"Wide-area, sub-decimetre positioning for airborne LiDAR surveys using CORSnet-NSW"

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CORSnet NEW SOUTH WALES

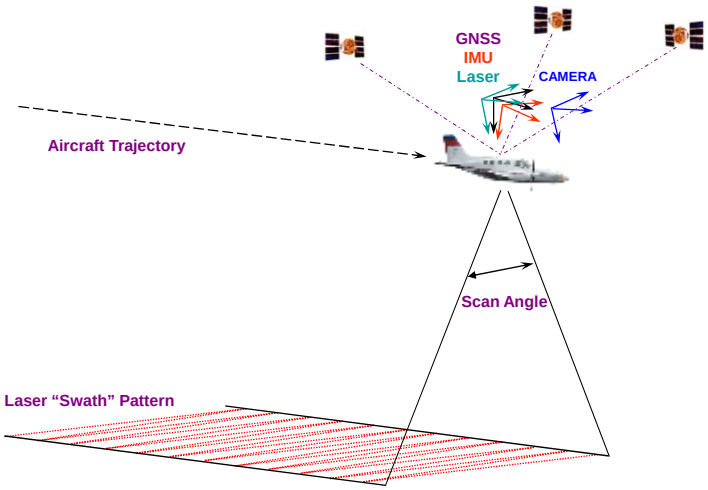
UNSW

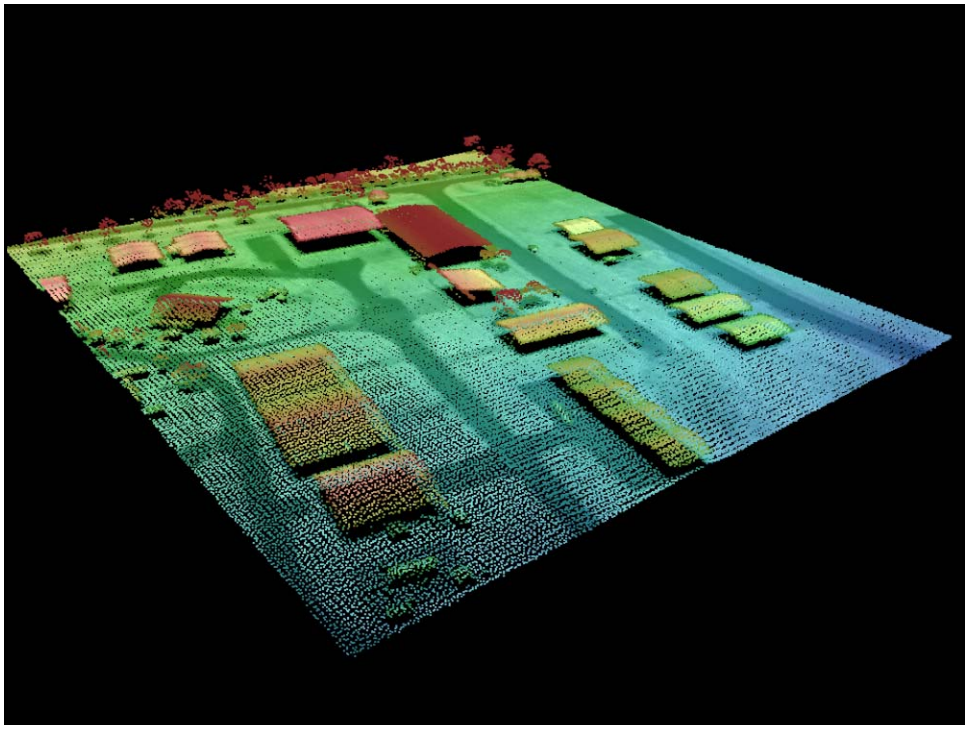
Wide-area kinematic GNSS

- This unique collaborative research project aims to demonstrate the potential for wide-area GNSS techniques to achieve accuracies comparable with those using local reference sites...
  – including analysis of the LiDAR ground data.

- The intent is to introduce both economic and logistical efficiencies by negating the need for local reference sites. The increased level of flexibility for flight operations is a bonus.

