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Windows-based PDAs For Emergency Service Patrol

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16. Abstract

The New Jersey Department of Transportation (NJDOT) Traffic Operations South had a need for efficient paperless case data entry solutions for their Emergency Service Patrol (ESP) personnel, to capture and collect traffic incidence assistance data. Currently, the paperless data entry system has been developed and implemented in the NJDOT Traffic Operations South ESP Team. The system uses Windows-based PDAs by Hewlett-Packard and custom developed software to collect the field data in the electronic format and then upload it into the centralized database for analysis and reporting.

NJDOT Traffic Operations North ESP team requires the customization and integration of the similar solution into its infrastructure. NJDOT Traffic Operations South ESP team requires observation of its paperless data entry system for one year, in order to identify system bottlenecks, develop solutions for them and investigate various way to improve system features, such as multimedia databases, integration with GPS/GIS, advanced reporting/alarm capabilities, etc.

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EXECUTIVE SUMMARY

The New Jersey Department of Transportation (NJDOT) Traffic Operations had a need for efficient paperless case data entry solutions for their Emergency Service Patrol (ESP) personnel. The traffic incident assistance logs were created using paper forms, which resulted in an unnecessary workload for database operators. Also, this substantial number of forms (about 400/day) exceeded the data entry capabilities of the departmental database operators, thus creating significant backlogs and delays. Researchers from Rutgers University Center for Advanced Infrastructure and Transportation developed and implemented the paperless data entry system for the NJDOT Traffic Operations South ESP Team in Year 1 of this project. The system used Windows-based PDAs by Hewlett-Packard and custom developed software to collect the field data in the electronic format and then upload it into the centralized database for analysis and reporting. The solution completely eliminated the data entry backlog, significantly simplified the incident data collection system, dramatically increased accuracy of the collected data and made the entire logging/reporting process very user-friendly. In Year 2 of the project the PDA-based paperless data collection system was updated and improved based on field usage experience by ESP South in Year 1. The second release of the system was implemented statewide.

BACKGROUND

The New Jersey Department of Transportation (NJDOT) Traffic Operations South had a need for efficient paperless case data entry solutions for their Emergency Service Patrol (ESP) personnel. The ESP personnel patrol designated areas throughout the State of New Jersey for the purpose of performing emergency services for motorists encountering minor and major accidents or incidents. At each accident scene or incident, a case description form is filled out by members of the ESP team, which includes data on motorist vital information, road conditions, etc. The existing data entry form that is used by the ESP team is paper-based and is submitted at the end of the work shift. The data entry operator then enters this information into the central database, where the information is collected for further analysis. The use of paper forms created an unnecessary workload for database operators. Also, this substantial number of forms (about 400/day) exceeded the data entry capabilities of the departmental database operators, thus creating significant backlogs and delays. Currently, the paperless data entry system has been developed and implemented in the NJDOT Traffic Operations South ESP Team. The system uses Windows-based PDAs by Hewlett-Packard and custom developed software to collect the field data in the electronic format and then upload it into the centralized database for analysis and reporting.

NJDOT Traffic Operations North ESP team requires the customization and integration of the similar solution into its infrastructure. NJDOT Traffic Operations South ESP team requires observation of its paperless data entry system for one year, in order to identify system bottlenecks, develop solutions for them and investigate various way to improve system features, such as multimedia databases, integration with GPS/GIS, advanced reporting/alarm capabilities, etc.

OBJECTIVES

The project was divided into four main objectives:

I. **Environment and Technology Research.** At this stage, NJDOT Traffic Operations North ESP structures (organizational, geographical, information, etc.) will be studied along with the survey of current state-of-the art in PDA technology. The data and experience from Year 1 will be fully employed at this stage: decisions will be made based on investigation of ESP North needs, technology review done for ESP South, updated technology review and observations of working ESP South data collection system.

II. **Development.** At this stage, PDA software and Master Database will be modified based on results of Stage I.

III. **Deployment and Training.** Upon completion of Stage II ESP North incident reporting will be migrated to the new PDA-based paperless system. Training will be provided to ESP Team members. Optionally, training will be provided to designated personnel who are responsible for the maintenance and troubleshooting of the PDA-based system, as it interfaces with the central server.

IV. **Observation and Support.** Throughout the course of the project both ESP South and ESP North systems will be under observation. The emerging technical issues will be investigated and addressed as they come up. Additionally, a research will be conducted on further improvements of the system: resolving bottlenecks, integration with GPS/GIS, etc.

INTRODUCTION

The Center for Advanced Infrastructure and (CAIT) at Rutgers, the State University of New Jersey proposed the development of hardware/software solution to address the needs of NJDOT Traffic Operations Emergency Service Program. The proposed solution utilized Windows-based PDA's to enter and stored ESP incident forms in an electronic format. The Interactive incident forms were developed as a stand-alone PDA software application. The application collected incident data and store it in the PDA's external flash memory as a database. The PDA database was imported into the central database of NJDOT Operations. The user data was imported by synchronizing the PDA with the client PC, along with the computer-to-computer data transfer into the server.

In addition to the dramatic reduction of workload for database operators, the PDA solution had several major advantages over traditional paper-based processes that include the following:

1. Ability of the PDA to execute custom software makes the ESP form "smart". The PDA form can suggest possible data entries instead of making user write/type them in. For example, the name of the PDA owner may be stored in the PDA, thus eliminating the need to write it in each case form. Obviously, this offers substantial reduction of time, required to fill out the form.

2. Increasing the saving of time through the multi-functional use of the PDA. For instance, the beginning and ending times of the emergency service is recorded and auto-inserted by the PDA's internal clock and accomplished with a single click, instead of the ESP having to input the time from his watch on a form.

3. Multimedia capabilities of Windows-based PDA's would be very helpful when an ESP needs to record notes, while performing field tasks. For example, an ESP can record a voice note, which can be played and transcribed at a later time.

4. Storing incident data in the database will allow information to accumulate between 1-2 days and then having it submitted to a central database as a "batch", when necessary.

5. Compiling database files in flash memory enables data storage power to be independent. In other words, if the PDA battery runs out, no case data is lost.

SUMMARY OF LITERATURE REVIEW

The technology survey was compiled, which described state-of-the-art PDA technology and selected “optimal” PDA configuration for the purpose of in-field emergency incident data acquisition by Emergency Service Patrol Team of NJDOT Traffic Operations. The excerpts from the survey are included below.

Objective

Our primary objective is to survey state-of-the-art PDA technology and select “optimal” PDA configuration for the purpose of in-field emergency incident data acquisition by Emergency Service Team of NJDOT Traffic Operations North and South.

