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Trigonometric Vertical Control No. 2

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This is an example of Trigonometric Vertical Control. This is the second of two reports.

INSTRUMENTATION AND SOFTWARE

Robotic Total Station – Leica TCRP 1201+ (1 arc second precision)
Prism – Leica GRZ 122 Pro Prism (2mm centering Accuracy)
Data Controller – Allegro CX
Data Controller Software – Carlson SurvCE v. 2.09
Office Software – Carlson Survey 2009 SurvNet (Least Squares analysis software current v. 7.0)

PROCEDURE

6 18" long, ½" rebars with caps were placed in various locations at the test site. The instrument was placed in the shade of a tree in a central location:

1. A traditional differential survey was performed (EL + BS = HI // HI – FS = Elevation)
2. The instrument was not moved. This can be observed as the constant HI value.
3. 3 Direct and Reverse observations were taken at each BS and FS.
4. The instrument was calibrated immediately prior to this survey.
5. The data consists of the first acquired observation. It should be noted that the SurvCE data controller software allows each observation to be viewed and either accepted or rejected in real time. There were no rejected observations in this survey.
6. The survey was performed robotically. Each sighting was acquired by sending a 'Power Search' command through the data controller. Power Search is the built in Leica technology that is commonly used to acquire initial robotic 'lock' on the target.
7. There were no prism rod measure ups (MU) used on the survey. An MU of 0.00 was set with a constant rod height. This eliminates the MU from the error budget.

DISCUSSION/ANALYSIS

The intent of this test was to validate the survey in Trigonometric Vertical Control No. 1.

1. The field procedure and point numbers for survey No. 2 and survey No. 1 are the same.
2. The instrument location for both surveys was constant.
3. The instrument was calibrated immediately prior to this survey.
4. The precision and resulting accuracy of the data indicates that the simple placement of the rod on each point is likely a major source of error. Since this data is so precise a more stable rod placement (i.e., something along the lines of a vertical deformation survey rod placement) is needed to evaluate the differences in elevations any closer than 0.003' +/-.

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LEAST SQUARES ADJUSTMENT REPORT
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Sat Apr 18 05:41:38 2009
Output File: C:\Carlson Projects\Test\Leica 1200\Park\PARK_1201_TEST_2.RPT
Curvature, refraction correction: ON
Maximum iterations: 10 , Convergence Limit: 0.001000
Local Coordinate System, Scale Factor: 1.000000
Horizontal Units: US Feet
Confidence Interval: 95.00
Default Standard Errors:
Distance: Constant 0.010 ,PPM: 5.000
Horiz. Angle: Pointing 1.0" ,Reading: 0.1"
Vert. Angle: Pointing 1.0" ,Reading: 0.1"
Total Station: Centering 0.005 ,Height: 0.005
Target: Centering 0.005 ,Height: 0.005
Azimuth: 2"
Coordinate Control: N:0.010, E:0.010, Z:0.010,


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  HORIZONTAL ADJUSTMENT REPORT
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Unadjusted Observations
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      LEAST SQUARES VERTICAL ADJUSTMENT REPORT
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Sat Apr 18 05:41:38 2009
Level File: C:\Carlson Projects\Test\Leica 1200\Park\PARK_1201_2.TLV
Output File: C:\Carlson Projects\Test\Leica 1200\Park\PARK_1201_TEST_2.RPT
Curvature, refraction correction: ON
Differential Leveling Standard Errors
   Avg. Dist. to BS/FS:50.0
   Rod Reading Err. per 100'/m:0.000
   Collimation Err. (sec.) 1.0:

