Automated Pavement Condition Collection Vehicle for City of Houston

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Executive Summary

The City of Houston is required to assess the pavement condition of approximately 16,000 lane miles every three years to be compliant with government requirements and to ascertain which streets to repair or overlay. The city's previous manual methods of assessment were time intensive, subjective, and nearly impossible on some streets due to safety concerns. Working with Idea Integration, a business solution provider in Houston, the city recently built an Automated Data Collection Vehicle which automatically captures pavement conditions while City operators drive it safely. The vehicle and system collects information including pavement distresses, images, and 360 degree video. This solution involves GIS processing that uses GPS and driving distance collected by the vehicle to divide the data and images by street section and an online mapping interface to view pavement conditions. The city is now able to assess all of its roadways safely in less than two years and more easily ascertain which roads to repair.

Business Needs and Objectives

Houston, Texas is the fourth largest city in the country with an approximate population of 2 million inside the city and another 3 million in the surrounding area. The majority of those people work in the city and travel on over 16,000 lane miles of roadway that are within the city limits daily. Maintaining, assessing and reporting on that extensive of an infrastructure poses several challenges to The City of Houston.

Efficiency

The City of Houston endeavors to overlay at least 280 lane miles of pavement each year. Additionally, the Governmental Accounting Standards Board (GASB) Statement No. 34 requires that the City of Houston assess its infrastructure every three years and report back on the condition of its assets.

The prior pavement assessment system required city employees to visually rate the pavement and enter the information into a software tool running on a laptop in their vehicles. While the system did not rely on written record keeping, it did require a city employee to manually assess the pavement for each stretch of roadway. This was a very time intensive process that was only possible on streets that were not heavily trafficked. It was nearly impossible to properly assess the condition of a major thoroughfare.

With the previous system, the City of Houston was unable to meeting the GASB 34 standards and was also unable to obtain enough data to make good decisions on which 280 lane miles needed to be overlaid.

Safety & Consistency

One of the main concerns of the previous system was safety. City of Houston employees needed to exit their vehicle to properly view the road and make the assessments. Major thoroughfares were impossible to safely rate and other streets posed a risk to the inspectors when they exited their vehicles. At times, the inspectors were unable to fully assess a section of roadway due to traffic or obstructions. The assessment would only be valid for the section of the road they were able to safely view. This would often lead to incorrect of inconsistent data.

Another concern with data quality and consistency is the subjectivity of the assessment itself. Inspectors were manually assessing the pavement conditions based on how poor they “felt” the roadway was. The necessary use of multiple inspectors would lead to inconsistent data and, in some cases, data that was entirely incorrect. For example, an inspector who is currently having back problems may feel that the “ride” of the road is much worse than an inspector who is feeling fine. Another good example would be with regards to pavement cracking. One inspector might judge the extent of the cracking for a length of road to be 40% while another would say it “looks” more like 30%. Beyond human subjectivity, the consistency for something like “ride” would also depend on the vehicle the inspector is driving at the time and how well it is absorbs the roughness of the road.

Data Interpretation

In addition to being unable to capture enough data in a timely manner, another issue that was often encountered was the inability to easily interpret and report on the data that the city had collected. The previous system was a Microsoft Access based system that did allow for some map visualization but was not robust enough for the level of reporting and analysis that was necessary.

The Access based interface required users to use common network file shares for data storage and the inspection team would bring their laptops in to synch up each day using those file shares. The heavy use and reliance on shared network resources attributed to the system's unreliability.

Being a desktop and file share based system, it was very difficult to share data with other departments and councilmen. If, for example, a councilman wanted to see the condition of the roads in his district, he would have to request that a report be run for him. Likewise, if the Stormwater department wanted to know what the street conditions were like in an area they were investigating for a drainage issue, they would also have to request a special report. The result of this limitation was additional work for the pavement team as well as having a large amount of data being stored and communicated in excel format.

Solution

Recognizing a need to make the process of assessing pavement more efficient and consistent, the City of Houston released a request for proposal for a Data Collection Vehicle in 2007. After an extensive review period the city selected Idea Integration, a Microsoft® Gold Certified Partner and a Business Partner with ESRI, as its prime vendor for the solution.

