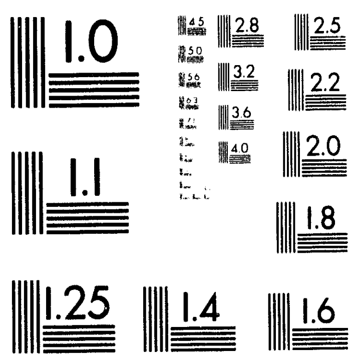
1.0
4.5
2.8
2.5
5.0
3.2
2.2
5.6
6.3
3.6
2.0
4.0
1.1
1.8
1.25
1.4
1.6

1 of 1

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DIFFERENTIAL GLOBAL POSITIONING SYSTEM FOR THE SURFACE-TOWED ORDNANCE LOCATING SYSTEM

TESTING, RESULTS, AND USER'S GUIDE

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SUMMARY

Researchers at Pacific Northwest Laboratory integrated and tested a Global Positioning System (GPS) for use with the Naval Explosive Ordnance Disposal Technology Center's (NEODTC) Surface-Towed Ordnance Locating System (STOLS). The GPS automatically and continuously provides latitude, longitude, and elevation information at the mobile GPS unit. The results of testing the GPS are shown in this report. The results reveal accuracies in the submeter range in real time and within a few centimeters using post-processing software. A description of hardware and software components is also included, along with system drawings and parts lists.

The GPS is composed of a base module and a mobile module that are operated in a differential mode. This method allows the system to achieve real-time centimeter accuracy as long as the base unit is located at accurately surveyed mark and there is sufficient satellite coverage. The base module components include a single-slot laptop PC, a NovAtel GPSCard and antenna, and a radio frequency (RF) modem with antenna. The base module provides differential corrections to the mobile module via the RF modem. The mobile module is composed of a board-level PC-104 computer and enclosure, a NovAtel GPSCard and antenna, a cathode ray tube (CRT) display, and an RF modem with antenna. The mobile unit has been configured with a 1.8-inch hard disk drive. This allows data collected during a survey to be easily combined with data taken at the base station PC and post-processed. The mobile unit receives differential corrections from the base station and produces real-time position solutions. Latitude, longitude, and elevation along with coordinates in northing and easting are displayed on the CRT. The northing and easting coordinates are sent through an RS-232 hardwired to the STOLS. This information is used to pinpoint magnetometer data taken by the STOLS and also to provide vehicle position to the operator.

A rugged version of the GPS mobile module was later developed. The rugged GPS package includes a PC-ISA single-board computer and enclosure, a NovAtel GPSCard and antenna, a thermo-electric cooler, a liquid crystal display, and an RF modem with antenna. The rugged GPS module operates using solid-state memory and has no means of internal data storage. A memory board

or mechanical hard disk drive could be added if internal storage is desired. The software for the rugged unit is the same as that for the original mobile unit. Drawings and parts lists for both mobile units appear in Appendices A and B.

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INTRODUCTION

The Surface-Towed Ordnance Locating System (STOLS) differential Global Positioning System (GPS) is made up of two parts--a monitor station fixed at a precisely known location and a mobile unit mounted on the STOLS vehicle.

The monitor station compares its known position with the position it derives from satellite information. The monitor station then computes position error corrections and sends them to the mobile unit via an RF modem.

The mobile unit also calculates its position from satellite information. By applying the corrections received from the monitor station, it can generate position solutions accurate to less than a meter. These positions are sent to the STOLS computer through a hardwired serial RS-232 link.

One monitor station and two mobile units were developed under this program. The first mobile unit was intended to demonstrate the use of GPS as a navigation subsystem for the STOLS. The second GPS rover unit was designed to improve the ruggedness for field applications.

SYSTEM QUICK START

NOTE: This section outlines a quick procedure to get the Global Positioning System (GPS) monitor station and mobile unit up and running. For more detailed information about the operation of the monitor station and mobile unit software, see the sections "MONITOR STATION SOFTWARE" and "MOBILE UNIT SOFTWARE" later in this document.

MONITOR STATION QUICK START

BEFORE turning on the monitor station computer (Toshiba laptop), make sure the following hardware connections have been made:

- The GPS antenna is connected to the GPSCard in the monitor station computer.
- The serial cable marked "BASE" is connected between the serial port on the GPSCard and the RF modem. Make sure you use the GPSCard's serial port, not the serial port on the computer itself.
- The RF antenna is connected to the RF modem.

NEVER operate the Toshiba laptop computer without a GPS antenna attached. This could damage the GPSCard.

Once the proper hardware connections have been made, turn on the computer and the RF modem. After the computer has booted up and is displaying the DOS prompt C:\>, type "monitor" to start the monitor station software. When functioning properly, the screen should clear and the following prompt should be displayed:

```
Enter (P)osition or (I)ntegrate Position? > _
```

In order to properly compute differential position corrections, the monitor computer must know the precise location of its GPS antenna. There are two ways for the computer to get this information. The above prompt is asking which method it should use.

The 'P' Option

When the GPS antenna position is already precisely known (as when it is situated over a survey point), the best method to use is to enter the position directly. This is done by pressing the 'P' key. Note that you do not need to press the 'ENTER' key after pressing 'P'.

After pressing 'P' the computer asks the operator to enter the latitude, longitude, and altitude of the monitor station's GPS antenna. The computer remembers which coordinates were entered the last time the program was run. When prompting for the latitude, etc., the computer displays the value that was last used in square brackets. If this value is already correct, no new number needs to be entered. Just press return. If this is a new site, enter latitude and longitude in degrees and decimal minutes and enter altitude in meters. For instance, 46 degrees 12.34567 minutes is simply entered as 46 12.34567. Note the space between the 46 and 12.34567. For north latitudes and east longitudes, use positive values. For south latitudes and west longitudes, use negative values. For instance, -119 6.54321 would mean 119 degrees 6.54321 minutes WEST longitude.

After entering the latitude, longitude, and altitude of the monitor station's GPS antenna, the monitor station will immediately start computing differential corrections and send them out over the RF modem. The transmit and receive indicators on the modem will begin flashing if the corrections are being sent.

The 'I' Option

When the GPS antenna position is not known or is only poorly known, use the integrate option by pressing the 'I' key. It is not necessary to press the 'ENTER' key after pressing 'I'.

After pressing the 'I' key, the following prompt is displayed.

```
Enter integration time in seconds [600] > _
```

The 'I' option tells the computer to calculate its position at one-second intervals for the number of seconds entered at this prompt. As before, the number in brackets is the default. If 600 seconds (ten minutes) is satisfactory, just press return.

At the end of the data gathering interval, the computer calculates its average position and uses this as its best estimate for the monitor's location.

Although this method is satisfactory, it is always preferable to enter in precise numbers using the 'P' option when they are available.

In order to compute satellite positions, the monitor station must be tracking a minimum of four satellites. When using the 'I' option, the message "Position data is INVALID" may be displayed initially. This means the computer has not yet had sufficient time to lock onto the necessary number of satellites. Once a sufficient number are locked, the "INVALID" message will change to "VALID" and a cycle count will be displayed. Once all the cycles have been completed, the computer will begin to compute differential corrections and send them out over the RF modem.

To exit the monitor station software and return to DOS, press the ESC key.

MOBILE UNIT QUICK START

BEFORE turning on the mobile unit's GPS computer, make sure that the following hardware connections have been made:

- The GPS antenna is connected to the GPSCard in the computer.
- The serial cable marked "VEHICLE" is connected between the serial port ON THE GPSCard (not the computer's serial port) and the RF modem.
- The RF antenna is connected to the RF modem.
- The RF modem power cable is attached to the "MODEM POWER" connector on the computer.
- The video monitor's video cable is attached to the "VGA" connector on the computer.
- The video monitor's 12 volt power cable is attached to the "CRT POWER" connector on the computer.
- The STOLS serial cable (part of the 24 volt power input cable from the STOLS vehicle) is connected to the computer's serial port labeled "RS-232" (not the GPSCard serial port).

- The 24 volt power input cable from the STOLS vehicle is attached to the "POWER IN" connector on the computer.

NEVER operate the mobile unit computer without a GPS antenna attached. This could damage the GPSCard.

Once the proper hardware connections have been made, turn on the computer. When operating properly, the computer will boot up and immediately begin running its GPS software. For basic operation, no user interaction is necessary other than initially turning on the system.

At this point the mobile unit should be receiving differential corrections from the monitor station and the current vehicle coordinates should be displayed on the screen. The transmit and receive indicators on the modem will begin flashing if the corrections are being received.

To exit the mobile unit software and return to DOS, press the ESC key. Alternatively, you can simply turn off the computer with the software running. This will not damage the system.

MONITOR STATION SOFTWARE

The monitor station software is a program called NBASE.EXE. It is normally started from the DOS batch file MONITOR.BAT, but can also be run directly. NBASE's main purpose is to set up the GPSCard in the monitor station computer to compute and send differential correction data over the RF modem. NBASE can also save various data generated by the GPSCard to disk for later processing with the SEMIKIN software package.

The usage syntax for NBASE is: NBASE [/Ffname]

The /F command line parameter is optional. It is used to tell the program to save the data logs generated by the GPSCard to the file named (fname). (fname) can be any valid DOS path\file. If the /F parameter is omitted, no data is saved.

After the NBASE software has been started, differential corrections will be generated and sent over the RF modem at the rate of one packet per second. Currently NBASE configures the GPSCard to send the differential corrections as an ASCII string using NovAtel's proprietary format. For details see section 5.1.9 of the NovAtel GPSCard manual.

Although the GPSCard can accept commands and log data over the computer's internal bus, once the card is configured and running, it only needs the computer for power. That means that once NBASE has configured the GPSCard to send differential corrections, the card will continue to do so even if NBASE is exited. This is a handy feature as it allows the computer to be used for other operations without affecting the corrections being sent. Note, however, that NBASE, NGPS, NVEHICLE and any other software that uses the GPSCard will likely reinitialize the card when started. This will shut down the differential corrections.

NORMAL STOLS OPERATION

Normally the monitor station is used to supply differential correction data to the mobile unit (via the RF modem) and nothing more. Under these conditions, NBASE should be started without the /F option since post processing of the satellite data is unnecessary. For details on starting and running the NBASE program under normal conditions, see the "SYSTEM QUICK START" section above.

After the computer is first turned on, it takes the GPSCard two to five minutes to acquire enough satellites to calculate valid position solutions. The system must be tracking a minimum of four satellites. Even with four satellites being tracked, the GPSCard may not be getting enough unique information to compute a valid position solution. This is typically due to satellite geometry.

When the system is first turned on, it is advisable to run NovAtel's NGPS program to monitor the number of satellites being tracked and the status of the position solutions. Once good solutions are being computed, exit NGPS and start the NBASE program.

Alternatively, if the NBASE 'I' option is being used to integrate the monitor station's position, it will display the solution status and number of satellites on the screen during the data collection phase. NBASE will not proceed with the integration until valid solutions are available. A status of 0 indicates valid position solutions are being computed. A status of 1 indicates that the GPSCard has not yet made sufficient observations to compute solutions. For more details see Table 5 on page 40 of the NovAtel GPSCard user's manual.

The NBASE software displays the following.

```
----------------------------------------------------------------

GPS Base Station Monitor:

Station must be tracking at least 4 satellites to generate
valid position solutions.

Monitor Coordinates:
     Latitude:   38 39.48312
     Longitude: -76 31.94974
     Altitude:   42.337

- Now tracking 06 Satellites -

----------------------------------------------------------------
```

The coordinates shown are the ones the monitor station is using as its known position. They are fixed at start up with the 'P' or 'I' options. Although it would be more informative if the real time coordinates the GPSCard is computing from satellite information could be displayed, this data is not available when the card is operating in monitor mode.

The last line of the display serves two purposes. First, it gives the number of satellites currently being tracked by the monitor station. A minimum of four satellites are needed to generate valid position solutions. Finally, at the start and end of this line are two ASCII rotating asterisks. These serve as an indicator that the program is running correctly. The twirlies (rotating graphics symbol) are generated inside the program's data acquisition loop. If the computer locks up for any reason, the rotating asterisks will stop.

POST-PROCESSING MODE

The NBASE program can be told to save pseudorange and ephemeris data collected from the satellites to a disk file. Pseudorange is data that is referenced to a satellite GPS unit. Ephemeris is the prediction of current orbiting satellite position. This file (along with a similar file from the mobile unit) can be post processed using the SEMIKIN software package. Post processing can greatly improve the accuracy of the mobile unit position estimates.

When operating the STOLS vehicle, the real time differentially corrected position estimates are adequate. However, the GPS system can also be used to survey in points using a known benchmark as a reference. For this application, post processing the data is desirable.

The general procedure for using NBASE to survey in points is as follows:

- Set up the monitor station so its GPS antenna is at a precisely known location (usually a survey benchmark).
- Start the NBASE program using the /F option to specify the file in which to save the pseudorange and ephemeris data.
- Once inside the NBASE program, use the 'P' option to enter in the coordinates for the survey benchmark. Be sure to compensate for the height of the GPS antenna above the benchmark.

At this point NBASE should start sending differential corrections and saving satellite data to disk using the file specified on the command line. Pseudorange data is saved at one-second intervals. Ephemeris data is stored in the same file at 30-second intervals. For details on the format of the data packets, see sections 6.1.12 (RNGB) and 6.1.15 (REPB) of the NovAtel GPSCard user's manual.

When saving data to a file, NBASE displays the following screen.

```
---------------------------------------------------------------
GPS Base Station Monitor:

Station must be tracking at least 4 satellites to generate
valid position solutions.

Monitor Coordinates:
     Latitude:   38 39.48312
     Longitude: -76 31.94974
     Altitude:   42.337

- Now tracking 06 Satellites -
Data will be logged to: fname
Data logging is OFF ('F' to toggle)

---------------------------------------------------------------
```

This is the same screen that is displayed when the system is used for normal STOLS operations with the addition of two new lines at the bottom. The "Data will be logged to:" line shows the filename entered on the command line with the /F parameter. The "Data logging is OFF.." line shows the current file logging status. When NBASE is first started, file logging is set to OFF which means that no data is being saved to disk. You can use the 'F' key to toggle the file logging status from OFF to ON and back again.

It is not necessary to toggle the status to OFF before exiting the program.

ERRORS AND TROUBLESHOOTING

Error [SendGPSCommand]: GPS Card Timeout

This message will occasionally be displayed when the NBASE program is started. This means the program sent a command to the GPS card but did not receive acknowledgement of the command in a reasonable amount of time (two seconds). When this happens NBASE sends the command again. NBASE continues to re-send unacknowledged commands until the GPSCard finally accepts them or the user aborts the program with the ESC key.

If this error occurs, the GPSCard will usually accept the command on the second attempt. If this error continually repeats, you should abort the program with the ESC key and re-start it. If the error persists, it may be necessary to shut off the computer and restart it.

Differential corrections are not being generated

One way to quickly check to see if differential corrections are being sent is to monitor the status lights on the front of the RF modem. When sending differential corrections, you should see a long pulse on the TX light followed by a short pulse on the RX light. This sequence should repeat at one-second intervals.

There is another, slightly more involved, way to verify that differential corrections are getting out. The serial cable normally connected to the modem can be connected to a computer running terminal emulation software. Since the differential corrections are sent as simple ASCII text, the strings will appear on the computer's display.

