

Shared Revisited

In the previous report prepared for E38 Survey Solutions, [Ground Truthing Report of the Emlid Reach RX](#) (last updated 20230626), in the last portion of that report entitled: [5 Shared Solutions](#) beginning on page 27, the baseline dataset was predicated upon OPUS post processed results for (5) individual 4-hour static observations. Each had been accepted by NGS as qualifying for its so-called Shared Solutions and intended chiefly for its still running campaign [GPS on Benchmarks](#).

In this report, the same 5 benchmarks in the NGS database have been used; however, I chose not to use the NGS published shared solution values for the baseline dataset for a couple of reasons; equipment consistency, and the fact that NGS rejected the 4-hour static session on U 159 (PE0020) - more on that below.

17U - Base Position used in these tests

The two RS2+ units were first each tested doing static observations on 17U, my go-to survey control mark used over the past quarter century in all manner of mad-scientist experiments. Each unit occupied the mark for

	Date	OPUS ELLIP HT	NRCAN ELLIP HT	ES MEPH ELLIP HT	ES VRS ELLIP HT
17U E38-RS2PLUS-1 Firmware v30.1 8243340725486FE7	2023/06/22	20.431	20.393	20.464	20.435
	2023/06/23	20.452	20.403	20.465	20.419
	2023/06/24	20.467	20.406	20.453	20.434
	2023/06/25	20.429	20.410	20.445	20.448
E38-RS2PLUS-2 Firmware v30.1 82432CFA33COD32D	2023/06/27	20.439	20.419	20.463	20.462
	2023/06/29	20.419	20.402	20.457	20.427
	2023/06/30	20.402	20.420	20.388	20.392
	2023/07/01	20.471	20.430	20.431	20.448
Average	20.439	20.410	20.446	20.433	
Stdev	0.024	0.012	0.026	0.021	

several hours on 4 separate days during which they (both) collectively logged about 100 hours at 30-second intervals. And it's here where I also started comparing post processing computational options and their respective positional varying results.

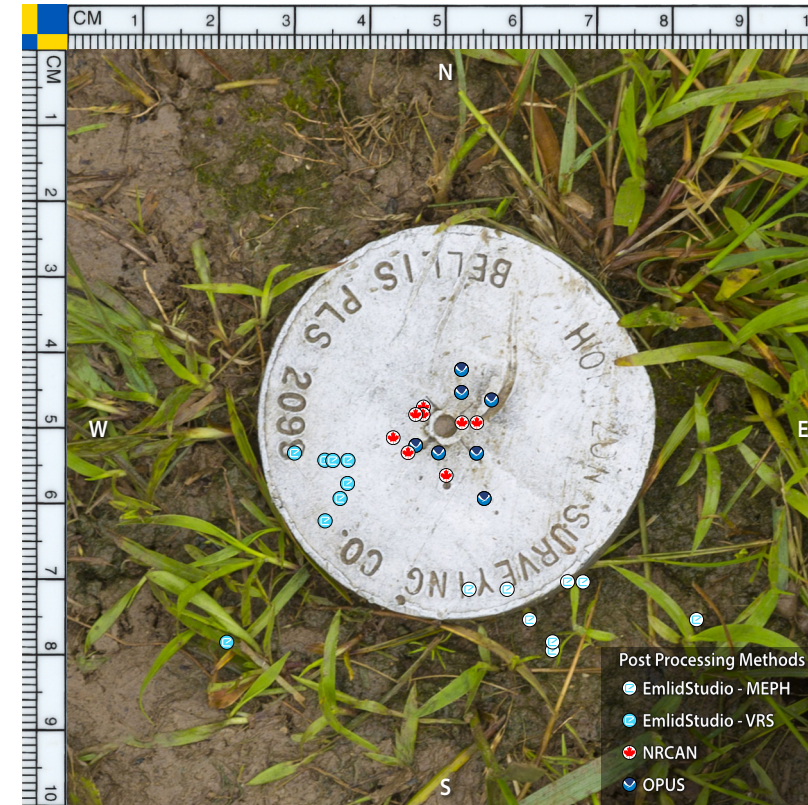
As previously stated, NGS would not process U 159 and OPUS aborted processing a 4-hour static observation using the RS2+ citing noise as the reason. In the past, and in similar noisy locations, 4-hour static sessions have always been processed by OPUS but ultimately were not accepted as a Shared Solution due to the GPS only noise. This is the first time that I've seen OPUS refuse to process a submission because of noise.

