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From  
De

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Subject  
Objet

**LONDON, ONTARIO CALIBRATION BASELINE - ADOPTED VALUES - 1996**

Security Classification - Classification de sécurité
Our File - Notre référence 2290/ L5
Your file - Votre référence
Date February 14, 1997

We have processed the 1990, 1991, and 1996 measurements of the London baseline with CALIB/LINCOMP programs and procedures.

There have been movements of about -0.3 mm and -2.8 mm at piers 2 and 6, respectively, from 1991 to 1996. A remeasurement to confirm the current positions of the piers is recommended, but with a low priority, for the 1997 field program.

A table of "ADOPTED VALUES" in CALIB format and copies of the report on data processing and recommendations are attached. A cautionary note about pier 6 has been added to the table of distances in Appendix C.

Please forward the report to the controlling agency.

L. Hennessey

c.c. S. Crossley  
File

**London Calibration Baseline  
1996 Adopted Values**

Authors: L. Hennessey, B. Bresee

**Baseline Site**

This linear baseline is located 3.9 km southwest of London, Ontario in the right-of-way of the eastbound lane of Highway No. 401. It runs parallel to the service road. To access the baseline, drive 3.7 km south on Wellington Road from the intersection of Exit No. 20 and Highway No. 401. Turn right and drive 3.9 km past Boswick Road bridge to the baseline. Pier 1 is the most easterly one on the baseline. All piers are built to Geodetic specifications.

The profile of the baseline shows an elevation change of -9.8 meters between piers 1 and 4, and -7.2 meters between piers 6 and 4. The steepness of the profile could produce difficulties in precise meteorological reductions. See Appendix A for a plan and profile view of the baseline.

**Measurements**

The 1996 measurements of this baseline were made by Hennessey from June 13-15, using the Mekometer ME5000 (serial number 357061). See Table 1 for the measurement history of this baseline.

Table 1: Measurement history

Date	Observer	Instrument	Serial Number
Aug. 3-7/1981	McEwen	Mekometer ME3000	218024
June 2-6/1982	Feeny	Mekometer ME3000	218024
June 13-16/1983	Feeny	Mekometer ME3000	218024
June 5-9/1990	Hennessey	Geomensor CR204	013
June 25-27/1991	Hennessey	Geomensor CR204	013
June 13-15/1996	Hennessey	Mekometer ME5000	357061

Currently, each baseline measurement for a year consists of at least three double (forward and backward) distance measurements between all intervisible piers using either the Geomensor CR204 or Mekometer ME5000 EDM instruments.

### NGBL Calibration

The scale bias for the Mekometer ME5000 was determined from calibration surveys on the National Geodetic Baseline (NGBL). The constant bias from the NGBL was used as a gross check on the value determined from the London baseline adjustment. The average scale bias from the two NGBL calibrations was applied to all distance observations. See Table 2 for the 1996 NGBL biases.

Table 2: Mekometer ME5000 biases derived from 1996 NGBL measurements

Date	Measurement Sets	Constant Bias Value $\pm$ Std.Dev. (mm)	Scale Bias Value $\pm$ Std.Dev. (ppm)
May 15-22	3	$0.0 \pm 0.1$	$-0.07 \pm 0.16$
July 17-18	3	$0.0 \pm 0.1$	$-0.27 \pm 0.13$
Average			$-0.17 \pm 0.15$

### Baseline Adjustment

The 1996 London baseline measurements were processed with the new baseline adjustment program CALIB (version 1.1, May 95). A minimally constrained adjustment was made with pier 1 fixed. An a priori standard deviation of 0.1 mm + 0.5 ppm was used for all Mekometer distances, and 0.1 mm for the centering errors. The results of the adjustments back to 1990 are summarized in Appendix B.

The constant bias from the CALIB adjustment was  $+0.1 \pm 0.1$  mm, which is consistent with the estimate obtained from the NGBL calibration (see Table 2). The variance factor for the 1996 adjustment was 1.221, which passes the Chi-square test. There were no residual outliers in the adjustment using all the observations. All residuals passed the Chi-square goodness-of-fit test for normal distribution. All tests were performed at the 95% confidence level.

