CHAPTER 17: DATA INTEGRATION WITH DOT MANAGEMENT SYSTEMS

In Phases I and II, the study team relied primarily on a "bottom-up" approach to product development, which starts with the needs of the immediate end users. Equipment operators, mechanics, managers, and maintenance supervisors identified the desired functionality of winter maintenance vehicles and, together with technology providers, the study team fulfilled those functions by incorporating off-the-shelf technologies on prototype vehicles. To maximize the value of this study, however, a "top-down" approach to product development is also required. In a top-down approach, the needs of management drive product development. During proof of concept for Phase II, CTRE used a top-down approach to consider possibilities for integrating data collected by the vehicles into state management systems. During Phase II, progress was made in defining both a data architecture compatible with DOT systems, as well as logical data transfer points from the vehicle to other business processes. This task required input from top DOT management personnel. The eventual integration of maintenance vehicle data into DOT management systems will ultimately depend on each state DOT's approval and budget allocation.

OBJECTIVE

Begin to develop systems and procedures that, in future phases, will allow data collected by the prototype maintenance vehicles to be integrated with DOT management systems.

MEASUREMENT

Format and content of data collected by the prototype vehicles are compatible with DOT management systems and are used in the management process.

DISCUSSION

The success of the maintenance vehicle research project depends on having a management system(s) in place to receive data collected by vehicle sensors or otherwise generated by the vehicles and to direct these data to appropriate management systems within the appropriate state DOTs. The best formula for success would be an iterative process of increasingly refined bottoms-up equipment/technology development that is compatible with a top-down system design and architecture development. This iterative process will assure that advanced technology implementations similar to the prototype maintenance vehicles will be deployed and integrated into the business process of the state DOTs.

Top-down Approach Implementation

The steps to consider for the prototype vehicles in each state include the following:

1. Develop high-level description of state highway agency business processes, including management systems, using data flow diagrams. Correlate the prototype maintenance

vehicle requirements established by the focus groups to the state's business/management system activities.

2. Develop a preliminary technical and physical architecture that addresses the vehicle, electronic equipment data capture capabilities, communication linkages from the vehicle to receiving locations, storage and retrieval of data, and management systems/reporting requirements. The architecture must also allow for interfacing with existing maintenance management systems (MMS).
3. Develop a logical data model that provides guidance for establishing a database for data from the prototype maintenance vehicle (eventually, from the vehicle fleet). This model could be based on a more detailed data flow diagram, entity-relationship diagrams, or an object-oriented analysis technique. Of importance here is the incorporation of real-time data.
4. Develop a preliminary design document for the state vehicle(s). The design should consider data that are recorded and then displayed to the equipment operator in the vehicle cab and/or forwarded to the database. Consider the input and output panels and screens inside the vehicle and analyze the safety and human factors. Finally, address the equipment interface opportunities and the communication system that could be utilized.

When the study advances to Phase IV, in which a fleet of 10 advanced technology maintenance vehicles will operate in each state, each of the above steps needs to be revisited and redefined. The data requirements will be set, but the reporting protocols may need to be redefined. The communication linkages will need to incorporate additional features such as vehicle-to-vehicle communications, bandwidth requirements, and integration into the existing communication configuration. There will most likely be a desire to interface with local officials and other government agencies to coordinate emergency response operations or to provide Intelligent Transportation System (ITS) information to the public.

Management Systems Interface

Several management systems currently exist in each of the state DOTs to provide management information to maintenance managers at all levels in the organization. These management systems generally include maintenance (MMS), payroll, equipment, purchasing and inventory, transportation inventory database, structures, and maintenance programs developed at the central office and at field locations. The basic systems that the prototype vehicles may eventually interface with are the MMS, payroll, and equipment.

The MMS is the primary system used by maintenance managers to obtain, establish, and adhere to their work programs; monitor the effectiveness of operations; and control expenditures to live within their budgets. Managers are also provided with data necessary to monitor and control the overall maintenance effort and to analyze performance against maintenance standards. A properly developed MMS is a closed circuit containing seven primary management functions: planning, budgeting, allocating, scheduling, performing, reporting, and evaluating. In addition, an MMS has common data sources and links to other systems, such as equipment, utility systems, and financial reporting/accounting systems.

An MMS addresses requirements in four areas:

1. System requirements—major tasks that need to be performed in the system. These tasks are organized by seven management functions: planning, budgeting, allocating, scheduling, performing, reporting, and evaluating. In addition, miscellaneous requirements are established by maintenance managers.

2. Interface requirements—lists the various systems that currently exist or are planned that should interface with the MMS. The type of information that passes between the various systems and the MMS is also defined.

3. Operational requirements—provides the features that should be included in the computer operations to ensure the system is easy to use and provides the proper information to users.

4. Support requirements—identifies the actions that must be taken to ensure successful implementation and ongoing operations once the system is installed.

Concept Vehicle Interface

The maintenance concept vehicles will have the opportunity to provide data to many of the management systems discussed and can be a primary data collector for the MMS. The vehicles can perform these data collection tasks while completing maintenance activities assigned by maintenance managers. The data can be available much more quickly than with conventional management systems and in many cases can be available in "real time." Some of the data collection potentials are discussed below as they relate to the various management systems previously mentioned. To perform these functions, the maintenance vehicles may need to be fitted with some additional equipment and software.

- Maintenance Management System (MMS) -- the data available from the concept vehicle that can be provided to the MMS include: vehicle utilization and equipment repairs, personnel information including labor hours and work elements accomplished, material and quantity usage, update base inventory database for work elements completed (i.e. completing an asphalt overlay), and work performed on bridge surfaces.
- Payroll—the data available from the concept vehicle, by location, that can be provided to the payroll system include labor hours worked, work elements accomplished, and overtime hours utilized.
- Equipment Management—the data available from the concept vehicle, by location, that can be provided to the equipment management system include vehicle hours, vehicle utilization, down time, equipment repairs, and work elements accomplished.
- Purchasing and Inventory—the data available from the concept vehicle, by location, that can be provided to the purchasing and inventory system include materials consumed and stockpile inventory.
- Transportation Inventory—the data available from the concept vehicle, by location, that can be provided to transportation inventory databases include work completed (such as an asphalt overlay) and inventory data collection of roadway features.

- Pavement Management—the data available from the concept vehicle, by location, that can be provided to the pavement management system would include: data relating to maintenance functions performed such as crack and joint sealing, edge rutting, shoulder slurry applications, traffic line painting, and other pavement related tasks.
- Structures Management—the data available from the concept vehicle, by location, that can be provided to the structures management system would include: inventory of guardrail etc., work tasks and related costs for work performed on the surface, and inventory of surface conditions.
- Public Information—the data available from the concept vehicle, by location, that can be provided to the public information system would include: roadway surface conditions, level of service reporting, weather conditions, and winter chemical and abrasive usage.

OBSERVATION

As demonstrated by proof of concept activities in Phase II, winter maintenance vehicles can function as mobile data collection platforms. If all maintenance vehicles are similarly equipped, they have the potential to input data as a fleet into management systems, providing automated, real-time data collection for many DOT management systems.