



SURVEYORS'

Optimizing Field Data Collection Combining GNSS and Total Station Data...

with Carlson Software

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About Today:

With the use of modern GNSS Equipment used more and more on everyday Land Surveying Projects we will take a deep dive into the tools available for today's users of Carlson Software's most recent product offering. Real world projects will be studied and with the use SurvPC 7 with advanced control survey field collection options is where we will start. From there we will take a look at processing GPS/GNSS baselines and how this is done within Carlson's Survey GNSS Post Processing Software. From there a discussion on Carlson Survey and the options for Least Squares Adjustment options in the popular Carlson Survey Software. Last but not least we will also review a feature that's been asked about by many of you, so we're doing a session on this as well! SurvPC's Trig Leveling functionality for level runs with your Total Station. The goal here is to do a live presentation and then review the data with you. Other subjects that we will cover is the workflow and how 'Your Data' can be used and evaluated for your Land Surveying Projects!

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Agenda for the Day!

- ❖ Project Settings – SurvCE/SurvPC (Field Software) and Carlson Software (Carlson Survey)
 - Setup and use within SurvPC
 - Setup and use within Carlson Survey
- ❖ GPS Field Location with GNSS – Topo Point Location vs. Control Point Location
 - Best Practices Discussion and review
 - Topo/Side Shot
 - Establishing the 'Base-Point' within SurvPC
- ❖ SurvPC – What's been added and updated as well as what's been their (Review and Discussion)...
- ❖ Importing, Exporting and Reporting from SurvPC / Field Data
- ❖ Introduction and to your .rw5 file – Let's process a file!
 - Processing of GNSS and TS Data
 - Compass and Least Sq Adjustment with Traverse Data as well as GNSS Data / Alta Survey / RPA Reports / Trig Leveling and More...
- ❖ Classroom Field Exercise on Trig Leveling – Report and Processing
- ❖ Finish up with some of the New Options within SurvPC 7 and other hidden 'Gems' within Carlson Software

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Useful Links

Carlson Software Website: www.carlsonsw.com

Carlson Academy Learning Center: <https://account.carlsonsw.com/login>

Carlson Software Knowledge Base Articles: <https://web.carlsonsw.com/files/knowledgebase/kbase05.php>

Carlson Software Manuals: <https://web.carlsonsw.com/files/manuals/manuals05.php>

Carlson Software YouTube Channel: <https://www.youtube.com/user/CarlsonSoftware/videos>

Carlson Software Support Information: <https://www.carlsonsw.com/support-and-training/>

NGS Website Info:
https://geodesy.noaa.gov/GEOID/GEOID18/maps/geoid18_difference_conus.png
https://geodesy.noaa.gov/GEOID/GEOID18/maps/geoid18_uncertainty_conus.png

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Yes, learning can be fun...

Let's make that a Goal of Today!



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Project Settings - Carlson Software

Desktop Software - Settings -> Configure

Drawing Setup...

Scale and Size Settings: English Units, US Feet, Horizontal Scale: 10.0, Vertical Scale: 5.0, Symbol Plot Size: 0.0000, Text Plot Size: 0.0000, Line Type Scale: 0.5000

Coordinate System: Local, Define Projection: USA-NAD83(2011) Pennsylvania (South), Project Scale Factor: 1.0000000000000000, Base 2

Angle Mode: Manual, Gon, Other

Projection: Pre-Defined, User-Defined, More Info, Zone

Define Projection: USA-NAD83(2011) Pennsylvania (South)

Project Scale Factor: Fixed -- Factor: 1.0000000000000000 Set

Input/Output Distance Scale: Fixed -- Factor: 1.0000000000000000 Set

Output/Plot Distance Scale: Fixed -- Factor: 1.0000000000000000 Set

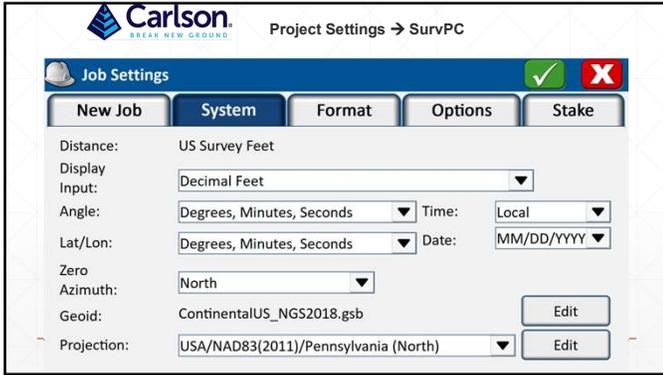
Project Name: Job Number

Project Location: Job Number

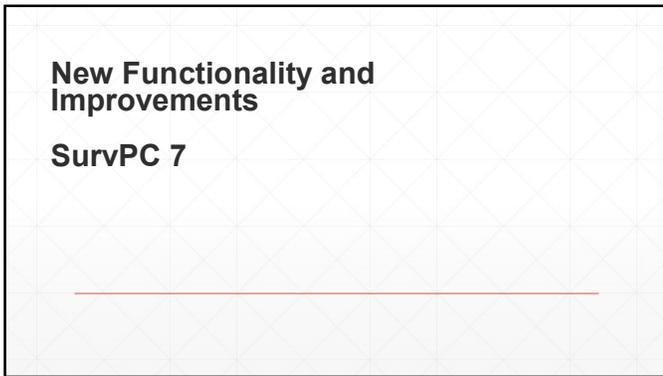
Rotation (deg mm): 0.0000

Buttons: OK, Cancel, Set Text Styles, Set Paper, Help

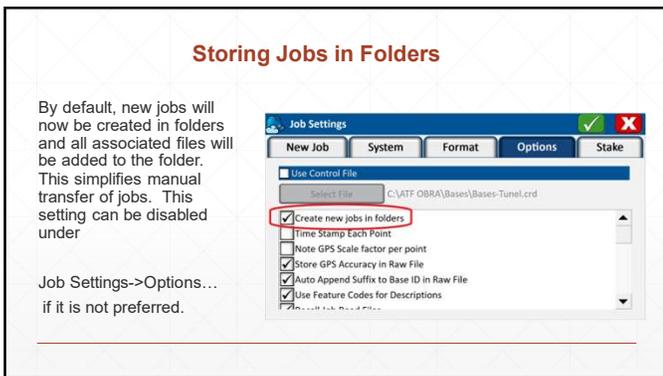
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Custom User Hotlist

A quick access user hotlist is now available by double tapping in the top bar. A selection of handy shortcuts come preinstalled with the software, and the user can customize the hotlist using the gear icon in the top bar.

Advanced users can even create their own hotlist items using python scripting!

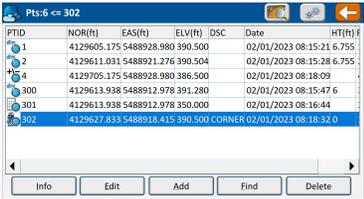


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New Interface with your Point List

The point list now includes columns for date/time, rod height, and point source, represented by an icon.

The point list now functions as a full featured raw data explorer and editor.



PTID	NOR(ft)	EAS(ft)	ELV(ft)	DSC	Date	HT(ft)
1	4129605.175	5488928.980	390.500		02/01/2023 08:15:21	6.755
2	4129611.031	5488921.276	390.504		02/01/2023 08:15:28	6.755
4	4129705.175	5488928.980	386.500		02/01/2023 08:18:09	
300	4129613.938	5488912.978	391.280		02/01/2023 08:15:47	6
301	4129613.938	5488912.978	350.000		02/01/2023 08:16:44	
302	4129627.833	5488918.415	390.500	CORNER	02/01/2023 08:18:32	0

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Rod height modification

Rod height can now be edited from the Point Info->Edit screen. The software will offer to modify the rod height of the current point only or reprocess the file. In a full reprocess, all points measured with the selected rod height will be adjusted, as well as cascading updates to all dependent points.