OPUS first began its Online Positioning User Service in March 2001¹. Even though GLONASS was available then, OPUS still today processes GPS only. This may eventually change, but when multi-constellation processing will actually begin for OPUS remains uncertain. However what is certain, is that on several occasions I have found Javad's DPOS has no problems whatsoever in processing the exact same data including GLONASS with results generally having much smaller residuals, and in some cases, have seen the OPUS-DPOS 2D positional deltas of 1 to 2 meters. Unfortunately,

the Emlid data cannot be processed through DPOS.

In addition to using OPUS for post processing the data for 17U, the Natural Resources of Canada PPP service has been

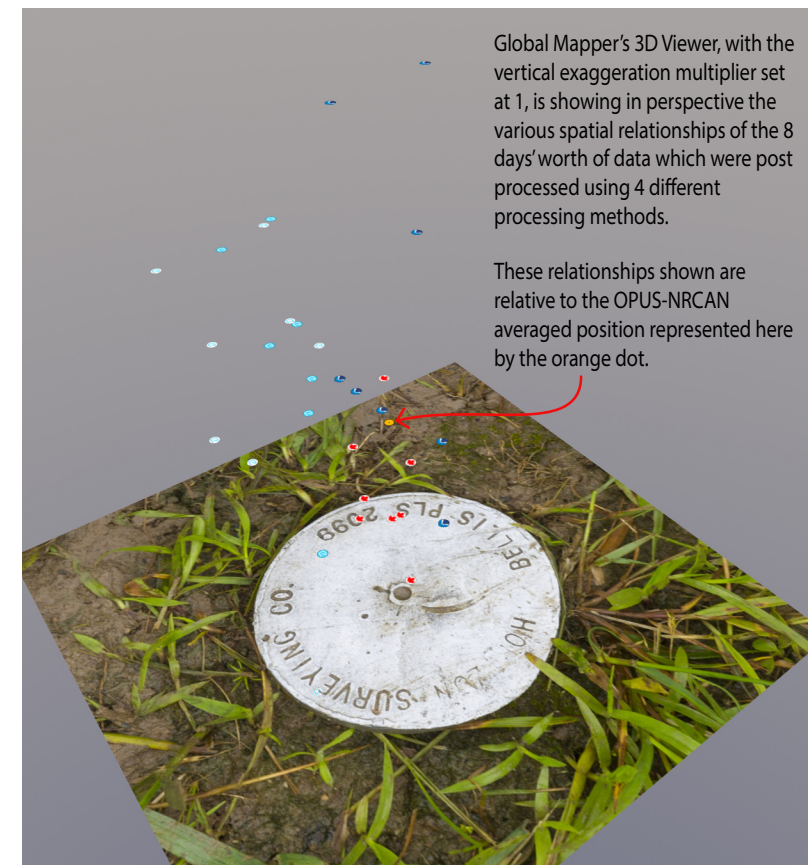
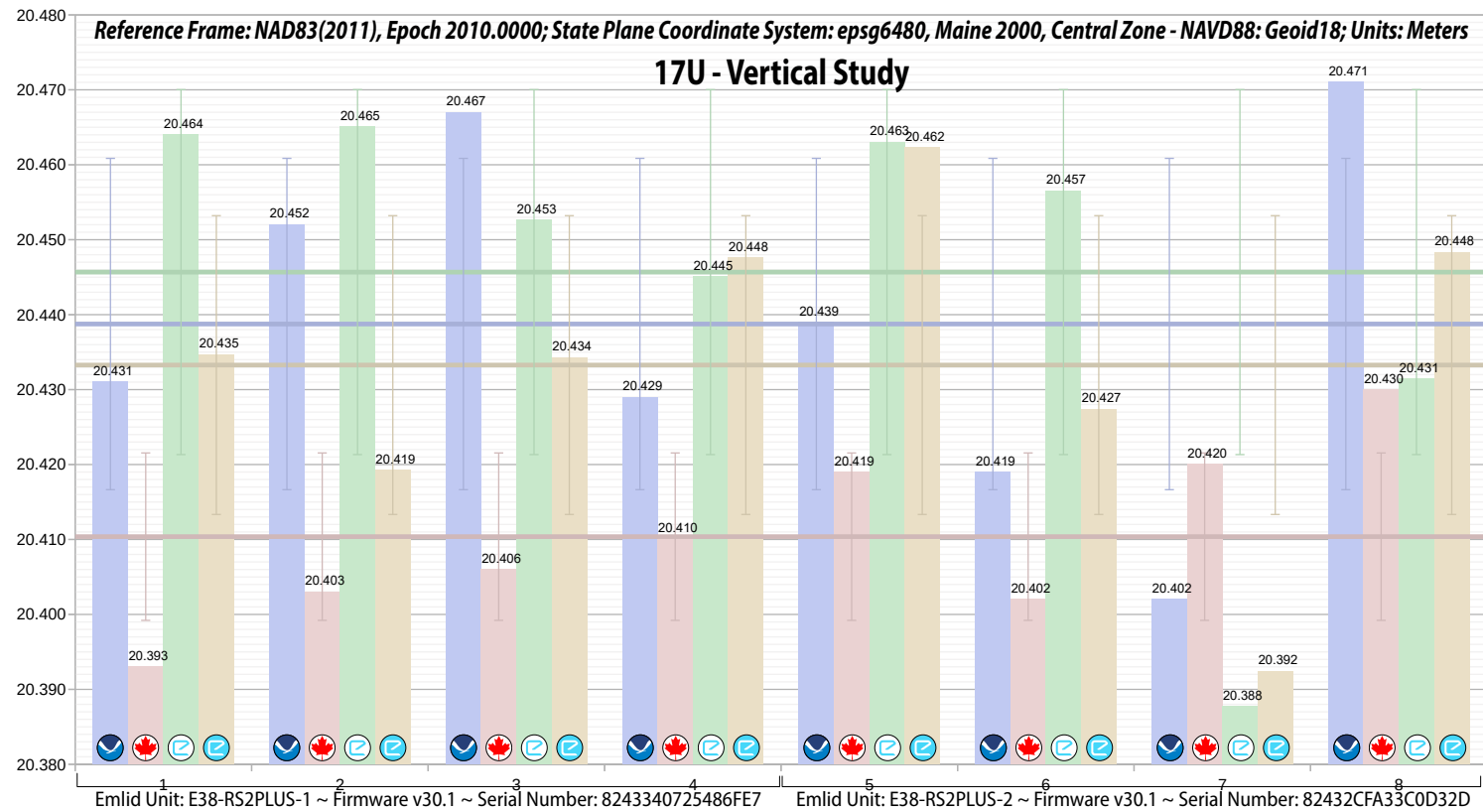
¹ NGS Geodetic Tool Kit, Part II: The On-line Positioning User Service (OPUS); Professional Surveyor Issue: May 2003; Authors: G.L. Mader, N.D. Weston, M.L. Morrison and D.G. Milbert



