ARCHAEOLOGY IN NEW ZEALAND

THE APPLICATION OF DIFFERENTIAL GPS TO ARCHAEOLOGICAL SURVEYING:
AN EXAMPLE FROM THE BAY OF PLENTY

Clayton Fredericksen, Auckland
Matthew Felgate, University of Auckland
Des Tatana Kahotea, Unitec Institute of Technology

This paper reports the use of differential global positioning system (GPS) in a site survey undertaken in the Papamoa region of the western Bay of Plenty (Figure 1). The survey was jointly funded by the Tauranga District Council and Historic Places Trust and carried out by the authors over seven days between 13th and 19th March 1996. A full description of the survey results can be found in the unpublished project report (Fredericksen *et al.* 1996), copies of which are lodged with the Tauranga District Council and Historic Places Trust (Wellington).

GPS AND DIFFERENTIAL GPS

GPS is based on determining your position on the earth's surface by reference to a group of orbiting satellites. The GPS system works by timing how long it takes a radio signal to reach a position from a satellite and then calculating the distance from that time. For this we need to know exactly when the signal left the satellite and GPS does this by generating the same random code as orbiting satellites at exactly the same time. Signal reception from at least four satellites is required to offset any minor differences in timing between signal transmission between transmitting satellites and GPS receivers. Nevertheless, discrepancies in the time between signal transmission and reception are present from ionospheric and atmospheric interference, as well as minor errors in satellite orbit tracking and tiny discrepancies in the atomic clocks on board the satellites. These sources of error are sufficient to offset the accuracy of a GPS receiver by up to 7m (Donnan 1996:68). However, the major error is purposefully introduced by the United States military, which maintains the GPS satellites, and is called 'selective availability'. This random error is ostensibly added for national security reasons and means that positions obtained by GPS may be between 100m and

500m out (Kilvington 1997), which at best is about the same level of accuracy as obtained by taking compass bearings and plotting a position onto an NZMS 260 topographic map.

