DEVELOPMENT OF STATEWIDE GIS-BASED FEATURES INVENTORY SYSTEM

Summary Report 474

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16. Abstract

The Arizona Department of Transportation (ADOT) has developed and implemented a component of a Maintenance Management System (MMS) called the Features Inventory System (FIS). With this system ADOT has the capability of tracking and maintaining an inventory of its highway features. These features can include anything found on or along a highway such as a guardrail, sign, lighting or other appurtenances. ADOT also needs to track the inventory of its highway features for the state legislative mandate in the maintenance appropriation (ARS 28-101) to provide level-of-service (LOS) conditions. These LOS condition measurements only have value if the population of the item, and how much of that population is in compliance, is known. The Feature Inventory System interfaces with the LOS System.

In the past, ADOT used numerous methods of tracking the highway features. Early on, a mainframe system was put in place to track the inventory. This system is now antiquated and difficult to update, and Maintenance District offices have turned to other technologies including the use of Access databases and Excel spreadsheets. In order to standardize and bring all of the highway features inventory information into one place, ADOT's Maintenance Section has replaced the antiquated mainframe system with a browser-based system to track, maintain and account for its highway features. Utilizing funding from this research project, the FIS was built around a comprehensive features inventory database and is a core component of ADOT's MMS.

This new system provides an application that is easier to utilize, and a database to store geographic information and other attributes of the highway features. This system also provides interfaces to other MMS modules, and is more robust than the mainframe system, incorporating an administrative function that allows key administrators to add new feature types, and define individual attributes for each feature type, as needed.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	Inches	25.4	millimeters	mm
ft	Feet	0.305	meters	m
yd	Yards	0.914	meters	m
mi	Miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	Gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	Ounces	28.35	grams	g
lb	Pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
	ILLUMINATION			
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	Poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	Square millimeters	0.0016	square inches	in^2
m^2	Square meters	10.764	square feet	ft^2
m^2	Square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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As a result of the recommendations from a research project conducted in 1999, the Arizona Department of Transportation (ADOT) has developed and implemented a component of a Maintenance Management System (MMS) called the Features Inventory System (FIS). With this system ADOT has the capability of tracking and maintaining an inventory of its highway features. These features can include anything found on or along a highway such as a guardrail, sign, lighting or other appurtenances. ADOT also needs to track the inventory of its highway features for the state legislative mandate in the maintenance appropriation (ARS 28-101) to provide level-of-service conditions. These level-of-service condition measurements only have value if the population of the item, and how much of that population is in compliance, is known. The Feature Inventory System interfaces with the Level of Service System.

In the past, ADOT used numerous methods of tracking the highway features. Early on, a mainframe system was put in place to track the inventory. This system is now antiquated and difficult to update. Maintenance District offices turned to other technologies to perform this task. These technologies include the use of Access databases and Excel spreadsheets. In order to standardize and bring all of the Highway Features Inventory information into one place, ADOT's Maintenance Section replaced the antiquated mainframe system with a browser-based system to track, maintain and account for its highway features. Utilizing funding from this Research Project, the Features Inventory System was built around a comprehensive features inventory database and is a core component of ADOT's Maintenance Management System.

This new system provides an application that is easier to utilize, and a database to store geographic information and other attributes of the highway features. This system also provides interfaces to other Maintenance Management System modules, and is more robust than the mainframe system, incorporating an administrative function that allows key administrators to add new feature types, and define individual attributes for each feature type, as needed. As this function is not available in the old mainframe system, new feature types that became available since its implementation in the 1970's were never added to the old mainframe system, and had to be tracked on spreadsheets. Any particular feature type, such as Signs or Guardrails, that require additional processing to handle complex business rules will require a management system of their own. These management systems will interface with the Features Inventory System, which will hold the core asset database for ADOT's Maintenance Management System.

SECTION II. ANALYSIS

The tools used in the past for the department to track and maintain these highway features include a mainframe system, which was implemented over 30 years ago. This system became difficult to use and has many shortcomings. These difficulties and shortcomings drove department staff to utilize other tools for tracking this inventory.

A. Link Feature File (Mainframe)

This system was called the Link Feature File. A link as defined by this system is the length of roadway from one milepost to another. These links are approximately 1 mile in length. Feature types in this system were determined and programmed into the system at the time of its development. It is not possible to add new feature types to this system without the assistance of a programmer. Therefore, any new feature types that have come about since the 1970's were tracked outside of this mainframe system.

Reports that were available from this system include

- Road Features Inventory Detail by Milepost
- Road Feature Summary Report

Both reports were available at the State, District, Area Org or Route level.

