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TESTING AND USE OF THE MAGNAVOX MANPACK GPS USER EQUIPMENT

by

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*Electromagnetic Section
Electronics Division*

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ABSTRACT

Since June 1985, Canada has employed the Magnavox GPS Manpack receivers in support of several programs. Primarily the set was used as a "reference" system during tests of the Primary Land Arctic Navigation System (PLANS) on board an M117 armoured personnel carrier during field trials at CFB Petawawa in Nov. 1985 and Sept. 1986. In addition, the set was employed in the same capacity during sea trials of the Marine Integrated Navigation System (MINS) off the west coast of Vancouver Island during Nov. 1986. During the sea trial, reference data was also being recorded from a Syledis shore-based reference system (2-5 metre accuracy). GPS Manpack data is compared to the Syledis data and results are contained in the report.

RESUME

Depuis juin 1985, le Canada emploie les récepteurs GPS Manpack de Magnavox dans plusieurs programmes. Ils ont été principalement utilisés comme référence lors des tests du système principal de navigation terrestre dans l'arctique (Primary Land Arctic Navigation System (PLANS)) à bord d'un véhicule blindé de type M117. Les essais ont eu lieu à la base des forces canadiennes à Petawawa en novembre 85 et septembre 86. Ces récepteurs ont aussi été utilisés lors des essais en mer du système intégré de navigation maritime (Marine Integrated Navigation System (MINS)). Les essais ont eu lieu près de l'île de Vancouver en novembre 86. Durant ces essais, un système de référence Syledis d'une précision de 2 à 5 mètres a aussi été utilisé. Les données du récepteur Magnavox et du système de référence Syledis sont comparées et les résultats sont analysés dans ce rapport.



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TESTING AND USE OF THE
MAGNAVOX MANPACK GPS
USER EQUIPMENT

1.0 INTRODUCTION

1.1 BACKGROUND

Under the Air Standardization Coordinating Committee (ASCC), Test Project Agreement TPA 839-53, Canada has had the loan of two Phase I, Magnavox Manpack Global Positioning System (GPS) receivers from June 1985 until December 1987.

During the period of this loan, the receivers have been employed in many applications including use as a 'reference' system during trials on a Primary Land Arctic Navigation System (PLANS) for tracked vehicles and a Marine Integrated Navigation System (MINS). In addition, numerous demonstrations to DND personnel were conducted showing the precision capabilities and potential of the Global Positioning System.

1.2 USER EQUIPMENT DESCRIPTION

The Phase I Magnavox Manpack GPS User Equipment is a single channel P-Code receiver intended for low dynamics applications; backpack, jeep, truck or tracked vehicle.

Performance specifications for the set are contained in Table 1-1 (excerpted from the Operator's Manual for the Manpack /Vehicle Navigation Set, September, 1978).

Table 1-1PERFORMANCE SPECIFICATIONS

Parameters	Characteristics
<u>ENVIRONMENTAL</u>	
Temperature Operating	-20 ⁰ to +55 ⁰ C (vehicle), 0 ⁰ to 55 ⁰ C for 6 hours (battery)
Storage	-40 ⁰ to +71 ⁰ C (no batteries)
Relative humidity	95% (0 ⁰ to 55 ⁰ C)
Altitude Operating	-300 to 4,500 meters
Temporary storage(24 hours)	-300 to 15,000 meters
Vibration	5.5 to 200 Hz
<u>PHYSICAL</u>	
Weight	9.3 kilograms (not including remote cables, batteries, or radio I/O)
Dimensions	
Height	89.0 centimeters (including antenna/preamplifier)
Width	32.1 centimeters
Depth	19.6 centimeters
Volume	Less than 20,000 cubic centimeters
<u>OPERATIONAL</u>	
Input signal levels	-163 to -150 dBw L ₁ 1575.42 MHz -166 to -150 dBw L ₂ 1227.60 MHz
Maximum dynamics	
Velocity	
Manpack	10 meters per second
Vehicle	30 meters per second (108 kilometers per hour, CDU displays up to 99 KMH)

