ARCPAD IN THE SEWERS

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By Mark Hill, PE
Project Engineer
Hirsch & Company Consulting Engineers

INTRODUCTION

The City of San Diego has more than 55,000 sewer manholes connected by 2,874 miles of sewer. This sewage collection system plays a critical role in protecting public health and the environment. It is estimated that the replacement cost for the City's sewers would be between 14 and 15 billion dollars; 10 to 15 percent of the City's total infrastructure value.

About a third of the sewers are over 50 years old and have been increasingly problematic in recent years. Sewage spills have caused the closure of beaches and damaged endangered species habitat.

The City of San Diego has been video inspecting sewer pipeline for years, but in 2000 they began an intensive inspection program, including both manhole inspections and sewer main inspections. This program was designed to identify problems that need maintenance and repair and areas where the lines could be recommended for replacement.

Hirsch & Company has been involved in the sewer inspection program since 1996, but only integrated GIS into the program in 2001 when the project expanded exponentially. Prior to this, Hirsch & Company kept all inspection data in a Microsoft Access database and the City generated any maps that were needed for the work. The addition of GIS, and specifically the geodatabase allowed the integration of the spatial information with the inspection data. This enabled the production of geographical statistics and better planning and coordination of the work.

Hirsch & Company began working with ArcPad to facilitate the manhole inspection data collection and to reduce data entry. This paper is focused on the use of ArcPad to collect field data and the integration of that data with a Microsoft Access Database.

THE PROBLEM

Field inspection crews carry out the manhole inspections required by the project. At the beginning, the crews were provided with a map of the manhole locations in an area that

needed to be inspected and copies of the two-page inspection form that the City requires to be filled out for each manhole. The crews would visit each site, do a video inspection of the manhole and fill out the inspection forms. The forms and the videos were turned in at the end of each day for transcription and data entry.

The original system worked, but it was problematic. Field crews would omit data on the sheets, requiring another crew to return to the site and complete the inspection. Pages from the inspections would get separated and misplaced. Field crews would check off manholes that had not been inspected, or forget to check off ones that had been. The data from the inspection sheets had to be manually typed into the database, increasing the chances of data entry errors.

These problems caused confusion and much expended time during the quality control phase. A two-man inspection crew would finish a 70-manhole task in about a week and it would take another week and a half to sort through the data, do the data entry, quality control, and generate a report. Something needed to be done to decrease the postproduction time required to generate the reports.

CHOOSING ARCPAD

It was decided that the field crews should enter the inspection data into a handheld computer at the manhole site. This would remove the need for secondary data entry and by using required fields would make sure that the manhole inspections were complete. All of the data would be in one place and could not get separated and lost. By using this method it would also be easy to determine which manholes had been inspected and which remained to be inspected.

After investigating and dismissing the use of a portable version of Microsoft Access that would work on Windows CE (The operating system for many handheld computers), it was decided that the data gathering could be done most effectively using ArcPad. This had the added benefit of giving the crews an electronic map to follow.

HARDWARE, SOFTWARE & DATA

The handheld computers chosen for the field crews were Compaq iPAQs with the fastest available processor. It was later discovered that the Hewlett Packard handheld computers, purchased by our subcontractors, outperformed the Compaq iPAQs. This is a moot point now as the two companies merged soon after the start of the project.

An additional memory storage card was purchased for each of the handheld computers.

Storing all of the collected data on the storage card provides protection from data loss if the main battery fails. It also makes it easy to transfer a task from one iPAQ to another if there is a problem.

The use of a Trimble handheld was considered. This would have given GPS capability along with the mapping tools, but it was decided that the expense wasn't justified. Part of the project was to survey the manholes using GPS. The Trimble wouldn't give the needed accuracy, so a survey crew would also need to visit the sites anyway, and it was decided that the field crews could easily visually determine from the map that they were at the correct manhole.

