PSPA PORTABLE CART AND OPERATION MANUAL

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16. Abstract

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PSPA Portable Cart and Operation Manual

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ABSTRACT

For the last ten years, the PSPA has been used on a number of concrete projects for estimating the modulus and strength of the slabs or for locating defects within the slab. The results of such studies have been documented in the reports for Projects 0-1735, 0-1700, 0-4188 and 0-4358.

Even though the data collection and analysis is reasonably rapid, the placement of the device from one point to the next as well as documenting the locations of the tests have been found to be cumbersome. In addition, to conduct all day testing, additional battery power is needed.

Under this project, a pushcart has been developed so that the PSPA can be placed on the pavement remotely and more securely. The pushcart is equipped with a GPS unit and a distance measuring instrument (DMI) so that the location of the device can be readily determined. The pushcart has been retrofitted with auxiliary power so that tests can be performed over a longer period of time without a need for changing or charging the batteries.

In this report, the characteristics of six aggregates are considered in multifaceted ways with emphasis on the geological, geotechnical and mix design. Based on a statistical analysis, several tests are proposed that should characterize the role of aggregates in the performance of the mixes. Parameters from some of these tests were then used in a micro-mechanical model to understand the performance of aggregates in different types of mixes.

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Chapter 1

Introduction

For the last ten years, the PSPA has been used on a number of concrete projects for estimating the modulus and strength of the slabs or for locating defects within the slab. The results of such studies have been documented in the reports for Projects 0-1735, 0-1700, 0-4188 and 0-4358.

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System Requirements

An Atmel microprocessor was used to interface the GPS and DMI components to the PSPA computer and a small program to display and store the GPS coordinates and DMI values was created using LabVIEW v6.0 software. The minimum requirements to connect the microprocessor and to execute the program are:

- IBM Compatible System,
- 128 Mb of RAM,
- Windows 95, 98, 2000 or XP,
- Pentium 3 or higher, and
- A spare USB connection.

Software Installation

The embedded microprocessor was programmed to behave as a Communications Device Class and as such it creates a virtual serial (COM) port which requires a device driver (at90usbxxx_cdc.inf) the first time the microprocessor is connected to the PSPA computer.

The GPS-DMI software was developed with LabVIEW v6.0 and is distributed in an executable installation package that does not require any licensing. One installation package (11.9 Mb) includes the LabVIEW v6.0 Runtime Engine which is needed in computers that have not had a LabVIEW stand alone executable previously installed in them. A second installation package that does not include this Runtime Engine is much smaller (591 kb) but can only be used if a previous installation of this or other LabVIEW v6.0 program has been done. Each package contains two files: a SETUP.EXE file and a DATA.001 file. Execute the setup program to begin the installation sequence. It is recommended to keep the default values to all the questions asked during installation in case of future upgrades or software maintenance.

Chapter 2

Cart Construction Details

The PSPA cart was built primarily with aluminum to ensure a light weight and strong construction. The initial cart design was to have a pneumatic lift mechanism, but after careful consideration of the pros and cons of such mechanism, it was decided to build the lift mechanism using an electric motor. The main reason for this change was battery consumption. While the pneumatic mechanism required the almost constant running of a small compressor to maintain the needed pressure to raise the mechanism with the enclosed PSPA, the motor only needs to operate (utilize battery power) during the lowering and lifting action. Other change that was included in the present design was the inclusion of rotating casters in the front end of the cart. The initial design had pneumatic tires all around to give the cart traction on rough surfaces, however the four tires were fixed and that limited the cart's maneuverability. The casters in the front end allowed the cart more flexibility while the pneumatic tires in the back gave it the needed traction. Figure 2.1 shows the initial cart design proposed for this project.
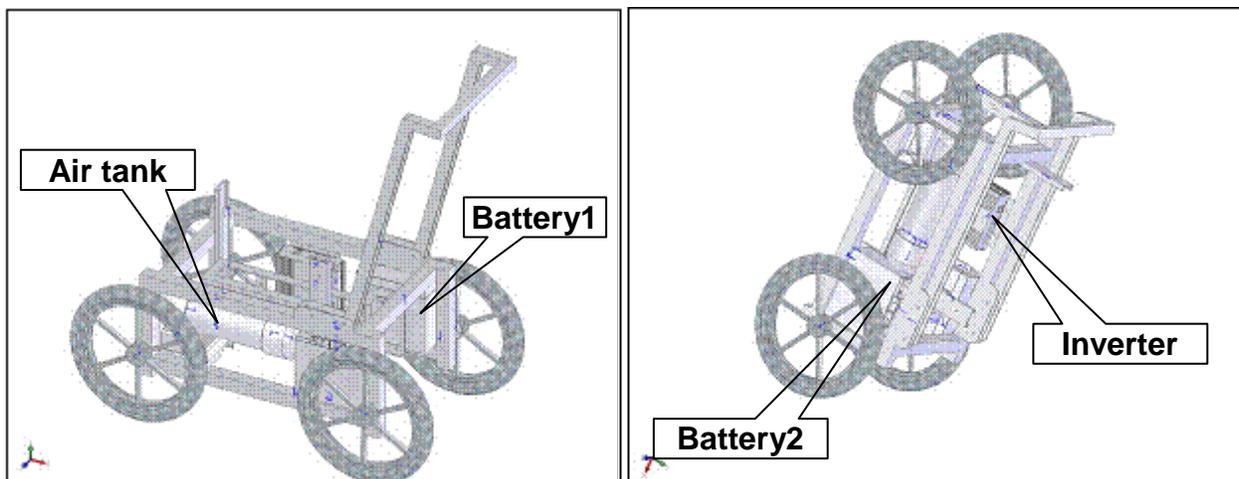

