

DESIGN SURVEY REPORT

ISSUE DATE:
09.14.2023

VERSION: 00



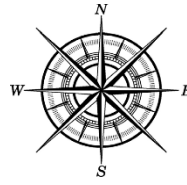
Kiewit | Massman | Traylor
a joint venture

VERSION HISTORY

VERSION NUMBER	PURPOSE DESCRIPTIONS	DATE
Version 0	Report for Submittal to ALDOT	09/14/2023

Table of Contents

1.0	Verification of Mobile Control Points.....	5
2.0	Mobile Mapping Target Layout and Collection	8
3.0	Mobile LiDAR Collection and Mapping Survey Report	18
4.0	Hydrographic Survey Data Collection and Mapping	49
	Attachment A : Field Notes	61
	Attachment B : CAD Files	62
	Attachment C : Raw Data	63
	Attachment D : Opus Reports	64



ROWE
ENGINEERING & SURVEYING

July 17, 2023

Alabama Department of Transportation
1701 I-65 West Service Road North
Mobile, Alabama 36618

RE: I-10 Mobile River Bridge Project

Gentlemen:

Enclosed herewith, please find the following reports:

- Horizontal and vertical control verification performed by Rowe Engineering and Surveying.
- Mobile mapping target layout and the collection performed by Rowe Engineering and Surveying.
- Mobile lidar collection, processing and extraction performed by EMC Inc.
- Hydrographic data collection, processing and mapping performed by EMC Inc.

If there are any questions, please call.

Respectfully,

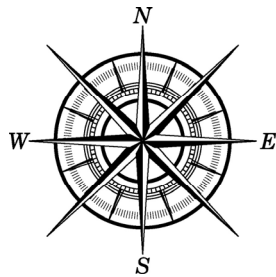
A blue ink signature, likely of a representative from Rowe Engineering & Surveying, written in a cursive style.

ROWE ENGINEERING & SURVEYING

A black ink signature, likely of a representative from EMC Incorporated, written in a cursive style.

EMC INCORPORATED

SECTION 1 : VERIFICATION OF MOBILE CONTROL POINTS



ROWE

ENGINEERING & SURVEYING

March 8, 2023

Via email only

Kiewit Engineering Group, Inc.
10055 Trainstation Circle
Lone Tree, CO 80124
Attn: Todd Shuey

RE: I-10 Mobile River Bridge Project
Control Survey Report

Dear Sir,

- I Task
Verify provided horizontal and vertical positions of approximately 18 control points known as Mobile County Points, as provided by ALDOT
- II Methodology
Using the published State Plane Coordinates for the control points, our field crews navigated to their respective locations and recovered each capped iron rod control point. Each control point has an aluminum cap and is stamped with a designation and year set (2015). After recovery of all points, 2½ hour Static GPS Observations were performed simultaneously on an average of three control points per session. These sessions were processed using OPUS Online Positioning User Service as provided by NOAA. Each day's sessions were processed more than 24 hours after collection to allow of that day's ephemeris to be downloaded. Occupations were performed using a two-meter rod affixed with a Carlson BRX7 GPS Receiver. The vertical position of the control points was verified by performing differential levels between the control points using a digital level (Leica Sprinter 150) and a barcode rod. Each loop was performed by collection of the back site and fore site reading and breaking the setup, reshooting the fore site and back site. This method was performed in order to avoid a return level loop. This method is commonly referred to as the double turn method in our firm. Control points 49-GG and 696 were held for both horizontal and vertical position as static observations very closely matched the published coordinates and elevations.

It should be noted that the level loops and static observations for each point varied very little with most being in the range of 0.02 feet or below. Additionally,

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differential leveling was done using a conventional survey level across the Mobile River from West bank to East bank. When using the true rod readings in this procedure, the elevations matched OPUS elevations very nearly. After applying curvature and refraction, we found closure error of around 0.22 feet. Since this problem could not be resolved, we then ran simultaneous static collection on the original points used in reciprocal leveling. These elevations were used instead of the reciprocal level results and did tie with existing ALDOT and OPUS elevations on the East side of the river.

Below are our final results for verification of ALDOT control:

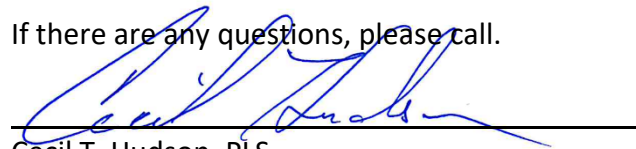
CONTROL POINT SURVEY (AS-SURVEYED)

Horizontal Datum: State Plane, AL WEST ZONE (102), NAD 83 (2011)

Vertical Datum: NAVD 88, Geoid (2018), US/FT

DESCRIPTION	NORTHING	EASTING	ALDOT (2015) ELEVATION	ELEVATIONS (ADJUSTED / LEVELS)
49-GG	240141.338	1791917.723	15.845	15.889
49-GH	240918.7742	1792984.139	33.121	33.155
692	241583.3661	1793805.417	15.920	15.963
693	NOT SURVEYED			
694	242643.823	1795152.441	17.948	17.980
695	243329.136	1795650.147	39.766	39.771
696	244644.3639	1796586.336	29.277	29.344
697	245646.891	1797207.778	30.976	30.941
698	246985.537	1797567.676	18.618	18.607
699	247922.651	1797704.007	19.234	19.229
700	248777.442	1798012.73	31.296	31.288
49-GC	249370.433	1797981.526	32.078	32.047
49-GD	249959.241	1799138.358	5.824	5.781
49-GE	251795.215	1802214.579	12.614	12.546
49-GF	251544.048	1803746.525	5.263	5.220
701	250893.183	1805138.218	5.393	5.340
702	250265.395	1806612.264	4.370	4.348
703	249475.876	1807946.782	19.804	19.840
704	NOT SURVEYED			

If there are any questions, please call.



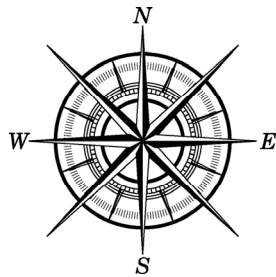
Cecil T. Hudson, PLS

Alabama Licensed Professional Land Surveyor

Registration No. 29983

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SECTION 2 : MOBILE MAPPING TARGET LAYOUT AND COLLECTION



ROWE

ENGINEERING & SURVEYING

June 8, 2023

Via email only

Kiewit Engineering Group, Inc.
10055 Trainstation Circle
Lone Tree, CO 80124
Attn: Todd Shuey

RE: I-10 Mobile River Bridge Project
Mobile Mapping Targets
Survey Report

Dear Sir,

- I Task
Set 274 Mobile Mapping Targets along the East and Westbound shoulder of I-10 and surface streets as depicted on the KMZ file provided.
- II Methodology
Targets were painted along the shoulder of all roads using a template and reflective paint. Additionally, a PK nail was set at the tip of the target on all asphalt surfaces with the PK nail being the actual control point. In situations where targets were painted on concrete surfaces, the tip (arrowhead) is the actual control point. The horizontal position of the targets was collected using RTK GPS with the base set on existing ALDOT control points (previously verified and adjusted by this firm).

For the Wallace Tunnel portion of the survey, control points were set at the entrance of the East and Westbound tubes of said Wallace Tunnel. Targets set along the entrance and inside the tunnel were collected using a total station and traverse method with the back site being collected and the fore site (target) collected and then a return check on the back site before moving the instrument ahead along the traverse.

The vertical portion of the survey was performed along the I-10 roadways using a Leica Sprinter 150 Digital Level with differential levels run between the targets and periodic tie ins to the existing ALDOT control. Elevations along the entrance and into the tunnel was carried using the Total Station with rod heights fixed for both back site and fore site shots. Elevations along elevated roadways was collected

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using RTK GPS only in order to minimize exposure to traffic along these restricted routes.

All points collected along I-10 and elevated roadways were performed at night with the help of a traffic control subcontractor. The majority of the work was performed as a shoulder closure with the exception of the Wallace Tunnel which required a right lane closure.

Below are our final results of targets collected:

TARGET POINTS				
Horizontal Datum: State Plane, AL WEST ZONE (102), NAD 83 (2011)				
Vertical Datum: NAVD 88, GEOID (2018), US/FT				
Point	Northing	Easting	Elevation	Target No.
2001	239168.041	1792269.029	14.662	PK 100
2002	239626.650	1792490.008	15.744	PK 101
2003	240073.279	1792683.666	14.099	PK 102
2004	240602.186	1792927.611	9.116	PK 103
2005	241053.057	1793135.289	14.137	PK 104
2006	241456.438	1793305.496	15.513	PK 105
2007	241918.044	1793518.265	14.930	PK 106
2008	242271.478	1793681.143	14.381	PK 107
2009	239845.958	1792784.543	15.883	PK 108
2010	240432.040	1793043.162	14.721	PK 109
2011	240690.411	1793368.355	12.161	PK 110
2012	241031.916	1793775.117	13.100	PK 111
2013	241309.635	1794150.639	15.001	PK 112
2014	241614.825	1794501.950	12.823	PK 113
2015	241924.233	1794901.015	12.412	PK 114
2016	242229.459	1795297.023	12.970	PK 115
2017	242540.801	1795688.240	9.663	PK 116
2018	242853.752	1796078.193	12.589	PK 117
2019	243241.127	1796318.128	13.355	PK 118
2020	243721.296	1796443.237	11.583	PK 119
2021	244035.982	1796802.406	9.563	PK 120
2022	244492.759	1797082.364	11.766	PK 121
2023	244944.457	1797174.111	12.449	PK 122
2024	240914.788	1793330.995	13.680	PK 123
2025	241186.428	1793665.719	15.402	PK 124
2026	241181.657	1793197.564	15.215	PK 125

2027	241438.093	1793631.271	14.664	PK 126
2028	240110.753	1791921.537	18.745	PK 127
2029	240407.336	1792320.382	16.355	PK 128
2030	240708.844	1792719.338	27.135	PK 129
2031	241008.272	1793115.819	33.734	PK 130
2032	241310.896	1793517.206	20.424	PK 131
2033	241601.651	1793902.878	16.969	PK 132
2034	241920.969	1794309.822	14.979	PK 133
2035	242220.875	1794708.198	14.765	PK 134
2036	242545.042	1795073.447	16.389	PK 135
2037	242915.901	1795372.089	31.253	PK 136
2038	243326.421	1795661.841	40.855	PK 137
2039	243662.234	1795895.491	32.903	PK 138
2040	244141.101	1796244.164	28.372	PK 139
2041	244479.169	1796480.656	29.803	PK 140
2042	244977.720	1796827.911	31.656	PK 141
2043	245393.652	1797087.293	31.393	PK 142
2044	245835.107	1797300.762	32.576	PK 143
2045	246305.048	1797456.677	31.492	PK 144
2046	246793.432	1797543.333	23.678	PK 145
2047	247286.430	1797620.734	17.513	PK 146
2048	247778.894	1797690.239	18.496	PK 147
2049	248263.134	1797775.441	24.640	PK 148
2050	248763.509	1797845.147	31.931	PK 149
2051	249310.120	1797922.228	32.899	PK 150
2052	249766.807	1797991.789	29.375	PK 151
2053	250247.784	1798094.162	23.993	PK 152
2054	250706.839	1798306.335	4.185	PK 153
2055	250948.950	1798739.902	-21.057	PK 154
2056	251101.681	1799219.042	-47.945	PK 155
2057	251253.064	1799693.770	-73.664	PK 156
2058	251407.665	1800179.101	-83.318	PK 157
2059	251560.387	1800657.510	-65.751	PK 158
2060	251709.966	1801126.603	-40.798	PK 159
2061	251862.045	1801603.761	-15.014	PK 160
2062	252027.981	1802078.534	11.644	PK 161
2063	252132.125	1802593.160	33.965	PK 162
2064	252135.811	1803110.717	38.549	PK 163
2065	252062.852	1803583.485	30.718	PK 164
2066	251914.975	1804048.810	23.099	PK 165

2067	251761.162	1804530.292	21.633	PK 166
2068	251609.142	1804985.657	21.598	PK 167
2069	251448.155	1805469.199	21.537	PK 168
2070	251284.744	1805960.354	21.541	PK 169
2071	251121.158	1806453.754	21.593	PK 170
2072	250976.530	1806887.725	21.532	PK 171
2073	250812.139	1807381.788	21.653	PK 172
2074	250649.423	1807871.849	21.921	PK 173
2075	250505.422	1808306.483	23.426	PK 174
2076	250343.061	1808798.087	26.478	PK 175
2077	250178.034	1809291.788	29.593	PK 176
2078	250029.161	1809742.172	29.545	PK 177
2079	249864.755	1810232.653	26.921	PK 178
2080	249701.051	1810725.808	23.928	PK 179
2081	249556.226	1811157.827	22.745	PK 180
2082	239994.768	1792001.470	18.770	PK 181
2083	240293.289	1792397.907	16.195	PK 182
2084	240595.192	1792798.824	27.047	PK 183
2085	240895.621	1793198.491	33.531	PK 184
2086	241191.681	1793591.171	20.921	PK 185
2087	241494.279	1793989.231	17.007	PK 186
2088	241784.021	1794401.532	14.903	PK 187
2089	242089.940	1794802.614	16.743	PK 188
2090	242431.470	1795189.565	20.766	PK 189
2091	242833.668	1795513.422	32.559	PK 190
2092	243299.844	1795838.022	40.186	PK 191
2093	243692.711	1796113.787	29.538	PK 192
2094	244060.641	1796357.685	28.366	PK 193
2095	244457.057	1796644.166	29.911	PK 194
2096	244878.662	1796939.443	32.048	PK 195
2097	245303.013	1797212.869	34.540	PK 196
2098	245641.078	1797382.616	35.618	PK 197
2099	246244.251	1797585.133	34.792	PK 198
2100	246718.288	1797678.122	25.682	PK 199
2101	247216.592	1797759.082	17.926	PK 200
2102	247716.231	1797832.699	18.071	PK 201
2103	248210.166	1797894.370	24.335	PK 202
2105	249171.115	1798122.359	40.703	PK 204
2106	249665.087	1798183.146	42.087	PK 205
2107	250127.835	1798224.430	30.998	PK 206

2108	250691.203	1798400.952	-0.055	PK 207
2109	250890.218	1798759.901	-21.021	PK 208
2110	251038.442	1799224.704	-46.789	PK 209
2111	251192.923	1799708.914	-73.623	PK 210
2112	251342.875	1800179.897	-83.495	PK 211
2113	251503.939	1800684.819	-65.198	PK 212
2114	251650.200	1801142.995	-41.080	PK 213
2115	251802.644	1801620.385	-15.328	PK 214
2116	251946.551	1802092.285	9.111	PK 215
2117	252026.846	1802595.364	31.847	PK 216
2118	251999.419	1803076.333	37.416	PK 217
2119	251875.232	1803532.374	30.488	PK 218
2120	251537.689	1804516.585	21.629	PK 219
2121	251395.940	1804975.502	21.800	PK 220
2122	251234.747	1805464.623	21.755	PK 221
2123	251070.450	1805958.356	21.705	PK 222
2124	250927.441	1806390.438	21.683	PK 223
2125	250762.399	1806883.126	21.730	PK 224
2126	250599.393	1807376.880	21.757	PK 225
2127	250454.674	1807811.805	21.880	PK 226
2128	250292.581	1808302.107	23.696	PK 227
2129	250128.808	1808795.871	26.971	PK 228
2130	249985.671	1809227.733	29.483	PK 229
2131	249815.316	1809736.988	29.386	PK 230
2132	249671.533	1810171.943	26.860	PK 231
2133	249508.520	1810662.644	23.912	PK 232
2134	249342.383	1811158.054	22.140	PK 233
2135	242104.120	1794092.912	13.065	PK 234
2136	242332.794	1794444.331	12.166	PK 235
2137	242417.695	1794863.263	11.653	PK 236
2138	242793.708	1795197.725	12.608	PK 237
2139	243302.041	1794801.189	13.182	PK 238
2140	243230.818	1795319.378	10.486	PK 239
2142	243823.931	1795784.213	11.442	PK 241
2143	243502.491	1796161.139	11.226	PK 242
2144	243570.404	1796148.673	11.757	PK 243
2145	244062.306	1796124.293	23.061	PK 244
2146	244537.791	1796362.430	10.049	PK 245
2147	243904.468	1796315.075	26.063	PK 246
2148	244627.546	1795915.746	11.553	PK 247

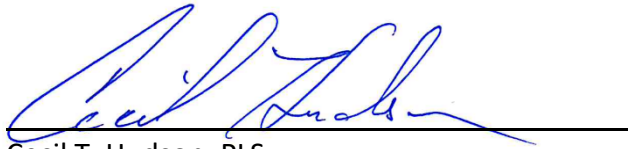
2149	244490.926	1796786.541	9.869	PK 248
2151	244144.225	1797782.279	46.816	PK 250
2152	244626.757	1796383.630	10.778	PK 251
2153	244148.063	1797489.631	11.235	PK 252
2154	244185.632	1797072.705	10.210	PK 253
2155	244781.289	1796518.971	15.707	PK 254
2156	245264.363	1797010.791	31.044	PK 255
2157	244204.327	1796848.196	17.549	PK 256
2158	244342.369	1798039.687	7.590	PK 257
2159	244446.950	1797496.290	12.982	PK 258
2160	244915.404	1797563.297	12.287	PK 259
2161	245398.145	1797631.734	9.937	PK 260
2162	246385.718	1797760.157	9.678	PK 261
2163	246898.305	1797836.549	9.074	PK 262
2164	247375.157	1797886.438	9.865	PK 263
2166	246379.667	1796490.761	12.786	PK 265
2167	245984.275	1796777.382	11.154	PK 266
2168	245757.522	1797137.875	11.874	PK 267
2169	245675.877	1797671.318	10.172	PK 268
2170	248699.305	1798411.893	7.994	PK 269
2171	248896.603	1798690.564	5.206	PK 270
2172	249286.638	1798855.454	6.069	PK 271
2173	246207.601	1797300.123	12.600	PK 272
2174	246599.776	1797398.280	11.030	PK 273
2175	247276.321	1797495.828	11.412	PK 274
2176	247635.994	1797548.169	10.865	PK 275
2177	248137.218	1797619.710	12.469	PK 276
2178	248633.436	1797704.598	12.524	PK 277
2179	249177.398	1797749.926	12.131	PK 278
2180	249668.231	1797784.966	11.551	PK 279
2181	250126.474	1797759.191	13.049	PK 280
2182	246478.962	1797455.389	26.761	PK 281
2183	245997.255	1797685.747	12.040	PK 282
1	246492.743	1797696.547	20.634	PK 283
2185	248806.371	1798132.942	9.896	PK 284
2186	248529.272	1798072.479	10.600	PK 285
2187	248461.879	1798624.116	5.503	PK 286
2188	248865.272	1799118.995	5.083	PK 287
2189	249321.927	1799209.490	6.070	PK 288
2190	249860.454	1799500.604	3.438	PK 289

