Finance Information Technology

Technology Solutions Group

Handheld Project
White Paper

November 30, 2007

Table of Contents

EXECUTIVE SUMMARY

The New York City Department of Finance (DOF) partnered with the Center for Urban Research (CUR) at the Graduate Center of the City University of New York (CUNY) to evaluate the effectiveness of handheld devices enhanced with geographic information system (GIS) maps to improve the efficiency and accuracy of data collection for property valuation and tax assessment purposes.

This report describes actual project implementation compared with initial objectives and expected outcomes, offers lessons learned and summarizes feedback from the DOF assessment team that field tested the devices and software application.

Our general assessment about the feasibility of using hand-held devices for field assessment work is that the relevant technologies available are advancing rapidly, but the effort to deploy them is still highly complex. Any plan to implement these solutions should provide for considerable contingency time and the project be structured with great flexibility so as to accommodate uncertainties. Although this project did not establish the certainty of increased efficiency and improved data quality, the results strongly suggest that can be the case. We conclude from this study that the technologies are effective, and that the key elements to a successful implementation are strong management support and focused attention on the cultural shifts required of organizations undertaking the adoption of hand-held devices.

Project objectives and outcomes

The grant application to the Office of Real Property Services explained that the project's primary objective was to identify how emerging handheld technologies can improve the efficiency of DOF's assessors and enhance the accuracy of data collection. A secondary objective was to determine how to make this more accurate data available to other government and non-governmental agencies that rely on up-to-date real property data. A third objective was to facilitate improved research on changing spatial patterns of development in New York City.

The expected outcomes of the project were as follows:

1. Development of a customized GIS application on a handheld device that assessors could use as a map-based data entry system;
2. Evaluation of the device and application and their effectiveness at improving data collection and data integration;
3. Data quality improvements for the information collected during the pilot project; and
4. An initial plan to expand the use of the application throughout Department of Finance, and to make it available to other assessment agencies throughout New York State for evaluation and further customization.

Field assessors who used the developed software application on the selected device reported that the solution worked well. The elimination of paper notes for capturing field data certainly improved data quality since automatic upload of the validated field data worked reliably.

However, the field study was not long enough nor deployed broadly enough to establish the solution's impact on productivity. The most we can say is that productivity was not undermined when using the device, despite the dramatic difference in how filed assessors performed their assessment tasks. This quick adoption and ease-of-use strongly suggests that productivity gains can be substantial.

Finally, the use of tools and platforms that already has a wide install base in the mapping and GIS industries to develop the successful software application, and our selection of one of the most advanced hand-held devices available for this use increases the potential for adoption in other jurisdictions. Our experience in the pilot, willingly shared, can also be helpful to other jurisdictions considering similar projects.

Overview of project activities

The grant proposal contemplated a project start in January 2006 and an end-date of December 2006. However, the grant approval timing and coordination of an agreement between DOF and CUR took longer than expected; work began in summer 2006. A series of detailed meetings were held between DOF and CUR to review assessor workflow, begin to understand the intricacies of DOF's CAMA system, and discuss the potential for wireless connectivity with CAMA.

The initial project scope anticipated that we would focus on new construction properties in order to evaluate the handheld application with a discrete number of assessors working with an important but manageable number of properties. It was assumed that the application would be developed on a consumer-oriented device, with ESRI's then-state-of-the-art mobile GIS software (ArcPad), and would enable assessors to seamlessly connect with CAMA from the field in real-time using only a wireless connection (i.e., with no need to "dock" the device to sync it with CAMA in the office).

The following sections discuss specific components of the project implementation, and how challenges were overcome in each of these areas.

Hardware

Appendix II is an evaluation conducted in fall 2006 of handheld devices for this project. It describes in detail the types of handheld devices that were reviewed, as well as the characteristics that DOF considered necessary for the selected device.

After reviewing the device marketplace, the project team concluded that the overriding criteria was whether a device was designed for intensive field use, i.e., it needed to be "ruggedized." The team selected a relatively new device made by Intermec, the CN3 (see photo at right). However, the cost for this device was higher than originally budgeted in our proposal – DOF eventually negotiated a price with Intermec of roughly $2,040 per device, compared with $700 per device as contemplated in the proposal to ORPS. DOF purchased 6 of these devices for the pilot project, rather than the 17 originally planned for.

Figure 1. Intermec CN3

Therefore, instead of issuing a device to all assessors on the new construction team, the project was redesigned so that the fewer devices were shared among a smaller population of assessors. Nonetheless, anticipating a broader deployment after the pilot, presentations were made to the full 17-member new-construction team so they can participate in planning the future deployment.

Software

Originally, the project anticipated that we expected that the data collection application would be designed within ESRI's ArcPad software environment (called "ArcPad Application Builder"), and that data collection would be map-centric. In other words, assessors would open an interactive map on the handheld of the property to be assessed, input data about the property through forms on the screen that had been designed in ArcPad Application Builder, and this data would automatically be added to the map display for review by the assessor, as well as uploaded to CAMA.

However, several technical obstacles required substantial changes in this approach. First, ArcPad Application Builder was too inflexible to handle the complexities of the CAMA data (more than 1,000 fields of data). Second, after reviewing the workflow of the assessors, we concluded that while interactive maps needed to be an important part of the handheld application, the assessors more often would be accessing information through data screens not maps. Finally, ArcPad is a stand-alone software application, and not easily integrated into a custom-built Windows Mobile software design.

As a result, the piloted application integrates the mapped display of parcel data with data entry screens that show CAMA data. The maps are used more as a tool to help assessors visualize property locations and orient themselves in the field. The application itself is focused more on data entry and potential valuation than on the maps themselves.

The piloted application is written in the C# programming language, integrated with Microsoft's .NET Compact Framework. The application also uses Microsoft's SQL Server Mobile to store and retrieve data that resides locally on the handheld.

During the project, ESRI released its new ArcGIS Server software with a Mobile Application Development Framework (ADF) for Microsoft .NET that enables software developers to incorporate interactive maps as a component of a larger application, and to create a web service that enables the handheld device to accept pre-configured map layers from a server. The Center for Urban Research has a full license through CUNY to all of ESRI's software releases, and was able to quickly deploy ArcGIS Server with the Mobile ADF (the Advanced, Enterprise level of ArcGIS Server 9.2).