Airborne LiDAR



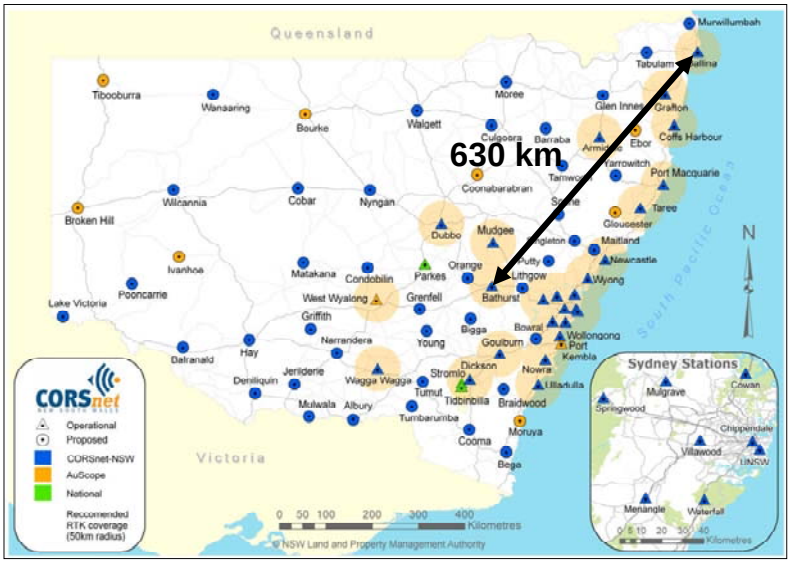


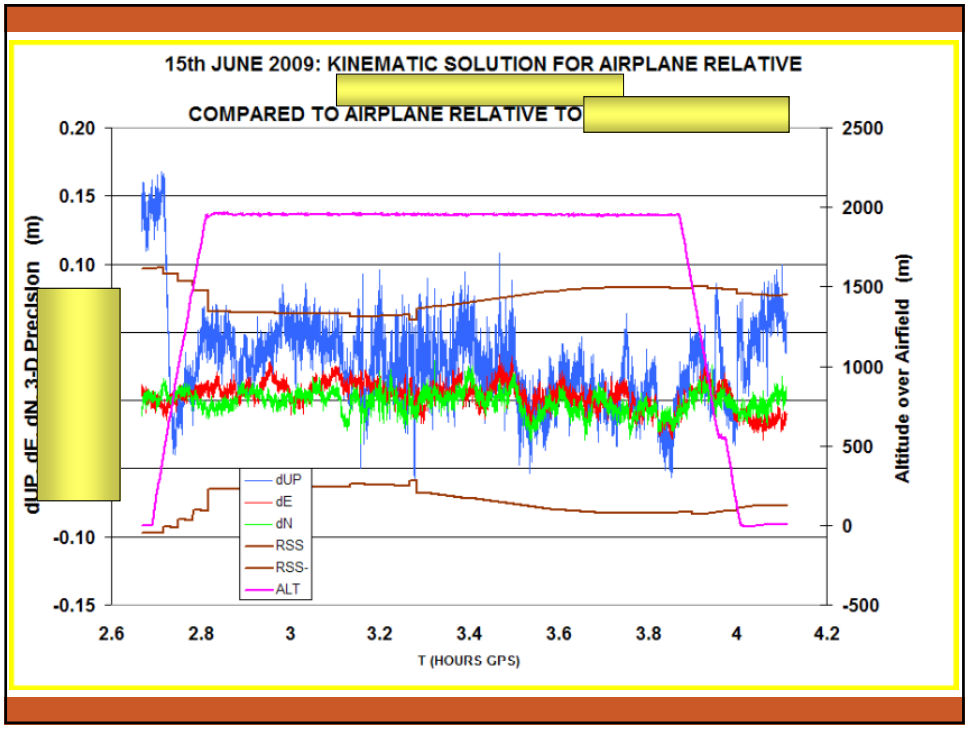
An accurate trajectory

- LiDAR accuracy requirement: **±30cm** (at 95%)
- Requires sub-decimetre aircraft trajectory using kinematic GPS post-processing
- Currently achieved using temporary GNSS reference sites established within the project extent:

  A costly and at times logistically difficult exercise with no flexibility for aircraft operations!

CORSnet NSW





Wide-area kinematic positioning

Software:

- Oscar Colombo's precise navigation and surveying software **"IT"** ("**I**nterferometric **T**ranslocation")
- **Refined** through its use in a variety of projects requiring precise navigation and, or static positioning
- **Follows** the IERS 2003 Conventions
- **Available**, mainly for collaborative research purposes, with a Free Software Foundation General Public License.