If differential corrections don't appear to be reaching the modem, make sure the cable connecting the Toshiba to the modem is the correct cable (it should be tagged "BASE"). The modem cables for the monitor station and mobile unit ARE NOT interchangeable. The monitor station cable can transmit data but not receive. The mobile unit cable can receive data but not transmit. If you are using a generic cable, be sure to disconnect the receive line.

Differential corrections reach the modem but aren't transmitted

If the TX and RX lights on the monitor station RF modem indicate that it is getting the differential corrections, but the corrections aren't being received at the mobile unit, check the T/E status light on the modem. If the monitor station modem is in contact with the mobile unit modem, this light should be lit continuously. If it is, look for the problem on the mobile unit side. If the light is flashing, it means one of two things.

If the light flashes at a one Hz rate, that means the modem is searching for its partner but has not yet established a connection. Verify that the mobile unit's modem is turned on and that dip switch 8 of both modems is in the ON position. If the modems still do not establish a link (T/E light continuously lit), make sure that each modem is set to a different address and each modem is aware of the other's address. As an example, maybe the monitor station modem's address is 1 and it is expecting to communicate with a modem at address 2. Similarly the mobile unit modem address should then be 2 and it should be expecting to communicate with a modem at address 1. In practice, the modem addresses should never change. They can be set using the UTIL.EXE software supplied by ESTeem. For details refer to the ESTeem modem user's manual.

If the light flashes at a two Hz rate, that means that the modem is aware of its partner but for some reason (mismatched baud rates, for example) it still can't send data successfully. If this is the case, make sure that each modem is set to 9600 baud. For details, refer to the ESTeem modem user's manual.

MOBILE UNIT SOFTWARE

The mobile unit software is a program called NVEHICLE.EXE. It is normally started automatically when the computer is turned on but can also be run from the DOS command line. Since the NVEHICLE code is started automatically when the computer is turned on, it is necessary to exit the program (using the 'ESC' key) and restart it manually from DOS if any of the command line options are to be used. This requires an IBM 101-key compatible keyboard.

NVEHICLE performs three main tasks.

- It configures the GPSCard to receive differential corrections from the monitor station via the RF modem.
- It displays position and status information on the CRT.
- It converts its position data into a format the STOLS computer can understand and ships it to the STOLS over an RS-232 interface.

Although it doesn't normally do so during normal STOLS operation, NVEHICLE can also save pseudorange data to disk for later processing.

The usage syntax for NBASE is: NVEHICLE [/Plat:lon] [/Ffname]

The /P and /F parameters are optional.

The /P parameter is used to enter in the coordinates of a reference point. When NVEHICLE is running, it displays the relative bearing and distance to this reference point on the screen. This feature can be used to navigate to a known coordinate point. Latitude and longitude should be entered in degrees and decimal minutes and there should be no spaces between the /P or the coordinates and the colon.

The /F parameter is used to tell the program to save the data logs generated by the GPSCard to the file named (fname). (fname) can be any valid DOS path\file. Normally no data is saved.

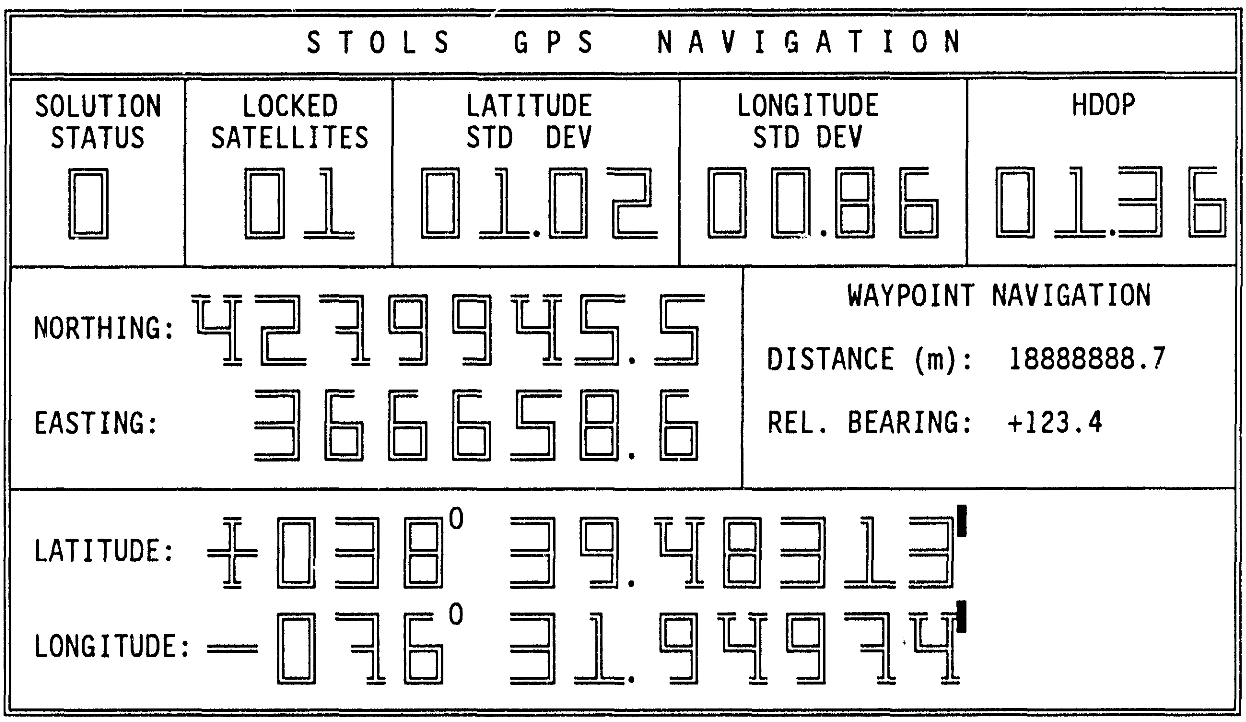
NORMAL STOLS OPERATION

For normal STOLS operation, the vehicle system is a plug and play system. The operator just needs to hook up the proper power and data cables (see the

"SYSTEM QUICK START" section for details) and turn the power on. NVEHICLE is started automatically. The GPSCard is automatically configured to expect differential corrections and will use them if they are available. As soon as valid position solutions can be computed, they will be sent to the STOLS.

Even though there is nothing for the operator to do other than turn the power on, it takes the system a little while to acquire satellites and begin computing valid position solutions. The longitude and latitude coordinates displayed on the screen will be all zeros until valid solutions are available.

When NVEHICLE is running, a screen similar to the following is displayed.



- "SOLUTION STATUS" field: This field indicates the GPS position solution status. 0 means valid position solutions are being generated; 1 means the GPSCard has not yet made enough observations to compute valid solutions. For details on these and other status codes, see Table 5 on page 40 of the NovAtel GPSCard user's manual.

- "LOCKED SATELLITES" field: This field shows the number of satellites the GPSCard is currently tracking. The GPSCard must be tracking at least 4 satellites to generate valid position solutions.

- "LATITUDE STD DEV" field: This field shows the standard deviation in meters of the latitude value being returned by the GPSCard. When differential corrections are being received, this number should be on the order of 1 meter. Without differential corrections, values between 20 and 40 are more typical.

- "LONGITUDE STD DEV" field: This field shows the standard deviation in meters of the longitude value being returned by the GPSCard. When differential corrections are being received, this number should be on the order of 1 meter. Without differential corrections, values between 20 and 40 are more typical.

- "HDOP" field: This field shows the horizontal dilution of precision. This is a multiplicative factor that modifies the ranging error. As this number increases, the survey becomes less reliable.

- "NORTHING" field: This field shows the current northing position in the UTM coordinate system. It is measured in meters.

- "EASTING" field: This field shows the current easting position in the UTM coordinate system. It is measured in meters.

- "WAYPOINT NAVIGATION DISTANCE" field: The first value shown in the "Waypoint Navigation" section is the distance from the current reference point in meters.

  NOTE: The coordinates of the reference point can either be set using the /P command line parameter when NVEHICLE is started or by pressing the 'P' key while NVEHICLE is running. Pressing the 'P' key sets the reference point to the current position of the vehicle.

- "WAYPOINT NAVIGATION REL.BEARING" field: The second value shown in the "Waypoint Navigation" section is the relative bearing in relation to the direction of travel to the reference point in degrees. Positive values mean "right" and negative values mean "left". For instance, in the display example, the driver would need to turn 12 degrees farther to the right in order to be heading directly toward the reference point.

  NOTE: The coordinates of the reference point can either be set using the /P command line parameter when NVEHICLE is started or by pressing the 'P' key while NVEHICLE is running. Pressing the 'P' key sets the reference point to the current position of the vehicle.

- "LATITUDE" field: This field shows the current latitude coordinate of the vehicle measured in degrees and decimal minutes. Positive values correspond to north latitudes and negative values correspond to south latitudes.

- "LONGITUDE" field: This field shows the current longitude coordinate of the vehicle measured in degrees and decimal minutes. Positive values correspond to east longitudes and negative values correspond to west longitudes.

POST-PROCESSING MODE

The NVEHICLE program can be told to save pseudorange data collected from the satellites to a disk file (ephemeris data is only saved at the station). This file, along with a similar file from the monitor station, can be post processed using the SEMIKIN software package. Post processing can greatly improve the accuracy of the mobile unit position estimates.

When operating the STOLS vehicle, the real time differentially corrected position estimates displayed on the screen are adequate. However, the GPS system can also be used to survey in points using a known benchmark as a reference. For this application, post processing the data is desirable.

The general procedure for using NVEHICLE to survey in points is as follows.

- Set up the monitor station as described in the "MONITOR STATION SOFTWARE: POST PROCESSING MODE" section above.
- Attach an IBM 101-key compatible keyboard to the mobile unit computer.
- Use the 'ESC' key to exit NVEHICLE when it starts after initial power up. This is necessary because to run in post processing mode, NVEHICLE needs to be started using command line parameters not normally used for regular STOLS operation.
- Restart the NVEHICLE program from DOS using the /F option to specify the file in which to save the pseudorange data.

When NVEHICLE starts it will immediately start saving pseudorange and position data to the file specified on the command line. Data packets are recorded at one-second intervals using NovAtel's proprietary binary format.

Note that although both pseudorange and position data is saved in the output file, only the pseudorange data is needed for post processing. The position data is saved as well to provide a record of the real time position solutions. For information on the data packet formats see sections 6.1.1 (POSB) and 6.1.12 (RNGB) of the NovAtel GPSCard user's manual.

The position and status screen displayed by NVEHICLE while it is saving a file is the same as the one displayed for normal STOLS operation.

REFERENCE POINT NAVIGATION

The NVEHICLE software maintains a single reference point and tracks its distance and relative bearing from the vehicle. These values are displayed on the normal NVEHICLE position and status screen. The coordinates of the reference point can be set by the user. This provides a convenient way to navigate the STOLS vehicle to any point with known coordinates.

When NVEHICLE is started automatically at power up, the coordinates of the reference point are initialized to 0 degrees latitude, 0 degrees longitude. That means that the "Distance and Relative Bearing" section of the display is not very useful under normal STOLS operation.

There are two ways two change the coordinates of the reference point, both of which require that an IBM 101-key compatible keyboard be attached to the mobile unit computer.

The first and most useful method is to enter the reference point coordinates on the command line using the /P parameter. This is the general procedure.

- Attach an IBM 101-key compatible keyboard to the mobile unit computer.
- Use the 'ESC' key to exit NVEHICLE when it starts after initial power up.
- Restart the NVEHICLE program from DOS using the /P option to specify the coordinates of the reference point. As an example, NVEHICLE /P46,1.23:-119,23.456 would start the NVEHICLE software with the reference point set to 46 degrees 1.23 minutes north latitude, 119 degrees 23.456 minutes west longitude. Note that the coordinates are entered in degrees and decimal minutes, a comma is used to separate the degrees field from the minutes field and a colon is used to separate the latitude field from the longitude field. Although a space is required after NVEHICLE, NO SPACES should appear anywhere in the /P string.

At this point the NVEHICLE position and status screen should be displayed and the "Distance and Relative Bearing to Waypoint" section should display valid values to the reference point (assuming the GPSCard is computing valid position solutions).

The distance field is straightforward; it simply shows the straight line distance between the vehicle and the reference point in meters. The relative bearing field needs a little explanation. This field shows the number of degrees right or left (positive and negative values, respectively) the vehicle must turn in order to be heading straight for the reference point. It would be most efficient if this angle was always the same with respect to the nose of the STOLS vehicle. Unfortunately, the GPS system doesn't know which way the nose is pointing so it uses as its reference the next best thing--the direction the STOLS vehicle is heading. Although these are almost always the same, this is an important distinction because it can create some unexpected results. For instance, when the vehicle is not moving, the relative bearing number is likely to jump around a great deal. This is because the GPS no longer has a clear sense of direction of travel. Also, if the STOLS is moving backwards, the relative bearing will flip 180 degrees and indicate how many degrees the REAR of the vehicle needs to come around to be heading toward the reference point.

ERRORS AND TROUBLESHOOTING

Error [SendGPSCommand]: GPS Card Timeout

This message will occasionally be displayed when starting the NVEHICLE program. What this means is the program sent a command to the GPS card but did not receive acknowledgement of the command in a reasonable amount of time (two seconds). When this happens NVEHICLE sends the command again. NVEHICLE continues to re-send unacknowledged commands until the GPSCard finally accepts them or the user aborts the program with the ESC key (requires an IBM 101-key compatible keyboard).

If this error occurs, the GPSCard will usually accept the command on the second attempt. If this error continually repeats, you should abort the program with the ESC key or simply re-boot the computer. If the error persists, it may be necessary to shut off the computer and restart it.

The position standard deviations are as large as several meters

This is a good indication that the mobile unit is not receiving differential corrections from the monitor station. Verify that the modem is receiving differential corrections and that it is attached to the mobile unit with the serial cable marked "ROVER". The serial cables for the mobile unit and monitor station are not interchangeable.

Make sure the serial cable is attached to the serial port on the back end of the GPSCard. The serial connector on the computer itself is used for the STOLS communication link.

If everything checks out on the mobile unit end, look for the problem on the monitor station end.

Differential corrections are not being received by the modem

One way to quickly check to see if differential corrections are being received by the RF modem is to monitor the modem's front panel status lights. When receiving differential corrections, you should see a long pulse on the RX light followed by a short pulse on the TX light. This sequence should repeat at one-second intervals.

If the modem is not receiving corrections, check the T/E status light on the modem's front panel. It should be continuously lit. A flashing T/E light may indicate a problem.

If the light flashes at a one Hz rate, that means the modem is searching for its partner but has not yet established a connection. Verify that the monitor station's modem is turned on and that dip switch 8 of both modems is in the ON position.

If the modems still do not establish a link (T/E light continuously lit), make sure each modem is set to a different address and each modem is aware of the other's address. As an example, maybe the monitor station modem's address is 1 and it is expecting to communicate with a modem at address 2. Similarly the mobile unit modem address should then be 2 and it should be expecting to communicate with a modem at address 1. In practice, the modem addresses should never change. They can be set using the UTIL.EXE software supplied by ESTeem. For details refer to the ESTeem modem user's manual.

If the light flashes at a two Hz rate, that means that the modem is aware of its partner but for some reason (mismatched baud rates, for example) it still can't receive data successfully. If this is the case, make sure each modem is set to 9600 baud. For details, refer to the ESTeem modem user's manual.

The mobile unit displays good coordinates on the screen but they don't get to the STOLS.

Make sure the STOLS serial cable (part of the main power cable) is securely fastened to the "RS-232" connector on the mobile unit computer. Do not connect the STOLS serial cable to the serial port on the back of the GPSCard. Although this will not damage the system, the GPSCard needs that port to receive differential corrections.