A modification report will be presented, and modifications will be tracked in point history!!!



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Improved Reporting

New HTML/PDF reports are available for **coordinate lists, stake reports, volume calculations and full job details**. Reports support email output and have fully customizable templates.

Other new export options include GVX, Full job as a ZIP, and GCP.



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Point Report

The report icon at the top of point info now generates a PDF or HTML point report with user selectable logo and options for session and measurement details. Report template can be fully customizable by editing the template file.

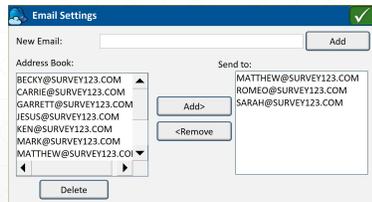


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Email Output – Email the project data to yourself or your project manager or tech in the office!

Email output is now available for reports, exports, and more throughout the software.

Use the address book to store frequently used addresses



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Carlson
BREAK NEW GROUND

Import Export vs. Data Transfer vs. Graphics vs. ????

- SurvPC 7 (NEW)
 - Imports/Exports
 - .txt, .csv, etc.
 - Don't forget about .crd/.crdb
 - Data Transfer
 - Project data
 - .crd
 - .rw5
 - Other files as well...

Export dialog box:

- Export: Coordinates
- File Type: PDF Report (*.pdf)
- Format: Point Report
- Email Coordinates
- Address Book

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Enhancements to Carlson Cloud

- Automatic login at startup
- Helmet indicates login status
- Online users now indicated in the user list
- Define user groups
- Send company or user-group wide announcements
- Separate chat windows for each conversation
- New user options for notifications
 - Unobtrusive helmet icon
 - Immediate screen popup (current method)
 - No notification

Sarah_W, limestone chat window:

Send To: Ken_T Groups Log off

09/09/22<< File attached https://parse.carlsonsw.com/1/files/IAWSLjB8wg4dR66;

Send

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Redundancy Notation and Blunder Detection

Average multiple measurement sessions automatically by using the same point ID. Configure a 2D or 3D coordinate match tolerance for blunder detection. Review session statistics to enable/disable measurements before storing the point, and access full details later in the point info screen.

Users who prefer the legacy "=" method of tagging points using the description field now have an option for auto tagging based on position. Using this method, when a measured position matches an existing point within the set tolerance, the description field will be replaced with the duplication tag of the user's choice automatically. In addition, positions manually tagged as being equal will be flagged as a potential blunder if positions do not match within tolerance.

Configure dialog box:

- General IMU Average GNSS
- Point Averaging Mode: From Raw Data
- Beep on rejected measurements
- Log Average Observations
- Automatically accept average results
- SurvNet duplicate point tag =
- Coordinate Match Tolerance: 0.998 ft 2D 3D

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Carlson
BREAK NEW GROUND

Import Export vs. Data Transfer vs. Graphics vs. ????

- SurvCE/SurvPC
 - Imports/Exports
 - .txt, .csv, etc.
 - Don't forget about .crd/.crdb
 - Data Transfer
 - Project data
 - .crd
 - .rw5
 - Other files as well...

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Enhanced Point Averaging options

GNSS Average now allows the selection of multiple requirements for average completion. Customize minimum measurement count, time, and required standard deviation between measurements.

The new redundancy sessions option allows for unattended measurement redundancy. Simply configure the required time delay and the software will perform repeated averages with RTK resets.

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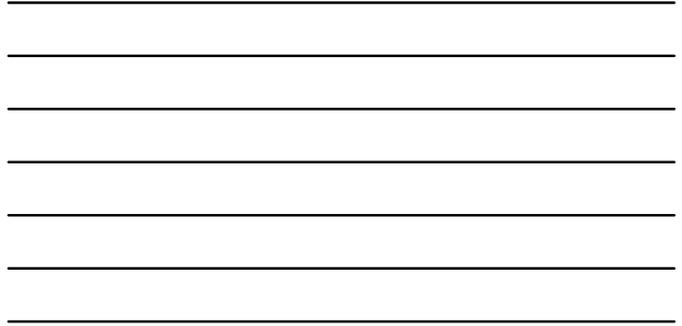


Carlson
BREAK NEW GROUND

Graphical Averaging Interface – Real Time!

- View error ellipses (1 sigma and 2 sigma) in real time or tap on graph to switch to elevation view
- Pause/Resume
- Choose to add more data at the end – Print and Report / Email

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SURVNET IN THE FIELD

BOUNDARY SURVEY CERTIFICATION

Field Procedures to reduce error

- **Dual baseline:** protects against wrong base setup or bad coordinate control
- **Time Delay:** protects against bad fix or multipath

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SurvNet In The Field

Settings ✓ ✕

Control

Include BP as control Add Control Points:

Standard Errors:

North: ft East: ft Elev. ft

RPA

Point Range:

Tolerance: ft PPM: KY Rural ▾

Blunder Detection 2D 3D Tolerance: ft

Minimum Time Delta: minutes Include Sideshots

Vector Std. Err. Factor: Auto Instrument Centering: ft

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Carlson SurvNet Least Squares Adjustment

SurvNet least squares adjustment is now available in SurvPC for GPS boundary survey certification. Access the feature through File->Raw data. Compute results and create and email HTML and PDF relative point accuracy reports without leaving the field. Simplified output screens allow quick assessment of survey quality. Easily modify settings and recompute, remove points, or resurvey data if necessary.

Results: floodwall089922 Adj Crd Control Connections

Solution converged in 2 iterations.
Failed the Chi-Square test at the 95.00 significance level (bestmisd)
23.654 +/- 17.422 +/- 38.120 (Auto-calculated Vector Std. Err. Factor 0.000)

Total Observations: 54 Total Unknowns: 15

Degrees of Freedom: 39

Number of Control Coordinates: 15

Results: park020122_sessions Adj Crd Control Connections

10 Connections Examined. All passed at tolerance of 0.070 + 100 ppm.
Worst connection (passed) at 0.0062 + 100ppm.

St.	1 St.	2 Result	Distance	Calculated Err.	Actual Semi-major	Allow Semi-major
1	4	✓	149.2186	0.0062 + 100ppm	0.0211	0.0849
2	4	✓	251.2695	-0.0046 + 100ppm	0.0205	0.0951
1	2	✓	107.7709	0.0064 + 100ppm	0.0172	0.0808
2	3	✓	162.2357	0.0021 + 100ppm	0.0183	0.0862

Save the report

Change Settings

Recalculate

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Relative Point Accuracy: Best Practices

BEST:
 Two or more local bases, 20 min time difference (setup base, measure, move base, measure)
 Single base + Network Base (NOT VRS) with time difference
 Single base + VRS - time difference (measure VRS, set up base, measure with base)

ACCEPTABLE:
 Two baselines, no time difference (two bases are setup simultaneously)
 Single base + Network Base (NOT VRS) no time difference (measure both before moving)
 Single base + VRS - no time difference (measure both before moving to next point).

ACCEPTABLE BUT... May struggle to pass
 Local base with time difference
 VRS with time difference - YES, but it may be harder to pass. Not ideal
 Network base with time difference

NOT RECOMMENDED:
 Single base with NO time difference (with RTK Reset)
 Single base, no time difference, no reset (just measure twice)
 Network base, no time difference, RTK Reset
 Network base, no time difference, no RTK Reset (just measure twice)
 VRS, no time difference, just RTK Reset
 VRS, no time difference, no RTK Reset (just measure twice)

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SurvNet In The Field

Settings ✓ ✕

Control

Include BP as control Add Control Points:

Standard Errors:

North: ft East: ft Elev: ft

RPA

Point Range:

Tolerance: ft PPM: ▼

Blunder Detection 2D 3D Tolerance: ft

Minimum Time Delta: minutes Include Sideshots

Vector Std. Err. Factor: Auto Instrument Centering: ft

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Final Report – Many Types To Review!

