# Using the Windows Program, EDMCheq.exe, (EDM Calibration)

## Introduction

EDMCheq.exe is a NCDOT stand-alone Windows program that will create, edit and process EDM Calibration data files. The purpose of an EDM calibration is to determine the scale and constant error of an EDM using a NGS calibration baseline based upon measured raw data.

All algorithms and formulas used in the EDMCheq.exe came from the National Geodetic Survey technical memorandum entitled "NOAA Technical Memorandum <u>NOS NGS-10: Use of Calibration Base Lines</u>, by Fronczek, December 1977, reprinted 1980, 38 pp." Some additional formulas were obtained from the NGS program calibrat.bas source code.

One of the best resources for EDM calibration information is the NGS website <u>http://www.ngs.noaa.gov/CBLINES/calibration.html</u>.

For information on North Carolina EDM Calibration baselines go the following website <a href="http://portal.ncdenr.org/web/lr/geodetic/maps/edm">http://portal.ncdenr.org/web/lr/geodetic/maps/edm</a>.

## **Preparing Data Files**

When processing an EDM calibration session using the NGS file format, both the published and measured data sets need to be used.

EDMCheq .exe uses the same data input file format as the NGS program calibrat. The published data consists of the horizontal distances between baseline monuments defined from either a user-defined data file or from one of the predefined NC calibration baselines. Another data file contains the reduced horizontal distances between baseline monuments measured in the field.

All the data for the published baselines in North Carolina are built into to program. Both the published and the measured data files use the same type records and format. Data records consist of three fields, The EDM station name, the prism station name, and the horizontal distance, either published or measured. The fields are separated by either commas or spaces.

Following is an example of a data file containing the published data for a baseline. The station names in the following example are alphanumeric. There are no naming restrictions other than not using spaces or commas in the station names. Every station name must exist in both the published and measured files.

SMITH\_0,SMITH\_150,150.0008 SMITH\_0,SMITH\_400,399.9772 SMITH\_0,JNX\_B,1100.0001 SMITH\_150,SMITH\_400,249.9764 SMITH\_150,JNX\_B,949.9991 SMITH\_400,JNX\_B,700.0226

Following is a portion of the data sheet for the Smithfield NC NGS Baseline. Notice that the published horizontal distances match the distances in the above listing. The NC EDM calibration data sheets can be found at the following website: <u>http://www.ncgs.state.nc.us/Pages/edm.aspx</u>.