Figure 2.1 – Proposed Cart for project 1735-3.

Other important change was the placement and size of the batteries. As can be seen in Figure 2.1, the batteries are placed in the rear and were 14 lbs each. The placement was changed because their

weight was actually needed in the front to ensure the PSPA maintained contact evenly when lowered. The weight of the batteries was considered excessive and after trying smaller batteries, it was determined that the 6 lbs batteries would provide sufficient power to satisfy the project requirement.

Folding Handle and Laptop platform

The cart has a folding handle which gives it a compact 24 in. in length, 14. in. in width and 14 in. in height when folded. The handle is attached to the cart by two aluminum angle hinges welded to the cart frame on the sides and a center fixture that serves as an adjustable hinge. The angle on the handle can be adjusted by aligning the teeth on the center hinge and affix it by tightening the wing nut which is part of that same fixture.

The handle includes a built-in platform for laptop placement. The platform was designed to allow the computer to remain on it, even when the handle is folded down. This allows the user to carry all the needed items for PSPA data collection within the cart. The platform is constructed with a cooling pad; which allows the laptop to remain cool during extended periods of operation. The cooling pad was initially powered through the USB port but was modified to utilize the PS2 port instead. That change freed the two USB ports from the laptop one of which will be used to interface the GPS and DMI attachment.

Figure 2.2 – Laptop Platform/Cooling Pad without and with laptop.

As depicted in Figure 2.2, the top of the handle has the controller box for the lift mechanism. The box is made of aluminum to ensure it will withstand the hardships of transport. It contains a snap-in rocker switch that minimizes the probability of incidental damage. There is also a two-color LED that displays the status of the lift mechanism. When the mechanism is in the down position the LED is red to warn the user against moving the cart while the PSPA is on the ground. When the mechanism is lifted the LED turns green during the lift portion and once is all the way up it goes off. This lets the operator know that the cart can be moved to the next point.

Batteries and Charger

The cart is also equipped with two Sealed Lead Acid (SLA) batteries which allow for safely transporting it (even on commercial aircraft) without the worry of acid leaks. These batteries are 12 Vdc-7.5 Ah, and at 6 lbs. each, are ideal in weight and are able to provide the power needed for the cart to operate continuously for at least 6 hours. SLA batteries are a special kind that requires a more precise charger than regular lead-acid batteries. DO NOT attempt to recharge these batteries with a regular 12 volt charger. The cart includes the required microprocessor controlled charger in one of the side enclosures. When the cart is not in use, the charger can be left plugged to an AC outlet without damaging or overcharging the batteries. Figure 2.3 shows one of the batteries and the charger.

Figure 2.3 – SLA battery and automatic charger.

The power of the batteries is routed through a three-way (ON-OFF-ON) rocker switch located in the back of the cart, below one of the angle hinges. As the description implies, the switch has three positions. The center position is the OFF position and no power flows in any direction. This is where the switch should be placed during transport. The switch is installed vertically, thus the other two positions would be top or bottom. When the top of the rocker switch is pressed, the system is powered up and all other components can be turned on to start acquiring data. When the bottom of the rocker switch is pressed the charger is connected to the batteries, can therefore be considered the charging mode for the cart.

Laptop DC inverter

In order to provide power to the laptop from the SLA batteries, a universal DC inverter was procured and is installed within one of the side enclosures. The universal inverter is a Targus model AC/DC 90u and provides enough power to the Panasonic laptop to extend its operation well beyond the capacity of its regular batteries.

A bracket was built to hold the inverter fixed and out of the way within a side enclosure. A hole in the back of the cart gives us access to the laptop power connection. Figure 2.4 shows the inverter with the included cables and tips.

Figure 2.4 – Targus AC/DC power inverter

GPS Holder

An aluminum holder was built to allow the GPS unit to remain stable and protected within the side enclosures. The holder has cutouts in the back to give access to the power-communications cable and to the external antenna connector. The holder swings out of the enclosure so that the user can slide the GPS unit and connect it before swinging it back within the enclosure. Figure 2.5 shows the GPS holder with the cable connections and inside the side enclosure.

