Improving Cadastral Infrastructure with RTK GPS in Australia

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Outline

- Cadastral surveying
- RTK GPS
- GAP project & study area
- Data processing
- Accuracy analysis
- Upgrade of survey control with GPS RTK
- Conclusions

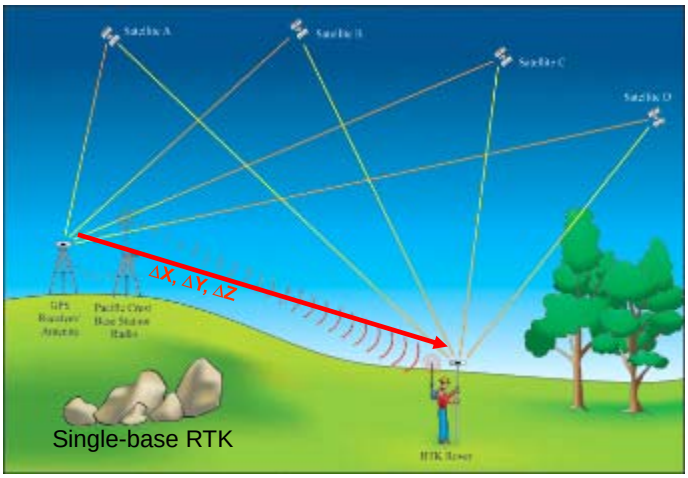
Cadastral Surveying

- Gathering evidence (position info) to define location of objects or land boundaries for purposes of identifying ownership and/or value of land parcels.
- NSW: Survey Control Info Management System (SCIMS).

	Point class	Typical applications
Established	3A	Special high precision surveys
	2A	High precision national geodetic surveys
	A	National and state geodetic surveys
	B	State survey control networks
	C	Survey coordination projects
	D	Approximate and lower order surveys
	E	Approximate and lower order surveys
	U	Unknown or unreliable

Horizontal survey control mark classes in AUS

Real Time Kinematic (RTK) GPS



Single-base RTK

Benefits of RTK GPS

- Usefulness in finding existing survey marks.
- Ability to connect to existing survey control over distances considered unfeasible using traversing techniques.
- Ability to easily survey irregular natural boundaries.
- Recently LPMA revised regulations to permit RTK GPS for cadastral surveys.

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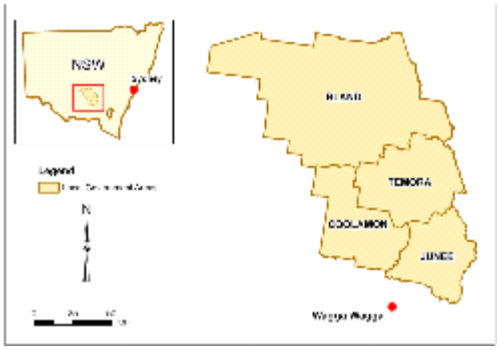
Geospatial Alliance Project (GAP)

- Consortium of 4 shire councils & 1 water council in NSW.
- Aim: provide best practice spatial information & management services, e.g. data capture, management & maintenance, GIS capabilities, technical support.



- Need for upgrade of survey control marks identified (many class U).
- Multi-year survey (2008-11) to observe all existing marks.

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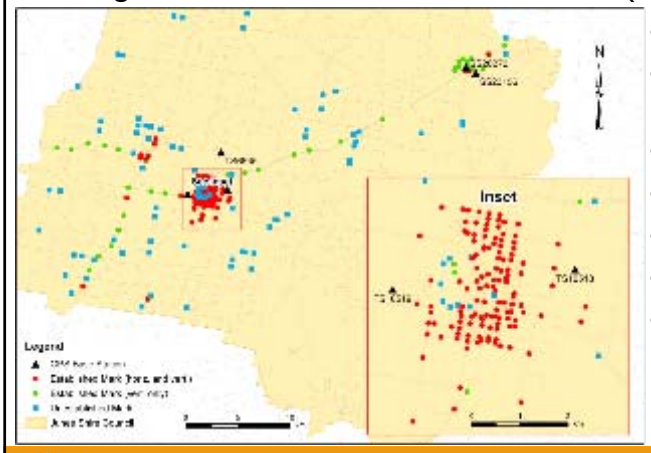
Study Area & Observations

- Junee Shire Council (2,030 km^2).
- Single-base RTK GPS observations (Jan-Aug 2008).



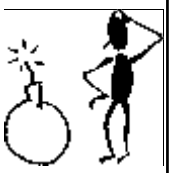
- 269 marks occ'd.
- 141 established in hz & vt.
- 43 established in vt.
- 5 RTK ref stns.
- 0.2-20km baselines.
- Multiple obs (3min).
- High redundancy (up to 6 baselines connected to each point).

