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PERFORMANCE EVALUATION OF A MAGNAVOX GPS Z-SET

by

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ABSTRACT

→ A Magnavox Global Positioning System (GPS) Z-Set Receiver was obtained on loan from the United States NAVSTAR/GPS Joint Program Office for evaluation. Tests were carried out in an electronically-equipped trailer, on-board a naval research vessel and in a Twin Otter flying laboratory. Data was manually recorded during static positioning tests and waypoint navigation tests. Results indicated a static positioning accuracy consistently better than 100 feet in both latitude and longitude under 4-satellite availability. ↗



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RESUME

Le Joint Program Office du système de localisation par satellite NAVSTAR nous a prêté un récepteur Z-set du système de localisation par satellite Magnavox pour en faire l'évaluation. Nous avons effectué des tests dans une remorque munie d'équipements électroniques et installée à bord de recherche, et dans un laboratoire aménagé à bord d'un Twin Otter. On a enregistré à la main les données lors de tests de positionnement au point fixe et de tests de navigation par point de cheminement. Dans tous les cas, la position au point fixe pouvait toujours être déterminée avec une marge d'erreur de moins de 100 pieds en latitude et en longitude, à partir de quatre satellites.

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1.0 BACKGROUND

The Navigation Sub-program at the Defence Research Establishment Ottawa is involved in many aspects of navigation technology. Over the past five years, direct support has been provided to the Canadian Marconi Company (CMC) who are under contract to develop a Class 'D' (2-channel, high accuracy, medium dynamics) GPS receiver scheduled for delivery in early 1984. In addition a newly-developed Marine Integrated Navigation System (MINS) designed and built at DREO began sea trials in mid-1982.

In order to satisfy the requirement for a reference system against which to evaluate the MINS and as preparation for delivery of the Canadian - built GPS receiver, a request was submitted to the GPS Project Office for the loan of a GPS receiver. A Magnavox GPS Z-Set was loaned to DREO for the months of October, November and part of December 1982. This report summarizes some of the tests performed on this receiver and the results obtained.

1.1 TEST PHILOSOPHY

Detailed performance evaluation of the Magnavox GPS Z-Set has been performed by the GPS Joint Program Office and it was not our intent to repeat any of that work. Instead, our evaluation was aimed at acquiring some 'hands-on' experience with the GPS System in as many environments as possible within the time span of the receiver loan. The principal purposes of the tests were to establish GPS as a credible primary location sensor at sea for testing and evaluating MINS-derived location accuracies and to demonstrate GPS to the Canadian Forces in various environments.

In preparation for the delivery of the CMC GPS receiver, test plans are in the process of being written for tests within land vehicles, ships and various aircraft. The Magnavox GPS Z-Set was employed (in a limited way) in each of these environments during our tests.

Since no interfacing capabilities were provided with the receiver, data collection was limited to that available through switch selection on the Control Display Unit (CDU). The results of these tests are presented here.

1.2 THE MAGNOVOX Z-SET

The Magnavox GPS Z-Set is a single-channel, low dynamics, C/A code-only receiver. Performance specifications for this receiver are taken from the Magnavox Z-Set User Manual (April 1982) and are shown in Table 1-1.

Photographs of the receiver as installed onboard a Twin Otter test aircraft are shown in Figures 1-1, 1-2 and 1-3. Figure 1-1 shows the Control Display Unit (CDU), on the right Figure 1-2 the Receiver Processor Unit (RPU)

| <u>PARAMETERS</u> | <u>CHARACTERISTICS</u> |
|---|--|
| <u>OPERATIONAL</u> | |
| RF Signal input level | -163 to -150 dBW, L ₁ 1575.42 MHz |
| Maximum dynamics | |
| Velocity | 0-400 meters per second |
| Acceleration | 0-5 meters per second ² (between 5 m/s ² and 10 m/s ² set will enter HOBYT) |
| Antenna coverage | Reception of satellite signals more than 5 degrees above horizon |
| Equipment stabilization period | Less than 15 minutes from turn-on to the start of data acquisition between 0 to + 490C |
| Static propagation delay error (GDOP less than 5) | Error in displayed navigation solution less than 180 meters |
| Fix accuracy | 500 meters |
| Pseudorange measurement accuracy | 15 meters (C/A-signal) |
| Jamming-to-signal power ratio | Up to 25 dB |
| Data recovery | Undetected bit error rate less than 0.00001 with jamming-to-signal ratio of 25 dB |
| Time-to-first-fix | |
| Normal (wide) acquisition mode | Less than 300 seconds |
| Narrow acquisition mode * | Less than 215 seconds |
| Digital output signal | 2.4 kilobits per second |
| <u>PHYSICAL</u> | |
| Volume | 0.016 cubic meter |
| Weight | 15 Kilograms |
| Power | 53 Watts |