Figure 2.5 – GPS Holder outside and inside enclosure

DMI attachment and bracket

The encoder procured for the DMI is a very basic unit; however, the wide thru-hole specification was precisely what was needed to allow the wheel shaft and nut to go through it freely. For the first

DMI, the holder was machined to place a bearing that would maintain the encoder wheel centered during cart wheel movement. An attachment was machined to fit into the inner wheel hub and ensure the cart wheel and encoder wheel moved in synch. A bracket to keep the encoder from spinning was machined as well. Figure 2.6 shows the encoder unit as shipped from the manufacturer.

Figure 2.6 – Encoder wheel holder and encoder IC element

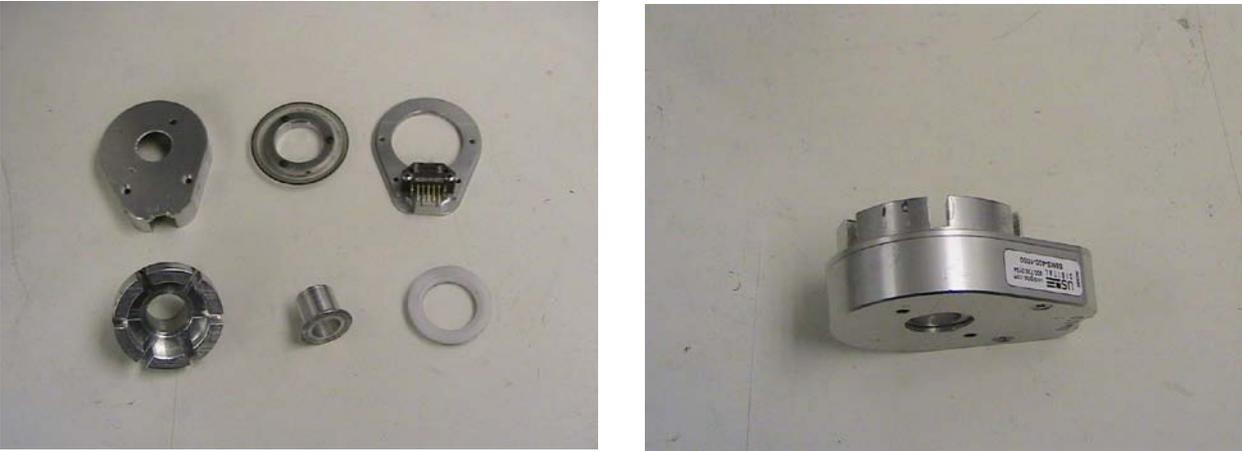

Figure 2.7 – Encoder after machining process

While the bracket setup worked adequately, the DMI was exposed and prone to impacts on the outside of the cart wheel. A second design was developed that would have the encoder permanently attached between the wheel and the cart, thus protecting during cart operation. Figure 2.7 shows the second DMI version after the machining process was finished.

Embedded Microcontroller

The microcontroller used to interface the GPS and DMI through the computer's USB port is an Atmel AT90USBKEY. The unit is compact and has headers to all its available ports; however, it lacks any physical connections to these ports. For that reason, a small interconnection board was built to have the serial connector for the GPS, and a latched, snap-in connector for the DMI. The two boards were placed in a small enclosure box to protect them from accidental grounding. Figure 2.8 shows the microcontroller and interconnect board outside and inside the side cart enclosure.

Figure 2.8 – Microcontroller and interconnect boards

Completed PSPA Cart

Figure 2.9 displays the completed PSPA cart with the handle in the extended and folded positions. Notice that in the folded position the laptop is secured on the laptop platform. Also
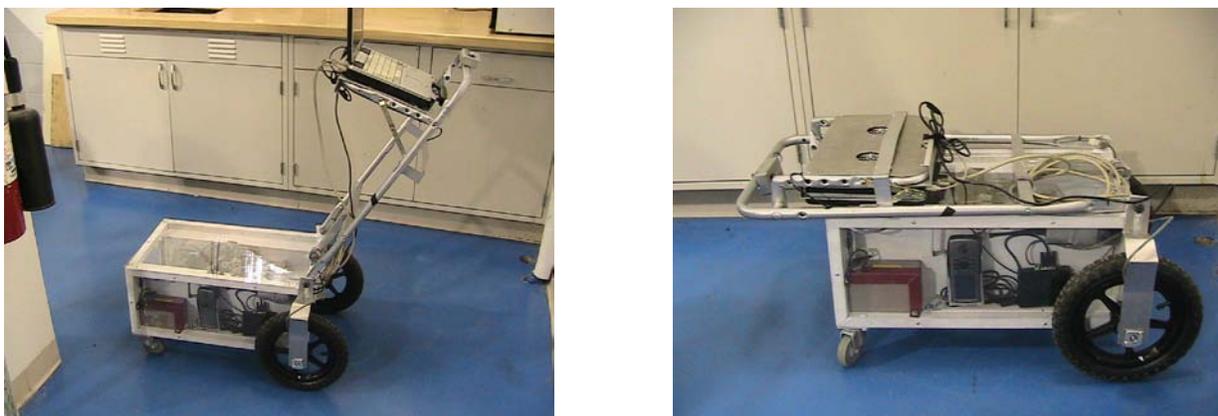
shown are clear polycarbonate sheets protecting the cart's side enclosures and top.