RF MODEM SET-UP

Each modem needs to be configured to work properly in the GPS system. Among other things, this requires setting up the RS-232 interface and choosing unit IDs. The following step-by-step instructions will guide you through the set up process.

EQUIPMENT NEEDED

- ESTeem model 96 radio modem
- Straight through (not null modem) RS-232 serial cable. Do not use the cables provided for normal GPS operation. These cables are specially wired and will not work properly during set up.
- ESTeem utility software for setting the modem frequency.
- PC running terminal emulation software. A simple terminal emulation program is provided on the ESTeem utility disk but its use is optional.

1) Setting the RS-232 Parameters

   On the back of the modem are 8 dip switches which are used to configure the modem's RS-232 port. The modem needs to be set for 9600 baud, no parity, 8 data bits. This corresponds to the following switch settings (1=ON, 0=OFF). For more information see page 1-5 of the ESTeem user's manual.

```
                                                |
          SW1  SW2  SW3  SW4  SW5  SW6  SW7  |  SW8
           1    0    0    0    0    1    1   |   0
           |    |    |    |    |    |    |   |   |
           |____|____|    |____|    |____|       |
           |              |         |            |
           |              |         |            |
     Baud rate        Parity    Data Bit   Not used for RS-232
```

   Switch 8 (SW8) is not used for RS-232 configuration; however, it must be in the OFF position in order to continue the set up procedure.

2) Connect Modem to PC

   Use a shielded, straight through (not null modem) RS-232 serial cable to attach the modem to a PC running terminal emulation software (like Telix, Kermit, SmartTerm, QModem, Procomm, etc). A simple terminal emulation program comes on the ESTeem utility disk but its use is optional. Be sure that the terminal's RS-232 port is also configured for 9600 baud, no parity, 8 data bits, 1 stop bit.

3) Turn on the Modem

Turn on the ESTeem modem. If the RS-232 ports on the PC and the modem have been configured properly, a welcome message should be displayed on your screen followed by the command prompt "CMD:"

If the welcome message is displayed, but the "CMD:" prompt doesn't appear, don't be alarmed. It is normally turned off during GPS operation. Try typing PROMPT ON:SA and then pressing return. That should restore the "CMD:" prompt.

NOTE: According to EST it is NOT necessary to have an antenna connected to the unit while it is turned on.

4) Set the Operating Frequency

If you need to change the modem's operating frequency, now would be a good time. Exit your terminal emulation program and run the program on the ESTeem utility disk for setting the frequency. Once the frequency has been changed, start your terminal program and reset the modem. That should bring you back to the modem welcome message.

5) Restore the Factory Defaults

At the command, prompt type FA and press return. This makes sure the modem is returned to its factory default configuration and provides a known starting place to begin our own configuration.

CMD: FA

6) Set the Unit Address

Each modem has a "unit address". This is a number between 0 and 253 that uniquely identifies the modem. To set the unit address, use the ADD command at the "CMD:" prompt. For example

CMD: ADD 1

sets the unit address to 1. During GPS operation two modems are used. Make sure each modem has a different unit address.

7) Set the Connect Address

During GPS operation each modem needs to know the address of the modem to which it will be talking. This is called the "connect address". For instance, assume the two modems are set as unit address 1 and unit address 2. Unit 1 will be talking to unit 2, so its connect address is 2. Similarly, unit 2 will be talking to unit 1 so its connect address is

1. To set the connect address, use the SETC command at the "CMD:" prompt. For example,

CMD: SETC 2

sets the connect address to 2.

8) Change the SENDPAC Character

The SENDPAC character is a special character that the modem watches for in the data to be transmitted. The modem waits until it sees the SENDPAC character before transmitting its data packet. The factory-default SENDPAC character is 13 (a carriage return). To work properly during GPS operation, this needs to be changed to 10 (a line feed). To make this change, use the SENDPAC command at the "CMD:" prompt.

CMD: SENDPAC 10

9) Turn the Command Prompt Off and Save the New Settings

Finally, the modem's "CMD:" prompt needs to be turned off (because it confuses the GPS system) and the new settings need to be saved. This ensures the new settings will be used the next time the modem power is turned on. To do this, use the PROMPT command and the SAVE command at the "CMD:" prompt. Since the PROMPT command will shut the "CMD:" prompt off, it is easiest to use both commands at the same time by putting them on the same line separated by a colon.

CMD: PROMPT OFF:SAVE

10) Selecting Transparent Mode

During GPS operation, the modems work in "transparent" mode. In this mode the modem powers up, expecting to be talking to its partner (whose address is set with the SETC command as described above). To select transparent mode, set dip switch 8 on the back panel to ON. Then turn off the modem. The next time it is turned on, it will be in transparent mode.

NOTE: Use transparent mode only during GPS operation. During set up or when changing operating frequencies, transparent mode must be turned off (switch 8 = OFF).

RUGGED GPS ROVER UNIT

The original GPS rover unit was designed as a prototype unit. Its purpose was to demonstrate the advantages of applying highly accurate GPS position data to the magnetometer information gathered by the STOLS. It was soon found that the unit needed to be in a more rugged form to be used on a daily basis at sites such as Twenty-Nine Palms, California.

· design for a ruggedized GPS rover unit was developed and the new version fabricated. The unit is configured as a PC-ISA bus enclosure that houses a GPSCard, a CPU board, and a display board. The display board that is currently installed drives the liquid crystal display (LCD) module. It can be replaced with the cathode ray tube (CRT) display card in order to operate the CRT display. Both boards should not be installed in the system at the same time. The unit is set up to operate from solid-state EPROM. No mechanical disk drives are used, although the software and hardware could accommodate one. The software used in the rugged GPS rover unit is identical to the software that resides on the original GPS rover unit. The rugged unit is equipped with a thermoelectric cooler. With the addition of the cooler and the replacement of the CRT display with the LCD module, the power consumption of the rugged version is very close to that of the original. The drawings and parts list for the rugged unit are shown in the Drawings section of this report.

TEST RESULTS

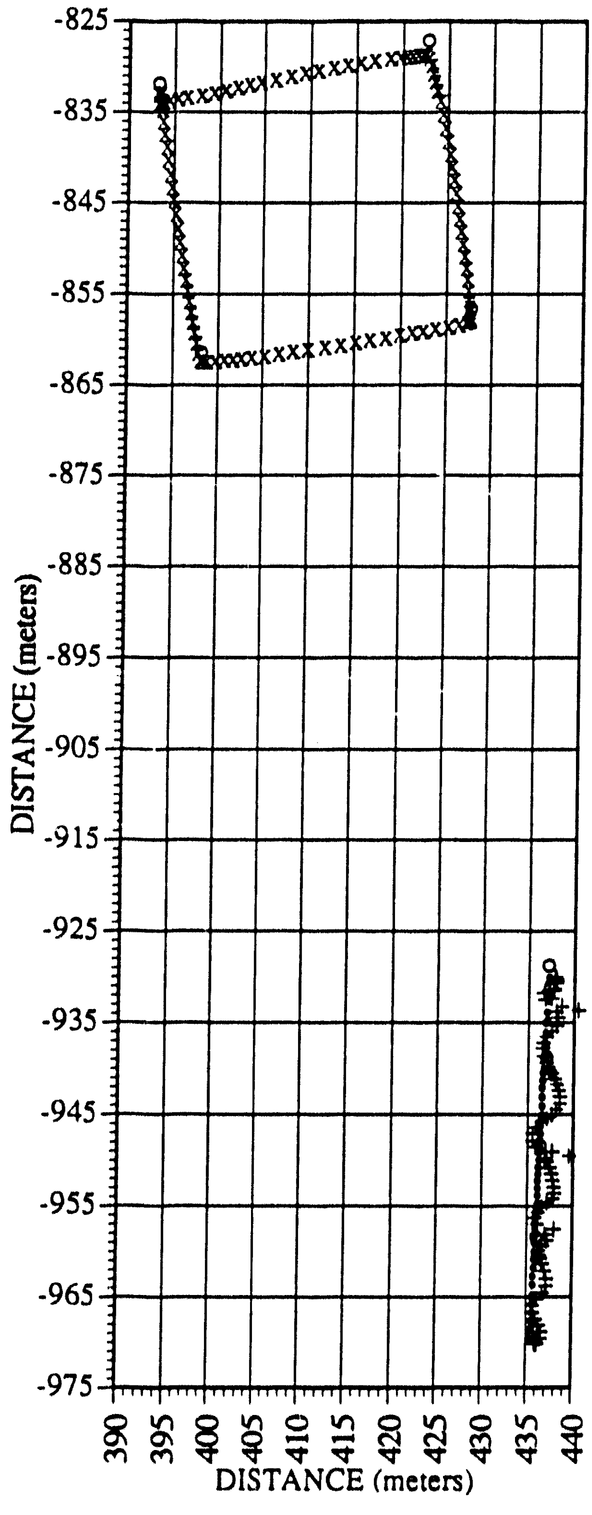
The NovAtel GPS receivers used in the Naval Explosive Ordnance Disposal Technology Center (NEODTC) GPS for the STOLS were tested at the Pacific Northwest Laboratory (PNL) and the Naval Research Laboratory (NRL). The PNL tests were performed in a parking lot near some low buildings. The survey markers were measured relative to each other and were not surveyed by other equipment other than the NovAtel system. The resultant data yield relative accuracies. The NRL tests were performed in a field in mostly clear sky but sometimes quite near trees and buildings. The NRL survey markers were measured using vendor-supplied GPS equipment. The marker accuracies were often in the millimeter range. The NRL results give a good indication of absolute accuracy.

PNL RESULTS

The NovAtel GPS receivers used in the NEODTC GPS were tested at PNL in a parking lot near some low buildings. This parking lot was east of the 2400 Stevens Building. The monitor GPS unit was positioned on top of the 2400 Stevens Building on a spot that had been statically surveyed using the NovAtel components. The results were post processed using SEMIKIN. The survey markers were measured relative to each other and were not surveyed by other equipment other than the NovAtel system. Five markers were laid out in straight line and surveyed using the GPS and SEMIKIN. These markers were measured by tape to be ten meters apart ±1 cm. Four additional markers were installed just north of the straight line group. These were arranged in a box configuration with 30 meter sides. These markers were measured by tape to be ten meters apart ±2 cm. See Figure 1 for a site overview.

Two kinematic surveys were performed on the straight line course. The first run was a simple pass going from north to south along surveyed path. The second pass was a curvy path trying to intersect the surveyed markers along the straight line. The results are shown in Figures 2 and 3. In addition to the line data, a kinematic run was performed on the box site. The run was started at the northwest corner and proceeded clockwise around the square and back to the northwest corner. The results are shown in Figure 4.

PNL Data after SEMIKIN Post Processing



Distance is relative to local 'CUE" monument.

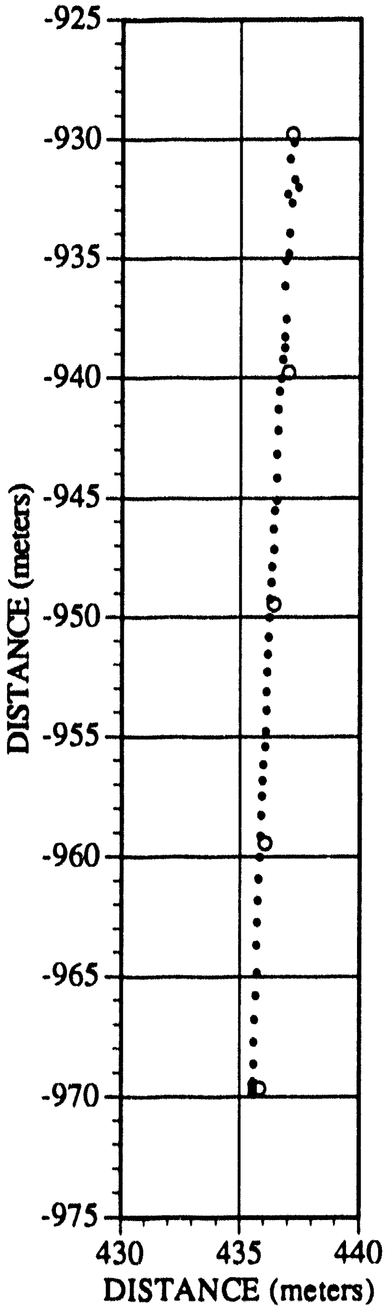
Circles represent static data.

Dots represent line kinematic data.

+ represents curvey kinematic data.

x represents box kinematic data.

FIGURE 1. PNL Site Overview



Distance is relative to local 'CUE" monument.

Circles represent static data.

Dots represent kinematic data.

FIGURE 2. PNL Straight Survey Path 40 Meters in Length after SEMIKIN Post-Processing

Distance is relative to local 'CUE" monument.

Circles represent static data.

Dots represent kinematic data.