For the first iteration of the project, Idea partnered with International Cybernetics and Immersive Media to deliver a vehicle capable of automatically assessing several different pavement distresses with very little manual input. The Data Collection Mobile Unit, or DCMU, collects 360° video and high resolution pavement images in addition to the pavement distresses.

The vehicle contains the following equipment to capture imagery and pavement distress data:

Item	Function
Road Profiler	Uses lasers and accelerometers to calculate the IRI (roughness) and rutting of the road.
Line-Scan Camera and Laser Illumination	CrackScope is a system that uses a line-scan camera and invisible laser illumination to capture high resolution image of the pavement surface. These images are then used to automatically detect the severity and extent of cracking.
360° Camera	The Immersive Media camera actually contains 11 different cameras each taking 30 frames a second to produce high quality 306° video.
GPS & DMI	The vehicle is equipped with a Trimble GPS receiver and DMI (Distance Measurement Instrument). The post-processing system uses the information from these two devices to segment the data by street section.

Figure 1 DCMU Vehicle and 360° Video Camera

Data Processing

The pavement distresses collected are Cracking, Rutting and Roughness. The data for these distresses is analyzed using a GIS post-processing application which segments the data by street section based on a City of Houston street layer and the GPS and DMI (Distance Measurement Instrument) information obtained from the vehicle. All of these distresses are then passed through a proprietary algorithm; the end result is a PCR (Pavement Condition Rating) score for each street section. The PCR score can be used by City of Houston personnel to make decisions regarding street repair and maintenance.

Data Visualization

The goal of the first phase of the project was a consistent and reliable pavement rating for each street section driven and the entire focus of the first half of the project was devoted to putting the vehicle into production, establishing the work-process, and calibrating the scoring mechanism.

The second phase of the project focused on creating an online application that provided the user many different ways to view and analyze the data and video collected by the vehicle. The main interface for the online application is a map based street viewer.

Map Interface

The map interface provides the user with several different methods to view the current street conditions of an area. Users who are only interested in a high level indication of street quality can simply zoom into an area on the map and the streets that have been driven will be color coded based on the level of distress. For a more detailed look at the pavement conditions, a user can use the map tools to draw a box around an area and view detailed information about each street section in the box including the PCR scores.

From this interface users can also play the video for a specific street section, view the high resolution pavement images and run different historical reports on the pavement quality for a specific street section.

The map interface also provides advanced search capabilities that allow the user to search for anything from a specific address to a council district. The system automatically detects what the user is searching for, zooms the map into the associated location, and highlights the area.

