"Life, the Universe and Everything
or
Technology and the Surveyor—1997"
ROBERT HOLLOWAY AND IAN P. WILLIAMSON

Abstract
Just as the sperm whale thought, in Douglas Adams' book "The Hitchhiker's Guide to the
Galaxy", after it had suddenly been called into existence and as it hurled towards the
alien planet below...

"What's happening? it thought.
Er, Excuse me, who am I?
Hello?
Why am I here? What's my purpose in life?
What do I mean by who am I?"
so too does the surveyor contemplate his raison d'être as he is confronted with an in-
creasing amount of technology in the form of magical "black boxes" operated by the
uninitiated.
This article deals with how the future surveyor resolves this challenge, and moves from
being a land data collector to that of land data manager by describing a day in the life of
a surveyor in 1997 and hopefully avoiding a similar fate to that of the whale.

Prologue
On 22 February 1978 the first satellite was launched by the United States to herald the
introduction of the Navigation Satellite Timing and Ranging Global Positioning System
(NAVSTAR GPS).
The NAVSTAR Global Positioning System is a space-based radio positioning, navigation
and time transfer system that can provide highly accurate three dimensional position
and velocity information along with Co-ordinated Universal Time (UTC) to an unlimited
number of suitably equipped users under all weather conditions, continuously, anywhere
on or near the surface of the Earth. (WOODEN, 1985)
The GPS system should be operational by 1989-1990 (barring further accidents) and
will consist of a constellation of 18 satellites plus three active spares to guarantee very
high system availability. The satellites will operate in circular 20,200 kilometre orbits in
six orbital planes, each having three satellites separated by 120 degrees and at an inclina-
tion of 55 degrees with 12 hour periods.
Each satellite will transmit a unique signal on two L-band frequencies: L1 at 1575.42
MHz and L2 at 1227.60 MHz (equivalent to wavelengths of approximately 19 cm and 24
cm, respectively). The satellite signals consist of the L-band carrier waves modulated
with a "Standard" or S code (sometimes referred to as C/A code), a "Precise" or P code
and a Navigation Message containing the co-ordinates of the satellites as functions of
time (the Broadcast Ephemerides). The S code is intended mainly for civilian use while

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the P code may be restricted to US military use by encrypting the code. (RIZOS et al, 1984).

The precise spacing of the satellites will ensure that a minimum of four satellites will be in view to a user at any time on a worldwide basis and enable an observer to solve for his three positional elements (latitude, longitude and height) plus the clock offset at the observer’s receiver (time). The positional elements are referenced to an Earth-centred co-ordinate system WGS72, and maybe WGS84 soon, and have to be transformed to a local co-ordinate system, if that is desired, by either solving for the transformation parameters or using known parameters from previous observations.

There are two modes of operation which can be used when obtaining an observer’s position with GPS. The first, called “Navigation Mode”, uses a single receiver to access the P-code, S-code or both simultaneously and gives an absolute position on the Earth in the same co-ordinate system as the satellite is tracked in. The second, called “Differential” or “Translocation Mode”, uses two receivers. The difference in the positional elements (dX,dY,dZ) can then be measured from a control point of known position to the unknown position of the second receiver.

The accuracies presently attained in Navigation Mode are ±5m using P-code receivers and approximately ±30m to 50m using S-code receivers. Relative positional accuracies obtained in Differential Mode are much better and usually expressed as a fraction of the baseline length between the two receivers. Accuracies of 1-2 ppm (10-20 mm for a baseline separation of 10 kilometres) are being achieved commonly today.

THE SCENE: A surveyor’s office in Perth, sometime in the future…

A surveyor sits at his word processor, typing a letter to a potential client:

GPS SERVICES (WA) Pty Ltd
10 Rokeby Road,
Subiaco,
29 May 1997.

The Manager
THE XYZ SURVEY Co.
26 Kings Park Road.
Perth.

Dear Sir,

The purpose of this letter is to introduce our company to you and to acquaint you with the comprehensive range of services which we offer to the surveying community, both public and private sectors.

The Global Positioning System (GPS) technology has been in use now for a number of years by many surveying companies in Western Australia. The internal precision of the system of 1-2ppm is able to be achieved regularly by its use in Differential Mode at great savings in cost and time to the public over conventional surveying methods.