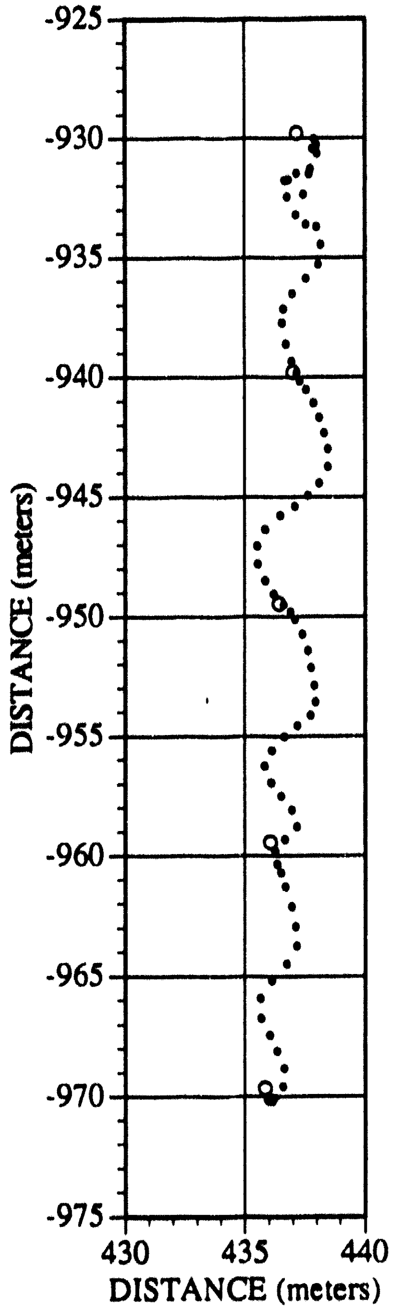
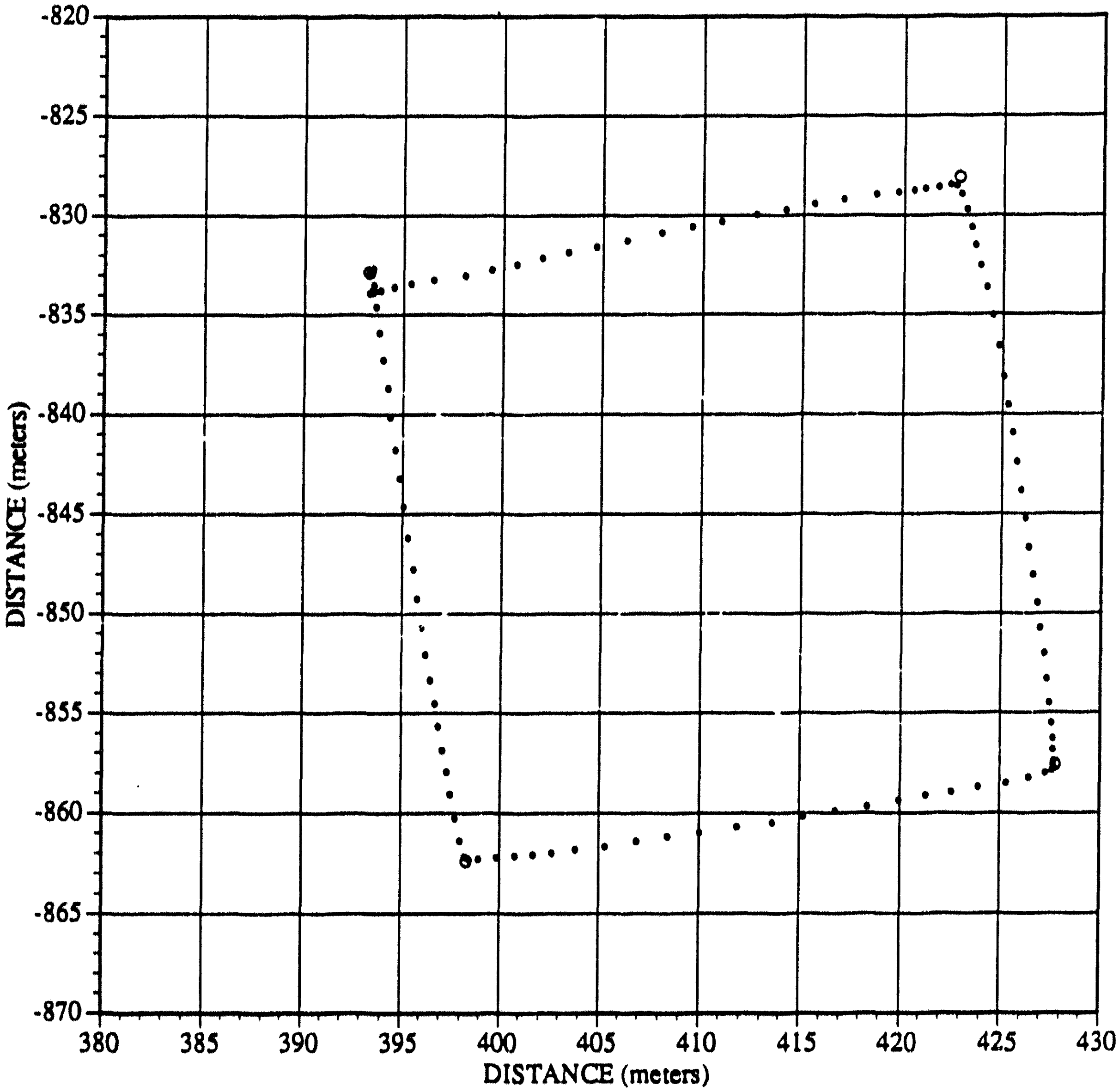


FIGURE 3. PNL Curvy Survey Path ~40 Meters in Length after SEMIKIN Post-Processing



Distance is relative to local 'CUE" monument.
Circles represent static data.
Dots represent kinematic data.

FIGURE 4. PNL Square Survey Path with 30 Meter Sides after SEMIKIN Post-Processing

The relative accuracy from the PNL tests are as follows:

Real-time Kinematic Straight line Data
Average error- 0.38 meters

Real-time Kinematic Curvy line Data
Average error- 0.32 meters

Real-time Kinematic Box Data
Average error- 0.41 meters

Post-processed Kinematic Straight line Data
Average error- 0.37 meters

Post-processed Kinematic Curvy line Data
Average error- 0.45 meters

Post-processed Kinematic Box Data
Average error- 0.21 meters

Post-processed Static Line Data
Average error- 0.16 meters

Post-processed Static Box Data
Average error- 0.11 meters

NRL RESULTS

The NovAtel GPS receivers used in the Remote Characterization System (RCS) and the NEODTC GPS were tested at a GPS test facility established by the Naval Research Laboratory at its Chesapeake Beach Detachment. GPS developers, vendors, and users were invited to participate in a competitive testing process. The following companies participated: Ashtech, Trimble, Sercel, Axyle, Del Norte, RACAL, NovAtel/Ross, and NovAtel/PNL. The tests were conducted on a playfield on which test points had been surveyed to accuracies in the millimeter to centimeter range. A base station was located at an unobstructed site on a hill on the east side of the site. Its location had been surveyed to millimeter accuracy. The field test involved a static measurement and two kinematic surveys.

The location of the static measurement was a fairly open area approximately 50 m from the base station. The first of the kinematic surveys was run on an open level area of the field. The area consisted of two parallel tracks 500 feet long and 25 feet apart, with markers staked at 100-foot intervals. The run initially followed two parallel tracks, then zig-zagged back and forth between markers on the tracks. At no time during this run was the base station ever out of sight. Wet trees were present at one end of this course, but did not seem to have any effect on the GPS satellite coverage. Seven satellites were available during this run. The second kinematic run followed a paved road loop which traveled up and down, through clusters of trees, and between buildings. The base station was out of sight at several points on the loop. Even with all of the potential blockage, the number of locked-in satellites never varied, and the RF link to the base station never failed. Seven satellites were locked in and utilized for this run as well. An overview and map of the site is shown in Figures 5 and 6 (McDonald et al. 1993, pp. 4 and 5).

An antenna choke ring for each antenna was utilized with the NovAtel/PNL GPS system to minimize the effects of multipath (GPS signals reflected from trees, buildings, and other features or structures on or near the test site.) The real-time position solutions and the log data needed for post processing were recorded at a rate of 5/s and 1/s, respectively. The base station antenna was mounted on a 2-m survey tripod. The base-station GPS receiver transmitted correction data to the mobile unit via an RF modem. The antenna for this modem was mounted on a tripod approximately 20 ft from the GPS antenna. The GPS antenna for the mobile unit was mounted on top of a GMC Suburban. The RF antenna for the mobile modem unit was also mounted on the roof of the Suburban, approximately 3 ft from the GPS antenna. The vehicle speed for these tests averaged about 5 mph for the track data and 6 mph for the road data.

The results, when compared to the survey marker locations established by NRL, were as follows:

Real-time Static data
- Standard Deviation: Latitude, ± 0.80; Longitude, ± 0.47
- Absolute Error: Latitude, 0.64 m; Longitude, 0.08 m

Post-processed Static data
- Standard Deviation: Does not apply.
- Absolute Error: Latitude, 0.05 m; Longitude, 0.10 m

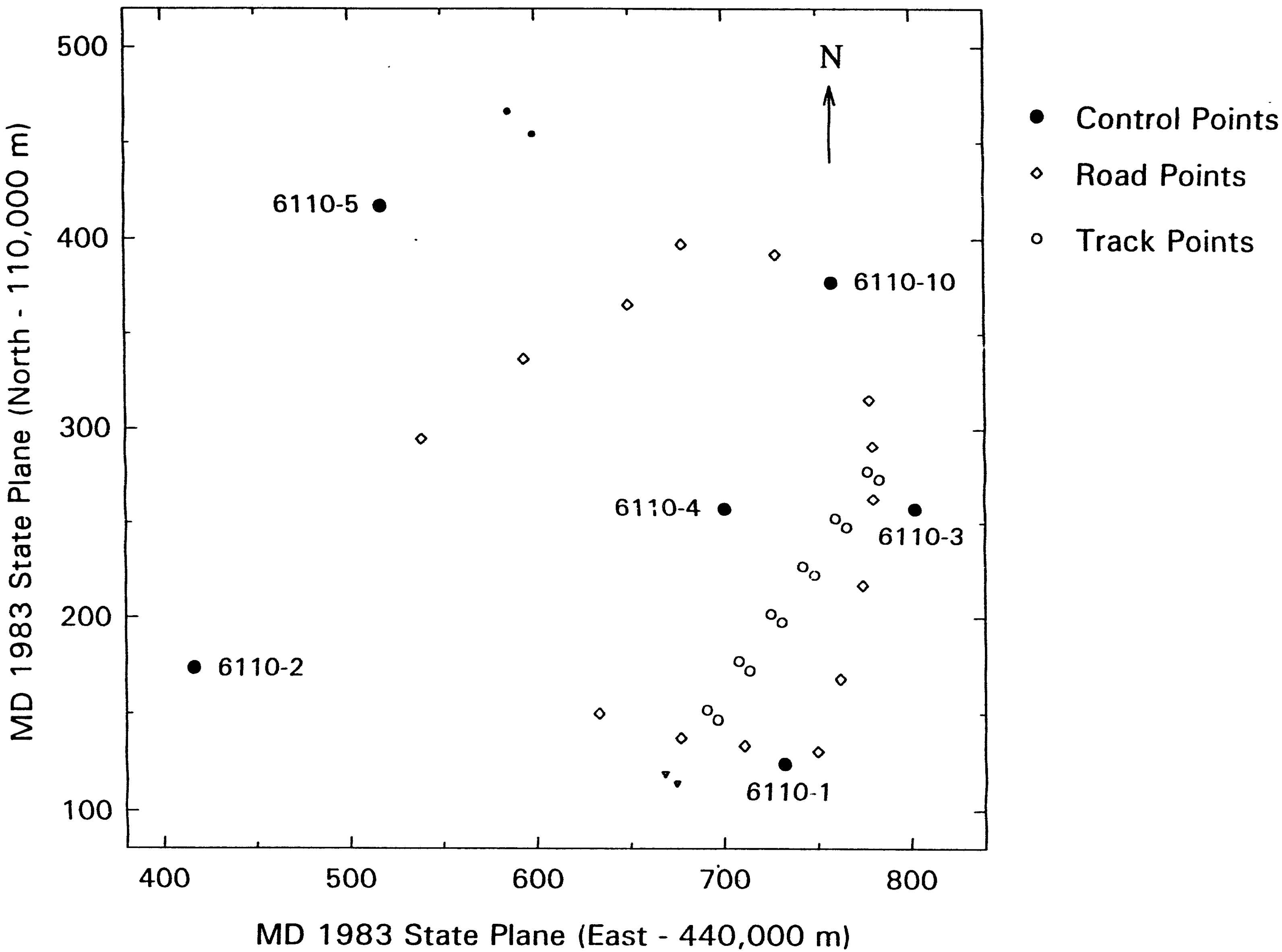


FIGURE 5. NRL Site Overview

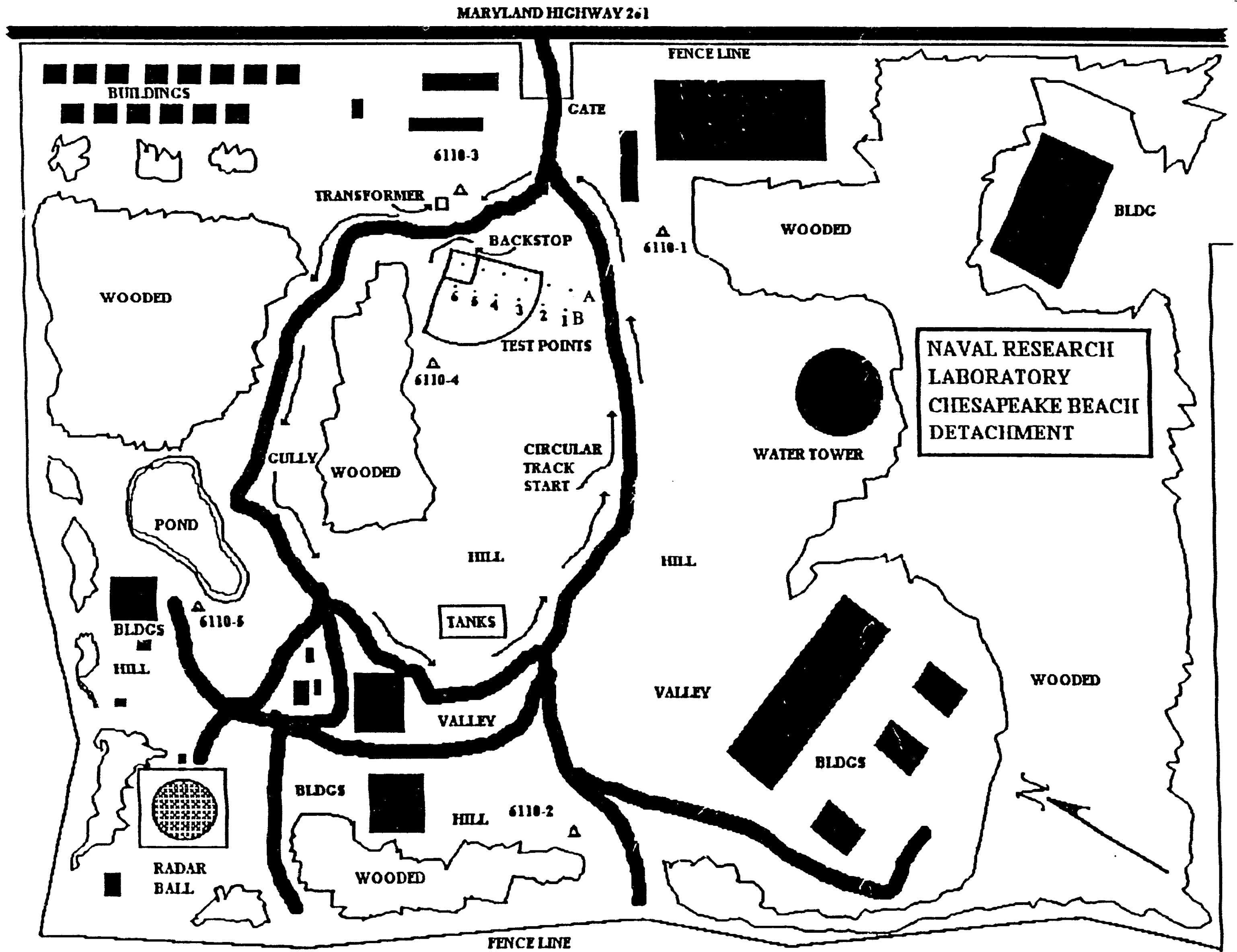


FIGURE 6. NRL Survey Test Site

Kinematic results are shown in the Figures 7 through 9 (McDonald et al. 1993, pp. 112, 113, and 115) and Tables 1 and 2 (McDonald et al. 1993, pp. 142 and 144).

Post processing the data allows the highest level of position accuracy to be achieved. SEMIKIN, a software package produced by the University of Calgary, was used to post process the data. The results are shown in the following Figures 10 through 12 and Tables 3 and 4 (McDonald et al 1993, pp. 158-162).

The tests conducted at NRL made a good comparison of GPS vendors and illustrated the capabilities of GPS in both real-time and post-processed mode. The only way these tests could have been improved would be to mount the rover hardware on a track. This would have allowed all the vendors to follow the exact same path and travel at a consistent speed.

