Automated Collection of Winter Maintenance Data

Applications and Challenges

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2006 National Rural ITS Conference Wednesday, August 16, 2006



Background

- Automated Vehicle Location (AVL) Systems
 - Automatically report accurate location information at high frequency (seconds to a minute) in real-time
 - Well-established technology used in a variety of fleet management applications
- Maintenance Data Collection (MDC) Systems
 - Report maintenance activities (and related information) as they occur
 - Automation of MDC is a new field with many challenges



What is MDC?

- Winter maintenance-related elements
 - Plow position (up, down front, wing, underbody)
 - Chemical application (material and rate)
 - Lane or lanes
 - Plowing
 - GPS and accurate mapping could be used to resolve this automatically
 - Chemical application
 - Trucks can apply to traveling lane, or to right/left side of vehicle (centerline of two lanes)



What else is MDC?

- Observed elements
 - Air temperature
 - Pavement temperature
 - Road condition
 - Weather condition
- Other potential elements
 - Summer maintenance activities
 - Other DOT-specific needs



Why MDC? Manual Reporting Issues

- Time consuming
 - Maintenance personnel do not need extra tasks during event
- Communications in Field
 - Internet often not available
 - Telephone service can be inconsistent
- Efficiency
 - Amount of information to be transmitted makes automated reporting by telephone difficult and error-prone
 - Internet reporting tends to incur significant delay between action and report times



Automating MDC Goals

- Provide <u>maximum</u> amount of accurate data with <u>minimum</u> amount of manual reporting
- Provide real-time data in a standard, easyto-interpret, consistent format that can be used by a variety of applications



Automating MDC Reporting Methods

- "Automated" MDC is generally a manual/automated mix
- Trucks usually have sensors, while drivers usually have touchscreens
- Automatically sensed information
 - Blade status
 - Air temperature
 - Pavement temperature
- Manually provided information
 - Road conditions
 - Weather conditions
 - Lane of travel/application
- Information provided via either method
 - Chemical application and rate





MDC Touchscreen – Colorado DOT



MDC Touchscreen – Colorado DOT

MDC Applications MDSS

- Maintenance Decision Support Systems (MDSS)
 - Provide an integrated suite of tools to aide maintenance personnel in decision-making related to winter maintenance activities
 - Static inputs include:
 - Information on DOT resources and practices
 - Road infrastructure metadata
 - Dynamic inputs include:
 - Weather observations and forecasts (dynamic)
 - Pavement conditions and previous road treatments (dynamic)
 - Pavement model outputs include:
 - Forecast pavement conditions
 - Forecast pavement temperatures
 - Outputs are based one of several future treatment models:
 - No further treatment
 - MDSS-recommended treatment
 - What-if? Alternative treatment selected by the user



MDC Applications - MDSS GUI Map view

File Report Data Sync Region Options Help



Processing: This is the one and only data cacher (junning right now) and I am proud to report I am done synchronizing for now.

MDC Applications - MDSS GUI Table view

File Report Data Sync Region Options Help

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Meridian Environmental Technology

MDC Applications Vehicle-MDSS

Wed 16:00 MDT

- In-vehicle information systems
 - Vehicle-MDSS
 - Data based upon current truck location
 - Route-specific
 - Concise
 - Local radar
 - Short-term forecast
 - Treatment recommendations
 - Allows personnel to adjust to evolving situations without returning to a computer





MDC Applications DOT Specific

- Automated generation of required activity logs
 - Significant benefit for the drivers
- Automated road report generation
- Real-time vehicle tracking
 - Supervisors can visualize the fleet using a spatial overview
- Historical tracking
 - Accurate response to queries about how a situation was handled
 - Definitive proof of activities
- Inventory tracking
 - Automated tracking of material usage and remaining supplies
 - Automated tracking of vehicle maintenance needs
- Others??



