries Business Association. (n.d.). Retrieved 3 October 2013, from <http://www.spatialbusiness.org/>

- Staiger, Rudolf. (2009). *Push the Button - or Does the Art of Measurement Still Exist*. Paper presented at the FIG Working Week "Surveyors Key Role in Accelerated Development", Eilat, Israel.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2009/papers/ps03/ps03\\_staiger\\_3513.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2009/papers/ps03/ps03_staiger_3513.pdf)
- Strauss, Anselm., & Corbin, Juliet. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (2nd ed.). California, USA: Sage.
- Stuchtey, Benedict. (2011). Colonialism and Imperialism, 1450-1950. *EGO European History Online*. <http://ieg-ego.eu/en/threads/backgrounds/colonialism-and-imperialism>
- Sturman, Brian., & Wright, Alan. (2008). *The History of the Tellurometer*. Paper presented at the FIG Working Week "Integrating the Generations". Stockholm, Sweden.
- Surveying and Spatial Sciences Institute. (2012). Surveying and Spatial Sciences Institute Strategy 2015 (pp. 17): Surveying and Spatial Sciences Institute.
- Surveying and Spatial Sciences Institute. (n.d.). Retrieved 30 April, 2014, from  
<https://www.sssi.org.au/>
- Surveyors Registration Board of Victoria. (n.d.) Retrieved 22 March, 2017 from  
<https://www.surveyorsboard.vic.gov.au/content/108/obtaining-registration.aspx>
- Taylor, J. C., & Wolfendale, A. W. (2007). John Harrison: clockmaker and Copley Medalist. A public memorial at last. *Notes Rec R Soc* ( 61), 10.
- Torge, Wolfgang. (1991). *Geodesy* (2nd ed.). Berlin: Walter de Gruyter.
- Torstendahl, Rolf. ( 2005). The Need for a Definition of 'Profession'. *Current Sociology*, 53(6), 48.
- Tout, T. F. (1916). *The English civil service in the fourteenth century*. England: Manchester University Print.
- Trimble. (2013). Transforming the way the world works. In T. N. Systems (Ed.), (pp. 20). California, USA: Trimble Navigation Systems.
- Trinder, J.C., & Fraser, C. S. (1994). The case for a Change of Name of Discipline in the Academic Context. *The Australian Surveyor*, 39(2), 5.
- Trutman, Herrn O. (n.d.). *The Theodolite and its Application* (A. H. Ward, Trans.). Heerbrugg, Switzerland: Wild Heerbrugg.
- Turner, G. L'E. (1991). Introduction: Some notes on the development of surveying and the instruments used. *Annals of Science*, 48(4), 4. doi: 10.1080/00033799100200311
- UKIPGa. (n.d.). United Kingdom Inter-Professional Group Membership. Retrieved 19 July, 2013, from [http://www.ukipg.org.uk/membership/list\\_of\\_members](http://www.ukipg.org.uk/membership/list_of_members)

