Improving the Cadastre using Existing Information

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ABSTRACT

Many people from both within and outside of the surveying profession use the Digital Cadastral Database (DCDB) on a regular basis. The uses of the DCDB are varied and numerous, but in most cases the DCDB is overlaid with other data. The advent of Web Map Services (WMS) from DFSI Spatial Services and many other organisations allows users to overlay data from vastly different sources. The expectation from the unknowing users is that this will simply work and the maps produced will look fine. Are these expectations reasonable? Does the data available stand up to the novice scrutiny? This paper examines a number of uses of cadastral data and the possible issues that might arise. Examples have been replicated from real-life examples. Some solutions are proposed for further consideration, including some that have been used by some users in recent times. This paper identifies some data issues that led to spatial errors within the DCDB which can easily be corrected. It also examines if our survey marking can contribute to cadastral inaccuracies. The question raised is: "Can we have too many survey marks?"

KEYWORDS: *DCDB, cadastral, marking, accuracy*.

1 INTRODUCTION

The Digital Cadastral Database (DCDB) was developed, in part, to replace the charting maps used as an index to find cadastral plans for survey and land titling purposes. The primary requirement for charting maps was the relative relationship of the land parcels, and, without further business drivers, spatial accuracy was assessed to this requirement.

At the time of the DCDB inception, a number of organisations were already capturing the cadastre for their area of interest, and in most cases this was captured into a Geographical Information System (GIS). In NSW, such organisations as the Metropolitan Water and Sewerage board and a number of local councils had a high percentage of plans captured. Following agreements, these formed the early basis for the DCDB at the cadastral level.

As the dataset grew in completeness and as the take-up of GIS increased within many organisations, the DCDB became a fundamental dataset for those organisations managing land in a wide variety of ways together with many infrastructure organisations such as utilities, transport, education and federal agencies. The increased availability of aerial photography led to the DCDB being overlaid over the photography – boundaries did not appear to coincide with fencing, and buildings appeared to be built over the boundaries.

Cadastral surveys were being connected to established Permanent Marks (PMs) and State Survey Marks (SSMs), providing significant improvement to the spatial accuracy of the DCDB, but also providing difficulties to others who had used the DCDB to capture

infrastructure. There have been many papers at previous APAS conferences, describing these issues and solutions available (e.g. Merritt and Keats, 1998; Merritt and Masters, 1999; Perry, 2001; Gardner et al., 2007).

These improvements in DCDB spatial accuracy are mostly focused around developing urban areas, taking advantage of the survey work that occurs as part of this development. In many respects, this is the area where improvements in the DCDB can also assist in the ongoing land development, if the timing of the updates fits in with the development activities.

How can we provide the same improvements in other areas? DFSI Spatial Services (then Land and Property Information) implemented a project utilising Real Time Kinematic (RTK) Global Navigation Satellite System (GNSS) technology for DCDB upgrades and checking (Haddon, 2003). This project certainly met the requirements in terms of upgrading the DCDB from a spatial accuracy, but may be considered not economically viable in areas of low-density land use.

Others that capture their own cadastral information or update a copy of the DCDB include local government authorities, large developers, public and private utility organisations, road and railway organisations at various levels and mining companies. These various organisations all have an interest in having an up-to-date cadastre, including spatial, subdivision and attribute information.

Local councils and authorities have an interest in updating the DCDB especially in areas of rapid land development where development proposals are based on more accurate survey control than the DCDB, with the subsequent subdivision plans also having good connections to established coordinates. The proposed cadastre is often used to locate new utility services, and the various authorities do not want to load GIS systems twice with different locations from different sources.

There are many other surveys that locate cadastral information for purposes other than preparing subdivision plans, easement plans and the like. There are also surveys locating infrastructure, which could be combined with other information to assist in the DCDB upgrade. Surveys required for engineering upgrades or construction often include sufficient cadastral information to ensure that engineering works do not cross existing boundaries. There have been many occasions where project managers relied on the DCDB only to find later that the boundary was not in the position indicated by the DCDB and subsequent cadastral surveys have led to engineering works just inside or sometimes outside the boundary.

Is there a way we can utilise the less complete cadastral information to improve the DCDB? Should we even try and improve the DCDB or leave it as it is until an appropriate cadastral survey is lodged for subdivision or the like? In the next section, some examples are given where surveyors have or have access to information that exists now, and at this stage this information is not normally used to improve this valuable dataset because we do not seem to be able to bring together all that is necessary to achieve these improvements.

2 EXAMPLES OF SURVEYS WHICH COULD IMPROVE THE CADASTRE

Most of the examples given in this section are from rail infrastructure and corridor areas due to the background of the author, although there could be similar examples in other areas. The

intention is to raise the opportunities and look for others to add to the list of available information and to develop ways to utilise this information for DCDB upgrade.

2.1 Wilton: Error in DP that Led to DCDB Error

In the Wilton area, there is a rail corridor, some of which has been defined and acquired for rail purposes, and the remainder covered in a government gazette but not yet visible in the DCDB. The rail corridor was partially constructed in the 1980s with the project put on hold with a change of government. Proposed boundaries were calculated with plans prepared in the areas where the land was privately held.

One such plan was deposited plan DP732649. This plan covers about 5 km of corridor and was prepared in 1985 and registered in 1986. It was utilised, together with others, in the capture of the DCDB in this mostly rural area.