* Position uncertainty <13 Km
Initial velocity uncertainty <17 m/s

TABLE 1-1

Performance Details

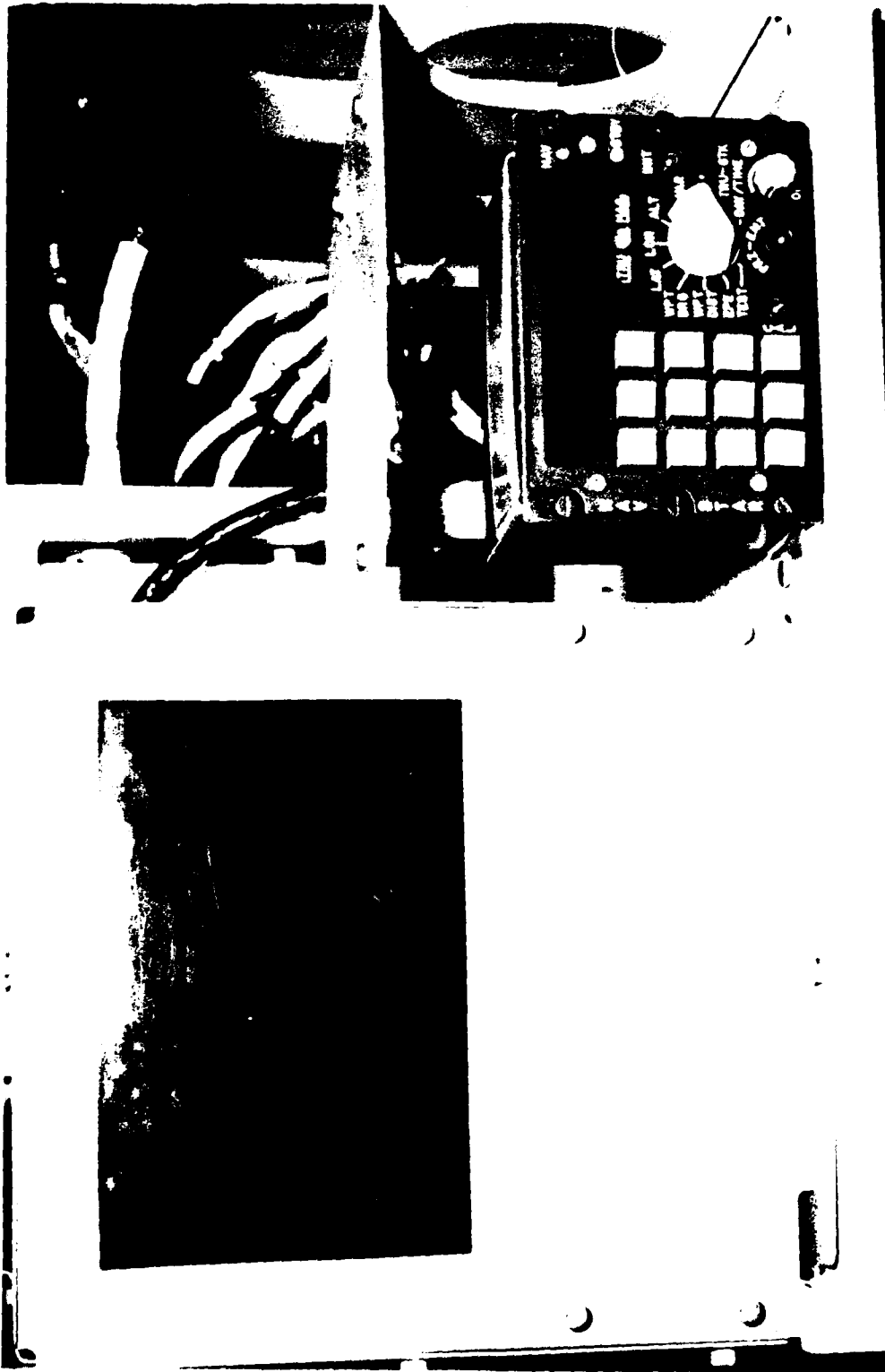


Fig. 1-1 Magnavox GPS Z-Set CDU



Fig. 1-2. W-2-2-2-2 Installation

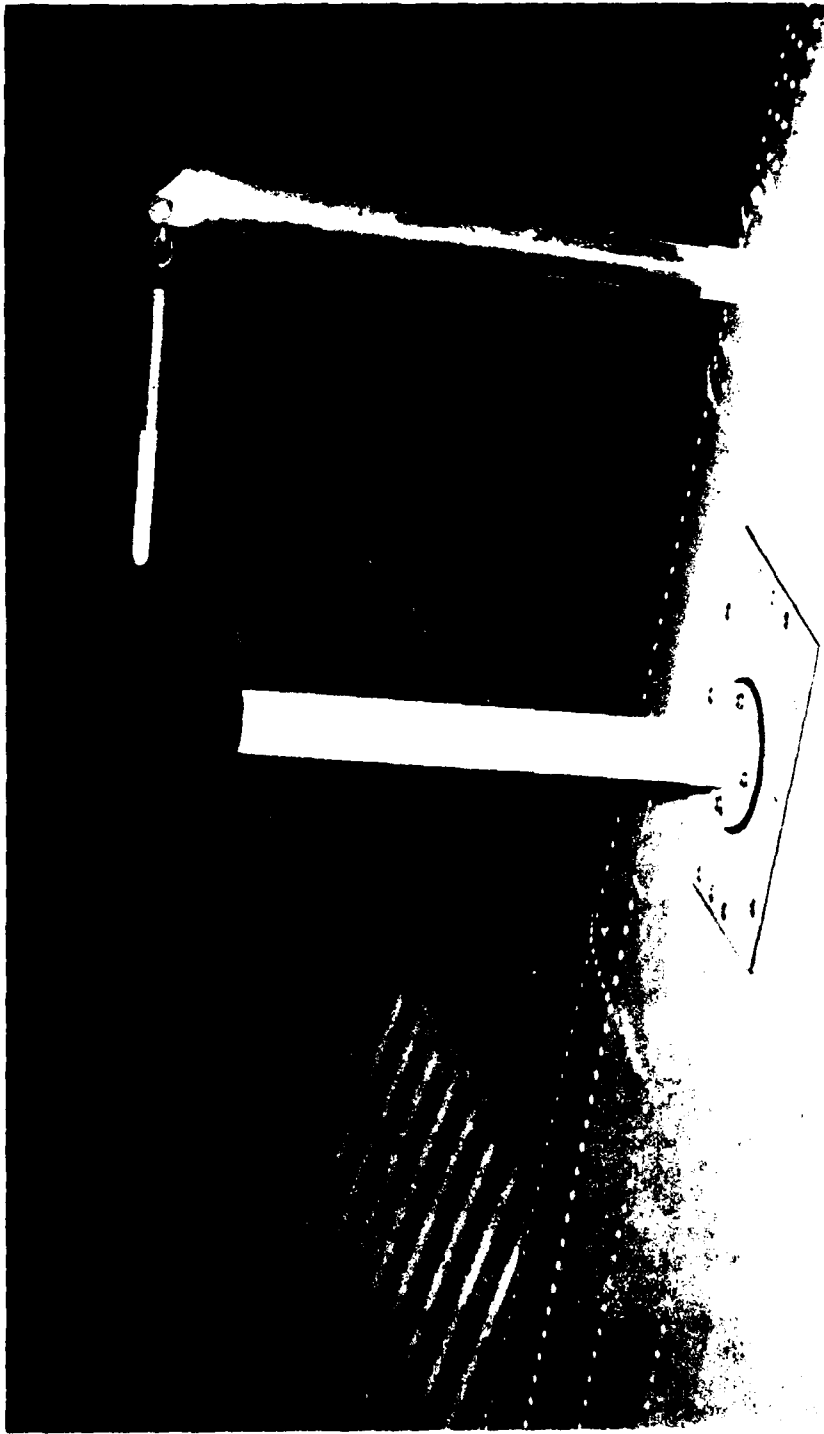


Fig. 1-3. 300 Ohm Attenuator, Model 100, Type 1000

and RF preamp and Figure 1-3 the Chu antenna that was employed during all of the tests.