Figure 2.9 – Completed PSPA cart with handle extended and folded

CHAPTER 3

Cart Operation

Laptop and PSPA Setup

The following series of steps assumes the cart and PSPA components are carried separately to the test site to minimize the risk of damaging either during transport.

The first step after arriving to a site is to setup the PSPA computer on the cooling platform. To do this, adjust the handle to an angle that is comfortable for the user. After that, bring up the laptop platform and slide the computer in place. Attach the side brackets to the laptop to ensure it remains safely on the platform. Connect the PS2 connector to the laptop to provide power to the cooling pad. Connect the PSPA cable, and the power connection from the DC power inverter. Connect the microcontroller USB cable to the corresponding USB port. Figure 3.1 displays the needed connections on the back of the PSPA computer.
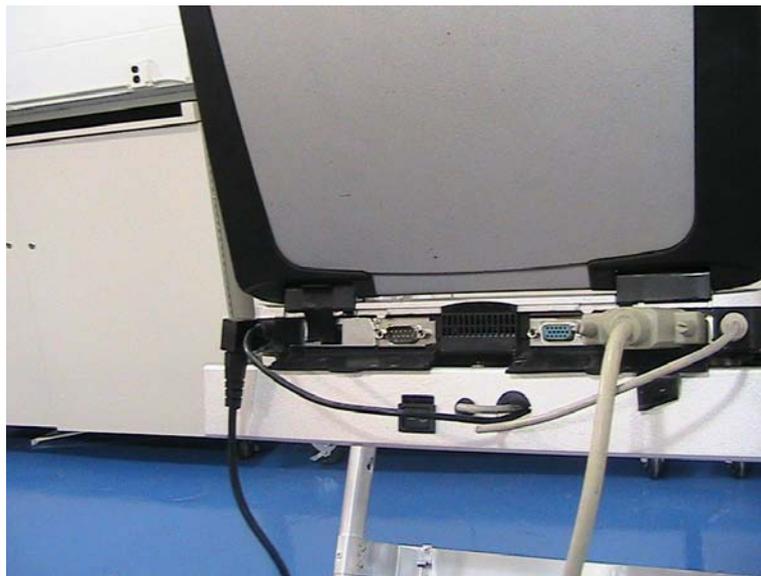

Figure 3.1 – PSPA laptop on platform with required connections

The next step is to place the PSPA into the lowering enclosure. First, remove the two thumbscrews that hold the back panel of the enclosure. Slide up the back panel to remove it. Insert the PSPA cable through the front section of the enclosure and then attach it to the PSPA. Slide the PSPA in the enclosure pulling the cable through at the same time. Make sure the PSPA sensor cables (yellow cables) do not get snagged with the enclosure edges during this process. The enclosure was built specifically for the PSPA and it should fit snuggly around it. Ensure the PSPA is all the way in, replace the back panel and tighten the thumbscrews. Figures 3.2, 3.3, 3.4 and 3.5 depict the previous steps.

