Geospatial Surveyors: what are they good for?

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SUMMARY

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Current and expected future technological changes mean that former time-consuming tasks are done by devices. As a result it is increasingly important for surveyors to define their professional role, not by what they do or what they produce, but by what they are good for - the positive results they contribute to clients or society, and the confidence they provide for the economic, social and environmental benefits of decisions based on that confidence.

In a world where anyone can use a measurement device, where that device has very high levels of redundancy and self-checking algorithms - what distinguishes the surveyor's measurements from anyone else's? When sufficiently precise global or local geospatial datasets can be routinely accessed and used by anyone through common devices such as smartphones, what will distinguish the geospatial surveyor's data from anyone else’s? Previously, surveying and mapping were clearly within the domain of a profession called Surveying. More recently, a focus on activities rather than outcomes, has created an artificial division between those who *gather* spatial data (surveyors) and those who *process* spatial data (cartographers, geospatial professionals or GIS managers).

A focus on outcomes reveals both groups as experts who obtain spatial information, assess its suitability for their clients’ needs, and process it to generate outcomes such as confidence in boundary location, good decisions based on spatial models, etc. The shared *outcomes* delivered for their clients, and for society, unify these experts more than their *activities* divide them. That is what geospatial surveyors are good for.

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1. INTRODUCTION

The words “professional” and “professionalism” are widely used in common speech. However, they are not necessarily confined to a reference to people who are members of a recognised profession. There are professional golfers, professional jugglers and professional comedians, and in this context the term is used to refer to those who earn their living from an activity in order to distinguish them from amateurs. Sportspeople “turn” professional. The concept is extended when such people, or anyone else, are described as demonstrating “professionalism”. Here the word is harder to define, but it is suggested that it means to carry out a task in such a way or to such a level, that it demonstrates some of the attributes that, while remaining undefined, might be expected of a member of a profession.

Such common use of these terms in the general sense confuses any discussion about the status of an occupation as a profession. In order to adequately discuss whether an occupation is a profession, it is necessary to understand something of the origins and derivation of what once were called the “learned professions”.

2. WHAT IS A PROFESSION?

The word “profession” originates from the verb “to profess”, that is, one who had taken the vows of a religious order (O’Day, 2000; Armstrong, 1994; Dyer, 1985). From the time of the Middle Ages there were three accepted or recognised “learned” professions, namely the Church, the Law and Medicine (O’Day, 2000).

Over time the number of occupations falling under, or claiming the status of, a learned profession has grown steadily. Fone (2010) interprets from O’Day (2010) “the development of an educated class between the non-working leisured classes and the merchants, traders, craftsmen and labourers who comprised the working population of [England]” generated those occupations which are now called the professions. She further proffers “that during this period there was a growth of groups of men in the law, the church, and medicine with a common educational background and steeped in the ideology of service to the ‘commonweal’” Fone (2010, p.1). Furthermore, printing allowed the greater production of books, education was becoming more wide spread, and the influence of the church was diminishing.

This elicits the first clue as to the fundamental requisites of a profession, which may be generally referred to as *education* and *service.* This view is supported by Wilensky (1964). It is no surprise that the range of new occupations desirous of claiming the status of a profession began to enlarge as education spread though Western civilisation.

Flexner (1915) listed five criteria that would need to be met in order for any occupation to be considered to have professional status, and the subsequent literature does not contest these, but tends rather to expand upon them. Flexner (1915) lists the following:

- specialised knowledge applied without bias;
- application of the knowledge to practical problems;
- theory and practice that can be educationally communicated;
- a trusted self-regulating professional body that confers professional status; and
- an ethic that puts client's and society's interests ahead of the self-interest of the practitioner.

Generally the issue of the sociology of professions has dissipated and the topic is rarely discussed (Saks, 2012). That aside, it is an appropriate place to start if there are doubts as to whether an existing occupation has changed significantly and in such a way that its classification as a profession is compromised, or that there are aspects of the discipline or specialties that may be considered to have achieved such status independent of their parent body.