Our company is proposing the concept of relative positioning with respect to a distant base master station. This would entail the installation of a GPS receiver, sited at the Perth Observatory, and being fully functional 24 hours a day, seven days a week. This would then allow the “freeing” of many more receivers, previously constrained to act as temporary base stations, and allow them to be used for position determinations.

The concept, as envisaged, would be able to determine positions within a radius of 100km of Perth to within 0.1m relative to the Perth Observatory. However the accuracies achieved in a remote survey within this zone would be far less, it being a function of the difference in distance between two control points established and the Perth Observatory.

We intend this system, as described, to be available for the use of all users of GPS

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receivers on a bureau basis. This will allow further reduction in costs to users and hence would follow benefits to the public.

I would appreciate any comments you have on this proposed service offered by our company and I would be happy to meet you for more detailed discussions if you are interested in participating.

Yours Sincerely,

A. Surveyor

The surveyor continues at his word processor, coffee cup beside him...

GPS SERVICES (WA) Pty Ltd
10 Rokeby Road,
Subiaco.
29 May 1997.

The President,
Institution of Surveyors, Australia
154 Hampden Road,
Nedlands

Dear Sir,

I wish to raise a matter of importance for discussion with the members of the Institution of Surveyors.

Many members of the Institution throughout Australia own and operate GPS receivers as an everyday tool to determine relative positions. The cost benefit over conventional surveying methods is now well established. Also, the accuracies inherent in the system of 1-2ppm of baseline length are able to be achieved repeatedly.

However, the limitation to higher order accuracies the GPS system is potentially capable appears to be the precise determination of satellite orbits. At present the satellite orbits, used by the various processing software programmes, rely on the Broadcast Ephemerides contained in the Navigation Message put out by each satellite and appear to be accurate to 20-100 m. The orbits are modelled from 5 tracking stations around the world and the predicted extrapolated orbits are “fed into” the satellites daily by the Master Control Station in Colorado Springs in the United States.

As a “rule of thumb” an improvement in the accuracy of orbit determination by a factor of ten corresponds to an equal improvement in baseline accuracy. Therefore, if a satellite orbit can be determined to an accuracy of 2m, the corresponding relative accuracy in baseline measurements will be in the order of 0.1ppm and so on.

I believe it is in the interests of the Divisions of The Institution of Surveyors to undertake, on a co-operative basis, the setting-up of a tracking network within Australia to model GPS satellite orbits to a higher accuracy than is currently available. This has been possible for a number of years with available technology and not too exorbitant cost.

The basis of this tracking network could be 3-4 tracking stations on well-defined points throughout Australia and would consist of a GPS receiver at these sites and orbit determination software. The orbit information could be available for post-processing of GPS measurements by members through access to a central control station via AUSSAT, modem and personal computer.

I see the advantages of this system to all members as:
• non-reliance on the United States for satellite ephemerides.
• consistent orbit information 24 hours a day, seven days a week without the sudden degradations that can now happen on weekends.
• accuracy of orbits in the region of 0.2m are possible which corresponds to a relative

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baseline accuracy of 0.01ppm (1x10^-4).
- much greater accuracies of receiver positions used with respect to a distant base mas-
ter station.
- opening of new horizons for the surveying profession by being able to tackle tasks
hitherto considered not able to be accomplished by the surveyor, i.e. crustal motion
studies, precise engineering surveys over large distances or between physically inac-
cessible points.
- accurate determination of velocity and position of moving objects such as ships and
aeroplanes. For example, this could eliminate the need for ground control in
photogrammetry.

I would like to raise this matter at the next General Meeting of The Institution of Sur-
veyors for discussion and the possibility of forming a working committee to investigate
the feasibility of establishing a tracking network.

Yours sincerely,
A. Surveyor

Ring, Ring... the surveyor answers his telephone.