Unfortunately, the new ArcGIS Mobile ADF software still had some bugs, but we were able to devise workarounds and develop the application within the revised project timeframe. The Center's subcontractor, 408 Group, – a sole proprietorship based in Brooklyn, NY with extensive experience designing mobile data collection applications for the US Census Bureau, New York City Department of City Planning and others – identified a bug that ESRI has added to its list of problems to fix in later releases of ArcGIS Server.

Relying on the Center's ESRI licenses enabled DOF to shift a portion of the budget for this project from software costs to development costs. During the pilot project and for the foreseeable future, the Center for Urban Research will continue to make use of its license for ArcGIS Server and will host the web service created for this project. The Department of Finance therefore will not need to purchase its own license for ESRI software. Eventually separate licenses will be required, but the city's Department of Information Technology and Telecommunications may be able to provide those. Also, the original proposal budget contemplated purchasing a license for ESRI's ArcSDE database engine, but for the pilot project we determined that ArcSDE was unnecessary. For now the project can rely adequately on ArcGIS's internal database structures without using the more advanced features and functionality that come with ArcSDE running on Microsoft SQL Server.

Connectivity

An important DOF criterion was that the handheld devices needed to connect to CAMA via a wireless connection so "live" CAMA data could be accessed by the assessor and new or updated data could be uploaded in real-time. To overcome several technological limitations, a modified version of this approach was implemented. These modifications required a substantial amount of additional programming and application development resources. One challenge was how to accommodate wireless connectivity while also ensuring that each assessor could use the handheld even if no wireless connection was available, since wireless service is limited in the geographic areas covered by the assessors.

The first step in evaluating wireless connectivity options was to determine wireless coverage throughout the city. The Center for Urban Research obtained a database from the city's Economic Development Corporation of "wi-fi" hotspots throughout the five boroughs, current as of November 2006. The list included 1,058 hotspots with mappable address locations. Roughly a third of these were characterized by EDC as free; the rest are fee-based.

The telecommunications industry standard for the typical outdoor range for wireless routers is approximately 300 feet. The Center therefore used its GIS to calculate the area within a 300 foot buffer around all hotspots and totaled that area citywide in order to compare it to the city's land mass. This analysis excluded large parks, airports, and major cemeteries in order to produce a denominator that accurately reflected the potential land area in which assessors would be working. This analysis determined that:

- The total wifi hotspot area is approximately 8 square miles;
- The total land area (minus the large parks, etc.) is approximately 272 square miles;
- Therefore, wifi hotspots only cover about 3% of the area in which assessors would be working; and
- Since only about a third of the hotspots are free, just 1% of the city is covered by free wifi access.

The map at right highlights the limited area covered by wifi hotspots (all areas in white are

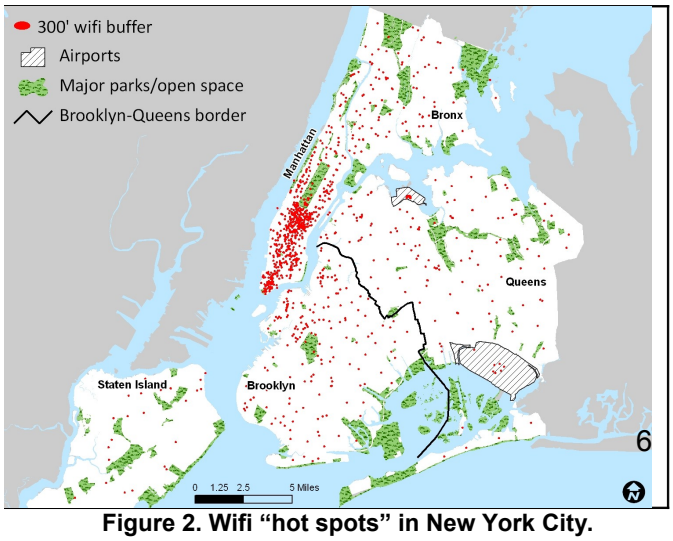

Figure 2. Wifi "hot spots" in New York City.

outside the hotspot coverage).

These findings indicated strongly that the assessors would not be able to rely only on wireless connectivity to access CAMA and/or upload data to CAMA, at least on a real-time basis. As a result, we implemented several contingencies. The handheld devices were configured so that they would be able to use a cellular network for Internet connectivity.

Even with access to a cellular data plan, however, there would be times when assessors will not be able to use the plan due to dead spots or other signal blockages. To address this problem, the project team decided that the CAMA data needed to be as redundant as possible on the handheld device. The application was designed so that it includes a local copy of the full CAMA data set. Each time an assessor updates a data record, it is changed on the local copy of the CAMA database and is also extracted and put in a "ready" state to be uploaded to the live CAMA system the next time the assessor is in reach of the cellular network or a wireless hotspot.

The pilot application also includes a "ping" feature that sends a request to the live CAMA system to compare the "date changed" for a data item for a given property, and then tells the assessor via a pop-up message if he/she has a current copy on the handheld or if the live data is more current. For the purposes of the pilot project, this confirmed that a wireless/cellular connection can be made with the live data, even though (for reasons described in the "Data" section below) the wireless/cellular connection does not actually download live CAMA data.

Data

The project proposal anticipated that the handheld application would be able to connect directly with DOF's CAMA system in a real-time environment. However, the CAMA system is maintained in a mainframe computer environment and is inherently complex, involving more than 1,000 fields of data with numerous business rules that control what fields can be updated by assessors and by others, and how certain fields are modified based on data entry elements.

The handheld devices use a Windows operating system and cannot connect directly to CAMA's mainframe system (which is also behind a firewall). Although an intermediate web-based interface could be programmed to facilitate this connection, the interface would need to replicate CAMA's mainframe business rules, and would therefore involve extensive programming that would be obviated by the eventual transition to a CAMA Windows system. DOF concluded that the programming investment would exceed the pilot project's budget and timeframe.

The handheld pilot application therefore includes a full copy of the CAMA data (as described in the "Connectivity" section above). The data access screens on the handheld that were designed and programmed for this project do not mirror CAMA business rules, but for now only data for a select number of fields are extracted for live uploads to CAMA (DOF's CAMA staff determined which fields can be modified without changes to the business rules, while also being useful for evaluating the benefit of a handheld application). The screens were designed in close coordination with the leaders of DOF's assessment staff so they mirror where necessary the data input flow on the current CAMA mainframe screens but also represent an improvement over this flow.