## Comparison with Previous Epochs

The results of the 1990, 1991, and 1996 adjustments were compared to check for any scale differences and pier movements between epochs. The analyses were performed with the new baseline comparison program LINCOMP (version 1.3, May 95). The reader is referred to the reports issued for 1990 and 1991 for details of those measurements. The earlier epochs in Table 1 are listed as a historical reference. The data prior to 1984 is of a lesser quality due to less rigorous meteorological measurements and methodology. It is also in a format that is not compatible with current processing software. Therefore, it is not analyzed in this report.

### Pier Movement Analysis

The pier movement analysis performed by program LINCOMP uses the “least absolute sum” (L1-norm) solution. Piers that are identified as having statistically significant coordinate differences are removed from the analysis by renaming them. The process is iterated until no “outliers” remain. For the comparisons between the 1990, 1991 and 1996 epochs, the piers in Table 3 were found to have moved. The coordinate difference is estimated from a combined CALIB adjustment of the two applicable epochs. A positive sign for the movement implies that the pier has moved away from the first pier (the distance has lengthened over time).

The movement at pier 6 is large and this pier should not be used in any calibration until a subsequent survey shows that it has stabilized. The largest possible scale error that might result from the use of pier 6 in the 1996 epoch is 6.9 ppm. The movement at pier 6 is the continuation of a historical trend.

Table 3: Pier movements on the London baseline

Comparison		Pier	Coordinate Differences	
From	To		Value $\pm$ Std.Dev. (mm)	95% Confidence Interval (mm)
1991	1996	2	-0.3 $\pm$ 0.1	-0.5 to -0.1
1991	1996	6	-2.8 $\pm$ 0.2	-3.1 to -2.5

### Scale Difference Analysis

Any scale difference between epochs is estimated with program LINCOMP using the least squares (L2-norm) solution with suspected pier movements removed. The estimated scale differences between the epochs are given in Table 4.

Table 4: Scale difference between epochs

Comparison		Piers Used	Scale Change	
From	To		Value $\pm$ Std.Dev. (ppm)	95% Confidence Interval (ppm)
1990	1991	1,2,3,4,5,6	-0.07 $\pm$ 0.56	-1.16 to +1.02
1991	1996	1,3,4,5	+1.70 $\pm$ 0.49	+0.75 to +2.65

The estimated scale difference from 1991 to 1996 is statistically significant at the 95% confidence level. The large standard deviation and confidence interval reflect the fact that the scale difference estimation is primarily based on the longer (less precise) distances.