Recent investigations of this corridor suggested to some that the earthworks built in the 1980s were not within the rail corridor. This conclusion was drawn by managers looking at GIS outputs including aerial photography and the DCDB. This conclusion did not 'feel' correct because it was known that the same surveyors oversaw the earthworks, established the control and prepared the cadastral plans, so a more detailed desktop examination was undertaken.

Figure 1 shows a plot of the area, with the DCDB in thin white lines, the corridor centreline in red, which coincides with the earthworks constructed in the 1980s. A search within the NSW railway plan room was undertaken, revealing a signed and registered copy of DP732649, the engineering designs and a set of field sheets. The engineering designs and the field sheets contained Integrated Survey Grid (ISG) coordinated information and the DP included links to the ISG control. The field sheets contain coordinates (in the ISG) of the proposed boundary (see Figures 2 & 3). These are plotted in light blue in Figure 1. There is a difference of up to 65 m in the position of the boundaries from the two sources.

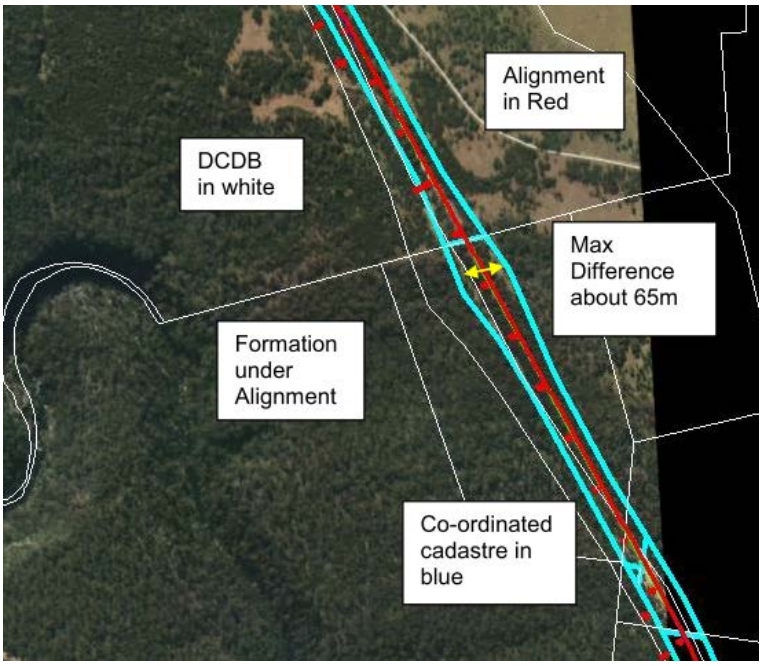
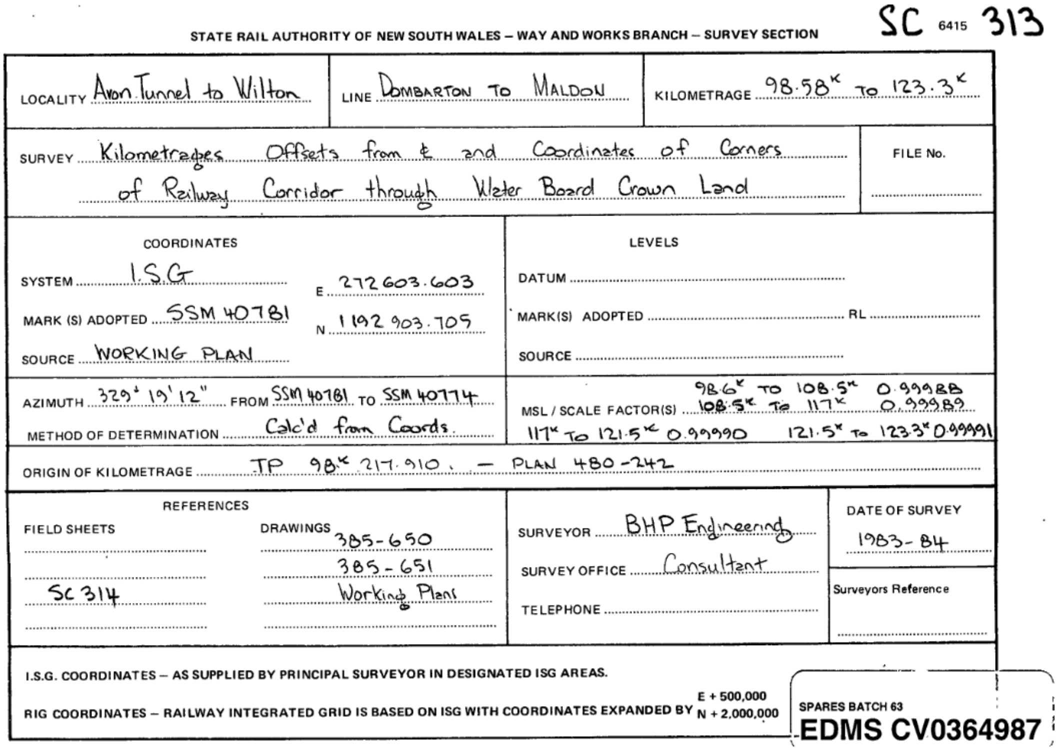


Figure 1: Wilton overlay.


