GPS TEST RANGE

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PART I

SITE SELECTION

INTRODUCTION:

It is desired to establish a permanent network of well established geodetic stations in the Ottawa area for the purpose of testing and calibrating GPS receivers. The Ottawa area is chosen in order to provide ready access to laboratory facilities for experimental set-ups and to minimize the problems of logistics.

SITE SELECTION:

The stations tabulated in Table 1 were selected from the Geodetic Framework on the basis of being in the Ottawa Region and located on bedrock. Four additional stations SHIRLEY, PZT, and ALGONQUIN were also considered as they are the possible future locations of VLBI experiments in the region. The stations of the National Geodetic Baseline (NGBL) were included because the relative positions of these stations are known with great precision and because of their proximity to SHIRLEY and PZT. A reconnaissance of the various stations was made with results as summarized in Table 1.

SELECTION CRITERIA:

1. Long Term positional stability: Station markers fastened to bed-rock.
2. Permanence.
3. Adequate view of the sky (Fig. 1) free from RF reflectors.
4. Accessible by a four wheel drive vehicle to within 30 m (length of antenna cable on the Macrometer).

5. Winter accessibility desirable but not mandatory.

6. Baselengths ranging from 2 to 60 km.

PERMANENCE:

As most of the stations in the Ottawa area are on private land or road allowances they are subject to destruction under pressure from development. Those on private land also require the permission of the landowner before use: this may be denied as in the case of ORMOND. Therefore it would be desirable to secure access to a select number of stations through procurement of easements or purchase of the land. Those with a suitability code of "Y" in Table 1 would be the recommended stations for such action. Stations on Federal lands, SHIRLEY, PZT and ALGONQUIN are not so affected.

VLBI SITES:

Shirley Bay: Two stations are located at the Shirley Bay establishment: SHIRLEY and PZT. Station SHIRLEY is underneath a steel survey tower and therefore unsuitable. Station PZT is located between two metal clad structures which because of their low profile are not expected to interfere with the signal. A third station might be on the doppler (TRANET) antenna platform, but possible interference with the doppler antenna makes this a hazardous site. The National Geodetic Baseline (NGBL)is situated along the road to this site. The NGBL comprises 14 piers whose relative positions distributed along 2.2 km are known to + 0.5 mm. These sites have not yet been connected to the

Geodetic Framework. (The necessary work to connect these sites to the framework is planned to be carried out in conjunction with the first MACROMETER test.)

ALGONQUIN: Of the sites investigated, ALGONQUIN is the most distant (180 km) from Ottawa. This station is a virtual point defined as the intersection of the horizontal and vertical axes of the radio telescope antenna (Gale, 1968). It is connected to the Geodetic Framework only by a spur tie and cannot be considered presently suitable for GPS calibration. This station would be best reserved for future use with longer base length instruments such as the dual frequency Macrometer or the TI receiver. Plans to acquire a mobile LBI system to be operated by the Geodetic Survey of Canada in conjunction with fixed observatories could make ALGONQUIN an important future location.

ACCURACY:

The accuracy of the various base line lengths (Table 2) as obtained from a network adjustment are tabulated in Table 3.

SUMMARY:

Fifteen stations in the Geodetic Framework in the Ottawa area were evaluated for use as a test range for GPS hardware. Eight of these proved to be suitable.

PART II

MACROMETER* TEST

INTRODUCTION:

A suitable suite of stations were to be chosen from those selected for the GPS test range to carry out a 30 day trial of the single frequency Macrometer GPS receiver.

SELECTION CRITERIA:

With the present GPS constellation only one baseline observation can be made per day. As the instrument was rented for only 30 days the utility of the observations must be optimized. Logistically everything is possible between 30 observations on a single baseline to one observation on each of 30 baselines. As one aspect of the test was to try to correlate errors with atmospheric events a large number of repeat measurements is indicated. On the other hand as Macrometer accuracy may be dependent on the length of the baseline a variety of baselines was desired. From preliminary information (Counselman, undated) baselines of approximately 10, 30 and 60 km appeared to be appropriate choices.