Approach

The PDA market is quite involved and offers a wide selection with devices of different levels of performance, various feature sets and pricing. Similar to Year 1, our approach when selecting a PDA is feature-based: we identify PDA features that are valuable in our application, evaluate the “importance” of each feature by assigning it a “weight”, and rate the PDAs based on those features. We then acquire the three PDAs with the highest ratings and perform “hands-on” analysis to select an “optimal” model. In Year 2, we updated the selection of features and PDA models based on performance of PDAs used by ESP South.

Laptop, Tablet PC or PDA?

Today’s computer market offers a great variety of computing devices: from room-sized supercomputers to palm-sized PDAs. In this survey we will attempt to choose the device optimal for our needs of in-truck data collection. Seemingly easy, this task may sometimes become quite difficult, due to the above-mentioned variety. Below we provide short reviews and comparisons of three main types of mobile computing devices: Laptops, Tablet PCs and PDAs in scope of their use in the mobile environment.

Table 1. Comparison of Laptops, PDAs and Tablet PCs.

	Laptop	**PDA**	**Tablet PC**
Mobility (size, weight)	Somewhat mobile - size of a large book, fits in bag	Very mobile – palm-sized, fits in pocket	Somewhat mobile – size of a large thin book
Display	12" – 15" 1024x768 – 1450x1200	3.5" – 3.8" 320x240 – 640x480	12" – 15" 1024x768 – 1450x1200
Autonomous power	Rechargeable battery – 1-7 hours	Rechargeable battery – 2-5 hours	Rechargeable battery – 1-5 hours
Selection of protective accessories	Average: not much is offered for regular commercial notebooks, military "protected" notebooks are very expensive	Excellent: a good selection of plastic, metallic and rubber protective cases, some of them airtight and/or waterproof.	Average.
Functionality	Extensive: offers a selection of programs and hardware to perform various tasks, can run heavy applications – graphics, multimedia, data processing.	Good: a wide selection of software and hardware to customize feature set. Is not recommended for computationally heavy tasks, but perfect for a wide range of simpler tasks.	Extensive: same as laptops.
Expandability	A wide selection of expansion devices of various standards: serial, parallel, USB, PCMCIA, Bluetooth, infrared (IrDA).	A wide selection of expansion devices of various standards: CF, SDIO, Memory Stick, Bluetooth, infrared (IrDA).	Same as laptops.
Information input	*Built-in*: Keyboard, mouse, touchpad *Add-on*: touch screen, joystick, etc.	*Built-In*: Touch screen *Add-On*: keyboard	*Built-in*: Keyboard, mouse, touch screen *Add-on*: joystick, etc.
Price	$800-$4000	$100-$600	$1200-$3500
Great for:	Work "on-the-go": virtually all computer-based activities (e-mail, word processing, graphics design, etc.), especially when large data storage (gigabytes) is required. Can be used by anyone who needs a mobile computer.	In-field data collection, wireless data exchange, organizer, sound recorder/player, GPS navigation, storing and reading a collection of reference materials.	Work "on-the-go" when large screen, high-capacity storage (hard drive) and high mobility are a must, and stylus input is highly desired.
Used by:	Office workers, software developers, home users, salesmen.	Medical personnel, military, traffic engineers, home users, police.	Sales personnel, medical personnel.

Having reviewed the pros and cons of laptops, tablets and PDAs we have come to the conclusion that PDAs are the optimal choice for our application for the following reasons:

- PDAs are very compact and easy to carry and manipulate – one can just it take out of his pocket, hold it with one hand and use the stylus with the other hand. No special PDA mount is required, neither is a special posture for working with PDA – the user may be standing or sitting. This is not the case with laptops, which must be placed on some sort of "desk" surface to be used comfortably. Tablet PCs are similar to PDAs in this aspect, but are much bulkier and heavier.

- It is easy to find a "ruggedized" protective case for the PDA, and those cases are much cheaper than Laptop or Tablet cases, because they are smaller and making them is easier – PDAs don't have many buttons. In addition PDAs themselves do not have many moving parts and therefore are more durable.

- PDAs are much easier to use in cars. Limited space inside the car makes using laptops inconvenient.

- PDAs are much cheaper – the most expensive PDA is cheaper than the least expensive Laptop or Tablet. The same holds for accessories. A mid-range PDA, good for data collection, costs around $300-400, whereas a Laptop used for similar purposes would cost $800-1000. We consider the price to be an important criteria because of the following:

    - When performing data collection, multiple units must be purchased. If they are too expensive, the organization may not be able to afford them.
    - The devices may be used in harsh environments – cold, heat, rain, snow, physical impacts, etc. Even protected, this increases the chances of physical damage, which in many cases renders the device completely un-recoverable. It is much cheaper to replace a PDA than a laptop or a tablet PC.
    - From time to time accessories must be purchased. For example, batteries tend to loose their capacity with time and must be replaced. This defines the maintenance cost, which for the PDA appears to be significantly smaller due to the lower price for accessories.

Palm vs. Pocket PC

In today's PDA world there exists a choice of several platforms, out of which two can be identified as main rivals: Palm and Pocket PC. Palm PDAs are based on the PalmOS operating system, and Pocket PCs run on Windows CE. We compared these two platforms and chose to use Pocket PCs, mainly for their native integration with Microsoft Windows environment and wider selection of devices. Reader can refer to Year 1 Technology survey for detailed comparison of two platforms.

Feature Review

According to our feature-based approach, we start with identifying the feature requirements imposed by NJDOT's Emergency Incident Management problem set and field environment. We explain and "weigh" each key feature on a scale of 0 (not important at all) to 10 (extremely important), and use them to select the device, which would best satisfy NJDOT's requirements. Below, we identify several key features and study them in more detail. Compared to Year 1 Survey, the feature set below is different – new features, such as screen size, have been added, and some features have been removed (availability of car chargers, styli). The feature values have also changed.

Table 2. List of important PDA features

	Feature	Weight
1	Processor Speed	5
2	Memory Size	7
3	Screen Size	6
4	Wi-Fi	6
5	Bluetooth	6
6	Compatibility with Otterbox Armor 1900 Case	10
7	Expansion Cards	8
8	Price	10

Feature-based PDA comparison

We selected a number of popular PDAs available on the market and performed comparative study by means of comparison matrix. When selecting PDA models we concentrated on manufacturers that are popular in the US, as we expected higher level of technical and customer support for them. Since Year 1, many changes have occurred: major PDA manufacturers Sony and Toshiba left the PDA market, and model lines of the remaining major PDA makers Dell and HP have changed significantly. All PDAs reviewed in Year 1 have been disonctinued.

First, we summarized features of each model, and then rated them based on our feature set. Each feature was assigned a value from 0 (extremely poor) to 10 (excellent). The feature value was then multiplied by its weight and all weighted feature values were averaged, resulting in the rating of a PDA device. The comparison matrix is shown below.