Wide-area kinematic positioning

Type of Solutions:

- **Recursive, Post-process** (Kalman filter + smoothing)
- **Kinematic** for aircraft and **Static** for CORSnet sites and local field stations.
- **Stop-and-Go** for rapid mobile surveys with pre-surveyed waypoints.
- **Differential, Precise Point Positioning, Mixed Mode** (Precise differential + Point positioning)

Data Corrected for:

- Earth-tide, neutral atmosphere radio signal delays, carrier phase windup, etc.

Processing Technique

Estimated Parameters:

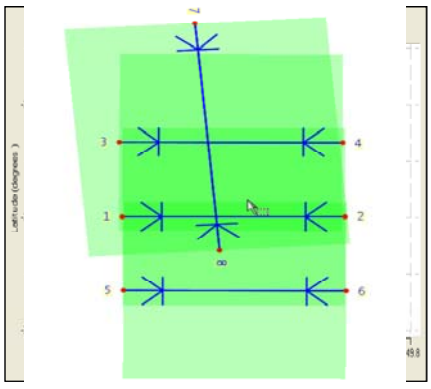
- **Receiver position** in the IGS05 reference frame, with the WGS84 reference ellipsoid, Earth spin-rate, light speed, GM constant.
- **Biases** in ionosphere-free carrier phase linear combination ("floated" ambiguities)
- **Neutral zenith delay** correction error.
- Broadcast orbit errors (in differential network solutions)

Integer Ambiguity Resolution:

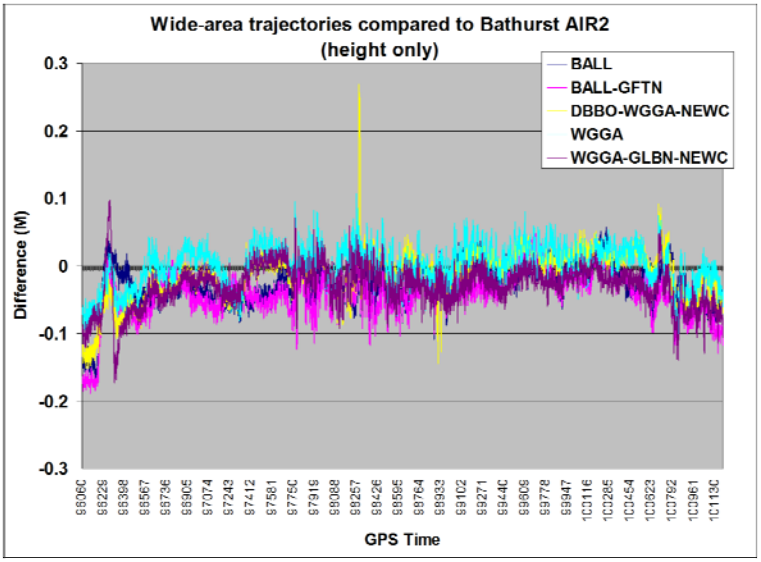
- **Short baselines** up to 20 km (minutes)
- **Baselines of unlimited length** (tens of minutes - or minutes with precise ionosphere correction)