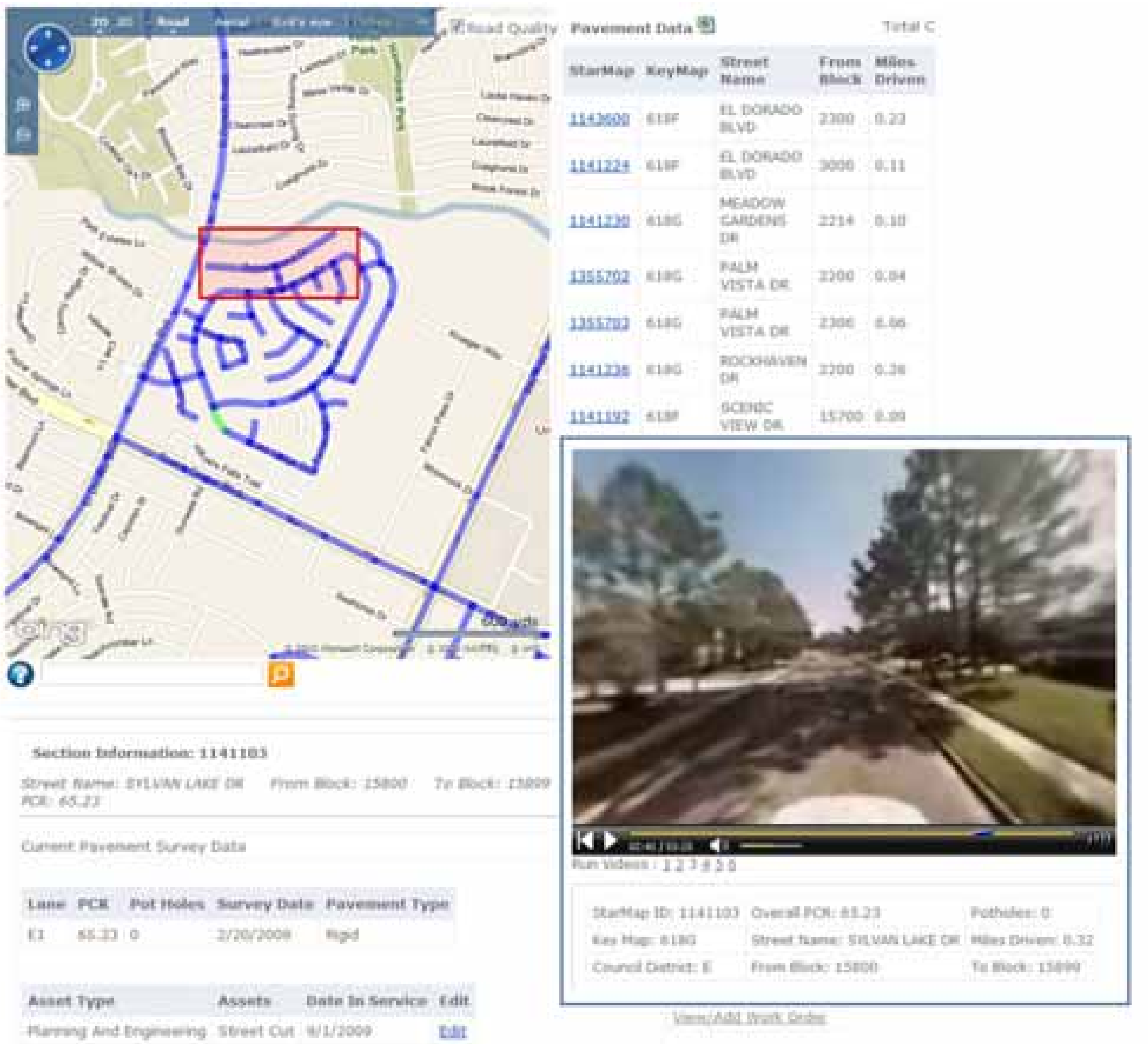

Figure 2 Map Interface and Video

Reporting and Search Interfaces

The online application also allows users to conduct text based searches that would bring back the same results as the map interface. Users have several different criteria they can use to narrow their search results. From those results, users can view video, section information, and images in the same manner as they do when using the map interface.

An extra layer of functionality is also provided with SQL Server Reporting Services (SSRS). All of the same criteria is that is provided in the search is provided here, however, SSRS allows for a much larger set of data to be returned and allows users to export that data into multiple different formats.