3. SURVEYING ***IS*** A PROFESSION

In making a comparison between the criteria deduced from Flexner (1915), the UKIPG (2013) and the discipline in both local and international contexts, land surveying can be shown to meet all criteria to make a legitimate claim that it is a profession within the currently accepted definition. 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 (BoK) that its practitioners must acquire. The BoK required in any specific discipline 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.

4. SURVEYORS FUNCTIONS IN THE PAST

During the classical period surveyors were educated, respected and important functionaries in the societies in which they lived, Egyptian, Greek and Roman. This may be considered the 1st 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 and telescopes invented and angular measurement became increasingly 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 17th 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 2nd paradigm of land surveying.

At an ever accelerating pace over the last 100 years, technology has impacted on every aspect of modern living. The first significant change to the skills of the land surveyor in over 300 years occurred with the application of photography to land measurement and analysis (Staiger, 2009), 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 20th 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 surveyors work or underlying methodologies. However it did increase 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 speed with which land surveying data could be processed and converted into the products required by clients.

The development of global navigational satellite systems (GNSS) 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 triangulation networks with origins in optical astronomical observations, in order to create and maintain high accuracy position identification. Satellite systems have rendered such systems largely obsolete and changed the methods by which accurate positioning is achieved. Trends in development of GNSS point toward sub-decimetre accuracy for hand-held mobile devices compared with the current 5-10 metre accuracy of a smartphone with GPS (Pesnya, et al 2016).

Further technological changes are in development or already developed. Multi-sensor instruments which (amongst other things) allow different types of systematic measurement error to be detected, estimated and eliminated by the use of different measurement systems that have different sensitivity to errors. Survey systems are available that not only include angular and distance measurements (total stations) but also GNSS, imagery and laser scanning within the one instrument.

An increasing range of mobile platforms for sensors are also being used. Aircraft and more recently satellite systems have been used for many decades and vehicle-mounted systems for many years. More recently "drones" (unmanned aerial vehicles – UAV – or more correctly, remotely piloted aircraft systems – RPAS) are in common usage and backpack-mounted or hand-held measurement systems are also under development or in use (Kukko et al, 2016).

The concept of a surveyor's measuring equipment set up on a tripod over a survey mark and manually operated by a surveyor is still applicable. But the days of this as a default concept may be numbered – particularly the assumption that a professional surveyor will manually operate the measuring equipment in the field in person.

Finally, the impact of Information Technology on the storage, management and manipulation of location data in GIS's 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, is not the sole prerogative of the land surveyor. Information technologists, geographers, architects, engineers, amongst others, are capable of using the information provided by GISs. 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?

5. CHANGE IN SURVEYING PRACTICE

When asked to describe what they do, surveyors most commonly describe themselves as professionals who measure the land. The physical act of measurement to objects in the world is the dominant characteristic that distinguishes surveyors from others in related areas of expertise such as photogrammetry, cartography and remote sensing.

For much of the history of the profession, this was a correct description. The measurement itself was a complex and time-consuming task requiring skill and care to perform correctly. Not only did this mean that surveyors typically reserved this task for themselves, it also meant that survey measurement networks were typically low redundancy – with only just enough extra measurements to detect errors.

A change over the last few decades has been that survey technicians increasingly undertake the measurement task. The measuring equipment has become faster to use and digital recording has reduced the risk of one source of errors. The decisions of measurement design – what to measure – remained much the same but it is more common for younger staff familiar with the latest instrumentation to be entrusted with making the measurements under the direction of the surveyor.

The advances in measurement technology, and in software for survey computations, means that the risk of error has decreased and the ability to quickly and cheaply make check

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measurements has increased. Surveyors are able to apply their skills more to measurement design and quality assurance. They remain in charge of the measurement process, applying their measurement expertise, but often not making the measurements themselves.