Unadjusted Trigonometric Level Report

```
 Header1:   Operator:DEG  loop Name: 2  Project Name:1201 TEST 2DEG
 Header2:   date:04/17/2009  pressure: 1240366  temperature:78 time:14:55:35
 Rod:       Rod Ht.    0.000
 Benchmark: Name: 1        El:    5.823
 Backsight: Name: 1        SD:  99.670 ZE: 089-22'09 VD:  -1.097 HD:  99.664 HI:   4.726 Desc: CR
 Backsight: Name: 1        SD:  99.669 ZE: 270-37'47 VD:   1.096 HD:  99.663 HI:   4.727 Desc: CR
 Backsight: Name: 1        SD:  99.671 ZE: 089-22'10 VD:  -1.097 HD:  99.665 HI:   4.726 Desc: CR
 Backsight: Name: 1        SD:  99.671 ZE: 270-37'45 VD:   1.095 HD:  99.665 HI:   4.728 Desc: CR
 Backsight: Name: 1        SD:  99.671 ZE: 089-22'09 VD:  -1.098 HD:  99.665 HI:   4.725 Desc: CR
 Backsight: Name: 1        SD:  99.670 ZE: 270-37'47 VD:   1.096 HD:  99.664 HI:   4.727 Desc: CR
                                       Average HI:    4.727


 Foresight: Name: 3        SD: 337.601 ZE: 090-03'06 VD:   0.303 HD: 337.601 EL:   4.424 Desc: CR
 Foresight: Name: 3        SD: 337.600 ZE: 269-56'56 VD:  -0.298 HD: 337.600 EL:   4.428 Desc: CR
 Foresight: Name: 3        SD: 337.600 ZE: 090-03'05 VD:   0.301 HD: 337.600 EL:   4.426 Desc: CR
 Foresight: Name: 3        SD: 337.600 ZE: 269-56'52 VD:  -0.305 HD: 337.600 EL:   4.422 Desc: CR
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Foresight:  Name: 3        SD: 337.601 ZE: 090-03'06 VD:   0.303 HD: 337.601 EL:    4.423 Desc: CR
Foresight:  Name: 3        SD: 337.600 ZE: 269-56'54 VD:  -0.301 HD: 337.600 EL:    4.425 Desc: CR
                                          Average EL:    4.425

Backsight:  Name: 3        SD: 337.601 ZE: 090-03'05 VD:   0.301 HD: 337.601 HI:    4.726 Desc: CR
Backsight:  Name: 3        SD: 337.600 ZE: 269-56'53 VD:  -0.302 HD: 337.600 HI:    4.727 Desc: CR
Backsight:  Name: 3        SD: 337.601 ZE: 090-03'06 VD:   0.303 HD: 337.601 HI:    4.728 Desc: CR
Backsight:  Name: 3        SD: 337.600 ZE: 269-56'53 VD:  -0.303 HD: 337.600 HI:    4.728 Desc: CR
Backsight:  Name: 3        SD: 337.601 ZE: 090-03'05 VD:   0.301 HD: 337.601 HI:    4.726 Desc: CR
Backsight:  Name: 3        SD: 337.600 ZE: 269-56'55 VD:  -0.299 HD: 337.600 HI:    4.724 Desc: CR
                                          Average HI:    4.726

Foresight:  Name: 2        SD: 280.671 ZE: 090-07'56 VD:   0.647 HD: 280.670 EL:    4.079 Desc: CR
Foresight:  Name: 2        SD: 280.670 ZE: 269-52'06 VD:  -0.642 HD: 280.669 EL:    4.084 Desc: CR
Foresight:  Name: 2        SD: 280.671 ZE: 090-07'55 VD:   0.646 HD: 280.670 EL:    4.081 Desc: CR
Foresight:  Name: 2        SD: 280.672 ZE: 269-52'05 VD:  -0.644 HD: 280.671 EL:    4.083 Desc: CR
Foresight:  Name: 2        SD: 280.672 ZE: 090-07'54 VD:   0.644 HD: 280.671 EL:    4.082 Desc: CR
Foresight:  Name: 2        SD: 280.670 ZE: 269-52'04 VD:  -0.645 HD: 280.669 EL:    4.082 Desc: CR
                                          Average EL:    4.082

Backsight:  Name: 2        SD: 280.670 ZE: 090-07'55 VD:   0.646 HD: 280.669 HI:    4.728 Desc: CR
Backsight:  Name: 2        SD: 280.670 ZE: 269-52'06 VD:  -0.643 HD: 280.669 HI:    4.725 Desc: CR
