Geodatabase Development for a Comprehensive School Transportation Management System in Detroit Public Schools

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The Institute for Geospatial Research & Education is a non-profit geographic information technology outreach center located at EMU.

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IGRE conducts research and also provides GIS consulting services in these areas:
- Application Development
- Customized GIS Training
- Parcel Data Automation & Maintenance, E911
- Centerline & Emergency Response Data Layers
- Automated Vehicle Location & Routing, Remote Sensing
- Web Publishing and Distributed GIS Systems.

Latest News

March 4, 2005
GIS Training Recently Completed
February 28th, 2005
ArcView 3.3 Training
Resource Recycling Systems, Inc.

March 8-9, 2005
Introduction to ArcGIS 9
Merit Network

March 14-15, 2005
Introduction to ArcGIS 9

125 King Hall, Ypsilanti, MI, 48197
Feedback: Rui Liao
Page Updated on February 17, 2005
Going Beyond AVL -
A Comprehensive
School Transportation Management System

Automatic vehicle locating (AVL) is a necessity for cost effective fleet management. But AVL functions alone will not guarantee achieving that goal. Cost effective fleet management and efficient resource utilization can only be accomplished through a smart integration of AVL with the business rules that guide fleet operation. Many of these rules can be enhanced with innovative GIS technologies.

The SMRT - Vehicle Management System developed by the Office of Student Transportation at Detroit Public Schools is illustrated as a case study integrating GIS and AVL in school bus fleet management.

In this presentation, we will illustrate how the integration of student enrollment data, home addresses, school programs and building data were analyzed with street networks data and school boundaries to determine transportation eligibility, ridership, bus stops and bus runs. Only when student data and locations are integrated, can GIS routing functions be used to optimize bus routes and to make efficient bus schedules.
SMRT – Vehicle Management System
(Strategically Managing Resources through Technology)

Office of Student Transportation

Detroit Public Schools
Office of Student Transportation’s Mission

Provide Safe, Efficient and Timely Delivery of all Eligible Detroit Public School Students to the Classroom
How can SMRT Technology “GPS and GIS” facilitate the Mission?

**GPS** – keeps track of the vehicles via Trunk Radio system

**GIS & Information Management Applications** perform spatial analysis, routing, scheduling and reporting
What are the Information Management Issues in Student Transportation?

- **Transportation Requests Data Management**
- **Daily Ridership** (determine eligibility via policy, SPEDs, health requests, supplemental education)
- **Scheduling** (things change daily)
- **Runs & Routes** (locations, street network, stops)
- **Performance Analysis** (Safe, Efficient, Timely?)
System Architecture – ArcGIS 9.x & Extensions

Back-End Applications (Server Based):
- Tools to perform the heavy-duty data processing tasks and complex spatial analysis functions required by the front-end applications
- Designed for deployment on desktop workstations and servers residing at DPS offices

Database Layers:
- The central structures required for information storage, data sharing and data mining
- A common geodatabase structure shared between departments, links back-end applications and front-end applications and allows for rapid development of new applications

Front-End Applications (Web Based Intranet/Internet):
- Tools to support specific business rules and functions required by each DPS department

Mobile Applications:
- Supports field-based functions for departments that need off-site access to data and require write access in the field
Common Database Framework is a distributed geodatabase using Microsoft’s SQL Server, IBM’s AS400 DB2, ESRI Spatial Database Engine - ArcSDE.

Common Database design incorporates a loosely coupled distributed system, which includes:

- Students Geodatabase
- Transportation Geodatabase
- Street Centerline Geodatabase
- School Buildings Geodatabase

Geodatabase structure allows quick development of additional applications, which can be easily integrated into the GPS/GIS database framework.