Table 3. Feature-based PDA comparison

Model	CPU	Memory	Screen	Wi-Fi	BT	Case	Cards	Price	SCORE
HP iPAQ hx2710	10.00	10.00	3.00	10.00	10.00	10.00	10.00	0.83	**5.45**
HP iPAQ hx2410	8.33	5.00	3.00	10.00	10.00	10.00	10.00	2.50	**5.12**
HP iPAQ hx4700	10.00	5.00	10.00	10.00	10.00	6.00	10.00	0.00	**4.94**
Dell Axim X50v	10.00	7.50	5.80	10.00	10.00	3.00	10.00	0.15	**4.49**
Dell Axim X50 520 MHz	8.33	7.50	3.00	10.00	10.00	3.00	10.00	1.86	**4.38**
HP iPAQ hx2110	5.00	5.00	3.00	0.00	10.00	10.00	10.00	4.17	**4.37**
HP iPAQ rz1710	6.41	2.50	3.00	10.00	10.00	6.00	5.00	5.84	**4.26**
HP iPAQ 5150	6.41	2.50	7.20	0.00	10.00	10.00	5.00	2.06	**3.85**
Dell Axim X30 - High-End	10.00	7.50	3.00	0.00	10.00	3.00	5.00	4.40	**3.62**
Dell Axim X50	6.67	5.00	3.00	0.00	10.00	3.00	10.00	3.56	**3.52**
Dell Axim X30 - Mid-End	5.00	5.00	3.00	0.00	10.00	3.00	5.00	5.25	**3.19**
Dell Axim X30 - Lo-End	5.00	2.50	3.00	0.00	0.00	3.00	5.00	6.61	**2.39**

Two models of HP's iPAQ hx2000 series top the list, offering high computational power, variety of networking options and excellent compatibility with Armor 1900 protective case at moderate price. Pocket PCs by Dell, although offering comparable features, fall behind due to incompatibility with the Armor 1900 case: Serial Pod was not available for Dell-manufactured PDAs due to the lack of serial connection in the synchronization port. Rewiring the Serial Pod to make it compatible with Dell PDAs is possible but is very tedious and time- and labor-intensive.

"Hands-On" PDA Comparison

We acquired several PDAs, as "representatives" of their family, and performed "hands-on" comparison. The PDAs we selected were: HP iPAQ hx2410 and HP iPAQ hx4700. Below are our "hands-on" comparative reviews.

Figure 1. "Hands-on" comparison PDAs.

Table 4. Summary of “hands-on” comparison PDA specifications.

Features	HP iPAQ h2410	HP iPAQ hx4700
Operating System	Microsoft® Windows ® Mobile 2003 Second Edition	Microsoft® Windows ® Mobile 2003 Second Edition
Processor	Intel® XScale™ Processor 520 MHz	Intel® XScale™ Processor 624 MHz
RAM	64 MB SDRAM	64 MB SDRAM
ROM	64 MB Intel StrataFlash® ROM	64 MB Intel StrataFlash® ROM
Screen	3.5" 240x320 TFT QVGA Screen, 65,000 colors Supports landscape and portrait display modes	3.8" 480x640 TFT VGA Screen, 65,000 colors Supports landscape and portrait display modes
Expansion Slot	1 Secure Digital / SDIO Now! / MMC (3.3v) 1 Compact Flash (CF) Types I/II	1 Secure Digital / SDIO Now! / MMC (3.3v) 1 Compact Flash (CF) Types I/II
Bluetooth	Integrated	Integrated
Wi-Fi	Integrated	Integrated
Infrared	Standard v1.2 (115 kbps) Infrared Port	Standard v1.2 (115 kbps) Infrared Port
Battery	Removable, Rechargeable 1440 mAh Lithium-Ion battery	Removable, Rechargeable 1440 mAh Lithium-Ion battery
Extended Battery	Removable, Rechargeable Extended Lithium-Ion battery	
Car Charger	iPAQ™ Universal auto power adapter	
External Keyboard	iPAQ™ Foldable keyboard	
Audio	Audio Controller AC-97 Codec Chip	
Microphone	Integrated Microphone and Speaker	
Navigation	5-way Navigation button Scroll Dial - Up, Down, Action 4 Program Buttons: Calendar, Contacts, Inbox, Home Reset Button Backlit Power Button, Record Button	
Dimensions	Length 4.71 in Width 3.01 in Height .65 in	Length 4.30" (closed) Width 3.0" Height 0.66"
Weight	5.8 oz	5.5 oz
Price	$379	$579

HP iPAQ h2410

Introduced in winter of 2005, this mid-size mid-range PDA is next generation model of its "instant bestseller" predecessor iPAQ 2210. HP introduced its three models of h2200 series (h2010, h2410 and h2710), aimed to cover all the needs of mid-range PDA market. The starter model h2010 has very similar feature set almost identical to that of 2210 with an addition of a faster CPU - 524 MHz vs. 400 MHz on iPAQ 2210. The middle model 2410 carries more memory and has built-in Wi-Fi wireless networking adapter. The high-end 2710 offers fastest processor and huge amount of memory.
Not only "internal features" were improved. The PDA went through some major external modifications as well. The case was changed from light-gray to dark-grey anodized aluminum, the buttons became angular instead of round, the navigation button became rectangular with the separate "action" button in the center, and two removable rubber grips on the sides were replaced by non-removable flat rubber grips. In addition, the PDA got a plastic flip screen protector. Overall, the external modifications significantly added to the physical sturdiness of the PDA and made it look much more elegant. Apparently, HP took a lot of customer feedback into consideration, judging by redesign of rubber grips (old ones used to fall of often) and the action button (in old design it was easy to press "up", "down", "left" or "right" instead of "action").
Out of three models, we chose 2410 for a detailed review due to following reasons:

- It offered most balanced feature set, including all features we had and liked on 2210 plus the features we wanted on 2210. h2010 had too little memory and did not have Wi-Fi adapter. h2710 was too much – for our application, powerful processor and that much memory did not justify extra cost.
- Price wise it was comparable to 2210.
- It came in the "value package", with a travel sync cable, instead of a cradle, which we wished we had on 2210.

After few weeks of using, we loved the h2410. It felt very strong and lasting and perfectly fit all the protective cases we tried. Most accessories used with 2210 and 5550 were reusable with h2410. The battery had 50% more capacity than 2210, which made the PDA last longer without charge. The PDA did not have any protruding buttons on the sides, which could come in contact with the protective case. It has been experience from Year 1 that this may potentially lead to the PDA motherboard damage.

We think that HP iPAQ 2410 is the best candidate for use in our application. It provides everything we need in the PDA (CPU speed, memory size, SD and CF slots, Bluetooth, Wi-Fi). It is based on the successful HP 2210 series, which already proved itself a winner, and it feels physically sturdier, which is quite important for our working conditions.