Backsight:  Name: 2        SD: 280.671 ZE: 090-07'56 VD:   0.646 HD: 280.670 HI:    4.728 Desc: CR
Backsight:  Name: 2        SD: 280.671 ZE: 269-52'06 VD:  -0.643 HD: 280.670 HI:    4.725 Desc: CR
Backsight:  Name: 2        SD: 280.671 ZE: 090-07'56 VD:   0.646 HD: 280.670 HI:    4.728 Desc: CR
Backsight:  Name: 2        SD: 280.672 ZE: 269-52'06 VD:  -0.643 HD: 280.671 HI:    4.725 Desc: CR
                                          Average HI:    4.727

Foresight:  Name: 6        SD: 188.584 ZE: 089-38'10 VD:  -1.198 HD: 188.580 EL:    5.925 Desc: CR
Foresight:  Name: 6        SD: 188.584 ZE: 270-21'49 VD:   1.198 HD: 188.580 EL:    5.924 Desc: CR
Foresight:  Name: 6        SD: 188.584 ZE: 089-38'09 VD:  -1.199 HD: 188.580 EL:    5.926 Desc: CR
Foresight:  Name: 6        SD: 188.585 ZE: 270-21'49 VD:   1.198 HD: 188.581 EL:    5.925 Desc: CR
Foresight:  Name: 6        SD: 188.583 ZE: 089-38'10 VD:  -1.198 HD: 188.579 EL:    5.924 Desc: CR
Foresight:  Name: 6        SD: 188.585 ZE: 270-21'49 VD:   1.198 HD: 188.581 EL:    5.925 Desc: CR
                                          Average EL:    5.925

Backsight:  Name: 6        SD: 188.583 ZE: 089-38'09 VD:  -1.199 HD: 188.579 HI:    4.725 Desc: CR
Backsight:  Name: 6        SD: 188.584 ZE: 270-21'50 VD:   1.199 HD: 188.580 HI:    4.726 Desc: CR
Backsight:  Name: 6        SD: 188.584 ZE: 089-38'09 VD:  -1.199 HD: 188.580 HI:    4.726 Desc: CR
Backsight:  Name: 6        SD: 188.584 ZE: 270-21'48 VD:   1.197 HD: 188.580 HI:    4.727 Desc: CR
Backsight:  Name: 6        SD: 188.584 ZE: 089-38'10 VD:  -1.198 HD: 188.580 HI:    4.727 Desc: CR
Backsight:  Name: 6        SD: 188.584 ZE: 270-21'50 VD:   1.199 HD: 188.580 HI:    4.726 Desc: CR
                                          Average HI:    4.726

Foresight:  Name: 1        SD:  99.673 ZE: 089-22'08 VD:  -1.098 HD:  99.667 EL:    5.824 Desc: CR
Foresight:  Name: 1        SD:  99.673 ZE: 270-37'46 VD:   1.096 HD:  99.667 EL:    5.822 Desc: CR
Foresight:  Name: 1        SD:  99.674 ZE: 089-22'07 VD:  -1.098 HD:  99.668 EL:    5.825 Desc: CR
Foresight:  Name: 1        SD:  99.673 ZE: 270-37'47 VD:   1.096 HD:  99.667 EL:    5.822 Desc: CR
Foresight:  Name: 1        SD:  99.674 ZE: 089-22'08 VD:  -1.098 HD:  99.668 EL:    5.824 Desc: CR
Foresight:  Name: 1        SD:  99.673 ZE: 270-37'48 VD:   1.096 HD:  99.667 EL:    5.823 Desc: CR
                                          Average EL:    5.823

Benchmark:  Name: 1        El:    5.823
```

                    VERTICAL BENCHMARKS

Station	Elevation	Std. Error
1	5.8230	0.010

POINTS TO BE ADJUSTED

Station
3,2,6

MEASUREMENT SUMMARY

From	To	Elev. Diff. (unadjusted)	StdErr
1	3	-1.3983	0.0004
3	2	-0.3430	0.0006
2	6	1.8430	0.0008
6	1	-0.1013	0.0009

ADJUSTED ELEVATIONS

Station	Adjusted Elev	Standard Dev.
1	5.8230	0.00080
3	4.4247	0.00081
2	4.0816	0.00083
6	5.9245	0.00082

ADJUSTED MEASUREMENT SUMMARY

From	To	Elev. Diff. (adjusted)	Residuals	Std. Dev.
1	3	-1.3983	-0.0001	0.000
3	2	-0.3431	-0.0001	0.000
2	6	1.8429	-0.0001	0.000
6	1	-0.1015	-0.0001	0.000

Vertical Sideshots
 Station   Elevation