NETWORK CONSIDERATIONS:

Modelling of several possible networks using Halpenny's NETOPT program (Halpenny, undated) indicates that the optimum net would comprise either four or five stations. In the five station case, however, each

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* Macrometer is a registered trademark of Macrometrics Inc., Woburn, Massachusetts, U.S.A.

baseline was observed only three times which is hardly a satisfactory statistical sample. Five observations per baseline in the four station case gives a marginal but workable number of observations per baseline. Note also that the three station case cannot provide the desired variety of baseline lengths in a closed figure. It was therefore determined that a quadrilateral provides the best compromise given the number of available observations.

THE TEST NET:

Two possible quadrilaterals were selected from the given sites and are shown in order of preference in Figures 2 and 3 respectively:

Figure 2 - Provides a good selection of base line lengths which bracket the expected maximum useful range of 60 km. It has the advantage of including the Shirley Bay-NGBL complex.

Figure 3 - Offers an intermediate length north-south base line at the expense of excluding the Shirley Bay Establishment.

REFERENCES:

Counselman, Charles C., no date. The Macrometer Interfermetric Surveyor. Macrometrics Incorporated, Woburn, Mass.

Gale, L.A., Nov. 1968. Report on the survey to connect the 150 ft. radio telescope at Lake Traverse, Ontario, to the Geodetic triangulation net. Geodetic Survey of Canada, Ottawa, Canada.

Halpenny, J.H., no date. Network Optimization Program. Data Center, EPB, Ottawa, Canada.

TABLE I

STATION SUITABILITY MATRIX

	SKY VIEW	ACCESS-ABILITY (30 m)	WINTER ACCESS	PERM-ANENT	BED-ROCK	SUIT-ABILITY	REMARKS
ORMOND	Y	Y	P	P	Y	?	-Owner uncooperative; access not granted
OSGOODE	Y	P	P	P	Y	P	-Private property; noisy dog
JOHNSTON	Y	Y	Y	Y	Y	Y	
CORKERY	N	P	P	P	Y	N	-Private property; noisy dog
CODY	Y	Y	Y	P	Y	Y	
PAMMURE	Y	Y	Y	P	Y	Y	
CARLETON	Y	Y	P	P	Y	Y	-100 m off road in pasture; 4wd access; plow in winter
ALMONTE	N	P	Y	P	Y	N	-Large trees 50, 240 & 310 deg.
MOHR	Y	N	N	P	Y	N	-Top of hill 300 m from road, rugged terrain
MORRIS	Y	Y	Y	Y	Y	Y	
METCALFE	Y	Y	Y	Y	Y	Y	-Microwave tower close by; line AC power available
SHIRLEY	N	Y	Y	Y	N	N	-Station under center of large metal tower
PZT	Y	Y	Y	Y	N	Y	-Metal Clad bldgs. close to station N and SE
NGBL	Y	Y	Y	Y	Y	Y	
ALGONQUIN	N	Y	Y	Y	P	P	-Elevated station on antenna pedistal; spur tie to Geodetic framework only; requires additional surveying before being useful. Possible bed-rock X-center site available but sky view may be obscured by 45 m antenna to the west.

Legend: Y = Yes N = No P = Possible with difficulty

TABLE 2

STATION SPACING (KM.)

