GNSS Showdown

A real-world performance comparison between Emlid and Trimble GNSS receivers

By Chris Nichols and Alistair Hart

PREFACE

Space-based position, navigation, and timing is a fast-evolving area that offers significant productivity gains for the geospatial industry. The recent emergence of new Global Navigation Satellite Systems (GNSS) constellations improves the experience for professional Surveyors, chasing reliable satellite coverage in the field. Users of modern multi-constellation GNSS receivers are now consistently reporting 30+ satellites above 15 degrees elevation, with 40+ satellites a common experience in many parts of Australia. The productivity gains on offer are prompting many survey professionals to upgrade their gear. However, the price can be a huge barrier to upgrading equipment.

In this article, Brian Blakeman Surveys (BBS) compares results of GNSS receiver performance between a new kid on the block Emlid and a market incumbent Trimble. So how do these receivers compare on performance?

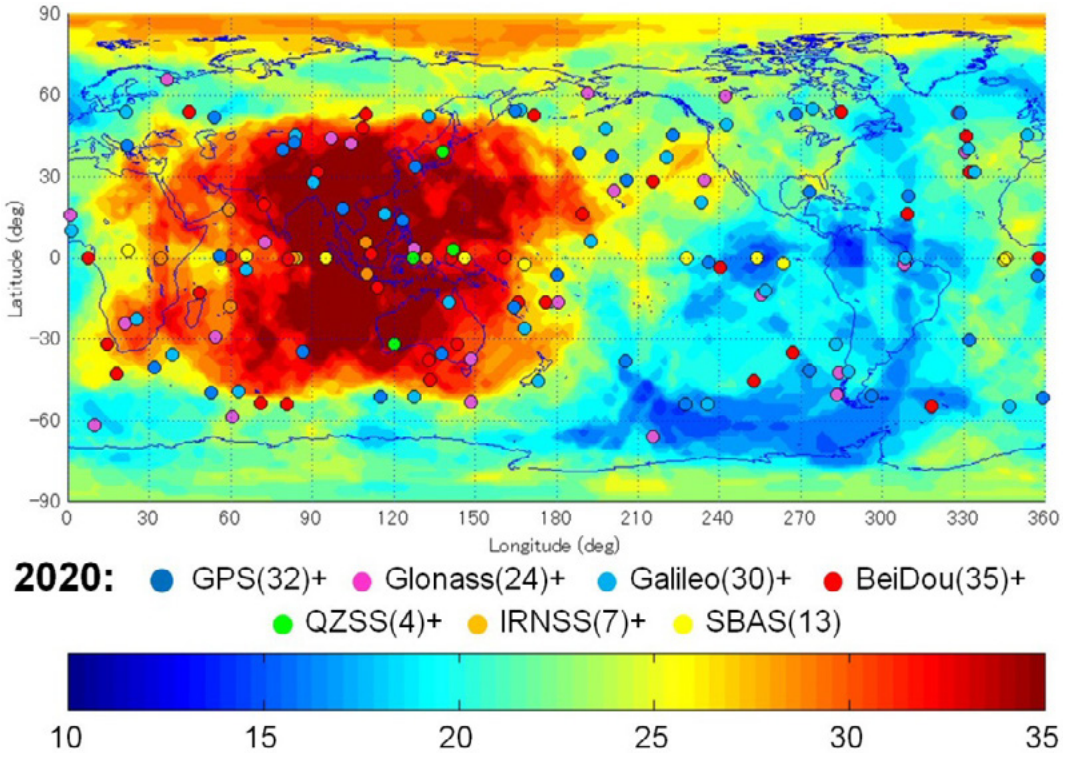

Figure 1 Number of visible GNSS satellites above 30° elevation expected in 2020 (Satoshi Kogure, JAXA)

EXPERIMENTAL DESIGN

Equipment spec sheets don't always tell the whole story. Therefore, the aim of this experiment was to undertake common 'real world' survey tasks and compare a high-end current model 'brand-name' receiver with an affordable alternative, evaluating the differences in performance. The survey was completed during January 2021 in central Australia, where a mix of urban and remote environments supports a range of equipment testing scenarios.