- UKIPGb. (n.d.). United Kingdom Inter-Professional Group Guide to the Revalidation of Professional Competence. Retrieved 13 June, 2013.  
[http://www.ukipg.org.uk/publications/Guide\\_to\\_Revalidation\\_of\\_ProfessionaoI\\_Competence\\_Final.pdf](http://www.ukipg.org.uk/publications/Guide_to_Revalidation_of_ProfessionaoI_Competence_Final.pdf)
- University College, London. (n.d.). Retrieved 22 August, 2016, from  
<http://www.cege.ucl.ac.uk/teaching/Pages/Postgraduate/bim.aspx>
- University of Cambridge. (n.d.). The medieval university. Retrieved 17 July 2013, from  
<http://www.cam.ac.uk/about-the-university/history/the-medieval-university>
- University of Glasgow. (n.d.). Retrieved 3 August, 2016, from  
<http://www.petriefied.info/appoint.html>
- University of KwaZulu. (n.d.). Retrieved 28 November, 2016 from  
<http://landsurveying.ukzn.ac.za/Homepage.aspx>
- University of Minnesota Rochester. (n.d.). Brief History of Geographical Information Systems. Retrieved 15 July, 2014, from  
<http://web.mst.edu/~rogersda/gis/History%20of%20GIS.pdf>
- University of New South Wales. (2017). UNSW University Archives. Retrieved 24 January, from <http://www.recordkeeping.unsw.edu.au/documents/Surveying-A274.pdf>
- University of New South Wales. (n.d.). Short-Range Distance Meter. Retrieved 4 July, 2014, from [http://www.gmat.unsw.edu.au/currentstudents/ug/projects/f\\_pall/html/e5.html](http://www.gmat.unsw.edu.au/currentstudents/ug/projects/f_pall/html/e5.html)
- University of Ottawa. (n.d.). Site for Language Management in Canada (SLMC): British Colonization. Retrieved 12 June, 2014, from  
[http://www.slmc.uottawa.ca/?q=british\\_colonization](http://www.slmc.uottawa.ca/?q=british_colonization)
- University of Oxford. (n.d.). A brief history of the University. Retrieved 17 July 2013, from  
[http://www.ox.ac.uk/about\\_the\\_university/introducing\\_oxford/a\\_brief\\_history\\_of\\_the\\_university/index.html](http://www.ox.ac.uk/about_the_university/introducing_oxford/a_brief_history_of_the_university/index.html)
- Unwin, G. (1908). *The Guilds and Companies of London*. London: Methuen.
- Usvat, Lilianna. (2013). Medieval Times Mathematics. *Mathematics Magazine*.  
<http://www.mathematicsmagazine.com/Articles/MedievalTimesMathematics.php#.UqUvnuK9LMk>
- van Gysen, Herman. (1996, Mar/Apr). Geomatics is about information and society. *Surveying World*, 4, 1.
- Victoria, Surveyors Registration Board of. (n.d.). Retrieved 22 March, 2017, from [www.surveyorsboard.vic.gov.au/content/108/obtaining-registration.aspx](http://www.surveyorsboard.vic.gov.au/content/108/obtaining-registration.aspx)
- Victorian Spatial Council. (2010, April). GeoDesign is 'new way to go' says Dangermond. *Landmark*, 37, 3.

- Wallis, David A. (2005). *History of Angle Measurement*. Paper presented at the FIG Working Week and GSDI-8 "From Pharoes to Geoinformatics", Cairo, Egypt.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/cairo/abstracts/wshs\\_01/ws\\_hs01\\_02\\_wallis\\_abs.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/cairo/abstracts/wshs_01/ws_hs01_02_wallis_abs.pdf)
- Walthrop, Wendy. (2011). Surveying Body of Knowledge - Land Stewardship. *Surveying and Land Information Science*, 71(3 & 4), 10.
- Walthrop, Wendy, & Lucas, Jeffery N. (2011). Surveying's Legal Body of Knowledge. *Surveying and Land Information Science*, 71(3&4), 15.
- Wells, Wendlynn. (2010). *By Any Measure*: University of New Brunswick, Fredericton, Canada.
- Whitehead, A. N. (1933). *Adventures in Ideas*: Cambridge at the University Press.
- Whiting, Brian (2012, Jan/Feb). Geomatics Education. *Geomatics World*, 20, 26-27.
- Wilensky, H. L. (1964). The Professionalization of Everyone? *The American Journal of Sociology*, LXX( 2), 21.
- Williamson, Ian., Enemark, Stig., Wallace, Jude., & Rajabafad, Abba. (2010). *Land Administration for Sustainable Development* (1st ed.). Redlands, California: ESRI Press Academic.
- Wolf, Paul R. (2002). Surveying and Mapping: History, Current Status, and Future Projections. *Journal of Surveying Engineering*, 128, 28.
- Wright, P. (1959). Definitions of a Profession. *Journal of Accountancy* (107), 1.
- York University (Toronto). (n.d.). Geomatics Engineering. Retrieved 8 August, 2016, from <http://www.bachelorsportal.eu/studies/91569/geomatics-engineering.html>.
- Young, Garfield. (2013). *Curriculum and pedagogical developments within university surveying & geomatics courses*. (PhD thesis), University of Nottingham. (13231)

## Wikipedia citings

<http://en.wikipedia.org/wiki/Surveying> Accessed 6 November 2013.