SC 6415 313

STATE RAIL AUTHORITY OF NEW SOUTH WALES – WAY AND WORKS BRANCH – SURVEY SECTION

LOCALITY Avon Tunnel to Wilton | LINE Dombarton to Maldon | KILOMETRAGE 98.58k to 123.3k

SURVEY Kilometrages Offsets from ℄ and Coordinates of Corners of Railway Corridor through Water Board Crown Land | FILE No.

COORDINATES
SYSTEM I.S.G | E 272 603.603
MARK (S) ADOPTED SSM 40781 | N 1 192 903.705
SOURCE WORKING PLAN

LEVELS
DATUM
MARK(S) ADOPTED | RL
SOURCE

AZIMUTH 329° 19' 12" FROM SSM 40781 TO SSM 40774
METHOD OF DETERMINATION Calc'd from Coords
MSL / SCALE FACTOR(S) 98.6k to 108.5k 0.99988, 108.5k to 117k 0.99989, 117k to 121.5k 0.99990, 121.5k to 123.3k 0.99991

ORIGIN OF KILOMETRAGE TP 98k 217.910 — PLAN 480-242

REFERENCES
FIELD SHEETS: SC 314
DRAWINGS: 385-650, 385-651, Working Plans
SURVEYOR BHP Engineering
SURVEY OFFICE Consultant
TELEPHONE
DATE OF SURVEY 1983-84
Surveyors Reference

I.S.G. COORDINATES – AS SUPPLIED BY PRINCIPAL SURVEYOR IN DESIGNATED ISG AREAS.
RIG COORDINATES – RAILWAY INTEGRATED GRID IS BASED ON ISG WITH COORDINATES EXPANDED BY E + 500,000 N + 2,000,000
SPARES BATCH 63
EDMS CV0364987

Figure 2: Title page for field sheets.

KILOMETRAGE	OFFSET	EASTING	NORTHING
121625.053	20.000	270308.105	1205634.029
121678.217	-25.000	270283.438	1205699.277
121678.217	20.000	270325.352	1205682.900
121731.380	-25.000	270305.072	1205749.641
121731.380	20.000	270345.806	1205730.517
121784.544	-25.000	270330.003	1205798.459
121784.544	20.000	270369.377	1205776.672
121837.708	-25.000	270358.120	1205845.513
121837.708	20.000	270395.961	1205821.160
121890.872	-25.000	270389.301	1205890.597
121890.872	20.000	270425.441	1205863.784
121944.060	-25.000	270423.422	1205933.529

Figure 3: Sample of field sheet data.

The boundary plan contained a number of references to survey control marks that were documented on the engineering designs, but these are not included on public record in the Survey Control Information Management System (SCIMS) as they were internal railway control marks. As an example, Figure 4 shows part of the plan in the subject area.

The investigation continued on two fronts, the first transcribing the field sheet information and plotting this over the aerial photography and the second to study and coordinate the DP to plot this over the aerial photography. During the second process, calculations revealed a drafting error in lot 8, where a dimension from the western boundary was put against the eastern boundary, also shown in Figure 4.

As the surveyor has since retired and could not be contacted, the Registrar General added a note to the plan, giving the calculated value. This was sent to the DCDB staff and the DCDB has been updated accordingly (Figure 5).