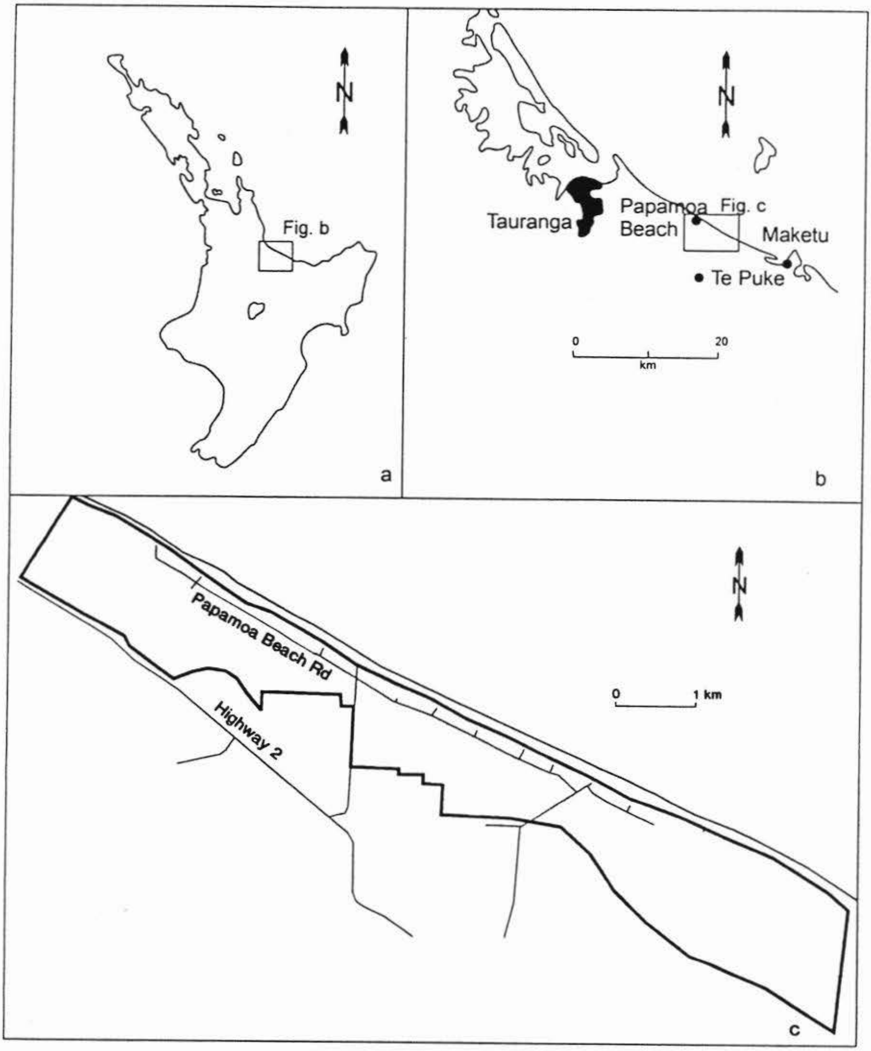

Figure 1. Papamoa archaeological survey area, Tauranga District, Bay of Plenty

These signal errors and resulting position inaccuracy are not particularly serious for yachties in the middle of the ocean, or trampers wishing to determine which ridge they are on. It can be a different picture for archaeology. The standard handheld marine receivers used by yachties and trampers have been employed by some consulting archaeologists to locate sites for cultural resource management projects. But the simple fact is that marine receivers cannot be used to fix site location with the level of accuracy required for this type of work. An error of 100m or greater is clearly unacceptable for planning purposes. Professional land surveyors employ *differential* GPS receivers, which routinely produce a locational error of less than 1m. The difference between standard marine GPS and differential GPS is that the latter system enables errors in the data to be corrected by comparing the received satellite signal with the signal received by a stationery GPS base station. As the location of the base station is known it is, at least in theory, a relatively straightforward matter to correct for any errors. Amazingly, the United States Coast Guard has developed a system for correcting random signal errors introduced by the United States military, and this has been made available to civilian companies. Base stations can be set up as part of a surveying project or correction data can be purchased from commercial providers who maintain permanent base stations throughout NZ. There are however areas of NZ not covered by base station receivers, which means either establishing an independent base station or resorting to obtaining correction data from a distant commercial station, with a resulting loss of precision in determining site location.

THE PAPAMOA SURVEY

The Papamoa survey was undertaken to record archaeological sites in a high priority zone which will be the focus of future residential development. The survey encompassed an area of approximately 1.5 km by 11 km. The dominant landform in this region consists of a series of Holocene dune ridges which are aligned parallel to the coast. These attain a maximum elevation of 15m above sea level and form a dune belt 100-1,350m wide. Prior to European drainage works the inter-dunal areas were characterised by swamps, while an extensive area between the dunes and the inland Papamoa hills consisted of one huge wetland. Today most of the swampland has disappeared, although remnants exist in places. The vegetation cover of the surveyed area is predominantly pasture.

Our brief for the survey was to traverse areas which had not previously been inspected by archaeologists. The objective was to supplement the Tauranga District Council's site inventory rather than to check the location of previously recorded sites. Accordingly, sites identified by other consulting archaeologists on subdivision lots within the Papamoa coastal zone were generally not inspected. This means that over one half of the sites recorded on the Papamoa coast have not been surveyed using GPS.

Sites were located visually or, in the case of subsurface shell midden, by probing using steel probes ('gumspears'). Recording was undertaken using a Trimble Pathfinder Pro XL differential GPS receiver. The GPS was set to take readings automatically every five seconds as the operator (Felgate) walked around the perimeter of each site. (The boundary of subsurface middens was marked beforehand by spraying the ground with fluorescent paint). In this manner both site location and site extent/shape were recorded. Readings were also taken along road verges and fencelines to facilitate measurement of the degree of error in fixing site location by referencing back to these known features. The accuracy of the position of legal land boundaries was assured by a recent Council resurvey. At the end of each day archaeological survey data were downloaded onto a laptop PC. Data were adjusted using weekly correction information purchased from the Rotorua office of the Department of Survey and Land Information (now Land Information NZ). This provider possessed the nearest GPS base station to the survey area. An error range of $\pm$ 0.5m was achieved in fixing site location and mapping site boundaries.

