Implementing a Highway Signs Inventory

A Case Study of Pocket Signs by Adaptive Geo

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Executive Summary

Comprehensive details about highway road-signs were collected quickly and accurately for a city's highways department using a data-collection system based around inexpensive Pocket PC devices. Information logged included location, type, size and condition of signs. Pocket PC devices offer an affordable combination of power and ruggedness, and for many outdoor data-gathering applications offer an attractive alternative to traditional portable data-collection devices.

Introduction

The use of portable data-collection devices is now a well-established part of many outdoor IT projects, and there are a wide-range of different devices in use, many with useful modifications for ruggedness, extended battery life and display visibility in strong daylight.

Figure 1 - Typical Modern Portable Data Collection Device

However, low volume sales of these devices and the costly modifications described above means that prices are high compared to mass-market PC computing equipment.

Similarly, support for software development on non-standard hardware often comes well below that available on desktop PC's – new programs need to be learned, and the features available in such programs are often below best in breed on a desktop PC.

Finally, incompatibility between existing portable data-collection devices means that a purchaser must make a commitment to a single hardware supplier. This is a distinct contrast to the intensely competitive PC market where consumers are used to exercising choice and using a range of suppliers.

These issues emphasize the importance of a suitable standard for both hardware and software to enable the provision of high quality outdoor systems at affordable prices.

Enter the Pocket PC

Figure 2 - Compaq iPAQ 3830

The rapidly developing world of the Personal Digital Assistant (PDA) offers a compelling alternative for portable data-collection. The demand for a small hand-held device with diary, contacts, word processing, simple email and so on has produced more and more powerful designs over the last few years. The underlying design requirements have been to reproduce on the small device the sort of office applications seen on a desktop PC.

Until 2001, Microsoft's attempts to gain a foothold in the PDA sector had met with only limited success. Then for the first time the combination of their new Pocket PC software and new hardware from Compaq (the iPAQ) made a Microsoft offering the most exciting in this market. A bright display, good battery life, stylish design and familiar software made for a winning combination.

One extra feature well worth noting is the touch-screen. Almost all interaction with the iPAQ is performed by touching objects on the screen in a very intuitive way.

With system software from Microsoft, and an agreed hardware standard, software for Pocket PC devices can be developed using powerful Microsoft development tools. Thus developers can leverage their existing Windows knowledge onto the new Pocket PC, giving fast development of high quality applications.

The Compaq iPAQ Pocket PC has made a big impression on the market and by 2002 had sold over two million units. Similar units are now available from manufacturers such as Toshiba, Casio and NEC, making for a rapidly maturing market in which the purchaser has great choice. Retail prices for comparable units at the end of 2002 start from $300 US.

Of course, just because the Pocket PC makes a great PDA doesn't mean that it is necessarily suited to another, very different kind of use like outdoors data-gathering. It is certainly not a unit that you would want to put unprotected into a heavy industrial environment. But as a pocket-sized device, it is easy to slip into the relative safety of a pocket, and given the costs involved it is not unreasonable to hold one or more units as spares.

A large spares and accessories market surrounds Pocket PC, and no doubt enhanced units are currently under development by the main manufacturers. Having multiple manufacturers for a product gives greater confidence of supply and future proofing of investment.

The Project

In the summer of 2001, the highways department of City of York Council in the United Kingdom approached Adaptive Geo (www.adaptivegeo.com), a US- and UK-based mapping company, with a requirement to take inventory of all street and highway signs in the City of York area.

Figure 3 - York Minster

York is a historic city of 185,000 people situated in the north of England. It has over 4 million visitors every year, making it the second most popular visitor attraction in the UK.

York is governed by the City of York Council (www.york.gov.uk). The highways department of the council has responsibility for 440 miles of roads, both urban and rural, and operates a Traffic Congestion Management System that coordinates the switching of traffic signals with traffic flows throughout the city. York is one of only 8 local authorities in the UK to hold a government award for Integrated Transport.

Taking inventory of street and highways signs was important to York for several reasons. In the first place, no comprehensive records existed in a single place of what was out there because the signs had been installed a few at a time over long periods of time, going back well before the age of computers. It was considered that a complete inventory would highlight all kinds of hidden information that was previously unavailable.

Secondly, York wanted a way to ensure that signs were maintained in good condition, and to reduce the incidence of damaged, dirty, or badly illuminated signs. Although there is at the current time no regulatory requirement to do this, York considered it good practice to take a pro-active approach to maintenance in this way.