The NovAtel system chosen by PNL to be used as the GPS for the RCS and the NEODTC GPS made a good showing at the NRL test site. The system accuracy was as follows:

Real-time Kinematic Track Data
Standard Deviation: 0.23
Mean Error: 0.53 m

Real-time Kinematic Road Data
Standard Deviation: 0.90
Mean Error: 1.01 m

Real-time Kinematic Combined Data
Standard Deviation: 0.71
Mean Error: 0.78 m

Post-processed Kinematic Track Data
Standard Deviation: 0.09
Mean Error: 0.13 m

Post-processed Kinematic Road Data
Standard Deviation: 0.24
Mean Error: 0.23 m

Post-processed Kinematic Combined Data
Standard Deviation: 0.19
Mean Error: 0.19 m

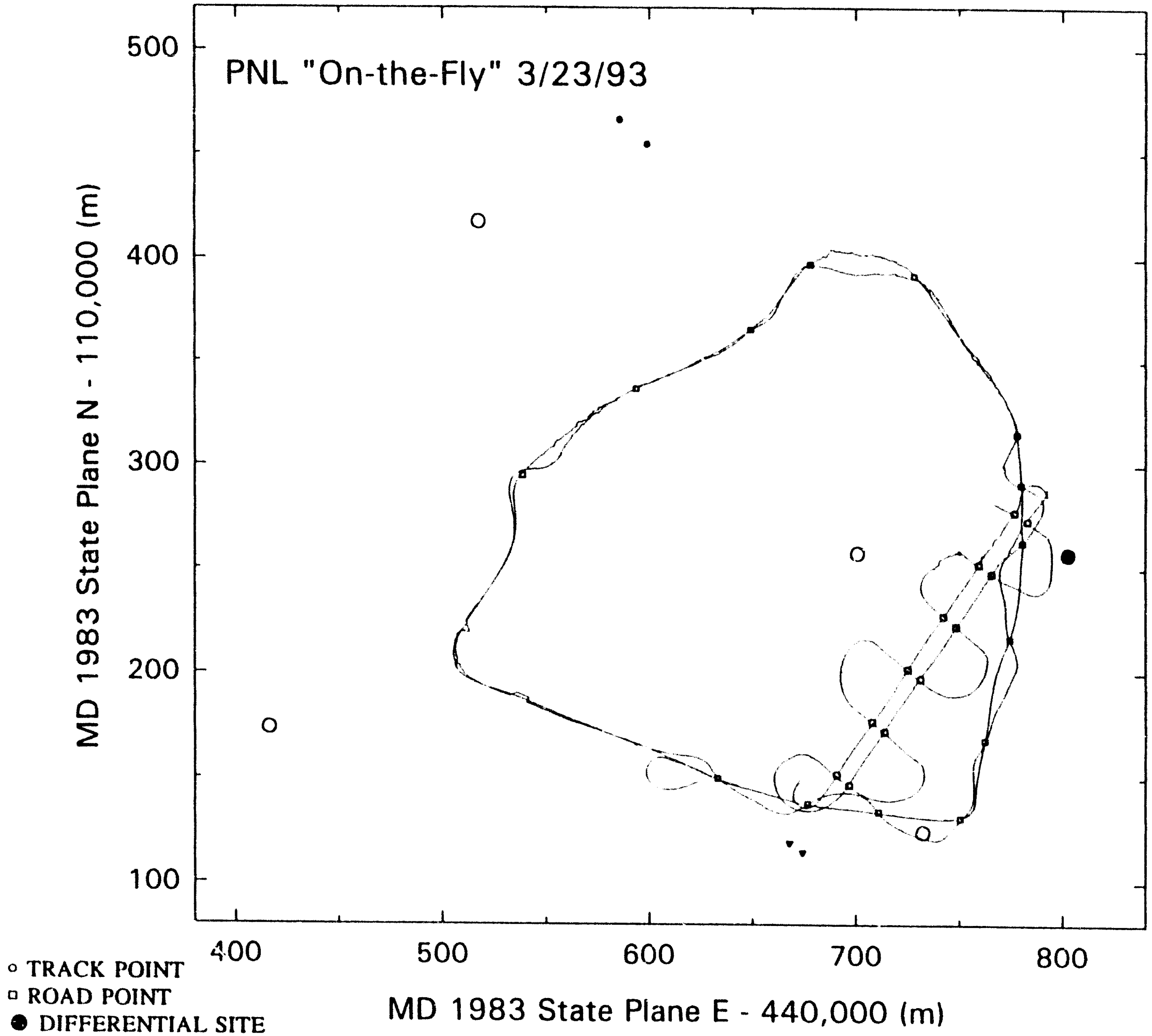


FIGURE 7. NRL GPS Survey

CBD NAV TEST

PNL "On-the-Fly" 3/23/93

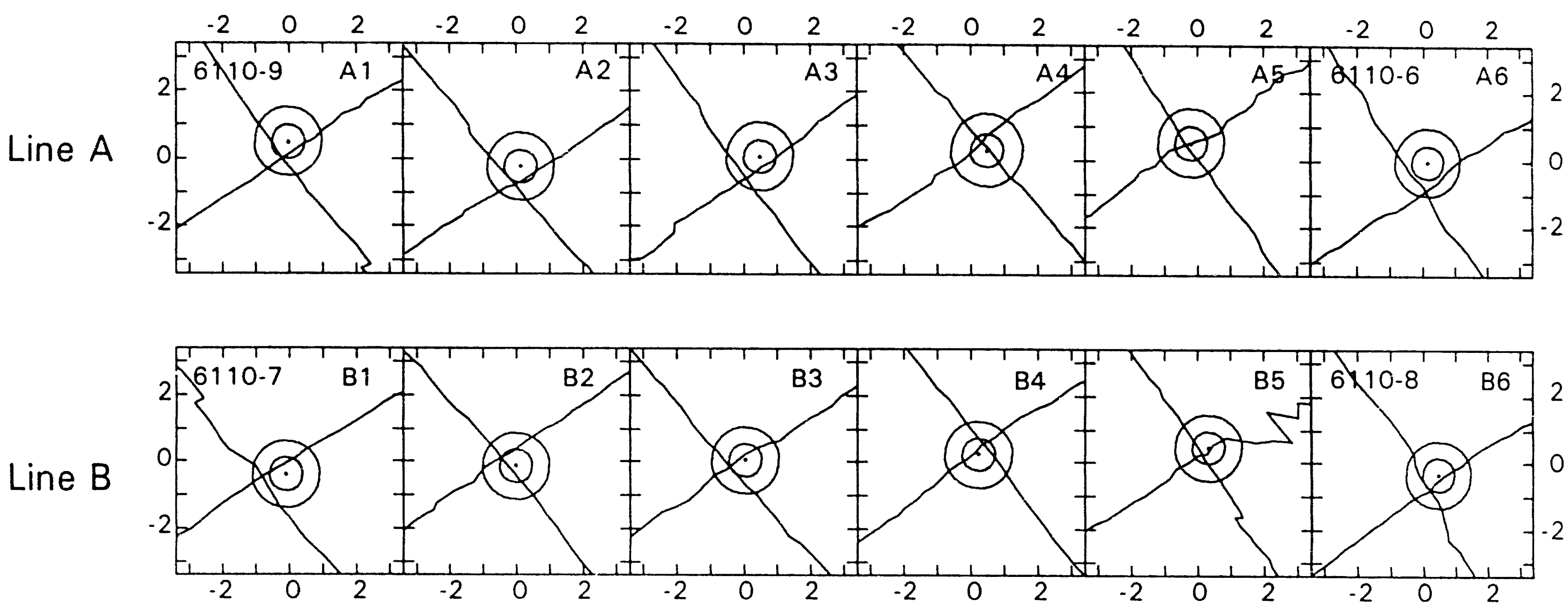


FIGURE 8. NRL GPS Track Targets

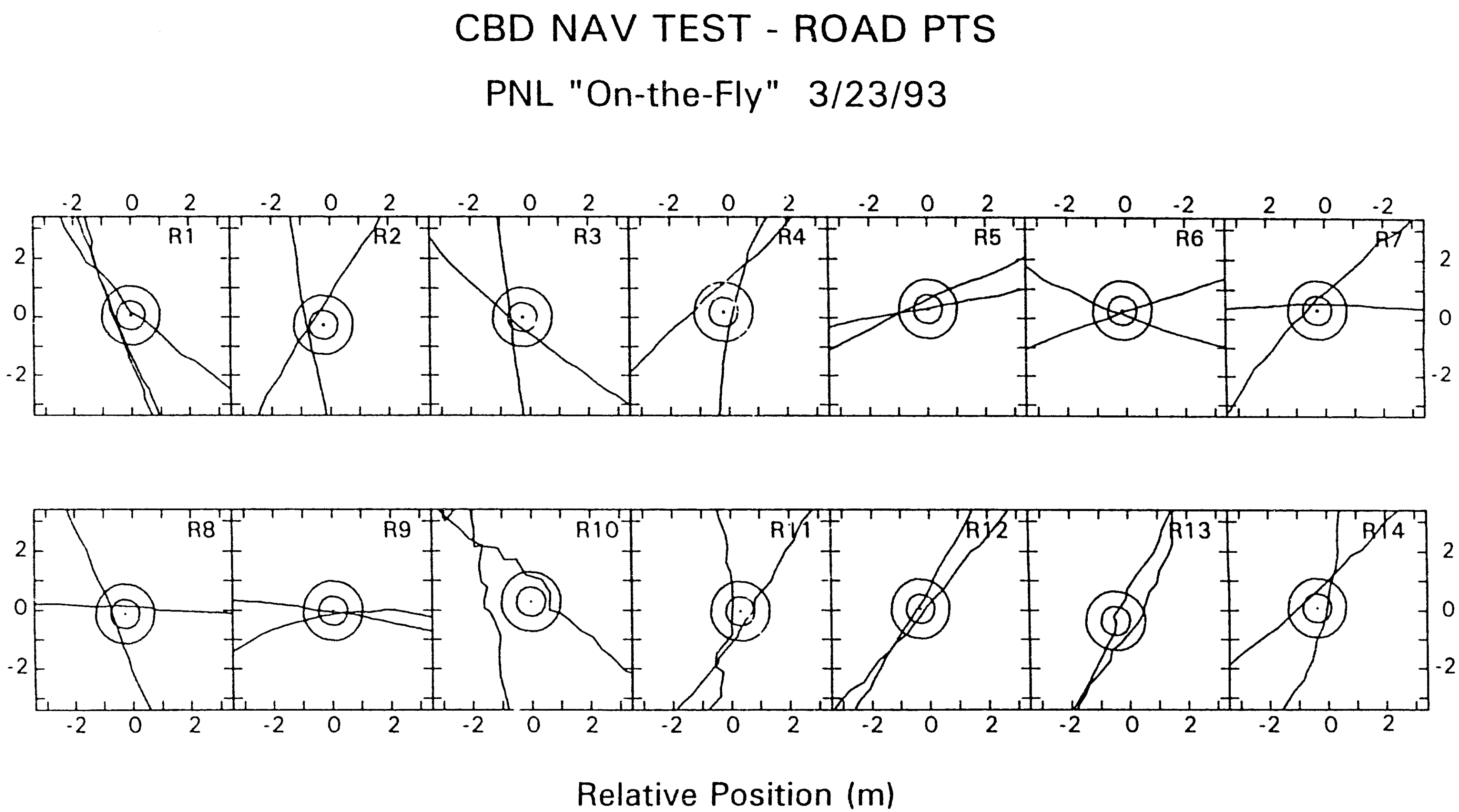


FIGURE 9. NRL GPS Road Targets

TABLE 1. NRL GPS Track Survey

PACIFIC NORTHWEST LABORATORY/NOVATEL

TEST DATE: 23 MAR 93
TEST SITE: CBD
NAVIGATION TYPE: GPS (REAL TIME)
TEST: TRACK TEST
DIFFERENTIAL SITE LOCATION: 6110-3

VEHICLE SPEED: 5 MPH
DROPOUTS (PER 1000 DATA POINTS): 12
DATA FREQUENCY: 5 HZ

LOCATION	≤0.5M	≤1.0M	>1.0M	DIST(M)	# SV	SIGNAL QUALITY	COMMENTS
LINE #							
A1		X		0.51	8	NO DATA	
A2		X		0.57	7	" "	
A3		X		0.76	8	" "	
A4	X	X		0.29	8	" "	
A5	X	X		0.13	7	" "	
A6		X		0.85	7	" "	
B1		X		0.70	7	NO DATA	
B2	X	X		0.49	7	" "	
B3		X		0.51	8	" "	
B4	X	X		0.36	8	" "	
B5	X	X		0.30	7	" "	
B6		X		0.85	8	" "	
TOTALS	5	12	0				

TABLE 2. NRL GPS Road Survey

PACIFIC NORTHWEST LABORATORY/NOVATEL

TEST DATE: 23 MAR 93
TEST SITE: CBD
NAVIGATION TYPE: GPS (REAL TIME)
TEST: ROAD TEST
DIFFERENTIAL SITE LOCATION: 6H0-3

VEHICLE SPEED: 6-7 MPH
DROPOUTS (PER 1000 DATA POINTS): 10
DATA FREQUENCY: 5 HZ

LOCATION	≤0.5M	≤1.0M	>1.0M	DIST(M)	#SV	SIGNAL QUALITY	COMMENTS
ROADTEST							
R1			X	2.0	7	NO DATA	
R2		X		0.53	7	" "	
R3	X	X		0.40	7	" "	
R4			X	1.8	7	" "	
R5		X		0.99	7	" "	
R6	X	X		0.10	7	" "	
R7	X	X		0.25	7	" "	
R8		X		0.56	7	" "	
R9	X	X		0.25	7	" "	
R10			X	2.5	7	" "	
R11			X	2.0	6	" "	
R12	X	X		0.12	7	" "	
R13		X		.66	7	" "	
R14			X	1.2	7	" "	
TOTALS	5	9	5				