Parameters	Characteristics
Acceleration	
Manpack	2.5 meters per second for 4 seconds
Vehicle	6.0 meters per second for 4 seconds
Antenna coverage	Reception of satellite signals more than 10 ⁰ above horizon
Equipment stabilization period	Less than 15 minutes from turn-on to the start of data acquisition between -20 ⁰ and 55 ⁰ C
RF signal input frequencies	
L1	1.57542 GHz
L2	1.22760 GHz
Signal propagation delay error	Measurement error of ionospheric signal delay less than 5 meters
Fix accuracy	
Horizontal stationary (dynamic)	15 meters (50 meters)
Vertical stationary (dynamic)	24 meters (50 meters)
Pseudorange measurement accuracy	
P-signal	1.8 meters
C/A-signal	18 meters
Jamming-to-signal power ratio	Up to 40 dB
Data recovery	Undetected bit error rate less than .00001 with jamming-to-signal ratio of 40 dB
Time-to-first-fix	
Normal acquisition mode	Less than 300 seconds
Direct acquisition mode	Less than 480 seconds
Time-to-subsequent-fix	20 seconds
Digital output signal	1.2 kilobits per second

2.0 TESTS AND RESULTS

2.1 LAND TESTS

During 1985 and 1986, DREO expended a great deal of effort in the development and testing of a Primary Land Arctic Navigation System (PLANS); an integrated navigation system for tracked vehicles operation in the far north.

Initial tests were carried out at CFB Petawawa near Pembroke, Ontario. The test system consisted of a 40 mile route through secondary roads and rough terrain along which survey markers with metal retroreflectors were installed. An infrared detector mounted on the side of the (armoured personnel carrier) testbed provided a time mark/interrupt whenever a retroreflector was passed along the route. The known position of the retroreflector was then compared to the PLANS position solution to evaluate system performance.

Since no formal survey positions existed within the test area (extremely rugged terrain prevented the conduct of a formal survey for practical reasons), it was decided to employ the GPS manpack to determine the 'survey' positions. The receiver was transported to each desired reference position, initialized and allowed to settle for 5 to 10 minutes while numerous position calculations were recorded. From this data, a 'best estimate' of position was determined. This, then, was considered the 'reference' position for test purposes. The accuracy of GPS alone was considered sufficient for the testing of PLANS since the PLANS performance specification is 150 meters (CEP) (an order of magnitude below GPS specifications).

Tests were carried out in November 1985 and September 1986.

Table 2-1 contains test data from one 'run' comparing GPS and PLANS latitude. Figure 2-1 is a plot of GPS and PLANS latitude. The corresponding longitude data is contained in Table 2-2 and Figure 2-2.

PLANS TRIAL SEPT. 1986

REF. NO.	GPS LAT. DEG.	PLANS LAT. DEG.	DELTA LAT. DEG.
1	45.8976	45.8976	0.000031
3	45.9300	45.9294	0.000644
4	45.9448	45.9441	0.000713
6	45.9570	45.9562	0.000861
7	45.9498	45.9489	0.000941
9	45.9522	45.9518	0.000433
10	45.9496	45.9491	0.000521
11	45.9566	45.9555	0.001105
12	45.9519	45.9508	0.001059
13	45.9486	45.9475	0.001067
14	45.9375	45.9360	0.001470
15	45.9226	45.9211	0.001531
16	45.9014	45.8992	0.002261
17	45.8876	45.8850	0.002657
18	45.8694	45.8702	-0.000799
19	45.8644	45.8614	0.003002
21	45.8716	45.8690	0.002633
22	45.8744	45.8726	0.001838