Smithfield EDM Calibration Baseline           FROM STATION TO STATION HOR DIST (M) SWITH 000 SWITH 150 156.0005 SWITH 000 SWITH 150 156.0005 SWITH 000 SWITH 150 100.0001 SWITH 000 SWITH 150 100.0001 SWITH 000 SWITH 150 100.0001 SWITH 000 SWITH 150 100.0001 SWITH 150 100.0001 SWITH 150 100.0001 SWITH 150 100.0001 SWITH 150 100.0001 SWITH 150 100.0001 SWITH 150 44.633 SWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 13.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 15.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 15.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF SWITHFIELD, N. C. AND 15.1 KM (8.2 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF DWITH 150 000 000T 5.4 (3.4 MI) NORTHWEST OF DWITH 150 000 000T 5.4 (3.4 MI) DWITH 150 54.000T 5.4 (3.4 MI) NORTHWEST OF DWITH 150 000 000T 5.4 (3.4 MI) NORTHWEST OF DWITH 150 0000 000T 5.4 (3.4 MI) NOT 150 0000 0000 0000 0000000000000000000										
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FROM STATION       TO STATION       HOR DIST (M)         HARK TO MARK (M) STO ERROR (M)       DEROR (M)         SVITH 000       SVITH 400       399.0772         SVITH 000       SVITH 400       399.0772         SVITH 000       SVITH 400       249.0774         SVITH 150       SVITH 400       249.0974         SVITH 400       349.0991       700.0226         SVITH 400       100.0001       0.1         SVITH 400       249.0991       700.0226         SVITH 400       100.001       0.1         SVITH 400       44.031       700.0226         SVITH 400       44.431       700.0226         SVITH 400       41.437       700.0226         SVITH 400										
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NUTH 160	SMITH 000	INX B	1100 0001	1100 0168	0.2					
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VILTH 400         JAK B         700.0226         0.1           STATION         NSVD 29 ELEVATION IN HETERS         700.0226         0.1           SUITH 400         47.494         SUITH 100         44.031           SUITH 100         44.031         SUITH 100         44.031           SUITH 400         41.431         SUITH 100         SUITH 100           SUITH 400         41.431         SUITH 100         SUITH 100           HE BASE LINE IS LOCAED ABOUT 5.4 (3.4 HI) NORTHHEST OF SMITHFIELD, N. C. AND 13.1 KM (8.2 HI)         SUITH SUITH 400           HE BASE LINE IS LOCAED ABOUTS.4.13.4 HI) NORTHHEST OF SMITHFIELD, N. C. AND 13.1 KM (8.2 HI)         SUITH SUITH 400           HE BASE LINE IS LOCAED ABOUTS.4.13.4 HI NORTHHEST OF SMITHFIELD, N. C. AND 13.1 KM (8.2 HI)         SUITH 500HEAD FOR ACCESS SEE           BELON).         HE BASE LINE IS A NORTH-SOUTH LINE WITH THE 0-METER POINT ON THE WORTH FUO. IT CONSISTS OF THE	CMTTH 150	JAIX P	040.0001	050,0045	0.1					
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THE BASE LINE IS LOCATED ABOUT 5.4 (3.4 HI) NORTHWEST OF SMITHFIELD, N. C. AND 13.1 KM (8.2 HI) SOUTH SOUTHEAST OF CLAYTON, N.C. AT THE JOHNSTON COUNTY AIRFORT (PERMISSION NEEDED FOR ACCESS SEE BELON). THE BASE LINE IS A NORTH-SOUTH LINE WITH THE 0-METER POINT ON THE NORTH END. IT CONSISTS OF THE	SMITH 400	44.03	7							
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BELOW). THE BASE LINE IS A NORTH-SOUTH LINE WITH THE Q-METER POINT ON THE NORTH END. IT CONSISTS OF THE	SOUTH SOUTHEA	SOUTH SOUTHEAST OF CLAYTON, N.C. AT THE JOHNSTON COUNTY AIRPORT (PERMISSION NEEDED FOR ACCESS SEE								
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THE BASE LINE IS A NORTH-SOUTH LINE WITH THE 0-METER POINT ON THE NORTH END. IT CONSISTS OF THE										
	THE BASE LINE									

If not using one of the predefined baselines, the published data file needs to be created using an ASCII text editor such as Notepad or UltraEdit, The published data can alternately be input using the EDMCheq.exe user interface.

Following is an example of a data file containing the measured data. All the station names found in the measured file need to exist in the published data file. There needs to be a minimum of three baseline stations and three baseline measurements. All distances, both published and measured, need to be horizontal distances. As with all least squares problems, the more redundant measurements that are taken the more confidence you will have in the solution.

```
SMITH_0, SMITH_150, 150.0048
SMITH_0, SMITH_400, 399.9773
SMITH_0, JNX_B, 1100.0032
SMITH_150, JNX_B, 950.0025
SMITH_400, JNX_B, 700.026
SMITH_150, SMITH_400, 249.9762
SMITH_0, SMITH_400, 399.9819
```

NGS publishes the baseline data in metric units. EDMCheq.exe is currently set up to only work in meters. When collecting the baseline distances collect them in meters or convert the distances to metric before processing.

## **Running EDMCheq.exe**

EDMCheq.exe is part of the NCDOT workspace. If you are running a NCDOT computer you should find the program EDMCheq.exe in the following folder,

C:\NCDOT\_V8\_WORKSPACE\LOCATION\_STDS\Standards\appl. There should also be a file called baselines.dat in the same folder. Baselines.dat contains the data for all the published baselines in North Carolina. This file needs to be in the same folder as EDMCheq.exe file. Double-click EDMCheq.exe to start the program. A short cut could be created for convenience. The program consists of a single dialog box as shown.

