SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION BRIDGE MANAGEMENT SYSTEM IMPLEMENTATION

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ABSTRACT: The South Dakota Department of Transportation (SDDOT) has successfully taken the standard product AASHTOWare® Pontis®, customized it, and incorporated it into the business practices of the agency. Key activities include: customization of the database by adding additional tables, creation of custom forms for data entry, creation of new structure lists built around SDDOT business practices, customization of the database security scheme, creation of data transfer techniques between Pontis and SDDOT legacy applications using the Pontis Data Interchange (PDI) process, customization of the Pontis check-out/check-in procedures, and customization of reports. Most recently, the SDDOT has embarked on a project called Concept to Contract (C2C) to incorporate all Management Systems in a way to create the new State Transportation Improvement Program (STIP). All current and proposed bridge projects will be moved from Pontis into the C2C program every spring so planners can better plan and program all projects within the SDDOT.

BACKGROUND OF SDDOT'S BRIDGE MANAGEMENT IMPLEMENTATION

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 required that all bridges on and off Federal-Aid highways in each state be included in a Bridge Management System (BMS). In January 1993, the SDDOT created a BMS Technical Committee. The Federal Highway Administration (FHWA) demonstrated Pontis 2.0 in June 1993. After evaluating this demonstration, the technical committee recommended adoption of Pontis.

A work plan to meet FHWA compliance was developed in 1994 to meet the mandated completion date of October 1, 1998. The Bridge Management System mandate from ISTEA 1991 was later dropped, but the SDDOT chose to continue with the development of a bridge management system using the Pontis product.

As part of ISTEA 1991, the National Bridge Inventory (NBI) was also included in the metrication process. In December 1995, a new "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges" was released by the FHWA. The main change was that all NBI data was to be submitted in metric to the FHWA starting in April 1997. Since the Pontis application was also metric, it was decided that this would be a good way to meet the metric deadlines. Although other metric mandates have been lifted, the NBI data submittal requirement remains. The SDDOT has submitted their data in metric using the Pontis program and database since 1997.

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With guidance from the South Dakota Bureau of Information and Technology (BIT) – Business Requirements group, the BMS Technical committee proceeded with the Pontis program using the Sybase's SQL Anywhere client-server database and using the Powersoft Infomaker program for report and form generation. The SDDOT utilized service units through AASHTO for the contractor, Cambridge Systematics Inc., to customize the database for data requirements beyond the FHWA NBI required data items and to create the customized data input screens for these additional data items. The Business Requirements group also recommended using only one application/database, both for Bridge Management and for bridge data inventory.

A work plan was developed for the contractor. South Dakota utilized service units late in 1996 and early in 1997 to accomplish the following tasks:

1. Install Sybase on a server and establish a client-server database,
2. Customize Pontis database including 6 custom tables and 4 custom/user forms,
3. Create a database security scheme,
4. Create a database/server backup procedure, and
5. Create Pontis Data Interchange (PDI) (Cambridge Systematics, Inc. 2005) procedures for updating Pontis with data from legacy mainframe applications.

The contractor made two site visits in the fall of 1996 and winter of 1997 to perform the work necessary.

In creating the customized database, all users of the old bridge inventory system were given the opportunity to submit ideas for deleting, keeping, or creating new data items for the new system. Four of the six new tables have custom forms that are accessible from within Pontis. These four custom tables include SDDOT specific bridge, roadway, structure unit, and inspection related information. Two additional custom tables were also created to track substructure items and accident data associated with bridges. All previous standard reports were reviewed. A new set of standard reports was created for use in Pontis that duplicated old reports, customized standard Pontis reports, or created new reports.

Average Daily Traffic (ADT), National Highway System (NHS), Lineal Referencing System (LRS), and accident data are all updateable by using the PDI process. These custom PDI files make it easy to extract data from mainframe legacy systems and update those data items in Pontis.

Customization and development continued throughout 1997. A training session was held in January 1998 for all state inspectors and consultants performing local government bridge inspections. This training session was carried out by two FHWA Region structures engineers along with engineers from the Office of Bridge Design. Training included the AASHTO Commonly Recognized (CORE) element concept. There was also a computer training session held for users that would be actually entering data into the program. In the spring of 1998, the data was transferred from the old mainframe system to Pontis and Pontis was implemented as a production system. A couple months after this implementation, the field personnel met with Central Office personnel to evaluate how things were going and what improvements were needed.

