Metropolitan
Transportation
Authority

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June 13, 2003

TO: BOARD OF DIRECTORS

THROUGH: ROGER SNOBLE
CHIEF EXECUTIVE OFFICER

FROM: JOHN B. CATOE, JR.
DEPUTY CHIEF EXECUTIVE OFFICER

SUBJECT: UPDATE ON SOFTWARE PROCUREMENT FOR HANDHELD DATA GATHERING DEVICES

ISSUE

At the March 2001 Board Meeting, MTA staff requested approval of a contract, in the amount of $235,000, for the development of customized software which would allow the replacement of Handheld Data Gathering Devices originally placed into service in 1984. Supervisor Molina asked that an approach be found that was less costly than the software development effort. Staff was asked to examine:

- The potential for using off-the-shelf software,
- The feasibility of writing the programs in-house,
- The availability and practicality of purchasing less expensive hardware devices, and
- Other agency's practices-alternative in use at other transportation properties.

Staff has developed a new approach that will meet these requirements.

DISCUSSION

In 1984, MTA staff in the Schedule Checking Department implemented an innovated, state-of-the-art Handheld Data Gathering System. The system expedites the compilation of ride-check, point-check and fare-check data from the field. It allows Schedule Checkers to enter data on the handheld computer and download it to the Schedule Checking Department on the same day. This efficiency eliminated data entry tasks and improved the quality of the resulting reports.

The hardware for this system is comprised of the following:

- 73 handheld devices made by Telxon
- 4 modems made by Universal Data Systems
- An AST 386 computer using a special board that allows 4 modems to connect to one computer

The software was written by the following:

- Computer Communications Specialists, Inc. developed the software to handle data communications and routing
- In house staff wrote the software that operates the Handheld devices

Symbol Technologies bought Telxon, so handheld device maintenance has continued uninterrupted in the 19 years since the units were purchased. Due to their age, eight of the handheld units must be sent in for repair in a typical month. Total repair costs are estimated to be $36,000 for the current budget year. When a unit fails in the field, the data collected by the schedule checker is lost. Redoing the work lost due to equipment failure will be about $15,000 this year.

The modems and computers that receive the collected data on the handheld units are antiquated and incompatible with MTA system protocols. Because anti-virus and firewall software are not available for these platforms, they are not part of MTA's computer network. Most of the existing software and technology is proprietary. Unfortunately, Universal Data Systems, AST and Computer Communications Specialists are no longer in business, so maintenance and support is difficult and expensive.

In March 2001, staff requested Board approval of a contract to design and develop schedule-checking software that would run on modern hand held devices. The Board was concerned about spending $235,000 to develop customized software, so staff was asked to study elements of the project. In response to this requirement, a comprehensive peer review was conducted regarding the data collections practices and tools of other transportation properties (Attachment A). Also, an independent consultant was commissioned to render and objective opinion regarding the cost-benefit of using consumer grade handheld devices rather than industrial grade devices (Attachment B).

Since that time of the original staff request, a couple of related events have occurred which provides opportunities to prudently move forward on this project. Staff has adjusted its plans accordingly.

The first event involves, the agency placement of a contract with Spear Technologies for the implementation of a new maintenance system. Dubbed M3, one of the project's features is the procurement of hand held devices from Symbol Technologies for use in the Maintenance Department. Symbol's unit operates on the Window's CE platform, so it fully integrates into MTA's client/server environment. After testing the Symbol device, it was determined that it will perfectly adapt to the Schedule Checker's environment.

The second event is the introduction of Schedule Checking software by Giro, Inc. This off-the-shelf solution will integrate seamlessly with MTA's schedule making software, HASTUS, which is also supplied by Giro, Inc. Moreover, Giro's software will operate on the handheld device supplied by Symbol without modification. Rather than expending $235,000 for development of customized software, as recommended two years ago, staff will now pursue an amendment to the existing contract with Giro, Inc. for licensing the Schedule Checking software at an estimated cost of $36,000.

NEXT STEPS

Staff will procure the Symbol Technology's handheld unit within the contract framework already in place with Spear Technologies for the M3 project. An amendment to MTA's contract with Giro, Inc. will procure the off-the-shelf software for the handheld units. Miscellaneous procurements will be placed for new server and modem equipment for the communications parts of the project.