MDC Challenges

 AVL has well-established standards, and simple, consistent formats

 MDC can be reported and interpreted in many varying ways

 No standards have yet been established for the recording, transfer, interpretation, or storage of MDC data



Communication Issues Truck to DOT database

- Communication options from truck to DOT database
 - On the road (real-time transfer)
 - Cellular Communication (coverage issue)
 - State Radio (bandwidth issue)
 - At the shop (delayed transfer)
 - Automated transfer when within close range
 - Manual transfer using data card inside shop
- Both systems must plan for delayed data transfer
 - Real-time data could be out of cellular/radio range
 - Will data be stored or lost?
 - Will delayed data be transferred in chronological order, or reverse order?
 - How will database handle ingestion of delayed data?



Communication Issues DOT database to end-user

- Communication options from DOT database to end-user
 - DOT database options
 - Within state network
 - Hosted by outside vendor
 - Relational database direct queries via XML
 - Allows for complete data transfer with no missed or duplicated data (using sequential identifiers)
 - Allows for targeted data acquisition
 - Hierarchical database transfer of ftp file(s)
 - One file updating every 5 minutes with new data
 - Simplest method
 - Data lost if not retrieved every x minutes
 - Time-stamped files every 5 minutes
 - Good solution if filenames are predictable
 - Delayed data goes under received time, not observed time
 - Old files must be purged regularly



MDC Formatting Issues Manual (touchscreen) data

- Only report upon update
 - If data is not updated regularly, most recent report continues to be used
 - Some units force a reset upon truck startup
 - Good "running screen" is vital for driver awareness
- Interpretation issues
 - DOT, drivers, and end-users must agree on the interpretation of subjective (and even objective) data elements
 - Report average condition or worst case?
 - Report traveling lane or application lane?
 - Report average chemical use or worst case?
 - Are lane numbers consistent?



MDC Formatting Issues Automated (sensor) data

- Reports are continuous
- Reports are generally combined with AVL data
- Temperature and blade status are usually straightforward
- Application material and rate are very difficult to automate
 - Every make and model of spreader generally has unique, proprietary output
 - Problems encountered with some equipment
 - Output differs depending upon operator setting
 - Output is a setting number, which can vary based upon local operation (i.e. application 4 for truck A is different than application 4 for truck B)



Post-processing Issues

- Convert each vendor-specific format into a common data format
- Convert potentially voluminous data into a snapshot of what each plow is doing at a given time
 - Use the latest location (within the last x minutes)
 - Search back through MDC reports for the last valid value for each parameter (since a reset point)
 - Result is a snapshot for that unit at that time
 - All units combined into one report for a complete maintenance data report for all active routes



Processing Delayed Data

- Including delayed data reports in the post-processed reports adds significant processing time
- When non-chronological data are received, our hierarchical database file for that truck must be completely re-written
- All summary reports from that time forward must also then be re-written
- This processing limits the frequency at which reports can be generated
- A relational database would likely be a better solution in the long-term



Mapping to Routes

- Significant logic required to map point-specific truck data onto MDSS Segments and Routes
 - Unidirectional vs. Bidirectional and lane issues
 - Varying conditions and maintenance along segment or route
 - Multiple trucks combining to work a segment or route
- Presently require a substantial portion of a route to be covered before interpreting an action or road condition
- This, plus data processing & upload lags, can cause a delay in the time it takes incoming data to be interpreted and portrayed in the MDSS GUI
 - Truck locations will show up sooner than their cumulative actions will be interpreted



Conclusions

- Automated AVL/MDC systems are evolving into the most efficient means of transferring maintenance reports from the field to the DOT
- Real-time use of this data is spurring new technology to improve DOT operations (MDSS, real-time road reporting, etc.)
- Significant spin-up issues
 - The use of previously tested systems should minimize this spinup, but state-specific equipment, data, operational, and/or communication issues will always need to be accounted for



Conclusions (continued)

- All parties (vendor, DOT, end-user) must work together more closely early in the process to minimize reporting and interpretation issues for a more efficient spin-up
 - Desired to maximize the return on the state's investment in the technology
- Vendors need to be able to respond efficiently to issues that arise during the deployment of these systems
 - This is particularly critical in the early deployment period when operational issues are most likely to be revealed
- Standards should be developed for both the MDC data systems, as well as those systems that feed the MDC (eg. chemical spreaders)



Questions or Comments?

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