With a robotic total station or laser scanner, it is no longer clear that the person who set up the instrument can claim to have made the measurements, although they do govern to some extent what measurements will be taken. Similarly with optical, radar or laser imagery from a range of platforms from satellites, aircraft, drones, vehicle mounted sensors or human carried sensors.

Another process, in this case a social process, has occurred over the same time frame. Many decades ago, lay people would seldom question a professional whom they had engaged as to how he or she would undertake their tasks. However access to information through the internet gives many people some understanding of the task – and also a belief (partly true) that measurement is not so complicated these days. They may believe that anyone can make measurements with the latest technology. And to some extent that also is true.

In response, surveyors, meeting with potential or current clients, need to focus on the result they will provide for their client – rather than the actions and processes they will use to achieve that result. This is now part of expected good customer service and business practice in all areas of business. Therefore the profession of surveying is moving away from being correctly defined as that where its members measure land.

If the outcomes these professionals achieve for clients is looked at instead, it can be said that they use a combination of new measurements (designed or made by themselves or others) and existing geospatial datasets to define the spatial relationships between objects in the real world of interest to their client - to solve client problems, provide client advice or provide client assurance.

6. SURVEYORS OUTCOMES IN A NEW WORLD

At a high level the outcome that geospatial surveyors deliver to clients, employers, governments, and other professionals, is to clarify the spatial relationships that need to be known with confidence to make good decisions or to correctly interpret other information. At a more detailed level, different groups of clients have different outcomes that they need assistance with. Landowners may need to know the location of their boundaries with confidence so that they can fully utilise or develop their land and avoid conflicts with neighbours. Or they may need their property subdivided into smaller saleable and profitable sections.

Surveyors have traditionally achieved these outcomes by undertaking a local survey based on survey marks, providing survey plans and boundary pegs. This continues today. However in an increasingly digital world, that may not always be the best way to achieve the landowner's land use or land development outcome. Accurate and 3 dimensional digital spatial models – such as Building Information Models (BIM) in the case of apartments –require spatial data management expertise. Lodged survey data is already required to be in digital format in many jurisdictions such as New Zealand.

Some other outcomes are:

- For earth scientists the outcome is that the sought "signal" in measurement data is clearly separated from the noise or systematic errors. One example of this could be the signal of sea level rise distinguished from the systematic error of land uplift. This requires measuring equipment or mobile platforms to be accurately located and datasets (including airborne or satellite data) finely calibrated to define spatial location.
- For building and construction, the outcome is that the construction is accurately designed and built. This depends on accurate spatial datasets before, during and after construction.
- A wide range of design and planning outcomes depend on a virtual model of the real world (land or sea) – particularly the landscape, sea floor, land cover, built objects, etc. These geospatial models are often derived from remotely sensed data and managed in GIS. Surveyors may use conventional techniques in enclosed or under-cover areas but mobile sensor platforms and short-range imagery are leading towards geospatial solutions here also.
- A wide range of navigation and positioning outcomes are achieved outdoors by GNSS positioning in relation to geospatial datasets. Significant investment in equivalent indoor positioning is also underway (Carle, 2016; Lemmens, 2016).

7. SUMMARY

It has been demonstrated above that surveying is a profession and that what distinguishes it from other related professions is the body of knowledge (BoK). Some aspects of the body of knowledge have not greatly altered over recent decades. For example the principles of cadastral boundary definition remain complex but largely unchanged.

However a key aspect of the body of knowledge relates to the "how" of location-based measurement – for example:

- How to design a system of measurement to meet the required accuracy
- How to choose the best measurement equipment to balance, efficiency with accuracy and quality assurance
- How to conduct accurate measurement using surveying equipment
- How to minimise random, systematic and gross errors
- How to apply check measurements to detect errors in the field
- How to "reduce" measurements to eliminate or minimise systematic errors
- How to conduct accurate survey or spatial calculations based on survey measurements
- How to reduce the impact of random errors and detect gross or systematic errors through survey adjustment.