Prepared by: Ed Muncy
Director, Service Performance Analysis

Attachement A
Ride Check Data Collection Practices At Other Agencies

Property Name	Lines Operated	Lines Checked	Number of Checker Personnel	Technology Based Process (Yes - No)			What type of technology is used?			Would this process work at the LACMTA?
				Ride Check	Point Check	Fare Check	Ride Check	Point Check	Fare Check	
AC Transit (Oakland)	200 Bus	All lines on a rotating schedule.	4 full time	Yes	No	Yes	Hand held PDA, customized, non-ruggedized Compaq Ipaq - each Unit costs about $400.00 each. Trapeze software is used for scheduling.	Currently, point check is done manually. In about a year the PDA will also be used for this purpose.	An electronic Fare Box gathers data.	Their Ride check program would probably work. The only draw back would be the type of equip. There is a concern that the PDA's would break often as they are not ruggedized. The point check program they are going to also would work, but the concern about the PDA's would be the same.
Albuquerque Transit	35 Bus	Each line checked 3 times a week.	10 Full time.	No	No	No	Ride check is done manually.	Point check is done manually by supervisors.	Not done.	The data collection process in Albuquerque is completely manual. This would obviously be a step backwards for the MTA.
Chicago Transit Authority	144 Bus 7 Rail	All lines 2 times a year.	8 Full time.	Yes	No	Yes	Hand held device, a larger PDA by Clever Devices, non ruggedized. Chest level infra-red APC program being implemented.	Transportation manager goes out two times a week, and does a manually check.	Electronic Fare Box.	Their current Ride check program is simular to our current method. The Point check program is completely manual, which would be a step backwards for the MTA.
Denver RTD	177 Bus 3 Rail	All lines checked on rotating basis.	15 Full time.	No	Yes	Yes	Ride check is done manually.	Supervisors take Laptop PC into the field and inputs check data directly.	An electronic Fare Box gathers data.	Their Ride check program is completely manual. The Point check program is basically a manual method, except the data is entered directly into a spreadsheet program. This would be a step back for the MTA.
Greater Cleveland RTA	109 Bus 3 Rail	Bus - 17 wkly Rail - 6 wkly	7 Full time.	Yes	Yes	Yes	Currently a Tesxon hand held is used, which employs an antiquated FORTRAN program. Will be transitioning to APC in approximately one to two years.	Point check is done manually. Will be transitioning to GPS technology in approximately one to two years.	An electronic Fare Box gathers data.	Currently their Ride Check program is very similar to ours. Their Point check program is completely manual. We are ahead of them in technology, this would be a step back for the MTA.
Dallas Area Rapid Transit (DART)	135 Bus 2 Rail	Manual for rail & NTD is by hand held	Contract out 20 - 30 people	Yes	No	Yes	Hand held PDA, non-ruggedized Compaq Ipaq. In the last two years only one unit has broken and two have been stolen.	Point check is done manually by supervisors. Will be transition to a PDA data collector in the future.	An electronic Fare Box gathers data. An in-house custom program was developed which helps DART to gather some ridership information.	This property is currently using hand-held PDAs to gather their Ride check data. Their Point check program is still done manually.
King County Department of Transportation (Seattle)	200 Bus	176 (APC's)	None	Yes	Yes	Yes	APC technology is used to collect ridership data. Currently they are using a "mat" in the stairwell which counts patrons as they board and alight. The property will be switching to an overhead infra-red counter in the future.	A transmitter has been placed on each coach. A receiver has been installed at each stop, as the coach passes the stop it registers the coach number and time.	An electronic Fare Box gathers data.	This property is ahead of us technologically. Their Ride check and Point check programs would probably work well for us.
Long Beach Transit	38 Bus	All lines checked on rotating basis.	5 Part time	Yes	No	No	Currently using an older hand held device from Siemens. Twenty-five buses have APC's.	Point check is done manually.	Fare Check is done manually.	Their program would not be a benefit to the MTA.
Metro Atlanta RTA	125 Bus 4 Rail	They check 546 trips a year.	6 Full time	Yes	Yes	Yes	APC on 10% of buses and manual data check.	They employ GPS technology, which aids in the collection of data, but mostly rely on manual check data.	An electronic Fare Box gathers data.	Their program employees a certain amount of technology, but would not be a step up for the MTA. This is a program still in development.

