POSITIONING AND MEASUREMENT INTO THE 21ST CENTURY

Matthew B. Higgins

Department of Natural Resources
Locked Bag 40 Coorparoo Delivery Centre Qld 4151
matt.higgins@dnr.qld.gov.au

6th South East Asian Surveyors Congress
Fremantle
1-6 November 1999

Matthew B. Higgins - B. App. Sc. Surv (QUT), M. Surv and Map Sci (UQ), Lic Surv (Qld), MIS Aust. He is currently a Senior Surveyor with the Department of Natural Resources, Queensland Australia. Matt holds Bachelor and Masters degrees in Surveying and is Licensed by the Surveyors Board of Queensland. He is presently undertaking a PhD at the University of New South Wales working in Geodesy. Matt is Vice Chair of FIG Commission 5 on Positioning and Measurement for the period 1998 to 2002. He is on the Editorial Advisory Board of GPS World Magazine and is a member of the Geodesy Sub-Committee of the Australian Academy of Sciences. He is Queensland representative on the Geodesy Group of Australia's Intergovernmental Committee on Surveying and Mapping. Matt is a member of the Institution of Surveyors Australia (Queensland Division).

ABSTRACT

Positioning and measurement is at the core of our industry and legitimizes our claim as a major player in all things spatial. This keynote paper considers the future of positioning and measurement. It begins with a definition and examination of the role and importance of positioning and measurement in our industry; taking account of the growing importance of spatial data infrastructure. General societal and economic influences are then covered; including the so-called information age, the knowledge society and continuing cultural and environmental sensitivity. The middle sections of the paper look at specific influences on the future of positioning and measurement; including data integration and continuing development, integration and automation of our technology. This leads to an examination of the implications of the manufacturers of equipment and software *bottling our knowledge* for a more spatially aware and spatially capable general public. The paper concludes by suggesting some questions that may help our industry to better understand the impact of the issues covered and to plan for the future.

INTRODUCTION

This is a keynote paper for several sessions grouped under the heading of *Positioning and Measurement*, which takes its context from the Commission of the same name under the Institution of Surveyors, Australia. The importance of positioning and measurement in our industry internationally is also reflected through Commission 5 of the International Federation of Surveyors (Federation International des Geometres – FIG). A definition of positioning and measurement convenient for this paper builds on that used for FIG Commission 5:

Positioning and Measurement concerns the science of measurement and acquisition of accurate, precise and reliable survey data related to the position, size and shape of natural and artificial features of the earth and its environment.

In terms of sub-disciplines, positioning and measurement covers such tasks as field surveys in all three dimensions using terrestrial, aerial or satellite based measurement systems, whether directly or remotely sensed and extends to calibration, testing and standardization activities. The definition correctly emphasizes the point that positioning and measurement is fundamentally about data. However, this paper also examines a broader perspective. Many readers would be familiar with the concept *of the progression from data to information to knowledge to wisdom*. Several pieces of data can be assembled to form information; information in turn can be assembled to form knowledge and enough knowledge can bring wisdom. This progression forms a useful framework for this paper's investigation of the future of positioning and measurement. This paper delves as far as knowledge; whether the paper reaches the level of wisdom is for the reader to decide.

A POSITION OF IMPORTANCE IN OUR INDUSTRY

Positioning and measurement answers our clients questions involving the adverb, *where?*. Discussions on the role of our industry could be much simplified by realising that we have a whole adverb largely to ourselves. Positioning and measurement is at the core of our industry and legitimizes our claim as a major player in all things spatial.

While it is at the core of our business, those involved in positioning and measurement should remember that it is only one discipline within our broader industry and there is a need for more emphasis on value adding in the activities we undertake. In a recent seminar, Edward De Bono outlined the importance of understanding what a business actually does. He pointed out that Ford Motor Company now makes more profit from financing vehicles than from producing vehicles. He claims that *"Ford is actually a finance company. It just sells cars to get customers through the door"*. Many directors of surveying firms may be able to relate to this. Some firms may well make more profit from value adding professional services such as land development than they do from field surveying. To paraphrase de Bono, "*the firm is actually a land development consultancy. It just does positioning and measurement to get customers through the door"*.