Table 2 - 1

PLANS VS GPS MANPACK

LATITUDE DIFFERENCE

PLANS TRIAL SEPT. 1986

GPS MANPACK VS. PLANS

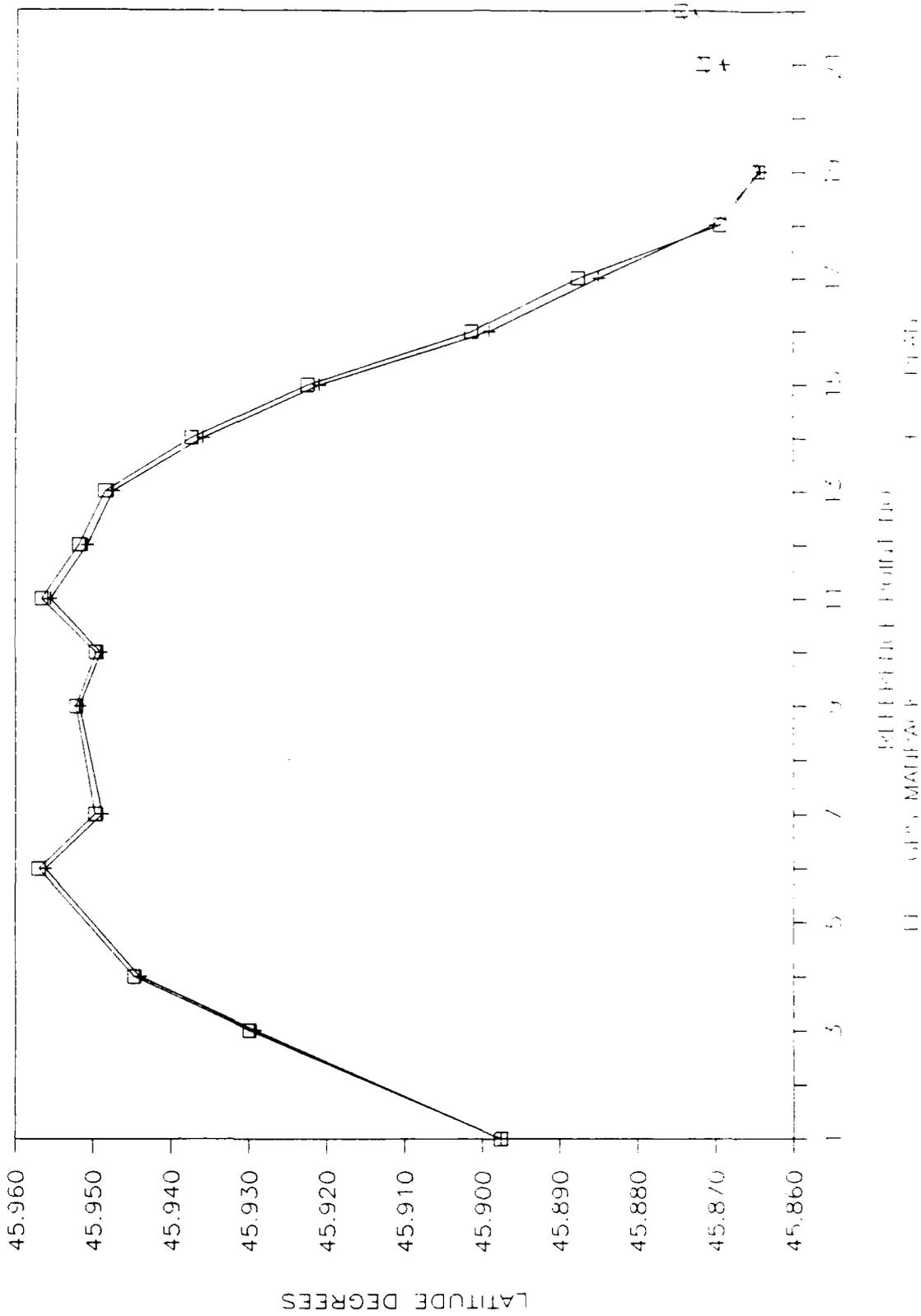


Figure 2-1
Latitude

PLANS TRIAL SEPT. 1986

REF. NO.	GPS LONG. DEG.	PLANS LONG DEG.	DELTA LONG. DEG.
1	77.3176	77.3178	-0.000119
3	77.3334	77.3331	0.000303
4	77.3491	77.3491	-0.000036
6	77.3862	77.3863	-0.000113
7	77.4124	77.4126	-0.000197
9	77.4589	77.4595	-0.000507
10	77.4786	77.4791	-0.000546
11	77.5003	77.5005	-0.000276
12	77.5246	77.5250	-0.000381
13	77.5487	77.5489	-0.000222
14	77.5590	77.5592	-0.000153
15	77.5561	77.5562	-0.000088
16	77.5594	77.5595	-0.000158
17	77.5465	77.5459	0.000567
18	77.5284	77.5307	-0.002265
19	77.5071	77.5085	-0.001341
21	77.4614	77.4631	-0.001707
22	77.4276	77.4301	-0.002565