HP iPAQ hx4700

iPAQ hx4700 is HP's top model and possibly the most equipped PDA on the market. It offers fastest CPU (624 MHZ Intel XScale), most memory (128 Mb), extensive networking connectivity (both Bluetooth and Wi-Fi) and, most of all, the large high-

resolution VGA screen. The traditional navigation button has been replaced with the touchpad, which can be used both in a traditional PDA way (4 navigation buttons + action button) and a notebook way (cursor positioning touchpad).
hx4700 is clearly a business-oriented model. Made of dark grey anodized aluminum in rectangular shapes, the PDA looks very elegant and well-built. The screen is magnificent – lager than other PDA screens (3.8" instead of 3.5") it offers 4 times higher resolution, which makes everything on it look very sharp. This PDA is definitely a market leader.

However, from the perspective of ESP field use, we were not in favor of this model, despite its most impressive characteristics:

- The screen was bigger, but not big enough. Although screen resolution quadrupled, the screen size, which is much more important to us, increased by only 7%.
- The power button was located on top surface of the PDA, instead of on front surface, as we would prefer.
- The touchpad buttons, which would be used to turn on the PDA while in the case, were hard to use through the protective plastic membrane. This could lead to use of excessive force when pressing them with subsequent PDA damage.
- The price was too high. It matched the PDA feature set well, but for our purposes, those features were not worth that much.

Conclusion: HP iPAQ hx4700 is an excellent PDA, possibly leading PDA in the market, but it is not the best PDA for us.

PDA Comparison Summary

All the devices offer comparable feature sets. However, even a subtle difference in features can make a big difference in the appropriateness of the device for our application. Below we review and discuss those "key" differences.

- Both PDAs offer two expansion cards, which may be very beneficial for future expansion. The SD slot will be used for storage memory expansion, to backup the EMS stops database and store GPS maps. Therefore, it becomes very attractive to have another expansion slot for other feature upgrades, such as CF GPS receivers, GPRS modems, digital cameras, etc. Axim X3i and Tungsten T3 offer only one SD expansion slot, which will be taken by storage memory card, preventing further functional expansions.
- Both PDAs offer both Wi-Fi and Bluetooth wireless connectivity. Bluetooth is used for short-range communication, such as connection with the mobile phones, GPS receivers, keyboards, etc. Wi-Fi is a long-range (up to 100') networking connection, which can be used to connect to NJDOT network to upload the stop data into the database.
- iPAQ h2410 is a better fit to the very attractive Armor 100 protective case.
-

iPAQ h2410 delivers balanced set of features at a moderate cost, while iPAQ hx4700 is very expensive, offering variety of extra features not required in our application.

Comparison of Cases

For the NJDOT Traffic Operations application, cases are of special interest, since the PDAs will be used “in the field”, in harsh conditions. Therefore, it becomes quite essential to select a case which provides a high level of protection to the PDA, without significantly obscuring its ergonomics. As we noted above, protection case selection was a highly-weighed feature for PDA rating. This year, we compared two cases: iPAQ Ruggedized Wireless Case offered by HP, and Otter Products Armor 1900 case. Both cases offer military-level protection (drop from 4 ft onto concrete, 10 min under water spray, 10 min under sand spray) and cost around $100.

HP iPAQ Ruggedized Wireless Case

This case is available as an accessory when purchasing the PDA directly from HP. The case is made of black plastic. The PDA is secured inside the case using a protective rubber “insert”, inside of which is custom for a specific PDA model, and outside fits tightly into the plastic protective case. The front of the PDA is protected by the transparent membrane. The bottom part of the PDA is accessible by removing rubber cap in the bottom part of the case, and same is for the top part. In addition the case comes with the “scanner” adapter for the top part.
We liked several things about this case:

- The customized rubber “insert”, different for different PDA models. We felt, it provided better impact protection than generic Velcro strap featured in Armor 1900.
- The case was smaller.
- For same $100, we got some accessories.

We did not like the following about this case:

- No bottom adapter was available to use sturdier “round” power connector to charge the PDA and serial cable to synchronize it. The standard 22-pin connector in the bottom of the PDA has to be used, and Year 1 experience has shown that this results in frequent damage of that connector.
- We would prefer yellow (not black) case, and this case did not come in the variety of colors.

Overall, HP iPAQ Ruggedized Wireless case leaves a very positive impression: it provides excellent protection at a moderate cost. However, there are several deficiencies, which are minor for other users, but major for us, such as unavailability of a power/synchronization adapter to reduce mechanical wear of a PDA’s 22-pin bottom adapter.

Otterbox Armor 1900

Armor 1900 was introduced in December 2004. It combined all best features of previous OtterBox cases, Armor 2600 and Armor 3600. Similar to its predecessors, Armor 1900 provided military-level protection. At the same time it was smaller, provided easy access to top and bottom parts of the PDA, and easy PDA installation and removal. It also came with a multitude of accessories, such as replacement screen membranes, various

adapters for both bottom and top parts (including permanent power/synchronization adapter), car mounts, etc.

We started using Armor 1900 immediately after it was introduced and so far have had very positive experience. The case provides very good protection from physical impact. The availability of serial connection adapter turned out to be essential in our application. Initially we used the native 22-pin PDA connector for charging and synchronizing, which turned out to be a bottleneck. The pins on the connector bent from the frequent connection/disconnection, which made PDA incapable to synchronize and/or charge. Armor 1900 offers a solution to this problem: a Serial Pod adapter, which goes into the bottom part of the case permanently, and converts the 22-pin PDA connector into external round AC connector and RS-232 serial port, both extremely durable.

Another “weak point” of the case we discovered was the latches. The case consists of several parts, held together by latches, attached to the surface of the case by molded dovetail joints. The joints broke off on several cases. However, latches still held, although less securely. They could be secured in place by screws, provided with the case. The manufacturer provided the lifetime warranty and already replaced several cases under that warranty.

We have been using this case and have been very satisfied with it so far. We would recommend continue using it in Year 2, equipped with the Serial Pod adapter.

Figure 2. Otterbox Armor 1900 protective case.

Stylus

The large plastic pen-sized stylus used in Year1 was not very successful. Although large and comfortable, it was not mechanically strong. The hollow plastic body of the stylus broke at the end where the tip was attached. We found other stylus, which we

feel is a much better candidate for our application – a basic industrial stylus by PDA Panache. This stylus is made of aluminum and uses steel thread.

Technology Survey Summary

Summarizing the above research, we would recommend the following configuration for trial in NJDOT Traffic Operations North and South environment for the purposes of In-Field Emergency Incident Data Collection:

Item	Price
HP iPAQ 2410	$379
256 Mb SD Memory Card	$30
Otterbox Armor 1900 Case	$100
Otterbox Serial Pod Adapter	$50
PDA Panache basic industrial stylus	$9
Car Charger	$23
Car Mount	$50
Total	$641

SUMMARY OF THE WORK PERFORMED

The software specifications were compiled and the PDA/workstation software was developed based on them.