Figures 3 through 8 show example displays pf data types available. (The application includes several dozen screens; these examples highlight the major CAMA categories):

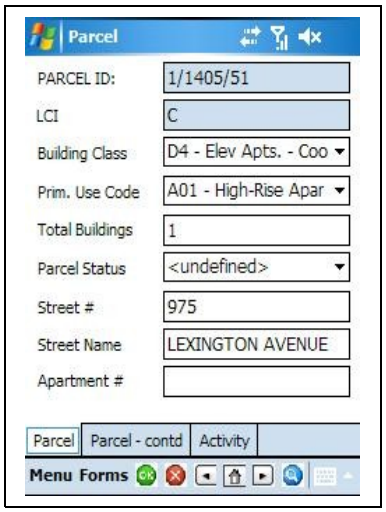

Figure 3. Parcel information

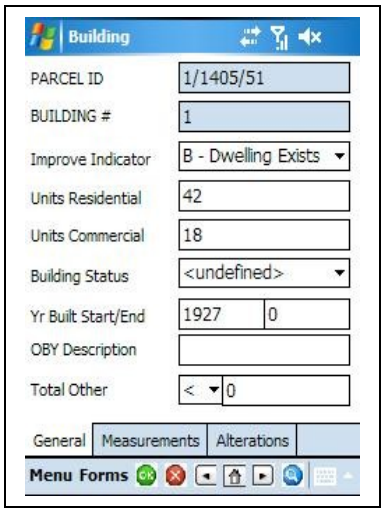

Figure 4. Building information

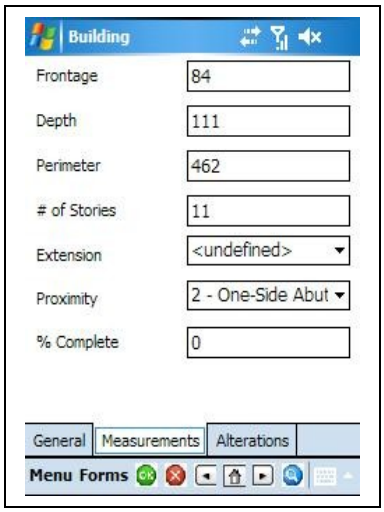

Figure 5. Building measurements

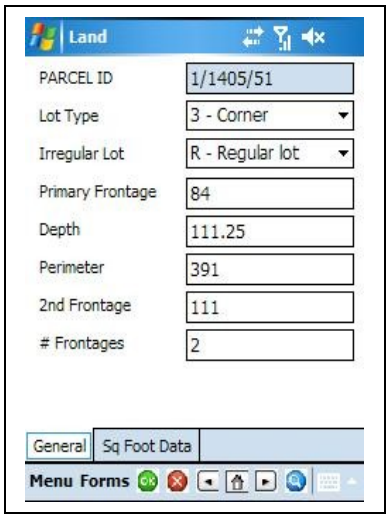

Figure 6. Land information

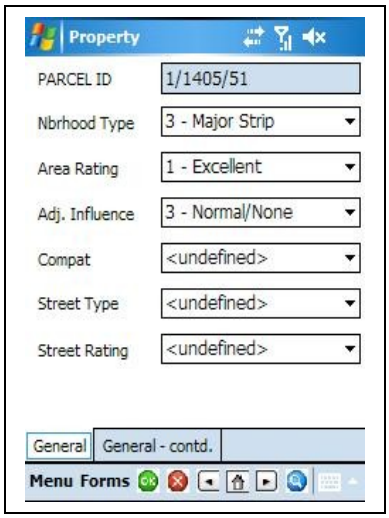

Figure 7. Neighborhood information

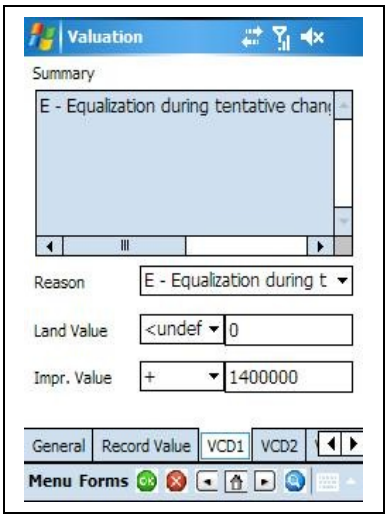

Figure 8. Valuation summary

One relatively simple but important design feature is in the use of drop-down lists on the handheld application for information such as property types, data categories, and building conditions. Currently the assessors manually write this information on paper in the field and then enter it onto mainframe terminals at their offices. Using drop-down lists ensures data consistency and seamless data entry with CAMA. The hundreds of codes and detailed descriptions for the drop-down lists, however, were not in electronic format and had to be entered manually (and checked by DOF staff) in order to integrate them into the handheld application.

A final data challenge involved the mapped representations of parcel boundaries. The Department of Finance does not yet have a digital tax parcel boundary map in GIS format. (This will be launched in 2008.) The City's Planning Department has a digital parcel map and has been updating

it regularly. However, the Planning Department's boundaries are schematic rather than precise delineations of the parcels; DOF's digital map will provide a more exact representation of the boundaries. Until DOF implements its in-house GIS boundary file, the pilot project needed to rely on the Planning Department's data for the handheld maps, resulting in maps that may be out of date in relation to the live CAMA data. The pilot project's focus on new construction properties, however, minimized the chance that this would cause a problem; "new construction" parcels use an existing parcel ID, ensuring that there was no mismatch of parcel IDs between the maps and CAMA for the purposes of the pilot.

Pilot project results

The handheld application was deployed for full testing in early summer 2007. The New Construction assessment team was trained to use the handheld device and the software application. By the end of the summer, assessors were taking the device to specific properties throughout the city to evaluate its effectiveness. At the end of the pilot period, an online survey was developed so the assessors could post their feedback about specific aspects of the application; the results of the survey were tabulated in late October 2007. These survey results can be viewed online at:

www.surveymonkey.com/sr.aspx?sm=gpES4sy_2fNhRMP2Rlx_2fF5XsVZ6zYKDcLn2usG2C2TJsw_3d

See Appendix I Handheld Pilot Assessor Survey results.