Table 2 - 2

PLANS VS GPS MANPACK

LONGITUDE DIFFERENCE

PLANS TRIAL SEPT. 1986

GPS MANPACK VS. PLANS

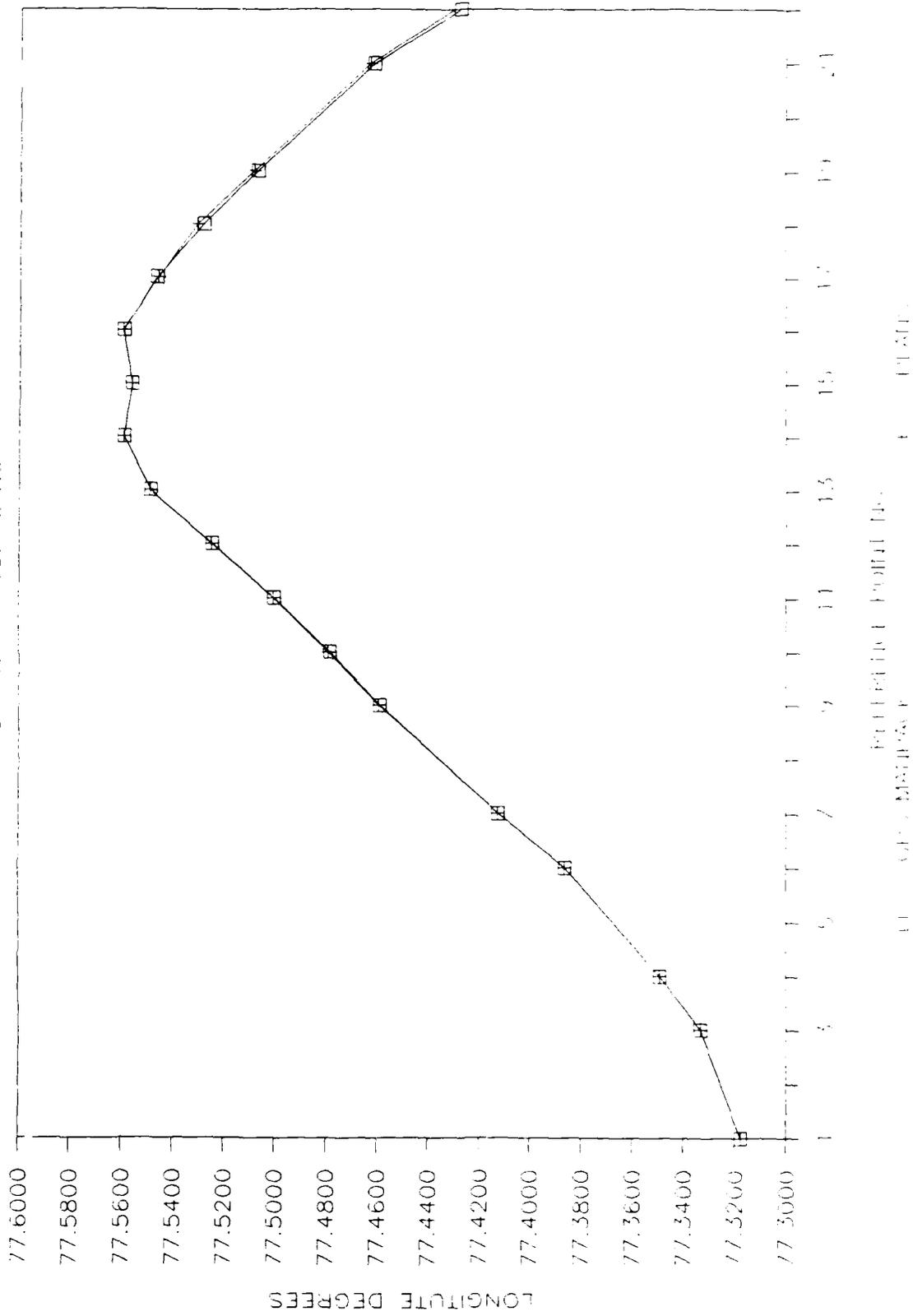


Figure 2-2
Longitude

2.2 SEA TESTS

Since 1982, extensive sea trials have been carried out on the DREO-developed Marine Integrated Navigation System (MINS). Trials have been carried out on both the Atlantic and Pacific coasts of Canada and numerous shore based reference systems have been employed including MAXITRAN, MINIRANGER and SYLEDIS. System accuracies (after post-processing) are estimated at 2-5 meters CEP.

On numerous occasions, the GPS manpack was employed during sea trials both as a system under test as well as an informal 'check' on reference system performance.

Over 150 Hours of GPS manpack data during sea trials has been collected. A typical plot of GPS versus a reference system (in this case, SYLEDIS) is shown in Figure 2-3 and Figure 2-4. The data is contained in Tables 2-3 and 2-4. Typical performance is 22 meters (95%).