B. Excel Spreadsheets

Any feature types that became available after the implementation of the mainframe system were tracked with spreadsheets. The spreadsheets simply listed information regarding the feature. There was no uniform format followed by individual districts in the use of these spreadsheets.

C. Various Access Databases

A few organizations utilized Microsoft® MS Access databases to track specific types of features. Again, no uniform standard followed.

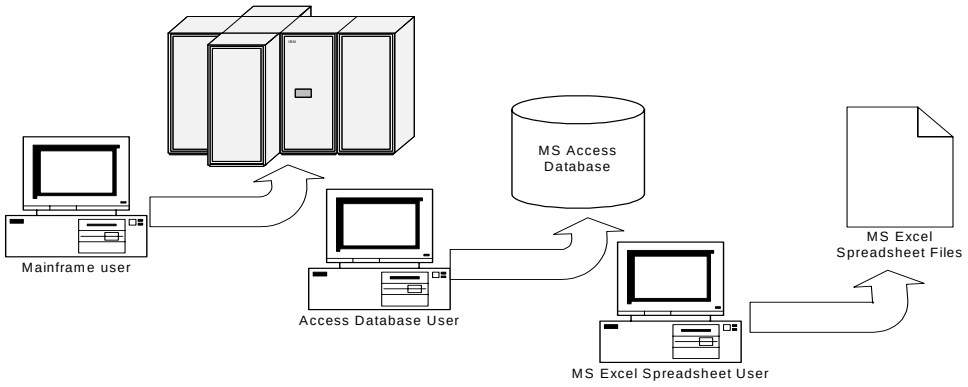

Figure 1 Old Features Inventory Process

D. History Data

Originally, this project intended to include populating the data also. However, it soon became apparent that much if not all of the data that was included in the legacy system had limited use. Attributes defined in the new system did not exist in the old. There was no way to convert the inventory into the new system since key information was missing. It was determined that the reports from the legacy system would be referenced to help locate existing features.

SECTION III. DEVELOPMENT

A. Goals

Develop and implement an application system, for use by ADOT's Intermodal Transportation Division (ITD) Maintenance Operations that will:

- Store Highway Feature Inventory data in a centralized database.
- Integrate with other management systems and databases in the Maintenance Management System.
- Contain an administrative function, which will allow administrators to create new feature types as needed.

B. Objectives

The following key objectives were sought with the implementation of this system.

Business Objectives:

- Robust functionality, which will allow creation of new feature types.
- Integration with other modules of the Maintenance Management System
  - Interface from Phoenix Traffic Operations Inventory Database to FIS
  - Interface from FIS to Performance Cost System (PeCoS)
  - Interface from Sign Management System (SMS) to FIS
  - Interface from FIS to Level of Service (LOS)
  - Interface from Permits System to FIS is underway.
- The Features Inventory database will be the core database for the Maintenance Management System. It will store basic information for each feature type, however any particular business rules for any feature type will be addressed by that feature type's own management system. For instance, signs require certain business rules; thus the Sign Management System will handle these rules.
- This system will also interface with the ADOT Information Data Warehouse (AIDW). Route, Milepost, Org Boundaries, Ramps, TI's, and Frontage Roads will be brought into the Features Inventory system from the AIDW who in turn receives this information from the Arizona Transportation Information System (ATIS).
- Users will have access to the data. Standard report queries will be built and easily accessible.
- Make the system Geographic Information System (GIS) ready. A future goal is to map these highway features to a GIS map. Longitude, Latitude, and Elevation will be attributes on every feature.

Technology Objectives:

- *Distributed system:* Intranet end-user interface, Active Server Page (ASP) with VB scripts and Active Reports. End users will access the system using Microsoft Internet Explorer. Data entry will be done at the Maintenance level. Data will be stored in a Central Database allowing for statewide reporting.
- *Integrated system:* As mentioned above, the system will integrate with other modules of the Maintenance Management System, the ADOT Information Data

Warehouse, and in the future with the ADOT GIS. This will reduce duplicate entry of data and provide users with visual/mapping reporting capacity.

- *Platform-compliant system:* The system will comply with ADOT's current and planned IT Platform. This platform consists of Microsoft® Windows 2000 Server, MS SQL Server 2000 Relational Database Management System.

SECTION IV. IMPLEMENTATION

The Features Inventory System was successfully implemented on March 21, 2003. ADOT now has the ability to track and maintain an inventory of Roadway, Signs, Striping, Electrical Systems, Natural Resources, and Landscaping assets. Interfaces to other Maintenance applications Sign Management System, PeCos (Work Mgmt Sys.), Level of Service and the Data Warehouse have been developed. These interfaces have been built to fall under the Maintenance Management System (MMS) umbrella. Maintenance permits will soon be loaded into FIS and an interface will be written.