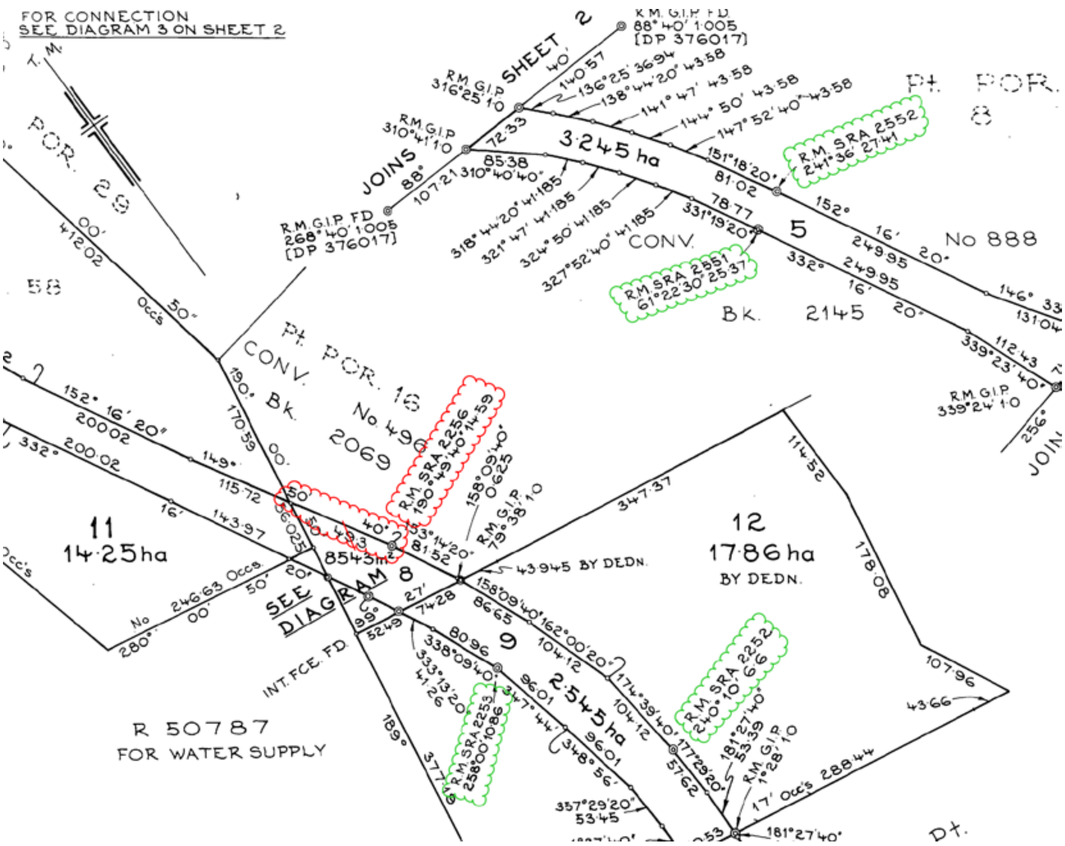


Figure 4: Part of DP732649.

Figure 5: Updated DCDB.

From this example, the following was learnt:

- Contact the Land Titles Office and report the DP error. They will endeavour to have the surveyor rectify the plan and if that is not possible, at least place a departmental note warning others of the possible error and sometimes indicate the correct information.
- Notify the DCDB update unit of the issue. This will save time when the area is readjusted.

2.2 Cobar to Elura and Parkes: SCIMS Information Showing Differences

The rail line from Cobar to Elura Mine was constructed in 1982. As part of the design and construction program, SSMs were placed along the corridor and coordinated. This control then formed the basis of subsequent aerial mapping and construction set-out.

The SSMs were placed near the corridor boundary with the offset from the rail line noted in the sketch, and the records were sent to DFSI Spatial Services to be loaded into SCIMS. Current aerial mapping has either used this control or agrees closely with the values. It is not clear how this information can be utilised, but, to the layman, the SCIMS information agrees with the aerial mapping and the DCDB must be in error. It should be noted that this information is now readily available via the SIX portal and the nswglobe.kml to any interested parties.

Figure 6 shows an extract from NSW Globe in Google Earth with the imagery, DCDB and Survey Marks layers turned on. The rail alignment was supplied to the Railways in ISG and is shown in red and is almost directly over the rail line. The cleared areas to the west are an access road and a powerline easement.

