Modeling Bus Routes and Bus Stops

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The Bi-State Development Council has begun building a dynamic segmentation model for its large bus routing system. The first requirement is the accurate inventory of all bus stops and existing bus routes. This task is being accomplished with a custom mapping and inventory system created by Spatial Data Research, which incorporates real-time differential GPS data logging with customized GIS attribution to manage the mapping of 18,000 bus stops on 114 bus routes. Bi-State manages light rail and bus service in six counties in two states for the St. Louis metro region.

Goals

The Bi-State Development Council, based in St Louis, is implementing a variety of technologies to improve the management and service provided by its metropolitan bus services.

One of these goals includes creating a comprehensive mapping database of all its bus routes and bus stops. The immediate goals of the project are four fold:

- Improve the bus stop maintenance program with the Facility Maintenance Department.
- Integrate rider volume information automatically collected on each bus to determine the number of riders getting on and off at each stop.
- Create a bus stop audit map for each route.
- Cultivate a relationship with St Louis University, utilizing their interns.

Long-term goals are more involved, utilizing the mapping data for a variety of analysis and planning functions. These long-term goals include:

- Planning future bus routes and stops.
- Tracking buses via GPS to monitor their status and schedules.
- Creating a real-time web site of bus schedules for the Customer Service Department.
- Building a dynamic segmentation model for more advanced GIS modeling.

The collection of bus routes and bus stops started in January 2000 and is expected to proceed through the summer.

Participants

The GIS/GPS inventory is being implemented and managed by the Research & Development Department at the Bi-State Development Agency. In this department, Transportation Planning is working with Facility Maintenance staff to conduct the inventory. R&D staff will maintain the relational databases to later be used in the dynamic segmentation models and to post bus schedules on a future web site for the Customer Service department.

Spatial Data Research, of Lawrence, KS, is providing the custom GIS/GPS software development and support in the design of the dynamic segmentation model.

Assisting Bi-State in collecting the GPS/GIS information are interns from St. Louis University. The interns will be working with Transit Service Managers and staff from Research and Development to map the routes and stops.

A total of three mapping crews are performing the mapping and inventory.

Mapping Software Requirements

Mapping of each bus route and stop is being accomplished in real-time using a laptop computer linked to a real-time differential GPS receiver.

A single software program was developed by SDR in Visual Basic utilizing several OCX controls to manage all data collection and mapping. The graphics engine utilizes MapObjects from ESRI with real-time differential GPS control driven by Trimble's Pathfinder Tools. The database storing all GPS and field-collected information is the DAO engine from Microsoft.

In real-time, the GPS builds a breadcrumb of the location of the vehicle being used to map the bus route and stops. Mapping begins at the beginning of the route, with the operator following the path taken by the bus and stopping at each stop to record information about the bus stop. The breadcrumb is superimposed over existing mapping data collected from the six counties where Bi-State provides service.

Database Initialization

Prior to starting a particular bus route, the field crews initialize the job. Initialization includes the field crew's name and the bus route they are mapping. This process serves the dual purpose of starting construction of the dynamic segmentation model database as well as indicating the crew responsible for data collection in case there is a quality control problem.

GPS Configuration

After the database is initialized, the software activates the GPS. Most GPS settings were pre-configured by SDR to minimize training on GPS use and to avoid the possibility of the user changing a setting that would degrade the quality of the mapping being performed.

Generally, setting for the GPS that were configured by SDR include masks for:

- Satellite elevation;
- Positional dilution of precision (PDOP);
- Signal-to-noise ratio mask.

Other "hard-set" configurations include differential GPS settings for:

- RTCM correction ages for Coast Guard correction signals;
- The frequency of the beacon signal.

All of these settings were optimized to allow the user to be productive, collecting bus stops and routes, while perhaps sacrificing positional accuracy of the positions being collected. For example, the GPS receivers being used, Trimble ProXR real-time beacon receivers, are nominally rated as sub-meter receivers under optimal circumstances. Realistically, they are 1-5 meter receivers under typical GPS data collection circumstances, such as tree canopy, urban canyons, multipath, etc. The crew couldn't afford to have to wait several minutes to collect a sub-meter position when a bus stop shelter is about 3 meters and the actual stop is about 10 meters in size.

However, positioning quality control information is provided in the interface created by SDR. For example, if the RTCM beacon is lost or its age mask is exceeded, the user is notified by a large GPS quality indicator in the User Interface.

User Interface

An overarching design issue in the development of the mapping software was its ease of use in the field. Both Bi-State and SDR agreed that if the integrity of the data collection model would not be compromised, that the data collection interface be streamlined as much as possible to enhance the safety of the data collection crew while minimizing their time and costs in the field.