The SDDOT inspects their bridges using the AASHTO CORE elements (AASHTO 2002) and uses the FHWA NBI translator to create the NBI deck, superstructure, substructure, and culvert ratings. The SDDOT has been collecting CORE element data since the spring of 1998. Very little customization was done to the CORE elements. Only a few sub-elements were created. For example, a sub-element called pre-cast culvert was created to track cast-in-place culverts apart from precast concrete culverts.

During the summer of 1999, South Dakota again utilized service units to accomplish some additional customizations. The main purpose was to customize the check-out and check-in process. The SDDOT wanted to limit the newly created bridge inspection to be checked-in and only certain data fields to be allowed to be updated from the check-out database into the master database. Some of the tasks accomplished included:

1. Creation of custom header PDI files,
2. Verification of only one new inspection in the check-out database,
3. Summarize changes in identified fields between master and check-out databases,
4. Customize structure lists to identify structures that are checked out,
5. Initial training on the preservation and programming modules was also included.

During the 2000 calendar year, South Dakota utilized the check-out process to send structure data to consultants performing local government bridge inspections. On average 2000 bridges are checked-out to consultants every year to perform local government bridge inspections. This procedure has saved many person-hours of time. Previously, consultants submitted paper forms and SDDOT personnel had to hand enter this new data.

During the winter of 2002, South Dakota again utilized service units to assist in the migration from Pontis 3.4.4 to Pontis 4.0. Cambridge Systematics rewrote custom views, revised custom reports, and modified the check-out/check-in process.

SDDOT BRIDGE INVENTORY

The SDDOT maintains 1812 state-owned NBI length structures (bridges and culverts) of which 1306 are bridges and 506 are culverts. There are 4064 local government owned structures of which 3427 are bridges and 637 are culverts. Like most state DOT's, a majority of the bridge structures on the state system were built during the Interstate era.

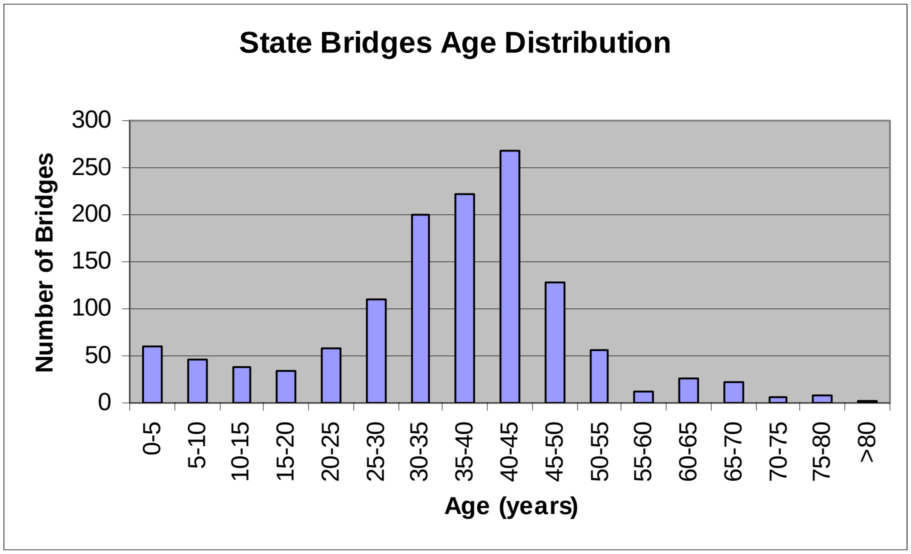

Figure 1 - Age Distribution Graph for State Owned Bridge

On the state system, 52% of the bridges are reinforced concrete slab bridges but only account for 33% of the bridge deck area. Steel girder bridges are 47% of the bridge deck area but are only 36% by number of bridges.