Satellite coverage during the entire test period was quite limited. Four-satellite coverage was available for only 2 hours a day but fortunately occurred during the late morning and early afternoon facilitating demonstrations to future operational users as an additional benefit to the tests. A computer plot of Geometric Dilution of Precision (GDOP) vs time of day is shown in Figure 1-4 and elevation angle vs time of day in Figure 1-5. Note that the best coverage in the Ottawa area occurred between 1745 and 1915 hrs (GMT) or 1245 and 1415 hrs local time with a GDOP between 2 and 7. (GDOP is an indicator of satellite geometry with respect to the user).

2.0 TEST PROCEDURES

Tests were carried out on three different platforms; a fully instrumented van, a naval research ship and a Twin Otter 'flying-laboratory' aircraft.

2.1 VAN TESTS

Tests on an instrumented van were carried out between 5 November and 1 December 1982. Prior to installation, the receiver was checked for proper operation. A problem was discovered with the Magnavox antenna so a Chu antenna (as shown in Figure 1-3) was substituted and receiver operation verified.

For the purposes of determining receiver static positioning accuracy, verifying proper operation and performing speed calibration and low-dynamics way point navigation, a survey crew was hired to locate and mark a series of existing first-order survey points which could be accessed by truck in the local Ottawa area. A list of the waypoints and their positions is given in Table 2-1.

Some of the selected survey points were in fact, some distance from the road so stakes were driven into the ground at the shoulder of the road and then the distance and bearing to the survey marker were taken if possible. The latitude and longitude of each stake was then calculated with reference to its nearby survey marker. By this method, the exact position of the stakes is known to within several feet and the van can be brought to a stop within twenty feet (or less) of most stakes.

Table 2-1 also contains the corrected latitude and longitude for each stake used in the tests. Unfortunately, some stake positions could not be accurately determined because the corresponding survey markers were several hundred feet away from the road in heavy underbrush; these were left uncorrected in the data.