“Data Driven / Information Driven” System
Back-end Sub-system (Server Based)

Portion of the system that performs the complex operational and analysis functions and employs the GPS/GIS functionality and business logic on a workstation and on mobile devices

- Data Check-in
- Eligibility Analysis
- Routing
- Scheduling
- Routing Analysis
- Performance Reports

Built on ArcGIS 9.x software capabilities and incorporates Network Analyst

Customized ArcGIS using Visual Basic and Visual C++ coding
Data Check-In Module

Conducts automated search for new student transportation requests by:

- Checking and Synchronizing the search with Total Transportation Requests files (TC) containing all current transportation requests
- Current Transportation Request files (CR) containing all daily changes in transportation requests
- Updates student geodatabase by synchronizing with the All Active Student file (AS) containing all active students in the Detroit Public Schools – 138,000 + students
Daily Information

- TC File
- CR File
- AS File

Geo-Code Execptions Report

Geo-Code Service
- Address Matching
- Geo-code Exception Reporting

Geo-Code Execptions Report

Student Synchronize Tool
- Synchronize the AS file with the Existing Student Geo-DB
- Geo-Code the new students based on home address

Active Students Geo-Database

Request Check-in Tool
- Make sure all requests all for active students
- Check-in today's transportation requests
- Geo-code new requests (based on pick-up and drop-off address)

Eligible Area of each school

Ride-ship Report and Alert
- Report New Ride-ship
- Generate Change Report
- Generate Change Alert

AM Request
PM Request

Updates Recording Database
- Additions
- Deletions
- Changings

Note: TC files contain today's transportation requests of special education; CR file contains all changes; AS file contains information of all active students.

Change alerts
Change reports
Invalid Request
Change Reports
The image shows a software interface for DPS Data Transformation Services. The interface includes a file path set to `E:\ArcGIS Setup Materials\AS400 Files\`. The interface lists AS400 text files to be checked in, with options for selecting different types of files. The AS400 text files include:

- AS: All Active Students
- SA: Special Education
- SI: Daily Special Education
- FA: Future Special
- FI: Daily Future Special
- MA: Temporary Medical Education
- MI: Daily Temporary Medical
- UA: Summer School
- UI: Daily Summer School
- NA: No Child Behind
- NI: Daily No Child Behind
- VA: Vocation and Technical
- VI: Daily Vocation and Technical

The AS400 file format and column delimiter settings are visible, with options for file type, row delimiter, and text qualifier.

A red box highlights the 'When' section, which shows:

- **Run immediately** with the date `1/4/2006`
- **Schedule for later execution** with the option to set a schedule.

The interface also has buttons for 'Stop', 'Ok', and 'Cancel'. Once the 'Ok' button is clicked, a message indicates that the program will check in data on 1/4/2006 immediately.
Once you click Ok button, the program will Check-In data on 1/3/2006 immediately.
AS060103.TXT

68000 Rows have been transformed or copied.

1/4/2006 8:01:19
DPS Data Transformation Services

File Path: E:\ArcGIS Setup Materials\AS400 Files\

AS400 text files to be checked in:
- AS: All Active Students
  - SA060103.TXT
- SA: Special Education
  - SA060103.TXT
- FA: Future Special
  - FA060103.TXT
- MA: Temporary Medical Education
  - MA060103.TXT
- UA: Summer School
  - UA060103.TXT
- NA: No Child Behind
  - NA060103.TXT
- VA: Vocation and Technical
  - VA060103.TXT

AS400 File Format and Column Delimiter:
- File type: ANSI
- Row delimiter: (CR)(LF)
- Text qualifier: Double Quote ("")
- First row has column names
  - Column Delimiter: Comma

When:
- Run immediately: 1/3/2006
- Schedule for later execution: Setting

Occurs every week on Monday, Tuesday, Wednesday, Thursday, Friday at 09:11:00 AM from 2005-09-02

Geocoding...16/166
090285580:: 2161 MORRELL ST DETROIT MI 48209
1/4/2006 8:01:19
Provides automated functions to determine student eligibility for transportation

Eligibility Changes Daily

Eligibility is determined by:
- Policy – student lives more than 1.5 miles from school building inside of the school attendance boundary
- Special Education Students
- Supplemental Education Requests
- Health Requests
- No Child Left Behind Transportation Requests
Routing Module

Provides automated functions to analyze AM and PM transportation requests

- Performs network analysis based on the street centerline network
- Creates raw routes and bus runs for each school (a raw route includes all the required information such as student ridership, identifies the street segments between each bus stop and analyzes the driving time between bus stops)
- If there are no changes the previously existing run and route is used
- If there are transportation changes (school change, student address change, etc.) the module adjusts existing runs and routes or creates new runs and routes
Run/Route Algorithm

Start

Transport Request Changes

Existing Routes & Runs

Parameters

Capacity

Update type?