Introduction

This document outlines the software (functional) requirements for the PDA-based mobile data collection system, to be used by Emergency Service Patrol of NJDOT Traffic Operations.

Definitions

Definition	Description
Application	A PDA-based software for logging ESP stop data.
Master Database	Database on the server that contains information about all ESP stops.
User	ESP Team member using the Application.
Administrator	ESP Supervisor with full access to the Master Database

Acronyms

Acronym	Description
NJDOT	Is representative of New Jersey Department of Transportation
ESP	Is representative of Emergency Service Patrol
Rutgers CAIT-LTAP	Is representative of the Local Technical Assistance Program of the Center for Advanced Infrastructure & Transportation at Rutgers, The State University of NJ
PDA	Is representative of Personal Digital Assistant - a pocket-sized computing device to be used for data collection

Prerequisites

Reference	Title
PDA_URD	User Requirements Document for the “Usage of Windows-based PDAs As Paperless Solutions For Emergency Service Providers“ project.

Related Documentation

Reference	Title
PDA Proposal	Proposal for “Usage of Windows-based PDAs As Paperless Solutions For Emergency Service Providers“ project.
PDA Tech. Review	PDA Technology Review Document.

Goals Of Application

NJDOT Traffic Operations North runs an Emergency Service Patrol program, which involves a number of specialized trucks (29 at this time) patrolling sections of major highways and reducing highway congestion by assisting disabled motorists, clearing highway lanes of debris, working with state police, etc. Each service stop must be logged in detail. Currently, paper forms are being used to log the service data in the field. At the end of a shift paper forms are brought into the office and information is manually typed into the database. Manual database population is a very time-consuming task, which also leaves a lot of room for error due to problems with handwriting, incorrectly filled forms, etc. The Application replaces the paper form with an electronic one, hosted on the PDA. Stop data will be collected in the electronic format and uploaded into the database automatically in less than a minute.

Features Of Application

- Application will run on PDA.
- Application will collect ESP stop data from the user and store it in the PDA memory.
- When PDA is synchronized with the PC, Application will upload the stop data into the Master Database and erase it from the PDA.
- Application will offer user-friendly means of searching and editing stop data.
- Application will be capable of analyzing data and generating reports.

Description Of Application Usage Environment

- Application will run in Windows Mobile 2003 Environment on the PDA.
- PDA is used mostly inside the ESP truck, and sometimes can be taken outside.
- One PDA will be assigned for each ESP truck.
- Master Database is hosted in MS Access 2000 environment.

Visual Constraints

- On-screen data entry controls, buttons and messages in the PDA Application will be implemented in large fonts and high contrast, in order to make them easily visible for people with weaker vision.

Design Constraints

- User interaction during the data entry will be minimized – type-in boxes will be replaced with drop-down selections, checkboxes, and radio buttons whenever possible.
- Selections in drop-down boxes can change with time. Database will be designed to accommodate this – selection changes in the Master Database will be reflected in the PDA Application via synchronization.
- All stop logs on the PDA will be periodically backed up onto the power-independent flash card.
- Database will be used to store images (digital photographs), one or more per stop.

User Profiles

- Users are ESP team members.
- Users may or may not be computer savvy.
- Administrator is ESP Team member, who has full access to the Master Database.

Access To Application Entities

- Full access will be granted to the User to his “today’s” ESP stop data stored in the PDA.
- Full Access to the Master Database will be granted to the Administrator.

Functional Requirements

Id	Description	References
FR_001	Application will be started by clicking on an icon on the PDA “Today” screen.	
FR_002	Application consists of the Database and front-end interface.	
FR_003	When started, Application will display the login screen.	URD FR_002
FR_004	In the login screen, current date will be recorded automatically.	URD FR_002, FR_001
FR_005	In the login screen, yard name will be recorded via drop-down list.	URD FR_002
FR_006	In the login screen, truck number will be recorded via drop-down list.	URD FR_002
FR_007	In the login screen, driver’s name will be recorded via drop-down list.	URD FR_002
FR_008	In the login screen, truck mileage at the shift start will be recorded via type-in text box.	URD FR_002
FR_009	In the login screen User will be able to exit the Application.	URD FR_003
FR_010	After the login screen, user can access the Main Menu screen.	URD FR_004

FR_011	Main Menu screen will display User's stop logs for the given day.	URD FR_005
FR_012	In the Main Menu screen User will be able to start a new stop log.	URD FR_006
FR_013	In the Main Menu screen User will be able to edit an existing stop log.	URD FR_007
FR_014	In the Main Menu screen User will be able to go back to the login screen.	URD FR_009
FR_015	The stop log will be divided into several pages/screens.	URD IR_002
FR_016	In each stop log page User can navigate to the next stop log page, previous stop log page or to the Main Menu screen.	URD FR_015, FR_017
FR_017	In each stop log screen a number of data controls are displayed, allowing User to store/update records in the database.	URD FR_012
FR_018	Some data controls will be "must fill".	URD FR_013
FR_019	If no data is entered in "must fill" controls, User is alerted and navigation is not allowed.	URD FR_013
FR_020	Some data controls will be enabled/disabled or shown/hidden depending on selections in other data controls.	
FR_021	Selection in some drop-down lists may change depending on selection made in the other drop-down lists.	
FR_022	At each navigation (next, previous, main menu), information in the data controls is saved to the database.	URD FR_012, FR_016
FR_023	When User starts a new stop, the stop log screen with empty data controls is displayed.	URD FR_010
FR_024	When User starts a new stop, Current Date, Mileage, Start Time, Driver Name and Truck No will be stored in the related fields automatically.	URD FR_002, FR_001
FR_025	When User starts a new stop, the first screen will display an option to cancel that stop without saving the data in the database.	
FR_026	When User completes the stop Log, Finish Time will be stored in the related field automatically.	URD FR_002, FR_001
FR_027	When User edits a stop, the stop log screen with data controls is displayed, with data fields containing values for that stop stored in the database.	URD FR_010
FR_028	When User edits a stop, the first screen will display an option to delete that stop.	URD FR_008
FR_029	When User exits the Application, after the shift is over, he is requested to enter truck mileage.	
FR_030	When connected to the PC, Application will upload all the stop data from the PDA into the ESP Master Database.	URD FR_017
FR_031	After successful upload, all ESP stop data will be erased from the PDA.	URD FR_018
FR_032	Application will allow controlling the selection in the drop-downs on the PDA from the Master Database	
FR_033	Application will allow Administrator to switch on/off the synchronization between individual drop-downs and Master Database	

Performance Requirements

Id	Description	References
PR_001	Responses to user's data entry actions will not exceed 1 sec.	URD PR_001
PR_002	Uploading ESP stop data to the ESP Master Database will not exceed 1 min.	URD PR_002

