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Trigonometric Vertical Control No. 1

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This is an example of Trigonometric Vertical Control. This is the first 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 ($EL + BS = HI$ // $HI - FS = \text{Elevation}$)
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 not calibrated 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

The intent of this test was to eliminate as much incidental error from the error budget as possible.

1. The constant location of the instrument provided a standard distance from the HI to the respective BS and FS. This eliminated any curvature and refraction issues.
2. The constant location of the instrument also allows the slope measuring capability of the instrument and accumulated error (HI value) of the survey to be evaluated easily.
3. An MU of 0.00 eliminated the rod measure up and instrument measure up errors from the error budget.
4. The instrument for this survey had not been calibrated for several weeks. Although handled carefully, the instrument was subject to the necessary handling and vibrations of traveling in a vehicle.
5. The accumulated distance for this survey (sum of BS and FS distance) is 2,631' +/-.

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LEAST SQUARES ADJUSTMENT REPORT
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Tue Apr 28 16:07:13 2009
Output File: C:\Carlson Projects\Test\Leica 1200\Park\PARK_1201_TEST_1.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,

=====
HORIZONTAL ADJUSTMENT REPORT
=====

Unadjusted Observations
=====

LEAST SQUARES VERTICAL ADJUSTMENT REPORT

Tue Apr 28 16:07:13 2009
Level File: C:\Carlson Projects\Test\Leica 1200\Park\PARK_1201.TLV
Output File: C:\Carlson Projects\Test\Leica 1200\Park\PARK_1201_TEST_1.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: 1 Project Name:1201 TEST
Header2: date:04/17/2009 pressure: 1240366 temperature:75 time:14:01:34
Rod: Rod Ht. 0.000

Benchmark: Name: 1 El: 5.823
Backsight: Name: 1 SD: 99.669 ZE: 089-22'12 VD: -1.096 HD: 99.663 HI: 4.727 Desc: CR
Backsight: Name: 1 SD: 99.668 ZE: 270-37'53 VD: 1.099 HD: 99.662 HI: 4.724 Desc: CR
Backsight: Name: 1 SD: 99.668 ZE: 089-22'13 VD: -1.096 HD: 99.662 HI: 4.727 Desc: CR
Backsight: Name: 1 SD: 99.668 ZE: 270-37'53 VD: 1.099 HD: 99.662 HI: 4.724 Desc: CR
Backsight: Name: 1 SD: 99.668 ZE: 089-22'11 VD: -1.096 HD: 99.662 HI: 4.727 Desc: CR
Backsight: Name: 1 SD: 99.668 ZE: 270-37'53 VD: 1.099 HD: 99.662 HI: 4.724 Desc: CR
Average HI: 4.726

Foresight: Name: 3 SD: 337.606 ZE: 090-03'08 VD: 0.306 HD: 337.606 EL: 4.419 Desc: CR
Foresight: Name: 3 SD: 337.606 ZE: 269-56'58 VD: -0.295 HD: 337.606 EL: 4.431 Desc: CR
Foresight: Name: 3 SD: 337.607 ZE: 090-03'09 VD: 0.308 HD: 337.607 EL: 4.417 Desc: CR
Foresight: Name: 3 SD: 337.606 ZE: 269-56'58 VD: -0.295 HD: 337.606 EL: 4.431 Desc: CR
Foresight: Name: 3 SD: 337.606 ZE: 090-03'08 VD: 0.305 HD: 337.606 EL: 4.420 Desc: CR