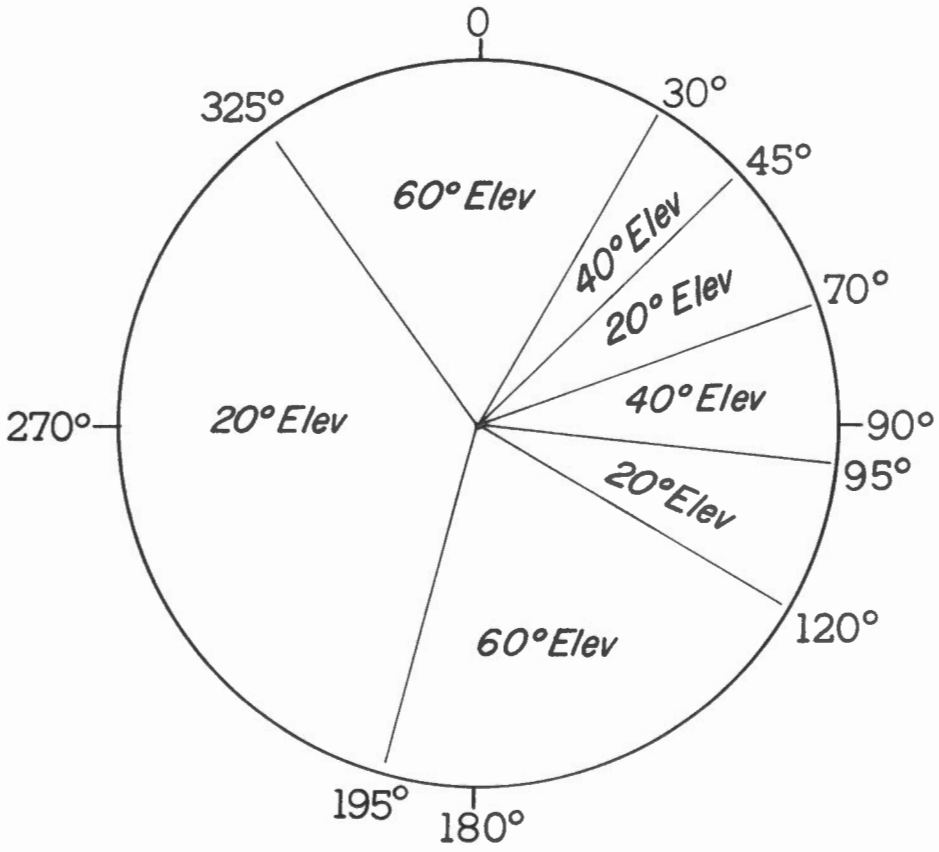
	ALGON-QUIN	MORRIS	MOHR	ALMO-NTE	CARL-ETON	PAN-MURE	CODY	CORK-ERY	SHIRLEY PZT	JOHN-STON	OSGO-ODE	ORMOND
METCALFE	218.80	66.27	63.47	61.97	58.31	57.93	53.31	47.59	40.12	11.46	5.48	11.78
ORMOND	227.93	75.38	72.22	67.44	63.09	65.91	60.85	54.80	50.10	22.34	17.23	
OSGOODE	214.24	61.89	59.28	59.43	56.16	54.16	49.80	44.32	35.45	6.90		
JOHNSTON	207.46	55.03	52.39	52.99	49.96	47.27	42.97	37.54	28.70			
SHIRLEY-PZT	178.79	26.72	24.70	34.27	34.27	21.68	19.88	17.81				
CORKERY	174.00	23.88	19.70	16.90	16.46	11.79	6.22					
CODY	167.79	18.26	13.92	14.97	16.69	5.66						
PAMMURE	162.40	12.84	8.42	16.42	19.98							
CARLETON	171.54	31.96	27.64	5.75								
ALMONTE	165.91	27.65	23.51									
MOHR	155.72	4.44										
MORRIS	152.61											

TABLE 3

BASELINE PRECISION (ONE SIGMA)
(Metres)

	ALGON-QUIN	MORRIS	MOHR	ALMO-NTE	CARL-ETON	PAN-MURE	CODY	CORK-ERY	SHIRLEY PZT	JOHN-STON	OSGO-ODE	ORMOND
METCALFE	0.239	0.028	0.026	0.029	0.029	0.025	0.024	0.023	0.018	0.015	0.014	0.018
ORMOND	0.241	0.032	0.030	0.036	0.028	0.030	0.030	0.029	0.022	0.018	0.019	
OSGOODE	0.238	0.027	0.024	0.026	0.026	0.023	0.022	0.020	0.016	0.010		
JOHNSTON	0.239	0.026	0.023	0.024	0.024	0.021	0.020	0.019	0.013			
SHIRLEY-PZT	0.238	0.024	0.022	0.023	0.023	0.020	0.019	0.019				
CORKERY	0.242	0.022	0.019	0.020	0.020	0.017	0.014					
CODY	0.242	0.022	0.019	0.021	0.022	0.015						
PANMURE	0.242	0.018	0.015	0.019	0.022							
CARLETON	0.247	0.027	0.025	0.016								
ALMONTE	0.247	0.025	0.023									
MOHR	0.240	0.011										
MORRIS	0.240											