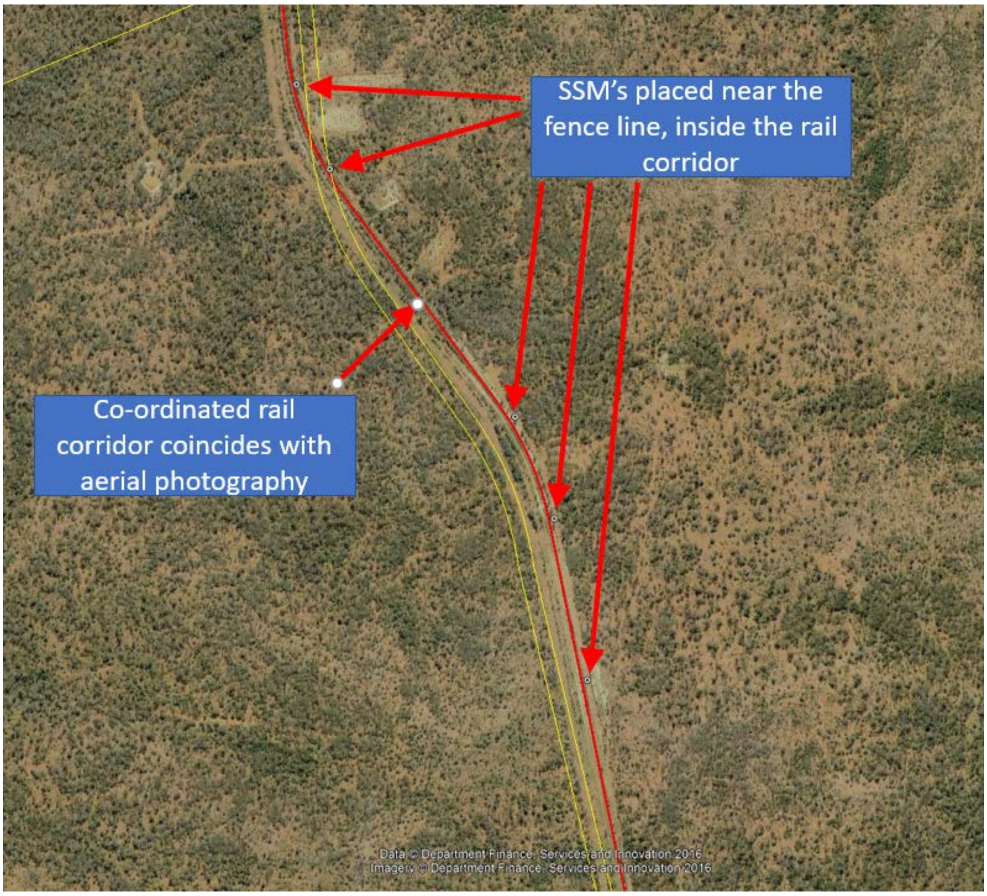
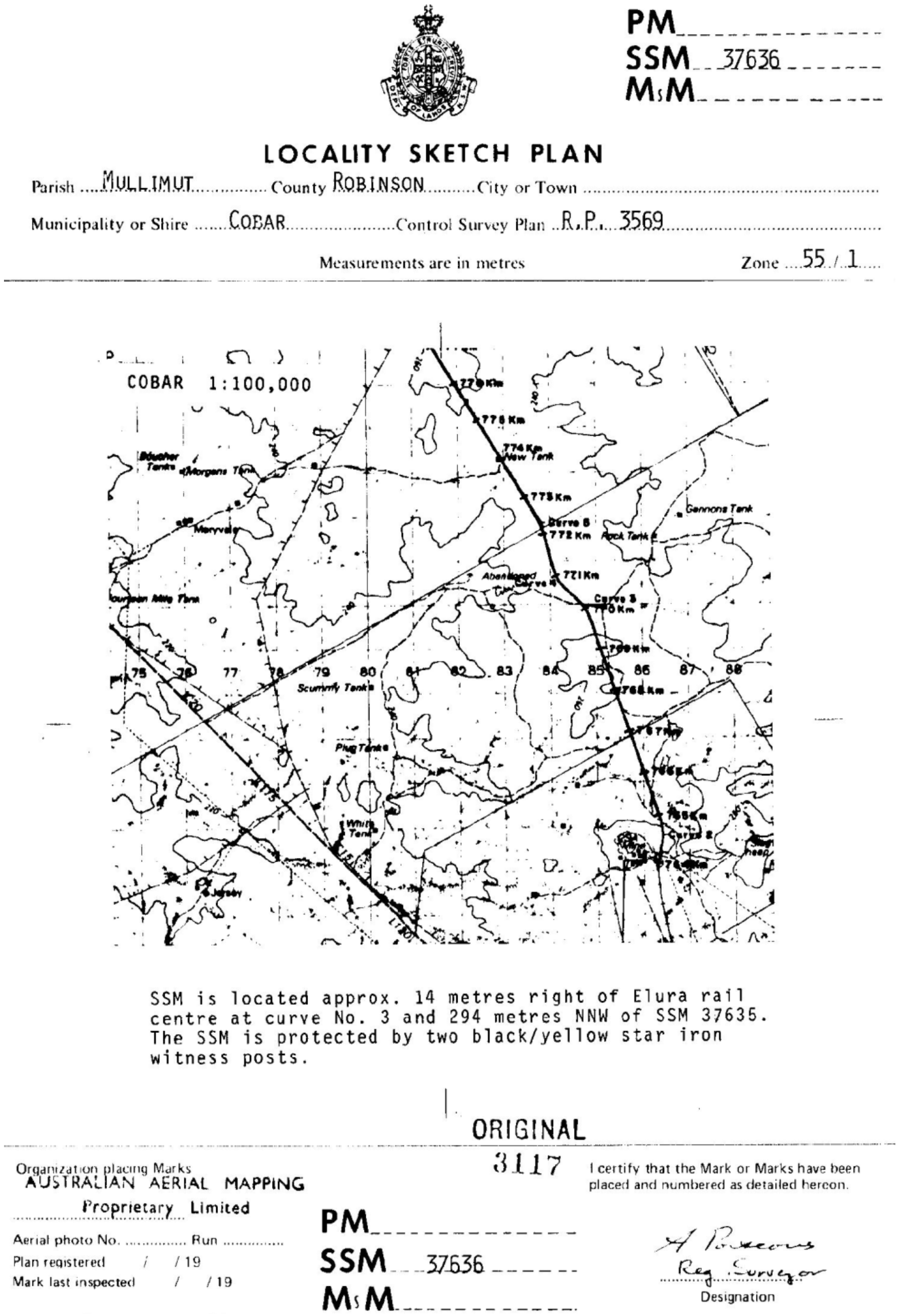


Figure 6: Cobar to Elura Mine overlay.

Further evidence of the SSM location relative to the rail line is shown in the sketch plans for each mark (Figure 7). Unfortunately the sketches are a photocopy of mapping with the rail line added. However, there is a note at the bottom of the sketch indicating the relative position of the SSM to the rail line. This again suggests that the aerial photography is being plotted in the correct position, so the question of accuracy of the DCDB is again raised.


PM
SSM 37636
MsM

LOCALITY SKETCH PLAN

Parish MULLIMUT County ROBINSON City or Town
Municipality or Shire COBAR Control Survey Plan R.P. 3569
Measurements are in metres Zone 55/1

COBAR 1:100,000

SSM is located approx. 14 metres right of Elura rail centre at curve No. 3 and 294 metres NNW of SSM 37635. The SSM is protected by two black/yellow star iron witness posts.

ORIGINAL
3117

Organization placing Marks AUSTRALIAN AERIAL MAPPING Proprietary Limited
Aerial photo No. .... Run ....
Plan registered / /19
Mark last inspected / /19

PM
SSM 37636
MsM

I certify that the Mark or Marks have been placed and numbered as detailed hereon.
Reg. Surveyor
Designation

Figure 7: Locality sketch for SS37636.

2.3 Parkes

A similar situation can be seen north-west of Parkes. The sketch plan of PM82742 shows the position of the PM with respect to a fence line and a nearby fence corner (Figure 8). Additional information indicates the length of the fence line (or possibly the boundary), the position of an unformed road and the railway line. Diagrammatically a dam is also plotted. This information should meet its objective to aid others in finding the mark. Can this information also aid in the positioning of the DCDB?