Interfaces Requirements

Id	Description	References
IR_001	Whenever possible, drop-down lists, radio buttons and checkboxes will be used as data controls.	URD IR_001
IR_002	On-screen data entry controls will be implemented using large font sizes.	URD IR_002
IR_003	Colors of on-screen controls and background will maximize their contrast.	URD IR_003

Test Requirements

Id	Description	References
TR_001	Quality Assurance will be carried out by the CAIT-LTAP	URD TR_001
TR_002	Upon completion of a beta-version, Application will be tested in the field by a test team of 2-4 ESP team members.	URD TR_002

Documentation Requirements

Id	Description	References
DR_001	Application Usage tutorial.	URD DR_001
DR_002	Application installation and configuration tutorial.	URD DR_002
DR_003	Master Database tutorial.	URD DR_003

Training Requirements

Id	Description	References
TrR_001	Training sessions will be conducted at NJDOT Traff. Ops. North location.	
TrR_002	ESP Team Members will be trained in basic usage of PDA's	TrR_001
TrR_003	ESP Team Members will be trained in using the Application	TrR_002
TrR_004	Administrators will be trained in installing, configuring and troubleshooting the Application on the PDA's	TrR_003
TrR_005	Administrators will be trained in maintaining the Master Database	TrR_004
TrR_005	Administrators will be trained in maintaining the Master Database	TrR_004

ESP Stop Information

Field	Type	Value Selection	Default Value
Date	Short Date		Today's date
Yard	Text, Must Fill	List of ESP Yards ("Cherry Hill", "Springfield", "Metuchen", "Hanover")	
TruckNo	Text, Must Fill	List of ESP truck numbers	
Driver	Text, Must Fill	List of ESP drivers	
StartMileage	Text, Must Fill	Mileage in the beginning of the shift	Last saved EndMileage
StopNo	Integer		Number of record
TimeIn	Short Time		Current time
HowDicovered	Text, Must Fill	"Found by ESP" "Dispatched by DOT/State Police"	
WaitTime	Short Time		
Weather	Text	"Clear", "Cloudy", "Rain", "Snow", "Sleet", "Fog"	
VehicleInvolved	Yes/No, Must Fill		"yes"
VehicleType	Text	"Auto/SUV", "Pickup", "Van", "Bus", "Single Unit Truck", "Combo Truck", "Motorcycle", "Mobile Home"	"Auto/SUV"
VehicleMake	Text	List of vehicle makes	
VehicleModel	Text	List of vehicle models	
Color	Text	List of vehicle colors	
LicenseNo	Text		
State	Text	List of US and Canada states, "Diplomat", "Other"	
StateOther	Text		
Location	Text, Must Fill	"In Freeway Lanes", "Left Shoulder", "Right Shoulder", "Median", "On Ramp", "Unable to Locate", "Rest Area/Other"	
ConstructionZone	Yes/No	"Yes", "No"	
LanesClosed	Text	Checkboxes	
Route	Text, Must Fill	"24", "78", "80", "280", "287", "440"	
RouteOther	Text		
RouteDirection	Text	"NB", "SB", "EB", "WB"	
MilePostInt	Integer		
MilePostDec	Integer		
ReasonForStop	Text, Must Fill	"Disabled", "Abandoned", "Debris", "Fire", Pedestrian", "Accident", "Lost", "Other"	
DisablementType	Text, Must Fill	"Out of Fuel", "Flat Tire", "Electrical", "Mechanical", Fuel System", "Cooling System", "Lock-Out", "Unknown", "OK – Cell Phone/Wave On", "Other"	
CorrectiveAction	Text, Must Fill	"Pushed from lanes", "Tagged", "Towed", "Self-Aid", "Jump Start", "Gave Gas", "Gave Directions", "Safety", "Added Water", "Other", "Remove Debris", "Replace Tire"	
AidNo	Text		
DOT Damage	Text, Must Fill	"Guide Rail", "Bridge", "Light pole", "Concrete Barrier", "Pavement", "Sound	

		Wall", "Overhead Sign Structure", "Ground Sign", "Storm Damage", "Fence", "Landscape", "Other"	
Remarks	Text	List of corrective actions, generic remarks, "Other"	
RemarksOther	Text		
TimeDeparted	Short Time		Current time
EndMileage	Text, Must Fill	Mileage at the end of the shift	
Images	Images	Photographs of the incident	

Reporting Requirements

ESP Master Database will store stop data for at least two consecutive years.
Based on information collected in the ESP Master Database, the Application will run following SQL queries to generate reports:

1. **Report:** Yearly summary, compiled for two consecutive years.

   Queries:

   - Total Number of stops: count of records for the given year.
   - Average number of stops/day: count of records for the given year divided by the number of days in that year.
   - Average number of stops/week: count of records for the given year divided by 52.
   - Average Motorist wait time (NJ State Police before ESP, NJ Emergency Service Patrol): sum of wait times divided by the number of stops, where wait time was greater than zero, for the given year.
   - Average time spent by NJESP per stop: end time subtracted from the start time, divided by the number of stops, for the given year.

2. **Report:** Quarterly summary, compiled for four quarters:

   Queries:

   - Total Number of stops: count of records for the given quarter.
   - Average number of stops/day: count of records for the given quarter divided by number of days in that quarter.
   - Average number of stops/week: count of records for the given quarter divided by number of weeks in that quarter.
   - Average Motorist wait time (NJ State Police before ESP, NJ Emergency Service Patrol): sum of wait times divided by the number of stops, where wait time was greater than zero, for the given quarter.
   - Average time spent by NJESP per stop: end time subtracted from the start time, divided by the number of stops, for the given quarter.
   - Reason for assist (in %): count of records for the given reason to assist divided by the total count of records, for the given quarter.

- Type of disablement (in %): count of records for the given type of disablement divided by the total count of records, for the given quarter.
- Corrective actions (in %): count of records for the given corrective action divided by the total count of records, for the given quarter.