C:\dat...\it\floodwall080922\floodwall08092220220906_164117.html ✕

Project Info

Job: Survey ID:

Projection: UTM Zone: UTM Datum: UTM Datum:

Scale: UTM Datum: UTM Datum:

Results

Session converged in 2 iterations.

Factor for Chi-Square test at 95% significance level: (pass/fail)

Chi-Square = 17.422 on 18.125 (Auto-adjusted) Vector Bas. Std. Factor (95%)

17.422 on 18.125

Flags: Unconverged: 0

Flags: Unconverged: 0

Number of Control Coordinates: 0

Control Vectors: 48

10 Connections Checked. All passed at tolerance of 0.001 = 100 ppm.

PL ID	Local Coordinates	Time Delta
1		89.150min 12 Sec.00ms
2		1 Hour 8.05min 55 Sec.00ms
3		1 Hour 8.05min 55 Sec.00ms

Adjusted Coordinates

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Let's look at that Raw File

- Carlson's .rw5 file 'reads or creates' a raw data file that contains various lines of data (records) that could be likened to a surveyor's field book. You can specify point coordinates, job information, notes, and the angles and distances that make up traverse or sideshots records (and much more)
- Once the raw data is created or read it can be processed/reduced to coordinates that are stored in the current coordinate (.crd; .crdb; .cgc; .mdb; .zak) file.

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Let's look at that Raw File

- When you select the *Edit-Process Raw Data File* command you are prompted to specify the name of the raw data (.RW5) file. The current coordinate file is used automatically. To change the current coordinate file, use the Set Coordinate File command in the Points menu before starting this command. If no coordinate file is current, the program will prompt you to set the current coordinate (.CRD/.CRDB) file.
- Within SurvPC/CE you also can access the 'Raw Data' for edits or adjusting field collected data.
- Reminder: It's *always advised* that you back up your work prior to any major editing of a .rw5 file ☺

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**Let's look at that Raw File
Carlson SurvNET**

- Processing a Traverse within SurvNET
- Processing a GNSS/GPS Control File
- Trig Level File
- Alta Survey Processing and Reporting
- And more...

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Useful Links – Again...

Carlson Software Website: www.carlsonsw.com

Carlson Academy Learning Center: <https://account.carlsonsw.com/login>

Carlson Software Knowledge Base Articles: <https://web.carlsonsw.com/files/knowledgebase/kbase05.php>

Carlson Software Manuals: <https://web.carlsonsw.com/files/manuals/manuals05.php>

Carlson Software YouTube Channel: <https://www.youtube.com/user/CarlsonSoftware/videos>

Carlson Software Support Information: <https://www.carlsonsw.com/support-and-training/>

NGS Website Info:

https://geodesy.noaa.gov/GEOID/GEOID18/maps/geoid18_difference_conus.png

https://geodesy.noaa.gov/GEOID/GEOID18/maps/geoid18_uncertainty_conus.png

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JOB:20230802_ALPHA-RTK_BMS

File	Equip	Survey	COGO	Road	BIM
1 Store Points			6 Feature Survey		
2 Stake Points			7 Resection		
3 Stake Line/Arc			8 Set Collection		
4 Stake Offset			9 Leveling ✓		
5 Elev Difference					

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Leveling

Instrument: Current Total Station Select

Level File: C:\Use...LEVELING\20230824_TRIG_LEVELING - Copy.tlv Select

Project: HAINESPORT BMS

Operator: JK

Loop: 1

Date: 08/24/2023 Temp: 70

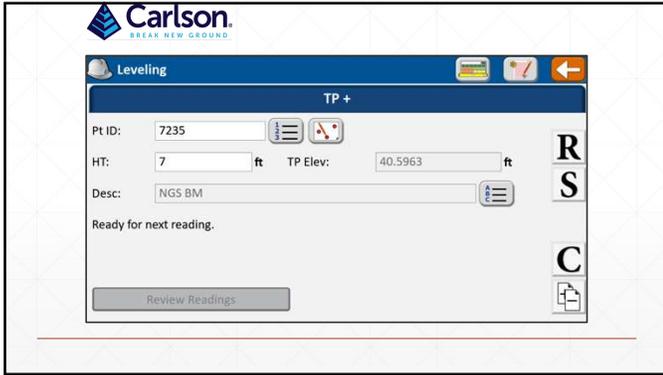
Time: 10:37:52 Press: 30

Use Road Files Select Road

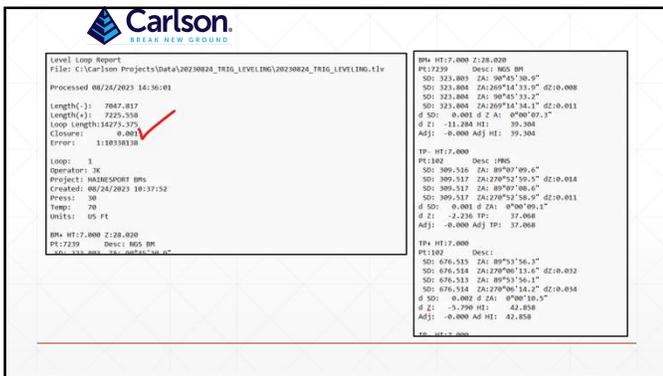
Centerline: C:\Carlson Projects\Data\CL1.cl

Profile: C:\Carlson Projects\Data\\$\$tmpppts\$\$.pro

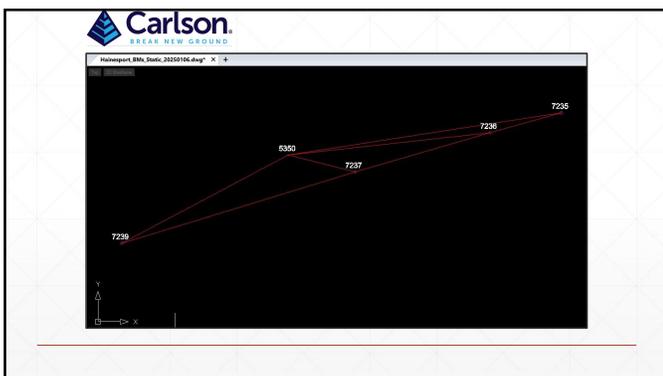
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FIRST OCCUPATION						
PRNO	Latitude	Longitude	Elevation	Desc	Date	Time
7239	39°58'59.26733"	-74°49'54.80899"	-22.8108	27239	00-02-2023	18:10:109
7237	39°59'09.38804"	-74°49'05.27432"	-17.9595	8844	00-02-2023	13:13:084
7236	39°59'14.55829"	-74°48'42.42849"	-18.7788	8843	00-02-2023	13:13:155
7235	39°59'17.19675"	-74°48'50.31220"	-18.1723	3 P 3	00-02-2023	13:12:102
5350	39°59'11.55464"	-74°49'16.62844"	-19.8858	HIDESPORT	00-02-2023	13:13:111

SECOND OCCUPATION						
PRNO	Latitude	Longitude	Elevation	Desc	Date	Time
7239	39°58'59.26435"	-74°49'54.80899"	-22.8790	27239	00-02-2023	13:10:153
7237	39°59'09.38115"	-74°49'05.27508"	-17.9679	8844	00-02-2023	14:12:015
7236	39°59'14.55755"	-74°48'42.42849"	-18.8787	8843	00-02-2023	14:13:113
7235	39°59'17.19677"	-74°48'50.31207"	-18.2381	3 P 3	00-02-2023	14:10:129
5350	39°59'11.55501"	-74°49'16.62834"	-19.1584	HIDESPORT	00-02-2023	14:10:136