Figure 8: Locality sketch for PM82742.

The current DCDB from NSW Globe (Figure 9) shows the PM to be located east of this fence corner in a possible but unlikely spot. This is due to the mark being in an adjustment and having reasonable coordinates (class B). In this area, the unformed road as shown in the DCDB appears to be a lot wider than the 20.115 m stated in the sketch. If these were adjusted the rail line in the photo would appear to be approximately in the centre of the corridor.

Figure 9: Parkes overlay.

The Australian Rail Track Corporation (ARTC) is currently undertaking rail upgrade works in this area (Oberg, 2018). It would be reasonable to assume that some sort of confirmation of the boundaries would have been undertaken, even if it is only a desktop exercise to coordinate the rail boundaries in this area to ensure works stayed within the rail corridor. If this is the case, this information could be a great aid in updating the DCDB.

2.4 Bogan Gate: Combining Mapping, SCIMS and Aerial Photography

In 1994, Freight Rail conducted a large mapping survey of rail assets across NSW (Latella, 1995). As part of this project, check points were required, and at each of these locations a pair of survey marks were utilised, and often placed. At Bogan Gate, two PMs were coordinated, with the check point on the track established. These PMs have good coordinates, and the connection to the track agrees with the aerial photography, but the DCDB appears to be too far south by 15 m or more (Figure 10).

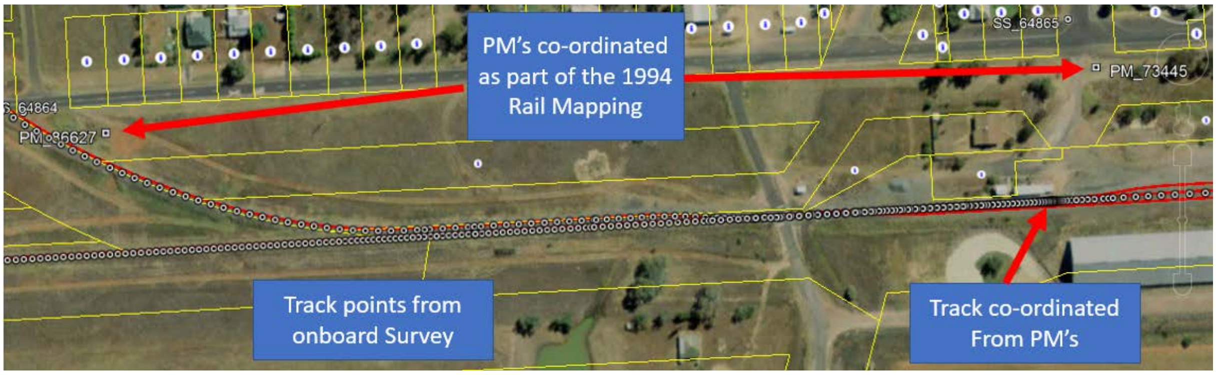


Figure 10: Bogan Gate overlay.

Again, independent data confirms the aerial photography. Can this then be utilised to improve the DCDB? To the average user of Google Earth and the NSW Globe dataset, the answer is yes and perhaps why has it not been done.

2.5 Helensburgh: Partial Boundary Survey in the Railway Plan Room

At Helensburgh, a survey was undertaken to mark the boundary of the rail corridor. This survey was documented in a set of field sheets registered in the railway plan room, which included the ISG coordinates of the corners. When an overlay is prepared with aerial imagery, the difference between the DCDB and this coordinated boundary is obvious. Figure 11 illustrates this difference, showing the DCDB in yellow, the existing track centrelines in red and the railway boundary definition in white.

Figure 11: Helensburgh to Helensburgh tunnel overlay.

Can this information be used to help improve the spatial accuracy of the DCDB? This information is easily available to the public, but it is registered in a government owned plan room.

3 TOPOGRAPHIC SURVEYS WITH BOUNDARY DEFINITION

In many engineering projects, surveys are acquired in the early stages to aid in the design. If the proposed works are to be near the cadastral boundary, a boundary definition is sometimes included so that design decisions can be made to either stay within the boundary or negotiate with the adjoining landholder.

These surveys are never seen by those who work diligently in upgrading the DCDB unless the works involve a subdivision and title transfer. The challenge is to those conducting the surveys, those having the surveys done and those managing the DCDB to consider if and how this untapped survey information can be utilised to the benefit of the wider community in order to improve the spatial accuracy of the DCDB.

The public survey system only holds information for some of the surveys undertaken, including cadastral boundaries where the plans are registered and survey control where some additional information (e.g. observations) are sometimes submitted to support the assigning of coordinates to control marks. There could be a case to have more of the underlining survey information registered and made available to other surveyors. This brings about issues around liability to third parties, but this can be managed with appropriate processes to the advantage of all involved. The survey information that is relevant to the DCDB could then be extracted and added to the inputs used to improve the DCDB.

4 CAN WE HAVE TOO MANY SURVEY MARKS?

The final area where surveys could help the DCDB is SCIMS. The intersection shown in Figure 12 includes a total of 10 marks in SCIMS, although some are replacements for others in approximately the same location. These are in a small area and fairly close to one another. Provided that these marks are in good condition, all should be fine to use. The more marks, the better? Probably not, although in this particular location many of the marks have been destroyed, and the PMs are used by Sydney City Council to aid in the fixing of the street boundaries.