2191	249896.335	1799097.056	7.401	PK 290
2192	249401.202	1798728.867	6.881	PK 291
2193	248923.931	1797173.377	12.480	PK 292
2194	248920.806	1797660.133	11.815	PK 293
2195	248895.932	1798210.382	8.120	PK 294
2196	249298.318	1798555.490	8.944	PK 295
2197	249613.656	1798841.202	8.496	PK 296
2198	250097.381	1799109.506	6.406	PK 297
2199	250580.265	1799260.144	4.287	PK 298
2200	250986.753	1799285.367	4.302	PK 299
2201	249019.376	1797153.879	12.444	PK 300
2202	249020.589	1797649.388	11.927	PK 301
2203	249016.806	1798153.034	9.795	PK 302
2204	249334.632	1798523.718	8.506	PK 303
2205	249676.211	1798832.668	7.911	PK 304
2206	250060.101	1799050.325	6.696	PK 305
2207	250574.994	1799044.762	6.716	PK 306
2208	249332.275	1798285.327	46.951	PK 307
2209	249729.786	1798646.213	57.249	PK 308
2210	250104.039	1798960.612	37.421	PK 309
2211	250547.611	1799171.134	30.269	PK 310
2212	251028.435	1799210.044	8.420	PK 311
2213	249833.402	1797861.266	12.242	PK 312
5	249423.103	1798018.991	28.385	PK 314
3	249799.382	1798384.980	21.003	PK 315
2218	251017.616	1799159.169	6.339	PK 317
2219	251484.021	1799062.451	4.363	PK 318
2220	251614.837	1799146.422	4.222	PK 319
2221	249711.405	1798183.802	65.105	PK 320
2222	250108.336	1797954.839	43.418	PK 321
2224	250014.675	1798527.771	27.591	PK 323
2226	251150.443	1799094.658	4.873	PK 325
2227	252571.292	1801990.056	4.602	PK 326
2228	252596.713	1802542.809	6.082	PK 327
2229	252403.214	1802979.373	7.872	PK 328
2230	252189.214	1803475.384	20.573	PK 329
2231	251999.857	1803913.931	24.615	PK 330
2236	250345.449	1799366.320	7.070	PK 335
2237	250660.709	1799404.050	7.392	PK 336
2240	250185.851	1801526.489	8.043	PK 339

2241	250626.969	1801581.221	10.135	PK 340
2242	251123.851	1801572.123	15.786	PK 341
2243	251646.656	1802145.725	13.165	PK 342
2244	251771.238	1802630.586	7.457	PK 343
2245	251551.185	1803046.204	6.545	PK 344
2246	251436.707	1803631.952	4.024	PK 345
2247	251261.379	1804006.338	3.850	PK 346
2248	251983.159	1801893.319	14.795	PK 350
2249	251946.076	1802215.571	15.725	PK 351
2250	251661.528	1801892.727	15.149	PK 352
2254	251445.931	1801520.438	17.829	PK 353
2255	251677.292	1801445.873	15.924	PK 354
2253	251935.993	1801766.471	14.689	PK 355
2254	252223.375	1802125.947	5.243	PK 356
2258	252297.353	1801716.562	6.686	PK 357
2260	251986.182	1802567.881	4.672	PK 359
2258	251580.900	1803487.172	3.913	PK 360
2261	251750.367	1803021.689	17.843	PK 360
2262	251817.416	1803513.200	28.519	PK 361
2263	251706.429	1804004.149	23.288	PK 362
2264	252399.984	1802004.366	4.913	PK 366
2265	252127.057	1802408.136	5.720	PK 367
2266	251911.077	1802859.288	5.649	PK 368
2267	251689.983	1803330.269	4.532	PK 369
2268	251453.180	1803818.195	4.705	PK 370
2269	251218.233	1804317.488	4.121	PK 371
2270	251026.570	1804732.674	3.622	PK 372
2271	250818.703	1805208.652	3.905	PK 373
2272	250626.831	1805618.980	3.541	PK 374
2273	250421.935	1806031.729	3.054	PK 375
2274	250203.909	1806505.463	4.497	PK 376
2275	249984.367	1807002.655	4.655	PK 377
2276	249761.137	1807441.680	5.193	PK 378
2277	249554.988	1807772.309	13.249	PK 379
2278	252380.332	1802173.738	4.433	PK 380
2279	252150.344	1802548.619	4.569	PK 381
2280	251921.700	1803031.519	5.057	PK 382
2281	251743.168	1803417.264	4.873	PK 383
2282	251316.187	1804334.710	4.437	PK 384
2283	251094.193	1804801.983	4.747	PK 385

2284	250893.333	1805231.746	4.427	PK 386
2285	250679.843	1805690.297	4.153	PK 387
2286	250431.399	1806223.803	3.974	PK 388
2287	250248.638	1806621.452	4.652	PK 389
2288	250050.960	1807048.077	5.309	PK 390
2289	249821.305	1807531.898	7.434	PK 391
2290	249548.501	1807936.350	18.387	PK 392
2293	251547.829	1803865.103	4.591	PK 395

If there are any questions, please call.



Cecil T. Hudson, PLS
Alabama Licensed Professional Land Surveyor
Registration No. 29983



SECTION 3 : MOBILE LiDAR COLLECTION AND MAPPING SURVEY REPORT

Survey Report

I-10 Mobile River Bridge Project
CPMS No. 100073596
Mobile LiDAR Collection and Mapping

EMC Job No. 23034

June 2023

Prepared for:

Kiewit Massman Traylor, A Joint Venture



Prepared by
2472 Sunset Drive,
Grenada, MS 38901
(662) 226-5166

Executive Summary

EMC was tasked with providing mobile lidar collection and extraction within the limits provided. The dataset was to be controlled using control information provided by the client. This is to certify that the lidar survey and resulting mapping efforts meet the requirements specified and that the project was performed under my supervision. Date of report: 6-22-2023.



Table of Contents

Section 1: Project Description

Section 2: Survey Summary

Appendices

Appendix A – Equipment Spec Sheets

Appendix B – Lidar to Control Target Comparison

Section 1: Project Description

EMC was tasked with collecting mobile LiDAR data and extracting requested features, on the specified areas within the I-10 corridor near Mobile, Alabama. Below is the initial scope of services as provided by the client concerning our teams' tasks for this project.

Kiewit Mobile Mapping Request

Project Requestor

Dexter Fordyce

Project Name

Mobile River Bridge (PDB)

District

KIE

Proposal Due Date

TBD

Project Manager

Dexter Fordyce

Proposal Start

TBD

Project Description

The project consist of a Type A Mobile Mapping collection of 40.5 miles (straight line distance), roughly a 122 miles of redundant collection.

The project is located in Mobile Alabama.

Project Limits (Google Map URL)

KMZ provided

Horizontal Datum

Alabama State Plane NAD 83/20

Vertical Datum

NAVD 88

Bid Level Survey Requirement

- ☒ Level A – Fully Controlled Acquisition
- ☐ Level B – Semi-Controlled Acquisition
- ☐ Level C – Uncontrolled Acquisition

CADD Deliverable Format

- ☒ MicroStation (DGN)
- ☐ AutoCAD (DWG)
- ☐ OpenLSEF Standards

DTM Deliverable Format

- ☐ InRoads
- ☐ Civil 3D
- ☒ TopoDot Ready

Deliverables**Survey Control Report**

- ☐ Simple Narrative
- ☒ Complete Report with Analytics

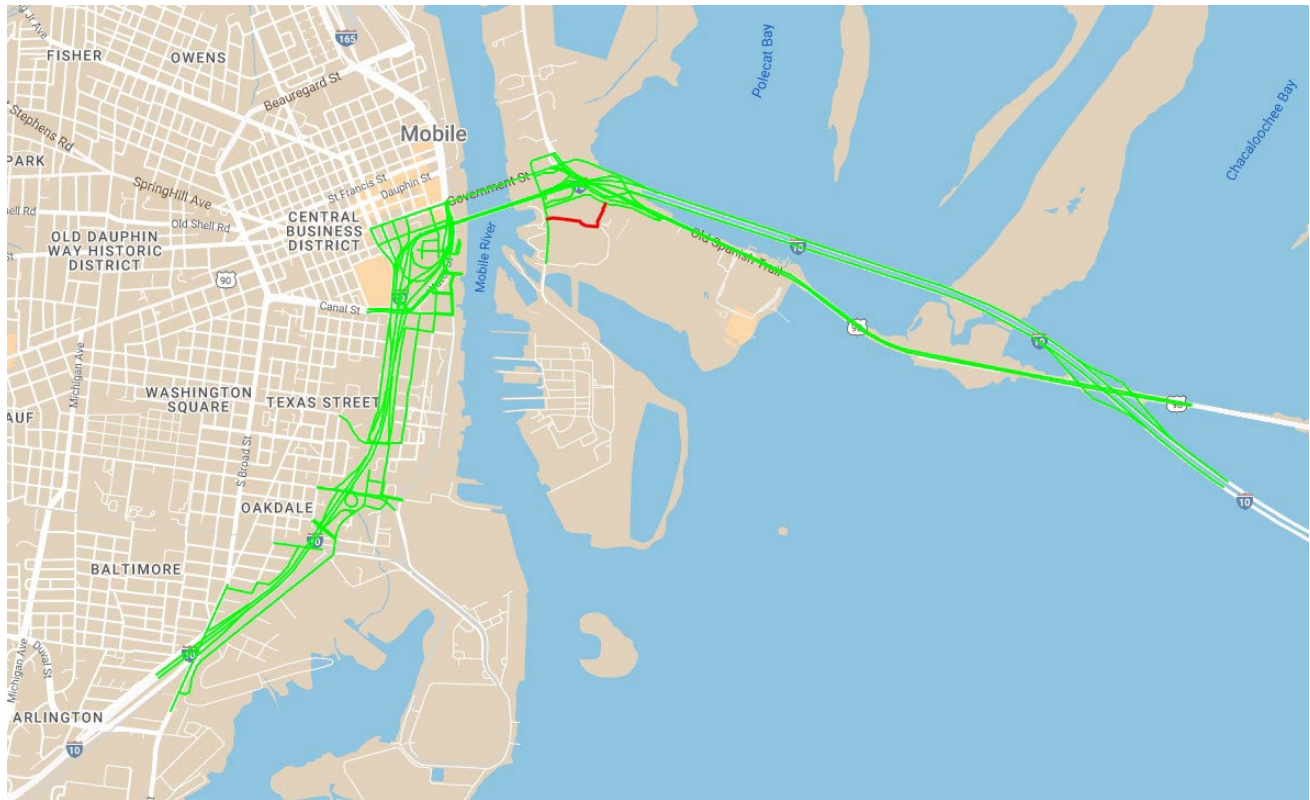
Raw Data

LAS Files – Tiled (\$)	A
-Ground Classified (\$\$)	A
-Completely Classified (\$\$\$)	A
-Colorized (\$)	A
-Cleaned of Noise (\$\$)	A
Trajectories in DGN or KML (\$)	A
Calibrated Images	A
Planar?	Yes
Panoramic?	Yes
Traffic control required	Yes
Who provides traffic control	Kiewit

Feature Extraction

Carriage Lane Lines (\$)	A
Edges of Pavement (\$)	A
Grade breaks (\$)	A
Digital Terrain Model - without breaks (\$)	N/A
Digital Terrain Model - using breaks & points (\$\$)	A
Curb and Gutter (\$\$)	A
Pavement Joints (\$\$)	N/A
Structures / 3D Faces (\$\$)	A
Barriers (\$\$)	A
Guard Rail (\$\$)	N/A
Bridge Clearance (\$)	A
Bridge Features (\$)	N/A
Approach Slab (\$\$)	A
Overhead Utilities (\$)	N/A
Visible Utilities (\$\$)	A
Drainage Catch Basins and Culverts (\$)	N/A
Overhead Catenary Systems - for Rail (\$\$\$)	N/A
Rail Head and Center Line (\$)	N/A
Signs and Sign Types (\$)	N/A
Trees - major trunks and drip lines (\$)	N/A
Vegetation Limits (\$\$\$)	N/A
ADA Ramps (\$)	N/A
Asset Management (TBD)	N/A

B: Vicinity Map



Section 2: Survey Summary

All Field design survey data collections and on-site work were executed by EMC, Inc Under the direction of an Alabama PLS Mark Mattox for the duration of the project.

Table 1 lists the personnel who will require access to the border location(s) and the survey site. Backup personnel will require access to the site in the event of unplanned occurrence(s) (e.g. illness, hardware malfunctions, etc.). All personnel are US citizens.

Name	Role	Contact Information
Josh Mattox	Project Manager	662-392-5877
Mark Mattox	AL PLS	662-226-5166
Jake Mattox	LiDAR Manager	662-392-5877
David Tubbs	LiDAR Technician	662-226-5166
Brantley Shaw	LiDAR Technician	662-226-5166

Mobile Lidar Collection was performed using a Riegl VMX450 running a 360-degree camera system. All lidar and Images were collected using RiAquire acquisition software. EMC ran a local GPS Base station during the entire collection to use in the post processing of the Lidar data. The collection vehicle collected every lane for the entire project area.

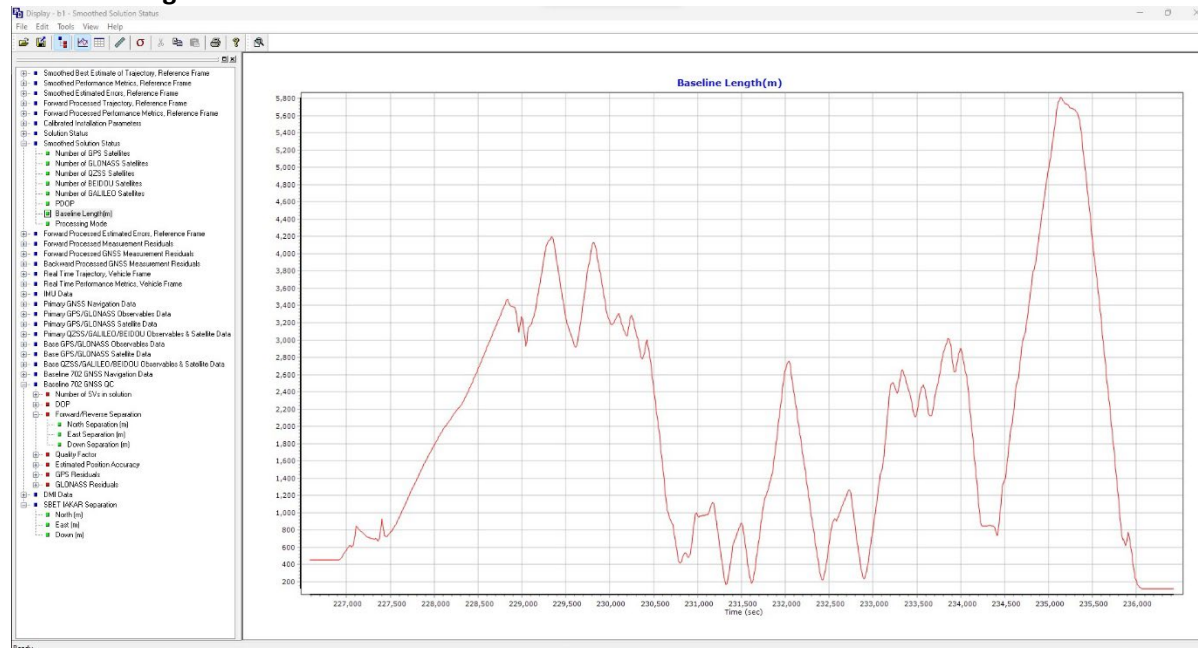
Upon completion of collection, the data were post processed first using Applanix PosPac software to obtain a PPK trajectory solution. That was then applied using Riegl RiProcess software. All initial

processing and checks were completed. Upon receiving the ground targets from the 3rd party contractor EMC imported that data and checked it against the lidar. A spreadsheet containing those results is included as appendix B to this report. Once the lidar was verified the data were colorized to produce RGB Laz files for use in data extraction. The images were also be exported as jpg images for use in mapping software. Finally, the data were imported into Microstation. Extraction was performed using Topodot software within the Bentley Openroads software suite.