THIRD OCCUPATION						
PRNO	Latitude	Longitude	Elevation	Desc	Date	Time
7239	39°58'59.26400"	-74°49'54.80841"	-21.9853	27239	00-02-2023	16:21:102
7237	39°59'09.38854"	-74°49'05.27488"	-17.8762	8844	00-02-2023	16:30:101
7236	39°59'14.55840"	-74°48'42.42864"	-18.8432	8843	00-02-2023	16:37:118
7235	39°59'17.19708"	-74°48'50.31115"	-18.2709	3 P 3	00-02-2023	16:40:100
5350	39°59'11.55519"	-74°49'16.62865"	-19.1644	HIDESPORT	00-02-2023	16:57:131

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Adjusted Grid Coordinates, (US Feet)						
Sta.	N:	E:	Z (geoid):	STERR N:	STERR E:	STERR Z:
5350	420175.740	402183.870	27.620	0.003	0.003	0.003
1104_BASE_1	487689.622	448147.979	55.588	0.000	0.019	0.033
7239	419089.364	399906.361	28.047	0.048	0.043	0.006
7237	419952.588	402986.823	41.373	0.039	0.036	0.005
7236	420470.151	404766.735	38.578	0.031	0.029	0.007
7235	420733.849	405710.782	40.577	0.036	0.035	0.008

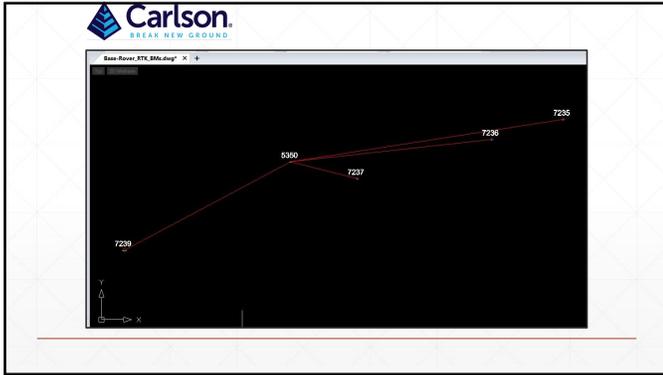
Statistic	Value
Solution converged in 2 iterations	
Total Observations:	62
Total Unknowns:	10
Degrees of Freedom:	44

Observation Count	Sum Squares of Stds	Std. Error of Unit Wt.
Coordinate:	3	0.000 0.000
Vertical:	8	4.544 0.933
Vector:	51	35.484 0.589
Total:	62	40.347 0.958

Reference Variance: 0.917
 Standard Error Unit Weight: +/- 30.958
 Passed the Chi-Square test at the 95.00 significance level
 27.575 <= 39.104 <= 64.201

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Station	Latitude	Longitude	Elevation	Desc	Date	Time
5358	39°58'11.15539"	-74°48'36.62872"	39.1236	MARKERSUM	07-27-2023	16:39:48
FIRST OCCUPATION						
7235	39°58'17.13609"	-74°48'38.31166"	-18.2093	3 P 3	07-27-2023	13:01:03
7236	39°58'14.55848"	-74°48'42.42826"	-18.8164	8843	07-27-2023	13:22:08
7237	39°58'09.38897"	-74°48'05.27425"	-17.9648	8844	07-27-2023	13:04:47
7239	39°58'59.54895"	-74°48'44.88838"	-22.0643	897239	07-27-2023	12:26:08
SECOND OCCUPATION						
7235	39°58'17.13759"	-74°48'38.31889"	-18.2393	3 P 3	07-27-2023	12:44:08
7236	39°58'14.55837"	-74°48'42.42826"	-18.8382	8843	07-27-2023	12:52:03
7237	39°58'09.38879"	-74°48'05.27426"	-17.9888	8844	07-27-2023	13:00:04
7239	39°58'59.54827"	-74°48'44.88721"	-22.0662	27239	07-27-2023	13:13:03
THIRD OCCUPATION						
7235	39°58'17.13609"	-74°48'38.31139"	-18.2197	3 P 3	07-27-2023	13:20:31
7236	39°58'14.55814"	-74°48'42.42864"	-18.8147	8843	07-27-2023	13:35:47
7237	39°58'09.38897"	-74°48'05.27425"	-17.9648	8844	07-27-2023	13:04:31
7239	39°58'59.54895"	-74°48'44.88838"	-22.0327	27239	07-27-2023	13:52:56

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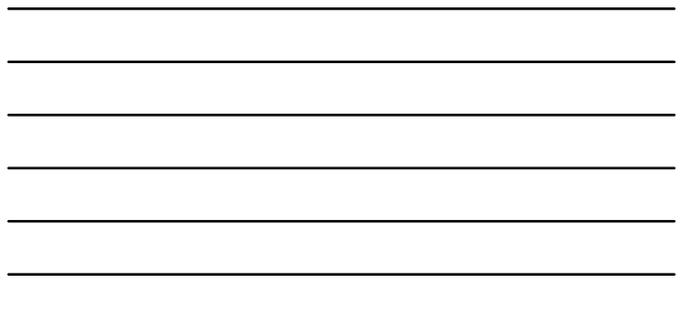
Station	N	E	Z (Geoid)	StErr N	StErr E	StErr Z
5350	420175.740	402103.870	37.620	0.003	0.003	0.003
7235	420733.831	405710.749	40.578	0.015	0.015	0.008
7236	420470.127	404766.770	38.579	0.013	0.012	0.007
7237	419952.518	402986.816	41.374	0.014	0.013	0.005
7239	415005.337	399506.330	25.047	0.018	0.019	0.006

Statistics
 =====
 Solution converged in 2 iterations
 Total Observations: 47
 Total Unknowns: 15
 Degrees of Freedom: 32

Observation Count	Sum Squares of StdRes	Std. Error of Unit Wt.
Coordinate:	3	0.000
Vertical:	8	4.985
Vector:	36	24.230
Total:	47	29.215

Reference Variance: 0.913
 Standard Error Unit Weight: (+/-) 0.955
 Passed the Chi-Square test at the 95.00 significance level
 18.291 <= 26.446 <= 49.480

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Carlson
BREAK NEW GROUND

POINT 5350
DESIGNATION - HAINESPORT
PID - DJ5350




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Carlson
BREAK NEW GROUND

```

00150# *****
00150# DESIGNATION - HAINESPORT
00150# PID - DJ5350
00150# STATE/COUNTRY - NJ/USA,ENGLAND
00150# COUNTY -
00150# ZONE QUAD - MOUNT HOLY (2005)
00150#
00150# *CURRENT SURVEY CONTROL
00150#
00150# NAD 83(2011) POSITION 39 58 18.5559920 N 88 48 34.4287240 W ADJUSTED
00150# NAD 83(2011) ELEVATION 20.196 (meters) 66(2/232) ADJUSTED
00150# NAD 83(2011) UTMZON 18Q
00150# NAD 83(2011) UTMX 37.62 (feet) ADJUSTED
00150#
00150# GROUND HEIGHT 10.471 (meters) GEOTID#
00150# NAD 83(2011) X 1,281,280.000 (meters) COR#
00150# NAD 83(2011) Y 4,722,430.000 (meters) COR#
00150# NAD 83(2011) Z 4,689,347.000 (meters) COR#
00150# LAPLACE COR# 1.32 (seconds) DELTA1C18
00150# SPHERICAL HEIGHT 11.842 (meters) 37.60 (feet) COR#
00150# MEAN SEA GRAVITY 980,196.8 (mgals) NAD83
00150#
00150# WGS 84 EARTH ACCURACY PERMITS PER RISE: HORIZONTAL POSITIONING ACCURACY
00150# STANDARDS:
00150# FREQ (cps) conf. int. standard deviation (std) GEOTID#
00150# RESOL (lines) 40.0 50.0 30.0 (meters)
00150#
00150# METERS 0.40 1.50 0.20 0.25 0.30 0.40000006
00150#
00150# *****
00150# Click here for local accuracies and other accuracy information.
  