The scope of the study included:

- Performance of internal RTK radios (UHF vs. LoRa)
- Managing new projects with local coordinate reference systems
- Comparing RTK performance in a variety of environments
- Comparing receiver performance against government survey marks
- Ease of use with NTRIP services (in this case, AUSCORS)
- Compatibility with AUSPOS for post-processing status logs
- Consideration of total cost of ownership/business models

UHF VS. LORA: RADIO PERFORMANCE

Most traditional survey GNSS receivers use UHF radios in the licensed 450-470 MHz band to broadcast corrections from base to rover. Some bands, including Emlid, are turning to 915 MHz spread-spectrum LoRa radio modems, which do not require licensing in Australia or New Zealand.

This test evaluated the internal radios without range-extending radio repeaters or external antennas.

Figure 2 Emlid Reach RS2 and Trimble R63 base units established for radio corrections range test. (Chris Nichols, BBS)

To run this test Emlid Reach RS2 and Trimble R63 base stations were established on an elevated position (sandhill) in a rural area. Emlid Reach RS2 and Trimble R10 rovers were mounted on the roof of a survey vehicle to conduct the radio range testing. The survey vehicle then drove both north and south along a road adjacent to base stations until a reliable fix was lost on each receiver.

Figure 3 Emlid Reach RS2 and Trimble R10 rover units mounted on survey vehicle for radio range test (Chris Nichols, BBS)

Toward the south, the road bends round to the left, around a hill. The Emlid Reach RS2 radio held a fix for approx. 6.5 km from the base. The Trimble R10 maintained a fix for approximately 7.3 km. Heading north, the road is relatively straight but rises over a crest. The Reach RS2 maintained a fix for approximately 6.5 km and the Trimble R10 for approximately 7.5 km.

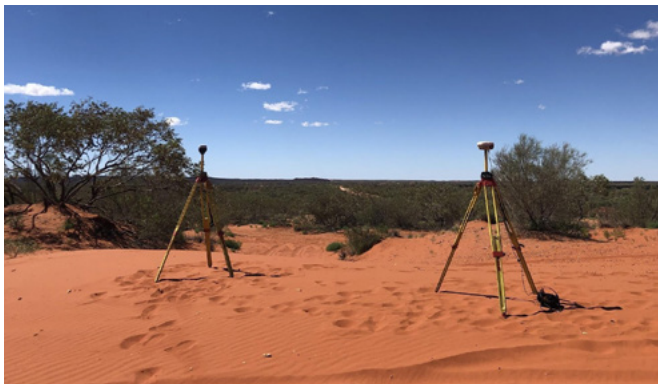

Figure 4 Base units established for radio corrections range test, looking south (Chris Nichols, BBS)

"Some of the range test terrains were quite complex with terrain and vegetation obstructions," said Chris Nichols from BBS. "Considering the relatively high frequency, I'm impressed with the range of the Reach RS2 radios," he continued.

MANAGING NEW PROJECTS WITH LOCAL COORDINATE REFERENCE SYSTEMS

When comparing the user experience between Emlid and Trimble software, BBS reported some differences and pros and cons for each manufacturer's approach.

For data logging, Emlid leverages iOS or Android devices with its free ReachView app. For this comparison, BBS used an iPad with the Emlid Reach RS2 receiver. For the Trimble R10, BBS used their familiar TSC3 data logger, running Trimble Access v2017.

Emlid's app-based data collector software has a minimalistic feel. Based on feedback from BBS, surveyors used to a Trimble Access workflow may take time to learn the new interface.

"Despite the learning curve, I found the ReachView status screen to be very handy, especially while I'm learning," Nichols continues. "It helps in knowing if you have a lock with the rover and the quality of measurements etc. Even knowing the baseline distance is helpful."

RTK PERFORMANCE COMPARISON: BASE AND ROVER (INTERNAL RADIO)

To undertake a comprehensive assessment, BBS surveyed 38 points with 30-second observations for each receiver.

To allow comparison between the receivers and known coordinates, twelve of the surveyed points were on existing marks originally surveyed with 3-minute observations (refer to Figure 9 below). For the remainder of the points, the observations for each receiver are compared to assess the relative precision of observed coordinates between Emlid's Reach RS2 and Trimble's R10.

The points were in a range of GNSS environments in terms of topography, vegetation, and buildings, and classified into easy, medium, hard, and urban points.