The example in Figure 12 brings about the issue of safety for surveyors as many of these marks are in the carriageway of two busy city streets. This in itself may cause even more marks to be placed in the footpath, so that surveyors do not need to close off a portion of the carriageway.

In this case, each survey mark is uniquely identified by its number and therefore there is little opportunity for errors to creep into the DCDB. There are locations where survey marks that are not uniquely identified have the possibility of causing errors in cadastral surveys, which then propagate into the DCDB. This example is only small but does show how problems may arise.

Figure 12: Intersection in Sydney (Bridge and Pitt Streets).

Let us examine three plans of the same corner. In the first plan (Figure 13), the surveyor found a RM GI pipe at corner Z in 1957 – this is on the line of the side boundary.

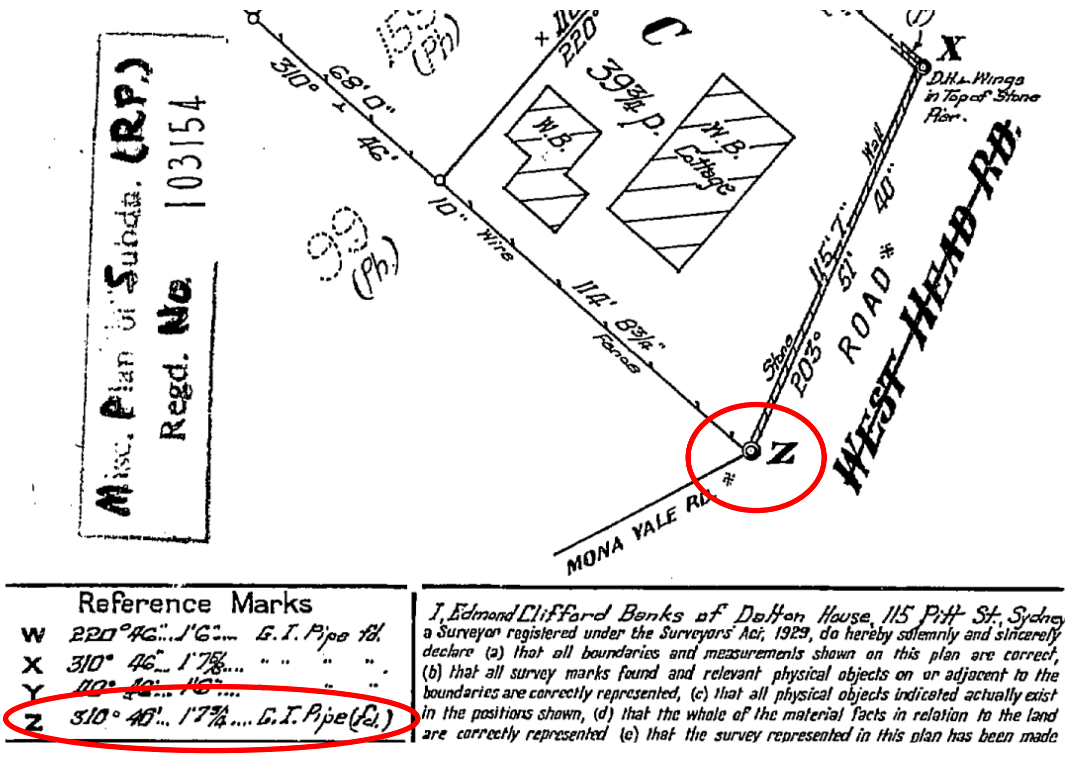


Figure 13: Part of FP403154, i.e. now DP403154 (1957).

A few years later, the road widening plan shown in Figure 14 found two RM GI pipes for the same corner – neither of these is on the line of the side boundary. The first is square to the old alignment, and the second is about 3.5° off the side boundary line and half an inch less.