The above should not down play the importance of the core business in securing the value adding business. The analogy above can be turned around to recognize that to continue getting customers through the door, Ford must continue to make vehicles that people want to buy. The issue for Ford was recognizing the balance between their core business and the need to diversify past only producing vehicles. If positioning and measurement is a service that clients need and differentiates us from others then we must recognize the current importance of that role and consider how that role may change in the future.

Positioning and measurement is also important in attracting new people to work in our industry, perhaps due to an *outdoors* or a *hi-tech* factor or both. After a time in the industry some may find themselves more involved in other fields such as land development or project management. However, if they knew, on leaving school, that they wanted to be involved in such activities would they have chosen our industry or perhaps business studies, engineering, architecture or environmental science?

In summary, positioning and measurement is at the core of our business, it is a key knowledge that helps differentiate us and attract clients and it helps attract new people to work in our industry. A crucial question is *will that always be so*? That question addressed later in this paper.

THE CONTEXT OF SPATIAL DATA INFRASTRUCTURE

Fundamentally, positioning and measurement is about supplying data. While the progression from data to wisdom described above suggests that data must be combined with other data and put to use in some product or process, it does have value in its raw form, especially in the context of spatial data infrastructure (SDI). A model for SDI has been set out by the Australian New Zealand Land Information Council (ANZLIC, 1996) and has four components; *Institutional Framework, Technical Standards, Fundamental Datasets and Distribution Network.* Coleman and McLaughlin (1998) describe the ANZLIC model as an example of a *data driven perspective*. While this may be so, it is important to realize that SDI is not just about databases. SDI is as much a *concept* as it is a *thing*. Other perspectives described by Coleman and McLaughlin include *technology driven, institutional, market driven* and *application driven*.

The data driven perspective is a useful one for this discussion and it is clear that a major focus for positioning and measurement is to capture the fundamental datasets of SDI. Coleman and McLaughlin (*ibid*) also make the point that: *The word "data" was chosen in lieu of "information" since the authors envision an environment in which much of the decision making with respect to packaging data into information will reside with the user.* This important point reflects the nature of infrastructure in that it should not be for any single purpose but for as many purposes as possible.

The final comment on SDI is that the components other than fundamental data are also relevant and form a useful check list. For example, positioning and measurement data is less useful if it is not captured to an accepted standard or if it is inaccessible.

INFLUENCES ON THE FUTURE OF POSITIONING AND MEASUREMENT

There seem to be several ways to describe the basis for the emerging society and/or economy; *service based, information age or knowledge society*. We are certainly moving away from an *industrial* basis. Drucker (1993) points out that by the year 2000, making and moving goods will account for no more that one sixth of the workforce of developed countries. The progression from data to wisdom described earlier, along with increasing globalization are also relevant general influences.

The Future is Digital

One characterization of the future is what Negroponte (1995) calls "*being digital*", where economies move from exchanging atoms to exchanging bits. Our industry has already seen this trend. Total stations, levels, and photogrammetry are all becoming increasingly digital and satellite based positioning and remote sensing are inherently digital. Manipulation and management of data are also increasingly digital processes.

However, it is in the delivery and use of our data that the full implications of being digital are still to be felt. *Web based business models* like the *Where-Is* street map products are possible pointers to the future. Many surveyors and cartographers may see products like Where-Is as having little effect on our industry. The publishers of Encyclopaedia Britannica learned that can be a dangerous mistake when they underestimated the effect on their business of CD-ROM and internet based encyclopaedias like Microsoft's Encarta.

Knowledge is THE Resource

We are moving into a knowledge based society. Drucker uses the term *post-capitalist society* to describe what is emerging. He believes that free markets are still the mechanism for economic integration but… "*the basic economic resource – 'the means of production' to use the economist's term – is no longer capital, nor natural resources (the economist's 'land'), nor 'labour'. It is and will be knowledge"*. In such a society, workers will fall into two categories; knowledge workers and service workers. Service workers will be those who do not have sufficient education to be knowledge workers. In the terminology used by Drucker, it is clearly desirable for our industry to be made up of knowledge workers rather than service workers.

Specialists in Multi-Disciplinary Organizations

Drucker was once of the opinion that people would need to be generalists to succeed in the future. However, he has changed his mind, realising that specialization is crucial to being a good knowledge worker. Within our industry, much of our professional development programme is focussed on general professional issues and on overviews of new developments. Such content may continue to be necessary but the "*hard yards*" of in depth learning in specialist areas will also be required by those wanting to secure new niches in future markets.