Attachement A
Ride Check Data Collection Practices At Other Agencies

Property Name	Lines Operated	Lines Checked	Number of Checker Personnel	Technology Based Process (Yes - No)			What type of technology is used?			Would this process work at the LACMTA?
				Ride Check	Point Check	Fare Check	Ride Check	Point Check	Fare Check	
Metro-Dade Transit (Miami)	90 Bus 1 Rail	Rail - Load Factor Qtly Sec 15 twice a month	2 Full time and 2 Full time (temp)	Yes	No	Yes	Hand held PDA used. The units are kept in Rhino cases and were ordered with plastic screens instead of glass.	Point check is done manually.	An electronic Fare Box gathers data.	Their program is effective for them. The use of PDA's is along the lines of current technology. The use of the Rhino case is a good idea. Point check is still done manually. This property is much smaller than the MTA.
New York City Transit	320 Bus	40		No	No	No	Ride check is done manually.	Point check is done manually.	NYCT Hires a consultant to do their fare check.	NYC does not employ any of the current (or past) technology. This program does not offer any options for the MTA.
NJ Transit (Newark)	183 Bus 12 Contract 1 Light Rail 1 Contract Rail	Sec 15 every trip once. Planning 208 trips annually.	4 Full time 17 Part time	Yes	Yes	No	Light and heavy rail use PDA's. Bus is done manually.	Light rail uses PDA, heavy rail does not do point checks, and bus is done manually.	Not done.	The Rail and Bus sides of this property are separate. The Bus operations does not employ any technology. The use of the PDA's isn't different from any other property contacted.
Orange County Transportation Authority	77 bus	Sec 15 weekday - 6 every other day	15 - employed through a contractor	No	No	No	Ride check is done manually. Data collection is done by contractor.	Point check is done manually. Data collection is done by contractor.	Fare check is done manually. Data collection is done by contractor.	This property does not use any means of technology based data collection. Would be a step back.
San Francisco Muni	70 Bus	Data Collection plan based upon FTA guidelines and Prop E requirements	25	Yes	Yes	No	Currently a Symbol Tech hand held is used, which employs an antiquated FORTRAN program.	Currently a Symbol Tech hand held is used, which employs an antiquated FORTRAN program.	Not done.	This property is still using antiquated technology. Does not offer any new options to the MTA.
San Diego Transit	28 Bus	N/A	N/A	No	No	No	SANDAG does all Point Checking. (SANDAG is like our COG)	Point check is done manually.	This property contracts with First Transit for Fare check.	This property is much smaller than the MTA and does not perform any data collection for itself, with the exception of a supervisor may do an "on-time" occasionally.
Santa Clara County Transportation	72 bus 2 rail	Bus - Checks for all lines once a yr. Rail - every 3 mo for weekend trips & every 2 mo for weekday trips	10 Full time will reduce staff when APPC is in full swing.	Yes	No	Yes	For FTA reporting they manually check the lines. For planning they use older Symbol Tech hand held devises. They plan to install APC's in 20% of their light rail and bus lines by the end of next year.	Point check not done.	An electronic Fare Box gathers data. Equipped with a GPS system which allows for validation of APC data. A manual sampling is done on a random basis.	This is also a program of mixed technology and manual data collection. The program as a whole would not benefit a larger operation such as the MTA. Parts of the technology based collection means would benefit the MTA, however they do not employ any technology that is not used by other properties.
Santa Monica Muni Bus Lines	15 Bus	549 Trips (NTD) Scheduling 3-5 lines a year Triannual every trip with contracted help	3 Temps	No	No	No	Ride check is done manually.	Point check is done manually by the supervisor.	Not done.	All data collection is done manually. This property is behind the MTA in the use of technology in data gathering, would be a step back.
Southeastern PA Trans Authority	168 bus/8 light rail/2 elevated subway/13 heavy rail/5 trackless trolley	FTA minimums/ checks done daily	50 Part time	Yes	No	No	Ride check is done manually. They are testing APC's on about 10% of their buses.	Point check is done manually.	Not done.	All data collection is done manually. They are beginning to test APC technology. This property is behind the MTA in the use of technology in data gathering, would be a step back.

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INVESTIGATION INTO COST BENEFITS OF CONSUMER GRADE VS RUGGEDIZED HAND HELD COMPUTERS

FINAL

JULY 2002

Attachment B

BACKGROUND

Presently, Los Angeles Metropolitan Transit Authority (MTA) staff use handheld data gathering devices to collect ridership data. These devices have completed their service life and are in need of replacement.

The replacement of these devices has raised a number of questions concerning the costs and benefits of industrial strength, ruggedized devices versus the more generally available, and less expensive, consumer grade products.