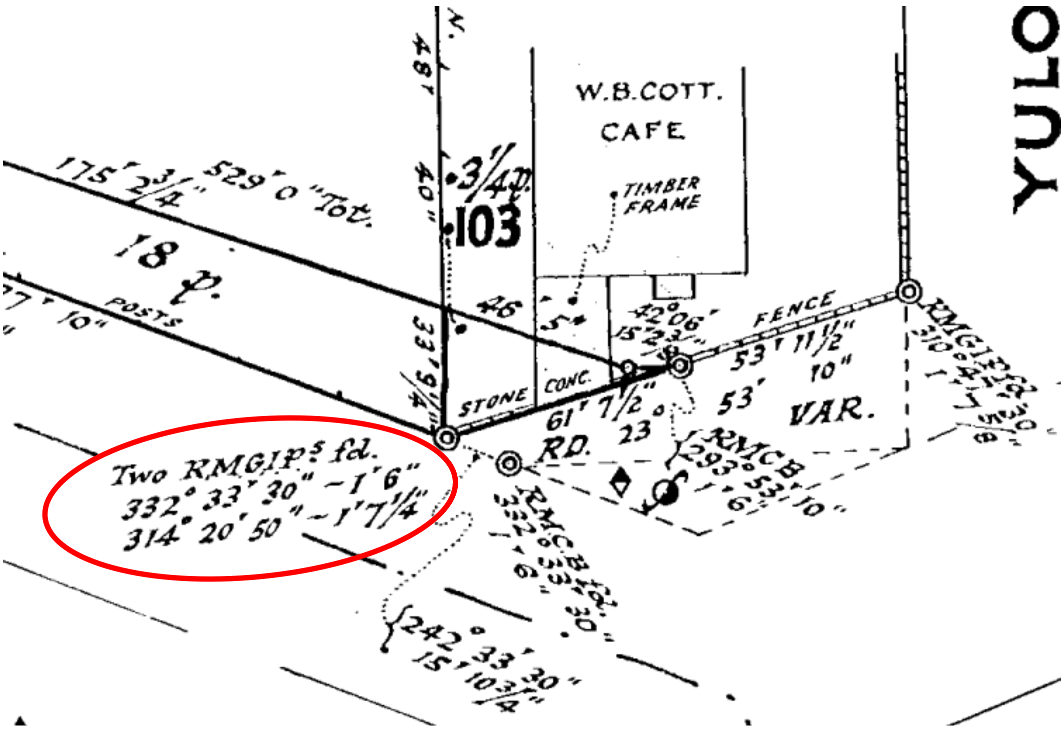


Figure 14: Part of road widening DP218268 (1963).

More recently, a community title plan found the first one of these RM GI pipes and shows a small excess (Figure 15). It must have taken some effort to confirm which GI pipe was found, and presumably the other GI pipe is either not there anymore or at least was not found.

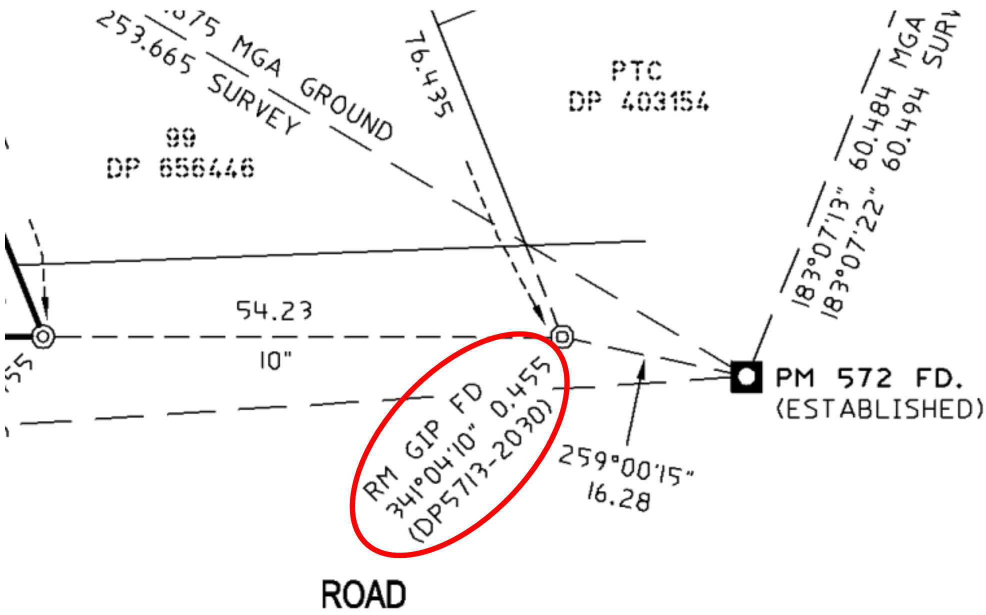


Figure 15: Part of DP270547 (2007).

It can be suggested that this is a case of too many survey marks. As these marks are not separately identifiable, and therefore the surveyor has to do more survey work to confirm

which mark is found. The same could be said for witness marks, i.e. those witness marks that are not separately identifiable could be confused for some other mark.

5 CONCLUDING REMARKS

The DCDB has become a popular tool to aid all sorts of people in all sorts of activities. Since the release of NSW Globe and the WRMS services, many people have access to the various spatial datasets available from DFSI Spatial Services. These various datasets do not always overlay correctly, and as the use of these datasets increases, the need to update the data grows.

Many of the examples outlined in this paper utilise aerial photography as a tool. In all cases where this occurs, there needs to be sufficient information to check the aerial photography geo-referencing. This checking can often be performed utilising various information available within the datasets, and sometimes information available from other datasets. Once the checking has been completed, the inferred positions of the DCDB can be extracted and compared to other information used to define the DCDB. Those updating the DCDB cannot take this or any other information on face value but once collaborated, this could be used to strengthen the overall DCDB in the area.

In addition to this check, the aerial photography can only assist in the location of fencing and other infrastructure, which in some cases may be deliberately not placed on the boundary. Furthermore, in more remote areas, the variation between fencing and boundaries may be much larger than what we see in more developed areas. In urban housing areas people might worry about 0.1 m, while in rural areas new fences are sometimes built beside (perhaps 1 m or more) the previous one to aid in the construction without letting stock escape from a paddock.

In a similar manner, PM and SSM sketches can be used to identify the relative positioning of the survey marks and fencing. However, in cases where the mark is not established, the spatial position is often determined from the DCDB and therefore cannot be utilised as evidence of the spatial position of the DCDB.

This paper has presented some ideas from one perspective. The challenge to the survey profession can be summarised as how can existing information and changes in the way surveys are completed and reported be utilised better to help the general community in their consumption of spatial data.

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