🔍 NC DOT, PCEDMCheq, (EDM Calibration)	- 0 <b>X</b>
Source for Published Baseline Distances	Open New
Credefined: Existing NC Baselines: Acheville FDM Calibration Baseline	Lord
Predenined: Existing indicate inest. Ashevine editionation baseline	Load
Measured EDM File:	Open New
Input Published: Measured:	
Save As	Save Save As
Date/Time         EDM Error         Comments           Date:         Constant Err. (mm):         2.0000         Comments           Time:         PPM Err.:         2.0000         EDM Description:	
Save As Help About Process	Cancel

#### **Designating Data Files**

Both the published data and the measured data need to be designated:

**Published EDM File**: The published data contains the station names and published horizontal distances for the calibration baseline being used. For NC DOT users the baseline being used should be available as one of the predefined baseline options. Alternately, the user can create a data file containing the published distances. If you are using one of the predefined baselines you will need to use the same point naming scheme as the predefined baselines. If the user needs to

create a published baseline file he can use the 'Open' button to designate an existing file, or he can use the 'New' button to create a new data file. One of the conveniences of the NGS format is that most users will always return to the same calibration baseline. So the user typically only has to define the 'Published EDM File:' once.

**Measured EDM File:** The Measured EDM file contains the station names and the measured horizontal distances between the baseline monuments. Use the 'Open' button to designate an existing data file .Use the 'New' button to create a new data file. This file can be manually created or it could have been created using a total station using the NCDOT TSC3 program EDMCheq.

Following is the EDM Calibration dialog box after both the published and the measured data source have been chosen. If choosing one of the predefined baselines, first pick the 'Predefined' radio button. Then choose the correct baseline from the combo box list. Then press the 'Load' button. After choosing the data source the contents are displayed in the edit fields. These values can be edited and saved to the same file using the 'Save' button or another file using the 'Save As' option. If a new calibration is being performed, use the 'New' button to designate the new data file name and then enter the data into the edit box and 'Save' the data once input is completed. The data file can alternately be created using any ASCII text editor.

🔍 NC DOT, PCEDMCheq, (EDM Calibration)
Source for Published Baseline Distances           C From File:         Open New
Predefined: Existing NC Baselines: Smithfield EDM Calibration Baseline     Load
Measured Distances
Measured EDM File: C:\data\EDMCalibrate\Airport\airport.txt
Input
Published:         Measured:           SMITH_0,SMITH_150,150.0005         Save         SMITH_0,SMITH_150,150.004         Save           SMITH_0,SMITH_400,399.9775         SMITH_0,SMITH_400,399.9775         SMITH_0,SMITH_0,SMITH_00,002         SMITH_0,SMITH_00,002           SMITH_150,SMITH_400,249.9770         Save As         Save As         SMITH_150,SMITH_400,249.976         Save As           SMITH_150,JNX_B,949.9994         SMITH_400,JNX_B,700.0222         SMITH_400,JNX_B,700.020         SMITH_400,JNX_B,700.020
Date/Time     EDM Error     Comments       Date:     23-04-2015     Constant Err. (mm):     3.0000       Time:     12:22:09     PPM Err.:     2.0000   EDM Description: Trimble S3
Save As Help About Process Cancel
Save As Help About Process Cancel

### **Date/Time, EDM Error, Comments**

In addition to the published and measured data there are six fields that need to be filled out. The fields, Comment, EDM Description, Date, and Time are all text fields that have no impact on any computations or processing. These fields only become part of the final report. The Constant Err. and PPM Err. define the predicted accuracy of the EDM being tested. EDM specifications as published by the EDM manufacturers are commonly entered here. These values are used in the computation of covariance, correlation, variance of Unit weight and standard error of unit weight. Additionally these values are used by the program to compute the standardized residual column in the output report.

#### **Processing the Data**

After both the published and measured data have been created and designated the **'Process'** button is pressed, and an output report is created. The report is displayed in the lower portion of the dialog box.