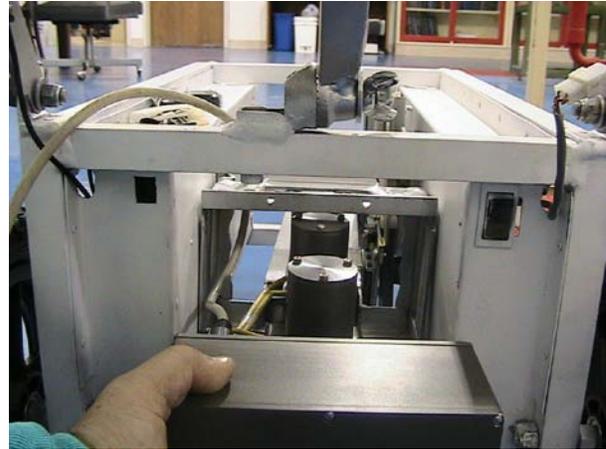Figure 3.2 – Removing Back Panel

Figure 3.3 – Sliding PSPA into Enclosure
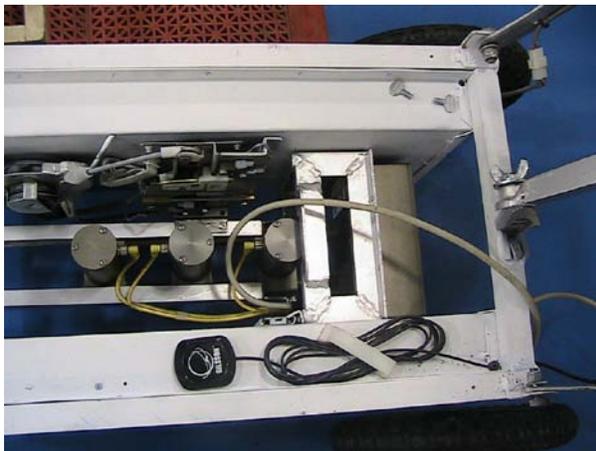
Figure 3.4 – Pulling PSPA cables
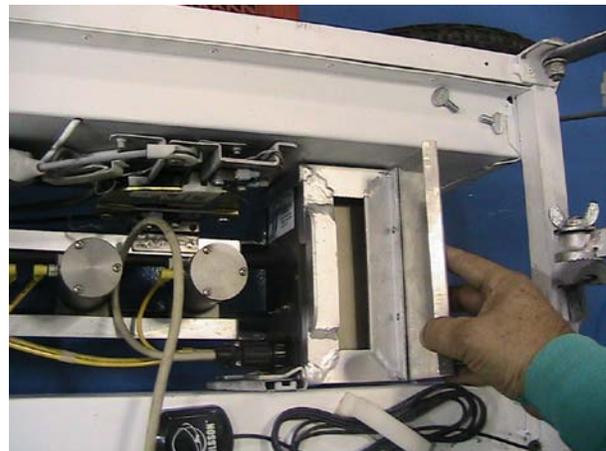
Figure 3.5 – Replacing Back Panel.

The length of the PSPA cable is helpful when the user does manual data collection; in this case however, its length appears to be cumbersome. A simple solution is to gather the cable in a loop and using the Velcro strap, attach it to the cart handle to keep it out of the way during the data collection process. For better results, the cable should have just enough slack to allow the PSPA to travel up and down without putting any strain on the cable connections.

GPS Setup

The cart is equipped with two position measurement devices: a global position system (GPS) and a distance measuring device (DMI). The GPS is a GPSMAP 76CSx model from Garmin and is accurate to within 3-5 meters in differential mode. While this accuracy only gives a general location for a test site, it does serve its purpose. The DMI will gives the accuracy needed to precisely define and locate test points throughout the test site.

The cart has a GPS holder in one of the side aluminum enclosures. The initial idea was to have this holder in a position that the user would be able to directly observe the GPS information, but after considering the possibility of damage to the GPS from sun or water exposure, it was decided that it would be better protected within one of the cart enclosures. Since the side enclosures are built from aluminum and the GPS signal is dramatically attenuated when there is no direct line-of-sight path to the satellites, an external antenna for the GPS was affixed to the top of the cart. Power for the GPS is also supplied by the two batteries as soon as the three-way switch is set to the top position, so the user can turn on the GPS unit immediately after. The GPS will take several minutes to lock onto the satellites and send this information to the microcontroller.

Figure 3.6 – Inserting the DMI in the wheel hub and DMI after installation

DMI Setup

As mentioned before, the cart has a DMI device which had both hardware and software put together in-house at UTEP. The hardware component is an encoder model E6MS-400-1000 from US Digital. The selected encoder provides 400 pulses per revolution, which when attached to the 12" diameter rear wheel will give us accuracy to within one tenth of an inch. The encoder had to be machined and an attachment built to retrofit it to the cart wheel. The installation of the DMI is done by simply aligning the grooves in the encoder attachment to the wheel inner-hub spokes and gently pushing until the attachment is inserted. Next, snap-in the DMI connector and slide wheel, DMI and axle bolt into position. Tighten the locknut to a snug fit and ensure the wheel turns freely. The DMI was designed to be permanently attached to the cart, so a light coat

of medium strength threadlock is recommended. Figure 3.6 displays the DMI during and after installation.

Microcontroller Setup

The microcontroller should always remain within the cart side enclosure. The only thing the user needs to do is to ensure the connections to the GPS, DMI and USB cable are properly done. As soon as the computer is powered up, it will supply the power to the microcontroller. The controller will automatically look for information coming into its ports and place it in the USB bus. Once the PSPA computers initializes, execute the DMI-GPS program and establish communication with the microcontroller. The information displayed will be updated every half second, so that if the cart moves while the DMI is attached, this motion will be reflected; if the GPS is connected and has position lock, the latitude and longitude will be updated as well.

