Integration of Management Systems for Maintenance Activities

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Pennsylvania's Maintenance Operations Resource Information System (MORIS) is a large and complex mainframe system that has been fully operational since 1986. MORIS captures information on all aspects of maintenance operations, including personnel, equipment, and materials. It is a "real-time" system, updated daily through transactions—such as payrolls, invoice documents, equipment usage information, and work activities—at terminals in the 11 district and 67 county offices and the three central warehouse functions (sign shop, equipment division, consumable supplies). Since 1986, MORIS has continually evolved through enhanced integrations with other management systems. These include the Roadway Management System, Bridge Management System, Accident and Reporting System, and the Fiscal Management and Information System. Each of these five systems is large and can operate independently. MORIS integrates functions and obtains key information from these systems to better manage the maintenance of Pennsylvania's roadways.

The Location Referencing System (LRS) is the key to the collection, storage, and integration of all roadway information within the Pennsylvania Department of Transportation (PennDOT). This common reference is specific to all location data and information shared among all management systems and data bases within PennDOT. It is the "common denominator" that allows these major mainframe systems to be integrated.

An integral part of PennDOT's computerized management systems for storing roadway data is the 14-digit location reference number, which designates the county, state route, segment, and offset of a point or feature on a state route (CO/SR/SEG/OFFSET).

Pennsylvania is divided into 67 counties. Each county (CO) has a number that represents the first two digits of the LRS number. In each county, the state route (SR) is assigned a four-digit number subdivided into approximately ½-mi segments (SEG). Finally, the four-digit offset number (OFFSET) is the distance (feet/meters) to a particular roadway feature from the beginning of the segment. Wherever practical, the beginning and end of a segment are established at permanent physical features such as intersections, bridges, railroad crossings, and so forth.

The LRS is not complicated, and anyone can easily take advantage of the benefits it offers. It adds permanence, accuracy, and stability to PennDOT's location signing system. It is easy to understand and inexpensive to maintain, and it generates a computerized representation of the state highway network.

For example, in the reference number (41/0220/0320/1036), CO (41) denotes Lycoming County, SR (0220) denotes U.S. Traffic Route 220, SEG (0320) denotes Segment 0320, and OFFSET (1036) denotes the distance to a feature from the beginning of Segment 0320.

The Maintenance Operations Resource Information System (MORIS) uses the LRS to reference its location-specific data. This is essential to efficient system integration.

MORIS Components

Within (MORIS), three separate operational components are integrated, as shown in Figure 1: equipment management, materials management, and highway maintenance management.

EQUIPMENT	MATERIALS	HIGHWAYS
20,000 PIECES	$100,000,000/YR	200 ASSISTANT MGRs
-INVENTORY	-COUNTY/STOCKPILE	700 FOREMEN
-EQUIPMENT #	-SIGN SHOP	-PLAN WORK
-W.O.	-WAREHOUSE	-DOCUMENT WORK
-E.C.C	-CENTRAL GARAGE	-ACCOUNTING
RENTAL RATES		
-UTILIZATION		
-813 COSTS		

FIGURE 1 Operational components of MORIS.

Equipment Management

The equipment management subsystem monitors the status and location of each unit of equipment in the PennDOT fleet, calculates equipment repair costs, and calculates equipment usage costs. The equipment subsystem conducts seven major processing activities:

1. It collects repair tasks reported to MORIS and provides a mechanism for the equipment manager to create repair work orders.
2. It maintains the accuracy of equipment inventory, both PennDOT-owned and rented units.
3. It maintains the accuracy of the tool inventory for the garage storeroom.
4. It allows equipment management to add and maintain standards for repair task completion, equipment use, and fuel consumption.
5. It helps equipment managers identify equipment retirements and acquisition by allowing the development of equipment age profiles by equipment type, and organization and analysis of maintenance cost versus purchase/rental cost analyses.
6. It calculates equipment rental rates once per year.
7. It allows the ability to request reports when they are wanted or needed.