Easy

This area was reasonably clear, with large sections of no vegetation surrounded by low vegetation. No issues with radios. NB. This is also where BBS conducted static observations for AUSPOS.

		Easting			Northing			RL - GRS80		
Point ID	Terrain/ Difficulty	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	ΔRS2 - R10
CP01	Easy	376704.661	376704.611	-0.050	7372611.403	7372611.414	0.011	582.490	582.448	-0.042
CP02	Easy	376731.875	376731.886	0.011	7372259.058	7372259.074	0.016	581.481	581.463	-0.018
CP03	Easy	376872.098	376872.101	0.003000000026	7371926.211	7371926.216	0.005	581.621	581.596	-0.025
CP04	Easy	377145.955	377145.961	0.006000000052	7372762.835	7372762.837	0.002	582.472	582.452	-0.02
CP05	Easy	377243.45	377243.461	0.01100000006	7372355.917	7372355.924	0.007	582.508	582.476	-0.032
CP06	Easy	377321.584	377321.6	0.016	7371988.982	7371988.993	0.011	582.885	582.843	-0.042
CP07	Easy	377683.401	377683.415	0.01400000002	7372869.095	7372869.108	0.013	582.339	582.297	-0.042
CP08	Easy	377785.136	377785.164	0.02799999999	7372408.559	7372408.573	0.014	582.964	582.931	-0.033
CP09	Easy	377869.895	377869.914	0.01900000003	7372004.838	7372004.846	0.008	584.959	584.922	-0.037

Figure 5 Summary of easy points with coordinate differences between Emlid Reach RS2 and Trimble R10

Medium

The terrain out here varied from high sand dunes to long flat terrain but with dense vegetation. Both units did well in this environment, and internal radios also performed well.

		Easting			Northing			RL - GRS80		
Point ID	Terrain/ Difficulty	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	ΔRS2 - R10
MR01	Medium	390212.502	390212.511	0.009	7351182.435	7351182.433	-0.002	567.626	567.621	-0.005
MR02	Medium	390495.86	390495.869	0.009	7350357.884	7350357.898	0.014	560.636	560.631	-0.005
MR03	Medium	390564.37	390564.384	0.014	7350691.368	7350691.357	-0.011	560.975	560.957	-0.018
MR04	Medium	390767.809	390767.827	0.018	7349500.176	7349500.158	-0.018	562.534	562.559	0.025
MR05	Medium	390829.094	390829.100	0.006	7350121.542	7350121.542	0.000	559.034	559.018	-0.016
MR06	Medium	390870.769	390870.773	0.004	7349193.659	7349193.664	0.005	566.925	566.902	-0.023
MR07	Medium	390923.012	390922.984	-0.028	7348977.981	7348977.985	0.004	570.695	570.709	0.014
MR08	Medium	390978.973	390978.956	-0.017	7349697.775	7349697.761	-0.014	562.544	562.56	0.016

Figure 6 Summary of medium points with coordinate differences between Emlid Reach RS2 and Trimble R10

Hard

Vegetation and topography challenged the GNSS receivers with obstructions and multipathing at these points. Both the RS2 and R10 radios worked well in this environment.

		Easting			Northing			RL - GRS80		
Point ID	Terrain/ Difficulty	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	ΔRS2 - R10
B01	Hard	389145.929	389145.923	-0.006	7373282.063	7373282.053	-0.010	566.972	566.977	0.005
B02	Hard	389283.948	389283.953	0.005	7373381.771	7373381.78	0.009	567.722	567.718	-0.004
B03	Hard	389342.553	389342.546	-0.007	7373276.577	7373276.557	-0.020	566.946	566.956	0.01
B04	Hard	389363.236	389363.242	0.006	7372987.644	7372987.638	-0.006	564.819	564.82	0.001
B05	Hard	389392.821	389392.818	-0.003	7373627.416	7373627.433	0.017	570.302	570.296	-0.006
B06	Hard	389413.338	389413.342	0.004	7372878.169	7372878.174	0.005	564.632	564.649	0.017
B07	Hard	389459.556	389459.558	0.002	7373450.186	7373450.186	0.000	568.293	568.301	0.008
B08	Hard	389578.585	389578.59	0.005	7373807.11	7373807.108	-0.002	600.775	600.788	0.013
B09	Hard	389629.667	389629.672	0.005	7373655.959	7373655.951	-0.008	581.028	581.025	-0.003
B10	Hard	389632.46	389632.456	-0.004	7373735.09	7373735.079	-0.011	585.253	585.268	0.015
B11	Hard	389652.965	389652.978	0.013	7373070.39	7373070.38	-0.010	568.137	568.154	0.017
B12	Hard	389657.372	389657.375	0.003	7373311.154	7373311.144	-0.010	567.759	567.753	-0.006