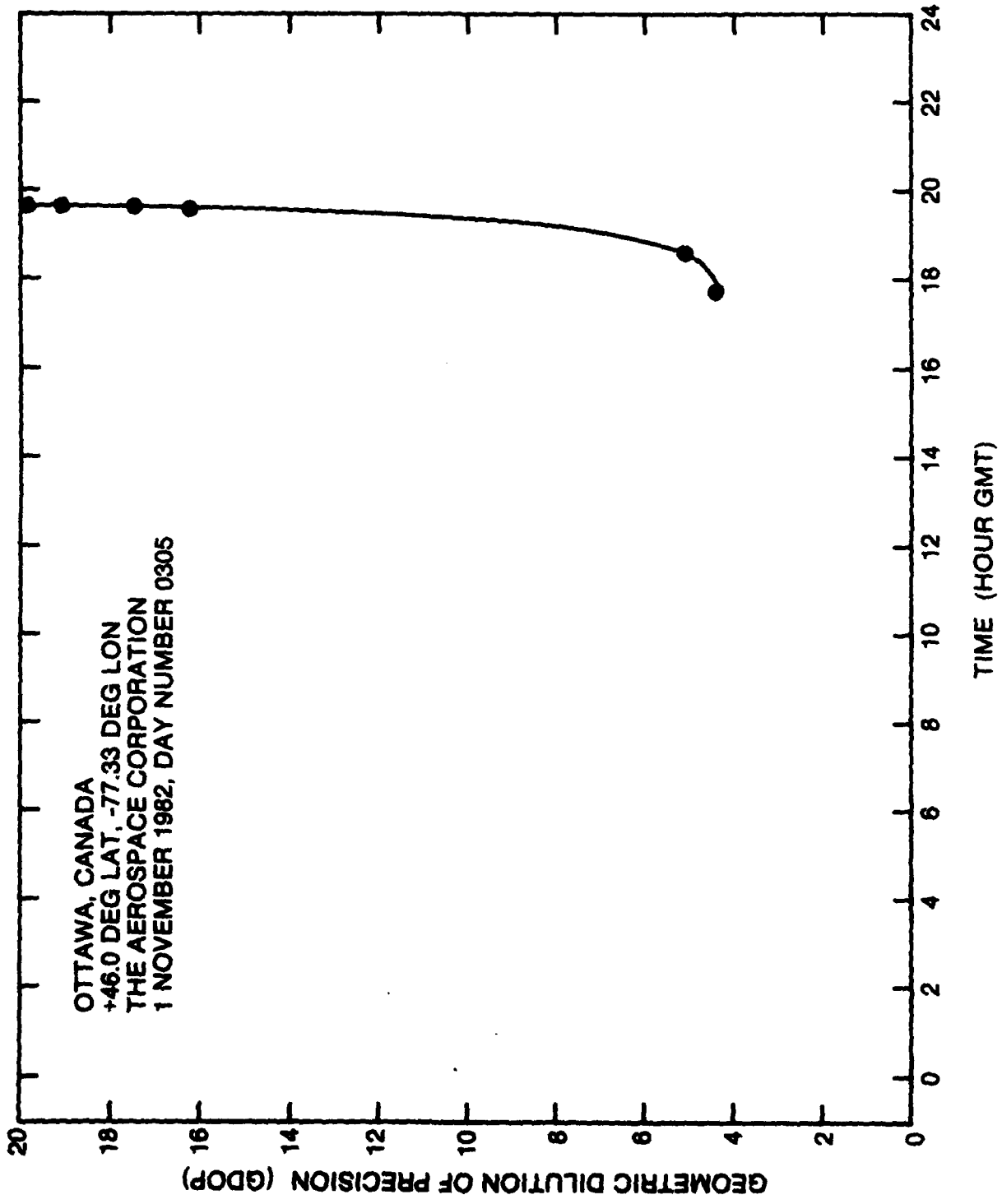


Fig. 1-4 4-Satellite Geometry

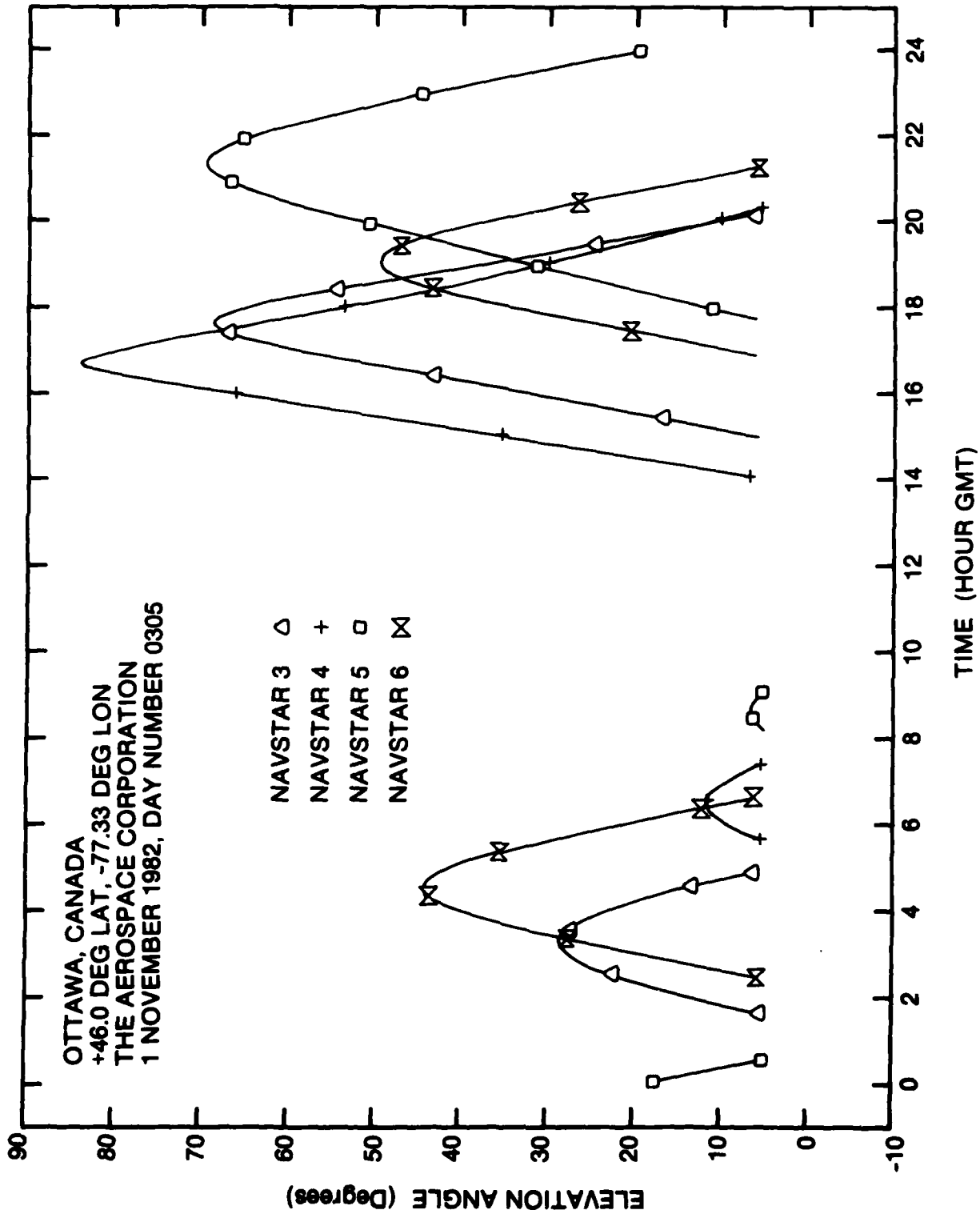


Fig. 1-4. Elevation Angles for NAVSTAR Constellation

| TEST POINT NO. | NAME | LATITUDE | LONGITUDE | (CORRECTED) STAKE POSITIONS | |
|-------------------|------------|-------------|-------------|--------------------------------|--------------------------|
| | | | | LATITUDE | LONGITUDE |
| 1 | DREO TOWER | 45° 20' 55" | 75° 52' 53" | 45° 20' 55" | 75° 52' 53" |
| 2 | WOODLAWN | 45° 27' 43" | 76° 04' 35" | (No correction possible) | (No correction possible) |
| | DIRLETON | 45° 29' 01" | 76° 09' 37" | 45° 27' 42.23" | 76° 04' 34.67" |
| 5 | ARNPRIOR | 45° 25' 23" | 76° 19' 39" | 45° 29' 01" | 76° 09' 39" |
| 9 | PANMURE | 45° 29' 18" | 76° 11' 04" | (No correction possible) | (No correction possible) |
| 8 | MARATHON | 45° 21' 06" | 76° 06' 50" | 45° 25' 23.12" | 76° 19' 38.68" |
| 0 | DREO TOWER | 45° 20' 55" | 75° 52' 53" | 45° 20' 18" | 76° 11' 04" |
| | | | | 45° 21' 5.4" | 76° 06' 49.73" |
| | | | | 45° 20' 55" | 75° 52' 53" |

NOTE: 1. This Route is a Subset of a Surveyed Route Containing a Total of 12 'Waypoints'.

TABLE 2-1

Route No. 1

The test procedure consisted of initializing the receiver at the start point, the DREO Tower, where all four satellites were acquired before each test was begun. The time, actual position, receiver latitude, longitude and altitude, Estimated Position Error (EPE) and number of satellites being tracked were recorded. An example of a test data sheet is shown in Table 2-2.

The position of each subsequent survey point along the route was then loaded into the receiver as a waypoint and the distance and bearing from the present (start) position to the first waypoint was also recorded. The van was then driven and parked at each waypoint where all receiver data were taken and the distance and bearing to the next waypoint were recorded.

This entire procedure was carried out six times between 5 Nov. and 1 Dec 1982. In actual fact, as many as 12 waypoints were used in some tests but limited satellite coverage often resulted in 2 and 3-satellite fixes with poor GDOP since the tests often over-ran the coverage times. Most data presented here are from a so-called 'short' route during which 4-satellite coverage was always available.