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Foresight: Name: 3	SD: 337.606 ZE: 269-56'58 VD: -0.295 HD: 337.606 EL: 4.431 Desc: CR
	Average EL: 4.425
Backsight: Name: 3	SD: 337.606 ZE: 090-03'07 VD: 0.305 HD: 337.606 HI: 4.729 Desc: CR
Backsight: Name: 3	SD: 337.606 ZE: 269-56'58 VD: -0.296 HD: 337.606 HI: 4.720 Desc: CR
Backsight: Name: 3	SD: 337.607 ZE: 090-03'09 VD: 0.307 HD: 337.607 HI: 4.732 Desc: CR
Backsight: Name: 3	SD: 337.606 ZE: 269-56'58 VD: -0.295 HD: 337.606 HI: 4.720 Desc: CR
Backsight: Name: 3	SD: 337.607 ZE: 090-03'09 VD: 0.308 HD: 337.607 HI: 4.733 Desc: CR
Backsight: Name: 3	SD: 337.606 ZE: 269-56'58 VD: -0.295 HD: 337.606 HI: 4.720 Desc: CR
	Average HI: 4.726
Foresight: Name: 4	SD: 296.445 ZE: 090-26'42 VD: 2.302 HD: 296.436 EL: 2.424 Desc: CR
Foresight: Name: 4	SD: 296.443 ZE: 269-33'25 VD: -2.290 HD: 296.434 EL: 2.436 Desc: CR
Foresight: Name: 4	SD: 296.445 ZE: 090-26'43 VD: 2.303 HD: 296.436 EL: 2.423 Desc: CR
Foresight: Name: 4	SD: 296.444 ZE: 269-33'25 VD: -2.290 HD: 296.435 EL: 2.436 Desc: CR
Foresight: Name: 4	SD: 296.445 ZE: 090-26'44 VD: 2.305 HD: 296.436 EL: 2.421 Desc: CR
Foresight: Name: 4	SD: 296.444 ZE: 269-33'23 VD: -2.293 HD: 296.435 EL: 2.433 Desc: CR
	Average EL: 2.429
Backsight: Name: 4	SD: 296.445 ZE: 090-26'42 VD: 2.302 HD: 296.436 HI: 4.731 Desc: CR
Backsight: Name: 4	SD: 296.445 ZE: 269-33'24 VD: -2.292 HD: 296.436 HI: 4.721 Desc: CR
Backsight: Name: 4	SD: 296.445 ZE: 090-26'44 VD: 2.304 HD: 296.436 HI: 4.733 Desc: CR
Backsight: Name: 4	SD: 296.444 ZE: 269-33'21 VD: -2.295 HD: 296.435 HI: 4.724 Desc: CR
Backsight: Name: 4	SD: 296.445 ZE: 090-26'44 VD: 2.304 HD: 296.436 HI: 4.733 Desc: CR
Backsight: Name: 4	SD: 296.444 ZE: 269-33'24 VD: -2.292 HD: 296.435 HI: 4.721 Desc: CR
	Average HI: 4.727
Foresight: Name: 5	SD: 112.559 ZE: 090-25'23 VD: 0.831 HD: 112.556 EL: 3.896 Desc: CR
Foresight: Name: 5	SD: 112.559 ZE: 269-34'39 VD: -0.829 HD: 112.556 EL: 3.898 Desc: CR
Foresight: Name: 5	SD: 112.559 ZE: 090-25'24 VD: 0.832 HD: 112.556 EL: 3.895 Desc: CR
Foresight: Name: 5	SD: 112.558 ZE: 269-34'40 VD: -0.829 HD: 112.555 EL: 3.898 Desc: CR
Foresight: Name: 5	SD: 112.559 ZE: 090-25'24 VD: 0.832 HD: 112.556 EL: 3.895 Desc: CR
Foresight: Name: 5	SD: 112.559 ZE: 269-34'41 VD: -0.829 HD: 112.556 EL: 3.898 Desc: CR
	Average EL: 3.897
Backsight: Name: 5	SD: 112.559 ZE: 090-25'24 VD: 0.831 HD: 112.556 HI: 4.728 Desc: CR
Backsight: Name: 5	SD: 112.558 ZE: 269-34'39 VD: -0.829 HD: 112.555 HI: 4.726 Desc: CR
Backsight: Name: 5	SD: 112.559 ZE: 090-25'24 VD: 0.832 HD: 112.556 HI: 4.728 Desc: CR
Backsight: Name: 5	SD: 112.558 ZE: 269-34'41 VD: -0.828 HD: 112.555 HI: 4.725 Desc: CR
Backsight: Name: 5	SD: 112.559 ZE: 090-25'24 VD: 0.832 HD: 112.556 HI: 4.729 Desc: CR
Backsight: Name: 5	SD: 112.558 ZE: 269-34'40 VD: -0.829 HD: 112.555 HI: 4.725 Desc: CR
	Average HI: 4.727
Foresight: Name: 2	SD: 280.670 ZE: 090-07'57 VD: 0.648 HD: 280.669 EL: 4.079 Desc: CR
Foresight: Name: 2	SD: 280.669 ZE: 269-52'12 VD: -0.635 HD: 280.668 EL: 4.092 Desc: CR
Foresight: Name: 2	SD: 280.670 ZE: 090-07'57 VD: 0.648 HD: 280.669 EL: 4.079 Desc: CR
Foresight: Name: 2	SD: 280.669 ZE: 269-52'12 VD: -0.635 HD: 280.668 EL: 4.092 Desc: CR
Foresight: Name: 2	SD: 280.669 ZE: 090-07'56 VD: 0.647 HD: 280.668 EL: 4.080 Desc: CR
Foresight: Name: 2	SD: 280.670 ZE: 269-52'11 VD: -0.636 HD: 280.669 EL: 4.091 Desc: CR
	Average EL: 4.085
Backsight: Name: 2	SD: 280.669 ZE: 090-07'56 VD: 0.647 HD: 280.668 HI: 4.733 Desc: CR
Backsight: Name: 2	SD: 280.669 ZE: 269-52'10 VD: -0.637 HD: 280.668 HI: 4.722 Desc: CR
Backsight: Name: 2	SD: 280.669 ZE: 090-07'57 VD: 0.648 HD: 280.668 HI: 4.733 Desc: CR
Backsight: Name: 2	SD: 280.668 ZE: 269-52'12 VD: -0.635 HD: 280.667 HI: 4.721 Desc: CR
Backsight: Name: 2	SD: 280.669 ZE: 090-07'57 VD: 0.647 HD: 280.668 HI: 4.733 Desc: CR
Backsight: Name: 2	SD: 280.668 ZE: 269-52'11 VD: -0.636 HD: 280.667 HI: 4.722 Desc: CR
	Average HI: 4.727
Foresight: Name: 6	SD: 188.588 ZE: 089-38'10 VD: -1.198 HD: 188.584 EL: 5.925 Desc: CR
Foresight: Name: 6	SD: 188.588 ZE: 270-21'56 VD: 1.204 HD: 188.584 EL: 5.931 Desc: CR
Foresight: Name: 6	SD: 188.588 ZE: 089-38'11 VD: -1.197 HD: 188.584 EL: 5.924 Desc: CR