Data Processing

- Adjustments based on baseline vectors, not RTK coords.
- Minimally constrained: 269 stns & 776 baselines
  → 23 baselines removed (3% of obs), 13 outliers flagged.
- Fully constrained: 184 marks constrained in height (C3 or better) & 146 marks fixed in the horizontal (B2 or better)

Point class/order	No. of fixed stations
2A0	9
A1	61
B2	76

Point class/order	Uncertainty
LAL1, LBL4, LCL3	1 mm
B2	10 mm
B3	30 mm
C3	30 mm



Data Processing

- Final GPS baseline weighting:

	STD	ppm	Centring from	Centring to
Horiz. component	10 mm	1	3 mm	5 mm
Vert. component	30 mm	3	3 mm	3 mm

- Additional info from DPs to supplement adjustment:
  - Upgrade to class C requires 3 baselines from 2 ref stns → add DP info to 2 GPS occupations
  - Observed directions & distances reduced to ellipsoid
  - 88 observations from 31 DPs, connecting 66 points

- DP ground obs weighting:

	STD	ppm	Centring from	Centring to
Direction	8”	–	2.5 mm	2.5 mm
Distance	10 mm	20	2.5 mm	2.5 mm

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Adjustment Results

- Identified problem at one of the ref stns (TS10518) → removed obs on 5-6 March (39 obs or 5% of survey).
- Removed 1 ground obs from DP (large residuals) → later identified as erroneous obs in DP.
- Final adjustment contained 714 GPS baselines.
- Five residuals flagged for diff to constrained ortho height → possible incorrect AHD71 heights in SCIMS.
- Initial 13 outliers passed but GPS obs to each mark disagree → later considered when assigning order.
- Overall GPS residuals small (<50mm in X,Y,Z).
- DP resids 10” & 10mm

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Absolute Accuracy: RTK vs. SCIMS

- Constrained adjustment, holding only 5 GPS ref stns fixed in hz & constrained in vt (no DP info used).
- Comparison RTK GPS vs. SCIMS on established marks:

	Easting	Northing	Horizontal	Vertical
RMS	7 mm	8 mm	11 mm	34 mm
Min.	-18 mm	-25 mm	0 mm	-65 mm
Max.	29 mm	36 mm	36 mm	137 mm

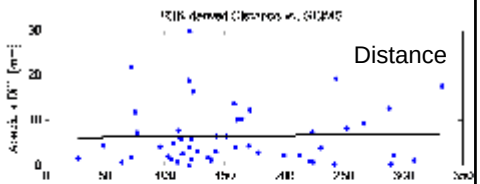
- RTK GPS well suited to improve survey control infrastructure for cadastral surveyors.
- Height diff >100mm in 7 cases (GPS obs agree well) → possible incorrect AHD71 heights in SCIMS (e.g. local distortions, weak levelling).

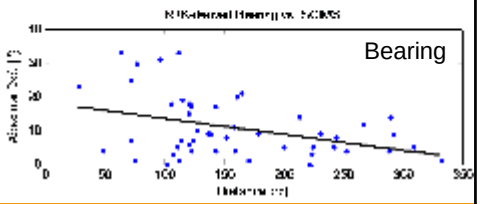
Relative Accuracy: RTK vs. SCIMS

- Compare bearing & grid distance betw. 50 established marks based on unadjusted RTK coords & SCIMS.
- Short distances (cadastral surveying): 30-330 m.

	Grid Distance	Bearing
RMS	9 mm	14"
Min.	-30 mm	-33"
Max.	14 mm	33"

- Required distance accuracy: 10mm+15ppm (1σ) → 11mm (50m) & 14.5mm (300m).
- Bearing errors → position errors:
  - 15" (100m) → 7.3mm
  - 10" (200m) → 9.7mm
  - 5" (300m) → 7.3mm





Upgrade of Survey Control

- Required: 3+ baselines observed from 2+ ref stns.
- All 128 unestablished marks either established to class C (55%) or at least updated to class D or E (45%).
  - 50 marks to class C (33 hz&vt, 17 hz) → RTK GPS
  - 21 marks to class C (13 hz&vt, 8 hz) → RTK GPS & DP info
  - 46 marks to class D (hz&vt) → only twice with GPS (no DP)
  - 5 marks to class E (hz&vt) → only once with GPS
  - 6 marks to class E (hz&vt) → discrepancies in GPS obs



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Conclusions

- RTK GPS achieved significant improvement of cadastral survey infrastructure.
  (55% unestablished → established).
- Improvements in GPS survey design → higher %age.
- RTK GPS brg & dist agree very well with SCIMS.
- CORSnet-NSW will improve infrastructure further.

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Questions…?

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FIG Congress 2010
Sydney, Australia
11-16 April 2010