Seventy seven previously unrecorded sites were located and mapped using the GPS. The vast majority were shell middens but three terrace sites, a pit complex and a small swamp pa were also newly recorded. Two sites previously recorded by a consulting archaeologist as midden exposures on remnant dune ridges in the middle of the interdunal swampland were found to be small pa. The GPS was found to be useful for mapping the major features of the three recorded pa, although the resulting detail and accuracy is obviously not as great as can be obtained using a theodolite (Figure 2). GPS can provide elevation data but owing to satellite geometry this measurement is accurate to only within a few metres, and therefore unsuitable for contour mapping in most archaeological situations.

A number of previously recorded sites were located and rerecorded with GPS. The accuracy of this original recording was found to be variable. Some sites had been recorded with a high level of accuracy while coordinates for others placed sites far from their actual location. In the worst instance a midden was found to be located 200m southeast of its position as recorded in the NZAA file.

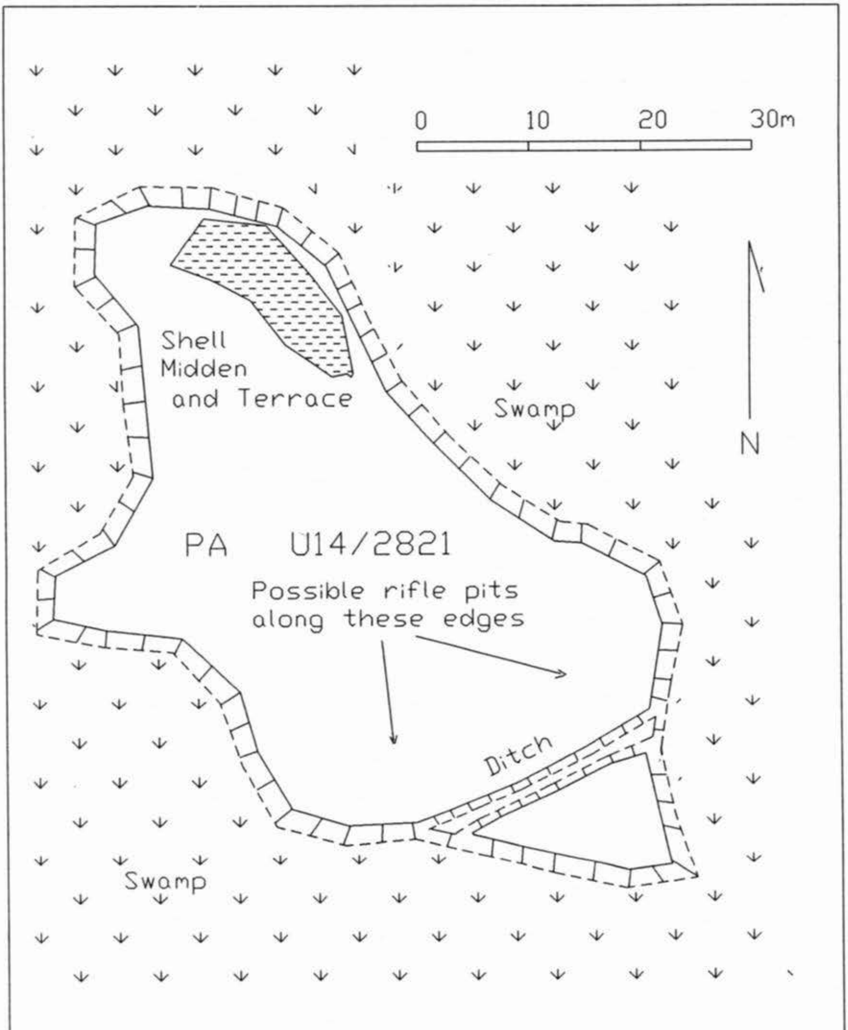

Figure 2. GPS survey plan of pa site U14/2821

The results of the survey were provided in both paper and digital data formats. Site distribution data were overlaid onto aerial photographs, which had been digitised and georectified to remove any distortions in scale. The same information was also overlaid onto large scale cadastral maps. Digital data were supplied to the Tauranga District Council in a form suitable for input onto their GIS system. Owing to time constraints details of each site were not included for GIS input, although fields containing the NZAA site numbers were added so that sites represented on the GIS system can be linked back to the NZAA file. This requirement to move between digital and paper databases is rather clumsy and ideally it would be preferable to have all site details (type, date recorded, size, possible future damage, etc) recorded on a GIS database. A complete conversion from paper to digital formats may take place in the near future.

CONCLUSION

The Papamoa project demonstrated how differential GPS can be readily applied to archaeological site surveying. The benefits of using GPS in this project were found to include:

1. Time/cost savings. Although using a differential GPS incurs costs not encountered with conventional archaeological survey methods, this is more than offset by the time saved in locating and recording sites. The time taken to record each site was reduced by at least half, and closer to 80% for larger and more complex sites. In seven days a team of three archaeologists was able to systematically survey an area of just over 15 km^2. If tape and compass techniques had been used to locate and record sites then this coverage would have taken considerably longer.