Drucker balances this view of increased specialization by noting that a particular knowledge (e.g. positioning and measurement) is useless by itself, it must be integrated with other "*knowledges*" to produce useful products and processes. Knowledge workers must function within an integrated, multi-disciplinary organization of other specialists.

A relevant point here is that measurement technologies will be increasingly homogenous across what we have typically seen as separate sub-disciplines. The technology does not care whether it is positioning a cadastral peg, a manhole, a seismic shot hole, an aerial target, a hydrographic sounding, a sacred site or an endangered habitiat. We already see specialist firms working in satellite positioning applying their knowledge to the measurement and processing processes with the cadastral or engineering surveying specialist (say) handling that part of the process that is specific to their sub-discipline.

This simultaneous need for specialization and multi-disciplinary cooperation seems paradoxical and has implications for organizations across our industry. The issue of multi-disciplinary cooperation has proved difficult for our professional organizations in recent times. The need to also deal with specialization in future will not make the problem of integration of professional organizations any easier to explain or to implement. In such an environment, a broad alliance with inclusion of specialized Commissions, along the lines of FIG, would appear to be a useful model.

Positioning and Measurement for Cultural and Environmental Applications

Other societal influences, worthy of mention, are the importance of cultural heritage and the environment. There will be continuing demand for measurement processes to be sensitive to such issues. For positioning and measurement there is also potential for new solutions to gather data for those applications. Non-invasive remote sensing technologies like photogrammetry and spectral and laser scanning are already in use in applications ranging from archaeological sites to assessing tree canopy cover to finding routes through environmentally or culturally sensitive areas.

On a global scale, geodetic knowledge is combining with many other disciplines to help understand global processes. Satellite radar altimetry is being used to measure sea surface height and temperature; vital to understanding climate variation. Satellite geodesy is monitoring the stability of high precision tide gauges that are measuring sea level variations linked to global warming.

Spatial Integration

Integration is an important word in our future. As well as the increased integration of our organizations outlined earlier, it will also affect our data and our technologies. For data, integration takes on a spatial context. Comparatively specific concepts like *coordinated cadastre* or *survey integration* will give way to broader concepts of spatial integration. The capabilities of integrated technologies along with the demands of GIS and the extension of SDI concepts will require high levels of spatial integration. However it is difficult to predict what other data a user may want to integrate. Therefore, the data itself will need to be as *"integratable"* as possible by being in a common reference system and to a known quality.

Integration of Technologies

Positioning and measurement technologies will also be increasingly integrated. The digital nature of the technologies will enable them to be integrated to mitigate each other's shortcomings. This can already be seen at several levels:

- At the international reference frame level we see collocation of very long baseline interferometry, satellite laser ranging, absolute gravimetry, high precision tide gauges and satellite positioning.
- So called *mobile mapping systems* are bringing imaging and scanning technologies together with satellite and inertial positioning (in airborne, marine and vehicle platforms).
- At the level of the survey party we see integration of total stations and real time satellite positioning.

As well as physical integration in the field, there is also much effort going into integration at the data processing level, under headings such as *data fusion*.

Some Specific Technological Developments

Specific technologies must reach a certain level of maturity before integration can be considered. In parallel with integration developments then, it is also important to watch the development of individual technologies.

Some complain about *technology push*. However, the cost of developing new technologies is such that they are rarely produced without some clear market in mind. The question may arise whether it is appropriate for a particular new technology to be applied in a given field but that is not really the *technology pushing*. Also, if one is not far enough ahead of developments, technology may well appear to be *pushing*; perhaps it is a matter of perspective.