used. And lastly, Emlid's own version of RTKLIB, Emlid Studio v1.5 has been used to post process 17U. This was done using Emlid Studio twice; 1) using the nearest single CORS MaineDOT's MEPH; and 2) MaineDOT's VRS. In all cases, the reference frame is NAD83 (2011) @ 2010.0000 and all positional values were transformed to the State Plane Coordinate System projection Maine 2000, Central Zone using Blue Marble Geographic's Geographic Calculator 2023. All ellipsoid heights were transformed to NAVD88, Geoid18 elevations, also using Geographic Calculator 2023.

The 2D results from all 4 post processing methods are shown in the figure to the right noting that the OPUS and NRCAN points generally fell in closer agreement and tighter grouping than either of the Emlid Studio sets. Accordingly, I selected the OPUS and NRCAN point features, averaged their positions, and then used its averaged 2D position for these tests involving 17U; i.e., 44.5445267710° N, 68.4171427049° W. The OPUS and NRCAN averaged heights were used for these tests as well; i.e., 20.425 m, ellipsoid height/ 44.935 m NAVD88, Geoid18.

17U - Points Detail
NRCAN & OPUS Averaged value at center of detailed 10 cm x 10 cm photo of the mark





E38-RS2PLUS Units 1 and 2 Logged RINEX Files – 22 June through 1 July 2023																		
17U E38-RS2PLUS-1 Firmware v30.1 8243340725486FE7	Date	Start	End	Duration	OPUSed	orbit	OPUS Date	OPUS Software	NRCANed	Type	NRCAN Date	NRCAN Software	ESed	VRS & MEPH	ES VRS Date	ES MEPH Date	ES Software	
	2023/06/22	13:10	23:59	10:49	yes	rapid	2023/06/27	page5 2008.25 master293.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
	2023/06/23	11:19	23:20	12:01	yes	rapid	2023/06/27	page5 2008.25 master250.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
	2023/06/24	10:12	22:43	12:31	yes	rapid	2023/06/27	page5 2008.25 master291.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
	2023/06/25	09:01	23:26	14:25	yes	rapid	2023/06/27	page5 2008.25 master253.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
17U E38-RS2PLUS-2 Firmware v30.1 82432CFA33C0D32D	Date	Start	End	Duration	OPUSed	orbit	OPUS Date	OPUS Software	NRCANed	Type	NRCAN Date	NRCAN Software	ESed	VRS & MEPH	ES VRS Date	ES MEPH Date	ES Software	
	2023/06/27	11:18	22:46	11:28	yes	Ultra-rapid	2023/06/28	page5 2008.25 master250.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
	2023/06/29	09:26	23:45	14:19	yes	Ultra-rapid	2023/06/30	page5 2008.25 master253.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
	2023/06/30	12:17	23:49	11:32	yes	Ultra-rapid	2023/07/01	page5 2008.25 master251.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	
	2023/07/01	09:31	23:31	14:00	yes	Ultra-rapid	2023/07/02	page5 2008.25 master253.pl 160321	yes	Rapid	2023/07/02	Software Version: 3.54.2	yes	MDOT	2023/07/14	2023/07/14	Version 1.5	

E38-RS2+ Unit 1 Post Processed Using OPUS & NRCAN							
17U E38-RS2PLUS-1 Firmware v30.1 8243340725486FE7	Date	OPUS LAT DMS	OPUS LON DMS	OPUS ELLIP HT	NRCAN LAT DMS	NRCAN LON DMS	NRCAN ELLIP HT
	2023/06/22	44 32 40.29626	-68 25 1.71358	20.431	44 32 40.29640	-68 25 1.71364	20.393
	2023/06/23	44 32 40.29652	-68 25 1.71365	20.452	44 32 40.29647	-68 25 1.71387	20.403
	2023/06/24	44 32 40.29626	-68 25 1.71379	20.467	44 32 40.29634	-68 25 1.71407	20.406
	2023/06/25	44 32 40.29630	-68 25 1.71390	20.429	44 32 40.29617	-68 25 1.71374	20.410
	Average			20.445			20.403
	Stdev			0.01812			0.00726

E38-RS2+ Unit 1 Post Processed Using OPUS & NRCAN and then Transformed Using Geographic Calculator 2023										
17U E38-RS2PLUS-1 Firmware v30.1 8243340725486FE7	Date	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18	O – N = Δn	O – N = Δe	O – N = Δup
	2023/06/22	116301.592	556251.622	44.941	116301.596	556251.620	44.903	-0.004	0.002	0.038
	2023/06/23	116301.600	556251.620	44.962	116301.598	556251.615	44.913	0.002	0.005	0.049
	2023/06/24	116301.592	556251.617	44.977	116301.594	556251.611	44.916	-0.002	0.006	0.061
	2023/06/25	116301.593	556251.614	44.939	116301.589	556251.618	44.920	0.004	-0.004	0.019
	Average	116301.594	556251.618	44.955	116301.594	556251.616	44.913	0.000	0.002	0.042
	Stdev	0.00386	0.00350	0.01812	0.00386	0.00392	0.00726			

E38-RS2+ Unit 2 Post Processed Using OPUS & NRCAN							
17U E38-RS2PLUS-2 Firmware v30.1 82432CFA33C0D32D	Date	OPUS LAT DMS	OPUS LON DMS	OPUS ELLIP HT	NRCAN LAT DMS	NRCAN LON DMS	NRCAN ELLIP HT
	2023/06/27	44 32 40.29608	-68 25 1.71350	20.439	44 32 40.29626	-68 25 1.71397	20.419
	2023/06/29	44 32 40.29662	-68 25 1.71365	20.419	44 32 40.29644	-68 25 1.71390	20.402
	2023/06/30	44 32 40.29662	-68 25 1.71365	20.402	44 32 40.29638	-68 25 1.71354	20.420
	2023/07/01	44 32 40.29648	-68 25 1.71347	20.471	44 32 40.29642	-68 25 1.71389	20.430
	Average			20.433			20.418
	Stdev			0.02965			0.01162