2. Accuracy. Site location was determined to within 0.5m. This is a vast improvement over conventional recording and provides a powerful tool for cultural resource management. The Tauranga District Council and individual landowners now know exactly where archaeological sites, including subsurface middens, are located. Residential development can be undertaken to minimise impact on the archaeological landscape. Additionally, as the extent of each site was mapped it is now possible to determine from the Council GIS database exactly how large a site is and what features it is comprised of (e.g. group of adjacent middens, cluster of pits, pa with transverse ditch, etc). This remedies the situation in which sites are depicted as a dot on a topographic map, with no additional information as to size or

composition. To obtain this kind of fine-grained information often requires tracking down a surveyor's unpublished fieldnotes or paying a visit to the local file keeper to peruse the requisite site record forms (which are not always conveniently available).

3. Flexibility. GPS survey data can be provided in both hardcopy and digital formats. Digital data can be entered onto a range of databases and GIS platforms. The two main advantages of presenting a seamless interface with GIS are that archaeological site distribution can be directly compared with a wide range of landscape attributes (topography, hydrology, soils, land tenure, land use patterns, etc) and survey information can be easily altered, updated or quantitatively assessed.

In conclusion, academic research and cultural resource management are both beginning to demand a higher level of sophistication in spatial recording than can be provided by conventional archaeological surveying methods. The use of differential GPS meets this requirement for accurate and flexible data capture. The greatest growth in the use of GPS will probably come from public archaeology as developers and particularly territorial local authorities begin to demand that data is recorded to a high level of accuracy and in a manner which will enable incorporation with other information packages. The Centre for Archaeological Research at the University of Auckland is currently the only facility in NZ which offers differential GPS as a tool for spatial data capture in the commercial arena of public archaeology. However, as technology becomes simpler and more affordable it seems likely that in the not too distant future a wide spectrum of heritage managers, including iwi organisations, government bodies and private consultants, will come to routinely apply differential GPS to archaeological recording.

ACKNOWLEDGEMENTS

Craig Batchelar (Director of Environmental Services, Tauranga District Council) was instrumental in setting up the Papamoa survey. We thank him for his interest and support. The Ngapotiki marae Tahuwhakatiki afforded comfortable accommodation and office space throughout the project. Hans Bader assisted in formatting data for the survey report and brought to our attention the Kilvington article referenced in this paper.

REFERENCES

Donnan, M. 1996 The miraculous world of handheld GPS. *Boatingworld,* February 1996: 64-69

Fredericksen, C., D. Kahotea and M. Felgate 1996 An Archaeological Survey of the Papamoa Coastal Zone, Tauranga District. Unpublished report to Tauranga District Council and New Zealand Historic Places Trust.

Kilvington, R. 1997 Inaccuracy of Global Positioning Systems. *Coastguard New Zealand,* December 1996/January 1997: 11