Thirdly, and just as importantly, in the event of a sign needing replacement, a complete inventory would provide the information needed to quickly provide an identical replacement. Designing a traffic sign involves various decisions even for a simple sign, and so it makes sense to have easy access to the original design.

Collecting the sign data was also viewed as a good test case for using the latest remote data-collection technology. Several other projects are under consideration, and will be highly beneficial to York if they can be developed quickly and at lower cost than previously estimated.

The Previous System

A manual system had been used from time to time to collect data, consisting of the printed maps available for the area, together with a notebook into which to sketch the signs.

Figure 4 - Manual System - Map and Sketched Signs

This was, of course, time consuming and not particularly accurate. The actual area for which data had been collected in this way was small, and it was not possible to quickly search and compare different signs.

Some of the old data might have been useful to keep, but instead the decision was taken to re-collect all data using the new Pocket PC system as it promised to be relatively inexpensive to do so, and this would mean all the data would be in the same form.

Development Work Begins

Using Pocket PC's for the data collection was agreed upon early on in development discussions. The bright display, hand-held size and low-cost were all significant factors. Adaptive Pocket Map – a system for viewing and annotating maps on Pocket PC devices was selected as the platform for the project.

The target absolute geographical accuracy was set at 3 meters, meaning that each sign logged should have its position determined to that accuracy. Two different methods were agreed on to make this possible.

In built-up areas, the detail available on the maps would be such that the actual position could be selected directly on to the map by pressing the "stylus" or pen onto the touch-screen. As you can see here on this picture, the outline of each house and its plot is clear to see, and at the maximum zoom factor where 1 meter equates to about 3 pixels, this makes locating a position accurate enough.

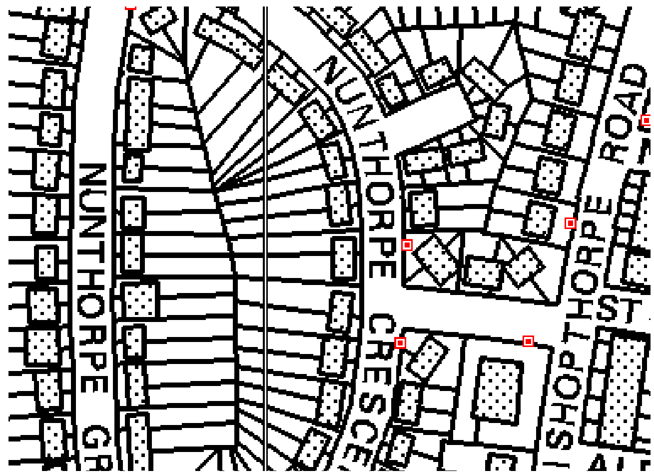


Figure 5 - Map Detail in a Built-Up Area

Away from built-up areas where there are not so many landmarks readily available, a Global Positioning System (GPS) unit is used to set the position. This is a piece of equipment that receives signals from a worldwide collection of circling satellites and can give an absolute measure of position. The accuracy achieved depends on how many satellites are visible from the location at any given time, and on the satellites' position in the sky, which is constantly changing. In practice, away from heavily built up areas and high buildings that can block the view of the satellites, the GPS unit gives a position anywhere in the world to an accuracy of about 4 meters, sometimes better, rarely worse.