Figure 7 Summary of hard points with coordinate differences between Emlid Reach RS2 and Trimble R10

Point ID	Terrain/ Difficulty	BM	Δ RS2 - BM	Δ R10 - BM	BM	Δ RS2 - BM	Δ R10 - BM	BM	Δ RS2 - BM	Δ R10 - BM
BM01	Medium	389145.933	0.004	0.010	7373282.052	-0.011	-0.001	566.992	0.020	0.015
BM02	Medium	389283.96	0.012	0.007	7373381.764	-0.007	-0.016	567.722	0.000	0.004
BM03	Medium	389342.558	0.005	0.012	7373276.55	-0.027	-0.007	566.967	0.021	0.011
BM04	Medium	389363.242	0.006	0.000	7372987.632	-0.012	-0.006	564.855	0.036	0.035
BM05	Medium	389392.827	0.006	0.009	7373627.418	0.002	-0.015	570.27	-0.032	-0.026
BM06	Medium	389413.345	0.007	0.003	7372878.161	-0.008	-0.013	564.696	0.064	0.047
BM07	Medium	389459.56	0.004	0.002	7373450.18	-0.006	-0.006	568.288	-0.005	-0.013
BM08	Medium	389578.586	0.001	-0.004	7373807.107	-0.003	-0.001	600.738	-0.037	-0.050
BM09	Medium	389629.682	0.015	0.010	7373655.955	-0.004	0.004	580.995	-0.033	-0.030
BM10	Medium	389632.465	0.005	0.009	7373735.079	-0.011	0.000	585.21	-0.043	-0.058
BM11	Medium	389652.973	0.008	-0.005	7373070.381	-0.009	0.001	568.161	0.024	0.007
BM12	Medium	389657.369	-0.003	-0.006	7373311.142	-0.012	-0.002	567.748	-0.011	-0.005

Figure 8 Summary of hard points and differences between existing known coordinates, Emlid Reach RS2 and Trimble R10

Urban

BBS collected some points within an urban environment, surrounded by single-story commercial properties. In this environment, sky visibility was significantly reduced, and both receivers performed well. The elevation mask was set to 15 degrees for both units throughout each test.

No issues with radios were reported, even around buildings. This is obviously very dependent on individual environments, and BBS suggests this should not be expected every time users operate outside of line-of-sight.

		Easting			Northing			RL - GRS80		
Point ID	Terrain	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	ΔRS2 - R10
UR01	Urban	385398.946	385398.96	0.014	7378977.409	7378977.417	0.008	595.063	595.085	0.022
UR02	Urban	385406.024	385406.029	0.005	7378924.193	7378924.193	0.000	594.952	594.981	0.029
UR03	Urban	385413.989	385413.985	-0.004	7378942.203	7378942.185	-0.018	595.017	595.092	0.075
UR04	Urban	385417.926	385417.925	-0.001	7378951.127	7378951.128	0.001	595.066	595.108	0.042
UR05	Urban	385422.204	385422.207	0.003	7378960.688	7378960.685	-0.003	595.082	595.112	0.030
UR06	Urban	385426.22	385426.243	0.023	7378969.923	7378969.927	0.004	595.036	595.038	0.002
UR07	Urban	385426.802	385426.815	0.013	7378968.579	7378968.592	0.013	595.034	595.051	0.017
UR08	Urban	385303.148	385303.158	0.010	7379089.707	7379089.713	0.006	594.744	594.752	0.008
UR09	Urban	385221.237	385221.237	0.000	7379133.405	7379133.431	0.026	595.755	595.744	-0.011

Figure 9 Summary of urban points with coordinate differences between Emlid Reach RS2 and Trimble R10

Both receivers performed well during this assessment. BBS reported finding good agreement with the marks and between Emlid's Reach RS2 and Trimble's R10.