Hirsch & Company was already set up with ArcView version 8.2 (since upgraded thanks to the maintenance program). ArcPad version 6.0.0.146 was purchased and has also subsequently been upgraded by ESRI's software maintenance program. Attempting to use ArcPad out of the box as an inspection tool proved to be difficult. The ArcPad Studio program hadn't been released yet and efforts to get ahold of a beta version failed. ArcPad Studio was purchased as soon as it was released, solving most of the problems.

At the beginning of the project Hirsch & Company had purchased GIS data from SanGIS, a clearinghouse for San Diego County GIS data. The data purchased included all of the general geographic information for the project area, streets and roads, and parcel information. Also purchased were the sewer and manhole layers for the project area (The City had to authorize SanGIS to provide the attribute data, which is only available for a City of San Diego job). The optional data that has proven valuable is the orthographically rectified photo for the project area. Unfortunately, the photo was taken in 1999 and is out of date in an increasing number of areas. Hopefully a new one will be available soon.

SETTING UP ARCPAD

The first attempt to use ArcPad for data collection involved taking the manhole feature class and making each of the inspection items a field in the attribute table, like an Excel spreadsheet. This would have made development of the inspection software very easy. The example in ArcPad Studio walks through creating forms for this scenario. In the case of the manhole inspection data however there were too many possible combinations of data to make a field for each one. For example, each manhole can have up to five sewer lines attached and each one of these sewer lines can have an unlimited number of defects. In most cases there are only two sewer lines having few, if any, defects. In order to provide for the worst case inspection (and everything in

between) the inspection interface would have been very cumbersome and the attribute table would have been very large and mostly empty.

It was decided to follow the same data format in ArcPad as in the existing Microsoft Access database. The manhole inspection data is stored in four tables, two for manhole data and two for pipeline data. In order to do this some visual basic programming was necessary so that the correct data would be written to the correct table. The only change made to the Microsoft Access database was the shortening of the field names to 10 characters or less; otherwise they would have been truncated when exported to ArcPad. The file structure for each manhole inspection task was set so that the same tables would be in the same directory each time. These were then referenced as a record source to write to and from when data was entered into a form.

Code was also written to verify that data had been entered for necessary fields and that the data was reasonable. For example, manhole depths entered as over 25 feet deep bring up a warning flag. Deep manholes do exist, but there aren't very many.

INTERFACE WITH ACCESS AND ARCVIEW

For each of the manholes to be inspected there is information that is known, stored in the database, that the field crews need to be able to access and verify. This information includes the diameter and the material of the connecting sewer lines, and the unique pipe number. In order to export this information to ArcPad, a map was created of the project area with the manhole feature class. The tables were then related to the manhole feature class based on the unique identifier for each manhole. When the tasks are exported to the iPAQ, the manholes in the task are selected and the related tables are exported to their appropriate directory. The shape files for the streets, manholes and sewer mains in the area are exported to another directory to complete the ArcPad data for the area.

The orthophoto is too large to be exported to ArcPad. A freeware utility downloaded from the ESRI website clips the image to what is currently on the screen and exports it as a Tiff. Arctoolbox provides a raster to MrSID utility that is used to make a task size orthophoto for use on ArcPad.

The field crews can now click on a manhole to be inspected, which brings up the inspection forms, enter the data, which is written to the four tables, and complete the inspection.

Once the inspection task is complete, the ArcPad tables are imported back into

Microsoft Access and because the field names are the same they are easily appended back to the original tables.

The interface is far from seamless, but it is still much more efficient than collecting data on paper and doing data entry into the database.

CONCLUSION

If possible, use ArcPad Studio and stick to creating forms to fill an attribute table for ArcPad applications. The development of specialized, multiple table applications for ArcPad can be tricky and hard to control.

The ESRI website has a bounty of useful tools for development of applications and programs.

The implementation of the ArcPad data collection has greatly improved the efficiency of the manhole inspection group. It now takes a field crew a day less to get through a 70-manhole task and it only takes two days to review the data, perform quality control, and generate a report.