### Adopted Distances

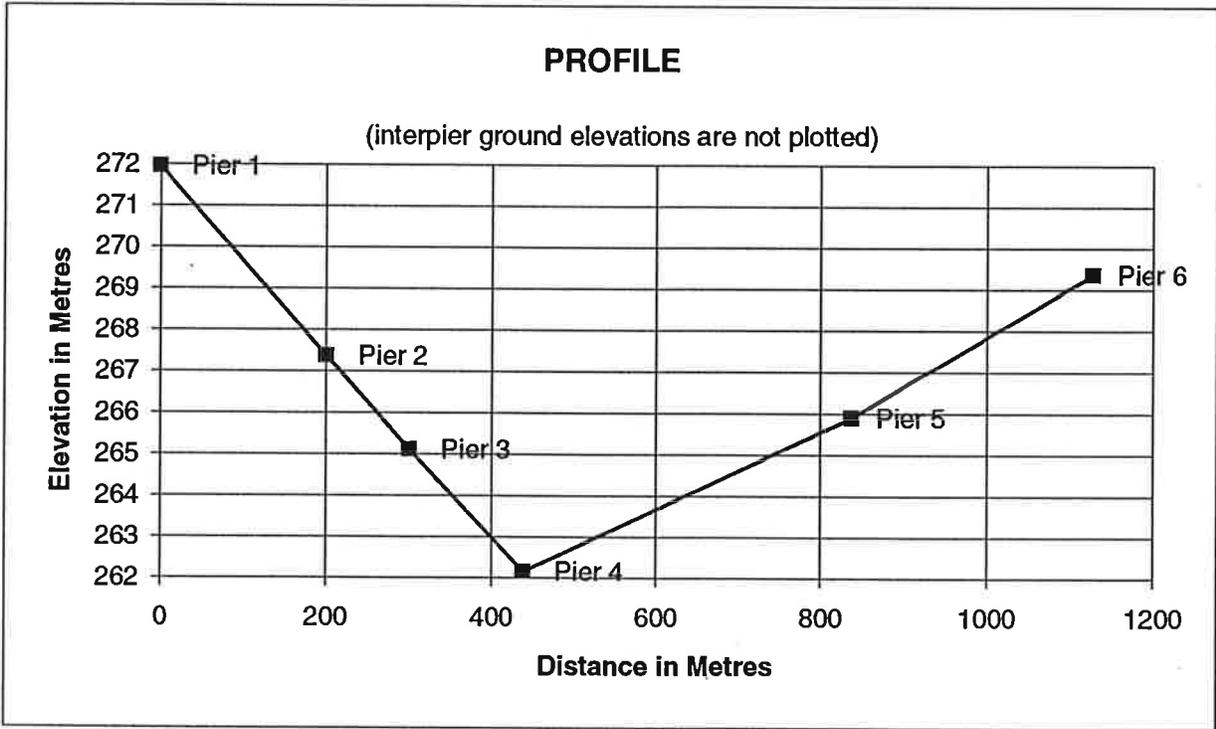
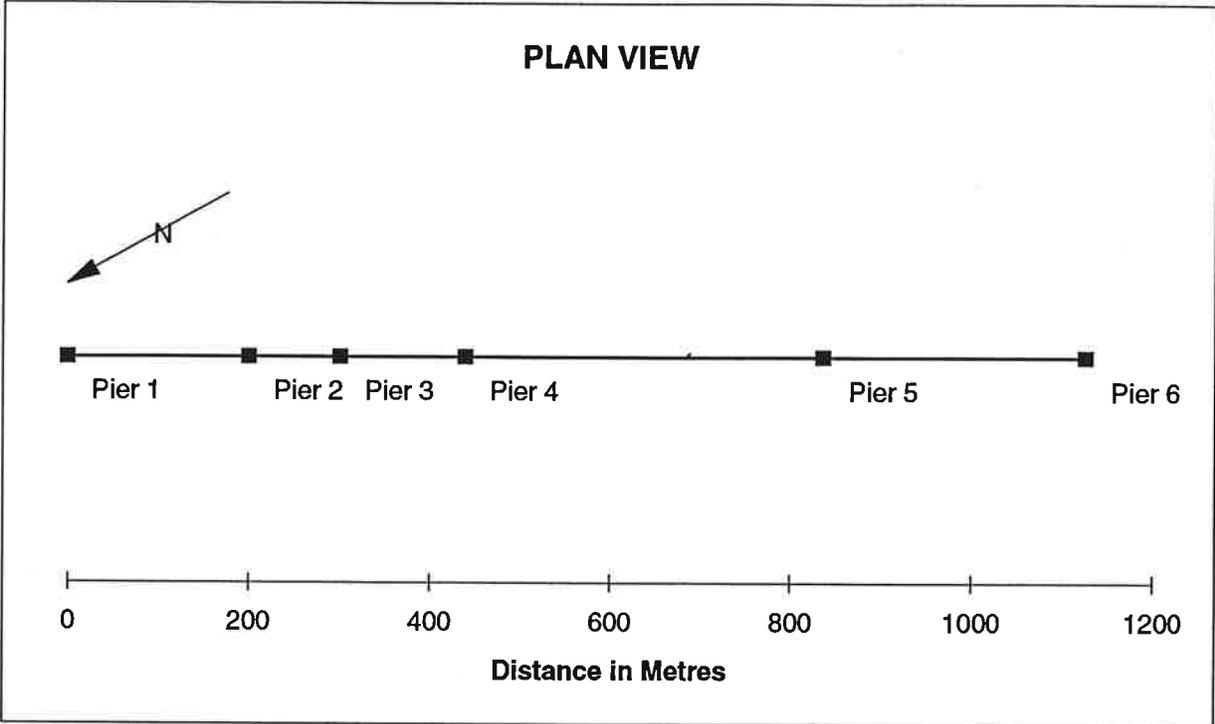
The Adopted Distances for the London baseline are given in Appendix C and are based on the 1996 measurements. This appendix gives the adjusted interpier slope distances, estimated standard deviations and elevation differences. The large movement at pier 6 is noted in the table.