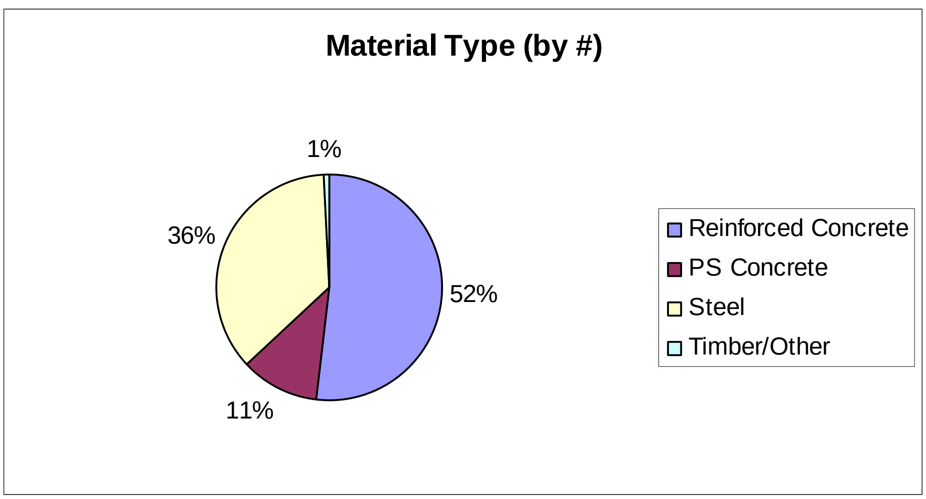

Figure 2 - Material Type by Number of Bridges

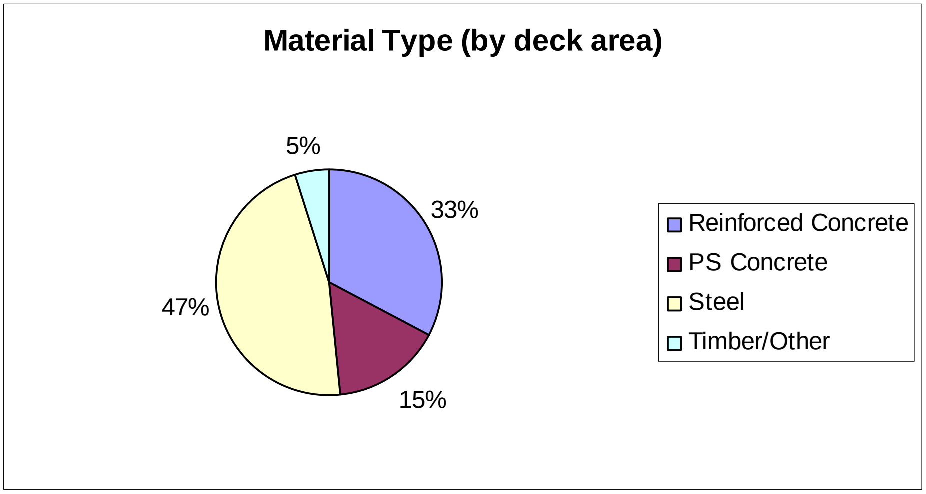

Figure 3 - Material Type by Deck Area

The 1306 state owned bridges contain 1,001,883 square meters (10,784,178 sq ft) of deck area and the 3427 locally owned bridges contain 628,724 square meters (6,767,537 sq ft) of deck area. The average state owned bridge was built in 1968 and is approximately 12.2 meters (40 ft) wide and 61.0 meters (200 ft) long. The average locally owned bridge was built in 1957 and is approximately 7.9 meters (26 ft) wide and 21.3 meters (70 ft) long.

Most bridges in the state are inspected every two years. South Dakota received approval from FHWA based upon the federal regulation 23 CFR 650 to inspect some of the bridges every 4 years. There are 439 state owned bridges that are currently eligible for 4 year inspections. These structure types are generally structures that do not change or deteriorate very fast. All major river bridge crossings are inspected every year. Underwater bridge inspections are performed every five years by an underwater inspection consultant.

BRIDGE MANAGEMENT IMPLEMENTATION WITH PONTIS

During 2002 and 2003, work started on setting up the various models within Pontis. The Policy Model (improvements) was the first model to be completed in Pontis. It was one of the easier models to set up since it was the current policies and standards of the department. The cost portion was accomplished by using the average bid costs available. We have used the default values for the user costs in the Cost Model. This is an area where the SDDOT needs to gather more data, perform additional research, and determine better costs. Historically the SDDOT has very few improvement type projects.

The more difficult task was developing the Preservation Model (Cambridge Systematics, Inc. 2005). The preservation policy requires that all the elements be defined. This includes all applicable condition states and all actions possible for each element. The SDDOT added various actions based on the type of work done by our department. For example, we use epoxy chip seal overlays, low slump dense concrete overlays, and membrane and asphalt concrete overlays. Most of the deck and slab elements did not contain all of these actions or did not have the actions in the condition states where we do that type of work. Efforts in developing the SDDOT's preservation policy were concentrated on the most common elements in our inventory and on the type of preservation work that we typically do in our state. The majority of the preservation work done in the SDDOT includes various deck treatments, waterproofing joints, bridge rail modifications, steel fatigue retrofits, approach slabs, and approach modifications.