Major Deliverables and outcomes

The major deliverables and outcomes of this project are:

- An administrative function for adding new features, which moves this task from technical staff to the key administrators.
- A core database model for the Maintenance Management System (MMS).
- Interfaces with the following systems:
  - Sign Management System
  - Pecos
  - Level of Service
  - ADOT Information Data Warehouse (AIDW)
  - Permits System.
- Ability to identify all the features that exist at accident locations and determine if features are missing such as signs.
- Facilitate elimination of duplicate entry.
- Functionality that is not available in Excel spreadsheets, non-relational flat files or Access database.
- A user front end similar to other MMS components, thus familiar to the Maintenance staff.
- A GIS ready system.
- Four standard queries with a few adhoc parameters, which can be exported to Microsoft® MS Excel for data manipulation and reporting. The users have access to all the data.

SECTION V. CONCLUSION

Now that the Features Inventory System database has been built and categories, features, sub-features and attributes have been defined, the next formidable issue is populating the database. As previously mentioned, the historical data is not of value for the new system.

The State Engineer's Office has launched a project goal to get the complete State inventory into the system within the next year. Maintenance has purchased 21 Trimble Global Positioning System (GPS) units to begin assisting with this effort. An in-house FIS Trimble/Pocket PC Software application has been developed to run on the Trimble and iPAQ Pocket PC that will allow the users to easily update and transfer data back and fourth between the Trimble/iPAQ and the FIS database. This software has the ability to capture GPS coordinates as part of the collection process. These data/GPS capturing capabilities have been developed using open technology (Windows CE platform & MS development tools). The immediate target hardware is Trimble and iPAQ, but may as well be anything else that runs Windows CE. As a result, the advantages to ADOT are: non-proprietary technology, minimal total cost of ownership (TCO), and portability (hardware-independent). The applications of the technology are not just limited to feature inventory, but also towards any data collection needs, such as Maintenance Level of Service and many data collection requirements as a result of the Storm Water Consent Decree.

The following tasks have been identified as part of the start-up project plan:

PROJECT MANAGEMENT / COORDINATION:

A business Project Manager will coordinate with many groups and different interests, making policy and procedural decisions, allocating resources, and securing funding.

A Steering Committee has been formed with representatives from Intermodal Transportation Division, Transportation Planning Division, and Information Technology Group. This group will help develop the project plan, detail the tasks to be undertaken, assign roles and responsibilities for each task, define milestones and completion schedule, define a list of products to be developed (software, documentation, training strategy and schedule, etc.), recommend procedures and processes for ongoing data collection, and develop total budget and resource requirements.

Determine processes to load data from as-builts, and how best to validate data between Maintenance and Construction.

PROTOTYPE / PROOF-OF-CONCEPT:

The objectives will be:

- To perform unit and Quality Assurance (QA) testing on this project

- Learn what kind of training will be required, how to Quality Control (QC)/QA the data collected, and how to enhance user manuals.
- Help estimate resources/budget needed to complete the statewide inventory within the State Engineer's 1-year mandate.
- 1-month pilot will also be part of this phase.
- A prototype team will be formed involving users from each of the Districts statewide and Business Area Experts.

DATA POPULATION IMPLEMENTATION:

Using lessons learned out of the prototype phase, the workgroup will finalize the implementation plan outlined above. Budget and resource requirements will be presented to management. Training manuals and training programs can be finalized. Processes and programs to automatically load feature/attribute definitions and edit rules from FIS into Pathfinder and down to the Trimble GPS units, as well as those to upload data into templates and into the FI database can be written. The fact that FIS is robust enough to allow features/attributes to be added and changed will impact how we build templates for both the data dictionary and data loading. We, again, do not want a programmer to be involved every time features/attributes are defined or enhanced. We also do not want separate programs to load data in from the Trimble GPS units and as-builts. The programmer who is most familiar with the FIS database design, can help with production programs.

SECTION VI. REFERENCE MATERIAL

The following documentation was created throughout the lifecycle of the project:

Document Name	Date Written
Feature Inventory Analysis	November 5, 2001
Project Investment Justification (PIJ)	January 22, 2002
FIS Scope of Work – Logical Design Proposal	June 27, 2002
FIS Interfaces	September 26, 2002
FIS Inventory Security	February 25, 2003
How to Setup Security in FIS	March 3, 2003
FIS System Manual	April 17, 2003
FIS Configuration Help	June 12, 2003
FIS User Manual – Data Entry & Reports Settings Screens	July 7, 2003