```

00150# The horizontal coordinates were established by GPS observations
00150# and adjusted by the national geodetic survey in June 2011.
00150#
00150# NAD 83(2011) refers to NAD 83 coordinates where the reference frame has
00150# been adjusted to the static North American tectonic plate. See
00150# NAD83 for more information.
00150#
00150# The horizontal coordinates are valid at the epoch date displayed above
00150# which is a decimal equivalent of Year/Month/Day.
00150#
00150# The orthometric height was determined by differential leveling and
00150# adjusted by the national geodetic survey
00150# in May 2011.
00150#
00150# Significant digits in the grid height do not necessarily reflect accuracy.
00150# GEOTID# height accuracy online available here.
00150#
00150# Click photographs. Photos may exist for this station.
00150#
00150# The X, Y, and Z were computed from the position and the ellipsoidal ht.
00150#
00150# The Laplace correction was computed from DELTA1C18 derived definitions.
00150#
00150# The ellipsoidal height was determined by GPS observations
00150# and is referenced to NAD 83.
00150#
00150# The dynamic height is computed by dividing the NAD83
00150# geopotential number by the normal gravity value computed on the
00150# geodetic reference system of 1980 (980.665) ellipsoid at 45
00150# degrees latitude (g = 980.665 gals.).

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POINT 7239
DESIGNATION - 27239
PID - DM7239

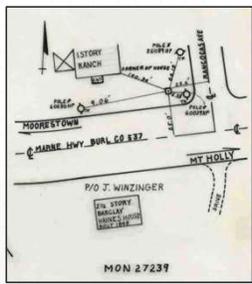



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POINT 7237
 DESIGNATION - 27237
 STATE/COUNTRY - NC/USA
 COUNTY - WYOMING
 QUAD - MOUNT HOLLY (2025)
 SURVEY CONTROL - FIRST CLASS II
 ELEVATION POSITION: 39 00 00.00 (N) 474 49 45.00 (E) SCALED
 HWD 88 ORTHO HEIGHT: 6.541 (meters) 21.452 (feet) ADJUSTED
 GEODESIC HEIGHT: 6.532 (meters) 21.434 (feet) CIPP
 MODELED GRAVITY: 980,186.1 (mgal) HWD 88
 VERT ORDER: FIRST CLASS II
 The horizontal coordinates were scaled from a map and have an estimated accuracy of +/- 8 seconds.
 The orthometric height was determined by differential leveling and adjusted by the NATIONAL GEODESIC SURVEY in May 2011.
 No vertical observational check was made to the station.
 Significant digits in the point height do not necessarily reflect accuracy.
 Height accuracy estimate available here.
 1:11k photographs - Photos may exist for this station.
 The dynamic height is computed by dividing the HWD 88 geopotential number by the normal gravity value computed on the Geoidetic Reference System of 1984 (GRS 80 ellipsoid at 45 degrees latitude ($g = 980.6199 \text{ gal/s}^2$)).
 The modeled gravity was interpolated from observed gravity values.
 NORTH EAST (1000' circular accuracy)
 127,720. 121,800. 00 (1/100 meters scaled)
 NATIONAL GRID SPATIAL ADDRESS: 1000045450000 03
 SUPERLEGGED SURVEY CONTROL
 No superlegged survey control is available for this station.
 1000' circular accuracy
 SETTING: 7' x 11" IN TOP OF CONCRETE MONUMENT
 1000' CIRCULAR
 1000' CIRCULAR
 PROJECTION: NAD83 / CONTINENTAL

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POINT 7237
 DESIGNATION - 27237
 STATE/COUNTRY - NC/USA
 COUNTY - WYOMING
 QUAD - MOUNT HOLLY (2025)
 SURVEY CONTROL - FIRST CLASS II
 ELEVATION POSITION: 39 00 00.00 (N) 474 49 45.00 (E) SCALED
 HWD 88 ORTHO HEIGHT: 6.541 (meters) 21.452 (feet) ADJUSTED
 GEODESIC HEIGHT: 6.532 (meters) 21.434 (feet) CIPP
 MODELED GRAVITY: 980,186.1 (mgal) HWD 88
 VERT ORDER: FIRST CLASS II
 The horizontal coordinates were scaled from a map and have an estimated accuracy of +/- 8 seconds.
 The orthometric height was determined by differential leveling and adjusted by the NATIONAL GEODESIC SURVEY in May 2011.
 No vertical observational check was made to the station.
 Significant digits in the point height do not necessarily reflect accuracy.
 Height accuracy estimate available here.
 1:11k photographs - Photos may exist for this station.
 The dynamic height is computed by dividing the HWD 88 geopotential number by the normal gravity value computed on the Geoidetic Reference System of 1984 (GRS 80 ellipsoid at 45 degrees latitude ($g = 980.6199 \text{ gal/s}^2$)).
 The modeled gravity was interpolated from observed gravity values.
 NORTH EAST (1000' circular accuracy)
 127,720. 121,800. 00 (1/100 meters scaled)
 NATIONAL GRID SPATIAL ADDRESS: 1000045450000 03
 SUPERLEGGED SURVEY CONTROL
 No superlegged survey control is available for this station.
 1000' circular accuracy
 SETTING: 7' x 11" IN TOP OF CONCRETE MONUMENT
 1000' CIRCULAR
 1000' CIRCULAR
 PROJECTION: NAD83 / CONTINENTAL

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POINT 7237
 DESIGNATION - 8844
 PID - DM7237