This body of knowledge is very closely linked to the survey measuring equipment and survey calculation tools in use. For many decades this equipment and the methods used remained similar or changed quite slowly. Total station bearings and distances today are not greatly dissimilar to historical measurements by Vernier theodolite and Gunter's chain.

The way measurements are made and their errors are controlled seems to be on the edge of significant change. There is a trend towards large numbers of measurements (high redundancy, low random error); multiple sensors to automatically detect and eliminate systematic errors; multiple options for sensor platforms to reduce costs; cloud based processing (software as a service) which can provide low cost processing power to anyone; and the routine use of large scale least squares adjustment to detect, eliminate, minimise or mitigate the effects of errors.

8. AN EXPANDED PROFESSION

So although the actions, tasks and procedures undertaken by surveyors can be expected to change significantly – thus changing the body of knowledge for the operational side of measurement and measurement design - nevertheless the basic outcomes being achieved by surveyors for the benefit of their clients and society in general will remain much the same.

The words that surveyors often use to describe their profession, and the body of knowledge that supports them, could therefore also change. In changing, some of the arbitrary divisions that have formed within the historically broader scope of the "surveying" profession – especially the division between those who measure the land (thought of as surveyors) and those who make those measurements understandable to lay-people (thought of as geospatial experts – but often including surveyors) – these divisions will become less apparent.

Those who measure, who go in the field, who get their boots dirty and face the weather, have for the last 50 or so years considered themselves somewhat separate to their colleagues who generally work in offices analysing the results of measurement data and creating spatial products (maps and plans) as tools to aid interpretation. In the 19th century and before, this division was not clear because the same people, surveyors, carried out both functions.

As technology increasingly takes over the expert aspect of field work, operating from a variety of fixed or moving platforms – not all mounted on tripods and not all with a person standing next to them – surveyors will find that the community outcomes they serve are similar or identical to those of the geospatial community – cartographers, GIS experts, remote sensing experts, developers of spatial software, etc.

Each of these groups will need a sense of the whole body of knowledge within which they operate, while being clear about which specialist aspects of this body of knowledge they have personally mastered. The community and client outcomes they all support are often of very high value and the expectation of professionalism are crucial. The demands of *education* and *service* will remain critical across this whole spectrum.

Because the terms “Surveyor” on the one hand and “GIS professional”, “GIS expert” or “Geospatial expert” on the other hand are widely used across the surveying and spatial domain, the term “Geospatial Surveyor” is suggested to describe a possible combined professional grouping that focuses more on the outcomes it achieves – what it is good for – rather than the rapidly changing set of tasks it performs. That name may not gain any more currency than the seldom used “Geomatician” but it does attempt to unify rather than divide and does recognise the long service to society that the historical profession of Surveyors provided.

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BIOGRAPHICAL NOTES

Brian Coutts, a Senior Lecturer at the New Zealand National School of Surveying and is a professionally qualified surveyor and planner. He is a former President of the New Zealand Institute of Surveyors (NZIS), President of the Commonwealth Association of Surveying and Land Economy (CASLE), Chair of the Cadastral Surveyors Licensing Board of New Zealand (CSLB) and Deputy Head of School of Surveying in New Zealand. He was Chair of the FIG Working Group on Voting Rights and is now the Chair of FIG Commission 1 and the ACCO representative on the FIG Council. His current research interest is focused on the breadth and depth of the changing role of the land surveyor over the last half century.

Donald Grant was the New Zealand Surveyor General from 2004 to February 2014. He holds a BSc Honours in Physics from Canterbury University, a Diploma in Surveying from Otago University and a PhD in Surveying from the University of New South Wales. He registered as a surveyor in 1979 and is currently registered as a Licensed Surveyor in Victoria. Don was elected as a Fellow of the NZ Institute of Surveyors in 2007 and is New Zealand's delegate to FIG Commission 7. In 2014 he took up the position of Associate Professor in Geospatial Science at RMIT University.

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