Software Setup

The final step to start collecting data is to run both the GPS-DMI program as well as the PSPA program. During trial tests both program run simultaneously without any discernible reduction in computer performance or of one program interfering with the other. Figure 3.7 shows a screenshot of both programs running at the same time. Both PSPA data and position information are collected for each and every point. The GPS data will appear at the bottom of the PSPA software screen and the DMI reading appears in the information box called "DMI." When available, both the GPS coordinates and the DMI reading will appear in the "Report Notes" tab.
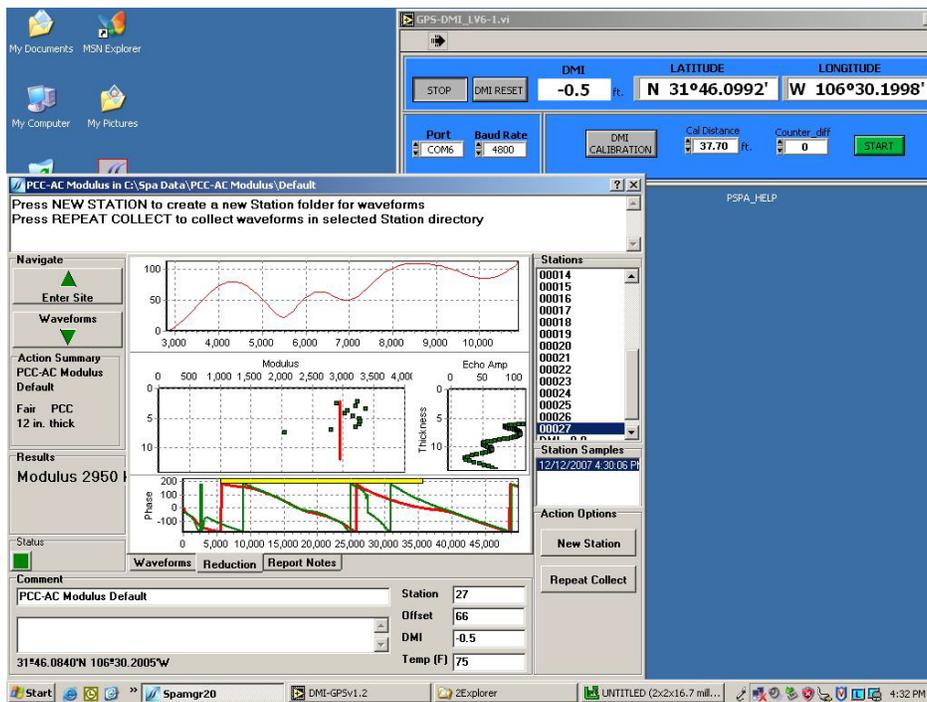

Figure 3.7 – PSPA and DMI-GPS running simultaneously in a computer

Collecting Position Information

The program used to collect position information is depicted in Figure 3.2. There are three sections in the program as delineated by the boxes. The top box displays the position information and allows the user to reset the DMI before starting data collection and to connect the program to the microcontroller. The program creates a temporary file that is updated every second and which the SpaMgr20 program reads every time a new station is created.
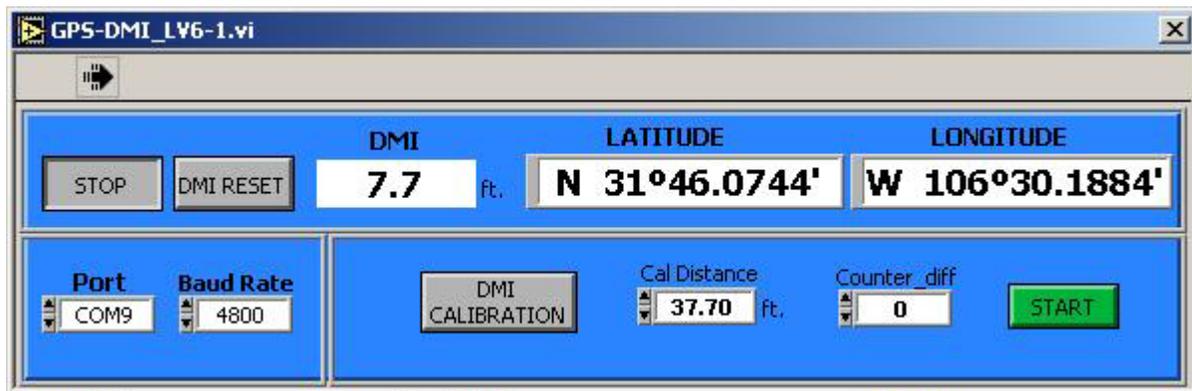

Figure 3.2 – Program used to collect cart position information.