🕐 NC DOT, PCEDMCheq, (EDM Calibration)								
Source for Published Baseline Distances								
C From File: Published EDM File:	Open New							
Predefined: Existing NC Baselines: Smithfield EDM Calibration Baseline	Load							
Measured Distances								
Measured EDM File: C:\data\EDMCalibrate\Airport\airport.txt	Open New							
_ Input								
Published: Measured:								
SMITH_0,SMITH_150,150.0005	▲ Save							
SMITH_0,JNX_B,1100.0000 SMITH_160_SMITH_100_240_0770	Save As							
SMITH_150,3MITH_								
SMITH_400,JNX_B,700.0222 SMITH_400,JNX_B,700.020								
	-							
Date/Time EDM Error Comments								
Date: 23-04-2015 Constant Err. (mm): 3.00 Comment: Clear, Light wind								
Time: 12:22:09 PPM Frr · 2.00 FDM Description: Trimble S3								
	*							
EDM Calibration Report Date: 23-04-2015	_							
Time: 12:22:09 EDM Description: Trimble S3	Time: 12:22:09							
Comment: Clear, Light wind Published Propling: Smithfield FDM Calibration Propling								
Measured Calibration File Name: C:\data\EDMCalibrate\Airport\airport.txt								
EDM Specifications: +/- 3.0 mm + 2.0 PPM								
Data:								
From To Observed Published Sta Sta Horiz Dist Horiz Dist Diff								
SMITH_0 SMITH_150 150.0040 150.0005 -0.0035 SMITH_0 CMITH_400 300.0270 -0.0005 -0.0005	+							
Save As Help About Process	Cancel							

To save the report to an ASCII text file press the 'Save As' button found on the bottom of the dialog box and enter a file name.

## **The Report File**

Following is a more complete view of the report as viewed in an ASCII text editor. The key items to review are marked in red.

airport.rpt - Notepad									
File Edit Format View Help									
EDM Calibration Report									
Date: 23-04-2015 Time: 12:22:09 EDM Description: Trimble S3 Comment: Clear, Light wind Published Baseline: Smithfield EDM Calibration Baseline Measured Calibration File Name: C:\data\EDMCalibrate\Airport\airport.txt EDM Specifications: +/- 3.0 mm + 2.0 PPM									
Data:									
FromToObservedPublishedSta.Sta.Horiz. Dist.Horiz. Dist.Diff.SMITH_0SMITH_150150.0040150.0005-0.0035SMITH_0SMITH_400399.9770399.97750.0005SMITH_0JNX_B1100.00201100.0000-0.0020SMITH_150SMITH_400249.9760249.97700.0010SMITH_150JNX_B950.0000949.9994-0.0006SMITH_400JNX_B700.0200700.02220.0022									
Results:									
FromToAvg. Observed Horiz. Dist.Published Horiz. Dist.Sta.Sta.Horiz. Dist.Horiz. Dist.SMITH_0SMITH_150150.0040150.0005-0.0035SMITH_0SMITH_400399.9770399.97750.00050.0009SMITH_0JNX_B1100.00201100.0000-0.0020-0.00170.4SMITH_150JNX_B950.0000949.97700.00100.00150.3SMITH_150JNX_B950.0000949.9994-0.0006-0.00030.1SMITH_400JNX_B700.0200700.02220.00220.00260.5	Residual								
Null Hypothesis, HO: EDM scale error and EDM constant error = 0.0									
Scale Error (ppm): 0.154 Constant Error: -0.0005m Scale Standard Error (ppm): 2.696 Constant Standard Error: 0.0019m									
Covariance: 4.328058 Correlation: 0.843601 Variance of Unit Weight: 0.532562 Standard Error of Unit Weight: 0.7297683									
Scale t-Value: 0.0571 Constant t-Value: -0.2644									
Degrees of Freedom: 4 Critical t-Value at the 5 percent significance level: 2.7760									
Passes the t-test for the scale error. (The scale factor is 0.0.) 0.05/1 is less than 2.7760.									
Passes the t-test for the constant error. (The constant is 0.0.) 0.2644 is less than 2.7760.									

1) The above report shows that the EDM has a constant error of -0.5 mm and .154 ppm.

2) Statistically speaking you cannot distinguish those computed errors from 0.0 indicating that the EDM is operating well within its specifications. This is shown from the results of the t-test. Note that the test is being performed to a 5% confidence level.