Project areas

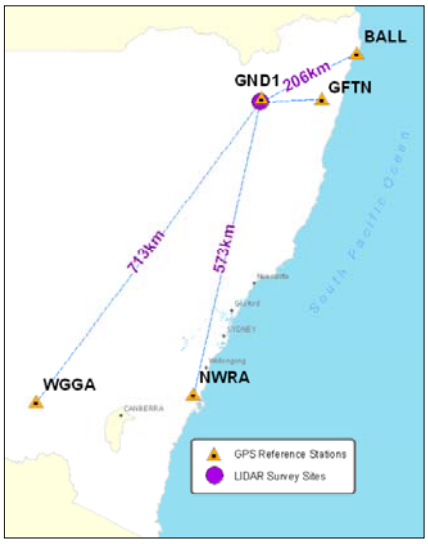
Survey 1: Bathurst



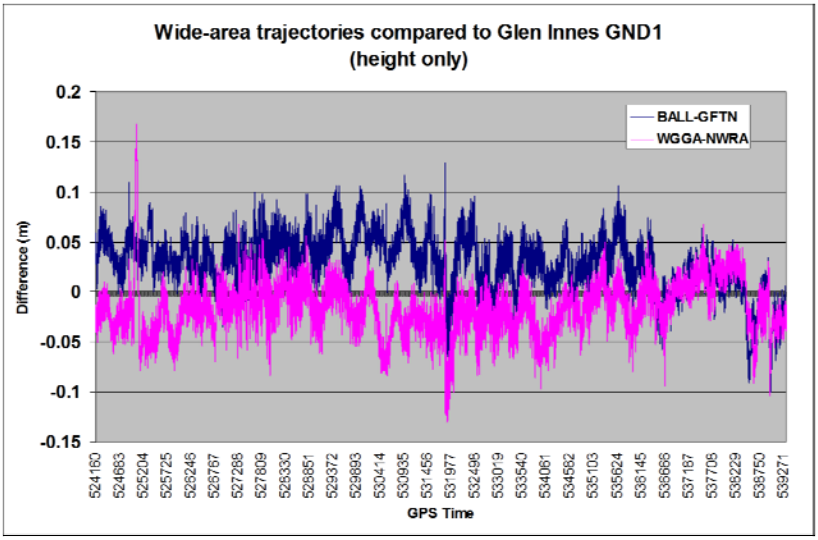
Results: Trajectory comparison



Survey 2: Glen Innes

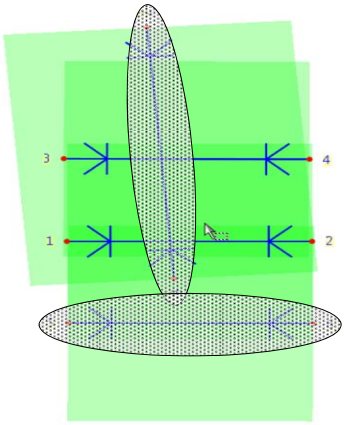


Results: Trajectory comparison



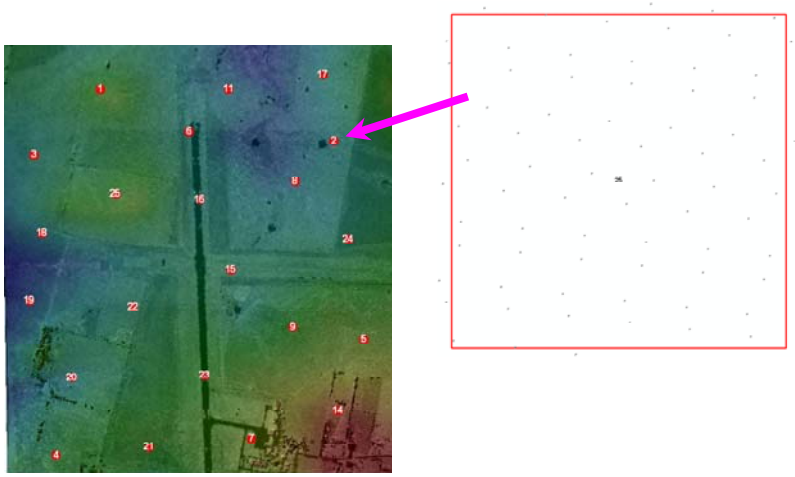
Test: Relative LiDAR

- Individual ground points - different trajectories
- 3 flight runs tested

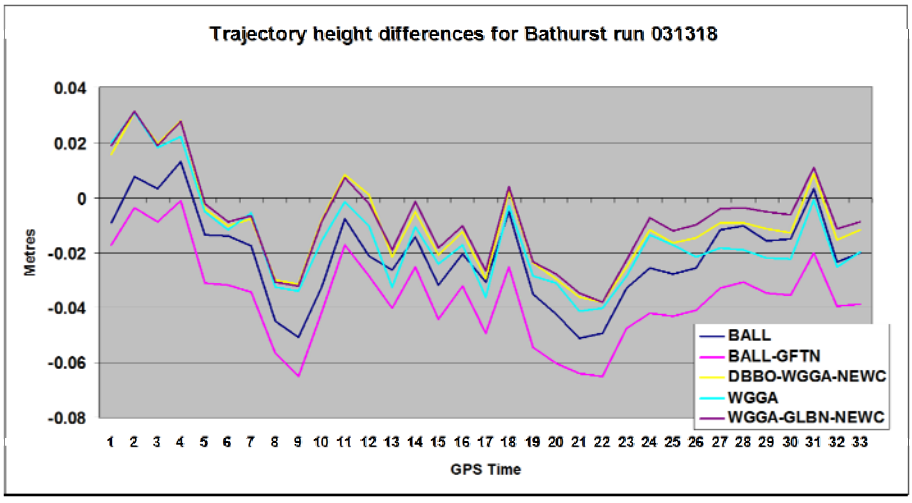


Test: Relative LiDAR

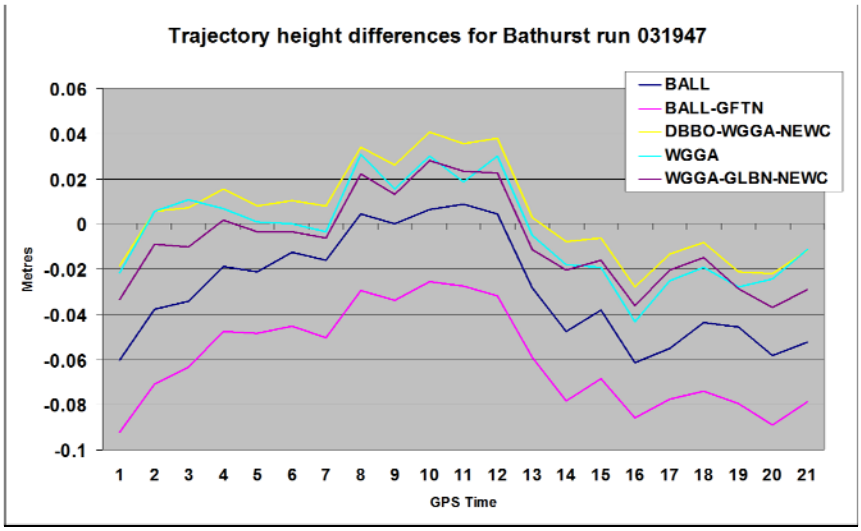
- Individual ground points - different trajectories



Trajectory comparison



Trajectory comparison



Relative LiDAR Comparisons Bathurst

031318

DBBO WGGA NEWC	dX	dY	dZ	Vector
Min	-0.035	-0.031	-0.020	0.029
Max	-0.026	-0.002	0.017	0.047
Mean	-0.031	-0.016	-0.008	0.038

WGGA GLBN NEWC	dX	dY	dZ	Vector
Min	-0.006	-0.029	-0.020	0.006
Max	0.004	0.003	0.017	0.032
Mean	-0.002	-0.015	-0.009	0.020

BALL GFTN	dX	dY	dZ	Vector
Min	-0.009	-0.036	-0.048	0.027