The bottom box on the left allows the user to set the parameters to establish communication with the microcontroller. To do this, first select the virtual communications port that is created when the microcontroller is connected to the computer and set the appropriate Baud Rate from the GPS. To find the port number, the user will need to open the Device Manager window and expand the Port (COM & LPT) device to locate the AT90USBxxx CDC USB to UART MGM (COMx) device. The x in the previous description stands for the port number the system created. This step needs to be done only once, since the port number for each computer will remain the same as long as the microcontroller is connected to the same USB port each and every time. Figure 3.3 displays a typical Device Manager window with the microcontroller port highlighted.

The bottom box on the right, allows the user to calibrate the DMI as needed. The initial calibration value used to calculate distance is a nominal value based on the rear wheel diameter. When the DMI CALIBRATION button is pressed the controls in the other boxes are disabled. The calibration process requires the use of a previously measured distance with defined endpoints. Set the cart at the starting point, enter the measured distance in the Cal Distance box and click on the START button. Move in a constant, steady fashion towards the endpoint and once it is reached click on the STOP button. The user may now click on the DMI CALIBRATION button to enable the other controls and continue with the data collection.
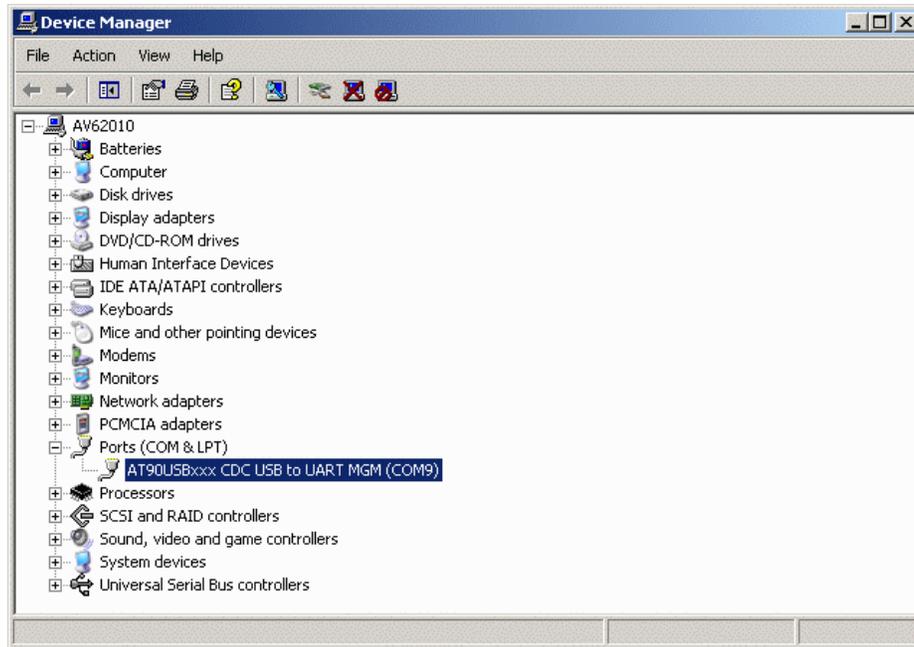
Figure 3.3 – Device Manager Window displaying microcontroller port

Appendix A

Parts List

Part #	Qty.	Vendor	Description	Unit price	
	20'	Armor metal	1" aluminum square pipe		
	2	Armor metal	1/16" aluminum sheet 15"x30"		
40148	2	Northern tool	12 1/2" x 2 1/4" 5-spoked wheel	8.99	17.98
189911	2	Northern tool	3" Swivel Plain Bearing, Non-marking caster	2.99	5.98
N491711	1	Parts Train	Rear Window Regulator w/motor	69.95	69.95
AT90USBKEY-ND	1	Digi-key	Kit Demo for AT90USB	31.92	31.92
TR7.5-12A	2	Batteryspec	Tempest Sealed Lead-acid AGM Battery	16.60	33.20
BC-12-1250	1	Batteryspec	Tempest Battery Optimizer	32.50	32.50
NC-500	1	2cooltek	Bytecc Aluminum Notebook Cooler	14.95	14.95
APM12US	1	Compusa	Targus Universal AC/DC Power Adapter	119.99	119.99
GPSMAP 76CSx	1	TheGPSstore	Garmin Color Handheld GPS	449.95	449.95
Gilsson R12C	1	TheGPSstore	PC/12 volt combo cable	24.95	24.95
Gilsson MCX	1	TheGPSstore	amplified antenna w/9' cable	29.95	29.95
E6MS-400-1000	1	US Digital	Shaft mount optical encoder 1"diam shaft	93.70	93.70
Con-FC5-24	1	US Digital	Finger latching connector	3.15	3.15
733024	1	Jameco	100' 3-conductor unshielded cable	30.15	30.15
733083	1	Jameco	100' 5-conductor unshielded cable	40.39	40.39
24811	1	Jameco	ic driver/rec max232cpe 5v	2.59	2.59
545596	5	Jameco	cap, tant,radial 1uF, 35 vdc	0.20	1.00
104943	1	Jameco	Right Angle PC Mount DB9 Male	0.61	0.61
11957	1	Jameco	Aluminum Case 3.9"x2"x1"	5.95	5.95
675471	1	Jameco	Hi-impact ABS plastic enclosure	4.75	4.75
224400	7	Jameco	receptacle 2-circuit connector	0.33	2.31
224485	7	Jameco	plug 2-circuit connector	0.30	2.10
224442	1	Jameco	receptacle 6-circuit connector	0.54	0.54
224522	1	Jameco	plug 6-circuit connector	0.45	0.45
224565	20	Jameco	.062" contacts male	0.18	3.60
224557	20	Jameco	.062" contacts female	0.18	3.60
836959	10	Jameco	.250" insulated receptacle red	0.21	2.06
841264	10	Jameco	.250" insulated receptacle blue	0.19	1.86
159581	2	Jameco	switch, vs micro	2.45	4.90
159581	2	Jameco	switch, vs micro	2.45	4.90