3. Summary of stops by month, compiled for two consecutive years: count of records for each month, for the given year.
4. Summary by type of vehicle, compiled for two consecutive years: count of records for each type of vehicle, for the given year.
5. Summary and percentages of origin of calls, compiled for two consecutive years:
   - Count of records for the given type of origin of calls, for the given year.
   - Count of records for the given type of origin of calls, divided by total count of records, for the given year
6. Summary by reason to assist, compiled for two consecutive years: count of records for the given reason to assist, for the given year.
7. Summary by type of disablement, compiled for two consecutive years: count of records for the given type of disablement, for the given year.
8. Summary of corrective actions, compiled for two consecutive years: count of records for the given corrective action, for the given year.
9. Summary by lane distribution, compiled for two consecutive years: count of records for the given lane, for the given year.
10. Summary for the given period of time (between specific dates): count of records where date is greater or equal to the period beginning date and smaller or equal to the ending date.
11. Summary for the given period of time (between specific dates) and a specific yard: count of records where date is greater or equal to the period beginning date and smaller or equal to the ending date and yard equals the specified yard.
12. Analysis of “danger spots” – sections of roads with high concentration of accidents: route names and mile posts will be used to calculate the density of accidents and locations with highest density will be selected.
13. Cross-tab query by road and reason to assist.
14. Cross-tab query by month and reason to assist.
15. “Odd hour stop” query – cross-tab query by summary of Reason for Stop and hour of a day.
16. “DOT Damages” query – list of incidents with DOT property damage. This query allows NJDOT Engineering and Maintenance Crew to promptly repair damaged property as well as get reimbursed by responsible parties’ insurance providers.
17. Listings by yards and date intervals.

ESP Synchronizer

This application runs on the PC workstation and allows customization of data synchronization between PDA and PC. The ESP Synchronizer application features following functionality:

- Synchronization of individual dropdowns, such as Driver, Truck, etc., can be turned on/off. This offers significant time savings when downloading stops and mileages from the PDA into the Database.
- Synchronization of all dropdowns can be toggled by a single button.
- Synchronization cache information, stored in the database (to increase synchronization speed) can be selectively deleted for a PDA with the specific DeviceID. This feature resolves the problem with dropdown items disappearing from the PDA and not reappearing after full synchronization.

Software Screenshots

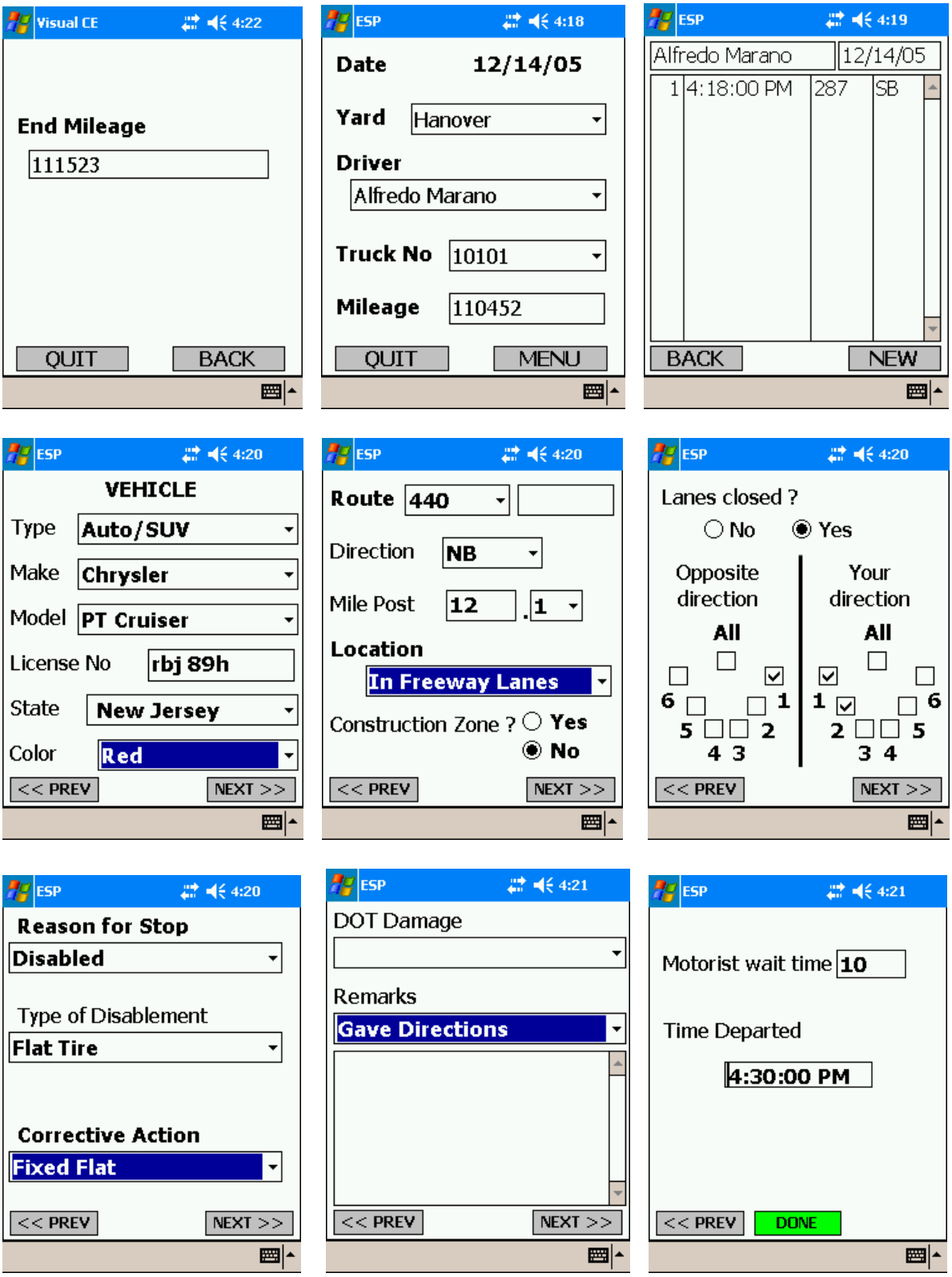

Figure 3. PDA Software screens.