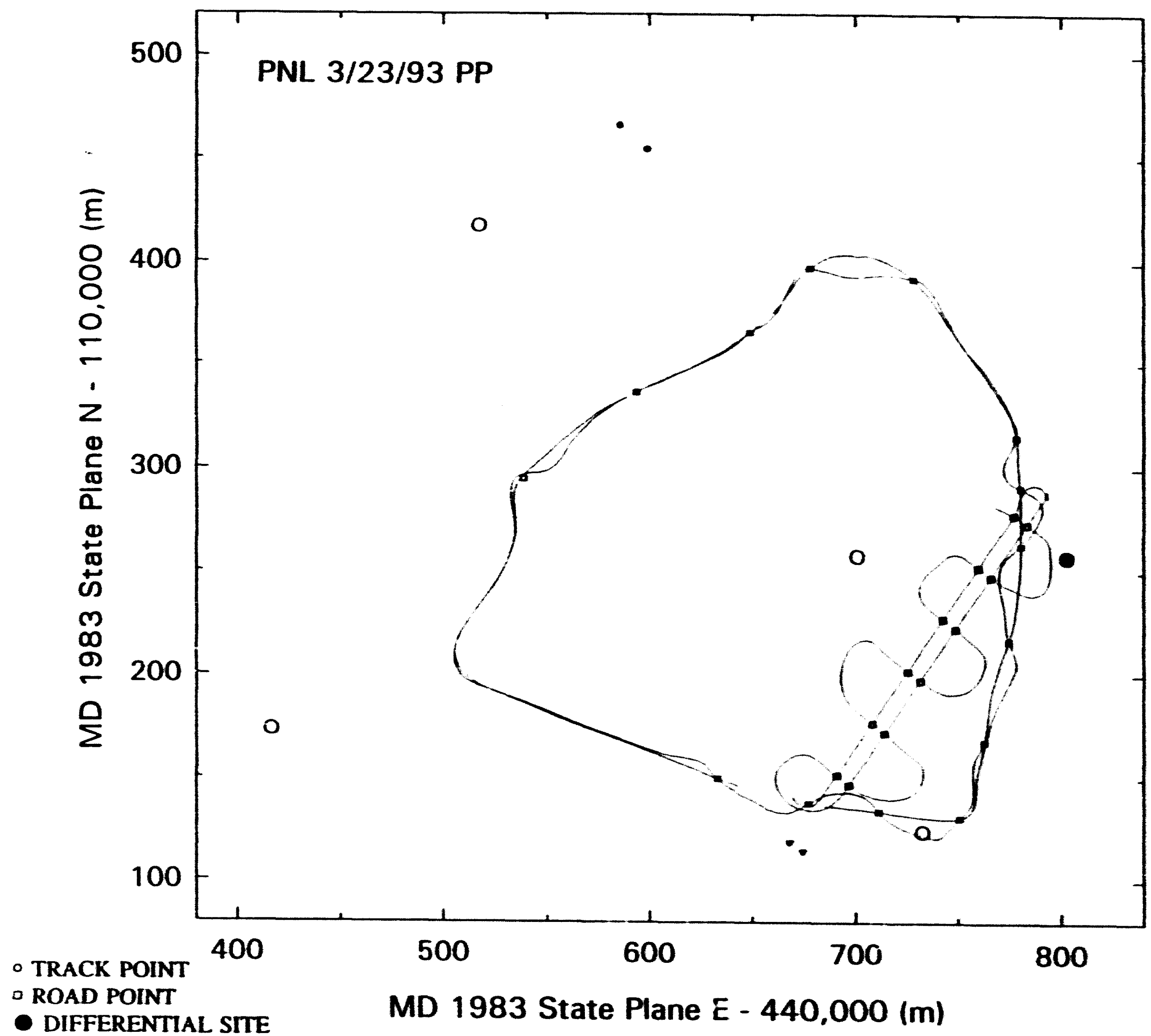


FIGURE 10. NRL Post-Processed

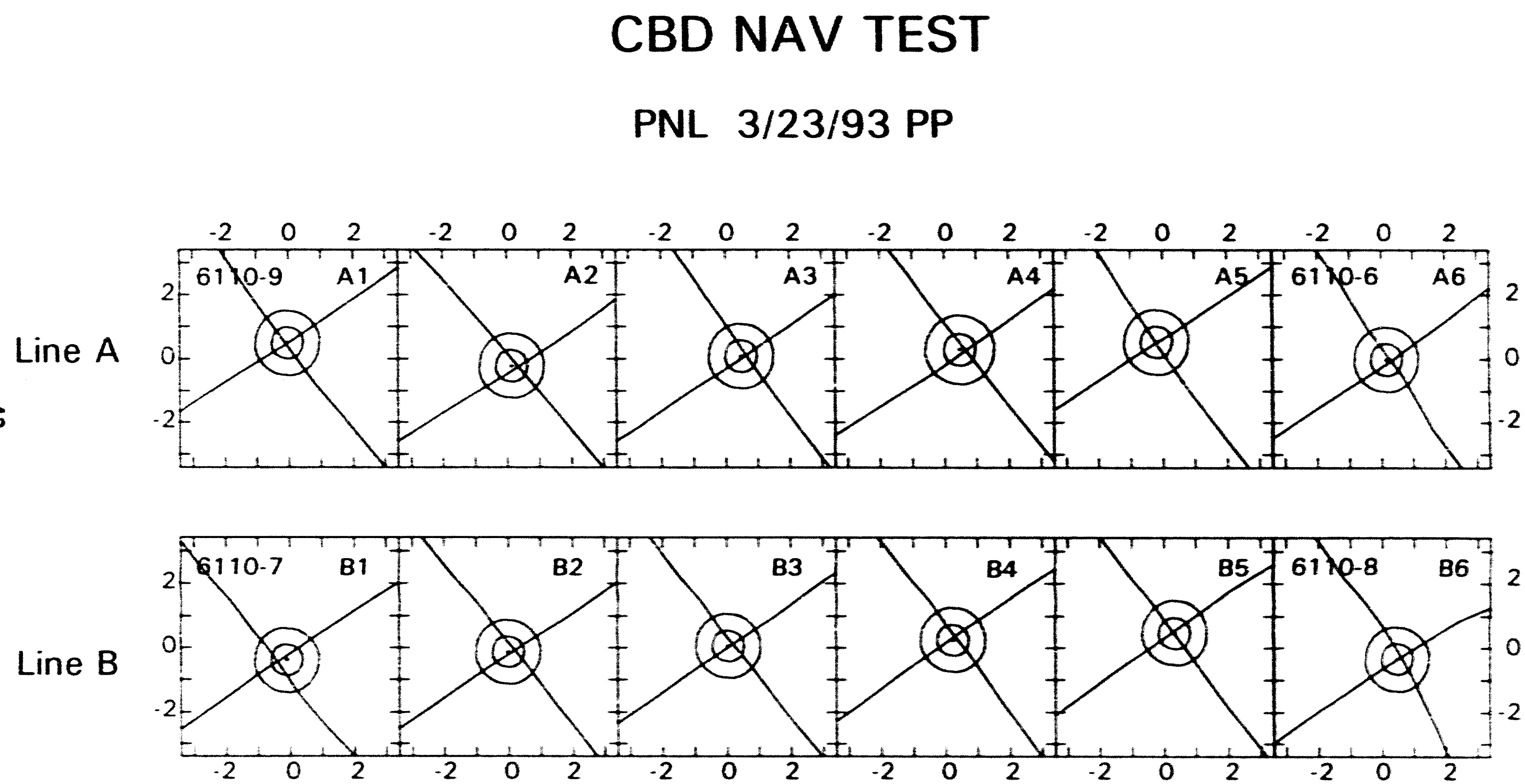


FIGURE 11. NRL Post-Processed Track Targets

TABLE 3. NRL Post-Processed Track Survey

PACIFIC NORTHWEST LABORATORY/NOVATEL

TEST DATE: 23 MAR 93
TEST SITE: CBD
NAVIGATION TYPE: GPS (POST PROCESSED)
TEST: TRACK TEST
DIFFERENTIAL SITE LOCATION: 6110-3 DATA FREQUENCY: 1 HZ

LOCATION	≤0.5M	≤1.0M	>1.0M	DIST(M)	# SV	SIGNAL QUALITY	COMMENTS
LINE #							
A1	X	X		0.0	8	NO DATA	
A2	X	X		0.19	7	" "	
A3	X	X		0.17	8	" "	
A4	X	X		0.20	8	" "	
A5	X	X		0.0	7	" "	
A6	X	X		0.15	7	" "	
B1	X	X		0.31	7	NO DATA	
B2	X	X		0.19	7	" "	
B3	X	X		0.15	8	" "	
B4	X	X		0.14	8	" "	
B5	X	X		0.0	7	" "	
B6	X	X		0.11	8	" "	
TOTALS	12	12	0				

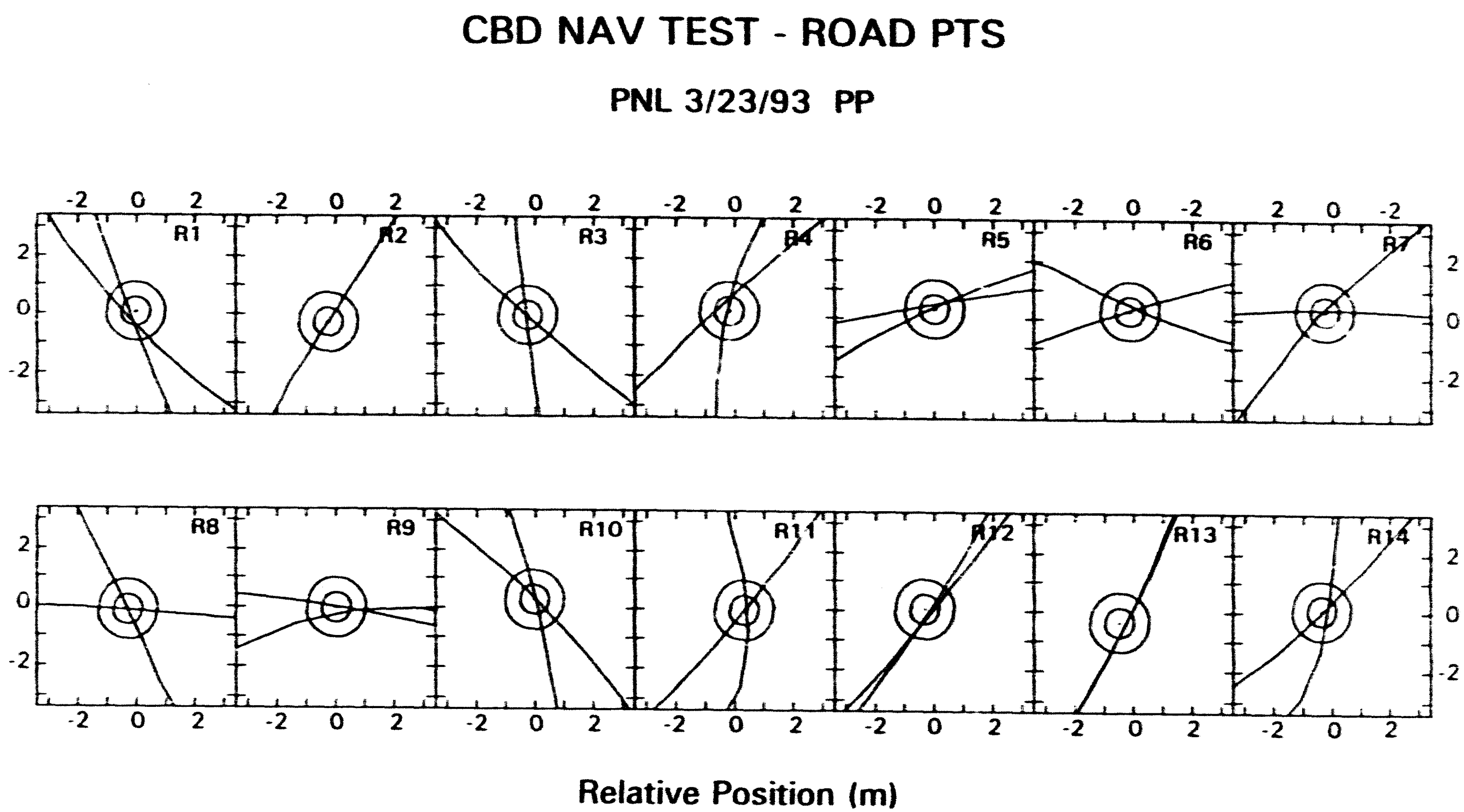


FIGURE 12. NRL Post-Processed Road Targets

TABLE 4. NRL Post-Processed Road Survey

PACIFIC NORTHWEST LABORATORY/NOVATEL

TEST DATE: 23 MAR 93
TEST SITE: CBD
NAVIGATION TYPE: GPS (POST PROCESSING)
TEST: ROAD TEST
DIFFERENTIAL SITE LOCATION: 6110-3 DATA FREQUENCY: 1 HZ

LOCATION	≤0.5M	≤1.0M	>1.0M	DIST(M)	#SV	SIGNAL QUALITY	COMMENTS
ROADTEST							
R1	X	X		0.33	7	NO DATA	
R2	X	X		0.0	7	" "	
R3	X	X		0.0	7	" "	
R4	X	X		0.42	7	" "	
R5	X	X		0.44	7	" "	
R6	X	X		0.25	7	" "	
R7	X	X		0.07	7	" "	
R8	X	X		0.0	7	" "	
R9		X		0.74	7	" "	
R10	X	X		0.0	7	" "	
R11	X	X		0.0	6	" "	
R12		X		0.51	7	" "	
R13	X	X		0.19	7	" "	
R14	X	X		0.28	7	" "	
TOTALS	12	14	0				

The Novatel/PNL system placed fourth in overall real-time system accuracy. This is illustrated in Table 5 (McDonald et al. 1993, p. 163). The key point to note here is that of the systems that used C/A-code GPS technology, NovAtel placed second only to Trimble. Of the other two systems that placed higher, one used P-code and the other was not actually a GPS at all.

The two primary factors that contributed to the selection of the NovAtel GPSCard for the RCS and the NEODTC GPS were packaging and GPS technology. The small size and printed circuit board format allowed for easy integration into the LSV. And the PC-bus communications were connected directly to the existing Ampro PC-104 processors which were onboard the LSV. The NovAtel GPSCard uses C/A-code GPS technology. In conversations with DoD, we learned this is the band of GPS that will be available for civilian use in the future. P-code will be encrypted and will not be usable by civilians when the full constellation of GPS satellites are in place in early 1994. During the time period preceding the encryption of P-code, the DoD will be testing their encryption techniques and P-code will not be available at these times either. We chose not to have a system that would be tied to the actions of the military and had a higher potential for future use.

TABLE 5. NRL Real-Time Navigation Test Results

REALTIME NAVIGATION TEST RESULTS

COMPANY	LOCATION ACCURACY (%)					DATA RATE (HZ)	SPEED MPH	DROPOUTS PER 1000 POINTS	SIGNAL QUALITY	STATIC DEV (dm)	
	TRACK(12)		ROAD(14)		TOTAL(26)					ΔX	/ ΔY
	≤.5m	≤1m	≤.5m	≤1m	≤1m						
RACAL(MW)	25%	83%	14%	21%	50%	1	4-8	92	0-13.8	+2.4	+3.7
SERCEL(GPS)	58%	100%	21%	57%	77%	1.67	7-10	10	GDOP 3.4-7.0	+7.6	+3.4
SERCEL AXYLE(MW)	100%	100%	29%	79%	88%	5	6-8	37	HDOP .04-.93	+0.2	+1.6
TRIMBLE VEHICLE(GPS)	100%	100%	50%	93%	96%	1	5-8	9	HDOP 1.00-2.50	-2.7	+1.5
TRIMBLE PORTABLE(GPS)	100%	100%	NA	NA	NA	1	3	0	NO DATA	NO DATA	NO DATA
DEL NORTE(GPS)	8%	8%	0%	21%	15%	1	3-4	47	SV's 5-7	-3.3	+5.5
DEL NORTE(MW)	8%	50%	7%	21%	35%	3	3-6	39	NO DATA	-1.5	-3.1
ASHTEC(GPS) REAL TIME	42%	100%	57%	100%	100%	2	5-7	2	HDOP 1.00-1.90	-4.2	+1.5
PNL(GPS) NOVATEL(RT)	42%	100%	36%	64%	81%	5	5-7	11	SV's 6-8	NO DATA	NO DATA
ROSS LABS(GPS) NOVATEL(RT)	25%	83%	29%	64%	73%	5	5-7	16	NO DATA	+0.9	-6.1