### Recommendations

Due to the statistically different coordinate differences at piers 2 and 6 between 1991 and 1996, it is recommended that care be taken in using the values for these piers listed in Appendix C. The movement at pier 6 is large and it should not be used, except for constant determinations by the overlapping lines method, until a subsequent survey shows that it has stabilized.

A remeasurement to confirm the current positions of piers 2 and 6 is recommended for the 1997 field program. The remeasurement should be assigned a low priority since there are 4 stable piers.

Hennessey/Bresee  
February 1997



# CALIB LEAST SQUARES ADJUSTMENT SUMMARY

# APPENDIX B

BASELINE NAME: LONDON, ONTARIO

Epoch Dates	Degrees of Freedom	Variance Factor	Statistical Tests		Derived Constant mm ± S.D.	Input Scale ppm ± S.D.	Comments
			V.F.	G.O.F.			
June 5-9 1990	120	1.313	Fail	Pass	+1.5 ± 0.1	-0.1 ± 0.3	1 Outlier not removed
June 25-27 1991	84	1.142	Pass	Pass	+1.5 ± 0.1	-0.5 ± 0.3	1 Outlier not removed
June 13-15 1996	84	1.221	Pass	Pass	+0.1 ± 0.1	-0.2 ± 0.2	No Outliers

LEGEND: V.F. - Variance Factor Test  
G.O.F. - Goodness of Fit Test

NOTE: All statistical and outlier tests performed with a 95% Confidence Level.

# 1996 ADOPTED BASELINE DISTANCES

# APPENDIX C

BASELINE NAME: LONDON, ONTARIO

Calib Version 1.1

1996 Epoch

February, 1997

Geodetic Survey Division, Geomatics Canada

From Pier	To Pier	Elevation Difference Metres (m)	Slope Distance Metres (m)	Std Dev (mm)
1	2	-4.580	200.7101	0.1
	3	-6.850	301.3618	0.1
	4	-9.800	439.4029	0.1
	5	-6.050	836.9842	0.2
	6	-2.600	1127.1805	0.3
2	1	4.580	200.7101	0.1
	3	-2.270	100.6517	0.1
	4	-5.220	238.6929	0.1
	5	-1.470	636.3060	0.2
	6	1.980	926.5215	0.2
3	1	6.850	301.3618	0.1
	2	2.270	100.6517	0.1
	4	-2.950	138.0412	0.1
	5	0.800	535.6787	0.1
	6	4.250	825.9040	0.2
4	1	9.800	439.4029	0.1
	2	5.220	238.6929	0.1
	3	2.950	138.0412	0.1
	5	3.750	397.6859	0.1
	6	7.200	687.9208	0.2
5	1	6.050	836.9842	0.2
	2	1.470	636.3060	0.2
	3	-0.800	535.6787	0.1
	4	-3.750	397.6859	0.1
	6	3.450	290.2354	0.1
6	1	2.600	1127.1805	0.3
	2	-1.980	926.5215	0.2
	3	-4.250	825.9040	0.2
	4	-7.200	687.9208	0.2
	5	-3.450	290.2354	0.1

**Note:** There has been large movement of about - 2.8 mm at pier 6 between 1991 and 1996. See report for details.