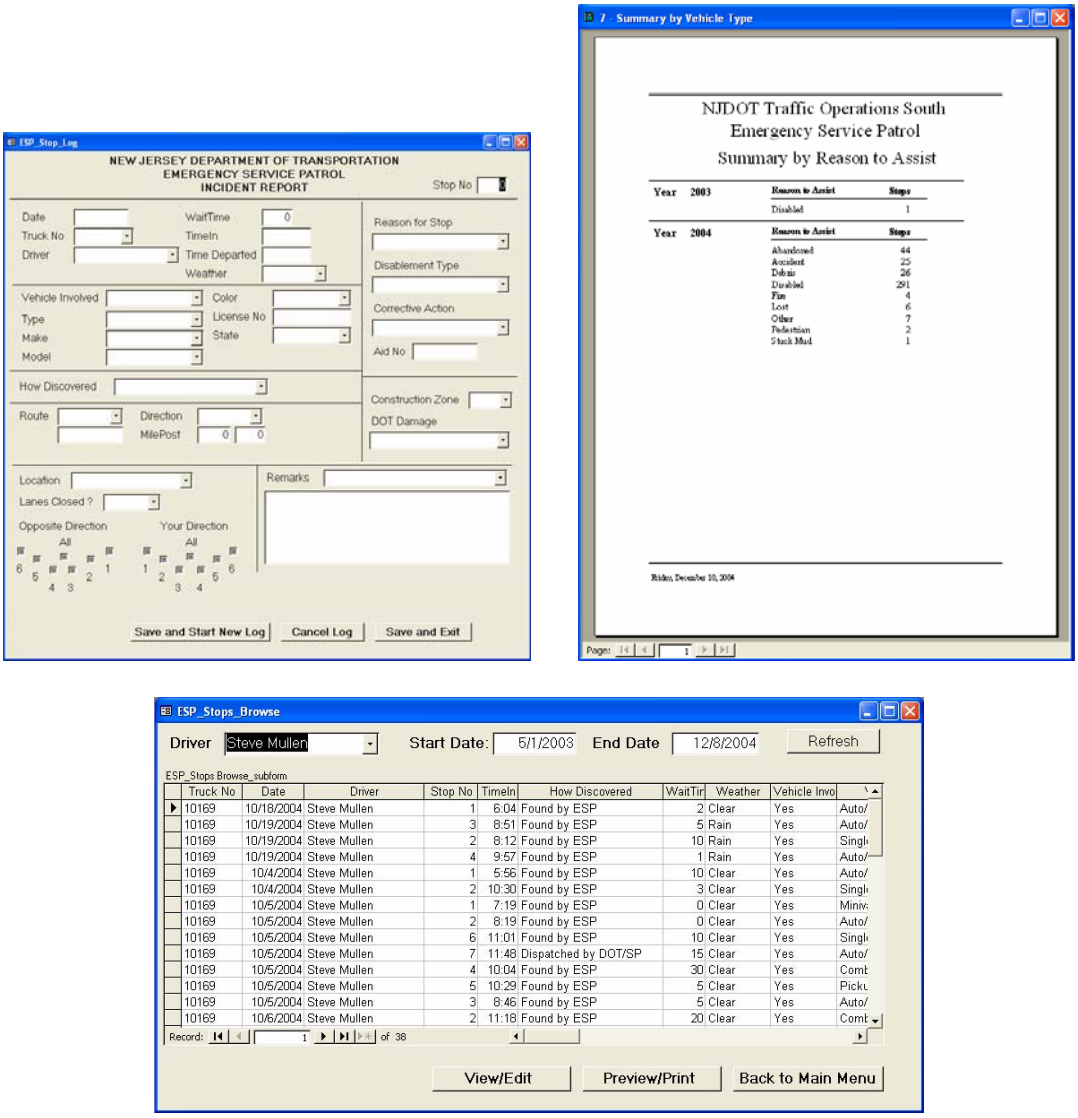

Figure 4. Database forms and reports.

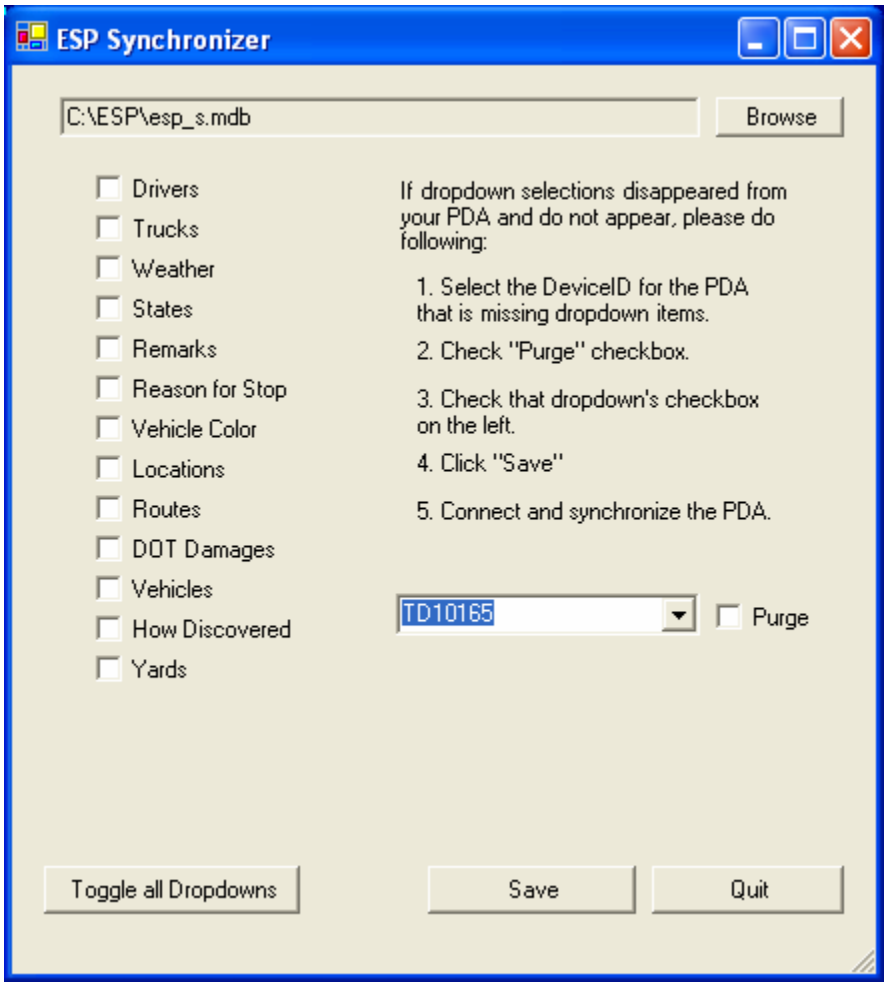

Figure 5. Synchronizer.

IMPLEMENTATION AND TRAINING

The system was implemented in NJDOT Traffic Operations Emergency Service Patrol infrastructure. For ESP North, 36 HP iPAQ 2410 PDAs were purchased, equipped with protective cases and necessary accessories (styli, flash cards), loaded with necessary software and distributed between drivers of two ESP South Yards: Hanover and Metuchen. Each yard received one PDA per truck plus 3 spares. Desktop workstations (3-4 at each yard) were loaded with the PDA synchronization software (MS ActiveSync, Syware VisualCE runtime). The Master Incident Database was loaded onto shared network drive S: on NJDOT Netware server. In ESP South new release of data collection software and the database was installed onto PDAs and workstations.

Three training sessions were conducted:

- Two sessions for drivers (one per yard) to train them in using the PDAs to capture the data electronically. User manual was created for this session and distributed to ESP drivers.

MAINTENANCE AND SUPPORT

Throughout the course of the project the PDA base data collection system was observed and maintained:

- Hardware and software issues were resolved on site, if possible.
- Repairable PDAs were sent to HP for evaluation and repair.
- Non-repairable PDAs were replaced by newer PDAs, funds permitting.
- Data collection software was revised and updated one time, removing software bugs and incorporating functional improvements suggested by ESP Crew.
- A number of hardware/software issues were resolved over the phone.