The deterioration elicitations were initially accomplished based on expert elicitation. These were then reviewed or validated based upon a previous research study (Fanous et al. 1993) that predicted the NBI condition deck, superstructure, and substructure ratings based on SDDOT historical NBI data. This study evaluated NBI condition ratings with structure age compared against the effects of bridge length, Average Daily Traffic (ADT), structure type and ADT, geographical regions in the state, structure types, and skew angles.

The study concluded that:

1. longer bridges deteriorate faster than shorter bridges,
2. bridges with higher ADT deteriorate faster than lower ADT bridges,
3. certain geographical regions deteriorate differently than other regions,
4. bridges with greater skews deteriorate faster than bridges with no or small skews,
5. concrete slab bridges deteriorate slower than other bridge types, and
6. concrete decks on steel girder bridges deteriorate faster than decks on prestressed concrete girder bridges.

By using the Bridge Analysis tool in the Project Planning Module of Pontis, one can compare predicted NBI ratings in Pontis with the research results by doing a Do Nothing analysis. In the future, as we do more element inspections, the historical data will slowly overtake the expert elicitations.

The cost elicitation's for element actions in the preservation policy were accomplished based on using average bid costs from previous years' projects. Some of the difficulty in accomplishing this task was that bid item quantity units are not in the same format as element quantities. In the following example, we had to take multiple bid items to create the element action cost.

Bridge Bid Item	Quantity	Units	Avg. Bid Cost (Yr. 2004-2005)	Total Cost	
Bridge Elevation Survey	1	Lump Sum	$ 942.00	$ 942.00	
LSDC Bridge Deck Overlay	22.3	Cu Yd	$ 285.98	$ 6,377.35	
Concrete Removal Type 1A	297.7	Sq Yd	$ 17.45	$ 5,194.87	
Concrete Removal Type 2A	73.5	Sq Yd	$ 3.50	$ 257.25	
Concrete Removal Type 1B	29.4	Sq Yd	$ 70.15	$ 2,062.41	
Concrete Removal Type 1C	14.7	Sq Yd	$ 55.98	$ 822.91	
Concrete Removal Type 1D	14.7	Sq Yd	$ 62.53	$ 919.19	
Concrete Removal Type B	10	Ft	$ 8.29	$ 82.90	
Class A45 Concrete Fill	3.9	Cu Yd	$ 180.50	$ 703.95	
Finishing and Curing	294	Sq Yd	$ 39.25	$11,539.50	
			Total LSDC cost =	$28,902.33	
			Total deck area =	297.7	Sq Yd
				$ 97	Per Sq Yd
				$ 11	Per Sq Ft
				$ 116	Per Sq M

Figure 4 – Cost Elicitation - Low Slump Dense Concrete Overlay - Bridge Deck

As part of developing the preservation policy, it was necessary to come up with the failure cost of each element. Failure cost is the minimum cost value used to force an action, other than Do Nothing, in the worst element condition state. A tool in Pontis can calculate the minimum failure cost of each element. SDDOT used 110% of this calculated minimum value, so if there are any minor revisions in the preservation model, it won't always be necessary to recalculate the failure cost. (Shepard, Johnson 2001) (Cambridge Systematics, Inc. 2005)

Pontis uses an optimal solution based on the least long-term cost. The resultant network bridge condition is lower than what the public or the SDDOT would desire. A National Cooperative Highway Research Program project titled 12-67, Multiple-Objective Optimization for Bridge Management Systems is currently underway to address this issue. The purpose of this project is to develop methodologies for an optimization of multiple, user-specified performance criteria. A bridge owner can set a performance criteria objective in addition to just the least long-term cost. The anticipated completion date for this project is summer 2006.

The SDDOT has a five-year Surface Transportation Improvement Program (STIP). New structure projects are recommended for the new fifth year of this STIP using Pontis to recommend bridge projects, along with inspector and bridge office personnel recommendations. We assume the current fiscal projects are in progress (or being completed) and the current years two through five projects are assumed to be completed as planned. The Pontis bridge simulation allows inspector work candidate projects, current projects in our long-range program (projects beyond the current five year STIP), and Pontis recommended work to compete against each other for the best recommendation for the new fifth year. All of these recommended work candidates are then used to create proposed projects.