Materials Management

The materials subsystem monitors inventory by location, estimates materials requirements on the basis of production units planned by activity in the annual work plan, and assists field personnel in acquiring and accounting for materials.

The materials subsystem performs five major functions:

1. It provides the tools to more accurately determine each organization's short- and long-term materials needs, as specified by the various highway work plans.
2. It records changes of on-hand balances of all materials controlled on MORIS. These changes occur through materials receipts, issues, and transfers. The system also provides the ability to plan physical inventories, record actual counts, and calculate variances. This component allows authorized personnel to set reorder points and quantities for materials controlled on MORIS.
3. It supports material acquisition by accepting validated orders from users.
4. It interfaces with the Fiscal Management and Information System (FMIS). It generates all accounting transactions related to material acquisition and usage and sends them to FMIS electronically each night.
5. It accesses all of the data generated by this subsystem to prepare operating and management reports.

Highway Maintenance Management

The highway maintenance subsystem supports maintenance planning, both short and long term, and records the actual production of highway maintenance crews for management reporting and accounting. The planning component develops long-range planning by using the Road Information File. The data for this file are collected throughout the year by field personnel and obtained through integration with the department's Roadway Management System (RMS).

Pennsylvania's RMS

Five major process components of Pennsylvania's RMS combine to provide pavement management system functionality. The key processes are described in this section.

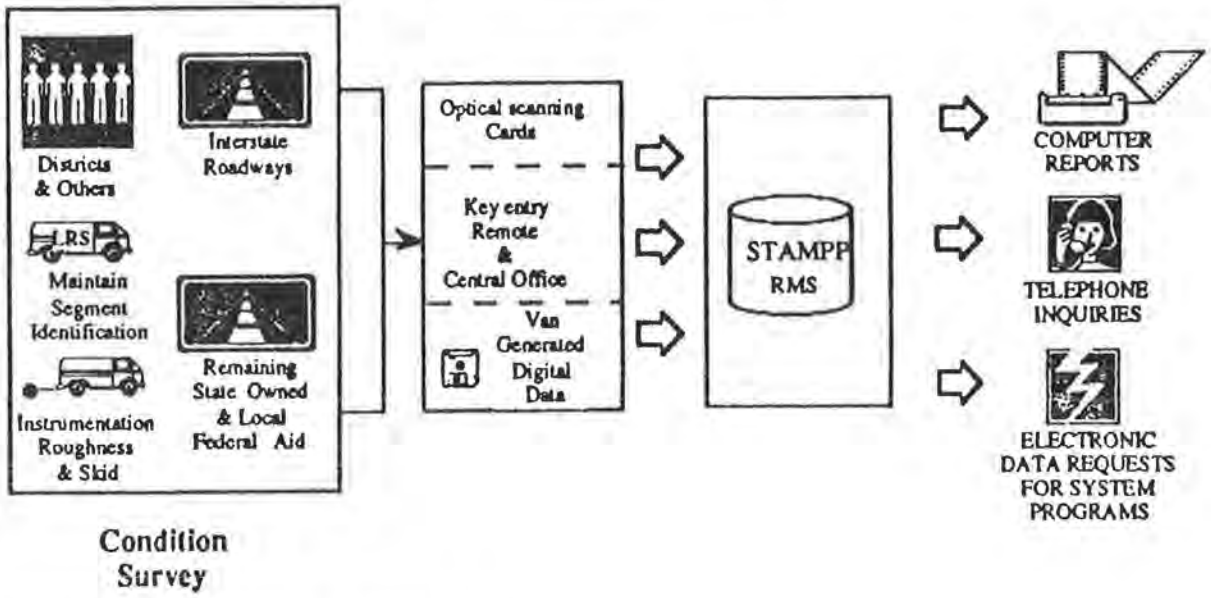

FIGURE 2 Data collection—condition survey.

Data Collection

The data collection process flow diagram is shown in Figure 2.