In addition a fifth-wheel system was used as a velocity reference during several tests. GPS velocity was recorded and later plotted for comparison.

2.2 SHIP TESTS

During the week of 15-20 Nov. 1982, the DREO - developed Marine Integrated Navigation System (MINS) was taken to Victoria, B.C. for demonstrations and sea trials onboard the research vessel CFAV Endeavour.

The GPS Z-Set was installed on the ship as a reference system against which MINS could be compared.

Unfortunately, due to the early hours of satellite visibility and the fact that the ship had not left dockside during the visibility period, due to bad weather no useful navigation data were acquired during this period. Plans are in progress to secure the loan of another GPS receiver during 1983 such that another series of sea trials can be carried out using GPS as a reference system.

2.3 AIRCRAFT TESTS

After completion of the van tests, the GPS Z-Set was installed in a Twin Otter research aircraft owned by the National Aeronautical Establishment. The photos previously shown as Figures 1-1, 1-2 and 1-3 are actually those of the installation on the Twin Otter.

DATE 5 Nov. 82 TEMP. 10°C HUMIDITY 70% CLOUD COVER Cloudy

| TIME (GMT) | WAYPOINT NO & LOCATION | RECEIVER | | | EPE | DIST | BRG | |
|------------------------|------------------------|-------------|-------------|-------------|-------------|------|----------------|--------------------|
| | | LAT | LONG | DIST | | | | |
| ARR. 1800 | 0 DREO TOWER | 45° 20' 55" | 75° 52' 53" | 45° 21' 01" | 75° 52' 54" | .01 | 10.6NM .0NM | 309.2°T |
| ARR. 1820 DEP. 1823 | 1 WOODLAWN | 45° 27' 43" | 76° 04' 35" | 45° 27' 43" | 76° 04' 35" | .01 | 3.8NM .1NM | 290.1°T 204.30T |
| ARR. 1836 DEP. 1839 | 2 DIRELTON | 45° 29' 01" | 76° 09' 37" | 45° 28' 59" | 76° 09' 33" | .01 | 9.0NM .1NM | 243.2°T 306.7°T |
| ARR. 1858 DEP. 1900 | 3 ARNPRIOR | 45° 25' 23" | 76° 19' 39" | 45° 25' 18" | 76° 19' 29" | .02 | 7.8NM .1NM | 130.1°T 332.4°T |
| ARR. 1912 DEP. 1912 | 4 PANMURE | 45° 28' 18" | 76° 11' 04" | 45° 20' 13" | 76° 11' 00" | .02 | 3.3NM .0NM | 61.3°T - |
| ARR. 1921 DEP. 1923 | 5 MARATHON | 45° 21' 06" | 76° 06' 50" | 45° 21' 06" | 76° 06' 50" | .02 | 9.8NM .1NM | 91.0°T 176.9°T |
| ARR. 1948 DEP. | 6 DREO | 45° 20' 55" | 75° 52' 53" | 45° 21' 00" | 75° 52' 53" | .03 | --- | --- |
| ARR. DEP. | 7 BLDG. T5 | 45° 20' 51" | | | 75° 53' 07" | .05 | --- | --- |

TABLE 2-2
GPS TEST DATA SHEET

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It was decided that in order to get useful results, it would be best to attempt a series of single point positioning tests over a precisely known and closely accessible survey point. Such a point was that of the intersection of two runways at the Ottawa International Airport. The aircraft could carry out touch-and-go passes from either runway, and it was estimated that an 'on-top' could be called with an error of less than twenty feet. In actual fact, the aircraft did not touch down on the runway, but rather 'glided' approximately six feet above the ground.

Two flights employing this 'touch-and-go' method were flown totalling over 25 data points. Data were recorded by voice onto tape and later transcribed to data sheets. Data recorded included EPE, latitude, longitude, altitude, speed, True Ground Track and time.

A series of waypoint navigation tests was also carried out. Three easily accessible landmarks in the Ottawa area (DREO Tower, Ottawa VOR and the airport runway intersection) were chosen as waypoints and the triangular route was flown several times. This test was used mainly to acquire a feel for receiver performance as a baseline for later comparison with other receivers and systems to be tested.

The tests were completed and the receiver was returned to the JPO on 10 Dec. 1982.

3.0 TEST RESULTS

Since all data were recorded manually, the data were limited to that which were available via the CDU only and by the one-second rate at which the displays are updated.

3.1 VAN TEST RESULTS

Table 3-1 shows a comparison between the survey marker positions and the GPS Z-Set positions for each of the six test runs as well as the averaged GPS Z-Set position. The most notable characteristic of the data is its repeatability; although each run was done on a different day and at a different time, rarely is the difference in position greater than one second of arc (approximately 100 feet) and is, in fact, usually identical.

It is interesting to note that for three of the waypoints (DREO Tower, Dirleton and Panmure) the marker at the roadside is actually several hundred feet from the survey point. Using the waypoint navigation function, it was possible to get a bearing and distance to the waypoint while parked at the roadside marker. The most notable example of this occurs using the data gathered at the DREO Tower. It can be seen from the averaged GPS positions

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| WAYPOINT NAME | Stake Position | | Receiver Position Run #1 (5 Nov) | | Run #2 (8 Nov) | | Run #3 (9 Nov) | |
|---------------|----------------|--------------|----------------------------------|-----------|----------------|-----------|----------------|-----------|
| | Lat. | Long. | Lat. | Long. | Lat. | Long. | Lat. | Long. |
| DREO TOWER | 45°20'55" | 75°52'53" | 45°21'01" | 75°52'54" | 45°21'01" | 75°52'54" | 45°21'01" | 75°52'55" |
| WOODLAWN | 45°27'42.23" | 76°04'34.67" | 45°27'43" | 76°04'35" | 45°27'44" | 76°04'35" | 45°27'43" | 76°04'34" |
| DIRELTON | 45°29'01" | 76°09'37" | 45°28'59" | 76°09'33" | 45°28'58" | 76°09'33" | 45°28'59" | 76°09'33" |
| ARNPRIOR | 45°25'23.12" | 76°19'38.68" | Missed | Marker | 45°25'24" | 76°19'38" | 45°25'24" | 76°19'38" |
| PANMURE | 45°20'18" | 76°11'04" | 45°20'13" | 76°11'00" | 45°20'14" | 76°11'06" | 45°20'14" | 76°11'06" |
| MARATHON | 45°21'5.4" | 76°06'49.73" | 45°21'06" | 76°06'50" | 45°21'05" | 76°06'50" | - | - |
| DREO TOWER | 45°21'55" | 75°52'53" | 45°21'00" | 75°52'53" | 45°20'58" | 75°52'52" | 45°20'58" | 75°52'52" |