[Surveyor] "Good afternoon. GPS Services Pty Ltd."
pause
[Surveyor] "Hello Frank. Sorry to hear about your football team on Saturday."
pause
[Surveyor] "OK. Now, you say you have a parcel of land on the corner of South Terrace
and Benningfield Road, Leeming that you intend to subdivide into 50 residen-
tial blocks."
pause
[Surveyor] "So, that's on the south-east corner, is it?"
pause
[Surveyor] "Have you discussed the development with the local authority?"
pause
[Surveyor] "Fine. Do you want us to handle the subdivision application with the Town
Planning Department and the Environmental Impact Assessment?"
pause
[Surveyor] "Great. If you could confirm those details in writing, the electronic mail
facility in "Viatel" is probably the quickest, we will start the ball rolling from
our end."
pause
[Surveyor] "I can access the Digital Cadastral Database at WALIS (Western Australian
Land Information System) and copy across the concept plan. I'll work out a
cost estimate for the various stages of the project and our fees. It should be
held in your electronic mail tomorrow morning."
pause
[Surveyor] "Righto. I'll get back to you when the application is ready for your inspec-
tion. Good-bye Frank."
click.
The surveyor places the receiver back and thinks, "I must start the search enquiries now if
I'm to have that estimate ready by tomorrow morning. More coffee."

The surveyor moves to his computer terminal and instructs it to dial the number of
WALIS and is immediately acknowledged as they are connected by optical fibre. The
only information he has is the suburb and street corner. He calls up a large scale map of
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Perth, which only shows road patterns, onto the screen, and is similar to a street directory but kept in digital form and is continuous. The large scale digital map is also the source of the city maps, held on laser disc, which coupled with a GPS receiver, make up the navigation systems that are so common today in trucks and cars used by many interstate drivers.

The surveyor moves the cursor, via the "mouse", and reads off the Australian Map Grid (AMG) co-ordinates for the particular street intersection of the proposed subdivision.

By inputting the AMG co-ordinates and a scale, a plan appears in the screen, which has as its centrefold the AMG co-ordinates. The surveyor sees the particular corner he is interested in and moves the cursor to that position and "zooms" in. The window, containing the street intersection, expands to fill the screen, showing the parcel in more detail.

He then selects, by the menu, and gets the Parcel Identifier, Certificate of Title details and the numbers of all related Plans and Diagrams that determine the land parcel boundaries to be obtained later from the Office of Cadastre (formerly the Office of Titles).

The surveyor next moves the cursor to each corner and bend around the perimeter in turn and selects point identification mode through the menu. The co-ordinates appear, as an Easting and Northing alongside each bend and corner on the AMG. These co-ordinates have the same legal significance as survey measurements; the weight of evidence of original monuments and substantial occupations is always preferred in the re-establishment of parcel boundaries. The Government offers no guarantees as to their accuracy, but they are very helpful in the planning and report preparation stage.

These co-ordinates form part of the digital cadastral database compiled by WALIS over many years. They have been gathered, firstly by digitising old survey maps and can only be considered to be of "plotting accuracy". However, the integrity of the database is gradually being upgraded by new co-ordinates determined by actual field survey methods, conventional and by GPS.

The surveyor now requires some background information about the parcel of land he is interested in for the preparation of the Environmental Impact Assessment. He selects from the utilities and service menu, and an overlay comes down and is superimposed onto the cadastral map on the screen. This shows topographic details such as heights in the form of contours. Also, other overlays show the locations of all sewer mains and connections, underground telephone lines, underground power lines and stormwater drainage for the particular area of interest. This map is able to be downloaded into his computer through the data line in a format that is compatible to be plotted on the flatbed plotter sitting beside the computer terminal. The map is also stored in digital form on the computer's hard disk so that it is available for later use.

Similarly, other overlays of interest are "pulled" down and superimposed over the cadastral map. These include a vegetation overlay, of interest in areas where a Tree Preservation Order is enacted, also a soil overlay to ascertain if the land is suitable for building and a geological overlay to determine the type of building foundations that will be required in the future and the presence of underground mines, if any, that may subside.

The surveyor now exits this part of the WALIS system and enters the textual cadastral database. Armed with the unique parcel identifier, as found in the previous database, the surveyor can access a new set of menus providing a new range of information. This includes street address, name of local authority (including information regarding minimum lot sizes, building setbacks, road widths and building densities), statutory valuation relating to the parcel, sales information and purchase prices for the area, any government overriding interests in the land or adjoining land that wasn't shown on the Certificate of Title, census information and any buildings that may be classified by the National Trust.
This information found is also downloaded onto the surveyor's computer and printed out on his local printer.