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```

PR225 *****
PR225 DESIGNATION - 2 P 1
PR225 PTD - PR225
PR225 STATE/COUNTY - NJ/PARLINGTON
PR225 COUNTY - NJ
PR225 USGS QUAD - POINT HULLY (2025)
PR225
PR225 *HAINESPORT SURVEY CONTROL
PR225
PR225* MAG DECLINATION - 10 30 17.22 (M) WPA 88 30.38 (M) 90.9122
PR225* MAG 88 OFFSET HEIGHT - 11.366 (meters)
PR225* MAG 88 OFFSET HEIGHT - 37.64 (feet) ADJUSTED
PR225
PR225 GEOD HEIGHT - -32.662 (meters)
PR225 GEOD HEIGHT - 107.82 (meters)
PR225 GEOD HEIGHT - 350.05 (feet) GCP
PR225 MODELED GRAVITY - 989.199.2 (mgals)
PR225
PR225 WEST ORDER - FIRST CLASS II
PR225
PR225 The horizontal coordinates were determined by differentially corrected
PR225 hand held GN observations or other comparable positioning techniques.
PR225 and have an estimated accuracy of +/- 3 meters.
PR225
PR225 The orthometric height was determined by differential leveling and
PR225 adjusted by the NATIONAL GEODETIC SURVEY
PR225 in May 2011.
PR225
PR225 Significant digits in the geoid height do not necessarily reflect accuracy.
PR225 GEOD508 height accuracy estimate available here.
PR225
PR225 Click photographs - Photos may exist for this station.
PR225
PR225 The dynamic height is computed by dividing the MAG 88
PR225 geopotential number by the normal gravity value computed on the
PR225 Geoid1 reference system of IGM 00 (IGF 00) ellipsoid at 45
PR225 degrees latitude (g = 9.80665 m/s^2).
PR225
PR225 The modeled gravity was interpolated from observed gravity values.
PR225
PR225
PR225: North East Units Estimated Accuracy
PR225 (M, M) - 126,288.0 121,651.2 M +/- 3 meters WGS 84 (EPS)
  
```

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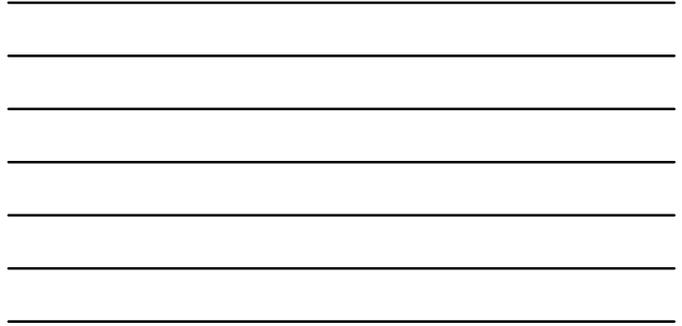
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Final_Adjusted_Coordinates

Name

- 1 Hainesport_BM_Static_Only_Compare_NCAT_N83-11_V88.xlsx
- 2 Compare_BMs_Static_Pub_Elev_w_Static_Trig_Leveling.xlsx
- 3 Compare_BMs_Static_Pub_Elev_w_RTN_Only_3_Occupations.xlsx
- 4 Compare_BMs_Static_Pub_Elev_w_RTN_Only_3_Occ_Trig_Leveling.xlsx
- 5 Compare_BMs_Static_Pub_Elev_w_RTN_Only_1st_Occ.xlsx
- 6 Compare_BMs_Static_Pub_Elev_w_RTN_Only_1st_Occ.xlsx
- 7 Compare_BMs_Static_Pub_Elev_w_RTN_Only_2nd_Occ.xlsx
- 8 Compare_BMs_Static_Pub_Elev_w_RTN_Only_2nd_Occ.xlsx
- 9 Compare_BMs_Static_Pub_Elev_w_RTN_Only_3rd_Occ.xlsx
- 10 Compare_BMs_Static_Pub_Elev_w_RTN_Only_3rd_Occ.xlsx
- 11 Compare_BMs_Static_Pub_Elev_w_RTN_Only_1st_2nd_3rd_Occ.xlsx
- 12 Compare_BMs_Static_Pub_Elev_w_RTN_Only_2nd_3rd_Occ.xlsx
- 13 Compare_BMs_Static_Pub_Elev_w_RTN_Only_1st_3rd_Occ.xlsx
- 14 Compare_BMs_Static_Pub_Elev_w_RTN_Only_3_Occupations.xlsx
- 15 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_3_Occupations.xlsx
- 16 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_1st_Occ.xlsx
- 17 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_1st_Occ.xlsx
- 18 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_2nd_Occ.xlsx
- 19 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_2nd_Occ.xlsx
- 20 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_3rd_Occ.xlsx
- 21 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_3rd_Occ.xlsx
- 22 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_1st_2nd_Occ.xlsx
- 23 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_2nd_3rd_Occ.xlsx
- 24 Compare_BMs_Static_Pub_Elev_w_B-R_RTK_Only_1st_3rd_Occ.xlsx
- 25 Compare_RTN_Only_1st_Occ_to_3rd_Occ.xlsx
- 26 Compare_RTN_Only_2nd_Occ_to_3rd_Occ.xlsx
- 27 Compare_RTN_Only_1st_Occ_to_3rd_Occ.xlsx
- 28 Compare_B-R_RTK_Only_1st_Occ_to_2nd_Occ.xlsx
- 29 Compare_B-R_RTK_Only_2nd_Occ_to_3rd_Occ.xlsx
- 30 Compare_B-R_RTK_Only_1st_Occ_to_3rd_Occ.xlsx
- 31 Compare_BMs_Pub_Elev_w_Trig_Leveling.xlsx

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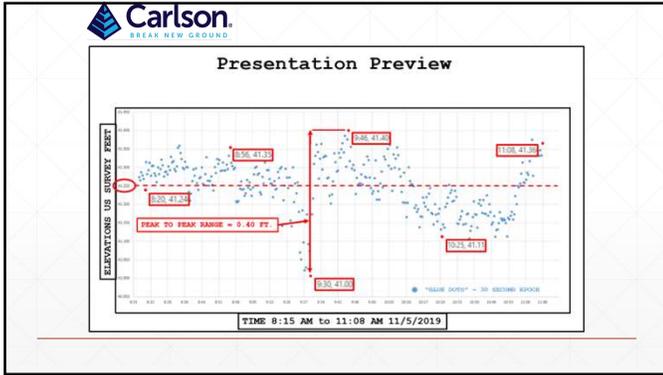
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31_Compare_BMs_Pub_Elev_w_Trig_Leveling.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Hainesport_BMs_Static_Adj_Horiz_and_Pub_Elev_V88.csv					Hainesport_BMs_Trig_Leveling_Only_Adjusted_CSV					Trig minus Pub			
2	POINT	NORTH	EAST	ELEV	DESIGNATION	PID	POINT	NORTH	EAST	ELEV	Dn	De	Dz	
3	5350	420175.74	402103.87	37.62	HAINESPORT	D15350	5350	-999999999	-999999999	37.611	#####	#####	-0.008	
4	7230	420733.38	403710.74	40.64	3 P 3	DM7230	7230	-999999999	-999999999	40.577	#####	#####	-0.063	
5	7230	420470.17	404766.76	38.56	8843	DM7230	7230	-999999999	-999999999	38.561	#####	#####	0.001	
6	7237	419952.51	402986.83	41.39	8844	DM7237	7237	-999999999	-999999999	41.357	#####	#####	-0.033	
7	7230	419009.31	399906.33	28.02	27230	DM7230	7230	-999999999	-999999999	28.02	#####	#####	0.000	

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**Maryland Society of Surveyors
2023 Spring Technical Conference**

Session: Least Squares Adjustments
Tuesday Feb 28, 2023 12 noon - 2pm.

Jim Carlson
Carlson Software

Jesse Kozlowski, PLS (NJ)
Independent Consultant

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Survey Measurement Analysis Software

Carlson SurvNET

MicroSurvey STAR*NET

Trimble TRIMNET Plus

Trimble Business Center

Carlson Since 1963

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Carlson SurvPC7 w/ SurvNet

The screenshot shows the SurvNet results window for project 230216-A-CROWSWOODS-1K. It displays a table of connection results:

Results	Points Used	Adj.Crd	Control	Connections
6 Connections Examined. All passed at a tolerance of 0.066 + 50 ppm.				
Worst connection (passed) at less than 50ppm.				
QC 1.0: 2 Results Distance Calculated Error Actual Semi-major Allow Semi-major				
3	✓	237.7611 less than 50ppm	0.0303	0.0775 0.1
1	✓	418.4138 less than 50ppm	0.0306	0.0865 0.1
2	✓	358.4309 less than 50ppm	0.0300	0.0836 0.1
3	✓	587.9535 less than 50ppm	0.0308	0.0950 0.1
4	✓	642.0738 less than 50ppm	0.0306	0.0950 0.1

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Why Least Squares?

- What is the alternative?
- Compass Rule? No.
- Combining GNSS Vectors, Total Station & Leveling - Only Least Squares.
- Unadjusted TXT or CSV files?
- ALTA-NSPS Relative Positional Precision.
- ASPRS Positional Accuracy Standards
- QA/QC Survey Data - Project Spec Achieved?

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Problem Guaranteed - No QA/QC

The screenshot shows a warning message: "Do NOT accept coordinate data exported out of the data collector from the field without QA/QC analysis and verification the project specification has been achieved." Below the message is a list of coordinate data:

```

\Temp\SurvFile_Copy 057 -Notepad
File Edit Format View Help
#-227,202978,888,224638,806,94,840,PAG NAIL SET
#0-1332,209223,808,120387,896,73,185,B CUT SET
#480,116288,235,126462,139,91,640,PAG NAIL FOUND
#0,282973,405,118862,453,40,960,NAIL TARGET
#11,201976,116,120907,233,61,610,NAIL TARGET
#105,201388,910,128023,255,41,564,NAIL TARGET
#100,202000,546,128880,305,41,607,NAIL TARGET
#105,201204,621,128663,889,41,521,DRILL HOLE W/NOISE PND
#100,201429,776,127967,867,37,860,NAIL TARGET
#1207,201438,484,127817,737,79,787,NAIL TARGET
#000,201429,776,127967,867,37,860,NAIL TARGET
#1001,201953,497,130056,784,85,818,NAIL TARGET
#000,201954,120,127943,135,57,770,PAG NAIL SET
#000,201713,921,129678,148,57,805,PAG NAIL SET
#000,201378,940,125492,899,57,796,PC NAIL FOUND
  
```

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QA/QC From Least Squares Adjustment

Point ID	Northing	Easting	Elevation	Description	Std. Dev. (N)	Std. Dev. (E)	Std. Dev. (Elev)
A-227	20279.888	124838.496	94.840	MARK NAIL SET	0.024	0.020	0.007
AD-312	120518.000	120517.000	70.140	9-CUT SET	0.020	0.017	0.009
4802	120518.200	120402.000	91.840	MARK NAIL FOUND	0.019	0.014	0.007
49	20279.600	124838.000	94.940	WALL TARGET	0.013	0.010	0.004
411	20279.104	124837.200	91.813	WALL TARGET	0.011	0.007	0.005
8101	20258.000	124832.000	91.044	WALL TARGET	0.009	0.011	0.006
8106	20258.348	124831.500	91.007	WALL TARGET	0.008	0.009	0.007
8101	20258.402	124831.000	91.002	ORILL HOLE W/ WOOD TARGET	0.006	0.010	0.006
9101	20258.776	124791.007	97.000	WALL TARGET	0.008	0.007	0.006
11107	20268.484	124811.707	79.707	WALL TARGET	0.008	0.007	0.006
9008	20268.360	124781.207	68.678	WALL TARGET	0.008	0.006	0.006
13001	20261.007	124826.204	95.818	WALL TARGET	0.008	0.006	0.006
9001	20258.120	124741.100	10.771	MARK NAIL SET	0.007	0.009	0.006
9006	20251.502	124876.148	17.800	MARK NAIL SET	0.007	0.006	0.007
9008	20258.948	124811.000	10.796	MARK NAIL FOUND	0.007	0.010	0.006

Standard Deviations

Insist On Receiving The Positional Accuracy Of The Control Points & Targets

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BRx7 GNSS Receiver Specifications

Accuracy	RMS (47%)	2DRMS (95%)
Positioning:		
Autonomous:	1.2 m	2.4 m
SBAS:	0.3 m	0.6 m
RTK (10):	8 mm + 1 ppm	15 mm + 2 ppm
RTK (1):	2.5 mm + 1 ppm	5 mm + 1 ppm

Performance:
 • Depends on multipath environment, number of satellites in view, satellite geometry.
 • (within 30°)
 • Depends also on baseline length
 • Requires II subscription from Hemisphere GNSS

Compenation (within 40°):
 • 5 cm (with 1.8 m pole)
 • Initialization Time: < 10 s

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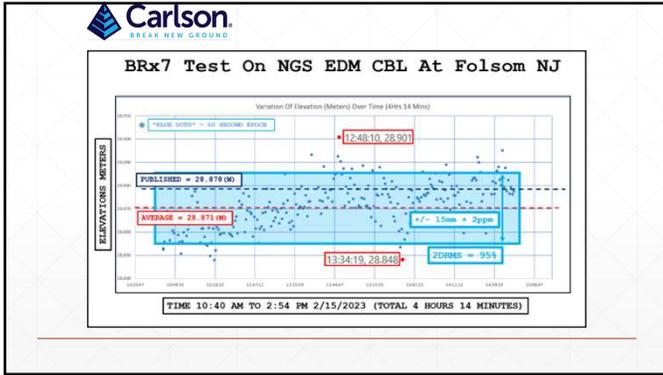
BRx7 Test On NGS EDM CBL At Folsom NJ

FOLSOM CBL 900
DU5349

National Geospatial Survey - Retrieved Date = FEBRUARY 19, 2023

015349	DESIGNATION - FOLSOM CBL 900	
015349	PTS - DU5349	
015349	STATE/COUNTRY - NJ/ATLANTIC	
015349	COUNTRY - US	
015349	USGS QUAD - NEWTONVILLE (2019)	
015349		NEAREST SURVEY CONTROL
015349	NAD 83(2011) POSITION - 39 31 44.33055(N) 074 51 38.76655(W)	ADJUSTED
015349	NAD 83(2011) ELLIP HT - 14.474 (meters)	ADJUSTED (06/27/12)
015349	NAD 83(2011) EPSG - 2011-00	
015349	USGS_83 ORTHO HEIGHT - 19.454 (meters)	62.51 (Feet) ADJUSTED
015349	USGS_83 ORTHO HEIGHT - 19.454 (meters)	
015349	NAD 83(2011) X - 1,288,188.264 (meters)	COMP
015349	NAD 83(2011) Y - 4,750,460.023 (meters)	COMP
015349	NAD 83(2011) Z - 4,043,475.809 (meters)	COMP
015349	LAPLACE COR - 0.41 (Centim)	COMP REFLECTOR
015349	DYNAMIC HEIGHT - 19.244 (meters)	62.48 (Feet) COMP
015349	MODELED GRAVITY - 980.176 (CGM1)	WGS 88
015349	VERT ORDER - FIRST CLASS II	
015349		
015349	Network accuracy estimates per IGSN Geospatial Positioning Accuracy	
015349	Standard:	
015349	IGSN (IGSN conf. est)	Standard Deviation (cm)
015349	North Ellip	0.9 0.9 0.9
015349	North	0.84 2.76 6.37 0.31 1.41 -0.00251742
015349		

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Standards, Specifications and Best Practices

The observing scheme for all stations requires that all adjacent stations (base lines) be observed at least twice on 2 different days and at two different times of the day according to observing procedures shown in item 4, on the previous page. The purpose is to ensure different atmospheric conditions (different days) and significantly different satellite geometry (different times) for the two base line measurements.