<http://en.wikipedia.org/wiki/Cadastre> Accessed 6 November, 2013.

<http://en.wikipedia.org/wiki/Theodolite> Accessed 14 May 2014.

<https://en.wikipedia.org/wiki/Geomatics> Accessed 14 November 2016.

## Other readings

- Abley, Steve (2011). What is a Professional? *Planning Quarterly*(180), 2.
- Alkan, Reha Metin. (2016, February). Lack of ability to adapt the current Geomatics Engineering education programs to the upcoming fields. *Coordinates*, 12, 1.
- Allan, A. L. (1998). Forty Years of EDM. *Survey Review*, 34(269), 16.
- Anonymous. (2010, April). GeoDesign is the 'new way to go' says Jack Dangermond. *Landmark*, 3.
- Anonymous. (2011). 'UNSW looking to rename spatial school'. *Spatial Source*. from <http://www.spatialsource.com.au/2011/04/05/article/UNSW-looking-to-rename-spatial-school/VTUQYUVJER.html>
- Anonymous. (2013, December). Geospatial tech is old hat to mapmakers. *Landmark*, 2.
- Anonymous. (n.d.). Thomas Kuhn. [http://en.wikipedia.org/wiki/Thomas\\_Kuhn](http://en.wikipedia.org/wiki/Thomas_Kuhn)
- Barry, Michael & Lani Roux. (2013). The Case Study Method in Examining land Registration Usage. *Geomatica*, 67(1), 11.
- Becek, Kazimierz. (2014). *The Internet of Things: Are We at the Fringes of a Paradigm Shift in Geomatics*. Paper presented at the FIG International Congress "Engaging the Challenges - Enhancing the Relevance", Kuala Lumpur, Malaysia.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2014/papers/ts01e/TS01\\_E\\_becek\\_7042.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2014/papers/ts01e/TS01_E_becek_7042.pdf)
- Bennett, R., Ogelby, C., & Bishop, I. (2009). One Strategy for Repositioning Spatial Sciences Education in Australia. *Journal of Spatial Science*, 54(1), 12.
- Blishen, B. R. (1969). *Doctors and Doctrines: The Ideology of Medical Care in Canada*. Toronto, Canada: University of Toronto Press.
- Booth, Stephen (2011, Nov/Dec). Benchmarking Geomatics. *Geomatics World*, 20, 1.
- Booth, Stephen (2011, July/Aug). We found the missing link but didn't tell anyone! *Geomatics World*, 19, 5.
- Booth, Stephen., & Groom, Richard. (2009, Sept/Oct). A profession in global crisis? *Geomatics World*, 17, 3.
- Booth, Stephen., & Groom., Richard. (2014, Jan / Feb). Web GIS set to transform Cartography - ESRI's Jack Dangermond. *Geomatics World*, 22, 2.
- Bozic, Branko., & Gospavic, Zagorka. (2009). *Scope of Competencies of Future Serbian Surveyors Educated under the New Master Study Program in Land Law and Economy*. Paper presented at the Navigating the Future of Surveying Education, Vienna, Austria.