E38-RS2+ Unit 2 Post Processed Using OPUS & NRCAN and then Transformed Using Geographic Calculator 2023										
17U E38-RS2PLUS-2 Firmware v30.1 82432CFA33C0D32D	Date	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18	O – N = Δn	O – N = Δe	O – N = Δup
	2023/06/27	116301.586	556251.623	44.949	116301.592	556251.613	44.929	-0.006	0.010	0.020
	2023/06/29	116301.603	556251.620	44.929	116301.597	556251.614	44.912	0.006	0.006	0.017
	2023/06/30	116301.603	556251.620	44.912	116301.596	556251.622	44.930	0.007	-0.002	-0.018
	2023/07/01	116301.599	556251.624	44.981	116301.597	556251.615	44.940	0.002	0.009	0.041
	Average	116301.598	556251.622	44.943	116301.596	556251.616	44.928	0.002	0.006	0.015
	Stdev	0.00806	0.00206	0.02965	0.00238	0.00408	0.01162			

E38-RS2+ Units 1 and 2 Post Processed Using Emlid Studio v1.5 together with MaineDOT MEPH							
17U E38-RS2PLUS-1 Firmware v30.1 8243340725486FE7	Date	ES LAT DDD	ES LON DDD	ES ELLIP HT	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18
	2023/06/22	44.544526541	-68.417142297	20.4640	116301.570	556251.651	44.974
	2023/06/23	44.544526590	-68.417142503	20.4651	116301.575	556251.634	44.975
	2023/06/24	44.544526537	-68.417142565	20.4526	116301.570	556251.629	44.963
	2023/06/25	44.544526514	-68.417142537	20.4451	116301.567	556251.632	44.955
17U E38-RS2PLUS-2 Firmware v30.1 82432CFA33C0D32D	Date	ES LAT DDD	ES LON DDD	ES ELLIP HT	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18
	2023/06/27	44.544526505	-68.417142537	20.4630	116301.566	556251.632	44.973
	2023/06/29	44.544526590	-68.417142480	20.4565	116301.575	556251.636	44.967
	2023/06/30	44.544526573	-68.417142606	20.3877	116301.574	556251.626	44.898
	2023/07/01	44.544526577	-68.417142675	20.4314	116301.574	556251.621	44.941

E38-RS2+ Units 1 and 2 Post Processed Using Emlid Studio v1.5 together with MaineDOT VRS							
17U E38-RS2PLUS-1 Firmware v30.1 8243340725486FE7	Date	ES LAT DDD	ES LON DDD	ES ELLIP HT	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18
	2023/06/22	44.544526730	-68.417142899	20.4347	116301.591	556251.603	44.945
	2023/06/23	44.544526732	-68.417142910	20.4192	116301.591	556251.602	44.929
	2023/06/24	44.544526683	-68.417142884	20.4343	116301.586	556251.604	44.944
	2023/06/25	44.544526662	-68.417142902	20.4476	116301.583	556251.602	44.958
17U E38-RS2PLUS-2 Firmware v30.1 82432CFA33C0D32D	Date	ES LAT DDD	ES LON DDD	ES ELLIP HT	epsg6480 Northing	epsg6480 Easting	NAVD88 Geoid18
	2023/06/27	44.544526517	-68.417143075	20.4623	116301.567	556251.589	44.972
	2023/06/29	44.544526731	-68.417142871	20.4274	116301.591	556251.605	44.937
	2023/06/30	44.544526705	-68.417142871	20.3924	116301.588	556251.605	44.902
	2023/07/01	44.544526740	-68.417142961	20.4483	116301.592	556251.598	44.958

Reference Frame: NAD83(2011), Epoch 2010.0000; State Plane Coordinate System: epsg6480, Maine 2000, Central Zone - NAVD88: Geoid18; Units: Meters