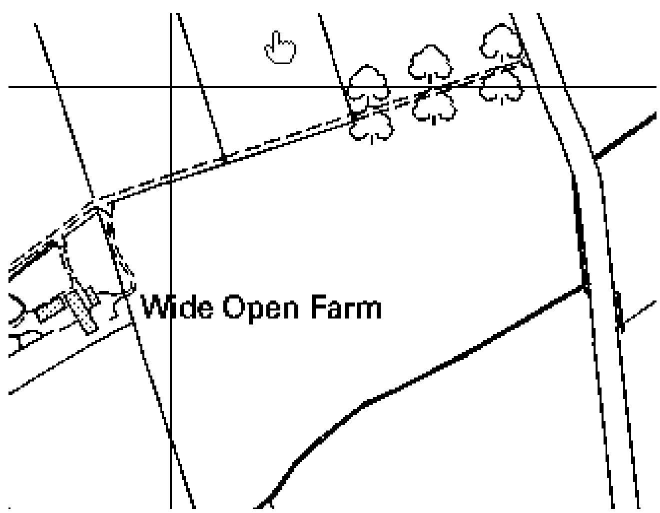


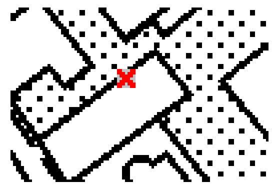
Figure 6 - Map Detail in a Country Area

The GPS unit chosen for the project was an Etrex unit made by Garmin (www.garmin.com), one of the leaders in consumer GPS. Although compact and low-cost (around $150 during 2002), the Etrex has a 12-channel radio receiver, which pretty much makes it state of the art among consumer GPS products. Garmin make more expensive units that offer such features as on-screen maps, but for this project maps were only needed on the iPAQ.

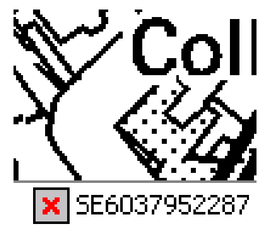
Figure 7 - Garmin Etrex GPS unit

The Etrex GPS connects to the iPAQ using a short cable. As long as it is attached and there are sufficient satellites in view, the GPS sends its current position every second.

In the Pocket Map software, if a GPS is attached then the position it is sending is displayed directly on the map as a red cross as shown here. The red cross moves around on the map as the location of the user changes.



A button at the bottom of the iPAQ display can be pressed to move the map so as to bring the red cross back into view again. The text next to the button – shown in this example as SE6037952287 – indicates the UK national grid position being provided by the GPS.



The position indicated by the GPS does not have to be used as the point at which data is logged – but if that is desired, then the user simply presses with the stylus at the place where the GPS marker is being shown.

The combination of heavy map detail in built-up areas together with good GPS coverage in rural areas provides an acceptable level of accuracy. Higher levels of accuracy could be obtained using a “differential GPS” transmitter and receiver. Fortunately, this was not needed for this project, as it would have led to a significant increase in cost.

Pocket Map Features

Pocket Map has all the convenience features for navigating maps that consumers have come to expect from desktop products such as Microsoft AutoRoute.

Extensive zooming and scrolling functions exist, appropriate for convenient use on the smaller display of the iPAQ, and adapted to the use of a stylus or pen as the main input method. The maps move around very smoothly, and there is Back/Forward/Home functionality similar to that found on web-browsers to ensure that the user does not get lost when navigating a map.

Figure 8 - The toolbar for zooming and scrolling functions

Two different scales of maps were used, chosen first because of their being already licensed by York, and secondly because of their "raster" format – this technically allows fast display and scrolling on a small device like an iPAQ. The two types of map are:

- Ordnance Survey 1:10,000 Scale Raster, Black and White
- Ordnance Survey 1:50,000 Scale Raster, Color

Both these forms of map data are created and licensed by the UK national mapping agency, the Ordnance Survey (www.ordsvy.gov.uk).

The 1:10,000 maps have been shown in all the screen-shots so far, as they provide the highest accuracy when entering a data point.

The 1:50,000 maps are useful when the map is zoomed far out, and are good for large-scale navigation as shown here.

Once a place has been located on this large-scale map, pressing down the stylus at the place and then selecting 'Zoom Right In' will bring back the high-resolution map centered on the given position.

Figure 9 - Detail of 1:50,000 Map

Pocket Map automatically switches between the two types of maps to suit the level of zoom selected by the user.

Pocket Map can also incorporate other sources of data including Address Point data, consisting of the location and details of all residential, business and public postal addresses. This was again already licensed by York from Ordnance Survey, and is superimposed on the background maps.

In this example, the 'Scaife Gardens' street has been selected. All addresses for that street are marked with a blue square. One particular address (number 46) is showing a yellow popup window with full details.

Nearby streets do not have their address points shown, as this can be confusing on a small display.