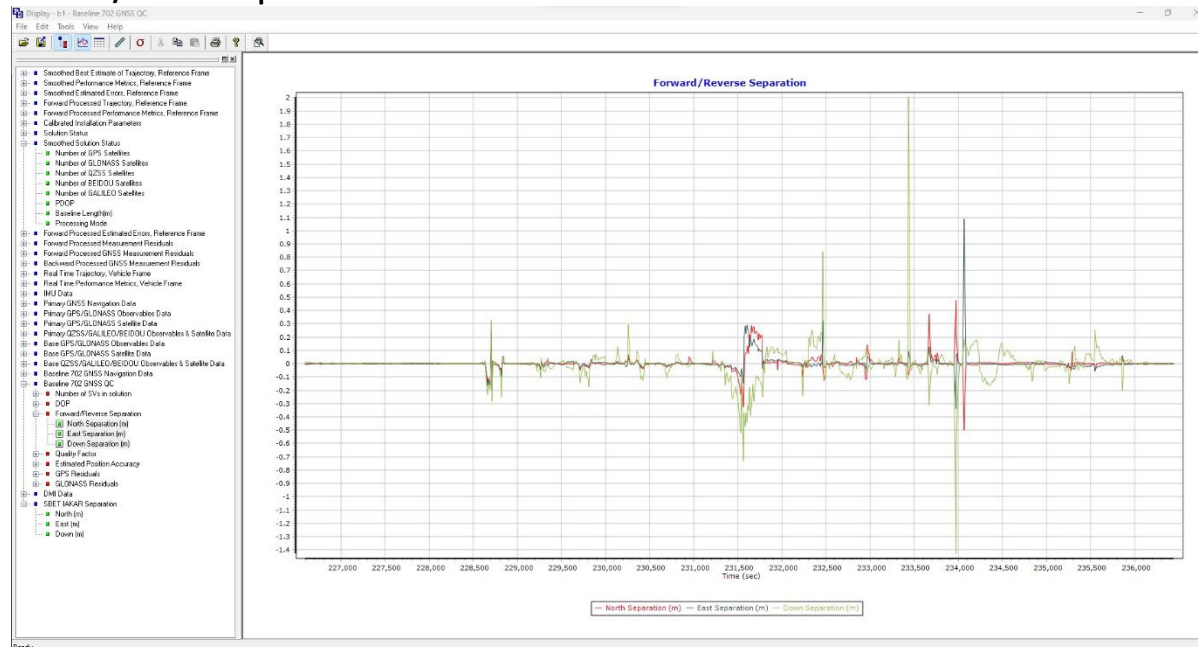
Data Processing Reports

Day 1 – Mobile River Bridge – Boat Data

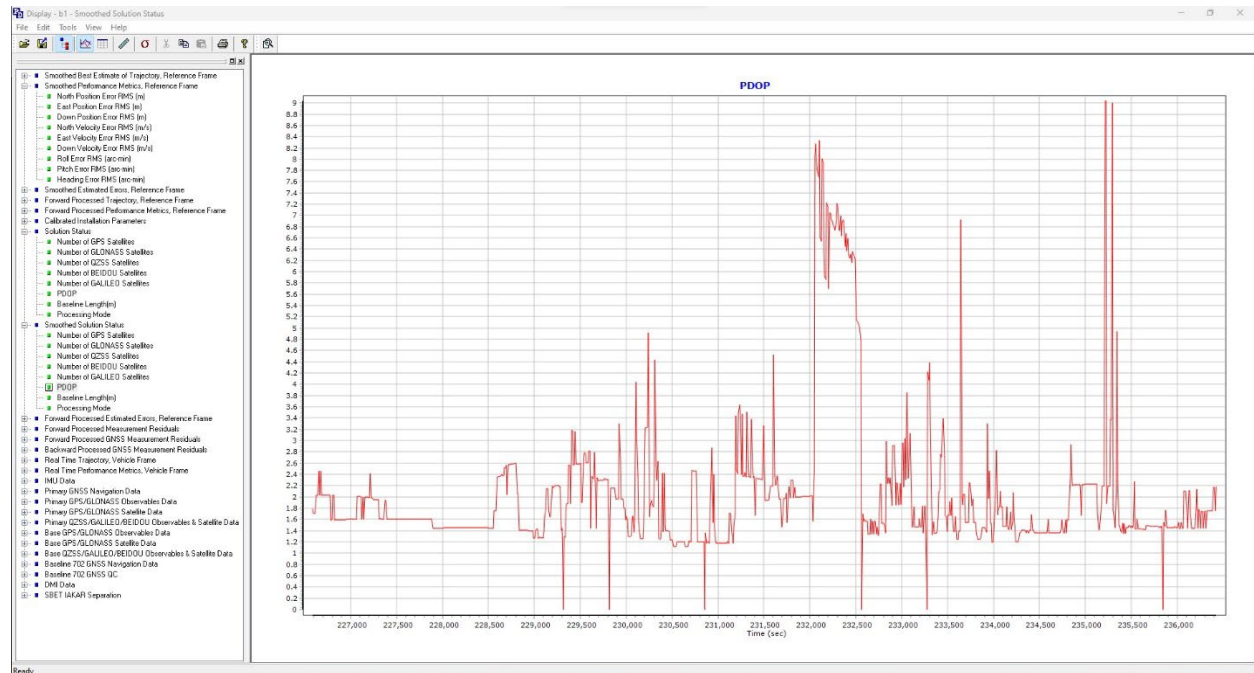
Baseline Length



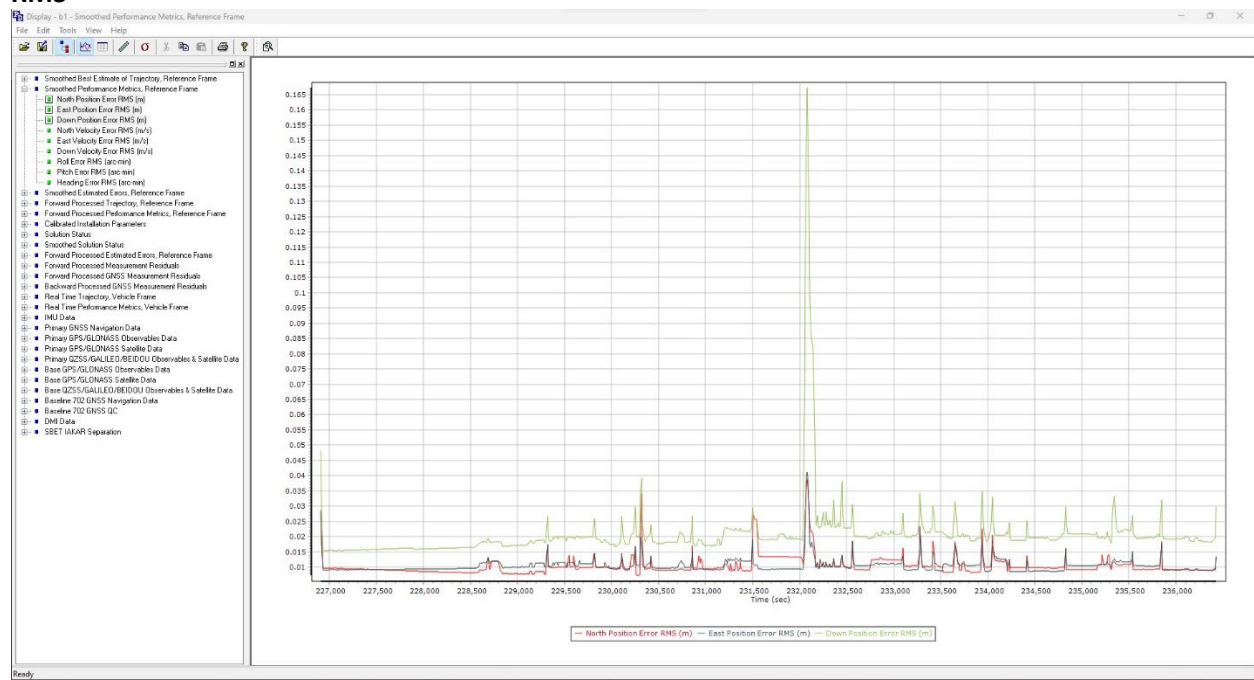
Forward/Reverse Separation



PDOP

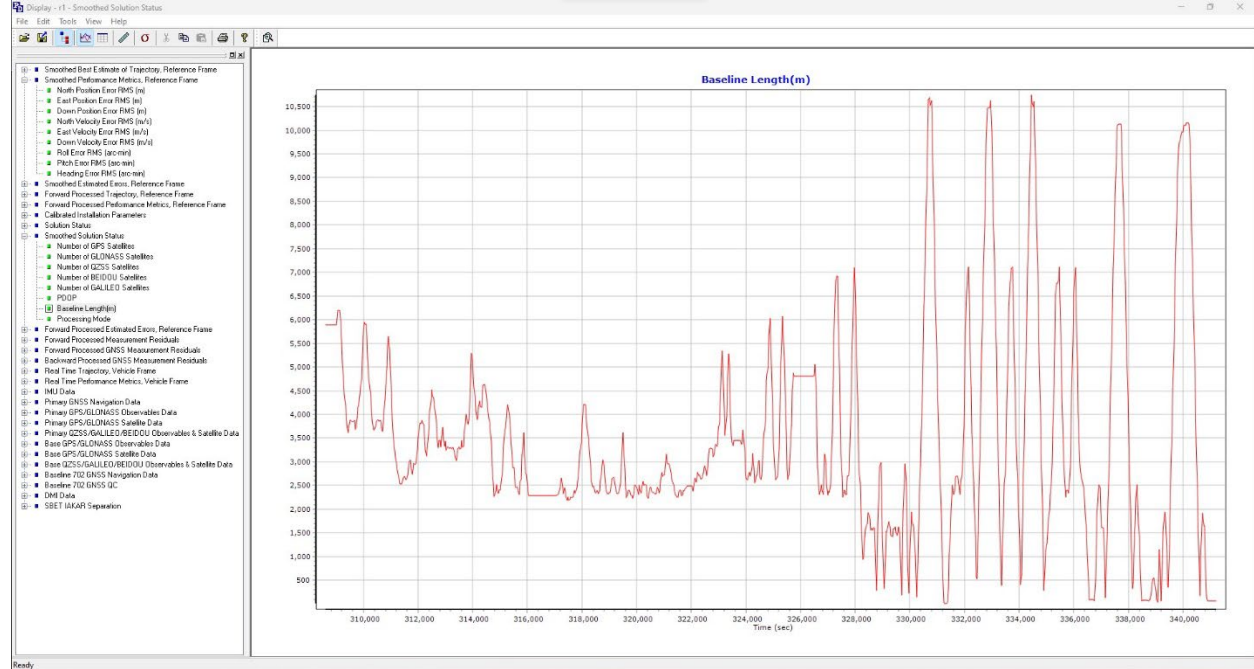


RMS

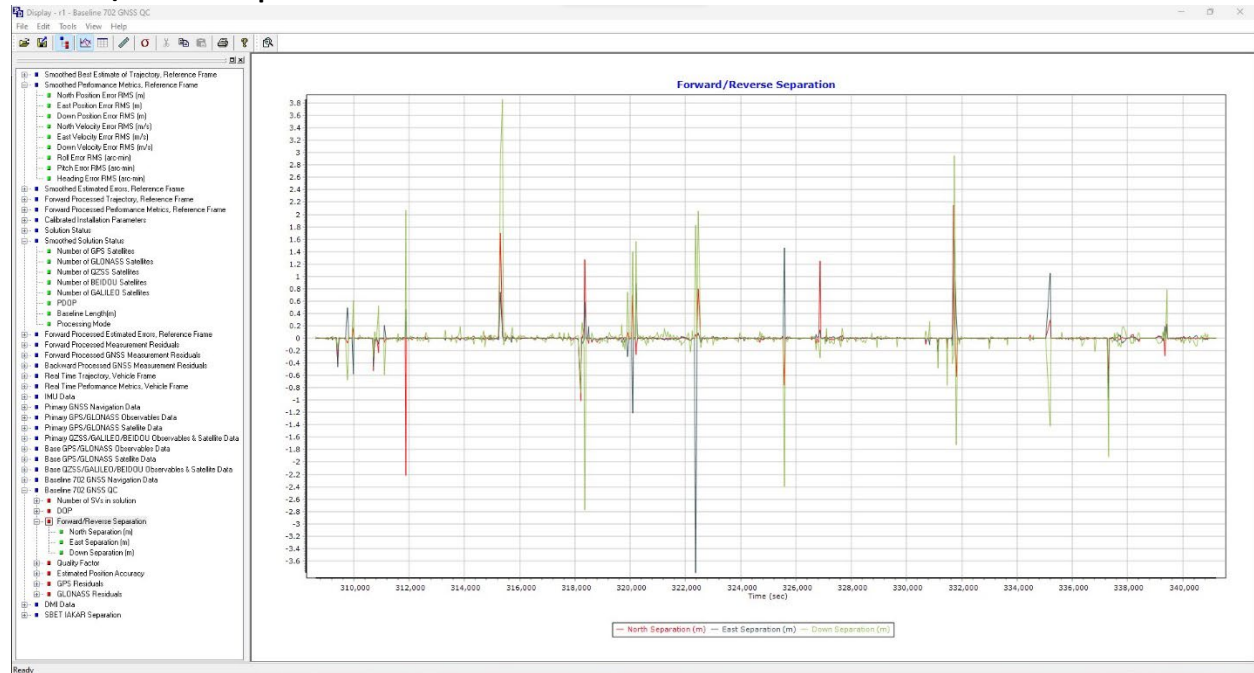


Day 2 – I-10 Corridor – Vehicle Data

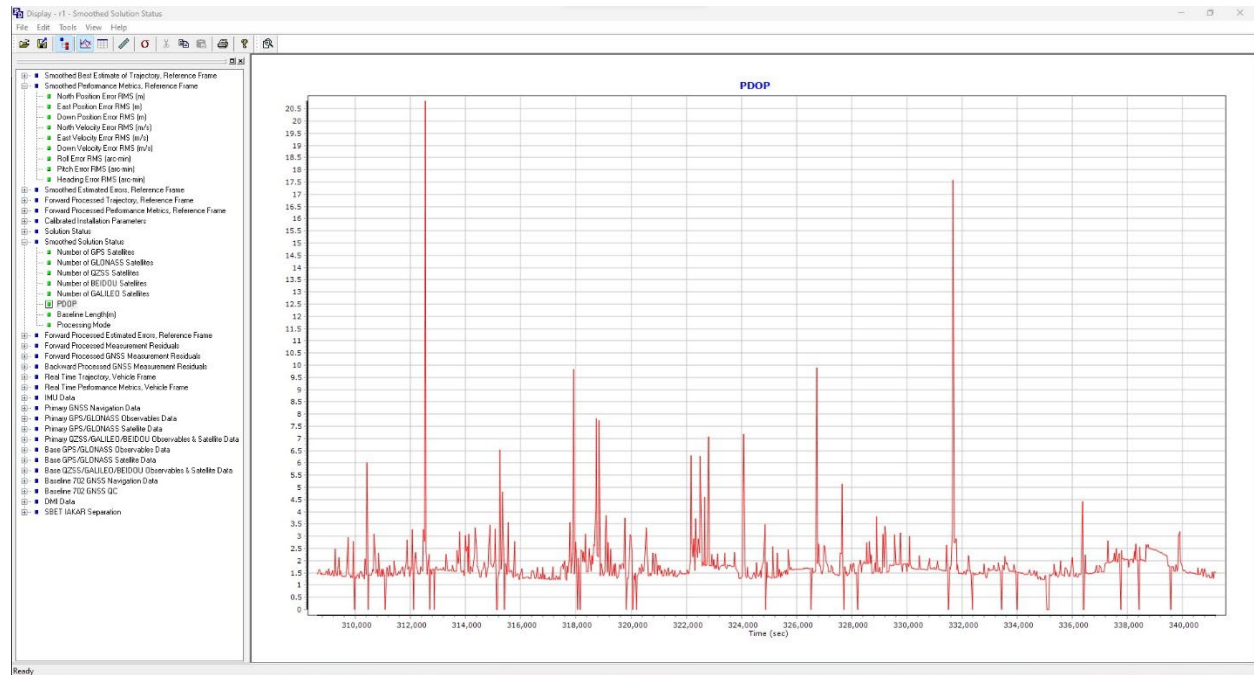
Baseline Length



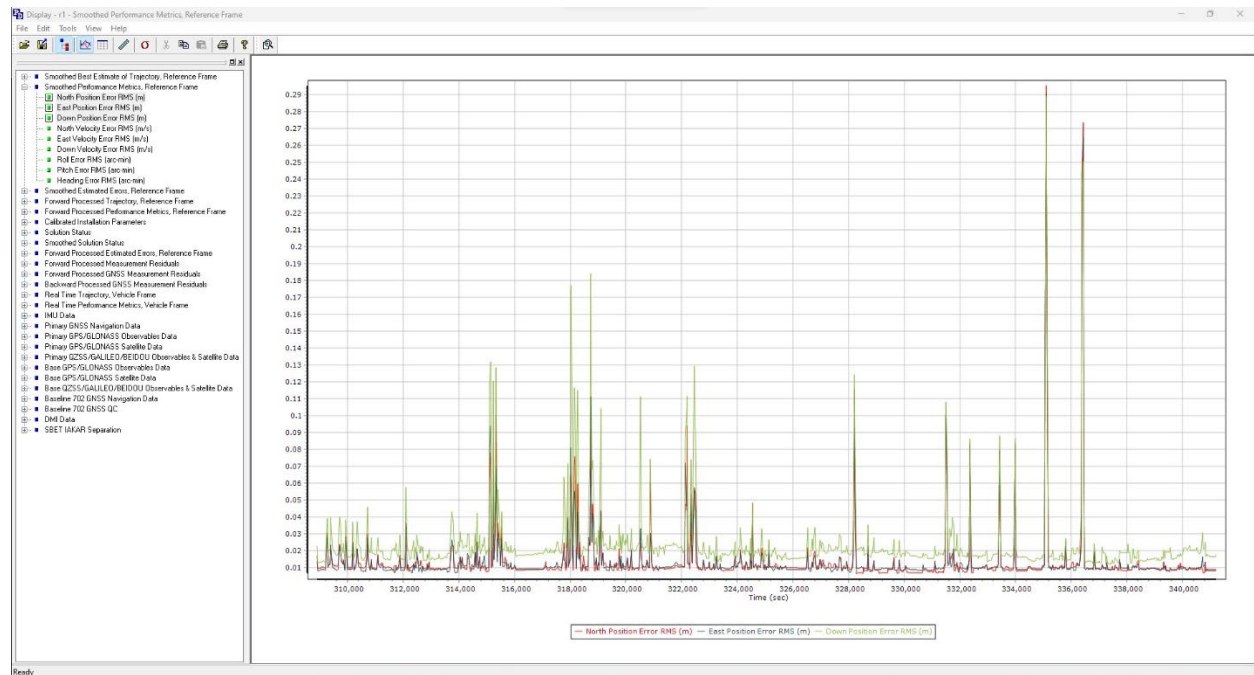
Forward/Reverse Separation



PDOP

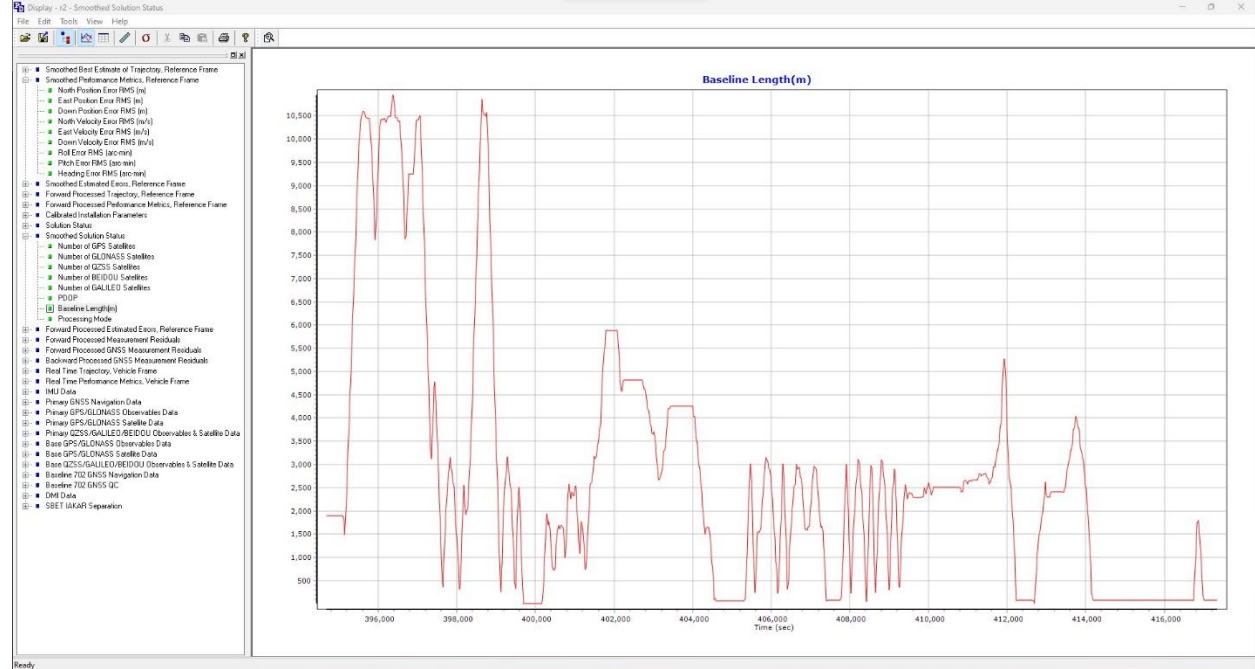


RMS

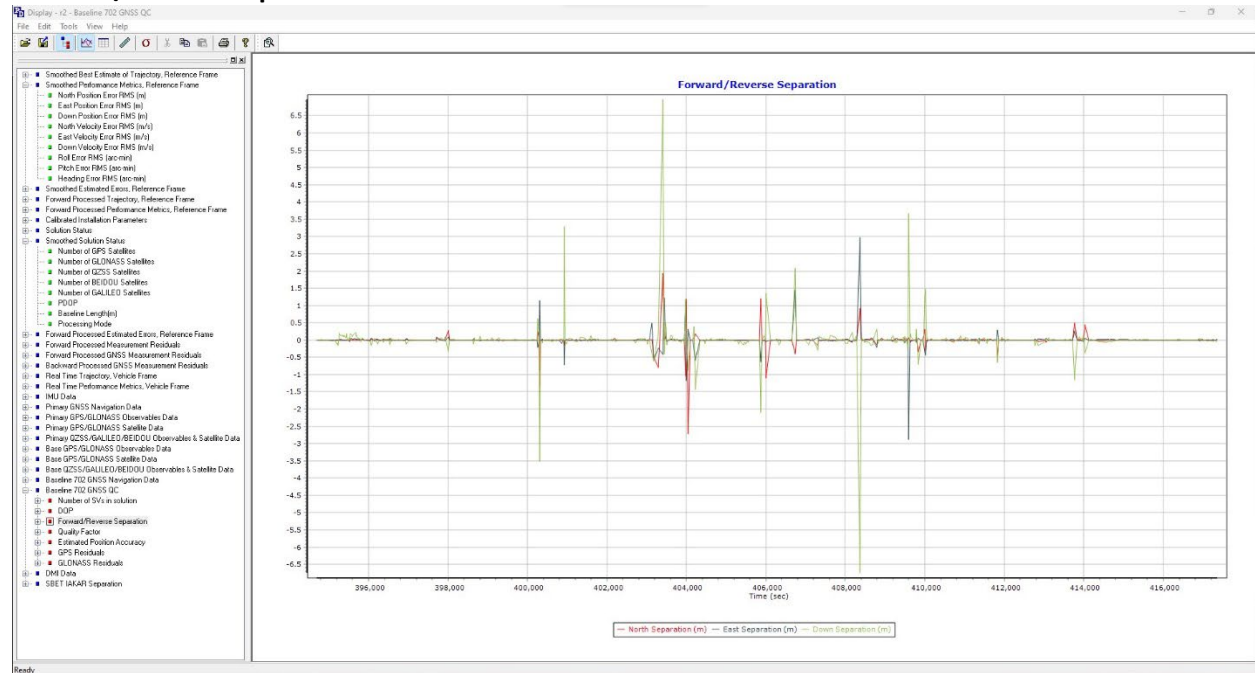


Day 3 – I-10 Corridor – Vehicle Data

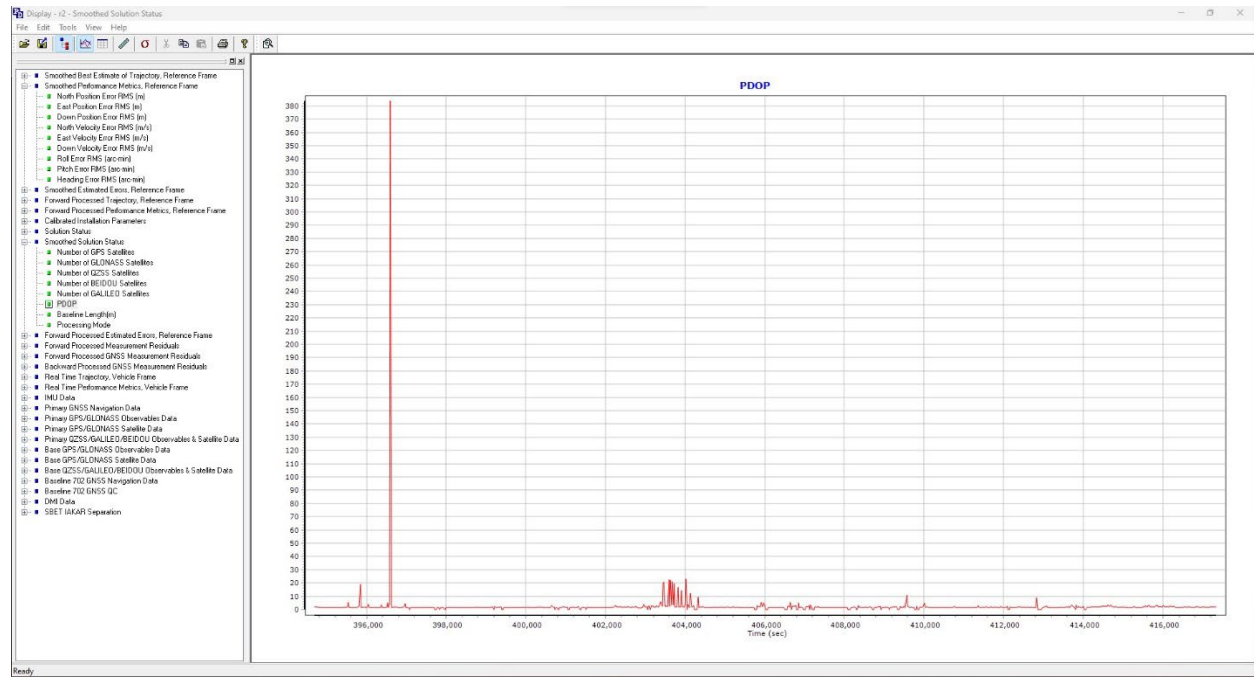
Baseline Length



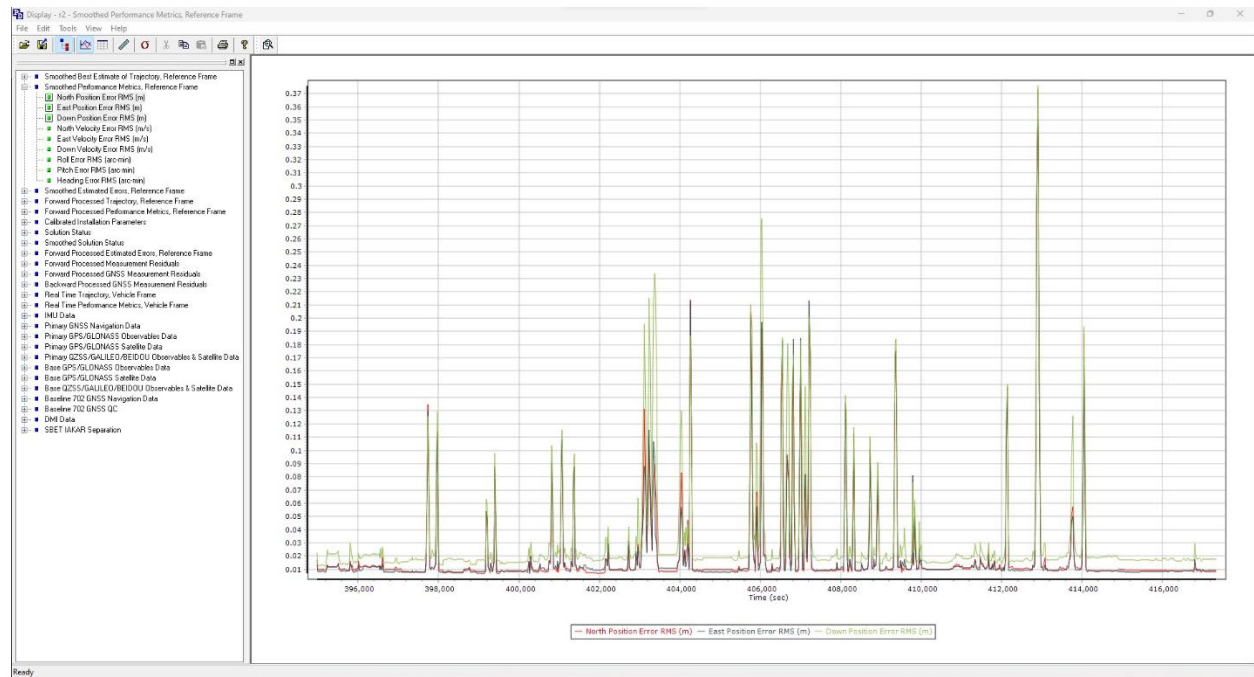
Forward/Reverse Separation



PDOP



RMS



Comparison of Elevation data from overlapping side runs



Deliverables

The final submittal includes the following:

- Survey Summary Report
- Calibrated and aligned point cloud
- LAZ/LAS files, tiled for use in TopoDot software
- Colorized point cloud
- Fully Classified Point Cloud
- Images
- Surface using feature line extraction

Appendix A – Equipment Spec Sheets

Compact Mobile Laser Scanning System

RIEGL VMX-450[®]

- 2 RIEGL VQ-450 scanners smoothly integrated with IMU/GNSS unit
- very high measurement rate up to 1.1 million meas./sec
- scanning rate up to 400 lines/sec
- eye safe operation (laser class 1)
- high penetration of obstructions (e.g. fences, vegetation) by means of echo digitization and online waveform processing
- precisely time-stamped images of up to 6 high-resolution cameras
- fully-calibrated system
- user-friendly mounting and installation, short setup time
- compact and lightweight design
- aerodynamically-shaped protective cover

The RIEGL VMX-450 Mobile Laser Scanning System offers extremely high measurement rates providing dense, accurate, and feature-rich data even at high driving speeds.

The roof-carrier mounted measuring head integrates two RIEGL VQ-450 laser scanners as well as inertial measurement and GNSS equipment, housed under an aerodynamically-shaped protective cover. A well-designed camera platform ensures user-friendly mounting and setup of up to six digital cameras.

Fast 3D data collection, featuring high accuracy and high resolution, provides a basis for a variety of applications like mapping of roadways and rail corridors (e.g. route inventory, noise protection, clearance gauge), waterways, ports, and harbors (e.g. river banks, jetties, cliffs) as well as extended urban and vacant areas.