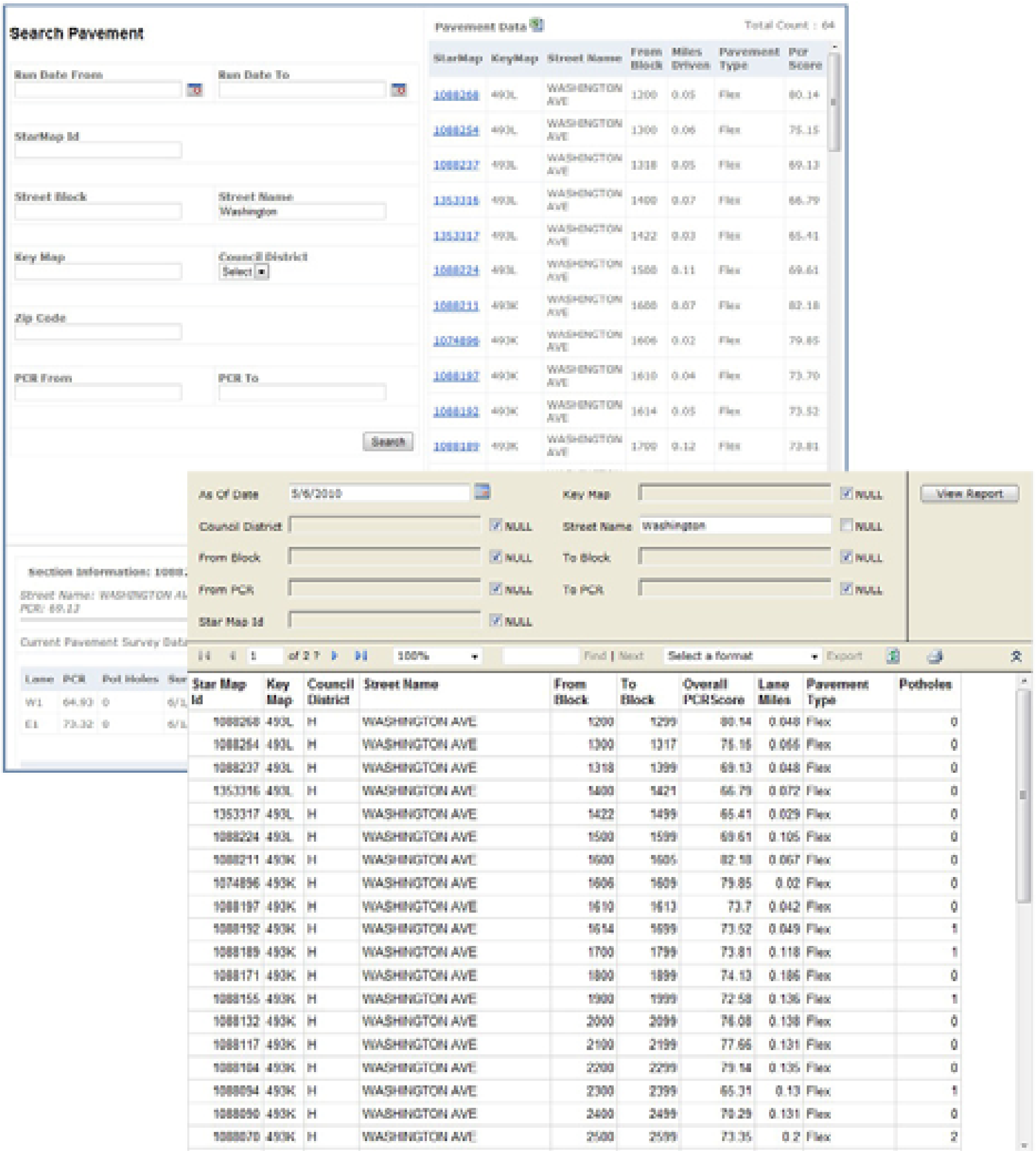

Figure 3 Search and Reporting

Benefits

With this new system, the City of Houston can now accurately and efficiently assess the pavement condition of all city streets in less than two years with a small team and one vehicle. This will allow the city to better ascertain which roads to overlay each year and the city will also be able to meet the GASB 34 requirements.

Efficiency & Safety

What would have normally taken the four man pavement crew several years to complete can now be done in less than two years. The Data Collection Mobile Unit is usually driven around 35mph on major thoroughfares and up to 20mph on residential streets. This allows the team to safely cover a large amount of territory in just one day. The pavement team stays inside of the vehicle the entire time and can collect data for several hours without returning to the office. The amount of time require to QA the processed data and video from the vehicle is a fraction of what it would have taken to collect the same amount of data with the previous system.

Consistency

By removing the 'human element', the new system has removed almost all subjectivity from pavement assessment. The pavement team has been trained in system testing and calibrations that are performed regularly on the equipment to ensure data quality and consistency.

Better Decision Making

The online interface allows the City of Houston employees to easily and quickly bring up data for a certain area to make decisions on everything from what needs to be overlaid to which section of town needs to assessed next. The multiple ways to view data combined with easy to use interfaces allows the system to be made available for decision making across all levels of the organization.

Better Service to Constituents

Having this system in place allows the City of Houston to respond much more quickly to citizen complaints and concerns. If for example, a citizen calls in about pothole in her area, the pavement team can quickly look up the street to view the score, images and video without sending a crew out to the location of the complaint. This type of easy, fast access to data will allow the City of Houston to respond to more issues much more quickly.

Scalable for Future Enhancements

The new system incorporates the latest versions of all equipment and software and has been architected with future enhancements in mind. For example, the next phase of this project will be to implement an interface that will allow City of Houston employees to tag right-of-way assets directly from the 360° video.

All pavement data is stored in a MS SQL Server DB and the system is equipped with 14 terabytes of usable storage for raw pavement data, 360° Video, and the high resolution pavement images.