Max	0.002	0.007	-0.014	0.054
Mean	-0.004	-0.015	-0.037	0.042

031947

DBBO WGGA NEWC	dX	dY	dZ	Vector
Min	-0.074	-0.007	-0.010	0.006
Max	0.013	0.002	0.023	0.075
Mean	-0.030	-0.002	0.009	0.039

WGGA GLBN NEWC	dX	dY	dZ	Vector
Min	-0.024	-0.003	-0.025	0.003
Max	0.013	0.005	0.007	0.033
Mean	-0.001	0.001	-0.006	0.013

BALL GFTN	dX	dY	dZ	Vector
Min	-0.018	-0.014	-0.080	0.045
Max	0.011	-0.001	-0.040	0.081
Mean	-0.008	-0.008	-0.057	0.059

Relative LiDAR Comparisons Bathurst

031318

DBBO WGGA NEWC	dX	dY	dZ	Vector
Min	-0.0	31	020	0.029
Max	-0.0	002	0.017	0.047
Mean	-0.031	-0.016	-0.008	0.038

200 km

WGGA GLBN NEWC	dX	dY	dZ	Vector
Min	-0.00	29	020	0.006
Max	0.0	0.003	0.017	0.032
Mean	-0.002	-0.015	-0.009	0.020

200 km

BALL GFTN	dX	dY	dZ	Vector
Min	-0.0	36	048	0.027
Max	0.0	0.007	-0.014	0.054
Mean	-0.004	-0.015	-0.037	0.042

600 km

031947

DBBO WGGA NEWC	dX	dY	dZ	Vector
Min	-0.0	0.0	010	0.006
Max	0.0	0.002	0.023	0.075
Mean	-0.030	-0.002	0.009	0.039