Eleven assessors submitted feedback via the online survey form. Most of them (8 of 11) have used the handheld device several times in the field. **The most important finding is that 9 of the 11 (82%) agreed that DOF should continue developing handheld devices for field work.**

Overall, all 11 assessors rated the ease of use of the handheld application as either "adequate" or "great" (none said "poor"). Ten of 11 rated its "intuitiveness of use" as adequate or great, and generally the assessors were satisfied with other features such as the device's ruggedness, battery life, keypad, and weight.

Reviews were not as uniform regarding the usefulness of the application for better data and valuation accuracy or complete work more efficiently and/or faster. Six of 11 assessors said that the device would provide for better data accuracy, four said it would not, and one said maybe. Responses were almost evenly split among Yes, No, and Maybe regarding the question of completing work faster or more efficiently. But all the assessors believed the device would definitely (9 responses) or possibly (2 responses) be useful to research properties.

The assessors generally believed the features of the application (such as parcel-level maps and the DOB website lookup) were either "very useful" or "somewhat useful". The only feature that was rated "not at all useful by a majority of assessors (7) was "Internet Access" – which indicates that the assessors are using the handheld for the tasks at hand, rather than using it to visit non-work-related websites.

Initially, two of the 11 assessors provided optional additional comments on the survey regarding whether DOF should continue developing a handheld application. Two additional assessors were

directly interviewed.

One respondent wrote "… it will be extremely useful for us to be able to do values in the field while we are looking at the property. It will be much more accurate and efficient. In the beginning it may take longer as we get used to the new system."

The other asked "why carry a device that weighs over a pound when paper weighs ounces and can be folded to any size. The handheld is a nice supplement, but not a replacement. The time saved by having the data instantly and checking it on the desktop is not worth the cost of a handheld."

Both of the assessors who were directly interviewed were enthusiastic about the pilot, highlighting the ability to use the map data, especially for vacant lots. However, one assessor pointed out that the battery life of the device was short, occasionally dying in the field. And both assessors mentioned that the assessor community is uncomfortable with change, especially when it comes to new technology. Nonetheless, both of these assessors thought the pilot should continue.

Summary of lessons learned

Hardware: As mentioned earlier this report, choosing a rugged handheld device is the only logical way to proceed. Devices get dropped, dirty, etc., so having a sturdy tool is essential.

Data complexity and redundancy: New York City's CAMA data is very detailed and complex. It was essential to be able to access and/or mirror CAMA rules on the handheld device. Data redundancy is key, especially in environments like New York City, where continuous live wireless or cell-based access is unrealistic at this time.

Support and education: Top-level support, especially from assessor management, is critical, as is educating assessors. Change is always challenging, especially when introducing new technology into an industry that has been performing its job manually (and successfully) for decades.

Next steps: Funding has already been requested for a continuation of the pilot with the goal of a full deployment of handheld devices for all field assessors.

How the application works

The following outlines help illustrate the handheld application's design and the work flow for assessors in the field.

Application design

1. **ArcGIS** – ESRI's desktop GIS software is used to create basemap map layout (MXD) files and publish them to ArcGIS Server as individual web services:
   - Five separate MXD files were created, one for each of the city's five boroughs;
   - Therefore, ArcGIS Server is running 5 separate web services.

2. The Center for Urban Research's consultant created **a customized installation package** that automatically consumes the web services and copies map layers and the map layout to the

handheld in mobile format.

3. A **copy of CAMA** needs to be exported and cleaned (field names and types made consistent) so it can be copied onto the handheld.

4. **Maps and CAMA data are copied** to each handheld's storage card (2GB storage space).

5. **The task list is copied** manually onto each handheld.

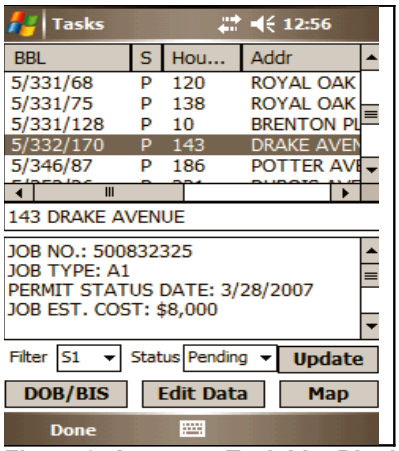

Figure 9. Assessor Task List Display.

Work flow

The application is organized around the areas of:

1. **Task Lists** – allows assessors to complete and track tasks (see screen at right).

2. **Parcel, Block and Building outline maps** – Assessors can see properties on a map, change their view, and click on the map to access other information (such as nearby parcels):

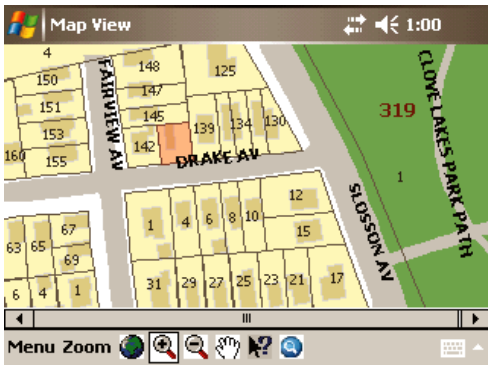

Figure 10. Parcel, block and building outline map

3. **Data entry forms** – Users can see all aspects of a parcel including building information, valuation, etc. Assessors can update selected information and have it uploaded to central computers. Screen shots of these entry forms are displayed in the "Data" section above;

4. **Contextual access to the New York City Department of Buildings website** – The application accesses the DOB building information database ("Bisweb") to check for construction permit and other information;

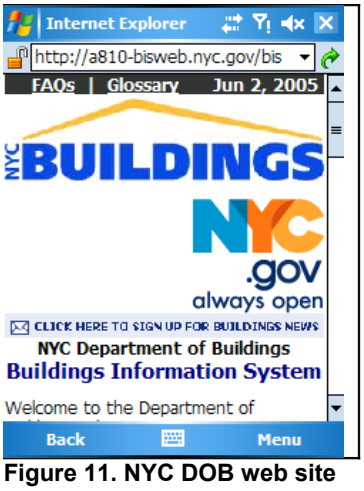

Figure 11. NYC DOB web site

5. **Confirmation whether local version of CAMA data is current** – The application "pings" the CAMA mainframe to determine if information for the parcel in question has been updated since the assessor went to the field.