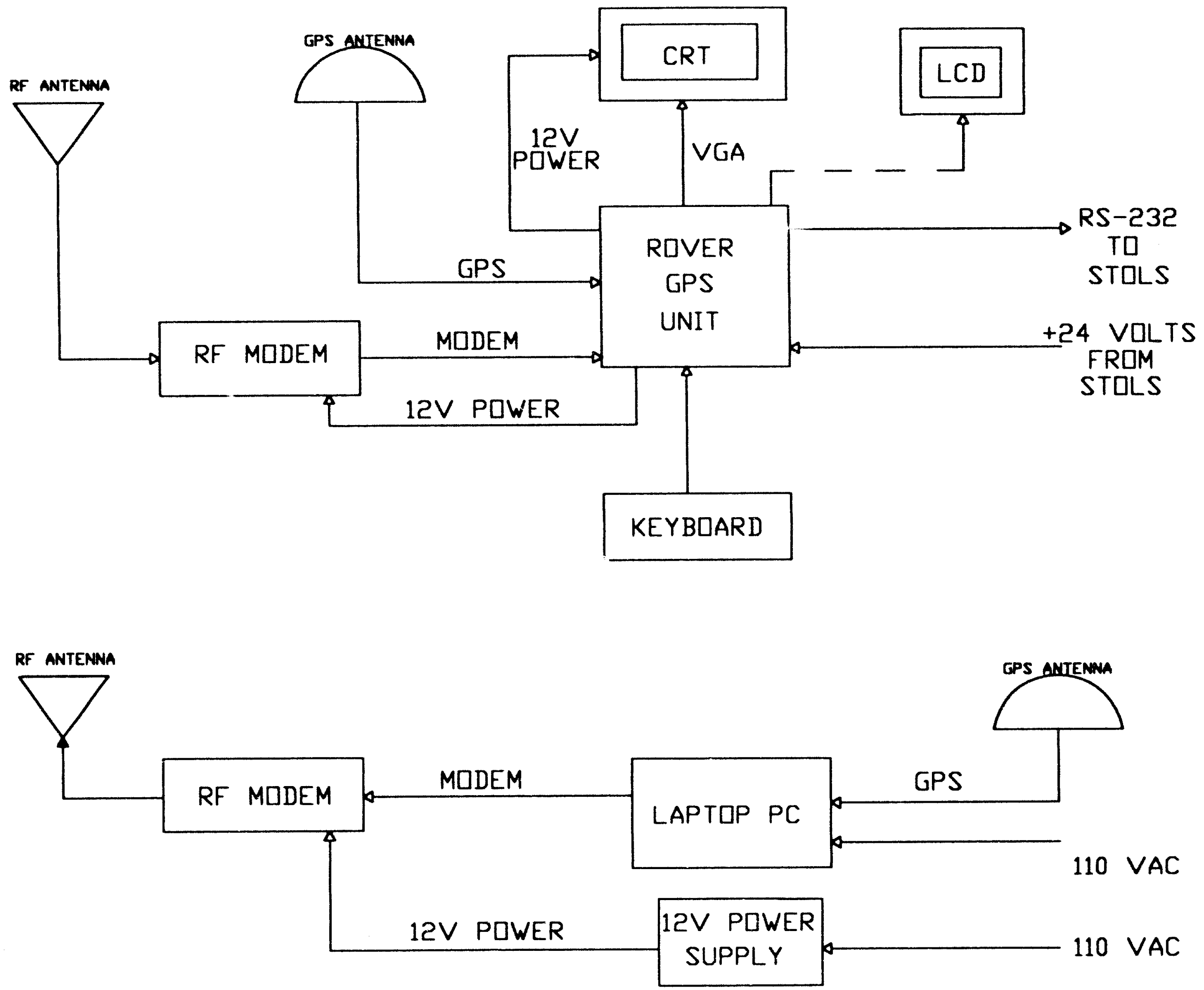
NRL CBD NAVIGATION REPORT

REFERENCES

McDonald, J. R., H. H. Nelson, and R. Robertson. 1993. Microwave and Differential GPS Navigation Systems; Field Performance Tests, Naval Research Laboratory, NRL/PU/6110-93-244.

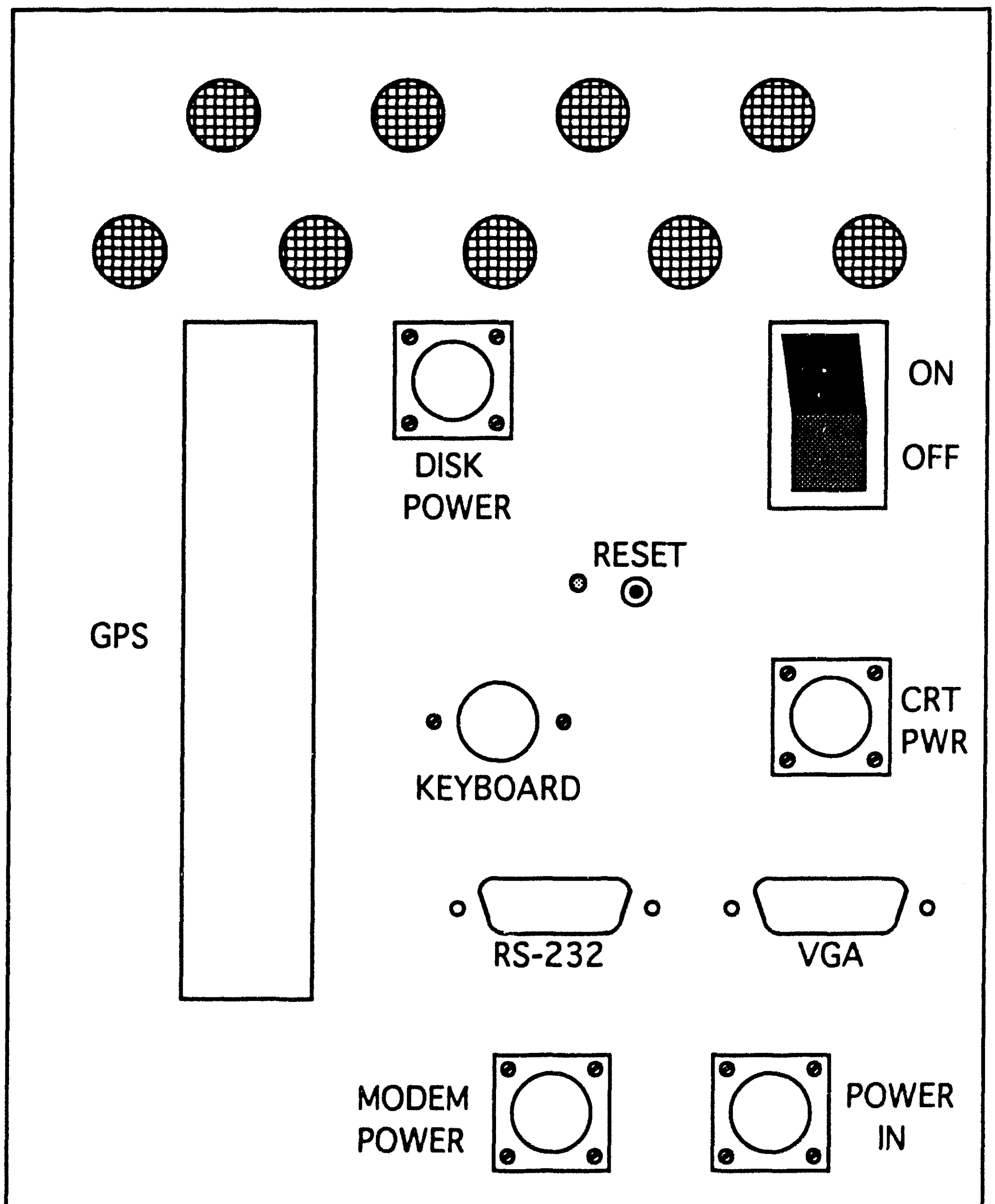
APPENDIX A

DRAWINGS

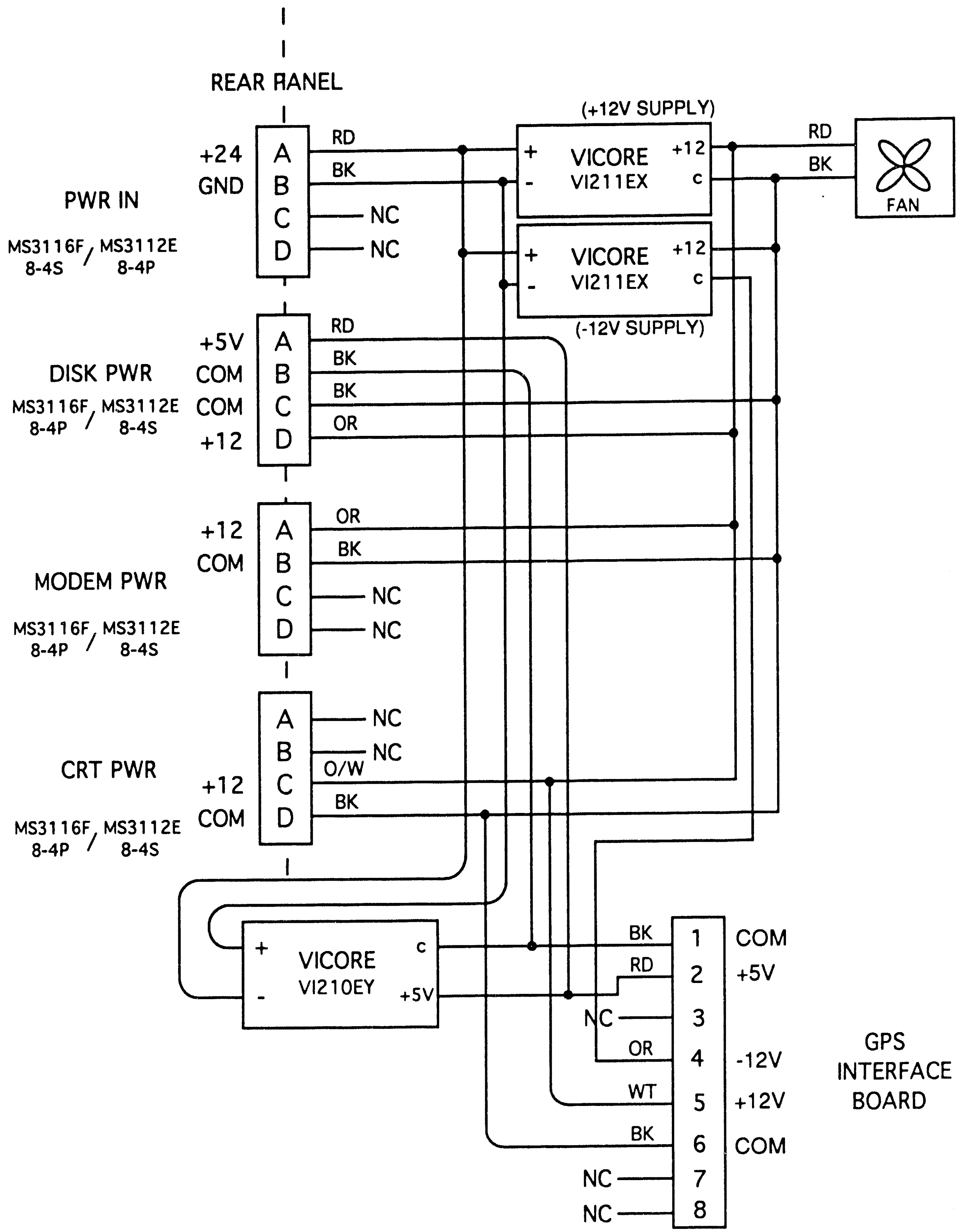


REV. NO. 0	NEODTC GPS BLOCK DIAGRAM
DATE: 8 SEPT 93	
DRWN: B QUINN	
ENGR: T STEWART	
FILE: NV_BLKDM	
NO. OF	DRWING NO. 9308-3