The surveyor now exits the system altogether after collecting a vast amount of information relating to the parcel of land he has been entrusted, by his client, to plan and coordinate its development. He is well on the way to being able to prepare his report for submission to the Town Planning Department and the Local Authority.

The sources of the information found in the various databases in the previous session are diverse. The role of WALIS is that it is the central repository and distributor of information and not the gatherer. The sources are always the Government departments that gather the original information in the performance of their statutory duties.

The surveyor, working locally at his personal computer, loads his subdivisional design programme into the computer's memory and recalls the digital cadastral map. He is then able to indicate the approximate locations of the road alignments, using the mouse. The planning constraints, to satisfy local authority and State Government conditions as well as environmental factors and economic viability, are entered into the subdivisional design programme as parameters. The remainder of the subdivision is then automatically designed by the programme.

The completed design is able to be viewed on the computer's screen in plan view as well as a three dimensional perspective using the contour overlay. He is able to make any amendments to the final design, if he wishes, by changing the road layout or any of the design parameters and the process repeated.

The surveyor, having finished his searching and design, moves back to his word processor... the used coffee cups are piling up.

GPS SERVICES (WA) Pty Ltd
10 Rokeby Road,
Subiaco.
29 May 1997

The Surveyor-General
Dept of Lands & Surveys
Cathedral Avenue,
Perth.

Dear Sir,

I wish to raise a number of matters with you that are of interest to myself and, I believe, my fellow colleagues in the surveying profession as a whole, and the GPS community in particular.

These matters relate to possible amendments to "The Regulations for the Guidance of Licensed Surveyors Practising Under the Transfer of Land Act, 1898", under which we all operate, to reflect the almost universal use of GPS receivers now as an everyday surveying tool.

GPS measurements can be incorporated into the Regulations and standards prescribed similar to the standards existing for chaining lines, angle reading and EDM measurements. Co-ordinates intrinsically impart no information by themselves; it is not until they are attached to a monument on the ground or associated with a corner on a parcel boundary that they become meaningful. It is only now that the surveyor has gained an additional "tool" to add to his arsenal for the measurement and delineation of land.

I see the role and advantages of GPS measurements being incorporated into and complementing the cadastral system in Western Australia as:

* the practice now of attaching co-ordinates to monuments and points on parcel boundaries on survey plans and diagrams.

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• the concept of the “portable monument”, that is of a GPS receiver being used to reinstate obliterated survey marks, while respecting evidence of original monuments and previous occupation.
• GPS receivers being used in a “control survey” to define a parcel of land before subdivision.
• the accuracies attainable using GPS far exceed the accuracies required and specified in the Regulations, particularly on medium and long baselines.
• co-ordinates derived from GPS observations being incorporated into the digital cadastral database to continually upgrade the integrity of the database.

I propose that GPS measurements become incorporated into the Western Australian cadastral system, not because we worship the god “technology” for the sake of technology itself, but because it is an efficient surveying tool that can complement our existing arsenal.

Yours sincerely,
A. Surveyor

The surveyor switches off his computer... as the sun sinks slowly in the west and another satellite rises in the east.

Epilogue
The foregoing scenario is entirely a figment of the authors’ imagination and any names and events are purely fictitious. However it is our opinion that some, or all, of the issues detailed will have to be tackled by the surveying profession in the future as this technology is available today.

Surveying, in its broadest sense, is about the collection, manipulation and distribution of land information with the surveyor being the land manager. This is as true today as when the ancient Egyptians used the pyramids to map Egypt 3,000 years ago. One has only to reflect the enormous technological advances made in the past ten years to ponder how this acceleration of technology will affect us in the next ten years.

Today the computer has made possible the establishment of digital cadastral databases and the resolution of positions on the Earth’s surface to millimetres with the use of satellites. It is the responsibility of the surveyor to bring together these new technologies to assist and aid him to efficiently perform his role, which is the legacy of his forebears.

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