- Bramald, Tom., & Allenby, Karen. (2015). Where do they go? *Geomatics World*, 23, 2.
- Cadges, Volkan., & Stubkjaer, Erik. (2009). Doctoral research on cadastral development. *Land Use Policy*, 26, 869-889.
- Carroll, Robert T. (2011). *The Skeptics Dictionary: A collection of strange beliefs, amusing deceptions, and dangerous delusions.* : John Wiley & Sons.
- Chester, Simon. (2012, April/May). Perspectives on the field. *Position*, 58, 3.
- Coutts, B. J. (2013). *Surveying: the Profession.* Paper presented at the Celebrating the Past - Redefining the future, August, 2013, Dunedin, New Zealand.
- Dann, Clifford. (1998). The Commonwealth Association of Surveying and Land Economy. *Survey Review*, 34(269), 3.
- de Buitleir, Murius. (2015, Sept.). People join our profession because it satisfies them intellectually. *Coordinates*, XI, 1.
- de Zeeuw, C. J. (2012). *Land Administration for people, profit and pleasure.* Paper presented at the FIG Working Week "Knowing to Manage the territory; Protect the environment; Evaluate the cultural heritage", Rome, Italy.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2012/papers/ts07b/TS07B\\_dezeeuw\\_5802.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2012/papers/ts07b/TS07B_dezeeuw_5802.pdf)
- de Zeeuw, C. J. (Kees), & Saltzmann, Martin. (2011, August 2011). Cadastre: Evolution or Revolution. *Coordinates: A monthly magazine on positioning, navigation and beyond*, VI.
- DeMers, Michael N. (2014). GIS. <http://www.britannica.com/EBchecked/topic/1033394/GIS>
- Dovis, Fabio. (2016). GNSS education has to be the enabler of a virtuous value chain. *Coordinates*, 12, 1.
- Eissfeller, Habil Bernd (2016). People are needed who are pioneering services and put them into practice. *Coordinates*, 12, 2.
- Encyclopedia Britannica Online. (n.d.). Retrieved 27 May, 2014, from  
<http://www.britannica.com/EBchecked/topic/506490/rod?sections>
- Enemark, Stig (2009). Proceedings FIG Commission 2: Surveying Education: Facing the Challenges of the Future *Navigating the Future of Surveying Education* (pp. 8-14). Vienna, Austria: Austrian Society for Surveying and Geoinformation.
- Fairhall, John. (2010, April-May). So long and thanks for all the fish. *Position*, 46, 1.
- Fairlie, Kate. (2009). Navigating the Global Consciousness: A Young Surveyor's Future *Proceedings FIG Commission 2: Navigating the Future of Surveying Education* (pp. 179-186). Vienna, Austria: Austrian Society of Surveying and Geoinformatics.

FIG. (2010). International Federation of Surveyors (FIG) Work Plans 2011-14. Retrieved 22 May 2013, from [http://www.fig.net/comm/wp\\_11\\_14/wp02\\_11-14.htm](http://www.fig.net/comm/wp_11_14/wp02_11-14.htm)

Frank, Steven. (2002). *US Surveying and Mapping Education Core Curricula*. Paper presented at the FIG XXII International Congress, Washington D.C., USA.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig\\_2002/Ts2-5/TS2\\_5\\_frank.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig_2002/Ts2-5/TS2_5_frank.pdf)

Fujii, Kazuaki. (2016, January). The education for cadastral surveying. *Coordinates, XII*, 5.

Greenfeld, J. (2010). *Surveying body of knowledge*. Paper presented at the FIG XXIV International Congress " Facing the Challenges – Building Capacity", Sydney, Australia.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2010/papers/ts03g/ts03g\\_greenfeld\\_4372.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts03g/ts03g_greenfeld_4372.pdf)

Greenfeld, Joshua. (2011a). GIS Body of Knowledge for Surveying. *Surveying and Land Information Science*, 71(3&4), 19.

Greenfeld, Joshua. (2011b). Surveying Body of Knowledge. *Surveying and Land Information Science*, 71(3 & 4), 2.

Groom, Richard (2010, Nov/Dec). Boundaries, Borders, Bathymetry, Mega Cities, the Profession . . . *Geomatics World*, 19, 2.

Groom, Richard. (2011, Nov/Dec). Untitled. *Geomatics World*, 20.

Halsey, A. H. (2007). British Universities and Intellectual Life. *Higher Education Quarterly*, 12(2), 11. doi: 10.1111/ISSN 1468-2273

Harper, Ian. (2011). The challenge before surveyors and surveying. *Coordinates, VII* (9).