Typical applications include

- Mapping of Transportation Infrastructure
- City Modeling
- Fast Mapping of Construction Sites
- Surveying of Mining / Bulk Materials
- Network Planning

visit our website
www.riegl.com



RIEGL[®]
LASER MEASUREMENT SYSTEMS

System Description *RIEGL* VMX®-450



1) The installed IMU is listed neither in the European Export Control List (i.e. Annex 1 of Council Regulation 428/2009) nor in the Canadian Export Control List. Detailed information on certain cases will be provided on request.

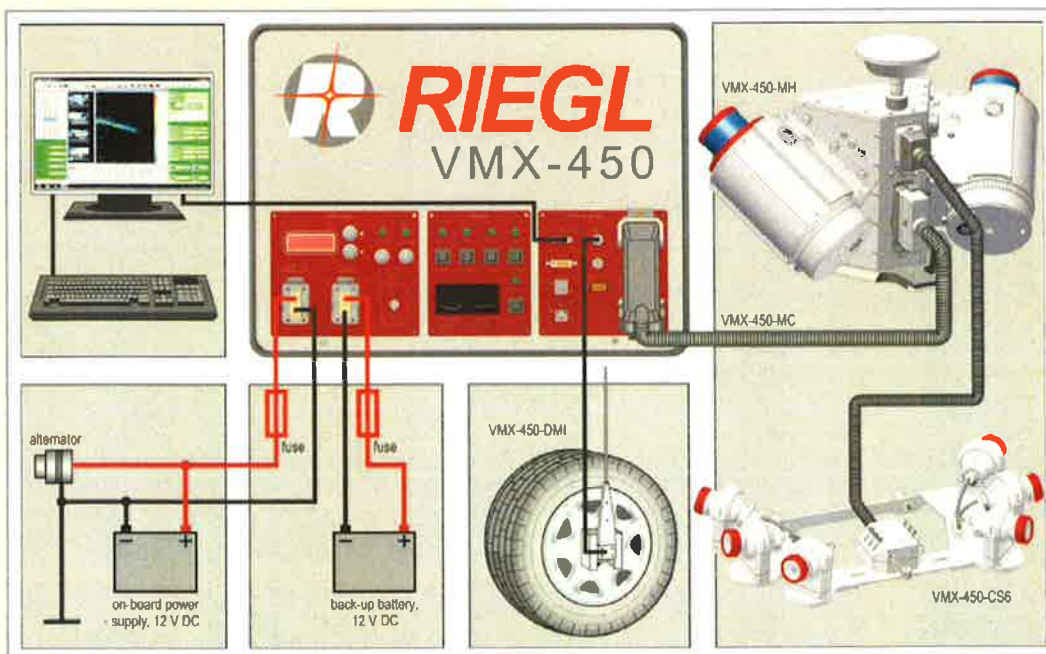
The *RIEGL* VMX-450 comprises fully-integrated and calibrated laser scanners, IMU/GNSS equipment, optional camera sub-system, and corresponding *RIEGL* software packages. Modular design and genuine mounting mechanism ensure quick setup on different vehicles (or vessels, railcars) and reduce post-processing efforts to a minimum in a seamless workflow from data acquisition to highly accurate survey-grade 3D point cloud in common global and local coordinate systems. The integrated IMU/GNSS allows the system to be operated practically worldwide¹⁾. System calibration is maintained even when the system is removed, shipped or stored.

Each of the two *RIEGL* VQ-450 laser scanners provides low-noise, gapless 360° profiles at a measurement rate of 550,000 meas./sec and a scan rate of up to 200 profiles/sec. *RIEGL*'s unrivaled echo signal digitization technology with online waveform processing results in excellent multiple target detection capability and provides calibrated amplitude and reflectance readings as valuable attributes to each point of the final point cloud.

The VMX-450-CS6 camera sub-system complements the scan data by precisely time-stamped images. Intrinsic calibration of the cameras is provided as well as seamless integration into the entire acquisition and processing workflow. Additional options include integration of POINT GREY Ladybug5 camera.

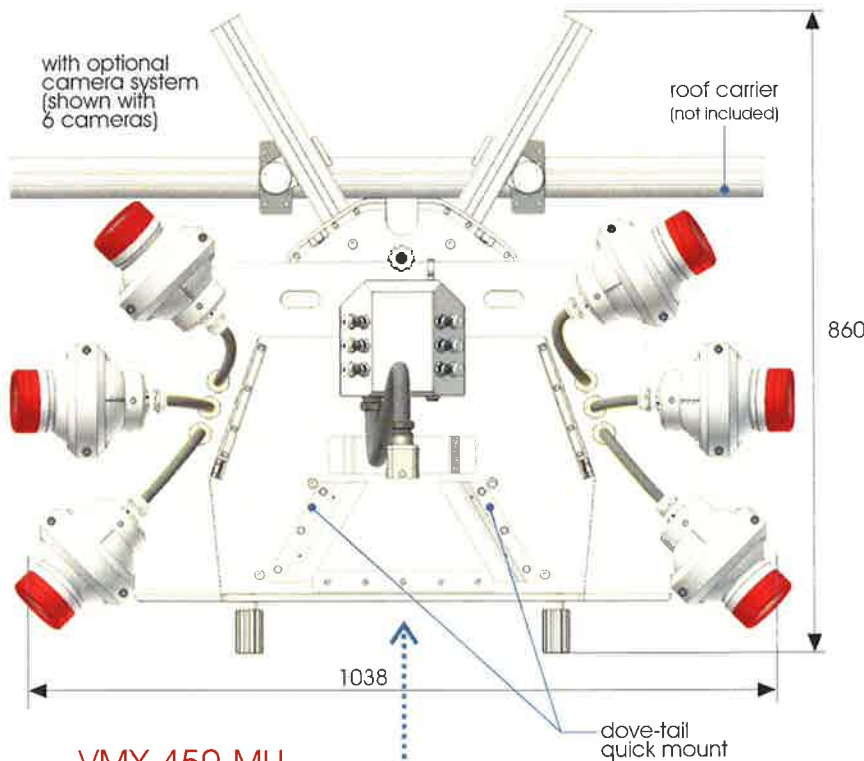
Data acquisition and operator control is accomplished through the compact control unit box VMX-450-CU, optimized for easy transportation and powered directly from the vehicle's onboard power supply. A handy touch-screen, feedback of device states and online monitoring data facilitate the operator's tasks in the field.

