Mobile GPS Data Collection for Infrastructure Management: A Case Study

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Agenda

1. Introduction to Capabilities

2. Case Study - City of Hamilton
   - Implementation
   - Results
Introduction

- Many jurisdictions have recognized the need to implement GIS-based Asset Management Systems (AMS).
- These systems require input data for all assets.
- Existing asset inventories:
  - Usually not GIS-referenced.
  - Data not always collected in a consistent manner.
  - Data spans many years.
  - Not representative of current state of assets.
A New AMS

- When implementing a new AMS, it is often necessary to collect new GIS-referenced data across the entire road network.
Introduction

- Using a mobile vehicle to collect roadway asset data.
- Asset types include:
  - Signs
  - Guardrails (Guiderails)
  - Catch basins
  - Traffic signals
  - Bus stops/bus shelters
  - Medians
  - Fire hydrants
  - Parking meters
  - Utility poles
  - Trees
Data Collection Options

- **Manual, walking surveys**
  - Used when very detailed information about each asset is required.

- **Semi-automated, vehicle-based collection**
  - Cost-effective approach for large-scale data collection when more basic information about each asset is required.
  - **Advantage:** Relatively low cost of data collection can be further divided among several departments for optimal use of available funds.
Vehicle-based Collection

- Data that can be collected for each asset:
  - GPS Positions
  - Asset Type (e.g. MUTCD code for signs)
  - Asset Dimensions (e.g. width, height)
  - Basic Condition rating
  - Digital image of each asset
  - Any other data that can be visually determined from images captured along the roadway.
Vehicle-based Collection

- Typical data collection vehicle will have:
  - High-resolution digital cameras
  - GPS receiver
  - Distance measuring instrument
  - Inertial sensor system
Vehicle-based Collection

- Panoramic imagery is collected at regular intervals along the roadway.
- Any assets that appear in the images can be inventoried.
How It Works

- The vehicle tracks its own GPS position as it drives along the road.
- Back at the office:
  - Asset positions are “marked” using the Surveyor software.
  - The software then “triangulates” the position of the asset.
Surveyor Software
What are the GPS positional accuracies of assets inventoried this way?

Answer: There are several options. It depends on the accuracy of the vehicle GPS.

The software used to mark the assets (Surveyor) adds only a small error component (20 to 50 cm).
GPS Positional Accuracies

● Four GPS options on the vehicle:
  - Real-time GPS
    ● 5 - 20 meter accuracy → not useful for asset inventory
  - Real-time Differential GPS (RT DGPS)
    ● 1 - 3 meter accuracy
  - Inertially-aided Real-time DGPS
    ● 1.0 - 1.5 meter accuracy
  - Inertially-aided Post-processed DGPS
    ● 0.4 - 1.0 meter accuracy
Real-time DGPS

- Real-time Differential GPS
  - Reasonable accuracy
  - Moderate coordinate availability
  - Low price
- Uses a differential correction signal broadcast from a service like OmniSTAR to adjust its position in real-time.

- Weaknesses:
  - Loss of GPS data during poor satellite visibility
  - Can have a jittery signal
Inertially-aided RT DGPS

- Inertially-aided real-time DGPS:
  - High accuracy
  - Excellent coordinate availability
  - Higher data collection costs
- Integrating GPS and inertial systems (e.g. POS/LV) improves data availability dramatically.
- Inertial systems use vehicle dynamics to provide coordinate fill-in during periods of GPS outage.
- Without the use of inertial technology, situations occur where it is not possible to obtain a GPS position for the roving receiver.
Inertially-aided Post-processed DGPS

- Inertially-aided post-processed DGPS:
  - Highest accuracy
  - Excellent coordinate availability
  - Higher data collection costs

- For data applications requiring the highest possible positional accuracy and coordinate availability, GPS data is collected using inertially-aided GPS receivers (on the data collection vehicle) and short base-line reference stations.

- This configuration provides both excellent coordinate availability through inertial fill-in, and accuracy through post-processing.
The City of Hamilton in Ontario, Canada implemented a Hansen AMS. The system required an initial input of accurate asset data. Roadware was selected to collect digital videolog and asset inventory on the City’s 6,500 lane-km network. Hamilton required that GPS positional accuracy would be +/- 1.5 m.
Asset Attributes Collected

- **Signs**
  - GPS position
  - Sign dimensions (width, height)
  - Digital image of each sign
  - MUTCD code, sign category, sign text
  - Curb present? (Y, N)
  - Side of road sign is on (Left, Right, Overhead)
  - Illumination device attached? (Y, N)
  - Multiple signs on same post? (Y, N)

- **Catch basins**
  - GPS position
  - Digital image of each catch basin
  - Catch basin type (Single, Double)
  - Grate type (selection from City list)
Routing

- Hamilton sent Roadware a database listing all City-owned streets that were to be collected.
- Roadware determined the most efficient way to collect the City’s road network.
- Right-of-way cameras were set up according to City specs.
- An integrated GPS and POS/LV system was chosen to meet the accuracy requirements.
Control Sites

- 5 control sites were set up within the City of Hamilton.
- An independent survey company collected very accurate (+/- 2 cm) GPS positions for 78 assets on the control sites.
Five Hamilton Control Sites
One example:
Dalewood Ave

Ground truth
Control Site Methodology

- At the beginning of data collection, all 5 sites were collected by Roadware’s vehicles.
- The asset positions were determined using Surveyor and these positions were compared to the ground truth data collected by the survey company.
- Every week thereafter, one site was collected and the results were again compared to the known asset positions.
Ground truth
Ground truth with Surveyor 2.0 results.
This site was run 3 times during the project.

Average errors:
08/22/04  1.13 m   PASS
10/17/04  0.69 m   PASS
11/27/04  0.58 m   PASS
# Control Site Results

<table>
<thead>
<tr>
<th>Site</th>
<th>RT DGPS</th>
<th>IA RT DGPS</th>
<th>PP IA DGPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cootes Drive</td>
<td>1.55</td>
<td>0.62</td>
<td>0.41</td>
</tr>
<tr>
<td>- rural, open skies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dalewood Ave.</td>
<td>13.2</td>
<td>0.88</td>
<td>0.80</td>
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<tr>
<td>- subdivision, tree cover</td>
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<td></td>
<td></td>
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<tr>
<td>King St.</td>
<td>1.84</td>
<td>1.10</td>
<td>0.72</td>
</tr>
<tr>
<td>- urban, few obstruct.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>James St.</td>
<td>N/A</td>
<td>1.84</td>
<td>1.09</td>
</tr>
<tr>
<td>- urban canyon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur Springs</td>
<td>51.8</td>
<td>1.05</td>
<td>0.80</td>
</tr>
<tr>
<td>- rural, high tree cover</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average error magnitudes, measured in metres (m)
Discussion of Results

- RT DGPS is not a good option for urban environments. It can be adequate for rural areas and major highways.
- With an inertial system, data availability is good even in urban environments.
- Post-processing provides even better GPS accuracy.
- It is possible to obtain excellent accuracy on a network level vehicle-based survey.
Limitations of Vehicle-based Collection

- Some assets may not be visible in the camera views.
  - Obstructed by traffic or parked vehicles
  - Covered by leaves or other debris
- Detailed data (like serial number of assets) cannot be determined.
- Asset condition cannot be assessed in detail.
Conclusions

- Vehicle-based data collection is a cost-effective way to gather accurate information about roadway assets.
- Various GPS accuracies are available depending on the project requirements.
- Vehicle-based collection cannot completely replace manual methods.
Questions?