TABLE 3-1

Van Test Results

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| WAYPOINT NAME | Receiver Position | | | | | | Average Position | |
|---------------|-------------------|----------------|-----------------|-------------|----------------|----------------|------------------|---------------|
| | Run #4 (25 Nov) | | Run #5 (30 Nov) | | Run #6 (1 Dec) | | Lat. | Long. |
| | Lat. | Long. | Lat. | Long. | Lat. | Long. | Lat. | Long. |
| DREO TOWER | - | - | 45° 21' 00" | 75° 52' 54" | 45° 21' 01" | 75° 52' 54" | 45° 21' 0.8" | 75° 52' 54.2" |
| WOODLAWN | 45° 27' 44" | 76° 04' 34" | 45° 27' 43" | 76° 04' 33" | 45° 27' 43" | 76° 04' 43" | 45° 27' 43.2" | 76° 04' 34.2" |
| DIRELTON | 45° 28' 59" | 76° 09' 33" | 56° 28' 59" | 76° 09' 33" | 45° 28' 59" | 76° 09' 33" | 45° 28' 58.8" | 76° 09' 33" |
| ARNPRIOR | 45° 25' 24" | 76° 19' 38" | 45° 25' 23" | 76° 19' 38" | 45° 25' 23" | 76° 19' 38" | 45° 25' 23.6" | 76° 19' 38" |
| PANMURE | 45° 20' 14" | 76° 11' 07" | 45° 20' 14" | 76° 11' 05" | 45° 20' 14" | 76° 11' 06" | 45° 20' 13.8" | 76° 11' 05" |
| MARATHON | - | - | 45° 21' 06" | 76° 06' 51" | 45° 21' 05" | 76° 06' 51" | 45° 21' 5.5" | 76° 06' 50.5" |
| DREO TOWER | 45° 21' 04" | 75° 52' 56" | 45° 21' 02" | 75° 52' 55" | 45° 20' 51" | 75° 52' 48" | 45° 20' 59" | 75° 52' 54" |
| | | (3 Satellites) | | | | (2 Satellites) | | |

TABLE 3-1

Van Test Results (Cont'd)

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that, in fact, GPS and the survey coordinates disagree by approximately 580 feet in latitude and 85 feet in longitude. While parked at the tower, the receiver consistently gave a bearing to the waypoint of 170° True. If one calculates the bearing from the latitude and longitude difference, the result is 168° True! Evidently, the survey location seems incorrect. In fact, after discussions with the survey crew, it was learned that the coordinates given to us had been taken from an old map and that the tower had since been moved. A comparison of the old map and the tower position led us to conclude that the tower had, indeed, been moved approximately 600 feet on a bearing of 350° T.

Table 3-2 shows the deviation between survey marker position and GPS position. Note that for the three corrected markers (Woodlawn, Arnprior and Marathon) the average GPS position is within 100 feet of the stated survey position. For the three uncorrected markers, the bearing and distance to the waypoint as given by the receiver agree closely with the calculations (as done for the DREO Tower). The consistency and repeatability demonstrated during these tests was most impressive.

In addition to static positioning and waypoint navigation, we were most interested in the velocity (Gnd-Speed) indication provided by the receiver. It is, in fact, this feature which has most impressed people to whom the system has been demonstrated. A 'fifth wheel' system connected to the test van allowed accurate velocity comparisons to be made during the tests. A velocity profile taken during one of the tests is shown in Figure 3-1. It can be seen that the velocity derived from the GPS receiver agrees very closely with that of the fifth wheel although a slight offset of approximately 1 to 1½ miles per hour is noticeable on several sections of the plot. This could be due to a miscalibration of the fifth wheel which was not checked before beginning the tests due to lack of time but has since been corrected.

3.2 SHIP TEST RESULTS

No useful data were acquired during the MINS sea trials since only a one-day trial was carried out and, unfortunately, satellite coverage was not available during the necessary time. An attempt will be made to repeat these tests in the spring and summer of 1983 during continuing MINS sea trials.

3.3 AIRCRAFT TEST RESULTS

Table 3-3 shows the data taken during a 1½ hour, point-positioning touch-and-go flight test using a runway intersection as a target point. Again, it can be seen that the data are very consistent; in fact, the limitation here is the 1-second update rate of the CDU displays which limits the resolution of the position data. When averaged, the GPS position is within 50 feet in latitude and 100 feet in longitude of the survey position. This data is presented in another fashion in Figure 3-2. Note the quantization error due to the arc second resolution of the CDU display. To eliminate possible