The included *RIEGL* software packages offer comprehensive and comfortable features in data processing, covering enhanced scan data adjustment tools, incorporating control points, synchronous measurements in scan data and images, colorizing point clouds, and even combination with other data sets of e.g. *RIEGL* airborne laser scanners. Finally, export your precise geo-referenced results in global and local coordinates or make use of direct interfaces to third-party software.

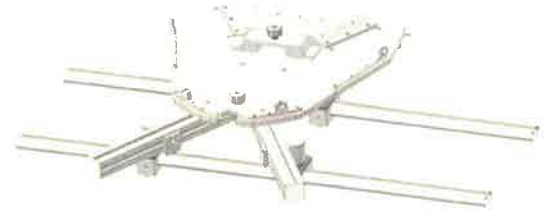


RIEGL VMX-450 system components with optional camera system VMX-450-CS6

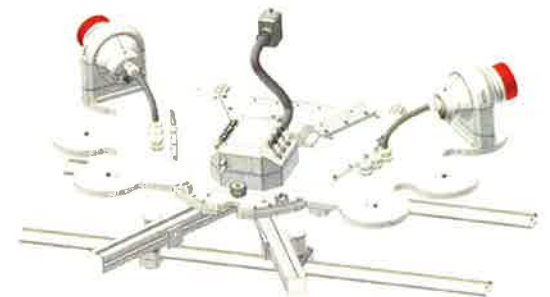
VMX-450-RM Roof Mount



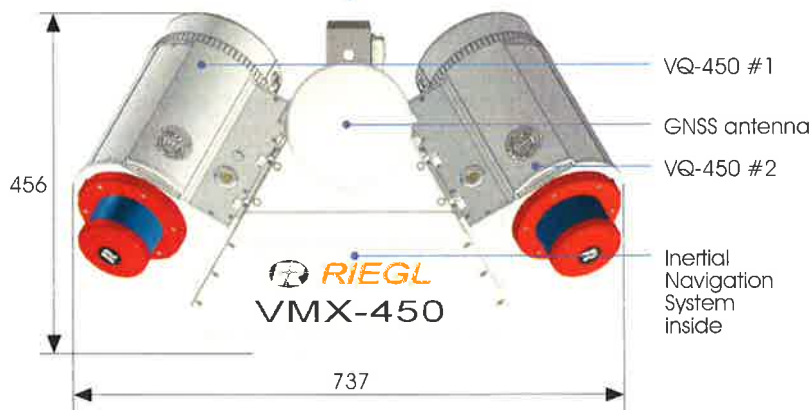
without camera system



with optional camera system (shown with 2 cameras)



VMX-450-MH Measuring Head



with optional camera system (typical configuration with 4 cameras) and protective cover

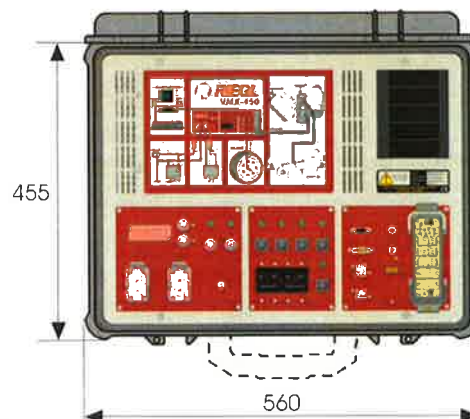


VMX-450-MC Main Cable



all dimensions in mm

VMX-450-CU Control Unit



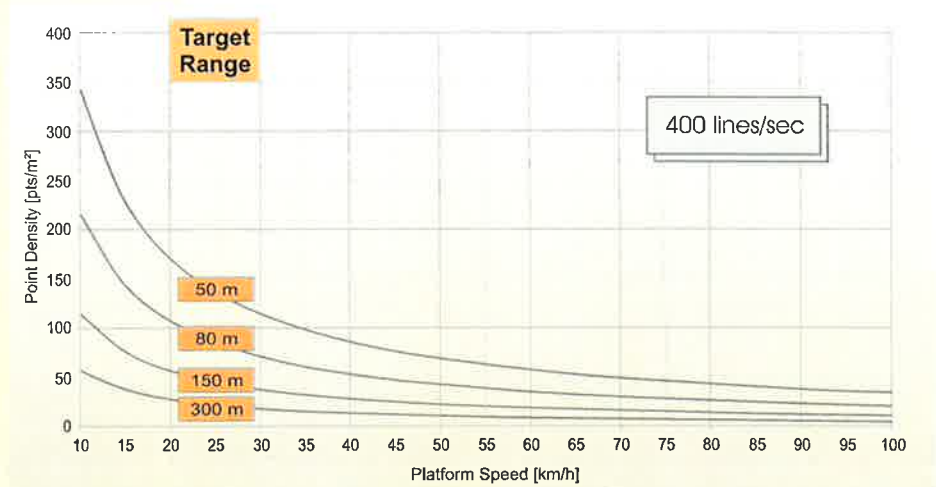
VMX-450-DMI

Distance Measurement Indicator

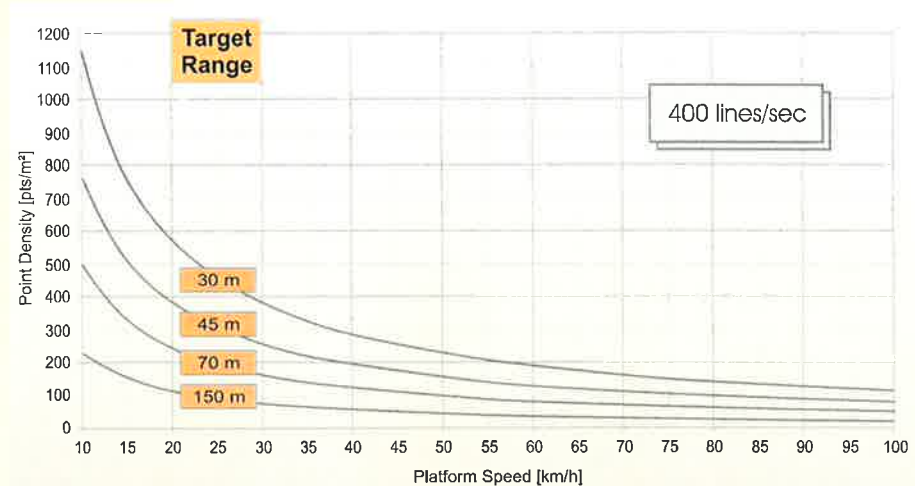


Point Density Charts *RIEGL VMX[®]-450*

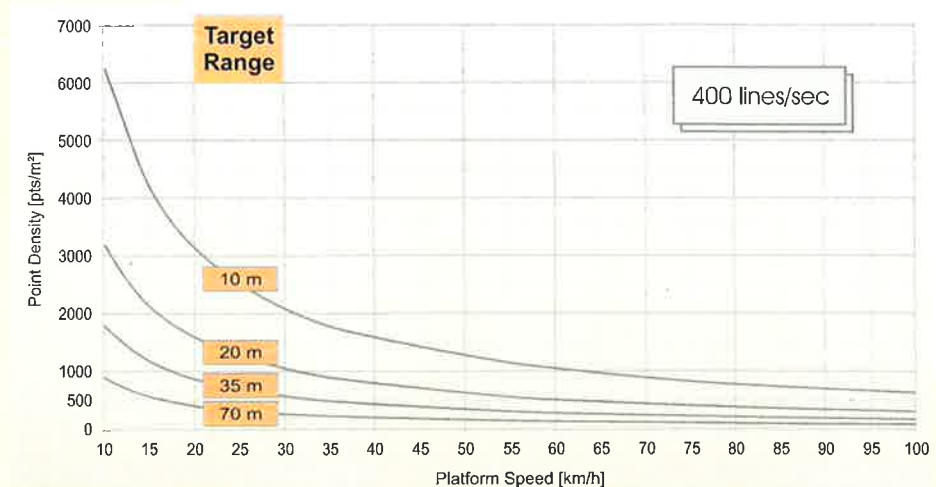
PRR = 300 kHz: for long range applications



PRR = 600 kHz: for medium range applications



PRR = 1.1 MHz: for high-resolution mobile laser scanning in urban areas



RIEGL Software for Mobile Laser Scanning

RIACQUIRE

- Project-oriented acquisition software for *RIEGL* mobile scan data
- Management of integration settings and calibration parameters
- Control and parameterization of scanners and cameras
- Online visualization of monitoring data and image preview
- Status feedback on all system components
- Quality assurance assistance by event history and project report

RIPROCESS

- Project-oriented processing software for *RIEGL* mobile scan data
- Fast access to point cloud data in different visualization formats
- Advanced scan data adjustment (relative and absolute)
- Tools for processing scan and image data
- Software plugin **RIPRECISION MLS** (optional) for fully automated scan data adjustment
- Synchronous measurements in point cloud and images
- Combination with *RIEGL* airborne laser data
- Data export into global/local coordinates and interfaces to third-party software
- Operation in a multiple-workstation environment and parallel task processing

RIWORLD

- Transformation of scan data into geo-referenced point cloud data
- Consideration of geometrical system description and calibration parameters (e.g. lever arms)
- Support of different formats of position and orientation data
- Smoothly integrated into RIPROCESS task management
- Interfacing to third party software packages



RIEGL VMX-450-CS6 Camera System (optional)

The standard configuration of the optional camera system comprises 4 cameras with 5-megapixel resolution. Images are precisely time-stamped and the intrinsic camera calibration is offered as a *RIEGL* factory service. The unique and flexible spherical mounting mechanism allows flexible orientation according to project requirements. The exterior orientation can be easily determined by tools within RIPROCESS. Additionally, a wide range of cameras can be added to the system like DSLR cameras, thermal or hemispherical cameras. Up to 6 cameras are supported in total.

5 MPx Camera Specifications:

2/3" color CCD, global electronic shutter (progressive scan)

Pixel Array: 2452 x 2056 (H x V), 3.45 x 3.45 μm^2

Interface: Gigabit Ethernet

Trigger: distance-based / constant time-interval (each camera individually)

Exposure: 38 μs to 60 s, auto / manual

Gain: 0 to 32 dB, auto / manual

Field of View: 80° x 65° (H x V), 5 mm lens

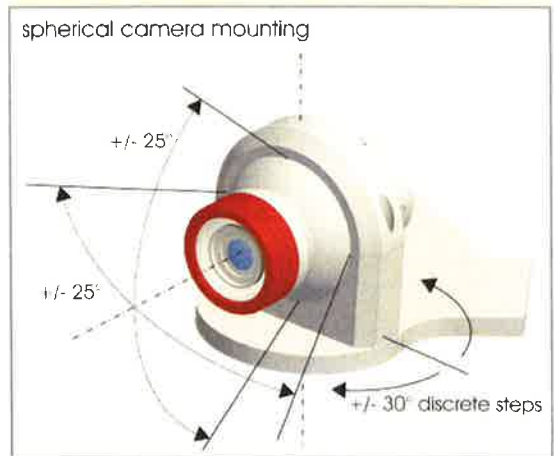
Max. frame rates: 3¹⁾ @ 6 cameras

5²⁾ @ 4 cameras

8³⁾ @ 2 cameras

Other lens types on request.

- 1) In a typical configuration with four 5 MPx cameras. Maximum frame rate of a single camera is 9 fps.
- 2) Limited by transfer rate to HDDs.
- 3) Limited by max. trigger rate of CCD sensor.



3D point cloud
(true color coded)

Technical Data Mobile Laser Scanning System *RIEGL* VMX[®]-450

Laser Product Classification

Class 1 Laser Product according to IEC60825-1:2007
The following clause applies for instruments delivered into the United States:
Complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant
to Laser Notice No. 50, dated June 24, 2007.



2 x VQ-450 Measurement Performance

Effective Measurement Rate ¹⁾	300 kHz	400 kHz	600 kHz	760 kHz	1.1 MHz
Max. Measurement Range ²⁾					
natural targets $p \geq 10\%$	300 m	260 m	200 m	180 m	140 m
natural targets $p \geq 80\%$	800 m	700 m	450 m	330 m	220 m
Max. Number of Targets per Pulse	practically unlimited (details on request)				

Minimum Range

1.5 m

Accuracy ^{3) 5)}

8 mm

Precision ^{4) 5)}

5 mm

Max. Effective Measurement Rate ¹⁾

1100 000 meas./sec (2 x 550 000 meas./sec)

Line Scan Speed (selectable)

up to 400 lines/sec (2 x 200 lines/sec)

- 1) Rounded values, selectable by measurement program.
2) The following conditions are assumed: target larger than the footprint of the laser beam, perpendicular angle of incidence, visibility 23 km, average ambient brightness.

- 3) Accuracy is the degree of conformity of a measured quantity to its actual (true) value.
4) Precision, also called reproducibility or repeatability, is the degree to which further measurements show the same result.
5) One sigma @ 50 m range under *RIEGL* test conditions.

IMU/GNSS Performance ⁶⁾

Position (absolute)

typ. 20 - 50 mm

Position (relative) ⁷⁾

typ. 10 mm

Roll & Pitch

0.005°

Heading

0.015°

- 6) One sigma values, no GNSS outages, with DMI option, post-processed using base station data.

- 7) With a control point spacing < 100 m.

Physical Data

VMX-450-MH Measuring Head

including GNSS antenna and protection caps

VMX-450 Protective Cover

VMX-450-CU Control Unit

VMX-450-RM Roof Mount

including mounting brackets

VMX-450-MC Main Cable

VMX-450-CS6 Camera System

Main Dimensions (L x W x H)

737 x 456 x 485 mm

Weight (approx.)

43 kg

620 x 747 x 364 mm

3 kg

560 x 455 x 265 mm

26 kg

778 x 515 x approx. 120 mm

13 kg

3 m (standard length)

5 kg

607 x 1038 x 208 mm ⁸⁾

19 kg ⁸⁾

- 8) Typical configuration with 4 cameras.

Electrical Data / Interfaces

Power Supply Input Voltage

11 - 15 V DC

Power Consumption

typ. 440 W (max. 680 W) ⁸⁾

Interfaces

LAN, 10/100/1000 MBit/sec

USB 3.0

DVI

SYNC OUT (synchronization output NMEA+PPS)

NAV RS232 (COM of IMU/GNSS system for RTK, SBAS)

interfaces for additional sensor devices (scanner, cameras, etc.)

removable hard disks for project data transfer

Environmental Data

Temperature Range

VMX-450-MH Measuring Head

-10°C to +40°C (operation) / -20°C to +50°C (storage)

VMX-450-CU Control Unit

0°C to +40°C (operation) / -20°C to +50°C (storage)

VMX-450-CS6 Camera System

-10°C to +40°C (operation) / -20°C to +50°C (storage)

Humidity

max. 80% non condensing @ +31°C

Protection Class

VMX-450-MH Measuring Head

IP64, dust and splash-proof

VMX-450-CU Control Unit

IP64 (closed lid), IP20 (open lid)

VMX-450-CS6 Camera System

IP65, dust and water jet-proof



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Trimble R12

GNSS SYSTEM



KEY FEATURES

- ▶ Next generation Trimble® ProPoint™ GNSS positioning engine. Engineered for improved accuracy and productivity in challenging GNSS conditions.
- ▶ 672-channel solution with Trimble 360 satellite tracking technology
- ▶ Trimble SurePoint™ tilt compensation and precise position capture
- ▶ Trimble xFill® correction outage technology
- ▶ Support for RTK level precision Trimble CenterPoint® RTX corrections technology
- ▶ Optimized for Trimble Access™ field software
- ▶ Android™ and iOS platform support
- ▶ Cellular, Bluetooth®, Wi-Fi data connectivity
- ▶ Military-spec rugged design and IP-67 rating
- ▶ Ergonomic form factor
- ▶ All day battery with built-in status indicator
- ▶ 6 GB internal memory

Learn more:
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PERFORMANCE SPECIFICATIONS

GNSS MEASUREMENTS

Constellation agnostic, flexible signal tracking and improved positioning ¹ in challenging environments with Trimble ProPoint GNSS technology	
Increased measurement productivity and traceability with Trimble SurePoint eBubble tilt compensation	
Advanced Trimble Custom Survey GNSS chips with 672 channels	
Reduced downtime due to loss of radio signal or cellular connectivity with Trimble xFill technology	
Signals tracked simultaneously	GPS: L1C, L1C/A, L2C, L2E, L5 GLONASS: L1C/A, L1P, L2C/A, L2P, L3 SBAS (WAAS, EGNOS, GAGAN, MSAS): L1C/A, L5 Galileo: E1, E5A, E5B, E5 AltBOC, E6 ² BeiDou: B1, B1C, B2, B2A, B3 QZSS: L1C/A, L1S, L1C, L2C, L5, L6 NavIC (IRNSS): L5 L-band: CenterPoint RTX
Iridium filtering above 1616 MHz allows antenna to be used up to 20 m away from Iridium transmitter	
Japanese LTE filtering below 1510 MHz allows antenna to be used up to 100 m away from Japanese LTE cell tower	
Digital Signal Processor (DSP) techniques to detect and recover from spoofed GNSS signals	
Advanced Receiver Autonomous Integrity Monitoring (RAIM) algorithm to detect and reject problem satellite measurements to improve position quality	
Improved protection from erroneous ephemeris data	
Positioning Rates	1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz