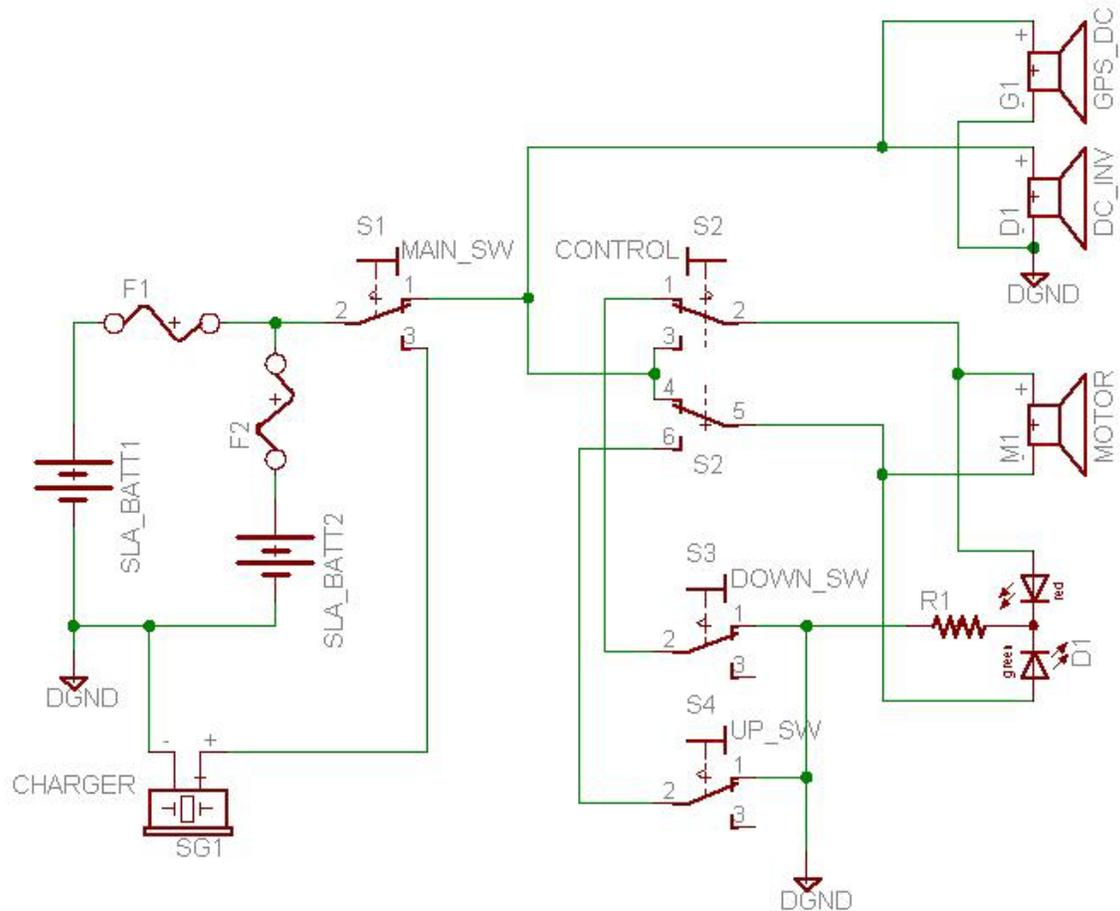| Part #	Qty.	Vendor	Description	Unit price	
617166	1	Jameco	dpdt, on-on, mini rocker switch	2.19	2.19
34673	1	Jameco	LED RED/GREEN	0.29	0.29
152726	1	Jameco	4-pin right angle header	0.55	0.55
152733	1	Jameco	single connector w/latch	0.37	0.37
181673	10	Jameco	female pins	0.11	1.10

Table A.1 – Cart Parts List

Appendix B

Wiring Diagram

Figure B.1 – Wiring Diagram