Surveyors are probably more familiar with the chi-square test than the t-test. But the two tests serve a similar purpose. The t-test is used to test whether the computed scale error and constant error differ significantly from 0.0 scale and constant error. If the results of the t-test indicate that the scale and constant error is significantly different from 0 that is an indication that the EDM is not working properly.

Be careful of treating the results of the t-test as a measure of the absolute correctness of the EDM. There can be instances where a passing t-test result is obtained when the scale and constant error are too large. There also can be instances though less common when you fail the t-test yet have perfectly acceptable scale and constant error results.

The results of the t-test are dependent on the Scale Standard Error and the Constant Standard Error. If the standard errors are very large you may pass the t-test when the scale and/or constant error are actually too large. Also, if the standard errors are very small the t-test may fail when the scale and/or constant error are perfectly acceptable.

Look at the entire report. Do not just look at the results of the t-test. Look at the computed scale error, the constant error, the differences, the residuals and the results of the statistical tests. As with all least squares reports, there is never one single value that can be relied on to determine if you have an adequate analysis. The report has to be reviewed in whole.

- 3) The values in the "Diff." column cluster around 0.0 without positive or negative values predominating indicating there is no systematic error.
- 4) The standardized residual is comparing whether the expected distance error is the same as the measured distance error. The measured distance error is the values in the 'Diff.' column. The expected distance error is computed from each measured distance and the expected error, 3mm & 2ppm, in our example. The standardized residual is computed by dividing the measured error by the expected error. Since we are hoping that the measured errors and expected errors be the same, we are expecting the standardized residuals to be close to one. In the above report all the standardized residuals are less than one indicating that the measured errors were less than what we were expecting. If any of the standardized residuals were greater than three, they would have been marked with an '\*' indicating a potential problem.

## A Report File with a Constant Error

```
badPrism.rpt - Notepad
                                                                                                             File Edit Format View Help
             EDM Calibration Report
Date: 05-22-2015
Time: 9AM
EDM Description: A not so accurate one
Comment: A comment
Published Baseline: Smithfield EDM Calibration Baseline
Measured Calibration File Name: C:\data\EDMCalibrate\2015_EDMCalibrateTraining\Data\badPri
EDM Specifications: +/- 2.0 mm + 2.0 PPM
Data:
                                   Observed
                                                      Published
   From
                   то
   Sta.
SMITH_0
                  Sta.
SMITH_150
                                   Horiz. Dist.
150.0036
                                                      Horiz. Dist.
150.0005
                                                                        Diff.
                                                                      -0.0031
   SMITH_0
                   SMITH_400
                                     399.9836
                                                        399.9775
                                                                      -0.0061
   SMITH_0
                   JNX_B
                                   1100.0058
                                                      1100.0000
150.0005
                                                                      -0.0058
                   SMITH 0
   SMITH 150
                                    150.0048
                                                                      -0.0043
                                                       249.9770
949.9994
                   SMITH_400
   SMITH_150
                                     249.9830
                                                                      -0.0060
   SMITH_150
                   JNX_B
                                     950.0038
                                                                      -0.0044
                   SMITH 0
                                                       399.9775
249.9770
   SMITH_400
                                     399.9822
                                                                      -0.0047
   SMITH_400
                   SMITH_150
                                     249.9831
                                                                      -0.0061
   SMITH_400
                                     700.0268
                                                       700.0222
                                                                      -0.0046
                   JNX_B
                   SMITH_400
   JNX_B
                                     700.0261
                                                       700.0222
                                                                      -0.0039
                                                       949.9994
                   SMTTH 150
                                     950,0059
                                                                      -0.0065
   JNX B
   JNX_B
                   SMITH_0
                                   1100.0051
                                                      1100.0000
                                                                      -0.0051
Results:
                                                                          4)
                                                                                        5)
                                  Avg. Observed
Horiz. Dist.
150.0042
                                                       Published
   From
                   то
                                                                                    Residual
                                                       Horiz. Dist
150.0005
399.9775
                                                                          Diff.
   Sta.
SMITH_150
                   Sta.
SMITH_0
                                                                                                 Std. Residual
                                                                                                  1.6
                                                                      -0.0037
                                                                                    0.0011
   SMITH_400
                   SMITH_0
                                     399.9829
                                                                       -0.0054
                                                                                    0.0005
                                                       249.9770
700.0222
949.9994
                   SMITH_150
SMITH 400
                                    249.9830 700.0265
                                                                      -0.0060
-0.0043
                                                                                                  2.4
   SMITH_400
                                                                                   -0.0012
   INX B
                                                                                    0.0009
                                                                                                   1.4
   JNX_B
                   SMITH_150
                                     950.0049
                                                                       -0.0054
                                                                                   -0.0002
   JNX_B
                   SMITH_0
                                   1100.0055
                                                      1100.0000
                                                                       -0.0055
                                                                                   -0.0001
 1)
     Null Hypothesis. HO: EDM scale error and EDM constant error = 0.0
     Scale Error (ppm): -0.599
Constant Error: -0.0047m
                                           2)
     Scale Standard Error (ppm): 1.103
Constant Standard Error: 0.0008m
     Covariance: 0.826773 Correlation: 0.83
Variance of Unit Weight: 0.201774
Standard Error of Unit Weight: 0.4491922
                                   Correlation: 0.831889
     Scale t-value: -0.5429
Constant t-value: -6.1786
     Degrees of Freedom: 4
Critical t-Value at the 5 percent significance level: 2.7760
           Passes the t-test for the scale error. (The scale factor is 0.0.)
             0.5429 is less than 2.7760.
 3) ***Eails the t-test for the constant error. (The constant is not 0.0.)
            6.1786 is greater than 2.7760.
*** Failing the t-test for the constant error is indicative of an incorrect prism constant. Check the prism constant setting on EDM/data collector.
```