POSITIONING PERFORMANCE³

CODE DIFFERENTIAL GNSS POSITIONING

Horizontal	0.25 m + 1 ppm RMS
Vertical	0.50 m + 1 ppm RMS
SBAS ⁴	typically <5 m 3DRMS

STATIC GNSS SURVEYING

High-Precision Static

Horizontal	3 mm + 0.1 ppm RMS
Vertical	3.5 mm + 0.4 ppm RMS

Static and Fast Static

Horizontal	3 mm + 0.5 ppm RMS
Vertical	5 mm + 0.5 ppm RMS

REAL TIME KINEMATIC SURVEYING

Single Baseline <30 km

Horizontal	8 mm + 1 ppm RMS
Vertical	15 mm + 1 ppm RMS

Network RTK⁵

Horizontal	8 mm + 0.5 ppm RMS
Vertical	15 mm + 0.5 ppm RMS

RTK start-up time for specified precisions⁶

	2 to 8 seconds
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TRIMBLE RTX™ TECHNOLOGY (SATELLITE AND CELLULAR/INTERNET (IP))

CenterPoint RTX⁷

Horizontal	2 cm RMS
Vertical	5 cm RMS
RTX convergence time for specified precisions - Worldwide	< 3 min
RTX QuickStart convergence time for specified precisions	< 5 min
RTX convergence time for specified precisions in select regions (Trimble RTX Fast Regions)	< 1 min

TRIMBLE XFILL⁸

Horizontal	RTK ⁹ + 10 mm/minute RMS
Vertical	RTK ⁹ + 20 mm/minute RMS

Trimble R12 GNSS SYSTEM

HARDWARE

PHYSICAL

Dimensions (W×H)	11.9 cm x 13.6 cm (4.6 in x 5.4 in)	
Weight	1.12 kg (2.49 lb) with internal battery, internal radio with UHF antenna. 3.95 kg (8.71 lb) items above plus range pole, Trimble TSC7 controller & bracket	
Temperature ¹⁰		
	Operating	–40 °C to +65 °C (–40 °F to +149 °F)
	Storage	–40 °C to +75 °C (–40 °F to +167 °F)
Humidity	100%, condensing	
Ingress protection	IP67 dustproof, protected from temporary immersion to depth of 1 m (3.28 ft)	
Shock and vibration (Tested and meets the following environmental standards)		
	Shock	Non-operating: Designed to survive a 2 m (6.6 ft) pole drop onto concrete. Operating: to 40 G, 10 msec, sawtooth
	Vibration	MIL-STD-810F, FIG.514.5C-1

ELECTRICAL

	Power 11 to 24 V DC external power input with over-voltage protection on Port 1 and Port 2 (7-pin Lemo)	
	Rechargeable, removable 7.4 V, 3.7 Ah Lithium-ion smart battery with LED status indicators	
	Power consumption is 4.2 W in RTK rover mode with internal radio ¹¹	
Operating times on internal battery ¹²		
	450 MHz receive only option	6.5 hours
	450 MHz receive/transmit option (0.5 W)	6.0 hours
	450 MHz receive/transmit option (2.0 W)	5.5 hours
	Cellular receive option	6.5 hours

COMMUNICATIONS AND DATA STORAGE

Serial	3-wire serial (7-pin Lemo)	
USB v2.0	Supports data download and high speed communications	
Radio modem	Fully integrated, sealed 450 MHz wide band receiver/transmitter with frequency range of 403 MHz to 473 MHz, support of Trimble, Pacific Crest, and SATEL radio protocols:	
	Transmit power	2 W
	Range	3–5 km typical / 10 km optimal ¹³
Cellular ¹⁴	Integrated, 3.5 G modem, HSDPA 7.2 Mbps (download), GPRS multi-slot class 12, EDGE multi-slot class 12, Penta-band UMTS/HSDPA (WCDMA/FDD) 800/850/900/1900/2100 MHz, Quad-band EGSM 850/900/1800/1900 MHz, GSM CSD, 3GPP LTE	
Bluetooth	Version 4.1 ¹⁵	
Wi-Fi	802.11 b,g, access point and client mode, WPA/WPA2/WEP64/WEP128 encryption	
I/O ports	Serial, USB, TCP/IP, IBSS/NTRIP, Bluetooth	
Data storage	6 GB internal memory	
Data format	CMR+, CMRx, RTCM 2.1, RTCM 2.3, RTCM 3.0, RTCM 3.1, RTCM 3.2 input and output 24 NMEA outputs, GSOF, RT17 and RT27 outputs	

WEBUI

	Offers simple configuration, operation, status, and data transfer
	Accessible via Wi-Fi, Serial, USB, and Bluetooth

SUPPORTED CONTROLLERS & FIELD SOFTWARE

	Trimble TSC7, Trimble T10, Trimble T7, Android and iOS devices running supported apps
	Trimble Access 2019.10 or later

CERTIFICATIONS

	FCC Part 15 (Class B device), 24, 32; CE Mark; RCM; PTCRB; BT SIG
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Trimble R12 GNSS SYSTEM



- 1 Challenging GNSS environments are locations where the receiver has sufficient satellite availability to achieve minimum accuracy requirements, but where the signal may be partly obstructed by and/or reflected off of trees, buildings, and other objects. Actual results may vary based on user's geographic location and atmospheric activity, scintillation levels, GNSS constellation health and availability, and level of multipath and signal occlusion.
- 2 The current capability in the receivers is based on publicly available information. As such, Trimble cannot guarantee that these receivers will be fully compatible with a future generation of Galileo satellites or signals.
- 3 Precision and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. The specifications stated recommend the use of stable mounts in an open sky view, EMI and multipath clean environment, optimal GNSS constellation configurations, along with the use of survey practices that are generally accepted for performing the highest-order surveys for the applicable application including occupation times appropriate for baseline length. Baselines longer than 30 km require precise ephemeris and occupations up to 24 hours may be required to achieve the high precision static specification.
- 4 Depends on SBAS system performance.
- 5 Network RTK PPM values are referenced to the closest physical base station.
- 6 May be affected by atmospheric conditions, signal multipath, obstructions and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.
- 7 RMS performance based on repeatable in field measurements. Achievable accuracy and initialization time may vary based on type and capability of receiver and antenna, user's geographic location and atmospheric activity, scintillation levels, GNSS constellation health and availability and level of multipath including obstructions such as large trees and buildings.
- 8 Accuracies are dependent on GNSS satellite availability. xFill positioning without a Trimble CenterPoint RTX subscription ends after 5 minutes of radio downtime. xFill positioning with a CenterPoint RTX subscription will continue beyond 5 minutes providing the Trimble RTX solution has converged, with typical precisions not exceeding 6 cm horizontal, 14 cm vertical or 3 cm horizontal, 7 cm vertical in Trimble RTX Fast regions. xFill is not available in all regions, check with your local sales representative for more information.
- 9 RTK refers to the last reported precision before the correction source was lost and xFill started.
- 10 Receiver will operate normally to -40 °C. Internal batteries are rated from -20 °C to +60 °C (ambient +50 °C).
- 11 Tracking GPS, GLONASS and SBAS satellites.
- 12 Varies with temperature and wireless data rate. When using a receiver and internal radio in the transmit mode, it is recommended that an external 6 Ah or higher battery is used.
- 13 Varies with terrain and operating conditions.
- 14 Due to local regulations, the integrated cellular modem cannot be enabled in China, Taiwan, or Brazil. A Trimble controller integrated cellular modem or external cellular modem can be used to obtain GNSS corrections via an IP (Internet Protocol) connection.
- 15 Bluetooth type approvals are country specific.

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Trimble TSC7

CONTROLLER

KEY FEATURES

- ▶ Optimized for Trimble® Access™ field software
- ▶ Large 7-inch multi-touch screen for finger or stylus
- ▶ Sunlight readable display
- ▶ Secure Windows® 10 Pro operating system
- ▶ Compatible with Microsoft® Office, web browsers, and other third-party apps
- ▶ Manages large project files, complex imagery, point clouds, and other 3D data
- ▶ Intel Pentium processor with 8 GB RAM and 64 GB internal memory
- ▶ Comprehensive connectivity options
- ▶ Front- and rear-facing cameras
- ▶ Backlit keypad with customizable button commands
- ▶ User-interchangeable EMPOWER modules, including a long-range radio
- ▶ Military-spec rugged design, engineering and performance
- ▶ Ergonomic form factor
- ▶ Hot-swappable batteries with LED indicators

Learn more:
geospatial.trimble.com/TSC7



Trimble TSC7 CONTROLLER

PHYSICAL SPECIFICATIONS	
Size	20.9 x 30.2 x 7.0 cm (8.2 x 11.9 x 2.76"). Angled design.
Weight	1.42 kg (3.12 lb)
Housing	Glass-fibre reinforced resin with integrated drop bumpers

ENVIRONMENTAL SPECIFICATIONS (MEETS OR EXCEEDS)	
Operating temperature	-30°C to 60°C (-22°F to 140°F) MIL-STD-810G 501.5 Procedures II (operation)
Storage temperature	-40 °C to 70 °C (-40 °F to 158 °F) MIL-STD-810G 501.5 Procedures I (storage)
Sand & dust	IP6x: 8 hours of operation with blowing talcum powder (IEC60529)
Water	IPx8: Immersion, up to 1 m (3.2 ft) depth for 2 hours
Drop	26 drops at room temperature from 1.22 m (4 ft) onto plywood over concrete MIL-STD-810G, Method 516.6, Procedure IV
Humidity	90 % RH temp cycle +30°C/-+60°C (86°F/140°F) MIL-STD-810G, Method 507.5, II
Vibration	Operating MIL-STD 810G 514.6 I & II, non-operating I, cat 24
Altitude	Operational at 4,572 m (15,000 ft), MIL-STD-810G, Method 500.5, (Altitude) I (storage) & II (operating)
Temperature Shock	Survives cycles between -30 °C and 60 °C (-22 °F and 140 °F), MIL-STD-810G, 503.5, I
Solar Exposure	Survives prolonged solar exposure, MIL-STD810G Method 505.5, II

SECURITY	
TPM 2.0 (Trusted Platform Module)	

CONFIGURATIONS	
EMPOWER module support	2 x module bays

CERTIFICATIONS	
Country certifications	FCC, NRTL, ICES, IC, ACMA, RSM, ANATEL, BIS, WPC, MCMC, CERT, CE, CB, TRA, NCC, ICASA, RCM, VCCI, KC, CCC, SRRC, FAC, EAC, BSMI approvals, NRTL scheme
Environmental	EU RoHS, China RoHS, REACH, WEEE

COMPATIBLE FIELD SOFTWARE	
Trimble Access version 2017.2x and Trimble Access version 2018 and later	
Windows 10 Pro 64 bit applications.	

ELECTRICAL SPECIFICATIONS	
Processor	Intel Apollo Lake - N4200, 64-bit quad-core
Memory	8 GB RAM, LPDDR4
Storage	64 GB eMMC
Expansion	via SDXC card up to 2 TB
Batteries	2 x 3100 mAh (22.53 Wh) min. capacity/3150 mAh (22.90 Wh) nominal capacity; removable, hot swappable, charge LED indicator
Battery life	Medium usage approx. 5 hours, can range 4-7 hours (depending on display settings, connectivity, data processing, ambient temperature, etc.)
Charging time	Full-charge 3.5 hours, fast-charge (80 %) 1 ¾ hours
Power input	19V/5A charging
Notification LED	Charging and power status
Display	7"; 1280 x 800 landscape, 16:10, 800 nits sunlight readable, LED backlit, Gorilla® Glass 3.0, 10 point capacitive multitouch with stylus, touch, and glove mode
Keyboard	QWERTY or ABCD, with backlight, numeric key block, Fn keys (6 physical + 6 2nd function Fn keys)
Audio	Speaker and dual digital microphone array with noise reduction
External speaker/microphone	3.5 mm mini-jack or wireless headset
I/O	User replaceable module. Standard: Charger/DC power-in, USB 3.1 Gen 1 type A host, serial RS232 DB-9
WWAN	Worldwide LTE in regions where it is available, and compatible with 3G networks AT&T and Verizon certified. MicroSIM card
Wi-Fi	802.11 a/b/g/ac/n (2.4 GHz/5 GHz ISM radio band)
Bluetooth®	BT 2.1+ EDR, BT 4.1
Camera	Rear camera 8 MP autofocus with flash Front camera 2 MP fixed-focus
GNSS	Integrated u-blox NEO-M8N, L1, GPS/GLONASS/BeiDou
Sensors	3-axis accelerometer, magnetic sensor, ambient light sensor, proximity sensor

Specifications subject to change without notice.



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Appendix B – LiDAR to Control Target Comparison

Index	Point	Easting	Northing	Elevation	Deviation Z	Template Name
0	2001	1792269.029	239168.041	14.662	-0.002	Survey Point
1	2002	1792490.008	239626.65	15.744	0.001	Survey Point
2	2003	1792683.666	240073.279	14.099	0	Survey Point
3	2004	1792927.611	240602.186	9.116	0.001	Survey Point
4	2005	1793135.289	241053.057	14.137	0.003	Survey Point
5	2006	1793305.496	241456.438	15.513	0.001	Survey Point
6	2007	1793518.265	241918.044	14.93	0.003	Survey Point
7	2008	1793681.143	242271.478	14.381	0.004	Survey Point
8	2009	1792784.543	239845.958	15.883	-0.001	Survey Point
9	2010	1793043.162	240432.04	14.721	-0.001	Survey Point
10	2011	1793368.355	240690.411	12.161	-0.002	Survey Point
11	2012	1793775.117	241031.916	13.1	-0.001	Survey Point
12	2013	1794150.639	241309.635	15.001	-0.002	Survey Point
13	2014	1794501.95	241614.825	12.823	0.001	Survey Point
14	2015	1794901.015	241924.233	12.412	0.003	Survey Point
15	2016	1795297.023	242229.459	12.97	-0.005	Survey Point
16	2017	1795688.24	242540.801	9.663	-0.002	Survey Point
17	2018	1796078.193	242853.752	12.589	-0.005	Survey Point
18	2019	1796318.128	243241.127	13.355	0	Survey Point
19	2020	1796443.237	243721.296	11.583	0.002	Survey Point
20	2021	1796802.406	244035.982	9.563	0.001	Survey Point
21	2022	1797082.364	244492.759	11.766	0	Survey Point
22	2023	1797174.111	244944.457	12.449	-0.002	Survey Point
23	2024	1793330.995	240914.788	13.68	0	Survey Point
24	2025	1793665.719	241186.428	15.402	0.009	Survey Point
25	2026	1793197.564	241181.657	15.215	0.003	Survey Point
26	2027	1793631.271	241438.093	14.664	0.001	Survey Point
27	2028	1791921.537	240110.753	18.745	0.005	Survey Point
28	2029	1792320.382	240407.336	16.355	0.001	Survey Point
29	2030	1792719.338	240708.844	27.135	0.002	Survey Point
30	2032	1793517.206	241310.896	20.424	0.012	Survey Point
31	2033	1793902.878	241601.651	16.969	0.002	Survey Point
32	2034	1794309.822	241920.969	14.979	0.006	Survey Point
33	2035	1794708.198	242220.875	14.765	0.007	Survey Point
34	2036	1795073.447	242545.042	16.389	0.003	Survey Point
35	2037	1795372.089	242915.901	31.253	0.001	Survey Point
36	2038	1795661.841	243326.421	40.855	0.009	Survey Point
37	2039	1795895.491	243662.234	32.903	0.002	Survey Point
38	2040	1796244.164	244141.101	28.372	0.002	Survey Point
39	2041	1796480.656	244479.169	29.803	-0.004	Survey Point
40	2042	1796827.911	244977.72	31.656	-0.001	Survey Point
41	2043	1797087.293	245393.652	31.393	0.007	Survey Point
42	2044	1797300.762	245835.107	32.576	0.003	Survey Point
43	2045	1797456.677	246305.048	31.492	0	Survey Point
44	2046	1797543.333	246793.432	23.678	-0.002	Survey Point
45	2047	1797620.734	247286.43	17.513	0.003	Survey Point
46	2048	1797690.239	247778.894	18.496	0.006	Survey Point
47	2049	1797775.441	248263.134	24.64	0.006	Survey Point
48	2050	1797845.147	248763.509	31.931	-0.001	Survey Point
49	2051	1797922.228	249310.12	32.899	0.004	Survey Point
50	2052	1797991.789	249766.807	29.375	0.006	Survey Point
51	2053	1798094.162	250247.784	23.993	0.003	Survey Point
52	2054	1798306.335	250706.839	4.185	0.002	Survey Point
53	2082	1792001.47	239994.768	18.77	-0.001	Survey Point
54	2083	1792397.907	240293.289	16.195	0.001	Survey Point
55	2084	1792798.824	240595.192	27.047	-0.003	Survey Point
56	2085	1793198.491	240895.621	33.531	-0.002	Survey Point
57	2086	1793591.171	241191.681	20.921	-0.004	Survey Point
58	2087	1793989.231	241494.279	17.007	-0.008	Survey Point
59	2089	1794802.614	242089.94	16.743	-0.002	Survey Point
60	2090	1795189.565	242431.47	20.766	-0.004	Survey Point
61	2093	1796113.787	243692.711	29.538	0.004	Survey Point
62	2095	1796644.166	244457.057	29.911	0.006	Survey Point
63	2096	1796939.443	244878.662	32.048	0.002	Survey Point
64	2097	1797212.869	245303.013	34.54	0.001	Survey Point
65	2098	1797382.616	245641.078	35.618	-0.009	Survey Point
66	2099	1797585.133	246244.251	34.792	-0.003	Survey Point
67	2100	1797678.122	246718.288	25.682	0.003	Survey Point
68	2101	1797759.082	247216.592	17.926	0.001	Survey Point
69	2102	1797832.699	247716.231	18.071	0	Survey Point
70	2103	1797894.37	248210.166	24.335	-0.001	Survey Point
71	2107	1798224.43	250127.835	30.998	-0.001	Survey Point
72	2108	1798400.952	250691.203	-0.055	0.002	Survey Point
73	2135	1794092.912	242104.12	13.065	-0.006	Survey Point
74	2136	1794444.331	242332.794	12.166	0	Survey Point
75	2137	1794863.263	242417.695	11.653	-0.001	Survey Point
76	2138	1795197.725	242793.708	12.608	0.003	Survey Point