Inventory

Pennsylvania's RMS contains an inventory of approximately 41,000 mi of PennDOT-owned roadways. RMS includes approximately 100,000 roadway segments. Of these, about 91,000 are actual roadway segments, approximately ½ mi long. The remaining segments are miscellaneous roadway facilities such as roadside rest areas, truck escape ramps, and interchanges. The segment length and feature locations are continually monitored while data are collected.

Condition Survey

Roadway condition data are collected each year as part of the regular pavement survey program. Visual inspections are made by two-person teams of evaluators who drive the shoulders at low speed and evaluate the pavement and shoulders. Guardrail and drainage surveys are also done. Condition data are recorded on computer-formatted paper forms and entered into RMS at district offices or other remote locations. Pavement data are collected annually for all Interstate roadways and biannually for the rest of the state system.

Roughness, skid, and structural strength data are collected at the network level by automated data collection equipment. International Roughness Index (IRI) data are collected using a South Dakota–type road profiler. Skid resistance data are gathered using a locked-wheel skid trailer. Structural adequacy of the pavement is measured using a falling weight deflectometer.

Treatment Specification

The specification of maintenance treatments is shown in Figure 3.

Pennsylvania's RMS contains the subsystem called Systemic Technique to Analyze and Manage Pennsylvania's Pavement (STAMPP). STAMPP uses a matrix of treatments and distress levels to determine a preliminary treatment.

The STAMPP program maintains distress conditions for bituminous and concrete pavements. These conditions are used to calculate the 14 possible treatment strategies for bituminous pavements and 10 possible treatment strategies for concrete pavements shown in Figure 4.

PennDOT also maintains treatment strategies for continuously reinforced concrete pavement, unpaved roads, drainage facilities and appurtenances, and guardrails.

A segment's roadway condition data, pavement history, average daily traffic (ADT), and class of highway are used to calculate the treatment. This pavement treatment matrix is maintained by PennDOT's Bureau of Maintenance and Operations, Roadway Management Division.

Cost Assignment

The RMS STAMPP unit price index is used to assign costs to recommended treatment levels. This index contains

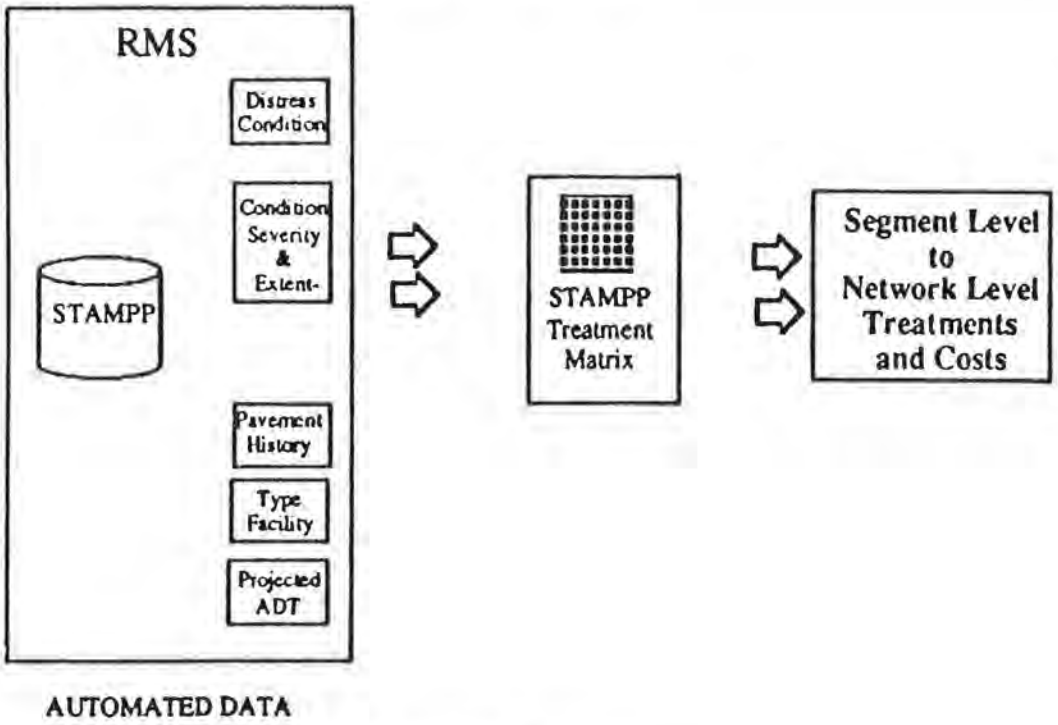

FIGURE 3 Pavement management—treatment alternatives.