In any case, positioning and measurement is clearly an area of our industry heavily affected by technology and no paper on future trends would be complete without some assessment of future development. An overriding trend will be continued development of space based technologies:

- A new generation of imaging satellites is coming that will cover a range of spectral and spatial resolutions.
- In September 1999, the US Department of Defense’s National Imagery and Mapping Agency is planning to launch the Shuttle Radar Topography Mission to produce global topographic data and a global DEM over 80% of Earth's land mass (between 60°N and 56°S) during an 11-day flight. The publicly stated parameters are 30m spatial sampling with 16m absolute (10m relative) vertical height accuracy and 20m absolute horizontal accuracy - 90% confidence level.
- and of course, satellite positioning will continue to have a profound effect…

The Global Positioning System (GPS) will continue to hold centre stage for some time but influences beyond GPS alone will have technical and organizational impacts under the more general term, Global Navigation Satellite Systems (GNSS). Developments we are already seeing include the growing importance of the Russian GLONASS system, the development of augmentations systems (ground and/or space based) and the European community’s desire for more influence.

Within GPS itself, a major milestone in the move to true dual use by the military and civilian sectors is the Presidential directive to remove selective availability (SA) by 2006. The report for the first Presidential review of SA is due in October 2000. Developments under the heading of *GPS modernization*, include the *second civil* *frequency*; adding a civil code to existing L2 frequency, enabling increased accuracy and reliability for the pseudo range measurements used in navigation receivers. The effect will be less marked for phase measuring surveying receivers that already use both frequencies. More importantly, a *third civil frequency* (at 1176.45 MHz and referred to as L5) will be introduced to ensure radio spectrum security of the GPS signals. Studies have shown that for surveying, the third frequency should lead to quicker and more reliable ambiguity resolution; the process at the heart of centimetre accuracy techniques. These new services will be phased in as satellites with the new capabilities are launched beginning in 2005 and will not be fully available until there are sufficient numbers of new satellites in the constellation.

Receiver technology will continue *being digital* in ever expanding ways; more digital channels on a single chip and each channel being more flexible. For example, one manufacturer (Javad Positioning Systems) has a design with 40 channels on a chip with each channel able to track either frequency of either GPS or GLONASS or any other similar signal source. A channel can also be the radio receiver for the real time base station data. This means that the same hardware is suitable for post processed single frequency GPS only through to real time surveying using both frequencies of both systems. Enabling the different levels of functionality only requires a password sent by email. This shift to being firmware rather than hardware driven is taking the marketing of satellite surveying from being the sale of hardware and software to being the sale of various levels of service. It is an extension of *versioning* as seen in software distribution and web based business models.

Another interesting illustration of future possibilities is *Auto GIPSY* (see UNAVCO, 1999); a GPS processing approach developed by NASA’s Jet Propulsion Laboratory (JPL). GIPSY is the software used by JPL in the processing of station positions and orbits for the International GPS Service (IGS). With Auto GIPSY, data from a geodetic quality receiver at a single stationary site anywhere in the world is placed on a computer on the internet (a so-called anonymous FTP site). The user then emails JPL giving the location of the data. The GIPSY server at JPL then automatically retrieves the data and processes it using orbit and clock corrections derived during IGS processing. The JPL computer then emails back saying that the processing is complete and where to retrieve the results. One could expect daily repeatabilities (from 24 hours of data) of a few millimetres horizontally and a centimetre vertically!

IMPLICATIONS FOR THE FUTURE

Bottling Our Knowledge

Given all of the above, we can expect continued high levels of integration and automation in our positioning and measurement processes. Manufacturers of equipment and software are effectively *bottling our knowledge*. The concern is that it will be difficult to be more than service workers if our knowledge has been automated and an implication of this *bottling of our knowledge* is the possible erosion of existing markets. One reason for this will be that less specialized people will be able to do their own positioning and measurement. For example, almost anyone can now do sub-metre accuracy positioning using readily available differential satellite positioning services. We already see that the major markets for real time satellite surveying systems offering centimetre accuracy are not surveying but areas like earthmoving, mining and precision agriculture. Taken to the extreme, the Auto GIPSY example above shows that anyone who can set up a GPS receiver and send an email can do reference frame level geodesy! Less educated users may make mistakes due to ignorance of some of the technical issues involved. However, such problems can largely be overcome by improving the design of the technology and/or the spatial data infrastructure and will be remedied with time.

Is the Knowledge Bottle Half Empty or Half Full?

Scenarios of loss of markets should be balanced by recognizing that it will be restricted to certain areas such as satellite positioning applications. The equipment is totally electronic and can be highly automated, plus costs can fall rapidly once development costs are recouped. Satellite positioning does not work everywhere and many problems will still require specialized solutions using comparatively expensive technologies, such as those that rely on precision optics and machining.