77	2139	1794801.189	243302.041	13.182	0.002	Survey Point
78	2140	1795319.378	243230.818	10.486	-0.001	Survey Point
79	2143	1796161.139	243502.491	11.226	0	Survey Point
80	2144	1796148.673	243570.404	11.757	-0.005	Survey Point
81	2145	1796124.293	244062.306	23.061	-0.001	Survey Point
82	2146	1796362.43	244537.791	10.049	0.008	Survey Point
83	2147	1796315.075	243904.468	26.063	0.008	Survey Point
84	2148	1795915.746	244627.546	11.553	0.003	Survey Point
85	2149	1796786.541	244490.926	9.869	-0.001	Survey Point
86	2153	1797489.631	244148.063	11.235	-0.013	Survey Point
87	2154	1797072.705	244185.632	10.21	0.001	Survey Point
88	2155	1796518.971	244781.289	15.707	0.003	Survey Point
89	2156	1797010.791	245264.363	31.044	-0.005	Survey Point
90	2157	1796848.196	244204.327	17.549	-0.002	Survey Point
91	2158	1798039.687	244342.369	7.59	0.008	Survey Point
92	2159	1797496.29	244446.95	12.982	-0.002	Survey Point
93	2160	1797563.297	244915.404	12.287	0	Survey Point
94	2161	1797631.734	245398.145	9.937	0.004	Survey Point
95	2162	1797760.157	246385.718	9.678	0.005	Survey Point
96	2163	1797836.549	246898.305	9.074	0.01	Survey Point
97	2164	1797886.438	247375.157	9.865	0.004	Survey Point
98	2166	1796490.761	246379.667	12.786	0.003	Survey Point
99	2167	1796777.382	245984.275	11.154	0.004	Survey Point
100	2168	1797137.875	245757.522	11.874	0.002	Survey Point
101	2169	1797671.318	245675.877	10.172	-0.002	Survey Point
102	2170	1798411.893	248699.305	7.994	-0.002	Survey Point
103	2171	1798690.564	248896.603	5.206	-0.006	Survey Point
104	2172	1798855.454	249286.638	6.069	-0.003	Survey Point
105	2174	1797398.28	246599.776	11.03	-0.003	Survey Point
106	2175	1797495.828	247276.321	11.412	0.01	Survey Point
107	2179	1797749.926	249177.398	12.131	-0.001	Survey Point
108	2182	1797455.389	246478.962	26.761	0.022	Survey Point
109	2183	1797685.747	245997.255	12.04	0.004	Survey Point
110	1	1797696.547	246492.743	20.634	0.008	Survey Point
111	2185	1798132.942	248806.371	9.896	-0.021	Survey Point
112	2186	1798072.479	248529.272	10.6	-0.013	Survey Point
113	2187	1798624.116	248461.879	5.503	-0.002	Survey Point
114	2188	1799118.995	248865.272	5.083	-0.001	Survey Point
115	2189	1799209.49	249321.927	6.07	-0.004	Survey Point
116	2190	1799500.604	249860.454	3.438	0.005	Survey Point
117	2191	1799097.056	249896.335	7.401	-0.006	Survey Point
118	2192	1798728.867	249401.202	6.881	-0.02	Survey Point
119	2193	1797173.377	248923.931	12.48	-0.02	Survey Point
120	2194	1797660.133	248920.806	11.815	-0.001	Survey Point
121	2195	1798210.382	248895.932	8.12	-0.01	Survey Point
122	2196	1798555.49	249298.318	8.944	-0.002	Survey Point
123	2197	1798841.202	249613.656	8.496	-0.006	Survey Point
124	2198	1799109.506	250097.381	6.406	0.002	Survey Point
125	2199	1799260.144	250580.265	4.287	0.001	Survey Point
126	2200	1799285.367	250986.753	4.302	0.011	Survey Point
127	2201	1797153.879	249019.376	12.444	0.015	Survey Point
128	2202	1797649.388	249020.589	11.927	0	Survey Point
129	2203	1798153.034	249016.806	9.795	-0.014	Survey Point
130	2204	1798523.718	249334.632	8.506	-0.003	Survey Point
131	2205	1798832.668	249676.211	7.911	0.003	Survey Point
132	2206	1799050.325	250060.101	6.696	-0.003	Survey Point
133	2207	1799044.762	250574.994	6.716	-0.008	Survey Point
134	2219	1799062.451	251484.021	4.363	0.002	Survey Point
135	2224	1798527.771	250014.675	27.591	0.004	Survey Point
136	2226	1799094.658	251150.443	4.873	-0.004	Survey Point
137	2227	1801990.056	252571.292	4.602	-0.006	Survey Point
138	2228	1802542.809	252596.713	6.082	0.003	Survey Point
139	2236	1799366.32	250345.449	7.07	-0.003	Survey Point
140	2237	1799404.05	250660.709	7.392	0	Survey Point
141	2240	1801526.489	250185.851	8.043	0.006	Survey Point
142	2241	1801581.221	250626.969	10.135	0.005	Survey Point
143	2242	1801572.123	251123.851	15.786	0.002	Survey Point
144	2243	1802145.725	251646.656	13.165	-0.01	Survey Point
145	2244	1802630.586	251771.238	7.457	-0.002	Survey Point
146	2245	1803046.204	251551.185	6.545	0.004	Survey Point
147	2248	1801893.319	251983.159	14.795	0.004	Survey Point
148	2249	1802215.571	251946.076	15.725	-0.009	Survey Point
149	2250	1801892.727	251661.528	15.149	0.031	Survey Point
150	2255	1801445.873	251677.292	15.924	0.001	Survey Point
151	2253	1801766.471	251935.993	14.689	-0.002	Survey Point
152	2258	1801716.562	252297.353	6.686	0.006	Survey Point
153	2258	1803487.172	251580.9	3.913	-0.014	Survey Point
154	2265	1802408.136	252127.057	5.72	0.002	Survey Point

155	2279	1802548.619	252150.344	4.569	0.005	Survey Point
156	2281	1803417.264	251743.168	4.873	0.016	Survey Point
157	2282	1804334.71	251316.187	4.437	0.006	Survey Point
158	2283	1804801.983	251094.193	4.747	0.008	Survey Point
159	2284	1805231.746	250893.333	4.427	0.004	Survey Point
160	2285	1805690.297	250679.843	4.153	0.005	Survey Point
161	2286	1806223.803	250431.399	3.974	0.006	Survey Point
162	2287	1806621.452	250248.638	4.652	0.002	Survey Point
163	2288	1807048.077	250050.96	5.309	0.003	Survey Point
164	2289	1807531.898	249821.305	7.434	0.008	Survey Point
165	2290	1807936.35	249548.501	18.387	0.001	Survey Point
166	2293	1803865.103	251547.829	4.591	0.009	Survey Point
167	2055	1798739.902	250948.95	-21.057	0.004	Survey Point
168	2056	1799219.042	251101.681	-47.945	0.005	Survey Point
169	2057	1799693.77	251253.064	-73.664	0.003	Survey Point
170	2058	1800179.101	251407.665	-83.318	0.005	Survey Point
171	2059	1800657.51	251560.387	-65.751	0.003	Survey Point
172	2060	1801126.603	251709.966	-40.798	0.002	Survey Point
173	2061	1801603.761	251862.045	-15.014	0	Survey Point
174	2109	1798759.901	250890.218	-21.021	0.001	Survey Point
175	2110	1799224.704	251038.442	-46.789	0.012	Survey Point
176	2111	1799708.914	251192.923	-73.623	-0.003	Survey Point
177	2112	1800179.897	251342.875	-83.495	0.001	Survey Point
178	2113	1800684.819	251503.939	-65.198	0	Survey Point
179	2114	1801142.995	251650.2	-41.08	0.004	Survey Point

AVG	0.0009
RMSE	0.0063
Within Tolerance (%)	100

SECTION 4 : HYDROGRAPHIC SURVEY DATA COLLECTION AND MAPPING

Survey Report

I-10 Mobile River Bridge Project

CPMS No. 100073596

Hydrographic Survey Data Collection and Mapping

EMC Job No. 23034

June 2023

Prepared for:

Kiewit Massman Traylor, A Joint Venture



Prepared by
2472 Sunset Drive,
Grenada, MS 38901
(662) 226-5166

Executive Summary

EMC was tasked with providing hydrographic data collection and mapping within the limits provided. The dataset was to be controlled using control information provided by the client. This is to certify that the survey and resulting mapping efforts meet the requirements specified and that the project was performed under my supervision. Date of report: 6-22-2023.



Table of Contents

Section 1: Project Description

Section 2: Survey Summary

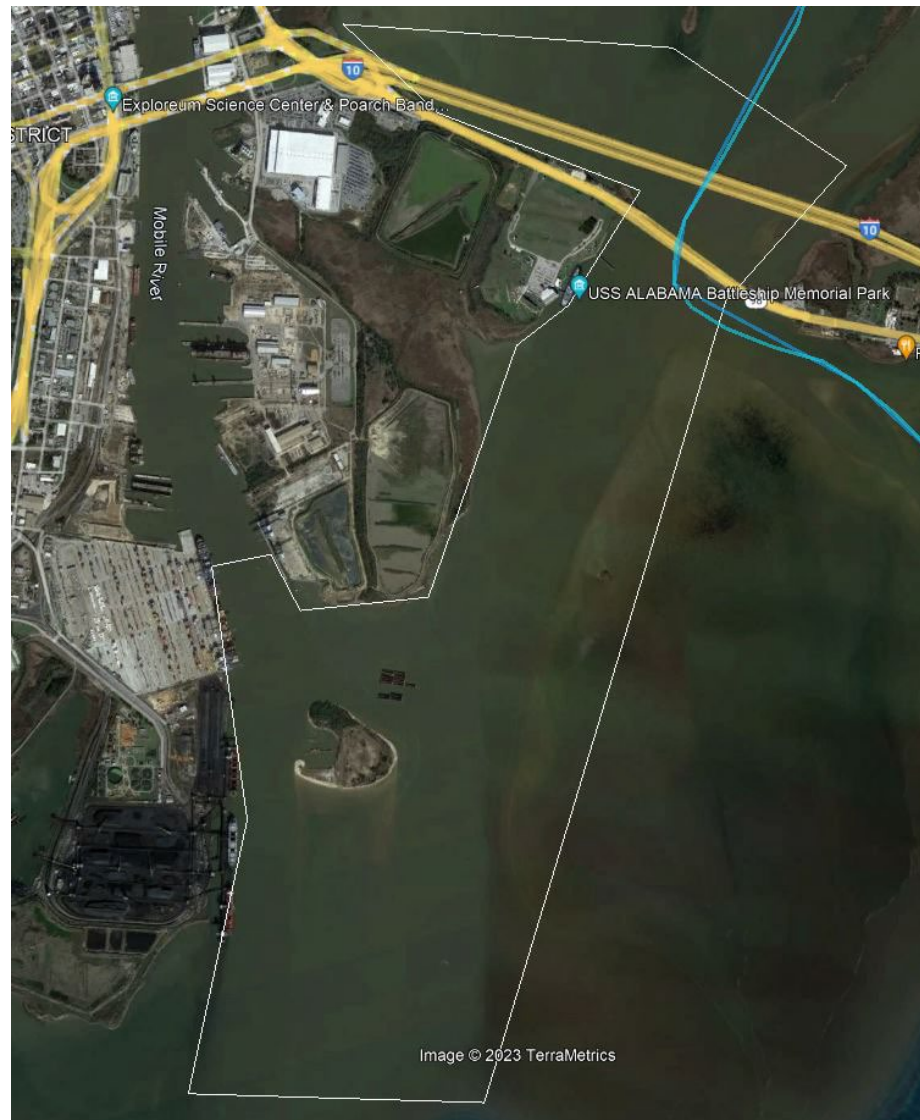
Appendices

Appendix A – Equipment Spec Sheets

Section 1: Project Description

EMC was tasked with collecting hydrographic data and mapping the data, on the specified area shown below near Mobile, Alabama.

Vicinity Map



Section 2: Survey Summary

Multibeam data collection was performed using a Reason T50 multibeam coupled with a Applanix PosMV inertial navigation system. All data was collected using Hypack/Hysweep Survey software. Upon arrival at the project a local patch test and bar check were performed. The patch test ensured all the mounting angles were accounted for between the multibeam and the POS IMU. The bar check ensured the proper draft settings were set inside the software. Hourly sound velocity casts were taken each day during collection to ensure that the speed of sound in the water was properly applied. A real time sound velocity sensor was also used to ensure that the beam steering function was being properly computed to ensure maximum accuracy. The GPS data was always collected for use in post processing to achieve PPK accuracy as well as water's surface shots taken hourly with RTK GPS to ensure the proper tide value were applied to the data. Additionally, we performed lead line readings, at periodic locations and intervals as requested on site to verify soundings. Lead line comparison is shown below. All the data was post-processed and combined inside of the Hypack software. Then the data was tide corrected and edited to remove any bad soundings from the data. Once checks were completed the data was exported to be used in Microstation mapping software to create the drawing and surface for use in the design.

Name	X	Y	Latitude	Longitude	Date/Time UTC	Lead Line Reading	Sonar Reading
Lead Line 1	1809133.21	248433.97	30 40 55.6189 N	088 00 25.1057 W	5/19/2023 14:51	6.3-6.4	6.3
Lead Line 2	1805777.65	251177.51	30 41 22.6224 N	088 01 3.6779 W	5/19/2023 20:55	5.2	5.2
Lead Line 3	1806130.39	243254.96	30 40 4.2226 N	088 00 59.2208 W	5/20/2023 13:13	10.5	10.5
Lead Line 4	1802031.14	239140.26	30 39 23.3071 N	088 01 45.9358 W	5/21/2023 15:00	13.3	13.3
Lead Line 5	1803280.21	241469.09	30 39 46.4155 N	088 01 31.7601 W	5/21/2023 15:48	10.7	10.7
Lead Line 6	1805997.34	246501.38	30 40 36.349 N	088 01 0.9153 W	5/21/2023 16:07	11.9-12.0	11.9
Lead Line 7	1808357.17	250974.51	30 41 20.73 N	088 00 34.1248 W	5/4/2023 20:41	4.1	4.1
Lead Line 8	1805984.11	242564.06	30 39 57.3775 N	088 01 0.8593 W	5/6/2023 16:38	8.6	8.5
Lead Line 9	1807028.69	250314.21	30 41 14.1345 N	088 00 49.3049 W	5/7/2023 13:02	4	3.84
Lead Line 10	1810805.92	250437.56	30 41 15.5245 N	088 00 6.0526 W	5/10/2023 14:16	9.5-9.6	9.4
Lead Line 11	1811086.69	250510.1	30 41 16.2549 N	088 00 2.8408 W	5/10/2023 14:17	9.4	9.42

Deliverables

The final submittal includes the following:

- Survey Summary Report
- XYZ of processed bathymetric data
- DGN and surface containing bathymetric data

Appendix A – Equipment Spec Sheets

POS MV 320 SPECIFICATIONS

MAXIMIZE YOUR ROI WITH POS MV 320

POS MV 320 is a user-friendly, turnkey system designed and built to provide accurate attitude, heading, heave, position, and velocity data of your marine vessel and onboard sensors. POS MV is proven in all conditions, and is the georeferencing and motion compensation solution of choice for the hydrographic professional.

POS MV blends GNSS data with angular rate and acceleration data from an IMU and heading from the GPS Azimuth Measurement System (GAMS) to produce a robust and accurate full six degrees-of-freedom position and orientation solution.