Observations on the second day should be completed between 27 and 33 hours after the completion of the first day's observations if the first day's observations were begun prior to 12:00 noon. Or, the observations should be completed between 15 and 21 hours after the completion of the first day's observations if the first day's observations were begun after 12:00 noon. This is necessary since the satellite constellation geometry repeats itself every 12 hours.

2 OCCUPATIONS SEPERATED BY DIFFERENT DAYS & TIMES

Examples: First-day observations begun during:	Second-day observations completed anytime between:
8:00 a.m. to 8:30 a.m.	11:30 a.m. and 5:30 p.m.
10:30 a.m. to 11:00 a.m.	2:00 p.m. and 8:00 p.m.
1:00 p.m. to 1:30 p.m.	4:30 a.m. and 10:00 a.m.
3:30 p.m. to 4:00 p.m.	7:00 a.m. and 12:30 p.m.

NOS NGS-58 GUIDELINES FOR ESTABLISHING GPS-DERIVED ELLIPSOID HEIGHTS 1997

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Standards, Specifications and Best Practices

NOS NGS-59 Guidelines For Establishing GPS-Derived Orthometric Heights 2008

2 OCCUPATIONS SEPERATED BY DIFFERENT DAYS & TIMES

NOAA Technical Memorandum NOS NGS 59
Guidelines for Establishing GPS-Derived Orthometric Heights

NOAA
National Oceanic and Atmospheric Administration
2008

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Standards, Specifications and Best Practices

An examination of commercial network RTK GPS services in Great Britain

AN EXAMINATION OF COMMERCIAL NETWORK RTK GPS SERVICES IN GREAT BRITAIN 2010

If the coordinate quality attainable from single epoch Network RTK is inadequate, we found that solution quality and robustness can be improved by implementing either single- or double-window position averaging. For topographic survey applications, a 5 second single-window average reduces the effect of individual coordinate solution variations. For more precise work, using two sets of averaged windows of around 3 minutes separated by around 20 minutes is found to yield 10-20% coordinate accuracy improvements compared with a single epoch solution. This could be further improved to up to 30% if the double window separation was extended to about 45 minutes, but beyond this separation no appreciable improvement was obtained.

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Standards, Specifications and Best Practices

FURTHER TESTING OF COMMERCIAL NETWORK RTK GNSS SERVICES IN GREAT BRITAIN

FURTHER TESTING OF COMMERCIAL NETWORK RTK GNSS SERVICES IN GREAT BRITAIN 2012

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Standards, Specifications and Best Practices

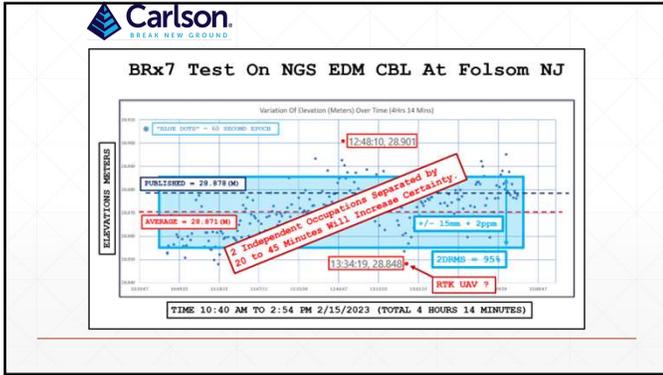
GUIDANCE NOTES FOR GNSS NETWORK RTK SURVEYING IN GREAT BRITAIN 2015

Improving solution robustness

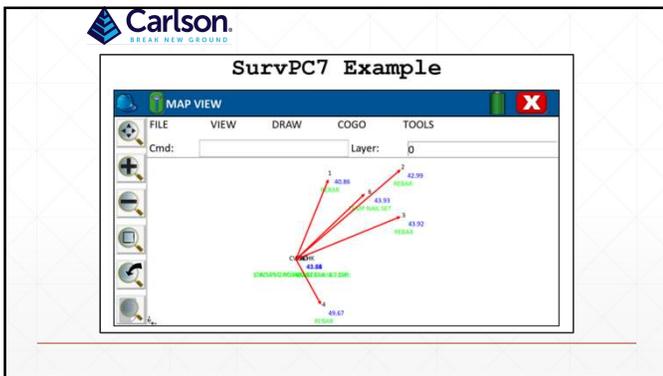
- For topographic survey, the use of a 5 second single window average will reduce the effect of individual coordinate solution variations.
- For precise work, especially where the height component is important e.g. control station establishment, the process of double window averaging should be undertaken. You should observe an averaged window of around 3 minutes followed by another averaged window of the same length separated from the first by a suitable time period (e.g. 20 minutes).
- On average, a time separation of 20 minutes will yield a 10 - 20% improvement in coordinate accuracy. A 45 minute separation will yield improved accuracies at the 15 - 20% level compared to a single epoch solution. Window separations of greater than 45 minutes do not typically provide appreciable further improvement to the determined coordinates.

"3 Hours Separation"
"Morning - Afternoon"
A thing of the past.

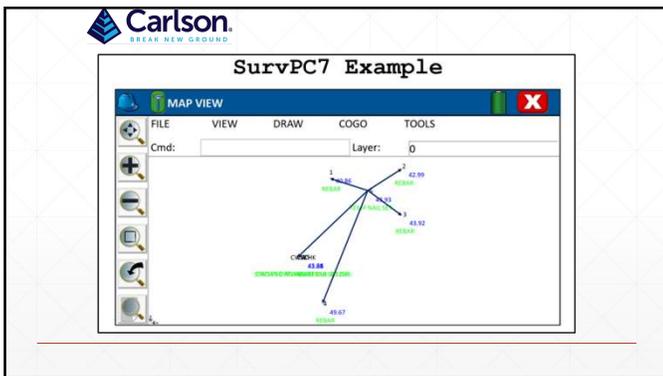
84



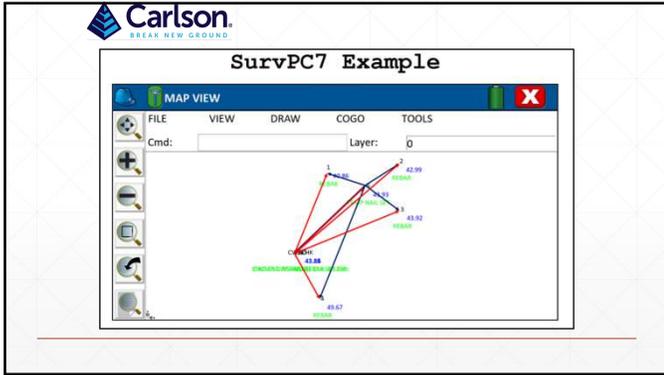
85



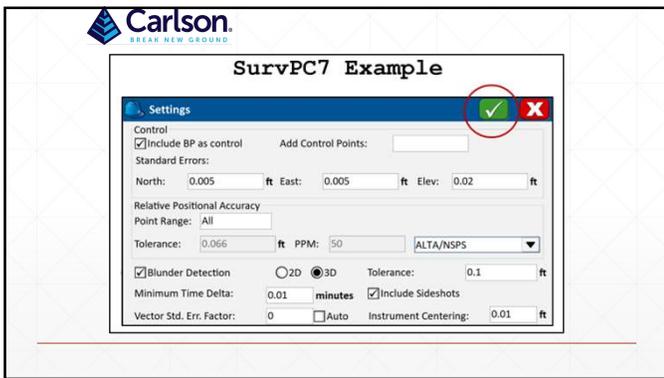
86



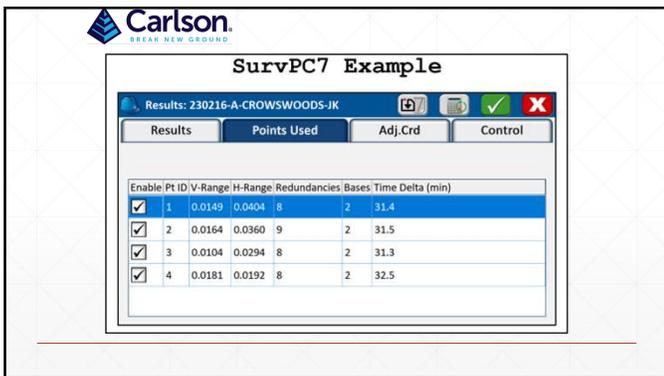
87



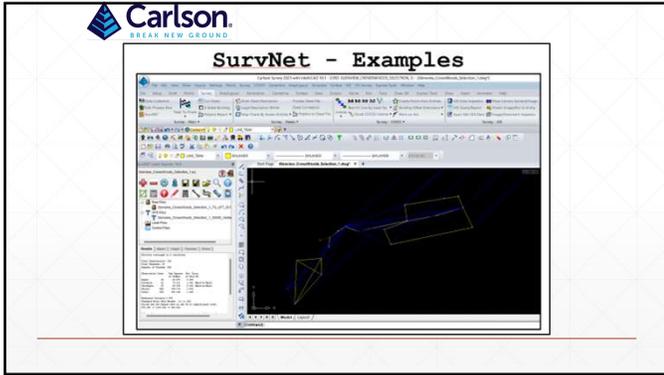
88



89



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