The preceding report was generated from data that was collected with an inappropriate prism. The user mistakenly used a prism that had the wrong offset for the total station that he was using. Note the following:

- 1) The Null Hypothesis is the default assumption that we are testing. Our assumption is: The EDM we are testing is well adjusted and has no systematic error with a constant error of 0.0 and a PPM error of 0.0. Another way of phrasing this is that we are testing whether the measured distances are the same as the published distances. We are using statistics to determine whether this is a statistically valid assumption.
- 2) The computed constant error is -4.7mm's or -.015'. Modern EDM's are certainly capable of measuring better than this. The ppm error is -.6, well within capabilities of modern EDM's. The most common cause of an excessive constant error is an incorrect prism offset. This is noted in the report.
- 3) Notice that the results of the t-test indicate that the null hypothesis is rejected for the constant error, i.e. the EDM has a systematic constant error.
- 4) Notice the 'Diff.' column and how there is a consistent negative value in the range of 3-6mm indicating a systematic error.
- 5) Notice the 'Residual' column. All the values are 1 mm or less with a roughly equal number of positive and negative values. For the above example the residual is computed as follows:

 $((-0.599 \times measuredDist \div 1000000.0 + -0.0047) + measuredDist) - publishedDist$ 

This value is the (corrected measured distance – the published distance). If distances are corrected using the computed scale and ppm error then good results are obtained.

6) Look at the entire report. Do not just look at the results of the t-test. Look at the computed scale error, the constant error, the differences, the residuals and the results of the statistical tests. As with all least squares reports, there is never one single value that can be relied on to determine if you have an adequate analysis. The report has to be reviewed in whole.

## A Report File with a PPM Error

The following report is from the example found in the NGS manual, <u>NOS NGS-10: Use of Calibration Base</u> <u>Lines</u>.

- 1) In this example the EDM has an excessive PPM error of 13.5 PPM. With a PPM error there is more error in longer distances than there are in shorter distances. The most common cause of a PPM error is not accounting for the atmospheric correction correctly. This is noted in the report.
- 2) In the 'Diff' column notice the 150m distance has a difference of .003m while the 1650m distance has a 'Diff' error of .02m. Also notice that all the 'Diff' distances are positive indicating a positive systematic error.