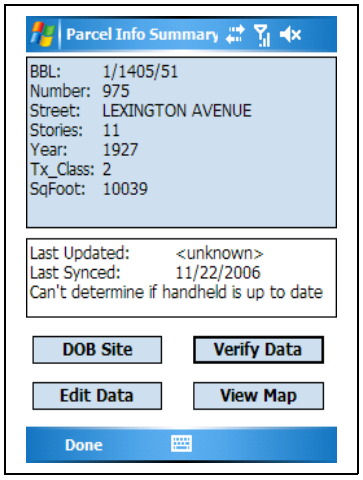

Figure 12. Parcel Info Summary

6. **Upload new/corrected data to a server** – data is saved locally each time the assessors moves from screen to screen (based on user prompts to confirm the updates or to revert to the original data if an error was made). When the assessor is ready to save the entire parcel's data changes, the application saves them locally and uploads them to the Center for Urban Research's server for storage in an ASCII delimited text file (see "Post Changes" in Figure 13).

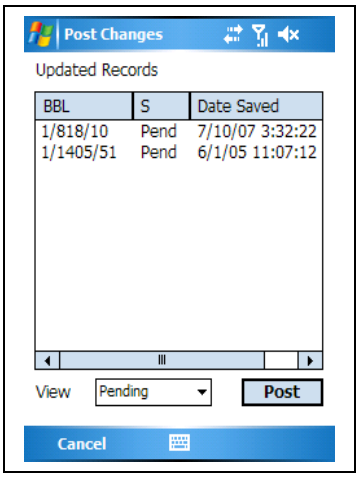

Figure 13. Post Changes

   a. Selecting "Post" posts changes for each listed BBL to CAMA. Once changes are posted successfully, the status will change from "Pending" to "Posted." Views of this screen may also be changed by selecting the "View" drop-down.

   b. During the pilot project, the text file on CUR's server was periodically and manually integrated with the CAMA mainframe. Beyond the pilot project, we will need to improve the upload process so it seamlessly connects with CAMA. For now, the following fields can be edited by the assessor, saved locally on the handheld device, and uploaded to CUR's server for eventual CAMA integration.

Field #	Field Name
91	BUILDING CLASS
92	PRIMARY USE CODE
96	TOTAL BUILDINGS
97	PARCEL STATUS
149	NOTE #1 CODE
149	NOTE #1
216	NEIGHBORHOOD TYPE
217	AREA RATING
218	ADJACENT INFLUENCE
219	PARCEL COMPATIBILITY
220	STREET TYPE
221	TRAFFIC LEVEL
222	SITE ELEVATION
223	LANDSCAPING
224	CORNER
225	DRIVEWAY TYPE
226	# OF PARKING SPACES:COVERED
226	# OF PARKING SPACES:UNCOVERED
235	VALUE STATUS

Field #	Field Name
300	LOT TYPE
301	LOT IRREGULAR
302	LOT PRIMARY FRONTAGE
302	LOT DEPTH
302	LOT PERIMETER
305	LOT SECONDARY FRONTAGE
305	LOT NUMBER OF FRONTAGES
871	MAJOR USE AREA:RESIDENTIAL SQUARE FOOT
872	MAJOR USE AREA:OFFICE SQUARE FOOT
873	MAJOR USE AREA:RETAIL SQUARE FOOT
874	MAJOR USE AREA:GARAGE SQUARE FOOT
875	MAJOR USE AREA:STORAGE SQUARE FOOT
876	MAJOR USE AREA:FACTORY SQUARE FOOT
877	MAJOR USE AREA:OTHER SQUARE FOOT
880	MAJOR USE AREA:OWNER OCCUPIED SQUARE FOOT
976	PARCEL OVERRIDE VALUE:LAND
976	PARCEL OVERRIDE VALUE:BUILDING
976	PARCEL OVERRIDE VALUE:REASON CODE
976	PARCEL OVERRIDE VALUE:REASON

Handheld Pilot

1. How often have you used the device in the field?

	Response Percent	Response Count
Never	0.0%	0
One time	27.3%	3
A few times	**72.7%**	8
Always	0.0%	0
If never, let us know why...		0
answered question		**11**
skipped question		0

2. How useful are the following handheld features?

	Very useful	Somewhat useful	Not at all useful	Response Count
Parcel-level maps	**50.0% (5)**	**50.0% (5)**	0.0% (0)	10
Direct access to CAMA data	**63.6% (7)**	36.4% (4)	0.0% (0)	11
Ability to record changes	27.3% (3)	**72.7% (8)**	0.0% (0)	11
BIS website lookup	**72.7% (8)**	27.3% (3)	0.0% (0)	11
Internet Access	20.0% (2)	10.0% (1)	**70.0% (7)**	10
			Other (please specify)	1
			answered question	**11**
			skipped question	0

3. How did the application perform while performing the following:

	Great	Adequate	Poor	N/A	Response Count
Accessing information within each form	18.2% (2)	**72.7% (8)**	9.1% (1)	0.0% (0)	11
Moving from form to form	9.1% (1)	**54.5% (6)**	36.4% (4)	0.0% (0)	11
Navigating between the forms and the map	9.1% (1)	**45.5% (5)**	36.4% (4)	9.1% (1)	11
Using the map	18.2% (2)	**45.5% (5)**	27.3% (3)	9.1% (1)	11
Search options	18.2% (2)	**72.7% (8)**	0.0% (0)	9.1% (1)	11
Posting data	0.0% (0)	30.0% (3)	0.0% (0)	**70.0% (7)**	10
				answered question	**11**
				skipped question	0

4. Screen size / Readability: Were the forms and the maps easily viewable (text, maps, map labels)?

	Response Percent	Response Count
Great	0.0%	0
Adequate	90.9%	10
Poor	9.1%	1
	answered question	**11**
	skipped question	0

5. Handheld vs Paper: Did the data entry options make it unnecessary to carry spreadsheets or other paper forms into the field?