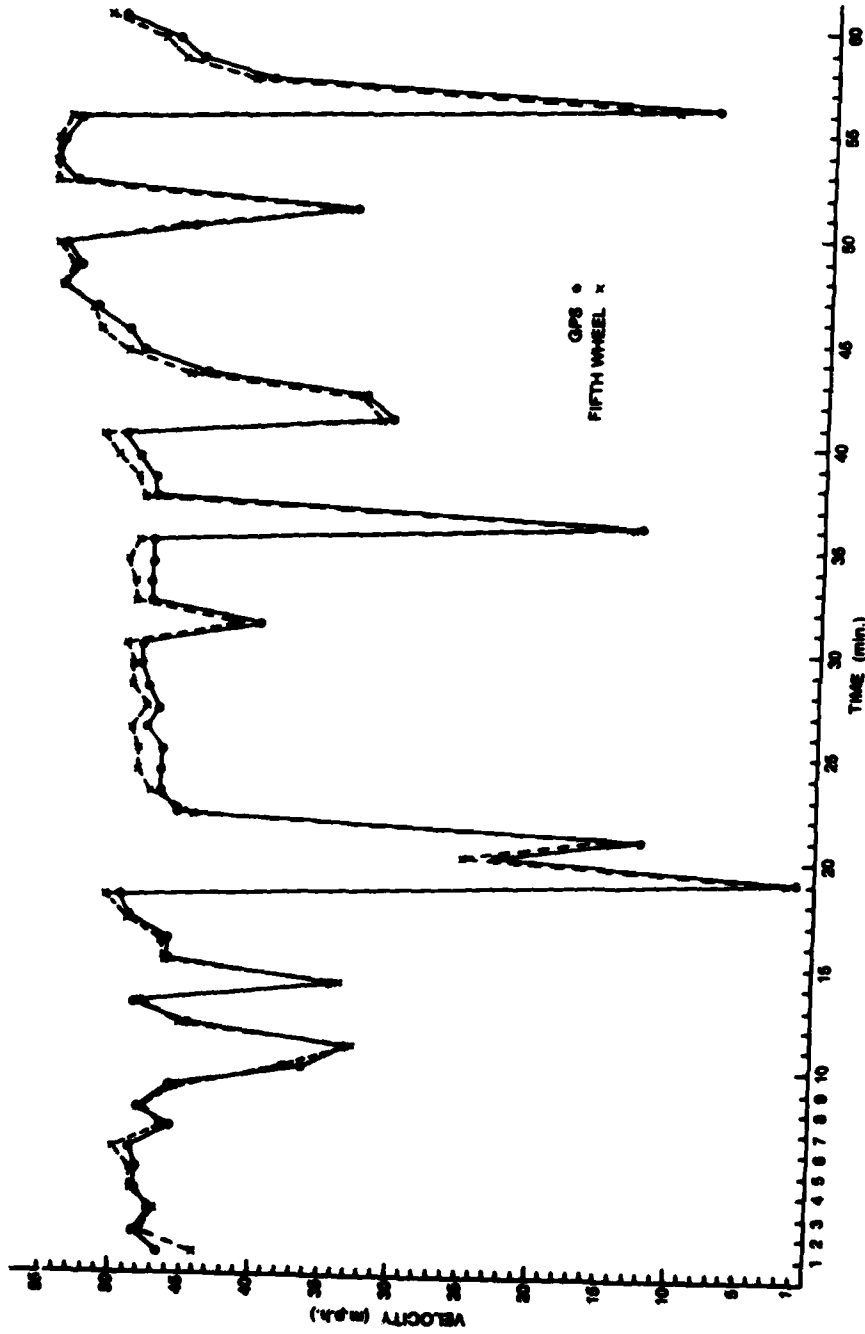


Fig. 3-1 GPS Velocity Profile

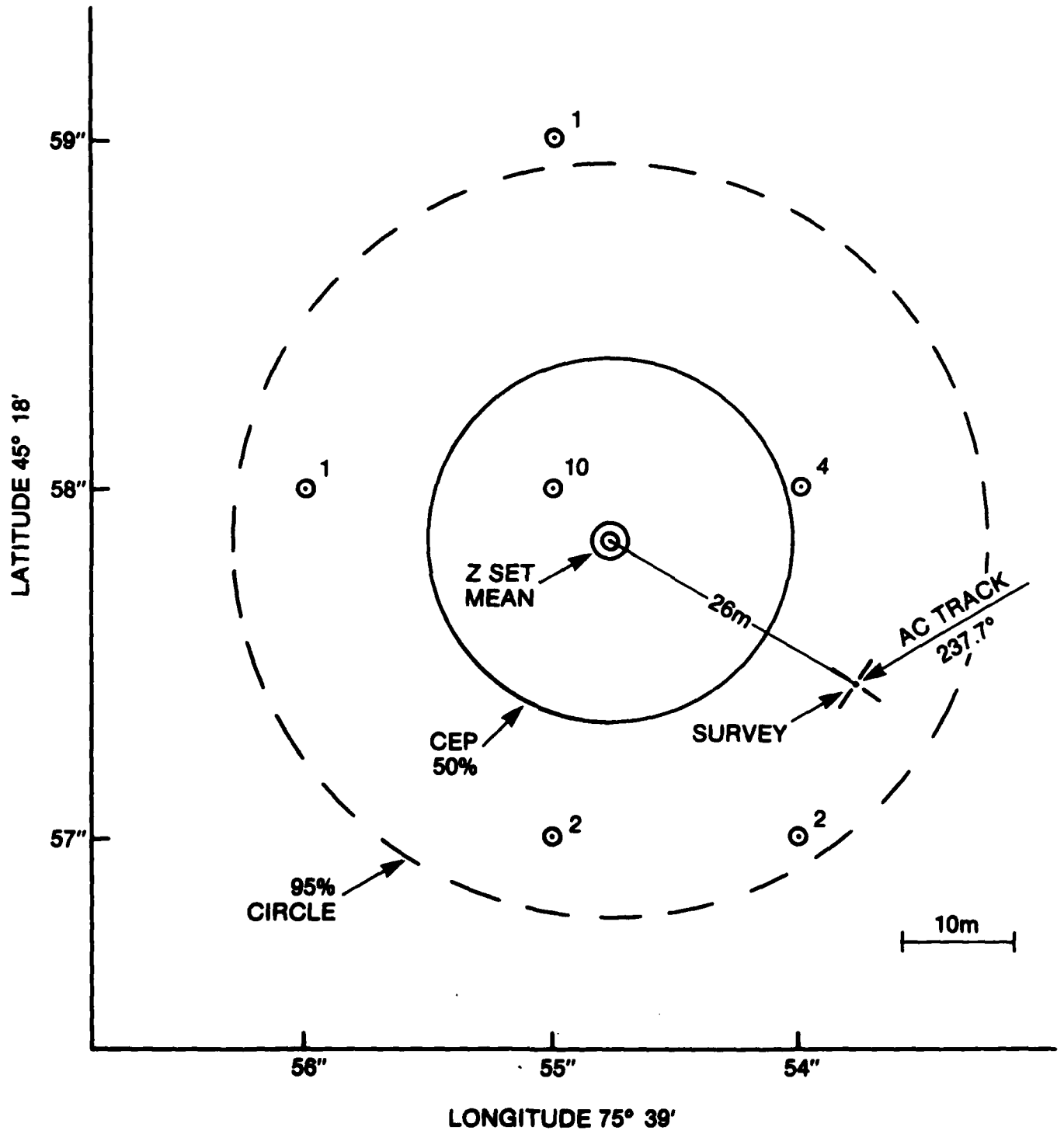


Fig. 3-2 Z-Set on Twin Otter (82/12/7)