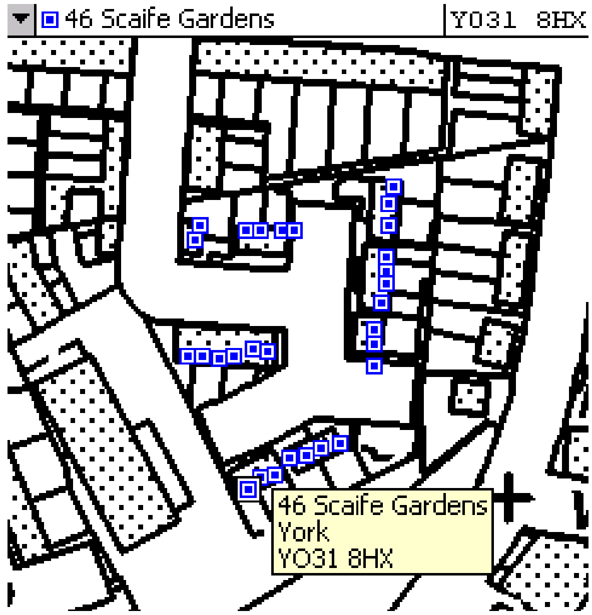


Figure 10 - Map with Address Point Data Shown

There are two ways to select a street. The first way is to simply touch the map in a place within a few meters of any address on the street. This way is very quick, and also allows neighboring streets to be easily selected for comparison purposes.

Alternatively, there is a small gray button at the top left hand corner of the display, which when pressed brings up an alphabetical list of all streets as shown here. The list can be scrolled up and down to find the required street, which is then just clicked on, at which point the map automatically moves to bring that street into view.

Next to each street on this list is shown also a typical post-code (zip-code) for the street, and also the number of private homes (in blue) and businesses (in green) to be found on that street.

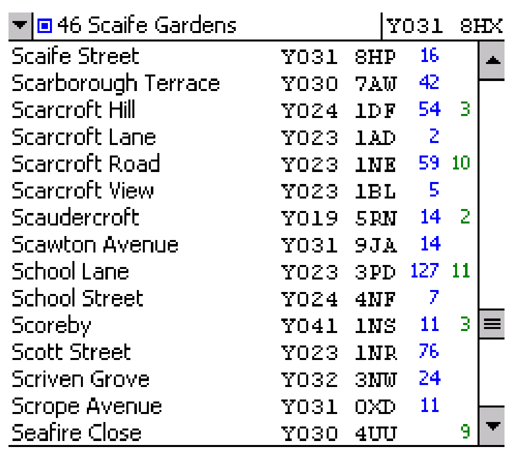


Figure 11 - Choosing a Street on the iPAQ

The combination of two scales of maps together with address points and GPS makes Pocket Signs a powerful hand-held tool for specifying a position at which to enter data.

The Data Entry System

City of York Council had exacting requirements for the data to be collected for each sign.

Many signs are UK Department for Transport standards, coming with an official "diagram number" such as these shown here. For example, a roundabout (traffic circle) has a diagram number of 510.

The official document providing detailed descriptions of these standard signs is titled 'Traffic Signs Regulations and General Directions' and can be obtained from the UK government (www.hmso.gov.uk).

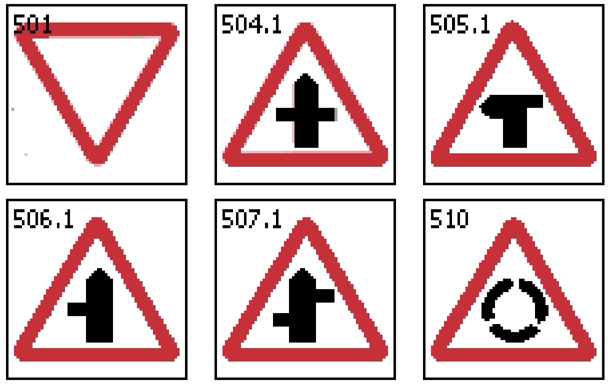


Figure 12 - Standard Signs With Diagram Numbers

However, many signs do not conform to a standard diagram number, usually because they contain specific information such as a distance ("London 245 miles").

For these, a feature was developed to make a quick sketch on the iPAQ like this:

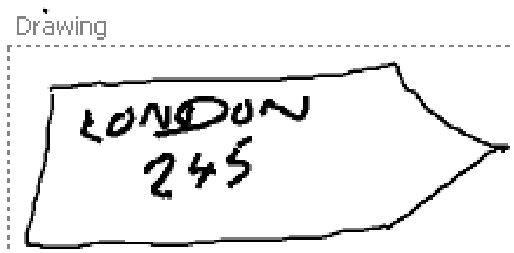


Figure 13 - Sketch of Direction Sign

and then taking a digital photograph of the sign using a normal digital camera.

Back at the office, the sketch was used to quickly identify the correct digital photograph, and the photograph was then associated with the rest of the data collected for the sign.