200 km

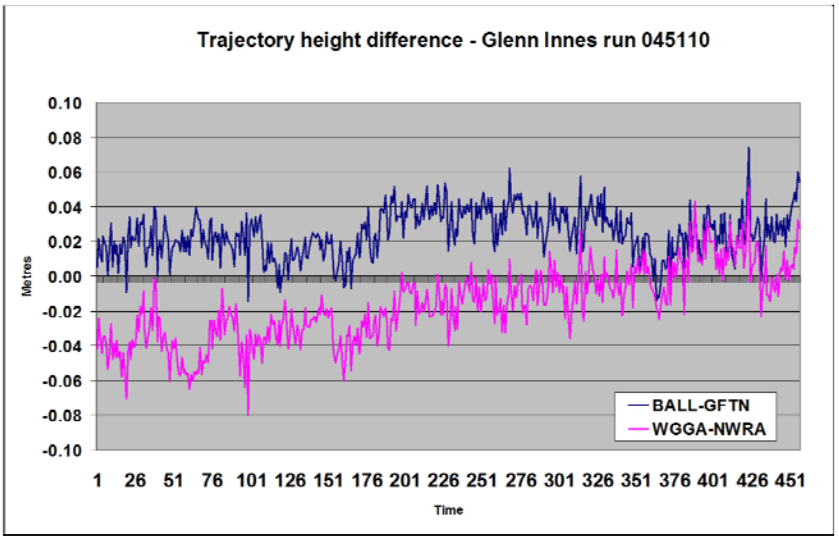
WGGA GLBN NEWC	dX	dY	dZ	Vector
Min	-0.0	0.0	-0.025	0.003
Max	0.0	0.005	0.007	0.033
Mean	-0.001	0.001	-0.006	0.013

200 km

BALL GFTN	dX	dY	dZ	Vector
Min	-0.018	0.0	0.0	0.045
Max	0.0	0.001	-0.040	0.081
Mean	-0.008	-0.008	-0.057	0.059

600 km

Trajectory comparison



Relative LiDAR Comparisons Glen Innes

BALL/GFTN	dX	dY	dZ	Vector
Min	-0.008	-0.027	0.004	0.015
Max	0.029	0.018	0.045	0.047
Mean	0.011	-0.004	0.025	0.031

WGGA / NWRA	dX	dY	dZ	Vector
Min	-0.050	-0.106	-0.050	0.029
Max	0.024	0.083	0.001	0.122
Mean	-0.017	-0.018	-0.024	0.066

Relative LiDAR Comparisons Glen Innes

BALL/GFTN	dX	dY	dZ	Vector
Min	-0.008	-0.027	0.004	0.015
Max	0.029	0.018	0.045	0.047
Mean	0.011	-0.004	0.025	0.031

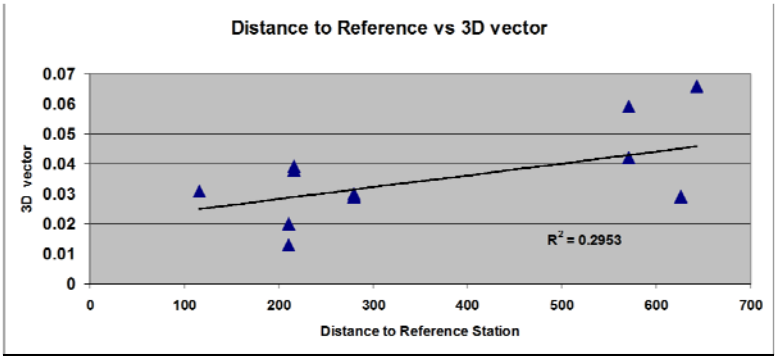
200 km

WGGA / NWRA	dX	dY	dZ	Vector
Min	-0.050	-0.106	-0.050	0.029
Max	0.024	0.083	0.001	0.122
Mean	-0.017	-0.018	-0.024	0.066