The aim of this research is to compare and contrast the costs of purchasing, maintaining, and using both the industrial grade and consumer grade of hand held data collection device.

These devices will be used primarily by the Service Performance Analysis Department. They may also be used for other applications within the MTA so flexibility and ease of use is a consideration.

In the volatile Information Technology industry, there are no guarantees of the longevity of a company or its products. Consideration is made therefore of the stability of the manufacturer, and the number of manufacturers who make compatible devices.

DEVICE REQUIREMENTS

Data is collected by the MTA on a full time basis. The devices need to be in action each business day over a life cycle of 7 years. Schedule Checkers keep devices with them, uploading data via telephone at the end of the day. The existing devices are very robust. They cope with riding round on public transport, and waiting in bus stops in all the weather conditions that the City of Los Angeles can produce.

The following represent the requirements for data collection devices.

- Battery Life. Standard battery configuration allows for at least 12 hours of continuous data collection, without recharge/replacement.
- Pen Based Data Entry.
- Easy to read (monochrome) back lit LCD display.
- Suppliers are established companies.
- Either WinCE/Pocket PC or Palm OS as an operating system. These industry standards allow many options for development of the data collection software.

- Modem. The devices must be able to communicate with a central server using a standard land line modem.

- Barcode scanning

Device failure is costly relative to the purchase price of the machines. This is due to a number of factors, including the full time nature of the data collection schedule. Repeat collection must be paid as overtime. The travel time required by collection officers to replace the faulty device causes additional disruption to the data collection schedule. It has been estimated by the MTA that the cost of a recollecting a day's worth of data is approximately $750. This does not include the cost of repairs to the device.

MARKET OPTIONS

Ruggedness

We have categorized 3 levels of ruggedness in the handheld computer market:

Highly rugged devices comply with the IP54 Environmental Sealing standards, against windblown dust and rain, and have a large range of operating temperatures from -4° to 122° F. They are also designed to withstand repeated drops from 4ft (1.2m) to concrete.

Middle grade ruggedness is achieved by fitting a rubberized case and or screen protectors to a standard consumer grade machine. These precautions add some degree of protection against accidental damage, and reduce normal wear and tear.

The standard consumer grade device comes without protection. It is possible to purchase either leather or nylon carry cases from third parties which will provide a measure of protection from damage. Due to the lack of protection, and the lack of availability of reliability data, we did not select any devices of this grade.

For all of the devices, the largest risk is dropping the unit while on the move. This can be minimized by the use of either neck straps or belt straps. We feel that the use of a strap or 'pocket' to carry the devices will significantly affect the number of breakages that occur. Similarly the anchoring of the pen (eg with fishing line) will reduce the losses of pens.

Operating System and Programming environment

The generally accepted market leaders in handheld device operating systems are Microsoft's Windows CE/PocketPC and Palm's Palm OS. Both operating systems have development environments that allow for the development and deployment of custom software applications. The Palm OS has the largest

number of third party applications, including many sophisticated programs for data entry.

Screen size

Neither the Pocket PC nor the Palm have large screens, which limits the size of attribute lists without reverting to scrolling. Scrolling lists can take longer for operators to find the correct selection.

The Palm devices reserve a portion of screen real estate as a 'Palm Graffiti' scratch pad. This further reduces the amount of screen that is available for displaying selection lists.

Data entry

The simplest form of data entry is to select from a pre-defined list, and most of the MTA data will be entered this way.

In the cases where text has to be entered, the Palm uses Graffiti, a simplified alphabet of letters entered on the Graffiti pad. Once operators are used to using this (some training/familiarisation is required), it is a quick and efficient means of entering information.

The Pocket PC devices do not have keyboards for input, and rely on the use of onscreen keyboards – the keys on the full QWERTY keyboard are very small, and may be difficult for some people to read/click.

Programming tools

The subject of programming tools is outside the scope of this study, but it is worth considering to some degree as it may impact the overall cost of operating hand held devices. The MTA already has in-house skills in Visual Basic, and we would therefore recommend use of the Microsoft toolset for software development.

TCal/TCos

The existing Telxon units were programmed in a proprietary TCal programming language. Unfortunately none of the new generation of devices support this language.

Windows CE/Pocket PC programming tools

Visual Basic	Microsoft provide a (free) development kit for Windows CE/Pocket PC. This is simple to learn for Visual Basic programmers, and is easier than writing in C++, but is still a fairly low level environment.
Pocket PC Creations	A form based application development environment with many applications in a variety of industries. Programmers do need to become experts in the (low level) Windows CE API, and can focus on application development issues.
AppForge Mobile VB	This product provides a means for Visual Basic programmers to develop on the Windows CE platform. It integrates into MS VB6, and is provides support for both Windows CE/Pocket PC and Palm OS.