MINS TRIAL NOV. 1987

GPS MANPACK VS. SELYDIS

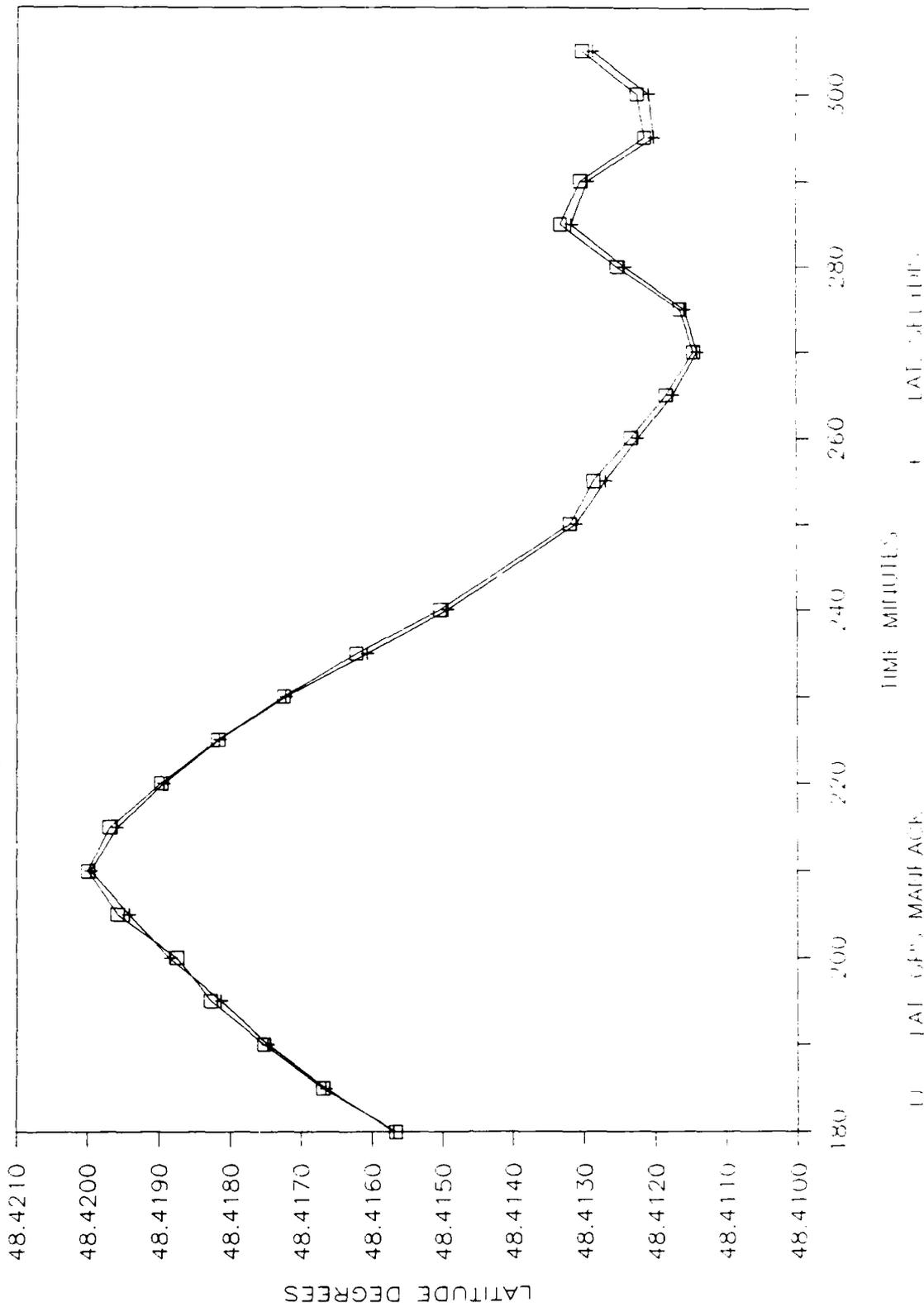
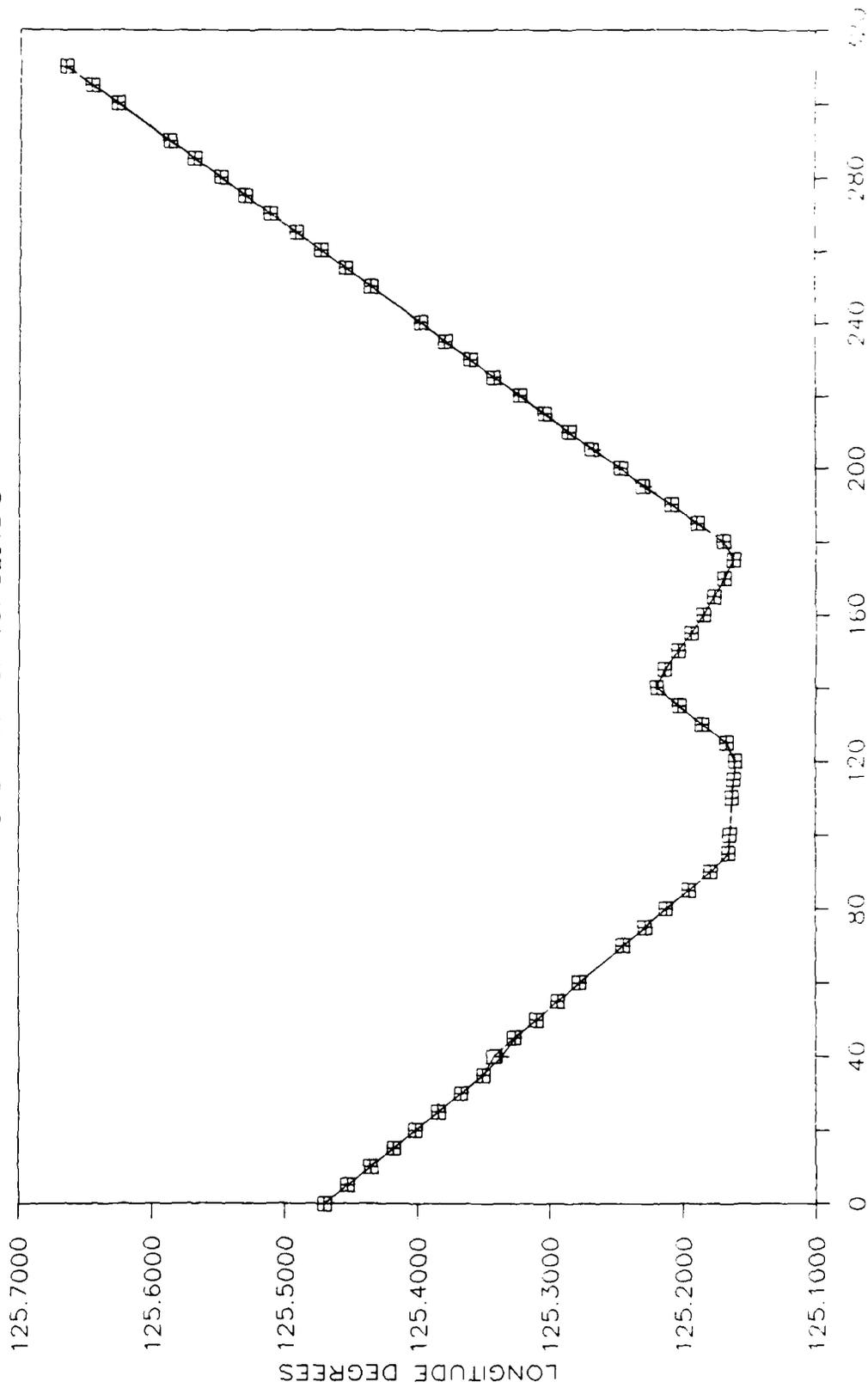