- 3) Finally, note that the constant error passes the t-test but the PPM error does not pass the t-test.
- Several values in the Standardized Residual columns have been flagged with an '\*'. Any standardized residual above three is suspect and is marked with an '\*' and should be reviewed.

```
newVersion.rpt - Notepad
                                                                                                                          File Edit Format View Help
              EDM Calibration Report
Date: 21-04-2015
Time: 13:52:58
EDM Description: Topcon
Comment: From NGS Manual
Published Baseline: C:\data\EDMCalibrate\2015_EDMCalibrateTraining\Data\badPPM\BeltPublished.
Measured Calibration File Name: C:\data\EDMCalibrate\2015_EDMCalibrateTraining\Data\badPPM\Be
EDM Specifications: +/- 2.0 mm + 2.0 PPM
Data:
   From
                    то
                                      Observed
                                                           Published
                                      Horiz. Dist.
149.9899
                                                          Horiz. Dist.
149.9929
149.9929
449.9990
                    Sta.
                                                                               Diff.
   sta.
   BELT_150
                     BELT_300
                                                                              0.0030
                                       149.9905
449.9916
   BELT_300
BELT_150
                    BELT_150
BELT_600
                                                                              0.0024
                                                                              0.0074
   BELT_600
BELT_150
                    BELT_150
BELT_1800
                                        449,9849
                                                           449.9990
1649.9959
                                                                              0.0141
                                      1649.9600
                                                                              0.0359
   BELT_1800
                     BELT_150
                                      1649.9728
                                                           1649.9959
300.0061
                                                                             0.0231 0.0058
   BELT_300
                    BELT 600
                                       300.0003
   BELT_600
                                        299.9984
                                                            300.0061
                                                                              0.0077
                     BELT_300
                                                          1500.0030
1500.0030
1199.9969
1199.9969
   BELT_300
BELT_1800
                    BELT_1800
BELT_300
                                      1499.9739
1499.9906
                                                                             0.0291 0.0124
   BELT_600
BELT_1800
                     BELT_1800
                                      1199.9866
                                                                              0.0103
                    BELT_600
                                      1199.9858
                                                                              0.0111
Results:
                                                                                  2)
                                    Avg. Observed
Horiz. Dist.
149.9902
449.9882
1649.9664
                                                           Published
Horiz. Dist.
   From
                    то
                                                                                Diff.
                                                                                           Residual Std. Residual
                    sta.
   sta.
                                                                             0.0027
   BELT_300
                     BELT_150
                                                            149.9929
                                                                                         -0.0010
                                                                                                          *3.7
   BELT_600
BELT_1800
                    BELT_150
BELT_150
                                                           449.9990
1649.9959
                                                                                           0.0030
                                                                                                                    4)
                                                                            0.0295 0.0055
                                                                                                         *5.6
   BELT_600
BELT_1800
                    BELT_300
BELT_300
                                      299.9993
1499.9823
                                                           300.0061
1500.0030
                                                                                           0.0010
                                                                             0.0207
                                                                                          -0.0012
   BELT_1800
                    BELT_600
                                      1199.9862
                                                           1199.9969
                                                                             0.0107
                                                                                           -0.0072
      Null Hypothesis, HO: EDM scale error and EDM constant error = 0.0
      Scale Error (ppm): 13.54
Constant Error: 0.0017m
                                 13.545 1)
      Scale Standard Error (ppm): 3.331
      Constant Standard Error: 0.0035m
      Covariance: 5.740159 Correlation: 0.752486
Variance of Unit Weight: 2.410506
Standard Error of Unit Weight: 1.5525804
      Scale t-Value: 4.0663
      Constant t-Value: 0.4744
      Degrees of Freedom: 4
Critical t-Value at the 5 percent significance level: 2.7760
                                                                                                                  3)
       ** Fails the t-test for the scale error. (The scale factor is not 0.0.)
               4.0663 15 greater than 2.7760.
            Passes the t-test for the constant error. (The constant is 0.0.)
               0.4744 is less than 2.7760.
     Failing the t-test for the scale error is indicative of not having the 
atmospheric correction set correctly. Check the atmospheric correction on
         the EDM/data collector.
```