This list of tools is not exhaustive - it is provided to list some of the more prominent programming tools available.

PalmOS programming tools

C++	The standard PalmOS programming environment is C++. A plugin for the MetroWorks CodeWarrior compiler allows cross-compilation. An emulator is available which can emulate the various processors and screen sizes of the various PalmOS based models (including third party Palm clones). There are many support groups and code libraries available. Palm have a strong developer program which allows access to pre-release hardware and software.
Satellite Forms	Satellite Forms is a mature forms design package for the Palm that provides facilities suitable for most data entry applications without the need for extensive low level programming.

Pendragon forms	Similar to Satellite forms, allows rapid form programming and application development. Data can be simply synched to a Microsoft Access database.
AppForge Mobile VB	This product provides a means for Visual Basic programmers to develop on the Palm platform. It integrates into MS VB6, and is provides support for both Windows CE and Palm OS.

This list of tools is not exhaustive - it is provided to list some of the more prominent programming tools available.

Peripherals

The device should support the following capabilities:

- Bar code scanning
- Modem communications for remote data transfer

These are not standard equipment on all models.

The devices are designed to sit in a cradle (usually to sync with a desktop PC), and also have an expansion slot (or slots) for additional peripherals such as modem/camera etc. The gold plating on the expansion slots are not designed to withstand the thousands of insertions that will occur in the life cycle of these devices.

The use of external peripheral snap-ons adds to the number of separate pieces of equipment being carried around, and increases the risk of loss or damage. In addition these devices (such as the modem card) often protrude from the case, and will easily break.

Batteries

Some units come with removable batteries, and some have internal rechargeable batteries. When it comes to the selection of a specific device it should have removable batteries, which allows easy replacement in the field (even if rechargeable batteries are used).

Bar code reader

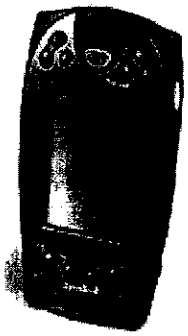
Currently all of the available fares are printed as bar codes on sheets of paper - which are scanned in as required. The stated requirement is to continue with this method of entering fare codes.

Communications

The stated requirement is for modem communications, although there are a growing number of devices which support wireless communications. At present this is not required, but it may be an option for the future.

The Devices

We chose 4 devices for comparison. These choices allow combinations of Win CE and Palm operating system, as well as high and medium levels of ruggedness. See table below

Ruggedness	Win CE	Palm OS
HIGH	Symbol PPT 2800*. 	Symbol SPT1800* 
Medium	Compaq H3850 	Symbol SPT1500* 

* - Integrated bar code reader

	Win CE devices			Palm devices	
Model	**Symbol PPT2800**	**Compaq Ipaq3850**		**Symbol SPT1800**	**Symbol SPT1550**
Rugged level	HIGH	Medium		HIGH	Medium
Screen Size	320x240	320x240		160x160	160x160
Modem	Snap on Cradle	Expansion pack and CF Card[i]		Snap on Cradle	Snap on Cradle
Barcode Scanner	Built in	Expansion pack		Built in	Built in
List Price	$1076	$599		$809	$595
Peripherals	$360	$728		$360	$360
Total	**$1436**	**$1327**		**$1169**	**$955**

It may be possible to purchase these units cheaper, depending on the promotions available at the time, and volume purchasing discounts.

ASSUMPTIONS

We make some assumptions in order to assign costs to the choice of a particular device.

Damage events

We were unable to obtain any information from the hardware suppliers about the likelihood of damage, or the number of times a device can be dropped before it is likely to fail and require replacement. We have two components to our costings:

1) Device repair/replacement
2) Loss of data/down time

The available maintenance agreements provide a means of fixing the per device cost – the supplier will replace/repair devices as required. Compaq will only provide this cover for three years, necessitating the purchase of new units after this time. No cover is available for peripheral devices. So in assessing the costs of device repair/replacement, our costs are assumed to be fixed.

In assessing the cost of loss of data or down time, we estimate the average cost to be a man day at overtime rates. In some cases the failure will occur at the beginning of the day, so no data is lost, and a return to base will be required to collect a new unit, which would only take an hour or two. In the worst case it would occur at the end of the day, necessitating the re-collection of the data as well as a trip to base to replace the unit. An estimate of this fully burdened cost is $750.