Original GPS Rover Unit Faceplate

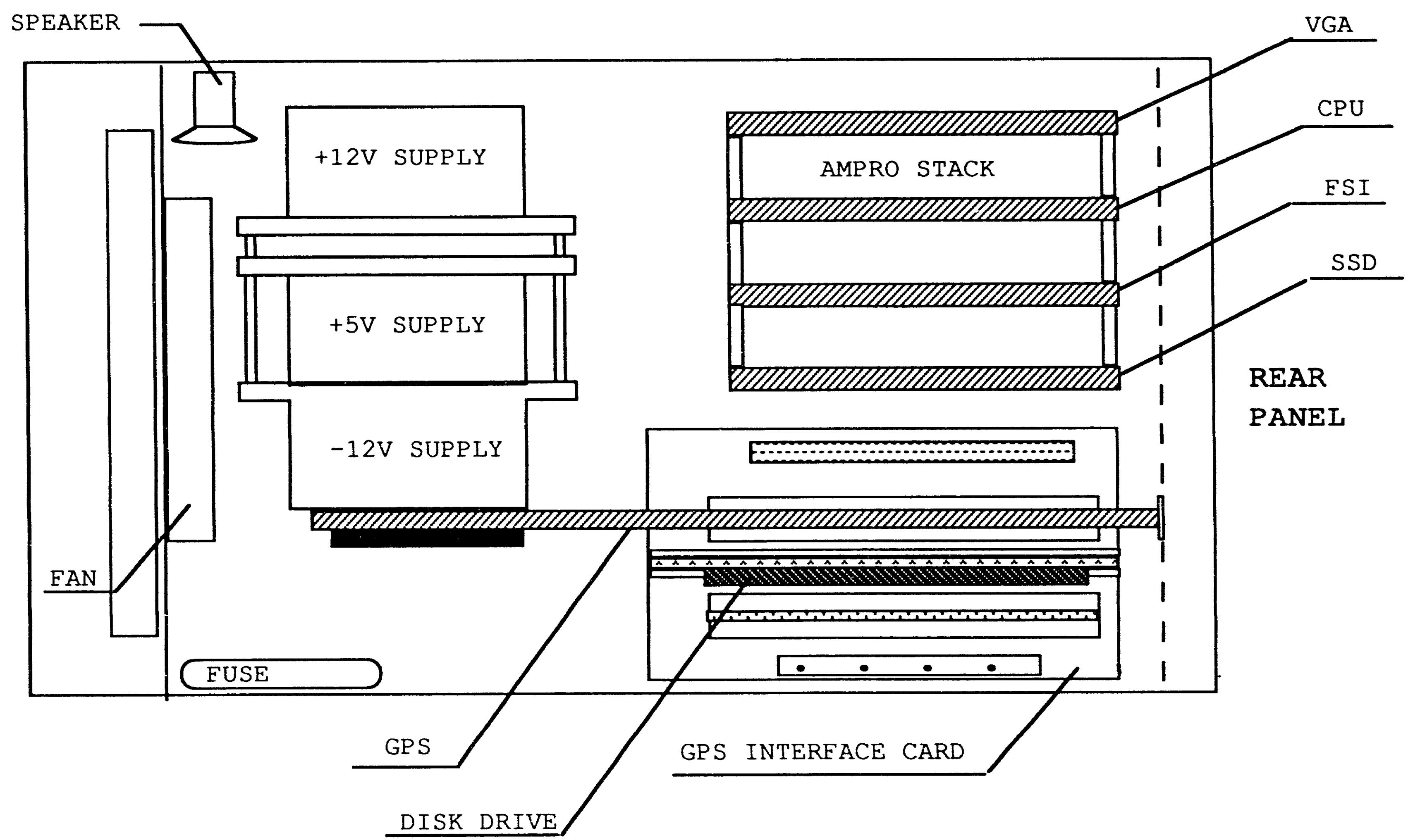


3/12/93 By AML for BKT



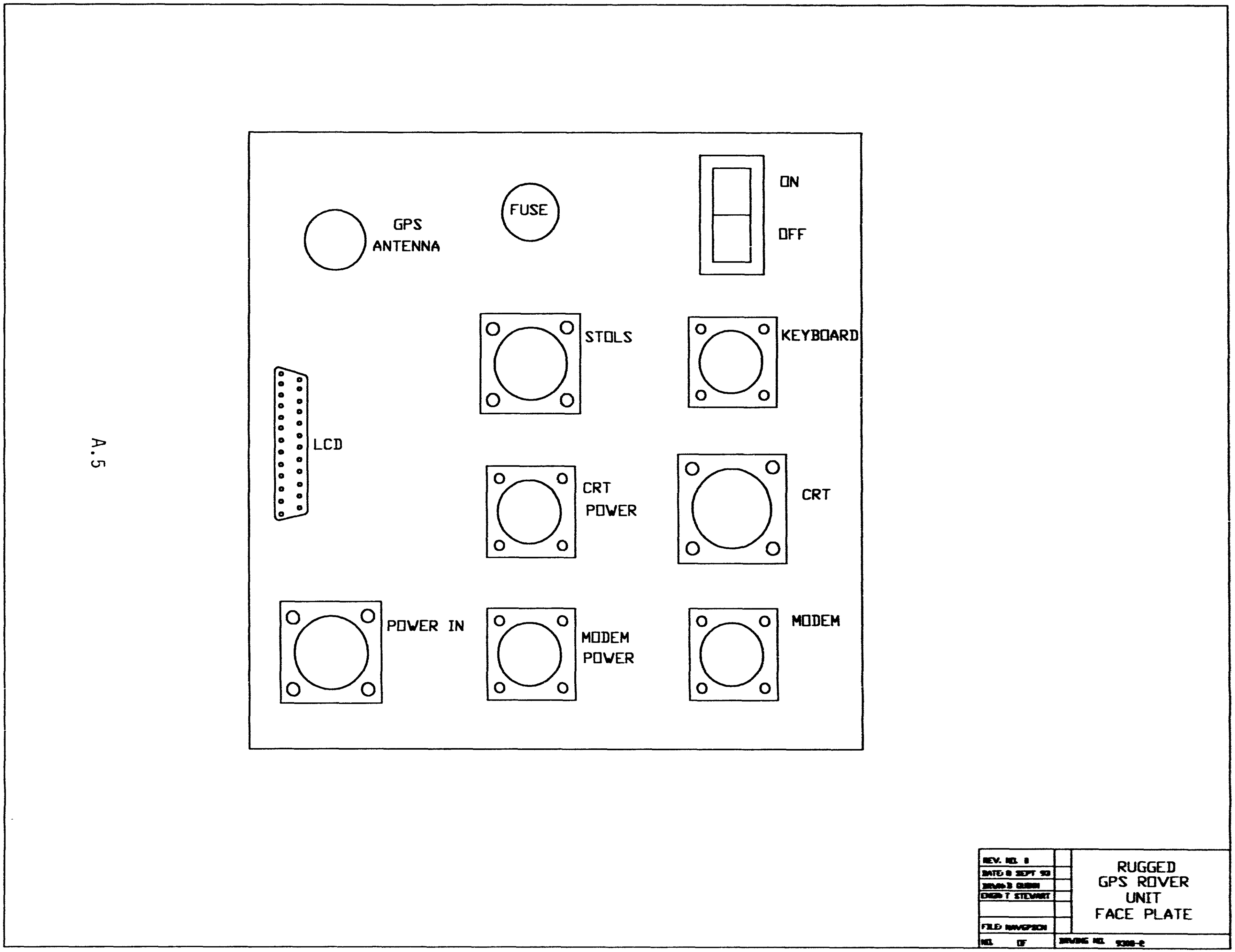
ORIGINAL GPS ROVER UNIT
INTERNAL WIRING
3/18/93 By AML FOR BKT

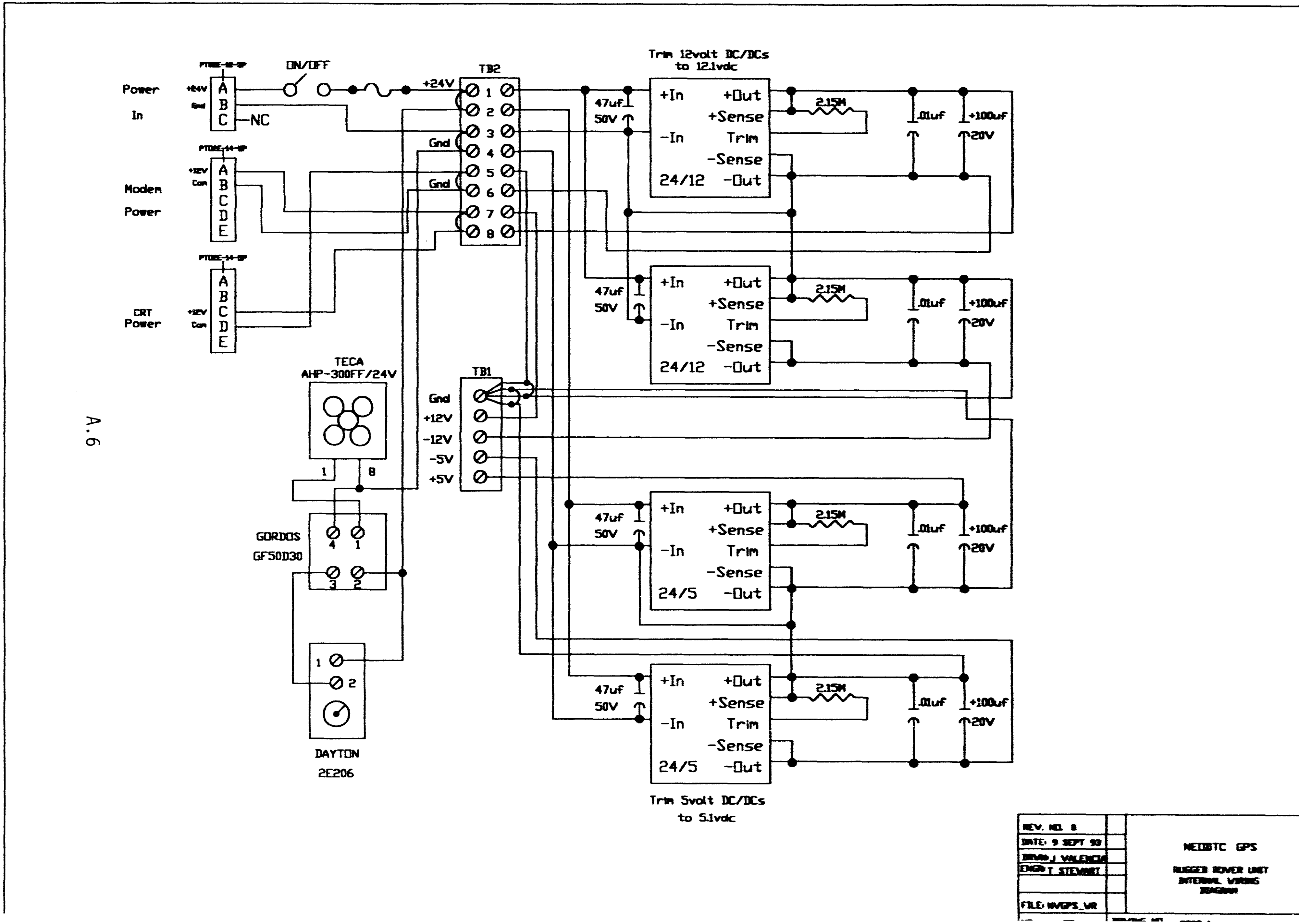
TOP VIEW

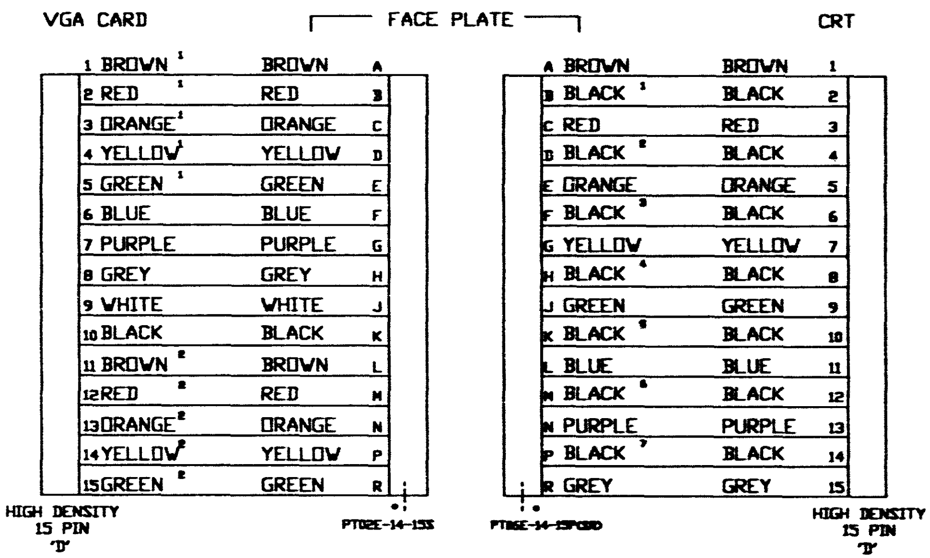


ORIGINAL GPS
ROVER UNIT
BLOCK LAYOUT

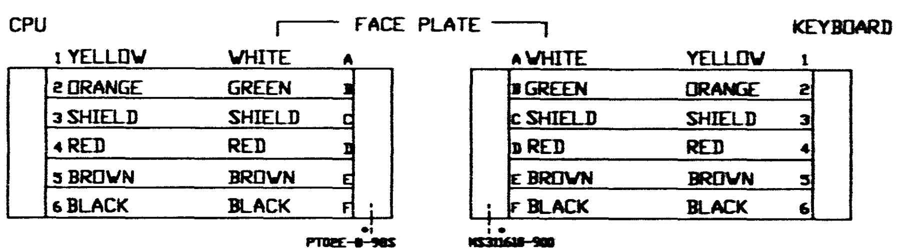
3/18/93 By AML For BKT


GPS
ANTENNA
FUSE
ON
OFF
STOLS
KEYBOARD
LCD
CRT
POWER
CRT
POWER IN
MODEM
POWER
MODEM
RUGGED
GPS ROVER
UNIT
FACE PLATE

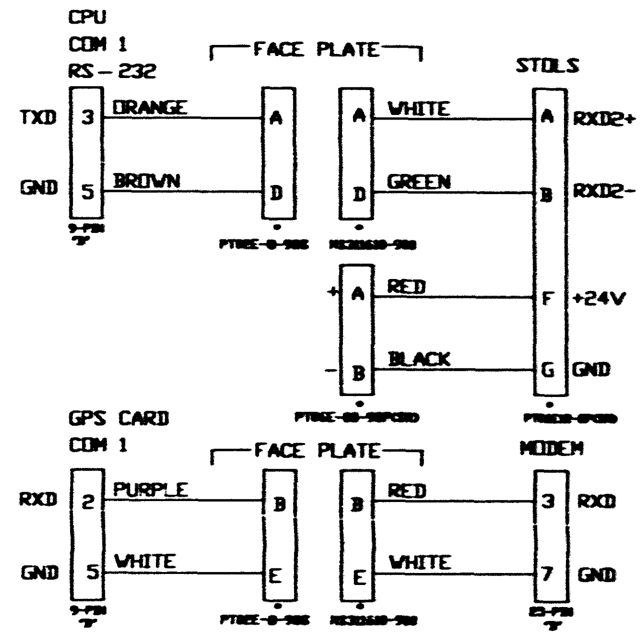

Power
In
+24V
Gnd
NC
ON/OFF
+24V
TB2
Gnd
Gnd
Modem
Power
+12V
Com
CRT
Power
+12V
Com
Trim 12volt DC/DCs
to 12.1vdc
47uf
50V
+In
+Out
+Sense
-In
Trim
-Sense
24/12
-Out
2.15M
.01uf
+100uf
20V
TECA
AHP-300FF/24V
TB1
Gnd
+12V
-12V
-5V
+5V
GORDOS
GF50D30
DAYTON
2E206
24/5
Trim 5volt DC/DCs
to 5.1vdc
REV. NO. 8
DATE: 9 SEPT 93
DRWN: J VALENCIA
ENGR: T STEWART
FILE: NVGPS_VR
NEODTC GPS
RUGGED ROVER UNIT
INTERNAL WIRING
DIAGRAM



CRT CONNECTOR DIAGRAM



KEYBOARD CONNECTOR DIAGRAM



A.7

REV. NO. 0	RUGGED GPS ROVER UNIT CABLE DIAGRAMS
DATE: 9 SEPT 93	
DRWN: B QUINN	
ENGR: T STEWART	
FILE: VGACONCT	
NO. OF	DRWING NO. 9308-4

APPENDIX B

PARTS LISTS

APPENDIX B

ORIGINAL GPS ROVER UNIT PARTS LIST

Bud Showcase enclosure BB-1800-BT

Ampro CoreModule/286 CMX-286-K-54
Ampro MiniModule/SuperVGA MMX-SVG-Q-01
Ampro MiniModule/SSD MMX-SSD-Q-51
Ampro MiniModule/FSI MMX-FSI-Q-51
Ampro MiniBackplane/AT EXP-MBA-Q-01

NovAtel 951R GPSCard

Vicor 24 vdc to 12 vdc, 75 watt DC/DC converter VI-211-EX
Vicor 24 vdc to 12 vdc, 50 watt DC/DC converter VI-2W1-CY (used as -12v)
Vicor 24 vdc to 5 vdc, 50 watt DC/DC converter VI-210-EY

Integral Stingray disk drive, 40 Mbyte

Bendix MS3112E8-4P connector, Power In
Bendix MS3112E8-4S connector, Disk Power
Bendix MS3112E8-4S connector, Modem Power
Bendix MS3112E8-4S connector, CRT Power

Howard 12vdc @ 0.1 amp fan 3-15-8311

15 amp fuse and holder

Alcoswitch DPDT on/off switch TRD21N10W'.

RUGGED GPS ROVER UNIT PARTS LIST

Advantech PC enclosure IPC-6706

Advantech CPU card PCA-6133-25
Advantech SVGA Module PCD-6142
Advantech RAM/ROM Module PCD-8931

Kinetic Computer Corp. LCD interface card

NovAtel 951R GPSCard

Vicor 24 vdc to 12 vdc, 75 watt DC/DC converter VI-211-IX
Vicor 24 vdc to 12 vdc, 75 watt DC/DC converter VI-211-IX (used as -12v)
Vicor 24 vdc to 5 vdc, 50 watt DC/DC converter VI-210-CX
Vicor 24 vdc to 5 vdc, 50 watt DC/DC converter VI-210-CX (used as -5v)

Texas Instruments EEPROM 27C040-12

Bendix PT02E-12-3P connector, Power In Faceplate
Bendix PT06E-08-98P(SR) connector, Power In Cable
Bendix PT02E-14-5P connector, Modem Power Out Faceplate
Bendix PT06E-14-5S(SR) connector, Modem Power Out Cable
Bendix PT02E-8-98S connector, Modem Faceplate
Bendix MS311610-900 connector, Modem Cable
Bendix PT02E-14-5P connector, CRT Power Out Faceplate
Bendix PT06E-14-5S(SR) connector, CRT Power Out Cable
Bendix PT02E-14-15S connector, CRT Faceplate
Bendix PT06E-14-15P(SR) connector, CRT Cable
Bendix PT02E-8-98S connector, Keyboard Faceplate
Bendix MS311610-900 connector, Keyboard Cable
Bendix PT02E-8-98S connector, STOLS Faceplate
Bendix MS311610-900 connector, STOLS Cable
Amphenol 31-2300 connector, GPS Antenna Faceplate
Pan Pacific TNC 3422 connector, GPS Antenna Cable

Teca thermo-electric cooler AHP-300FF/24 VDC

Gordos solid-state relay GF50D30

Dayton temperature controller 2E206

15 amp fuse and holder

Carlingswitch on/off switch RA 901/911 T85

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