PERFORMANCE SUMMARY - POS MV 320 ACCURACY

POS MV 320	DGPS	RTK	Accuracy During GNSS Outage
Position	0.5 - 2 m ¹	Horizontal: +/- (8 mm + 1 ppm x baseline length) ² Vertical: +/- (15 mm + 1 ppm x baseline length) ²	~ 6 m for 60 s total outages (DGPS) ~ 3 m for 60 s total outages (RTK) ~ 2 m for 60 s (post-processed DGNSS) ~ 1 m for 60 s total outages (IAPPK)
Roll & Pitch	0.02°	0.01° (0.008° with post processing)	0.02°
True Heading	0.01° with 4 m baseline 0.02° with 2 m baseline	-	1° per hour degradation (negligible for outages <60 s)
Heave TrueHeave™	5 cm or 5% ³ 2 cm or 2% ⁴	5 cm or 5% ³ 2 cm or 2% ⁴	5 cm or 5% ³ 2 cm or 2% ⁴

PCS OPTIONS

COMPONENT	DIMENSIONS	WEIGHT	TEMPERATURE	HUMIDITY	POWER
Rack Mount PCS	L = 442mm, W = 356mm, H = 46mm	3.9 kg	-20 °C to +70 °C	10 - 80% RH	AC 120/230 V, 50/60 Hz, auto-switching 40 W
Small Form Factor PCS	L = 167mm, W = 185mm, H = 68mm	2.5 kg	-20 °C to +60 °C	0- 100% RH	DC 10-34 V, 35 W (peak)

INERTIAL MEASUREMENT UNIT (IMU)

ENCLOSURE	DIMENSIONS	WEIGHT	TEMPERATURE	IP RATING
Between Decks	L = 158 mm, W = 158 mm, H = 124 mm	2.5 kg	-40 °C to +60 °C	IP65
Between Decks	L = 150 mm, W = 130 mm, H = 148 mm	2.8 kg	-40 °C to +60 °C	IP65
Submersible	Ø172 mm X 206 mm (base plate Ø209 mm)	3.9 kg	-40 °C to +60 °C	IP68

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

COMPONENT	DIMENSIONS	WEIGHT	TEMPERATURE	HUMIDITY
GNSS Antenna	Ø178 mm, W = 73 mm	0.45 kg	-50 °C to +70 °C	0-100% RH

¹ Depending on quality of differential corrections

² Assumes 1 m IMU-GNSS antenna offset

³ Whichever is greater, for periods of 20 seconds or less

⁴ Whichever is greater, for periods of 35 seconds or less

1. ETHERNET INPUT OUTPUT

Ethernet	(10/100 base-T)
Parameters	Time tag, status, position, attitude, heave, velocity, track and speed, dynamics, performance metrics, raw IMU data, raw GNSS data
Display Port	Low rate (1 Hz) UDP protocol output
Control Port	TCP/IP input for system commands
Primary Port	Real-time (up to 200 Hz) UDP protocol output
Secondary Port	Buffered TCP/IP protocol output for data logging to external device

2. SERIAL RS232 INPUT OUTPUT

5 COM Ports	User assignable to: NMEA output (0-5), Binary output (0-5), Auxiliary GNSS input (0-2), Base GNSS correction input (0-2)
-------------	--

3. NMEA ASCII OUTPUT

Parameters	NMEA Standard ASCII messages: Position (\$INGGA), Heading (\$INHDT), Track and Speed (\$INVTG), Statistics (\$INGST), Attitude (\$PASHR, \$PRDID), Time and Date (\$INZDA, \$UTC)
Rate	Up to 50 Hz (user selectable)
Configuration	Output selections and rate individually configurable on each assigned com port

4. HIGH RATE ATTITUDE OUTPUT

Parameters	User selectable binary messages: attitude, heading, speed
Rate	Up to 200 Hz (user selectable)
Configuration	Output selections and rate individually configurable on each assigned com port

5. AUXILIARY GNSS INPUTS

Parameters	NMEA Standard ASCII messages: \$GPGGA, \$GPGST, \$GPGSA, \$GPGSV Uses Aux input with best quality
Rate	1 Hz

6. BASE GNSS CORRECTION INPUTS

Parameters	RTCM V2.x, RTCM V3.x, CMR and CMR+, CMRx input formats accepted. Combined with raw GNSS observables in navigation solution
Rate	1 Hz

7. DIGITAL I/O

1PPS	1 pulse-per-second Time Sync output, normally high, active low pulse
Event Input (2)	Time mark of external events. TTL pulses > 1 msec width, rising or falling edge, max rate 200 Hz

8. USER SUPPLIED EQUIPMENT

- PC for POSView Software (Required for configuration): Pentium 90 processor (minimum), 16 MB RAM, 1 MB free disk space, Ethernet adapter (RJ45 100 base T), Windows 98/2000/NT/XP/Windows 7
- PC for POSpac MMS Post-processing Software: Pentium III 800Mhz or equivalent (minimum), 512 MB RAM, 400 MB free disk space, USB Port (For Security Key), Windows XP or Windows 7

Scan the QR Code on your mobile device to access information on POS MV



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capture everything. precisely.

Teledyne RESON

SeaBat[®] T50-P

Ultra high resolution portable
Multibeam Echosounder

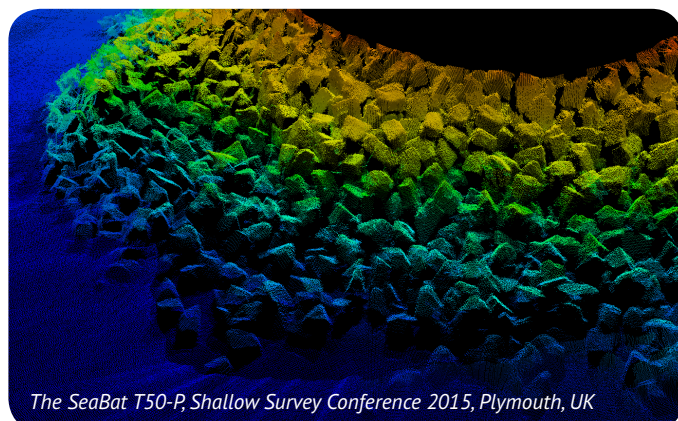


Unprecedented clean and ultra high data quality for faster operational surveys and reduced processing time

The SeaBat T50-P is the new addition to the leading SeaBat T-series product range, engineered from the ground up to evolve with your business. Combined with the Portable Sonar Processor, the SeaBat T50-P provides unprecedented survey data, providing faster operational surveys and reduced processing time.

The SeaBat T50-P is fully frequency agile from 190 to 420 kHz, allowing for improved swath performance and reduced survey time under difficult conditions.

The SeaBat T50-P is designed for fast mobilization on smaller vessels. The Portable Sonar Processor and sonar head form a compact system, securing minimal interfacing and low space requirements.



The SeaBat T50-P, Shallow Survey Conference 2015, Plymouth, UK

SeaBat T50-P standard configuration

Portable Sonar Processor

- Reduced cable connections – fast mobilization
- Single-point, accurate, sensor time-tagging
- Water-resistant IP54 rated
- 24VDC and 100-230VAC for maximum flexibility
- 25m cable to wet-end components

T50 sonar head assembly

- 190 – 420kHz wide-band
- Robust titanium housing
- Less than 8kg in water

PRODUCT BENEFITS

- Unprecedented clean and ultra high data quality for faster operational surveys and reduced processing time
- Fully frequency agile from 190 to 420 kHz, allowing for improved swath performance and reduced survey time under difficult conditions
- Designed for smaller vessel portable use. The compact system allows for fast mobilization, minimal interfacing and low space requirements
- Significantly reduced amount of data collected with the intelligent data reduction algorithms in the compressed water column feature

Teledyne RESON SeaBat® T50-P

SEABAT T50-P SYSTEM SPECIFICATIONS

Input voltage	24VDC or 100-230VAC 50/60Hz
Power (typical / max)	150W / 300W
Ingress protection	Water resistant (IP54)
Transducer cable length	25m (standard) Optional: 10m, 50m or 100m
Temperature (operational / storage)	Portable Sonar Processor: -5°C to +40°C / -30°C to +70°C

	Height [mm]	Width [mm]	Depth [mm]	Weight [kg/air]	Weight [kg/water]
T50 Rx (EM7218)	102.0	460.0	90.7	8.2	3.9
T50 Tx (TC2181)	86.6	93.1	280	5.4	3.4
Portable Sonar Processor	131	424	379	14	N/A

T50 Acoustic performance	400kHz (max. frequency)	200kHz (min. frequency)
Across-track receiver beam width¹	0.5°	1°
Along-track beam width¹	1°	2°
Number of beams	Min 10, Max 512	
Swath coverage (up to)	150° Equi Distant, 165° Equi Angle	
Typical Depth (CW²)	0.5-200 meters	0.5-400 meters
Max Depth (CW³)	250 meters	475 meters
Typical Depth (FM²)	0.5-225 meters	0.5-550 meters
Max Depth (FM³)	300 meters	575 meters
Ping rate (range dependent)	Up to 50 pings/s	
Sample rate	34 kHz or 66 kHz	
Pulse length (CW)	15 – 300µs	
Pulse length (FM)	300µs – 10ms	
Depth resolution	6 millimeters	
Depth rating (sonar head)	50 meters	

For relevant tolerances for dimensions above and detailed outlined drawings see Product Description

1 Nominal values

2 This is a depth range within which the system is normally operated, from the minimum depth to a depth value corresponding to the max. swath -50%.

3 This is the single value corresponding to the depth at which the swath is reduced to 10% of its max. value. For actual swath performance refer to Product Description.

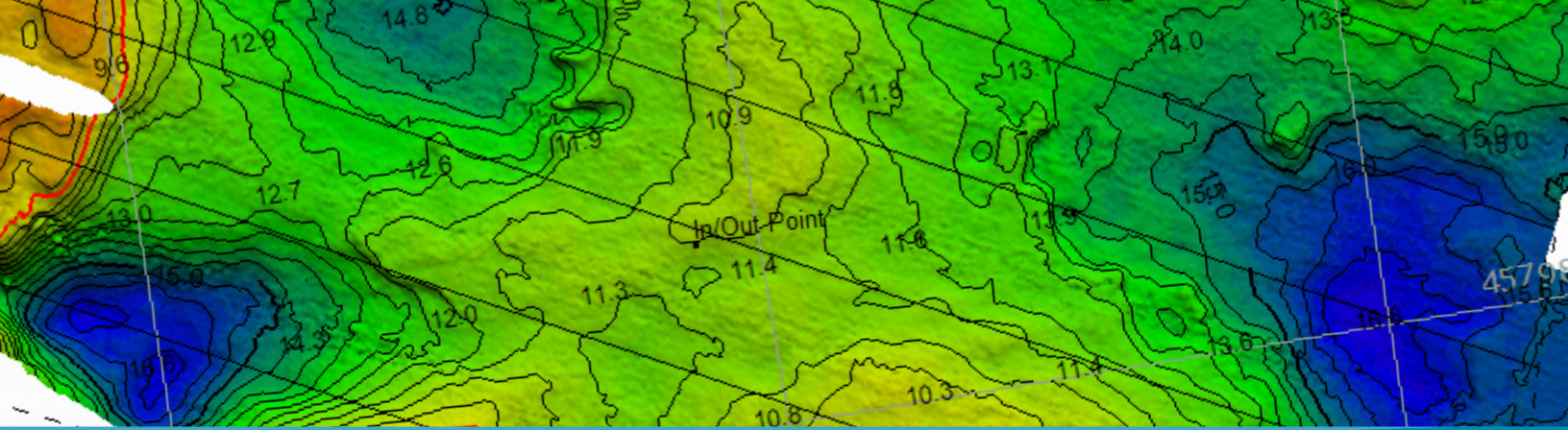
4 An extinction coverage of +/-20° is observed at about 530 meter water.

T50-P Scope of supply

- Receiver EM7218
- Projector TC2181
- Portable Sonar Processor
- 25m Receiver cable
- 25m Projector cable
- Waterproof cable set
- Wet-end bracket
- 3-year warranty

Optional extra features

- 10m, 50m or 100m cable
- Hydro dynamic fairing
- Dual head bracket
- Motion and positioning sensors
- RESON Sound Velocity Probes
- Teledyne PDS Survey Package
- RESON Service Level Agreements
- Normalized backscatter
- X-Range - improve range and reduce external noise
- Multi-Detect - multiple detections for enhanced detail over complex features and water column targets
- FlexMode – increase data density where you need it most
- Pipe Detection & Tracking – optimize detection of pipes
- Full rate dual head across the entire frequency range

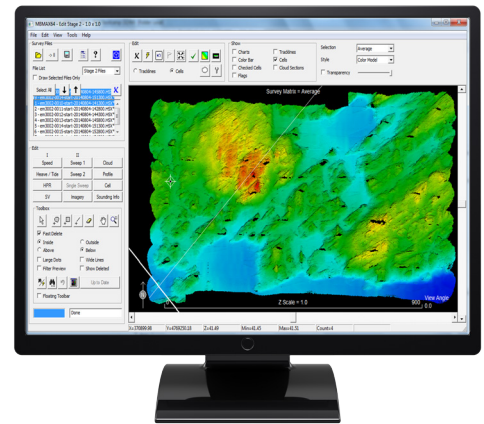


HYSWEEP®

SOFTWARE FOR CALIBRATING, COLLECTING AND PROCESSING MULTIBEAM, TOPOGRAPHIC LASER BACKSCATTER AND WATER COLUMN DATA

About HYSWEEP®

HYSWEEP® is the add on module to allow for the data collection and processing of your multibeam sonar and lidar systems. Tools for system calibration (Patch Test) make the set up simple to do. Online displays for real time CLOUD shows the system in operation. Processing large data sets are efficient with the 64 bit processing module. The software interfaces with nearly all multibeam sonars on the market today.

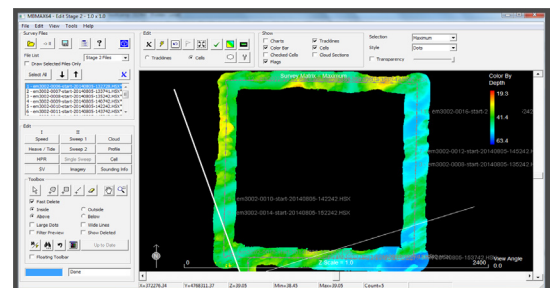


Features

- Acquisition of backscatter, intensity and water column from multibeam sonars can be done simultaneously with the sounding data
- Complete software package for acquisition and processing
- Tools for data analysis include CUBE, Wobble Analysis, Beam Angle Test
- Export to ASCII XYZ, LAS, Matrix file and custom format. Data can be gridded to a dozen different methods, including average, mode, median, standard deviation and more.

Benefits

- The HYSWEEP® Patch Test is simple to use, with just a few survey lines needed to run for an automatic computation of the mounting offsets.
- HYSWEEP® Survey provides the real time coverage display, TPU and other QC tools for a real time analysis of the data - before you go back to the office for data processing.



Included in HYSWEEP®

HYSWEEP® SURVEY provides you with a coverage plot, real-time TPU displays, and QC tools needed to efficiently complete your multibeam survey.

REAL TIME POINT CLOUD: The program runs in conjunction with HYSWEEP® SURVEY and displays both multibeam and topographic laser data in a corrected and geo-referenced, color-coded point cloud. The REAL TIME POINT CLOUD program is useful for easier feature detection and data quality control.

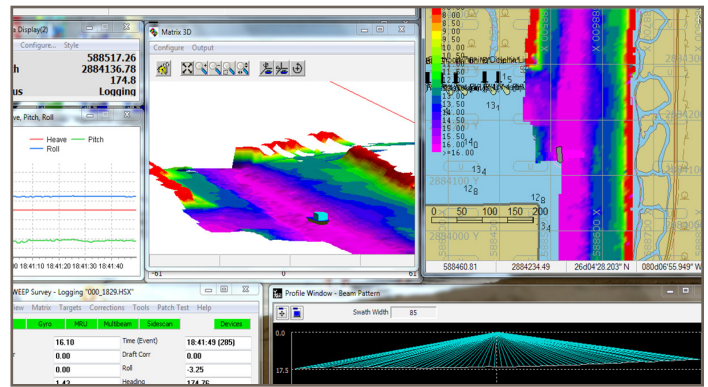
The HYSWEEP® Water Column Logger allows users to ensure that targets above the seabed, such as wrecks, are fully detected, and to confirm the least depth in the water when fine features such as cables or masts may otherwise be missed with the multibeam sonar.

The HYSWEEP® multibeam editor allows you to review your raw data components, incorporate sound velocity and water level corrections (including RTK TIDES and VDATUM), and apply statistical filters to quickly clean your data and output a variety of data subsets.

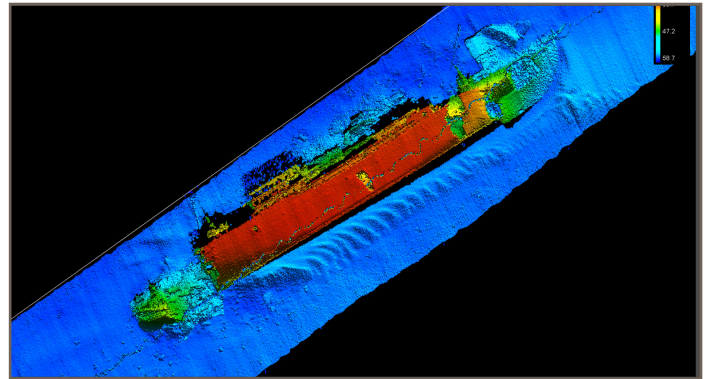
GEOCODER™ is included in the program (licensed from UNH-CCOM) and allows you to generate mosaics and perform bottom classification from average backscatter and snippet data.

HYSWEEP® includes interfaces for the following systems:

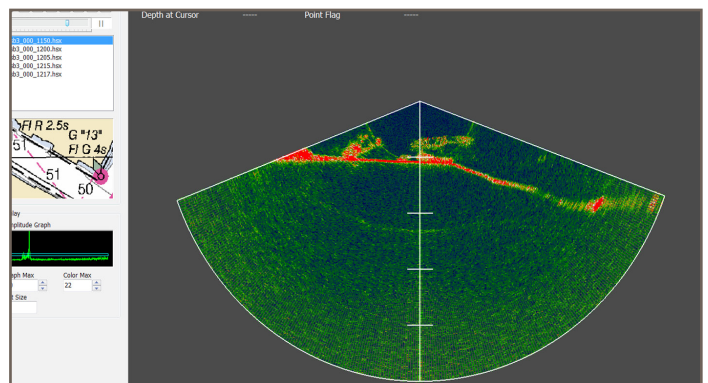
Atlas, Fansweep, Hydrosweep	Odom ES3, MB1, MB2
Bathy Swathplus	Optech ILRIS
Blueview multibeam	PingDSP 3DSS-DX
Edgetech 4600 and 6205	R2Sonic Sonic 20XX Series
GeoAcoustics GeoSwath	Reson 71xx, 81xx, 91xx, T20, T50
IBeam	Riegl LMS and V Series
Imagenex Delta T, DT100,101,102	Reinshaw
Kongsberg MS1000	Ross Smart Sweep
Kongsberg EM1002/2000/2040/710	SEA Swath Plus
Kongsberg EM 3000/3002/3002D/302	Seabeam 2100/3000/SB1000
Kongsberg Mesotech M3	Tritech Gemini
Klein HydroChart	Tritech SeaKing
Leica PS20	Velodyne HDL, VLP
Norbit WBMS	WASSP Multibeam



The HYSWEEP® SURVEY program showing 3D Seafloor, Beam Pattern, Coverage Map, and Motion Correction. Over 20 real-time windows can be chosen.



HYSWEEP® includes 3D visualization and processing tools using our CLOUD program.



The HYSWEEP® WATER COLUMN PLAYBACK allows you to replay the water column data provided by modern multibeam sonars.

ATTACHMENT A : FIELD NOTES (SEE ZIP FOLDER)

ATTACHMENT B : CAD FILES (SEE ZIP FOLDER)

ATTACHMENT C : RAW DATA (SEE ZIP FOLDER)

ATTACHMENT D : OPUS REPORTS (SEE ZIP FOLDER)