	Response Percent	Response Count
Yes	40.0%	4
No	60.0%	6
	answered question	**10**
	skipped question	**1**

6. Battery Life: How often did you need to recharge the battery?

	Response Percent	Response Count
Multiple times during the day	0.0%	0
Daily	100.0%	11
Weekly	0.0%	0
answered question		11
skipped question		0

7. When recharging the battery did you: (Select one)

	Response Percent	Response Count
Recharge in the field	0.0%	0
Return to the office to recharge	100.0%	11
answered question		11
skipped question		0

8. Durability: Were you ever prevented from using the device due to a drop or liquid spill?

	Response Percent	Response Count
Yes	9.1%	1
No	90.9%	10
answered question		11
skipped question		0

9. Rate the following features/functions on the handheld:

	Great	Adequate	Poor	N/A	Response Count
Battery Life	9.1% (1)	**63.6% (7)**	18.2% (2)	9.1% (1)	11
Charging/Docking Station	18.2% (2)	**63.6% (7)**	0.0% (0)	18.2% (2)	11
Car Charger	0.0% (0)	0.0% (0)	0.0% (0)	**100.0% (11)**	11
Ruggedness	18.2% (2)	**36.4% (4)**	9.1% (1)	**36.4% (4)**	11
Use in the Sun	9.1% (1)	**45.5% (5)**	36.4% (4)	9.1% (1)	11
Key Pad	10.0% (1)	**80.0% (8)**	10.0% (1)	0.0% (0)	10
Camera	10.0% (1)	20.0% (2)	0.0% (0)	**70.0% (7)**	10
Weight of Device	18.2% (2)	**54.5% (6)**	27.3% (3)	0.0% (0)	11
Ease of Use	18.2% (2)	**81.8% (9)**	0.0% (0)	0.0% (0)	11
Intuitiveness of Use	20.0% (2)	**70.0% (7)**	10.0% (1)	0.0% (0)	10
				Other (please specify)	2
				answered question	**11**
				skipped question	0

10. Will a handheld device be useful in the field ...

	Yes	No	Maybe	Response Count
To research properties	**81.8% (9)**	0.0% (0)	18.2% (2)	11
For better data & valuation accuracy	**54.5% (6)**	36.4% (4)	9.1% (1)	11
For completing work more efficiently	**45.5% (5)**	36.4% (4)	18.2% (2)	11
For completing work faster	**36.4% (4)**	**36.4% (4)**	27.3% (3)	11
			Other (please specify)	1
			answered question	**11**
			skipped question	0

11. What challenges were you faced with using the device during the test period?

	Response Count
	6
answered question	6
skipped question	5

12. What suggestions do you have to increase the usefulness of the device? New functionality? New features? Alternatives the pilot team has not considered?

	Response Count
	3
answered question	3
skipped question	8

13. Other comments you would like to share that would help determine the usefulness and future development of a handheld device for fieldwork:

	Response Count
	1
answered question	1
skipped question	10

14. Should the Agency continue developing handheld devices for field work?

	Response Percent	Response Count
Yes	81.8%	9
No	18.2%	2
Please Explain (optional)		2
answered question		11
skipped question		0

15. Please provide your name so the pilot team can contact you for clarification. (Optional)	
	Response Count
	6
answered question	6
skipped question	5

APPENDIX II: Handheld Technology Evaluation (October 25, 2006)

The following is a memo provided to DOF by the Center for Urban Research, evaluating possible handheld devices for the pilot project. Based on this review and subsequent meetings with DOF, we decided to use one of the only ruggedized devices commercially available at the time – the Intermec CN3.

Memo

To: Phillip Leclair, Department of Finance

From: Steven Romalewski, Center for Urban Research / The Graduate Center

Date: October 25, 2006

Re: Phase 2 Deliverable: DOF/CUNY ORPS project – handheld GIS survey instrument for property assessment

---

Review of task

Phase 2 of the pilot project involved a survey of the "best in class" handheld technology in order to prepare an assessment for Department of Finance, as well as a review of DOF's current data collection procedures and data management tasks. The goal was to evaluate which handheld options would be best for this pilot project. The task included an investigation of the feasibility of wireless capabilities of the handheld devices.

CUR has undertaken the following activities to prepare this evaluation. We have:

- reviewed DOF's data collection procedures and management tasks through a series of meetings, conversations, and emails with DOF project staff;
- reviewed offline literature related to the handheld industry, especially conference proceedings from URISA and ESRI, journals such as *Government Technology* and *Mobile Government*, and ESRI's *ArcNews* and *ArcUser* publications;
- reviewed online material including vendor websites, hardware and software reviews at www.mobiletechreview.com, www.mobilitytoday.com, www.carrypad.com, and www.ruggedpcreview, and listservs and blogs of handheld device users;
- physically examined a variety of handheld devices and purchased a Pocket PC phone for initial testing (a UTStarcom PPC-6700 sold by Sprint);
- interviewed practitioners who have used handhelds in the field for data collection; and
- retained a consultant – Michael Uffer, principal of Dev408 – to advise CUR on the latest industry trends (whose credentials include evaluating handheld technology options for the US Census Bureau and developing a mobile phone-based application for the New York City Department of City Planning).

CUR's findings, along with research, advice, and observations from our consultant, are summarized

in this report. A matrix comparing DOF's business and workflow requirements with specifications of the major handheld devices and related technology components is attached. Finally, we provide recommendations for the purchase of handheld devices for this project.

DOF preferences

Department of Finance's assessment team has expressed the following preferences regarding the development of a handheld application. None of these items have been presented by DOF as absolute requirements, but they provide constraints and benchmarks against which each technology option can be evaluated. The list below is not in any particular order of priority.

- no docking – wireless or cellular access to live data from the field is essential;
- battery life – the short battery life of Tablet PCs (only a couple of hours per charge, at best) was a key reason those devices were not well received by DOF's assessors;
- weight – based on the Tablet PC experience, the assessors would prefer a device under 2 pounds, preferably less than a pound;
- screen size – assessors are expecting a screen that can display a map of streets and major parks at the Community District level, then more detail such as tax parcels, building footprints, and streets when zoomed in to a several-block area or smaller. They also need to be able to access websites that display text and some graphics (such as the Department of Buildings BISweb site);
- screen resolution – should be adequate to view a map of tax parcels (labeled by ID), building footprints, and streets (labeled by street name) for a several-block area;
- screen glare – the devices will be used outdoors, so the need to minimize glare is important;
- keyboard – CAMA has several "short notes" fields that assessors rely on regularly. They will need the ability to enter this text on the handheld, so small keyboards or touch-screen keypads might be a concern;
- speed – processor speed (and therefore response time of the maps and websites on the handheld) is important. We originally expected each handheld to run ESRI's ArcPad; ESRI recommends a CPU speed of at least 450 MHz for ArcPad (and faster is preferable). However, if the handheld device for this pilot project does not need ArcPad, and may use a web service to transfer map images and data, processor speed may be less important than network connectivity and bandwidth;
- software – if data transfer relies solely on html/xml, the device only needs a web browser. But if it involves local data storage, ArcPad mapping functionality, and/or other software, it needs to be able to have this software either pre-installed or downloadable via the Internet;
- camera – the preference is to have an integrated camera with the handheld. Neither CAMA nor RPAD currently have an immediate way of linking photos with parcel data, but once the photos are tagged with a parcel ID they can be stored and eventually integrated with other assessment data;
- cost – the original proposal for this project included a budget that allocated approximately $700 per handheld for a total purchase of 17 handhelds. Based on our evaluation below, DOF may need to be flexible regarding this price range, especially if so-called "ruggedized" handhelds are used (these can cost upwards of $2,000);