Figure 10 Urban testing conditions at site UR02, with Emlid Reach RS2 on survey pole

RTK PERFORMANCE COMPARISON AGAINST GOVERNMENT SURVEY MARKS USING LOCAL BASE

BBS assessed the performance of Emlid's RS2 and Trimble's R10 receivers against two coordinated reference marks (aka CRMs or government survey marks) and compared the results of the observations against each other and the known coordinates for each mark.

The tests were done using MGA94 Zone 53 and ellipsoidal heights. Ellipsoidal heights, rather than the Australian Height Datum, were selected for reasons including ICSM SP1 recommendations on height comparisons and uncertainty with regard to the AHD values for some local marks in Alice Springs.

	Easting			Northing			RL - GRS80		
Point ID	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	ΔRS2 - R10
S01029.026	385303.148	385303.158	0.010	7379089.707	7379089.713	0.006	594.744	594.752	0.008
S01029.027	385221.237	385221.237	0.000	7379133.405	7379133.431	0.026	595.755	595.744	-0.011
Point ID	CRM	Δ RS2 - CRM	Δ R10 - CRM	CRM	Δ RS2 - CRM	Δ R10 - CRM	CRM	Δ RS2 - CRM	Δ R10 - CRM
S01029.026	385303.155	0.007	-0.003	7379089.709	0.002	-0.004	594.755	0.011	0.003
S01029.027	385221.234	-0.003	-0.003	7379133.41	0.005	-0.021	595.742	-0.013	-0.002

Figure 11 Summary of results for RTK performance against government marks

BBS testing found good agreement with the marks and both Emlid's Reach RS2 and Trimble's R10.

RTK PERFORMANCE AGAINST GOVERNMENT SURVEY MARKS USING AUSCORS

This test was conducted to evaluate the comparative results of Emlid's RS2 and Trimble's R10 receivers when connected to Geoscience Australia's free AUSCORS service.

Figure 12 Screengrab showing the NTRIP profile used for the performance test with corrections from AUSCORS

Figure 13 Emlid Reach RS2 setup on a CRM for AUSCORS-based RTK testing

For this test, each receiver was connected to AUSCORS (Alice Springs station 31NA00AUS0), and then a coordinated reference mark was surveyed with each receiver.

The table below summarises the relative performance.

	Easting			Northing			RL - AHD		
Point ID	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	Δ RS2 - R10	Emlid	Trimble	ΔRS2 - R10
S01029.025	385388.914	385388.92	0.006	7378990.158	7378990.165	0.007000000216	579.389	579.42	0.031
Point ID	CRM	Δ RS2 - CRM	Δ R10 - CRM	CRM	Δ RS2 - CRM	Δ R10 - CRM	CRM	Δ RS2 - CRM	Δ R10 - CRM
S01029.025	385388.930	0.016	0.010	7378990.172	0.014	0.007	579.554	0.165	0.134

* Approx. difference between AHD and 'local' AHD is 0.120m

Figure 14 Summary of results for RTK performance against government mark using AUSCORS corrections

In Alice Springs, there is a known offset between AHD and derived AHD of approximately 0.12 m to 0.13 m. This is evident in the RL deltas above and needs to be taken into consideration when undertaking surveys.

From the results above, we can see good agreement between the RS2 and the R10. The difference between both receivers and the CRM is as expected from NTRIP corrections using AUSGeoid derived AHD heights when checking on local CRMs.