The interface is largely a graphical representation of the route of travel along a bus route with buttons to control the view of the map, buttons to map the bus stops, and a GPS feedback area.
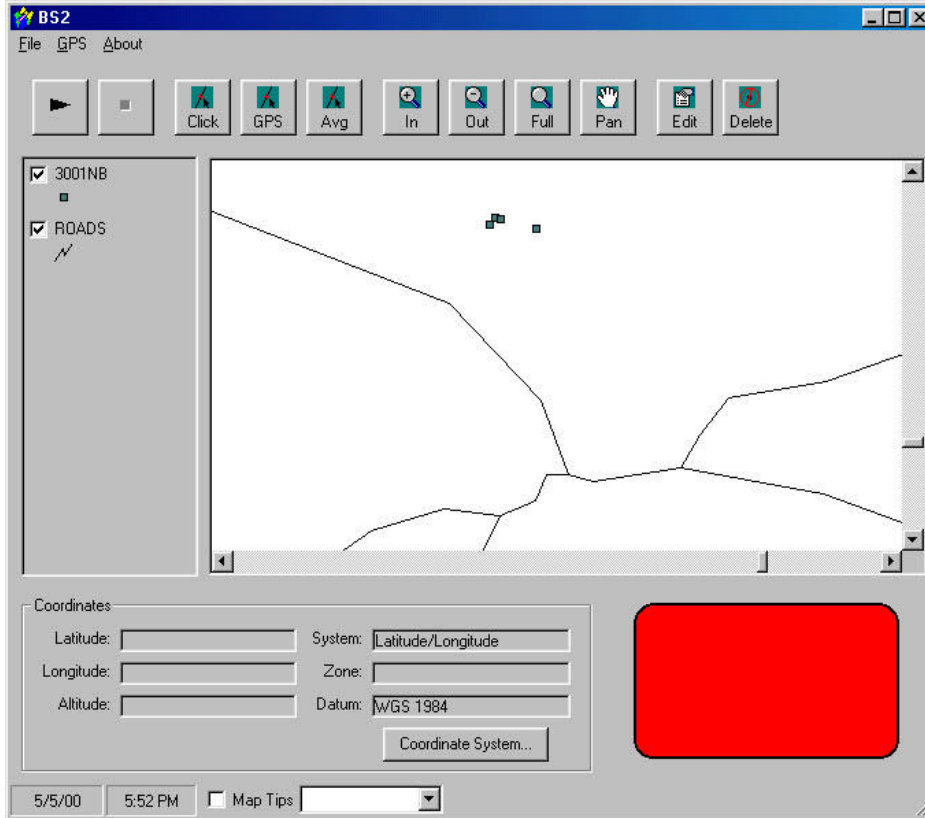
The menu interface is not heavily used in the field due to the difficulty of using a mouse in a car. Most of the interface is operated from large buttons that can be activated with function keys.

Buttons

The GPS is started by pressing the "play" button, found at the top right. Once the GPS is started, the "play" button changes to a "pause" for a momentary

interruption of the GPS data logging or "stopped" by pressing the adjacent "stop" button.

The next buttons collect bus stops. The three buttons labeled "Click," "GPS," and "Avg" all collect the same database information, but use a different method of recording the location of the bus stop. Click allows the operator to map a bus stop as an off set from their current location, meaning that if they can't drive their vehicle to the actual bus stop, the feature can still be mapped. Pressing the "GPS"

Plane Coordinate systems are currently used, necessitating coordinate support for both zones.

The lower right of the interface has a large colored box. When the GPS is not operating, the box is filled with a black color. When the GPS is operating, and differential corrections are being applied and all other functions are working properly, the box turns green. If the differential corrections are lost or the PDOP is too high, the box turns red. This very visual system allows the user to easily understand the status of the GPS positioning.

Mapping a Bus Stop

Mapping a bus stop is accomplished by pressing one of the three bus stop buttons. After any of the three buttons is pressed, a dialog appears allowing the operator to describe the type of bus stop.

Automatically recorded are the coordinates of the bus stop, the date, time and the GPS information of the location.

The user then selects various attributes of the bus stop, such as is it a shelter (including shelter type) or just a bus stop sign, is there a bench, a trash can,

button places a bus stop at their current position. Using the "Avg" button begins an averaging of 10, two-second GPS epochs to achieve a better GPS position for the bus stop. Most bus stops are mapped using the "GPS" button.

The In, Out, Full, and Pan buttons control the display of the map.

The last two buttons, "Edit" and "Delete" allow the user to edit the bus stop attributes.

At the bottom of the screen are displays of the current GPS position and the transformed coordinates. Because Bi-State mapping spans two states, two State

sidewalk access, and several other notes such as requiring maintenance.

The user also appends information about the bus route to the bus stop. This includes the route number, the direction of the route, the primary road route is following, and the nearest cross street.

The data loaded is stored in the database tables and will later be used to create the dynamic segmentation models.
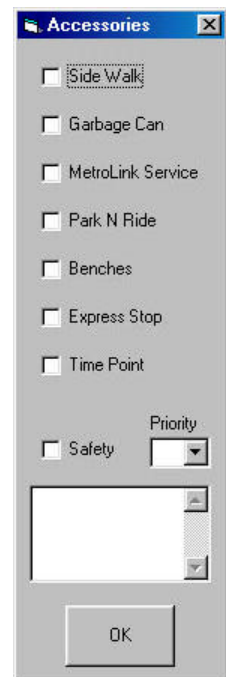
Enhancements

Bi-State has already collected about 40 routes and 2,000 bus stops with the existing system developed. Several enhancements are now being considered to further improve the data collection process including:

- Design and build a cellular interface to transmit field data back to Bi-State;

- Interface Bar Coding with GPS data collection software;

- Integrate automated passenger counting system with bus stop databases to plan future bus routes and stops for Planning and Customer Service departments.

Summary

The mapping of bus routes and bus stops at Bi-State has been designed to not only collect the GIS information in the most efficient manner possible, but to also generate large databases to be used in sophisticated data modeling. Even with only a few of the total bus routes and stops now inventoried, the project has been successful enough to consider other activities that can be accomplished with the GPS field crews.