GPS SKYVIEW CHART FOR JULY, 1983
(OTTAWA)



Satellite elevation in degrees for various azimuths in degrees

Fig. 1

FIGURE 2

SCALE 1:250,000

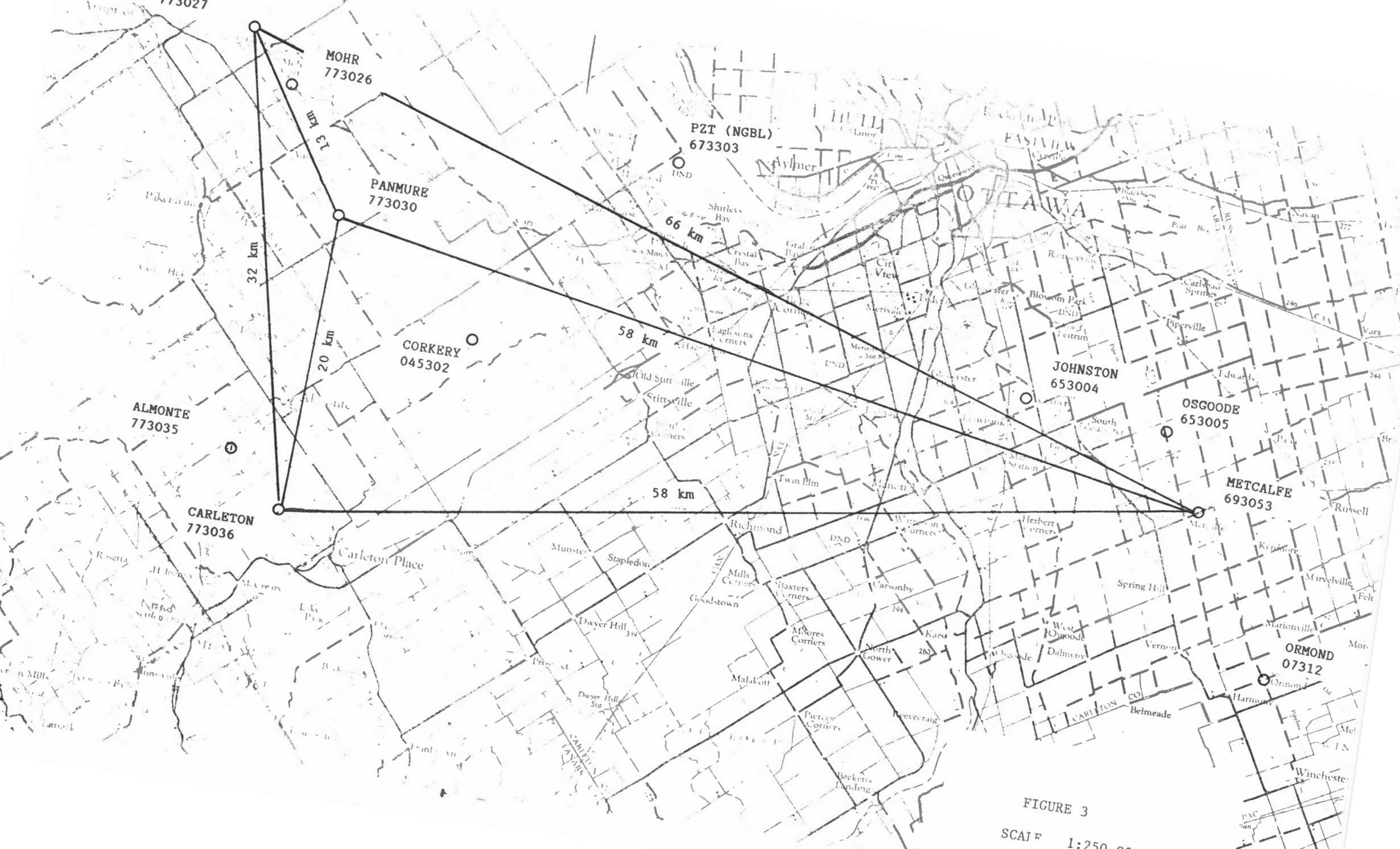


FIGURE 3

SCALE 1:250,000