As we have no facts on breakages, we can construct a scenario which will allow us to compare devices within a realistic framework. Let us say that each device will be dropped by each Schedule Checker twice a week, making a total of 104 drops per year. If we categorize these drops into minor, serious and fatal, we can estimate the number of breakages. A minor drop is one that causes no damage to either a rugged or non-rugged device. A serious drop is one that causes some form of lasting damage to the device. A fatal drop is one that will break any device, such as being dropped from a moving bus, down a drain etc.

It is reasonable to assume that the rugged devices will withstand more serious drops than the devices protected only by a rubber boot. Let's say that a non-rugged device will fail every 5 serious drops, and the rugged device will fail after 20 serious drops. So let us put together a table of the events, and possible breakage rates to produce an estimated cost:

Event	Number	Rugged failures	Non-rugged failures
Minor	47	0	0
Serious	47	2.35	9.4
Fatal	10	10	10
Total failures	**104**	**12.35**	**19.4**
Total cost		**$ 9,260**	**$ 14,550**

COSTING

We have not made any allowance for costs of phone calls for data uploading, as we assume this to be the same for all devices.

Purchase costs

Unit	SPT1550	SPT1800	SPT2800	IPAQ H3850
OS	Palm	Palm	Windows CE	Pocket PC
Rugged	Medium	High	High	Medium
Unit price	595	809	1,076	599
Rubber Case	-	-	-	99
Modem	360	360	360	130
Scanner	-	-	-	499
TOTAL PRICE	955	1,169	1,436	1,327

Maintenance costs

Unit	SPT1550	SPT1800	SPT2800	IPAQ H3850
Bronze	37	74	92	
Silver	60	95	112	
Gold	98	139	157	
Compaq accident				73*
Annual Maint cost	60	95	112	73
7Yr Maint Cost	420	665	784	511

Labor Failure costs

Unit	SPT1550	SPT1800	SPT2800	IPAQ H3850
Annual cost	14,550	9,250	9,250	14,550
7 year cost	**101,850**	**64,750**	**64,750**	**101,850**
TOTAL 7 YEAR OPERATIONAL COST	**$103,225**	**$66,584**	**$66,970**	**$103,688**

- Compaq offer a 3 year accidental damage replacement. At the end of the 3 years another unit would have to be purchased
- 7 year cost for Compaq assumes 2.3 times purchase cost

Training

Training for a menu driven ridership data collection system should be easily achievable in a half day session. Several sources report that training for operators of Palm based scanning applications in industrial scenarios can be achieved in between 3 and 4 hours, depending on the complexity of the application. This includes operators learning to use the graffiti data entry language.

The cost of training is largely device independent. We assume an in house train-the-trainer approach to training. A system trainer would train 5 supervisors. The supervisors would then be able to train the other operators in groups of five or six.

With a session ratio of 1 instructor to 5 students and training 5 super users and 30 operators, the training cost would be approximately 18 operator days. Assuming $500 per operator day, the training cost is $9,000.

Stage	Half Days		
	Trainer	Supervisor	Operator
1	1	5	0
2	0	5	25

CONCLUSION

Standard consumer grade devices are not suitable for use as data collection devices because they lack support for bar code readers. This eliminated many of the devices from this investigation.

Some consumer devices can be fitted with peripherals such as bar code readers and modems, and can also be fitted with a rubber boot, to provide protection against water dust and accidental damage. The rubber boot is not compatible with the necessary peripherals. Repeated removal and refitting of peripherals is not practical, and will reduce the reliability of the devices.

In looking at maintenance options, no long term support is available for consumer grade devices, necessitating repeat purchases and making them more costly than rugged devices. The market for these devices is evolving rapidly, and the devices are not engineered for long term use.

The largest cost of all in this equation is the cost of labor required to re-collect lost data. The estimated costs are approximately 29 times the cost of purchase and maintenance of the devices.

In summary, we recommend the MTA to purchase Rugged devices for the following reasons:

- Standard consumer grade devices do not support bar code readers
- Consumer grade devices do not have long term support
- Device purchase price is negligible compared to cost of lost data
- Rugged devices should be used to reduce loss of valuable data

Attachment B

Final Report on the ***Investigation into Cost Benefits of Consumer Grade versus Ruggedized Hand Held Computers*** by Horizon Research Corporation.