statewide unit cost data that are updated annually and reflect regional differences. An average statewide unit price index also is maintained.

Life-Cycle/Performance/Optimization Analysis

The PennDOT Pavement Performance Modeling Program is a performance modeling, life-cycle cost analysis, and a PC computer program for network/project optimization. The program consists of four major modules:

- The grouping module defines groups of pavements with similar deterioration characteristics.
- The modeling module builds a performance model for each group, developed for variable conditions on the basis of historical data.
- The application module applies the developed performance models to a life-cycle costing analysis and an optimization process for maintenance and rehabilitation planning.
- The data base module imports data to and from the RMS, PennDOT's central roadway data base.

Planning, Programming, and Project Selection

Using these pavement data sources and working knowledge of the roadway network condition, the county manager and the PennDOT central office establish county goals for surface improvements and estimated budgets. The county manager assembles a preliminary list of projects for district committee consideration. The district planning and programming process uses the following seven criteria:

1. Pavement conditions,
2. County maintenance budget,
3. Equitable geographic distribution of improvements,
4. Roadway functional class,
5. Impact of improvements on overall roadway network,
6. Safety, and
7. District mileage goals for surface improvements.

The Annual Work Plan (AWP), Surface Improvement Program (213 Program), and Period Plan (PP) are developed from these processes using the RMS, Bridge Management System, and Accident Record System data.

The AWP is typical of most maintenance management systems. This plan is developed on the basis of available budgets and prioritized pavement, bridge, and safety needs.

213 Program projects are programmed from deficiencies identified by the road survey. Maintenance overlays, seal coats, and shoulder upgrades are developed on the basis of the AWP.

Bituminous Treatment Strategies
Routine Maintenance
Crack Seal
Skin Patch
Manual Patch
Mechanized Patch
Base Repair
Joint Repair
Widen
Seal Coat
Level and Seal Coat
Mill, Level, and Seal Coat
Resurface
Level and Resurface
Mill, Level, and Resurface

Concrete Treatment Strategies
Routine Maintenance
Spot Joint Seal
Joint Seal
Joint Rehabilitation
Spall Repair
Joint Replace
Slab Stabilization
Slab Stabilization and Grind
Slab Replacement
Major Rehabilitation

FIGURE 4 Bituminous and concrete treatment strategies.

The PP is also developed using data from the road survey. Surface improvement projects and routine maintenance such as sealing cracks, replacing pipe, and grading shoulders are scheduled by route on the period plan.

The labor, equipment, and materials necessary to do the planned activities are added to the weekly plan screen in MORIS. Once the weekly plan is built, the daily payroll documents are printed from the weekly plan screen. MORIS preprints most of the information required on the daily payroll, including the names and social security numbers of the crew members, activities to be done, location of the work, and equipment unit identification. The foreman adds hours, production, and weather and work break information, and makes any necessary modifications. MORIS passes all cost accounting data to FMIS. Crew costs from the payroll and invoices from purchasing are also integrated with FMIS. Maintenance activities and costs are then passed to the Roadway and Bridge Management Systems for maintenance history records.

Conclusion

The integration of maintenance activities with other mainframe management systems in Pennsylvania is vital to the day-to-day operations of PennDOT. Many examples of system integration exist within PennDOT, and a few were summarized in this paper. System development and integration efforts continue to evolve at a rapid pace with the explosion of information technology and the ever-changing needs of the user community.