| | <u>POSITION DEVIATION</u> <u>Δ Lat. Δ Long.</u> | <u>DISTANCE</u> <u>GPS TO SURVEY MARKER</u> | <u>CALCULATED</u> <u>BEARING</u> | <u>GPS RECEIVER</u> <u>BEARING TO WAYPOINT</u> |
|------------|--|--|-------------------------------------|---|
| DREO TOWER | -5.8" -1.2 | 580' South 85' East | 168 ⁰ T | 170.3 ⁰ T |
| WOODLAWN | -1.07" +.47" | 107' South 35' West | - | - |
| DIRLETON | +2.17" +4.00" | 217' North 280' West | 295.5 ⁰ T | 306.7 ⁰ T |
| ARNPRIOR | -.48" .68" | 48' South 48' West | - | - |
| PANMURE | +4.17" -1.0" | 417' North 71' East | 13.6 ⁰ T | 17.4 ⁰ T |
| MARATHON | -.1" -.77" | 10' South 54' East | - | - |
| OREO TOWER | 04.0" -1.0" | 400' South 71' East | 166 ⁰ T | 170 ⁰ T |

Δ Lat = Survey Lat. - Avg. Lat. (GPS)

Δ Long = Survey Long-Avg. Long (GPS)

1 sec = 30,m ≈ 100' of Latitude

1 sec ≈ 71' of Longitude

TABLE 3-2

GPS Deviation From Survey Marker

| PASS # | LATITUDE | LONGITUDE | GND SPD | Gnd Tk | EPE |
|--------|-------------|-------------|----------|--------|-------|
| 1 | 45° 18' 57" | 75° 39' 54" | 73 knots | 237.8 | .01NM |
| 2 | 45° 18' 58" | 75° 39' 54" | 74 | 237.4 | .02 |
| 3 | 45° 18' 57" | 75° 39' 55" | 67 | 238.2 | .04 |
| 4 | 45° 18' 58" | 75° 39' 55" | 74 | 238.1 | .02 |
| 5 | 45° 18' 57" | 75° 39' 54" | 76 | 237.8 | .02 |
| 6 | 45° 18' 58" | 75° 39' 55" | 75 | 238.0 | .02 |
| 7 | 45° 18' 57" | 75° 39' 55" | 74 | 237.7 | .02 |
| 8 | 45° 18' 58" | 75° 39' 55" | 77 | 237.5 | .02 |
| 9 | 45° 18' 58" | 75° 39' 55" | 80 | 237.1 | .02 |
| 10 | 45° 18' 58" | 75° 39' 54" | 81 | 237.6 | .02 |
| 11 | 45° 18' 58" | 75° 39' 55" | 80 | 237.3 | .02 |
| 12 | 45° 18' 58" | 75° 39' 55" | 78 | 237.4 | .02 |
| 13 | 45° 18' 58" | 75° 39' 54" | 84 | 237.7 | .02 |
| 14 | 45° 18' 58" | 75° 39' 54" | 80 | 236.6 | .04 |
| 15 | 45° 18' 58" | 75° 39' 55" | 81 | 238.3 | .03 |
| 16 | 45° 18' 58" | 75° 39' 55" | 79 | 237.6 | .02 |
| 17 | 45° 18' 58" | 75° 39' 55" | 72 | 237.5 | .03 |
| 18 | 45° 18' 59" | 75° 39' 55" | 73 | 238.7 | .03 |
| 19 | 45° 18' 58" | 75° 39' 54" | 87 | 237.8 | .04 |
| 20 | 45° 18' 58" | 75° 39' 54" | 78 | 237.6 | .04 |
| 21 | 45° 18' 58" | 75° 39' 54" | 81 | 237.0 | .04 |

GPS Avg. Lat = 45° 18' 57.86"

GPS Avg. Long = 75° 39' 54.71"

Runway Intersection:

Lat = 45° 18' 57.44"

Long = 75° 39' 53.75"

Δ Lat = .42" Δ Long = .96"

TABLE 3-3

Twin Otter/GPS Data 7 Dec. 82

measurement biases, the same survey point was approached from a different direction along the second runway. The results indicated no significant bias:

GTK = 237⁰ Avg. Lat. = 45⁰ 18' 57.85"
(Runway 07)

Avg. Long = 75⁰ 39' 56"

GTK = 306⁰ Avg. Lat = 45⁰ 18' 58"
(Runway 24)

Avg. Long = 75⁰ 39' 56"

It is interesting to note at this point that during the circuits being run between the Airport runway intersection, DREO Tower and Ottawa VOR, the results were, again, much the same except for the DREO Tower. Using the (incorrect) coordinates for the tower, each time the waypoint was passed, displays frozen and the data recorded, the results indicated that the actual waypoint location was 5 arcseconds in latitude and slightly less than 2 arcseconds in longitude away on a bearing of approximately 166⁰ True. As discussed in section 3.1, the reason for this was later discovered yet the consistency and accuracy of the data in its agreement with the earlier van tests was most impressive.

4.0 CONCLUSIONS

Evidently, these tests were not by any means extensive nor did they prove anything new or remarkable about the Magnavox GPS Z-Set or the GPS System in general. On the other hand, the remarkable repeatability and consistent system performance did a great deal to improve our confidence and expectations of GPS performance. This will be invaluable in the upcoming extensive tests of the Canadian-built receivers. The opportunity to demonstrate the system to potential military users and employ it in various operational environments helps lend credibility to the high expectations one has of GPS when reading the literature.

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| 13 ABSTRACT A Magnavox Global Positioning System (GPS) Z-Set Receiver was obtained on loan from the United States NAVSTAR/GPS Joint Program Office for evaluation. Tests were carried out in an electronically-equipped trailer, on board a naval research vessel and in a Twin Otter flying laboratory. Data was manually recorded during static positioning tests and waypoint navigation tests. Results indicated a static positioning accuracy consistently better than 100 feet in both latitude and longitude under 4-satellite availability. | | |

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