- data storage capacity – this may or may not be a concern, depending on how much data needs to be stored locally on each handheld device; and
- reliability – the device needs some level of protection against dropping, liquid damage, or other physical hazards.

Online/offline connectivity

DOF's preference to avoid physical docking of the device in order to transfer data is likely the most important constraint for this project. It will be a major determinant in the selection of a handheld device, and will substantially impact application development. It is also somewhat untested; we could find no other handheld project of this complexity either in New York City or elsewhere that relied solely on wireless connectivity for data transfer.

There are three general data connectivity options for handheld devices. They are listed below with major pros and cons for each one.

1. **Standalone with sync ("docking")**: Though DOF strongly prefers not to use a system that relies on docking, we review here the pros and cons to ensure all the options are fully evaluated. With docking, all data is transferred to/from the device using a sync technology (such as Microsoft's ActiveSync). It requires a docking station or cradle physically connected to a desktop computer or server via a USB cable, and uses desktop sync software to upload/download data to the device.
    - **Pro:**
        i. direct access to DOF server(s);
        ii. work flow is not interrupted if wireless/cellular network goes down or is unavailable;
        iii. more control over application design – can use off-the-shelf software such as ArcPad with ArcPad's Application Builder toolset;
        iv. syncing tools are built-in to the application – no need to account for web connectivity and wireless communication protocols.
    - **Con:**
        i. requires assessors to physically visit an office that is connected to DOF's local area network;
        ii. limits the ability for ad hoc in-the-field assessments;
        iii. if the device is lost or stolen, the data is also lost or stolen;
        iv. requires a system that allows for disconnected editing, which may result in data being locked (for viewing, editing, and/or analysis) until the assessor successfully docks and syncs his/her handheld.

2. **Online**: data is transferred via a wireless or cellular network. Requires one or more of the following technologies:
    - *WiFi* – data is transferred to a server using a wireless connection, which requires proximity to a node or "hot spot" that is linked to a wireless network,
    - *cellular* – requires a phone and data plan that uses a cellular broadband network to transfer data, and/or
    - *Bluetooth* – local wireless connection to a laptop or other computer, which then requires

desktop sync software to transfer data to DOF's servers.

- **Pro:**
  i. assessors do not have to physically visit an office to access and transfer data;
  ii. cellular networks use broadband connectivity, so speed of transferring data and/or websites is impressive; and
  iii. ad hoc assessments in the field are possible, because the assessor simply needs to download or access in real-time the data and maps for his/her area via the online connection.
- **Con:**
  i. if data transfer relies on a wireless network, it needs to be secure. Many individuals and organizations have set up wireless routers that can be accessed by anyone with a wireless-capable device, but these routers often have unsecured connections that allow for easy interception of your data transmission;
  ii. secure wireless access is far from ubiquitous in New York City. According to DOF, the city's municipal wireless system for emergency responders is not yet available for this project;
  iii. cellular connectivity is more widespread, though even cell networks have "dead zones";
  iv. if neither a cell nor a wireless connection is available for the assessor's particular location, data transfer will be prevented;
  v. the application needs to account for the possibility of a "dropped call" or other interruption in connectivity, especially if this occurs while data is being transferred; and
  vi. ongoing costs will be incurred for data plans and related carrier charges.

3. **Hybrid:** a combination of the above two options, which could involve:

- *Cached transactions* – data entered is stored on the device until it can be uploaded to server,
- *Pre-populated basic data* – basic data such as lists, enumerated values, etc are stored on the device,
- *Synced tasks* – tasks for the assessor are synced on a regular schedule,
- *Synced maps* – GIS maps are generated and synced as needed based on the tasks, and
- *Ad hoc tasks* – assessor can create an ad hoc task based on discovering something in the field. Supporting data needed for the task can be downloaded to the device using an online connection.
  - **Pro:**
    i. includes redundancy for data collection – if the wireless/cell connection is unavailable, data is still stored locally.
  - **Con:**
    i. more complicated to design. It is basically a combination of options 1 and 2, and therefore will involve the components of both; and
    ii. may still require physical docking and syncing of the device.

Issues particular to the Online option

Assuming we will develop an application that relies to some extent on online connectivity (option 2

or 3 above), several issues will need to be addressed regardless of which device is selected. These may not be critical at the pilot project stage, but DOF will need to consider them in advance of a full rollout of handheld devices. We will track these as part of the pilot project in order to provide feedback for each item.

1. *Coverage* – is all of NYC covered by the specified communication technology;
2. *Roaming* – will the data communications link be retained if the assessor is moving from place to place;
3. *Signal strength* – how good is the signal strength indoors and behind barriers;
4. *Cost* – presumably New York City has a standard calling and data plan from preferred vendors. Is this plan adequate compared with the amount of data that will be transferred for the pilot project and going forward;
5. *Connection* – will the connection persist over the time that may be required to record data;
6. *Initial time to establish connection* – how long does it take to connect to the server each time a form or set of forms is completed; and
7. *Power consumption* – using a data connection consume more power than offline applications. How long will the power last based on the projected data transfer and connection technology.

Other factors

Physical characteristics

Other issues related to the device itself will need to be considered regardless of which device is selected. An assessment of each item is outside the pilot project's scope, but the pilot will help DOF understand how each issue would be addressed for a full rollout.