The proposed projects are reviewed by the Office of Bridge Design and scoped to address typical bridge rehabilitation work items. Indirect costs like mobilization, traffic control, contingency, and preliminary and construction engineering are then added to the project costs. The program simulation is then run again. The projects are ranked in priority based on only judgment at this time. The SDDOT is evaluating various performance measures and/or indices to rank projects more objectively.

Some of the performance measures currently being evaluated include various FHWA NBI items and Health Index related items. This includes Federal Sufficiency Rating, Deficiency, Bridge Funding Eligibility, Condition Ratings, Network Health Index, and component Health Indexes.

Performance Measures	**2005**	**2004**	**2003**	**Range (Low – High)**
Federal Sufficiency Rating (FSR)	88.2	88.1	86.8	0 - 100
Structurally Deficient	127 bridges	119 bridges	141 bridges	
Functionally Obsolete	102 bridges	110 bridges	108 bridges	
Deck Rating	6.1	6.2	6.1	0 - 9
Superstructure Rating	6.3	6.3	6.3	0 - 9
Substructure Rating	6.7	6.7	6.7	0 - 9
Structure Evaluation	6.1	6.1	6.1	0 - 9
Replacement Candidate	24 bridges	22 bridges	27 bridges	
Rehabilitation Candidate	119 bridges	118 bridges	130 bridges	
Structurally Deficient and FSR < 80	91 bridges	82 bridges	97 bridges	
Network Health Index	89.5	89.7	90.0	0 - 100
Decks/Slabs Health Index	83.9	84.4	82.2	0 - 100
Superstructure Health Index	87.8	87.9	86.0	0 - 100
Substructure Health Index	96.9	96.9	96.2	0 - 100
Bearings Health Index	85.4	86.1	94.7	0 - 100

Table 1 – Potential Performance Measures

INTEGRATING BMS WITH OTHER SYSTEMS

The SDDOT currently has a department project called Concept to Contract (C2C). C2C has an enterprise vision to have several computer programs work together as a system to share common information regarding highway construction projects. C2C is a computer system that will follow the life of the construction project from the time it is first thought of, all the way until it is let for bids to be built. By using new technology and automation, we will be much more efficient as we provide even higher quality projects to contractors in a shorter period than we do today.

C2C includes the following sub-systems:

1. Maintain Candidate – a consolidated database containing all of South Dakota's state highway system needs.
2. Scoping and Estimating – identifies alternatives for specific work to be done on the project and how much it will cost.
3. Scheduling and Task Management – will identify what tasks need to be done to get a project let for bids as well as who will do them and when.
4. Program Management – produces a list of projects to do, when to do them, and where the money will come from (includes contract maintenance projects.)
5. Funding – identifies funding to be used on what projects and when to use it.
6. Bid Letting – allows preparation of bidding documents and electronic interaction with contractors (includes informal bidding.)

All of the above computer sub-systems will be able to produce easy to understand reports in various formats so anyone can understand a project and its status. By having all of these needs in one place, a more coordinated effort can be put forth to improve our highway system more efficiently.

The Maintain Candidate Module will address the need to do more thorough planning for highway construction work by locating all of our highway needs in one computer system. Today, there are two separate management systems, pavement and bridge, that identify needs for those two highway components. Pavements and bridges are only a portion, although the majority, of the total highway composition and there are multiple lists of needs in areas of safety, maintenance, and traffic that exist in various formats (paper, spreadsheets, personal databases, memory, etc.). This module identifies conditions or situations that indicate construction, reconstruction, rehabilitation, or maintenance needs to be done at a location on our state highways. It does not provide the solution, the Scoping Module does that. It only assists in the coordination of the multiple needs across South Dakota.

In order to properly establish a scope of work for highway construction projects, the newly developed Scoping and Estimating module will allow multiple alternatives to be explored before making a decision on what would provide the citizens of South Dakota the most efficient use of limited funds. This is done as best as can be done today without automation, but is laborious and may not be providing the optimum result every time. Automation will force stringent rules to be applied and improve the decision-making process.