Hashimi, Sayed R., Krakiwsky, Edward J., & Cannon, Elizabeth. (1993). Educating Surveying-geomatics Engineers: U.S. and Canadian Perspectives. *Surveying and Land Information Systems*, 53(4), 6.

Hickling Arthurs Low (HAL) Corporation. (2001). Geomatics Sector: Human Resources Study: Executive Summary. Ottawa: Canadian Council of Land Surveyors, Canadian Institute of Geomatics and Geomatics Industry Association of Canada.

Jaya, Eresta Virgo. (2015, Sept.). Young generation still posses the enthusiasm and keen interest in surveying. *Coordinates, XI*, 1.

Kubo, Nobuaki. (2016). The ultimate goal of the university is creating innovation and new values. *Coordinates, 12*, 2.

Kuhn, Thomas. (1977). *The Essential Tension*. Chicago: The University of Chicago.

Lassen, Tim. *New Cadastre in the Russian Federation*. Royal Institution of Chartered Surveyors. London, UK.

- Linklater, Arno. (2013). *Owning the Earth*. London, UK: Bloomsbury.
- Lisec, Anka., Drobne, Samo., Petrovic, Dusan., & Stopar, Bojan. (2009). *Professional Competencies of Surveying (Geodetic) Engineers*.
- Longhorn, Roger. Those pesky definitions again: please define the 'Geomatics' market for me. *Geoconnexion International*, 1.
- Mahoney, Rob., & Darvill, James. (2010). Geospatial information and the surveying profession (1st edition ed.). London: Royal Institution of Chartered Surveyors.
- Mahoney, Rob., Hannah, John., Kavanagh, James., & Plimmer, Frances. (2009). *Where is Surveying Heading - Issues in Educating the Public?* Paper presented at the Navigating the Future of Surveying Education, Vienna, Austria.
- Mahoney, Rob & James Darvill. (2009). Geospatial information and the surveying profession (pp. 34). London, UK: Royal Institution of Chartered Surveyors.
- Martens, David B. (2003). Steve Fuller's Thomas Kuhn. *Social Epistemology*, 17 (2 & 3), 225-228.
- McCoy, Malcolm. (2011a). *Spatial Sciences Institute*. Conference address. ISA Tasmania.
- McCoy, Malcolm. (2011b). *Skill Shortage - An Employers perspective*. Paper presented at the National Education & Skills Summit.
- McLaren, Robin. (2011). Crowdsourcing Support of Land Administration (pp. 31). London, UK: Royal Institution of Chartered Surveyors.
- McRae, J. A. (1972). [Pers.comm.].
- Miller, Caroline. (2013). When is a Planner really a Planner? *Planning Quarterly* (190), 3.
- Murphy, Jon. (2013). GIS Certification: is it worth it? *GoGeomatics Canada*, 1.
- Musgrave, Alan. (2009). *Secular Sermons*. Dunedin: Otago University Press.
- Musgrave, Alan E. (1971). Kuhn's second thoughts. *British Journal of the Philosophy of Science*, 22(1971), 287-306.
- North, Jennifer (Ed.). (2010). *Building a Name: The History of the Royal Institution of Chartered Surveyors*. Bury St Edmunds, UK: Arima Publishing.
- Onsrud, Harlan J. and Jeffrey K. Pinto. (1993). Survey and Comparative Analysis of Alternative Names for an Academic Discipline. *Surveying and Land Information Science*, 53(2), 15.
- Pajares, Frank. (n.d.). The Structure of Scientific Revolutions by Thomas Kuhn. Outline and Study Guide: The Structure of Scientific Revolutions. Retrieved 26/04/2010.