Figure 2-3
Latitude

MINS TRIAL NOV. 1987

GPS MANPACK VS. SELYDIS



□ GPS MANPACK
+ SELYDIS

Figure 2-4
Longitude

MINS TRIAL NOV. 1987

TIME MIN.	GPS LAT. DEG.	SEL LAT. DEG	DELTA LAT. DEG.	TIME MIN.	GPS LAT. DEG.	SEL LAT. DEG	DELTA LAT. DEG.
0	48.7382	48.7374	0.000747	250	48.4132	48.4131	0.000086
5	48.7305	48.7302	0.000353	255	48.4129	48.4127	0.000172
10	48.7235	48.7229	0.000608	260	48.4123	48.4122	0.000103
15	48.7158	48.7151	0.000711	265	48.4118	48.4117	0.000097
20	48.7079	48.7075	0.000425	270	48.4114	48.4114	0.000050
25	48.7006	48.7000	0.000597	275	48.4116	48.4116	0.000061
30	48.6930	48.6922	0.000750	280	48.4125	48.4124	0.000114
35	48.6848	48.6846	0.000142	285	48.4133	48.4132	0.000156
40	48.6760	48.6760	-0.000011	290	48.4131	48.4130	0.000106
45	48.6664	48.6660	0.000375	295	48.4121	48.4120	0.000133
50	48.6584	48.6580	0.000389	300	48.4123	48.4121	0.000169
55	48.6508	48.6505	0.000267	305	48.4130	48.4129	0.000147
60	48.6432	48.6428	0.000375				
70	48.6278	48.6274	0.000442				
75	48.6201	48.6198	0.000389				
80	48.6123	48.6119	0.000414				
85	48.6043	48.6040	0.000353				
90	48.5961	48.5957	0.000319				
95	48.5868	48.5863	0.000481				
100	48.5749	48.5743	0.000597				
110	48.5499	48.5493	0.000614				
115	48.5371	48.5365	0.000586				
120	48.5247	48.5241	0.000633				
125	48.5162	48.5161	0.000092				
130	48.5121	48.5120	0.000078				
135	48.5084	48.5082	0.000211				
140	48.5040	48.5034	0.000528				
145	48.4928	48.4923	0.000458				
150	48.4810	48.4807	0.000286				
155	48.4695	48.4692	0.000283				
160	48.4586	48.4580	0.000586				
165	48.4469	48.4463	0.000583				
170	48.4350	48.4344	0.000608				
175	48.4225	48.4225	-0.000033				
180	48.4157	48.4157	-0.000028				
185	48.4167	48.4167	0.000042				
190	48.4175	48.4175	0.000058				
195	48.4183	48.4181	0.000144				
200	48.4188	48.4189	-0.000106				
205	48.4196	48.4194	0.000161				
210	48.4200	48.4200	0.000036				
215	48.4197	48.4196	0.000106				
220	48.4190	48.4189	0.000039				
225	48.4182	48.4182	0.000017				
230	48.4173	48.4172	0.000031				
235	48.4162	48.4161	0.000153				
240	48.4150	48.4149	0.000108				