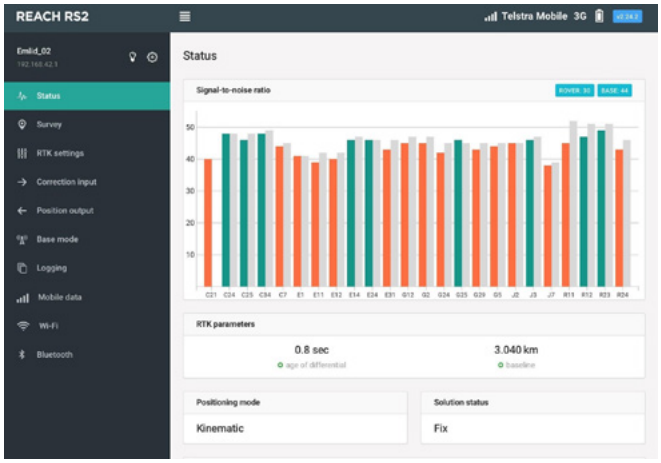

Figure 15 ReachView 2 status screen showing corrections (grey bars) from AUSCORS

COMPARING RINEX LOGS POST-PROCESSED ON AUSPOS

The purpose of this relatively simplistic test was to assess the relative useability of each receiver in capturing AUSPOS logs to determine the coordinates of a point on the ground and to compare those derived coordinates to the known coordinates for that point.

Receivers tested included Emlid's RS2, Trimble's R63, and Trimble's R10. Logging periods were 4 hours 45 minutes for the RS2 and R63 and 4 hours 30 minutes for the R10. The approximate baseline from this known point to Geoscience Australia's Alice Springs station (ALIC00AUS0) is 13 km.

COMPARISON OF ALL UNITS TO KNOWN COORDINATES OF IL01 (Known)								
Easting xri	Easting xmi	ΔX	Northing yri	Northing ymi	Δy	Elevation (GRS80) zri	Elevation (GRS80) zmi	Δz
IL01_RS2	IL01 Known		IL01_RS2	IL01 Known		IL01_RS2	IL01 Known	
379614.867	379614.908	**-0.041**	7372311.853	7372311.816	**0.037**	586.12	586.048	**0.072**
IL01_R63	IL01 Known		IL01_R63	IL01 Known		IL01_R63	IL01 Known	
379614.873	379614.908	**-0.035**	7372311.843	7372311.816	**0.027**	586.015	586.048	**-0.033**
IL01_R10	IL01 Known		IL01_R10	IL01 Known		IL01_R10	IL01 Known	
379614.847	379614.908	**-0.061**	7372311.847	7372311.816	**0.031**	586.09	586.048	**0.042**

**Approx. Baseline to ALIC = 13km*

Figure 16 Summary of AUSPOS results for each receiver on a known mark, and alignment with existing known coordinates

Chris Nichols from BBS made a number of observations from this test, with pros and cons for each receiver brand. Chris says, "Setting the Reach RS2 to log data, within the ReachView app, is an easy process; once you have worked it out".

"On the one hand, the ReachView app allows the Reach RS2 to log automatically when the device is turned on. This is definitely a quicker workflow. On the other hand, care must be taken that the device is set up prior to logging and instrument heights are recorded manually, as there is no way to input this into the app."

IN CONCLUSION

The results show that there are a number of subtle differences in the receivers assessed. Each receiver has its pros and cons across features, performance, and price.

When asked what he thought of the different software as an end-user, Nichols noted, "As of testing, the ReachView 3 app works for basic point collection and stakeout, with CRS and Geoid selection. Based on the two updates we received in the few weeks of testing, we can see the app evolving quickly to better align with the needs of Surveyors. Emlid team is very responsive on the online forums and is quick to implement user requests. Having regular free updates and the manufacturer working directly with customers is certainly of benefit."

The take-home message for professionals looking to upgrade their gear is to do your homework, analyze business requirements carefully and take a close look at all the options in the market.

Given the delta in equipment cost, to find that sweet spot between productivity and value-for-money, be sure that you know what you need and need what you pay for.

FOOTNOTES

Brain Blakeman Surveys were engaged on a commercial basis by Map Gear, the Aust/NZ distributors for Emlid, to complete a performance assessment of Trimble and Emlid receivers. The purpose is a 3rd party performance comparison by an active and qualified member of the survey fraternity.

ABOUT THE AUTHORS

Alistair Hart is general manager of Map Gear, distributors for Emlid, and an online shop for mapping, surveying, and high-end positioning and navigation components. Alistair has been active in the survey and mapping industry for 27 years.

Chris Nichols is a surveyor at Brian Blakeman Surveys (BBS) and founder of Central Drone Surveys. BBS has been surveying for 30+ years in Central Australia and has been using Trimble equipment for the last decade, including R63 and R10 receivers.

All photos and figures courtesy Chris Nichols, Brian Blakeman Surveys.