This technique was used for any sign that did not conform to a standard diagram number.

Figure 14 - Digital Photograph of Direction Sign

Once the sign has been selected, the user is prompted to provide further information about it, including overall size, the size of the lettering, and illumination type. This data was entered using large push buttons that could be quickly and accurately chosen with a finger-push, with the added benefit of audio feedback- on pressing the 63mm button, for instance, an audio message from the iPAQ speaker confirms "63 millimeters".

The example shown here allows entry of the size of lettering on the sign.

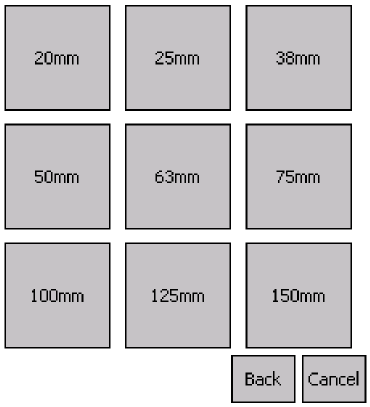


Figure 15 - Choosing Lettering Size on the iPAQ

Once all the data for a sign has been entered, a red square appears on the map indicating the location of the data that was entered.

Progress of the data collection exercise can be judged by the patterns of red squares appearing along the streets on the map.

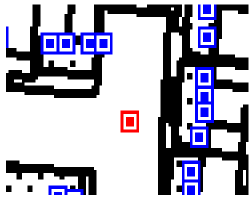


Figure 16 - Red Square Indicates New Data Point

The iPAQ can store over 10,000 data points in its memory, but in practice the procedure for data collection was to collect a day's worth of data on the iPAQ and then return the unit to the office at the end of the day for data upload to a PC database, and also to allow the iPAQ to recharge its batteries overnight.

At the same time, photographs taken on the digital camera would also be uploaded to the PC, the digital camera's memory cleared, and the camera also left to recharge overnight.

The camera used was a Kodak DX3500, an inexpensive 2.2 mega-pixel unit. An extra compact flash memory card was plugged into the camera to give a daily capacity of around 400 pictures.

Figure 17 - Kodak DX3500 Digital Camera

The Adaptive Pocket Signs package also includes a utility to upload data from an iPAQ to a Microsoft Access database in a desktop PC.

Pocket Signs proves to be a very efficient and accurate method of gathering information about highway signs. A team of two temporary workers with no similar prior experience collected the data.

Figure 18 - Collecting Data Outside York Minster – the Largest Gothic Cathedral in Northern Europe, dating from 1220. The signs are a 617, a 637, and a 638.

Typically, about 2400 data points were collected in 70 man-hours, giving an hourly rate of about 35 data points an hour.

This is remarkably fast considering the depth of data being collected, and the traveling time between the various signs, on foot in built-up areas and on bicycle or by car in more rural areas.

The Data Collected

To give an idea of the data built up, this is a screen-shot from a desktop PC application, showing part of central York.

Each red dot marks the location of a traffic sign and its data collected using Pocket Signs.