Add

School

Change Type

Address

Find nearest existed run from the new address

Try to fit the new request in

Can fit in

Re-Distribute

Add to the selected run

Add a bus

Generate new runs using re-distributed results

End

Remove from the run

Try to merged remain requests into other runs

Successful

Spit and merged remain requests into other runs

End

Run the delete algorithm over the current school

Run the add algorithm over the current school

Run the delete algorithm over the new school

Run the add algorithm over the new school
Module links the vehicle geodatabase table with the raw routes to create scheduled routes. A scheduled route is defined as having all of the information that a raw routes contains plus:

- Vehicle ID
- Driver information
- Start time
- Arrival time
- Other relevant information

If there is no change in the existing route, the previous schedule will be reused, otherwise the time schedule will be re-generated.
Where:

- **TA** is the arrive time, for example, **TAschool** is the arrive time to the school; **TAn** is the arrive time to pickup student n
- **TSn** is the travel time for segment n
- **Duration** is the time needed for pick-up or drop-off

**Parameters**

- Tolerance Time Frame
- Duration of pickup
- Duration of dropoff

**Arrive Time:** **TAschool**

1. Calculate time of Segment n (from school to the n): **TSn**
2. **TAn** = **TAschool** - **TSn** - **Duration**
3. Calculate time of Segment n-1 (from n to n-1): **TSn-1**
4. **TAn-1** = **TAn** - **TSn** - **Duration**

5. **Calculate time of Segment 1** (from 2 to 1): **TS1**
6. **TA1** = **TA2** - **TS1** - **Duration**
Front-end Sub-system

Web-based system designed to allow transportation administrators and the public to view:

- Bus stop locations
- Query bus stop location data
- Perform online location queries
- Allow authenticated users view routes
- Check vehicle status
- Browse performance reports

All queries can be performed using a Web-browser, such as Microsoft’s Internet Explorer or Mozilla Fire Fox

Capabilities provided by customizing the ESRI ArcIMS interface and associated functions, using Java and DHTML technology
Front-End Sub-System

Web Server
ArcIMS Application Server

Online Transportation Managing Modules
- Online Locator Service
- Online Stop Query
- Online Routing Query
- Online Bus Tracking
- Online Alert/Report
- Complaint Response

DPS Common Geo-Database
- Student Info
- Transportation
- Schools
- Public Safety
- Emergency

Note: ✔️ is Only for administrative purpose
Administrative Reports

Crystal Report templates are used to report on the following:

- Geo-code Exception Report
- Home Address Exception Report
- Pick-up Address Exception Report
- Drop-off Address Exception Report
- Request Exception Report
- Ridership Report based on school
- Performance Exception Report
- Time Exception Report (early or late exception)
- Stop Exception Report (not on scheduled stops)
- Route Exception Report (not on scheduled route or streets)
- Request is not for an active student
- Request is not in an eligible service area

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Leveraging Technology – Inter-Departmental Uses

**Risk Management/Public Safety**
- GPS Bus Locations
- School Locations and Student Populations
- Street Centerline Network
- Bus Routes and Schedules
- Evacuation Sites

**Food Service**
- School Locations and Student Populations
- Street Centerline Network
- Managing Deliveries and Routes
- Managing Logistics

**Facility Management**
- Facility Locations
- Facility Capacity
- Facility Condition

Managing School Closures based on Student Demographics

**Administration**
- Tracking Students
- Tracking Teachers
- Tracking Test Scores
- Monitoring Individual School Performance
  - Track Average Class Size
  - Monitor Staff to Student Ratios
  - Track Parental Contact Percentages
- Percent of teachers with emergency or provisional credentials
- Percent of classes not taught by “highly qualified” teachers
- Track Adequate Yearly Progress (AYP) reading and math
- Track “School Choice” notifications to parents for schools that do not make AYP for 2 years
- Track Transfer Requirements
Conclusions

In order to effectively and efficiently manage the resources allocated to school districts, in support of student achievement, the integration of many different data layers is essential.

Knowing where a bus is without knowing where it should be is a useless endeavor – AVL is not enough!

The data integration power of GIS coupled with the location power of GPS provide the backbone for a system that enables school administrators to more efficiently and effectively allocate resources in support of student achievement in any school district.
Questions?

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