650 km

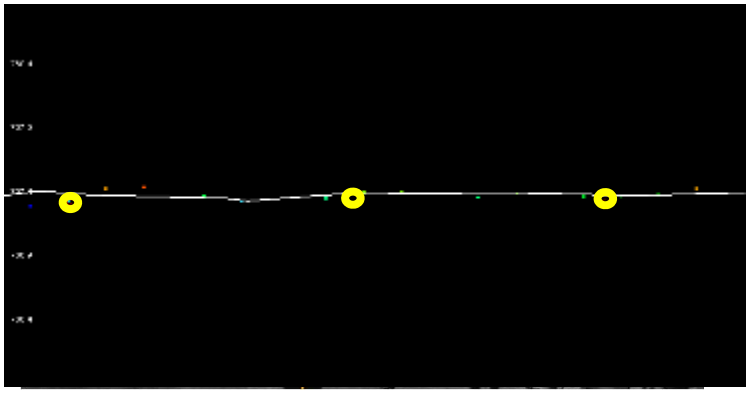
Results: Relative LiDAR

	Test areas	Points	Min avg. separation	Max avg. separation
Bathurst 1	25	1700	0.020 m	0.042 m
Bathurst 2	20	1217	0.013 m	0.059 m
Glen Innes	46	4620	0.047 m	0.066 m



Test: Ground Truth

Comparison of LiDAR to surveyed ground check points

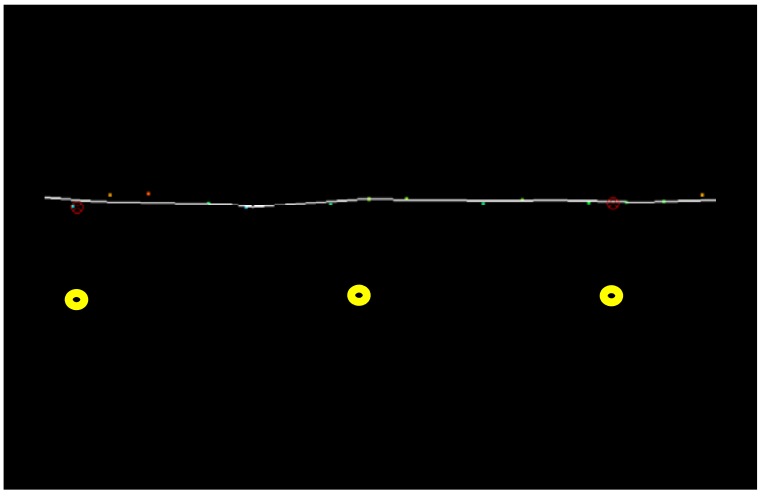


Results: Ground Truth

- Results show systematic vertical offsets

	Original			
TRAJECTORY	Mean	Min	Max	RMSE
GrafNavAIR2	0.008	-0.074	0.097	0.034
AIR2	-0.102	-0.177	-0.002	0.106
BALL	-0.102	-0.177	-0.002	0.106
BALL/GFTN	-0.117	-0.191	-0.015	0.122
DBBO/WGGA/NEWC	-0.089	-0.161	0.009	0.094
WAGG	-0.098	-0.170	0.000	0.103
WAGG/GLBN/NEWC	-0.090	-0.164	0.008	0.096

LiDAR Adjustment



Results: Ground Truth

- Results show systematic vertical offsets
- Identical when 'block shifted' by error mean, as per standard LiDAR practice

		Adjusted			
TRAJECTORY		Mean	Min	Max	RMSE
GrafNavAIR2		0.000	-0.082	0.089	0.033
AIR2		0.000	-0.075	0.100	0.032
BALL		0.000	-0.075	0.100	0.032
BALL/GFTN		0.000	-0.074	0.102	0.032
DBBO/WGGA/NEWC		0.000	-0.072	0.098	0.032
WAGG		0.000	-0.072	0.098	0.032
WAGG/GLBN/NEWC		0.000	-0.074	0.098	0.032

Results: Ground Truth

Adjusted			
Mean	Min	Max	RMSE
0.000	-0.082	0.089	0.033
0.000	-0.075	0.100	0.032
0.000	-0.075	0.100	0.032
0.000	-0.074	0.102	0.032
0.000	-0.072	0.098	0.032
0.000	-0.072	0.098	0.032
0.000	-0.074	0.098	0.032

Conclusion

- Demonstrated that wide-area GNSS solutions are capable of achieving nearly identical results to that of a local reference station
- Significant benefits for airborne LiDAR survey: greater flexibility, reduced cost and simplified logistics
- Further testing required for other airborne applications such as digital imagery

Thankyou!