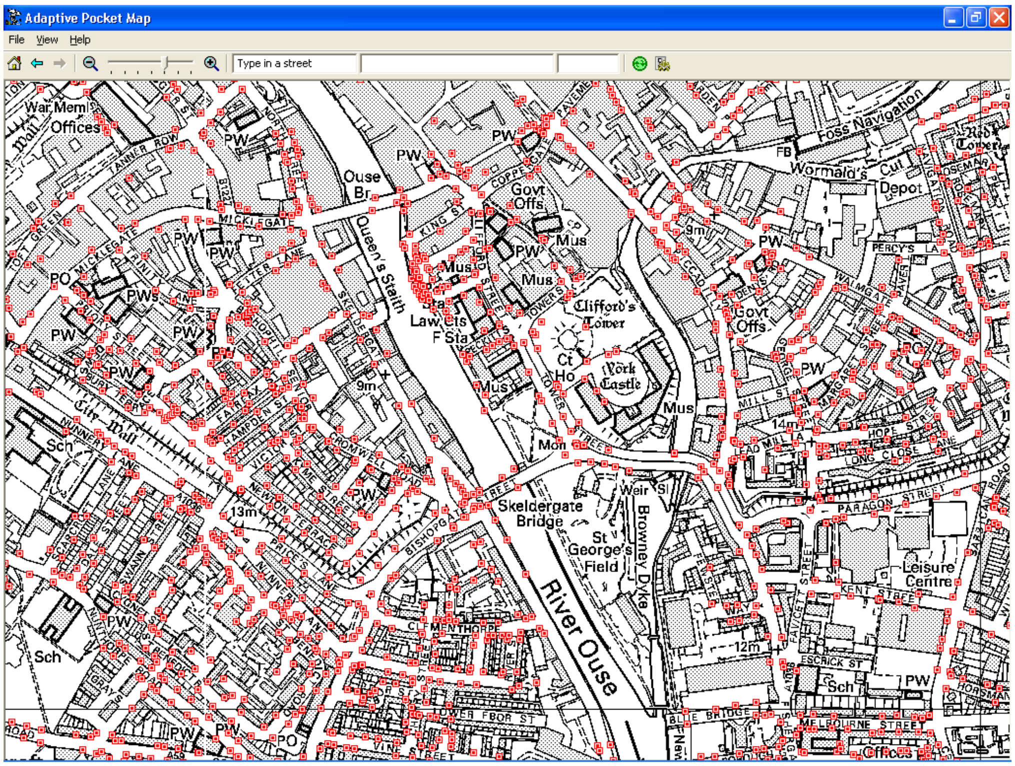
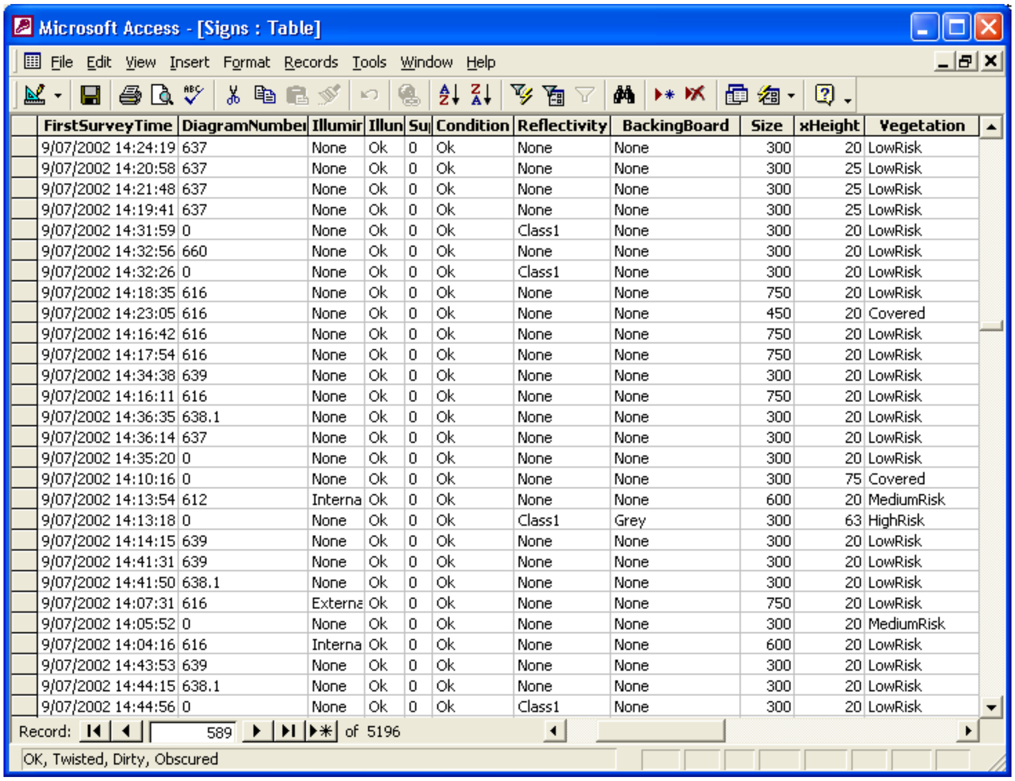


Figure 19 - Data from Central York

Part of the same data, shown in its Access database table looks like this:



	FirstSurveyTime	DiagramNumber	Illumir	Illun	Su	Condition	Reflectivity	BackingBoard	Size	xHeight	Vegetation
	9/07/2002 14:24:19	637	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:20:58	637	None	Ok	0	Ok	None	None	300	25	LowRisk
	9/07/2002 14:21:48	637	None	Ok	0	Ok	None	None	300	25	LowRisk
	9/07/2002 14:19:41	637	None	Ok	0	Ok	None	None	300	25	LowRisk
	9/07/2002 14:31:59	0	None	Ok	0	Ok	Class1	None	300	20	LowRisk
	9/07/2002 14:32:56	660	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:32:26	0	None	Ok	0	Ok	Class1	None	300	20	LowRisk
	9/07/2002 14:18:35	616	None	Ok	0	Ok	None	None	750	20	LowRisk
	9/07/2002 14:23:05	616	None	Ok	0	Ok	None	None	450	20	Covered
	9/07/2002 14:16:42	616	None	Ok	0	Ok	None	None	750	20	LowRisk
	9/07/2002 14:17:54	616	None	Ok	0	Ok	None	None	750	20	LowRisk
	9/07/2002 14:34:38	639	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:16:11	616	None	Ok	0	Ok	None	None	750	20	LowRisk
	9/07/2002 14:36:35	638.1	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:36:14	637	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:35:20	0	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:10:16	0	None	Ok	0	Ok	None	None	300	75	Covered
	9/07/2002 14:13:54	612	Interna	Ok	0	Ok	None	None	600	20	MediumRisk
	9/07/2002 14:13:18	0	None	Ok	0	Ok	Class1	Grey	300	63	HighRisk
	9/07/2002 14:14:15	639	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:41:31	639	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:41:50	638.1	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:07:31	616	Externa	Ok	0	Ok	None	None	750	20	LowRisk
	9/07/2002 14:05:52	0	None	Ok	0	Ok	None	None	300	20	MediumRisk
	9/07/2002 14:04:16	616	Interna	Ok	0	Ok	None	None	600	20	LowRisk
	9/07/2002 14:43:53	639	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:44:15	638.1	None	Ok	0	Ok	None	None	300	20	LowRisk
	9/07/2002 14:44:56	0	None	Ok	0	Ok	Class1	None	300	20	LowRisk

Figure 20 - Data Viewed in a Database

The 'Vegetation' column is interesting – some signs are at risk of being covered up, either now or perhaps in the Spring, by vegetation growing in front of them.

By searching during May and June for signs with a medium or high risk of being covered up, the work of the maintenance men in cutting back the growth can be directed exactly to where the problems are likely to be occurring.

Comments from City Of York Council

Peter Evely is Head of Highway Regulation for the City of York. He has this to say about Pocket Signs.

“Here at York, our highway maintenance budgets are constantly under pressure, so we need to work smarter, and the only way to do that is to have more high quality information, such as that provided by Pocket Signs.

“With high quality information, we can stop just reacting to, for example, a damaged sign, and start doing planned maintenance instead, which is much less expensive.

“Under the Highways Act of 1980, we have a statutory duty to ensure that highways are safe. If we are sure we have the most up-to-date and accurate information about the condition of the highways, then amongst other benefits it becomes easier to defend cases brought concerning highway condition. A reduction in overall claims is becoming evident since such systems have started to be put in place.

“We have been impressed with many aspects of the Pocket Map concept, and have subsequently placed further orders for different Pocket Map based applications.

“It’s vital to have technology like this to stretch budgets. Without such technology it becomes harder to meet all statutory requirements within spending constraints.”

Conclusion

City of York Council now have – for the first time - a full computer-based inventory of their highway signs and can easily update the inventory at regular intervals using Pocket Signs.

This will provide considerable benefits in terms of the maintenance of signs, for example the risk of cover by vegetation is now catalogued and appropriate preventive measures can be taken to keep signs visible.

Repairs, replacements and modifications can all be specified accurately and simply. Time on site visits will be reduced with consequent improvements in efficiency and cost saving.

Future developments planned include improved facilities for searching and filtering the data collected, and also the building of a history of the lifetime condition of highways signs on the York road network.

Adaptive Pocket Signs is the first application to be built on the foundation of Adaptive Pocket Map. Further applications are planned for users in the public sector, utilities and other businesses where the geographical location and specification of assets is a prime requirement.

References

Details about Pocket PCs of all kinds can be found at
www.microsoft.com/mobile/pocketpc

Compaq have their iPAQ product details here: www.compaq.com/products/handhelds

Garmin's Etrex GPS unit can be seen here: www.garmin.com/products/etrex

A nice explanation of global positioning using satellites is to be found here:
www.trimble.com/gps

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