The scoping module will initially work from the high-level scope objectives that have been defined in the Maintain Candidate Module. By starting with identified component(s), associated needs, and the endorsement to explore alternative options, one or more options will be developed to address the need by identifying route location (normally shown on a map using GIS and given a name.) For each option, highway segments are identified with various alternative "scope of work" or choices created for each component and segment. Then, each choice is related to other choices to develop scenarios for each option. From there, the evaluation and selection process takes over. A recommended preferred alternative is then programmed as a construction project. Detail will be enough for a surveyor, designer, and other parties to know exactly what is expected. Any changes or additions will require formal approval.

In order to coordinate multiple people on multiple projects, a sophisticated tool (Scheduling and Task Management Module) is needed to improve communication on what we expect people to do and when to do it. We have a good system today, but it is located on the mainframe and does not allow employee interaction nor is it very adaptable to changing conditions.

To address the need of the Department's desire to improve communication and coordination, as part of the C2C Project, SDDOT evaluated off-the-shelf scheduling and project management tools as a replacement for their existing custom application. In January 2005, the Department decided to move forward with procuring Primavera software through Catalyst, Inc. The implementation phase of the project has been started.

Based on the new business processes sequencing, the Scoping Module will need to be directly referenced by the existing Programming/STIP Module to show the decision-makers the multiple alternatives produced and how the recommendations can be funded in what year. Some enhancements will use GIS mapping tools and provide running totals of budget availability so our executives can see immediate results of their various decisions. "What if" analysis capability will allow several scenarios to be explored before making a final recommendation to the Transportation Commission. When unplanned needs occur, the impacts the "emergency" have on existing projects in the program can be evaluated.

The full set of transportation projects is programmed with assigned priorities to determine how the projects will be funded. Both construction and maintenance activity projects are programmed. Funding options are analyzed for both federally available funds and state-budgeted funds. This process produces the STIP reports for approval. The program is monitored to verify how the plan is progressing and to make adjustments as necessary.

With all the construction project activity in the department, funding must be applied in order for the projects to become a reality. Having a system that interacts with the above modules regarding what funding is used on what project (or portion of a project) will allow us to improve sharing such information.

The Funding Module is currently being explored via Business Process Reengineering and will require a review of best practices across the nation. It is hopeful that an existing system is available that meets our requirements and can be integrated with all of SDDOT systems.

All of the work activities in the scoping and scheduling phases lead to survey and design where a final set of project plans are produced. The plans are used to produce a bid proposal document that is used to advertise for bids. Proposal documents are sent to interested contractors who may then choose to submit a bid. Received bids are read after the deadline for bid submittal and the contract is awarded to the lowest bidder.

The objective is to eliminate reentry of data from the plans to the bid documents to the contractors and back from the contractors. Electronic bidding will result in faster turn around and reduced errors. The contracting industry has been asking for this for several years and a system has finally been developed by the State of Utah Department of Transportation (UDOT) that will address both SDDOT's needs as well as the contractors.

UDOT's Project Development Business System has been obtained and rewritten to meet SDDOT requirements. This suite of products includes Project Administration, Electronic Bidding, Civil Rights Management, and Project Estimating Tools. Modules of the UDOT system to be implemented are Project Administration, Estimating, and Electronic Bidding. SDDOT has added a Letting Administration module. We have started training the contractors on the Electronic Bidding Portion. The web site for letting and project information should be up and running in a test environment. Mock lettings are scheduled in September (21st of that month), October, and November. Full production (first time for SDDOT to be electronic on bidding) is scheduled for January 18th, 2006.

CONCLUSIONS

The SDDOT has been able to utilize a standard product that was developed to meet the needs of 50 states and various international agencies, customize the product, and incorporate it into its business practices. This standard product, Pontis, is being used as the SDDOT bridge inventory database and as its Bridge Management System tool. The SDDOT custom data is being collected and stored in the Pontis database. The Pontis database was customized with custom tables and forms, along with custom reports. Using the PDI features of Pontis, data from legacy systems can be used to update Pontis. By customizing the check-out/check-in procedures, the SDDOT is able to do electronic data transfer with consultants contracted to do local government bridge inspections.

The SDDOT has been able to initially develop the models in Pontis to recommend work for bridge projects. The Preservation policy will not be mature until there have been more inspection cycles completed. There are some areas of the models that will need more data gathering or research to improve the results.

The SDDOT has started a project to integrate all management systems together to improve the STIP programming process. The SDDOT will also be considering Asset Management and life cycle costing in the future.

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Trademarks