Table 2 - 3

MINS VS GPS MANPACK LATITUDE DIFFERENCE

MINS SEA TRIAL NOV. 1987

TIME MIN.	GPS LONG. DEG.	SEL LONG. DEG.	DELTA LONG.	TIME MIN.	GPS LONG. DEG.	SEL. LONG DEG.	DELTA LONG.
0	125.4700	125.4704	-0.000361	250	125.4704	125.4358	0.034567
5	125.4528	125.4528	-0.000061	255	125.4528	125.4550	-0.002128
10	125.4351	125.4353	-0.000178	260	125.4353	125.4739	-0.038581
15	125.4180	125.4181	-0.000103	265	125.4181	125.4930	-0.074903
20	125.4014	125.4010	0.000331	270	125.4010	125.5122	-0.111208
25	125.3843	125.3843	-0.000025	275	125.3843	125.5312	-0.146869
30	125.3673	125.3673	-0.000006	280	125.3673	125.5501	-0.182778
35	125.3497	125.3506	-0.000878	285	125.3506	125.5696	-0.218983
40	125.3358	125.3363	-0.000550	290	125.3363	125.5888	-0.252486
45	125.3262	125.3262	0.000022	300	125.3262	125.6272	-0.301033
50	125.3104	125.3102	0.000117	305	125.3102	125.6468	-0.336561
55	125.2940	125.2939	0.000086	310	125.2939	125.6662	-0.372267
60	125.2779	125.2775	0.000364				
70	125.2449	125.2443	0.000622				
75	125.2287	125.2282	0.000533				
80	125.2125	125.2119	0.000528				
85	125.1955	125.1955	0.000014				
90	125.1794	125.1793	0.000092				
95	125.1657	125.1655	0.000197				
100	125.1645	125.1645	0.000047				
110	125.1629	125.1628	0.000100				
115	125.1618	125.1618	0.000017				
120	125.1601	125.1604	-0.000264				
125	125.1669	125.1674	-0.000503				
130	125.1854	125.1853	0.000056				
135	125.2024	125.2034	-0.001008				
140	125.2193	125.2197	-0.000372				
145	125.2136	125.2133	0.000317				
150	125.2034	125.2034	-0.000022				
155	125.1936	125.1937	-0.000069				
160	125.1847	125.1845	0.000206				
165	125.1761	125.1760	0.000022				
170	125.1691	125.1689	0.000222				
175	125.1618	125.1620	-0.000178				
180	125.1695	125.1698	-0.000278				
185	125.1889	125.1896	-0.000786				
190	125.2081	125.2087	-0.000650				
195	125.2300	125.2282	0.001828				
200	125.2466	125.2474	-0.000867				
205	125.2686	125.2668	0.001789				
210	125.2854	125.2864	-0.001000				
215	125.3040	125.3049	-0.000875				
220	125.3229	125.3237	-0.000747				
225	125.3427	125.3422	0.000492				
230	125.3601	125.3609	-0.000736				
235	125.3790	125.3799	-0.000844				
240	125.3978	125.3986	-0.000797				

Table 2 - 4

MINS VS GPS MANPACK LONGITUDE DIFFERENCE

14.

3.0 SUMMARY

The Magnavox manpack GPS receiver was employed extensively as a test system, a reference system and a demonstration system in both land and sea environments from June 1985 until December 1987.

Performance of the receiver was consistently within the GPS UE specifications.

Data is available on all tests performed.

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ABSTRACT

Since June 1985, Canada has employed the Magnavox GPS Manpack receivers in support of several programs. Primarily the set was used as a "reference" system during tests of the Primary Land Arctic Navigation System (PLANS) on board an M117 armoured personnel carrier during field trials at CFB Petawawa in Nov. 1985 and Sept. 1986. In addition, the set was employed in the same capacity during sea trials of the Marine Integrated Navigation System (MINS) off the west coast of Vancouver Island during Nov. 1986. During the sea trial, reference data was also being recorded from a Syledis shore-based reference system (2-5 metre accuracy). GPS Manpack data is compared to the Syledis data and results are contained in the report.

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MANPACK
P-CODE
SATELLITE NAVIGATION

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