- Pupedis, Gita., & Bellman, Chris. (2012, Mar/Apr). Enter Gen Z - the next Spatial Professionals. *Geomatics World*, 20, 3.
- Rizos, Chris. (2016, February). Why Surveyors are GNSS Experts. *Coordinates*, 12, 1.
- Royal Institution of Chartered Surveyors. (n.d.). RICS Oceania Branding designations. Retrieved 19 October, 2011.
- Rubner, Michael. (2008, Nov). Dealing with crises via surveying and mapping. *ACSM Bulletin*, 1.
- Schuckman, Karen., & van Sickle, Jan. (2010, August). Education in Surveying: the Geospatial Technology Competency. *Professional Surveyor*.
- Shipman, Steve. (1998, July/Aug). A new era - looking to the future. *Surveying World*, 6, 1.
- Smith, Jim. (2009, March). 60 years of RICS Geomatics. *CASLE Newsletter*, 4.
- Stanbridge, Rory M. (2015, Sept.). There has never been a better time to enter the surveying profession. *Coordinates*, XI, 2.
- Teo, Chee Hai., & Frank, Steven. (2011). Surveying Education: A view from FIG. *Coordinates*, VII (9).
- Thurston, Jeff. (2013, January). Geomatics Leadership in Canada: Assessing The State and Challenges. *GoGeomatics Canada*, 3.
- Triglav, Joc. (2009, Sept.). From Measurement to Management. *GEOInformatics*, 3.
- Trinder, John. (2015, Sept.). Profession is not popular amongst school leavers. *Coordinates*, XI, 1.
- Unger, Eva-Maria. (2015, Sept.). This is an exciting profession. *Coordinates*, XI, 1.
- Vannozzi, A Richard. (2011). *Perspectives on the Future of the Surveying Profession*. Thompson School of Applied Science. Retrieved from [proceedings.esri.com/library/userconf/survey11/.../pap\\_3845.pdf](http://proceedings.esri.com/library/userconf/survey11/.../pap_3845.pdf)
- Velde, Gina. (2013, Feb / March). The Changing Role of the Surveyor. *Position*, 3.
- Vernier, Pierre. (1631). *La construction, l'usage, et les proprietes du quadrant nouveau de mathematique*. Brussels.
- Waters, Robin. (2012, Apr-May, 2012). Maps and mantras. *Land Journal*, 2.
- Yong, Hwee Loi. (2015, Sept.). We have to gear ourselves for the 'new frontiers' that will continue to unfold. *Coordinates*, XI, 1.

Young, Garfield., Roger, Murphy., & Smith, Martin. (2010). *Investigating how education is shaping the modern Surveyor/Geomatic Engineer*. Paper presented at the FIG XXIV International Congress, Sydney, Australia.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2010/papers/ts08g/ts08g\\_young\\_murphy\\_et\\_al\\_4062.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts08g/ts08g_young_murphy_et_al_4062.pdf)

Young, Garfield., Smith, Martin J., & Murphy, Roger. (2011). *Making surveying education relevant*. Paper presented at the FIG Working Week "Bridging the Gaps between Cultures", Marrakech, Morocco.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2011/papers/ts08h/ts08h\\_young\\_smith\\_et\\_al\\_4833.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2011/papers/ts08h/ts08h_young_smith_et_al_4833.pdf)

## **Appendix 1**



## **Appendix 1**

### ***The Changing Role of the Land Surveyor***

#### **CONSENT FORM FOR PARTICIPANTS**

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-

1. My participation in the project is entirely voluntary;
2. I am free to withdraw from the project at any time without any disadvantage;
3. Personal identifying information [e.g. *audio-tapes etc*] will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;
4. This project involves an open-questioning technique. The general line of questioning includes the future direction of the land surveying profession. The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops and that in the event that the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind.
5.  I give my consent to be identified in any report as a result of this project.
6. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I agree to take part in this project.

.....  
(Signature of participant)

.....  
(Date)

.....  
(Printed Name)



[The advertisement which will be used to recruit participants should be attached to the application for ethical approval. This template can be used to develop the advertisement. Please ensure the standard of the written material is of the highest quality, with correct spelling and grammar. You may wish to include an image to increase your advertisement's appeal.]