Foresight: Name: 6 SD: 188.587 ZE: 270-21'56 VD: 1.204 HD: 188.583 EL: 5.931 Desc: CR
 Foresight: Name: 6 SD: 188.588 ZE: 089-38'11 VD: -1.197 HD: 188.584 EL: 5.924 Desc: CR
 Foresight: Name: 6 SD: 188.587 ZE: 270-21'55 VD: 1.204 HD: 188.583 EL: 5.931 Desc: CR
 Average EL: 5.928

Backsight: Name: 6 SD: 188.589 ZE: 089-38'09 VD: -1.199 HD: 188.585 HI: 4.729 Desc: CR
 Backsight: Name: 6 SD: 188.586 ZE: 270-21'56 VD: 1.205 HD: 188.582 HI: 4.723 Desc: CR
 Backsight: Name: 6 SD: 188.589 ZE: 089-38'11 VD: -1.197 HD: 188.585 HI: 4.731 Desc: CR
 Backsight: Name: 6 SD: 188.587 ZE: 270-21'56 VD: 1.205 HD: 188.583 HI: 4.723 Desc: CR
 Backsight: Name: 6 SD: 188.589 ZE: 089-38'11 VD: -1.197 HD: 188.585 HI: 4.731 Desc: CR
 Backsight: Name: 6 SD: 188.587 ZE: 270-21'55 VD: 1.203 HD: 188.583 HI: 4.725 Desc: CR
 Average HI: 4.727

Foresight: Name: 1 SD: 99.673 ZE: 089-22'11 VD: -1.096 HD: 99.667 EL: 5.823 Desc: CR
 Foresight: Name: 1 SD: 99.673 ZE: 270-37'53 VD: 1.099 HD: 99.667 EL: 5.826 Desc: CR
 Foresight: Name: 1 SD: 99.673 ZE: 089-22'11 VD: -1.097 HD: 99.667 EL: 5.824 Desc: CR
 Foresight: Name: 1 SD: 99.674 ZE: 270-37'53 VD: 1.099 HD: 99.668 EL: 5.826 Desc: CR
 Foresight: Name: 1 SD: 99.673 ZE: 089-22'12 VD: -1.096 HD: 99.667 EL: 5.823 Desc: CR
 Foresight: Name: 1 SD: 99.673 ZE: 270-37'53 VD: 1.099 HD: 99.667 EL: 5.826 Desc: CR
 Average EL: 5.825

Benchmark: Name: 1 El: 5.823

VERTICAL BENCHMARKS

Station	Elevation	Std. Error
1	5.8230	0.010

POINTS TO BE ADJUSTED

Station
3,4,5,2,6

MEASUREMENT SUMMARY

From	To	Elev. Diff. (unadjusted)	StdErr
1	3	-1.3981	0.0004
3	4	-1.9960	0.0006
4	5	1.4678	0.0008
5	2	0.1888	0.0009
2	6	1.8424	0.0011
6	1	-0.1033	0.0012

ADJUSTED ELEVATIONS

Station	Adjusted Elev	Standard Dev.
1	5.8230	0.00231
3	4.4248	0.00235
4	2.4286	0.00240
5	3.8961	0.00244
2	4.0846	0.00245
6	5.9266	0.00241

ADJUSTED MEASUREMENT SUMMARY

From	To	Elev. Diff. (adjusted)	Residuals	Std. Dev.
1	3	-1.3982	-0.0001	0.000
3	4	-1.9962	-0.0002	0.001
4	5	1.4676	-0.0003	0.001
5	2	0.1885	-0.0003	0.001
2	6	1.8420	-0.0003	0.001
6	1	-0.1036	-0.0004	0.001

Vertical Sideshots

Station	Elevation
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