1. *Data security* – protecting any locally-stored data if the device is lost or stolen, through password protection or encryption. If we follow the Online option and no data is stored locally on the device, this is a moot point. However, DOF will also need a plan for replacing the devices themselves, and consideration of backup devices per assessor;
2. *Total battery life* – how long it will take before the battery cannot be recharged or the discharge time is too short for effective use;
3. *Time to full recharge* – how long to recharge device from typical discharge state to full charge; and
4. *Ruggedized device* – if a device is selected that is not sold off-the-shelf designed to withstand drops, etc., can it be customized and converted to a ruggedized format.

Deployment/Upgrade/Bug Fixes

Finally, once DOF is ready for a larger-scale deployment of the handheld application, DOF will need a plan to provide new versions of the assessment application as well as bug fixes to a distributed inventory of handheld devices. Also, a plan for upgrading devices will be needed, ensuring that the application is compatible with the new device or vice versa.

Hardware Platforms

We reviewed the following major hardware types for this evaluation:

- **Pocket PC** – handheld devices that are computer-only (no phone/cell connectivity, but that

include wireless or Bluetooth capability);

- **Pocket PC phone** – a cell phone that uses a Windows operating system and includes mobile versions of Windows-based software applications;
- **Palm-based Pocket PC phone** – the same as above, but runs either on a Palm operating system or combines Palm features with a Windows operating system;
- Java Platform, Micro Edition (**Java ME**) phone – a cell phone that can run Java ME software – if the application needs to be developed in Java;
- "**Ruggedized" devices** – devices that have been enhanced to protect against liquid damage, drops, etc.; and
- **Ultra Mobile PCs** – a lighter-weight version of Tablet PCs that run on a desktop Windows operating system such as XP (rather than Windows Mobile or Windows CE) and include an actual hard drive and tend to have larger screen size than Pocket PCs.

Several new and popular mobile devices were not reviewed because they did not incorporate a touch screen for data input. These include Blackberry and the Motorola Q (though the Q does run on the Windows Mobile operating system).

Evaluation summary

The attached matrix lists specifications for most of DOF's preferences for each of the hardware platforms listed above, using a reference device as an example. We did not find adequate reviews or vendor information regarding some preferences, such as screen glare. We will need to evaluate these categories as part of the pilot project.

The following table shows photos of each reference device (not to scale). A detailed specification sheet for each one is attached.

Pocket PC Dell Axim X51v	**Pocket PC phone (Windows)** Sprint PPC 6700	***Pocket PC phone (Palm)*** Palm Treo 700wx
		
(Actual size: 4.7" H x 2.9" W x 0.7" D)	(Actual size: 4.3" H x 2.3" W x 1.0" D)	(Actual size: 4.4" H x 2.3" W x 0.9" D)

H(eight) = top to bottom; W(ide) = left to right; D(epth) = back to front

Java ME phone Nokia E62	**Ruggedized device** Intermec CN3 Mobile Computer	***Ultra Mobile PC*** OQO model 01+
	 *Numeric keypad on left, QWERTY keypad on right*	
(Actual size: 4.6" H x 2.8" W x 0.6" D)	(Actual size: 6.3" H x 3.2" W x 1.3" D)	(Actual size: 3.4" H x 4.9" W x 0.9" D)

H(eight) = top to bottom; W(ide) = left to right; D(epth) = back to front

Despite the price ($2,695), a ruggedized device such as the Intermec CN3 appears to be the most appropriate for this project. It is fast, sturdy, uses the latest cellular and wireless connectivity standards, and has substantial battery capacity.[1]

Other ruggedized devices offer similar features at comparable list prices. We provide URLs in the "Other Devices" section below for additional information.

Note that only the ruggedized device vendors provided data about their capacity to withstand drops and resistance to dust and water. The non-ruggedized devices are designed mainly for consumer uses, not heavy in-the-field usage.

If the cost or other factors with ruggedized devices is a barrier, we would alternatively recommend either an Ultra Mobile PC or a Pocket PC, mainly due to their screen size, storage capacity, and processor speed.

Both of these alternatives, however, have significant drawbacks. The ultra mobile PCs do not have built-in cellular connectivity nor are they field-tested for sturdiness. Though they have substantial data storage capacity, this is based on a built-in hard drive which typically is a delicate hardware component. The pocket PCs typically have no keyboard for data entry, and the Dell Axim has neither a built-in camera nor cell connectivity.

[1] New York City already has experience with Intermec devices. The NYC Department of Health and Mental Hygiene used an Intermec device (the 760) during the 2004 Republican National Convention for collecting environmental and health monitoring data (see http://epsfiles.intermec.com/eps_files/eps_cs/NYC_DOH_cs_web.pdf).

For the pilot project, we recommend initially purchasing one ruggedized device, one ultra mobile PC, and one pocket PC. We would design a test application in November to demonstrate how data input fields and maps would be displayed by each of the devices. The test application would not necessarily be connected to CAMA, but instead would enable CUR and DOF to take our evaluation one step further based on physical inspection of the devices and especially to see how the device displays input forms, interactive maps, and web sites. This assessment would determine which device to focus on for in-the-field testing in early 2007.

Other devices

In all, we reviewed several devices in each of the major categories listed above. Some, especially in the ruggedized category, were close in style, specifications, and cost to the example device included in our evaluation matrix. We can provide documentation for each of these other devices if DOF wants to compare further.

- **Pocket PC**
  - HP iPAQ
- **Pocket PC phone**
  - Cingular 8125
  - T-Mobile MDA
- **Palm-based Pocket PC**
  - the Treo is Palm's primary phone device
  - Palm sells a Pocket PC (no phone) called the LifeDrive Mobile Manager that runs on the Palm operating system
- "**Ruggedized" devices**
  - jett.xl by Two Technologies (http://www.2t.com/jettxl.htm)
  - Symbol MC70 (http://www.symbol.com/mc70)
  - Dolphin 7900 by Handheld Devices (http://www.handheld.com/Site.aspx/na/en/product_center/hardware/?product=81)
- **Ultra Mobile PCs**
  - Samsung Q
  - Sony Vaio UX

Several new devices that are just now being marketed were not included in detail in our review, but seem promising. These include:

- the HP iPAQ hw6920 series Mobile Messenger;
- the HP iPAQ rx5915 Travel Companion; and
- the Palm Treo 700p (runs on Palm OS).

Next steps

We look forward to DOF's input and feedback on the above evaluation and recommendations. We hope to meet with DOF soon to discuss our suggestions for initial device purchases and development of a test application.