Another perspective on this issue is to see it as an opportunity rather than a threat. What work is there for surveyors in improving the spatial data infrastructure to enable increased use of positioning technologies by the general public? For example, the often quoted scenario of *everyone being able to position there own cadastral boundaries to a centimetre*, assumes significant changes to the current infrastructure in all four of the components outlined earlier.

To switch briefly back to *threats*; perhaps there is a broader threat to our whole industry, not just positioning and measurement specialists. If we are unable to deliver the infrastructure expected by a more spatially aware and spatially capable general public, another industry may take up the challenge.

Back to *opportunity*; the 19th Century French Economist, Jean Baptiste Say, said that *"People do not know they want something until they see they can have it… then they can't live without it."* Linking Say's observation to the previous sections would suggest that there should always be scope for new niche markets and applications. For example, while the market for sub-metre positioning may shrink, the millimetre market may grow. Improving technology means that very high precision tasks in industrial metrology or deformation analysis that may have previously been impossible or prohibitively expensive could become feasible.

However, of more general relevance is that increased client demand should also be reflected in some of the issues outlined earlier; with more call for specialist knowledge being applied in multi-disciplinary teams doing value adding, data integration, interpretation and analysis.

The final implication to note here comes from where this section started; to recognize the increasing importance of the suppliers of our equipment and software. While other sectors of the industry will research and develop new concepts, it is the large supplier companies, operating globally rather than just locally, that have the *critical mass* to bring major new innovations to market. In that context, the suppliers are having an expanding influence on the future agenda for our industry and that may require a larger role than, for example, simply populating trade displays at our conferences.

CONCLUSION

This paper has outlined some of the societal and economic influences on the future of our industry. It has also examined influences specific to the future of positioning and measurement. Dealing with the future will require learning to adapt to rapid change and accepting and dealing with uncertainty and complexity.

Predicting the future is impossible. Management thinkers, strategic planners and futurists have techniques to help develop strategies under such conditions but that is beyond the scope of this paper.

This paper has attempted to take the simple approach of extrapolating trends that are already having an impact; what Drucker has called *"the future we already have"*. If there are no clear answers one is left with questions. Different questions will affect different parts of our industry in different ways and it is up to individuals to decide what questions matter most to them.

From what has been covered in this paper, the author is left with the following questions that may help our industry plan for the future:

- What is needed to ensure our industry adapts to the knowledge society?
- Is our industry optimized for an economy based on highly specialized people working in multi-disciplinary teams?
- How do we develop knowledge workers and get the best return on the investment in their knowledge?
- How do we *be digital*?
- How will information age business models (e.g. via the Web) affect the delivery and use of our data and how will that affect other aspects of our industry from the front counter back?
- What effect will the expanding importance of cultural and environmental issues have on the future of positioning and measurement?
- If positioning and measurement is at the core of our industry what needs to be done to recognize that role and adapt to any changes to that role?
- What are the implications of our positioning and measurement knowledge being *bottled* in increasingly automated technology and processes?
- How can we be involved in improving all components of the spatial data infrastructure to meet the expectations of a more spatially aware and spatially capable general public?
- How can we make the data we capture as *integratable* as possible?
- What will be the effect of increasing integration of the technologies we employ?
- How can we capitalize on continually increasingly demanding clients as an opportunity for future business?
- How can we harness the expanding influence that the suppliers are having on the future agenda for our industry?

REFERENCES

Australian New Zealand Land Information Council, 1996, *Spatial Data Infrastructure for Australian and New Zealand – a Discussion Paper,* ANZLIC, Canberra, November.

Coleman, David, J. and John McLaughlin, 1998, *Defining Global Geospatial Data Infrastructure (GGDI): Components, Stakeholders and Interfaces*, Geomatica, Vol 52, No. 2, 1998, pp 129 to 143.

Drucker, Peter F., 1993, *Post-capatilist Society*, Butterworth Heinman Ltd, Oxford.

Negroponte, Nicholas, 1996, *Being Digital*, Hodder Headline Australia Pty Ltd.

UNAVCO, 1999, A Description of the e-mail service Auto GIPSY, at http://www.unavco.ucar.edu/processing/gipsy/auto_gipsy_info.html