INNOVATIVE ASSET MANAGEMENT

Full Paper

OWNER INITIATED MODERNIZATION OF BRIDGE SAFETY INSPECTIONS

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ABSTRACT

This paper reports on an "asset management" research program that is applicable to both the private and public sectors. This work presents the strategies and endeavors initiated and driven by a public sector owner in an effort to modernize their current asset management practices. The Commonwealth of Virginia's Department of Transportation (VDOT) is attempting to modernize a bridge safety inspection processes that requires over 14,000 bridges be inspected at least once every two years. The research effort involved investigating the capability to transform and replace paper-based inspection practices with advanced mobile computing practices. A series of owner-agency initiated research proposals are discussed and the impacts each would have on the procedural processes directed at transforming current work processes with newer mobile handheld computing processes. Ultimately the DOT selected a phased proposal and activated the first phase. This first phase research approach is presented, as are the results. The research determined that field inspections are readily transformable from one that relies on field marking paper reports and then returning to the office for semi-manual reporting to one that is electronically assisted in the field by using handheld computers. Identifiable areas of assistance are field data capture, automated asset inventory updates, and semi-automated report production. From this analysis a series of strategies and recommendations were identified. The owner-agency's decision to abandon a controlled phased study in favor of an ad-hoc in-house development process is then presented and discussed.

Keywords: Asset Management, Mobile Computing Inspections, Process Mapping, Bridge Inspection

1. BRIDGE INVENTORY MANAGEMENT APPROACH AND PHILOSOPHY

The annual cost for maintenance and improvements to the world's transportation infrastructure is billions of dollars. Much of this cost is associated with bridge maintenance, rehabilitation and replacement (MR&R). Within the Unites States, an individual state department of transportation (DOT) is eligible for federal highway support funds through the Federal Highway Administration (FHWA). Eligibility is contingent on each state establishing its own methodology to inspect and report bridge deterioration in compliance with National Bridge Inspection (NBI) Standards. All states report their inspection results in a standard format for inclusion within the NBI inventory (NBIS 23, 2002). State and federal laws and associated policies mandate the frequency of inspections. These inspections range from a monthly cycle to once every four years with a routine bridge inspection usually required once every two years. Within the state of Virginia alone, there are approximately 22,000 structures (bridge and culverts,) requiring between 7,000 – 10,000 inspections annually.

The primary objective of any bridge management system (BMS) is to make the best use of available funds in an overall bridge MR&R program while maintaining an infrastructure that's safe for public usage. Without regular maintenance, the overall conditions of any infrastructure element including a bridge will deteriorate over time. Therefore, a BMS must utilize accurate and accessible inspection information to predict a bridge's structural conditions over time.

A fully functioning enterprise wide BMS, or any other infrastructure management system, involves four major informational processes. These processes span the entire structure's life cycle. First, among these processes is the maintenance of an accurate inventory of structure information. This information must be retrievable, updatable, and reflective of the actual inventory item. Second an enterprise wide BMS needs to maintain a consistent and timely inspection and reporting process. Third, a needs assessment process that is coupled to a strategic MR&R optimization program is necessary to meet the goals of a safe and effectively administered infrastructure. Fourth, an MR&R projects development program allows for timely and cost effective budget allocations consistent with infrastructure management goals. At the state level each of these processes is handled internally across several different operational departments, including information technology (IT.)

1.1. INFORMATIONAL FRAGMENTATION OF THE INSPECTION PROCESS

At present, the VDOT bridge management enterprise has coherence in intent although throughput is slowed by the fragmentation of informational support tools. This system wide fragmentation has both technical hindrances and cultural bottlenecks that must be overcome if an effective and integrated BMS is to be achieved. Research to modernize the BMS can be extensive and cumbersome crossing many DOT operational domains.

Bridge information in Virginia, like many other states has a combination of IT tools that assist in managing its inventory. Virginia in particular combines this information within two distinct database applications, 1) Highway Traffic Records Information System (HTRIS), a coded inventory only database that exists within a Disc Operating System (DOS), and 2) Pontis, a well developed software application that operates within a Windows Operating System environment and maintains significant amounts of condition state data. The

HTRIS inventory application is a relic of the 1980's, yet does all that is asked of it which is little more then maintaining inventory data. As currently used by the owner/agency Pontis data is typically restricted to coded entries although it has capabilities for modeling and simulating "what-if" scenarios within an MR&R project decision making environment. A third component of Virginia's overall BMS is a non-indexed structural inspection report (SIR) that is the only visual and verbally description of a bridge's condition. The two databases (HTRIS and Pontis) help the state meets its obligation for compliance with federal laws and NBIS. The SIR is composed of written commentary, deterioration quantities, graphical data, and photographs compiled from inspector observations and allows for a non-codified assessment of a structure's condition. Collectively these three applications form the backbone of informational support and inspection data for Virginia's BMS.

The "bridge management databases" themselves are diverse and have low interoperability and fragment the inspection process. There is limited throughput within these three databases as they cross the four BMS domains of inventory, inspection, needs assessment, and project/program development. With the advent of wearable and handheld computing the opportunity for transforming an inherently fragmented paper based asset management process into one that is seamlessly integrated has become achievable by any large asset owner, public or private.

2. OWNER INITIATED TRANSFORMATION OPPORTUNITY

It was this awareness of a fragmented process that precipitated the VDOT Bridge and Structures Division (BSD) to embark upon an initial investigation to minimize or eliminate all inspection process fragmentation within the inspection domain by advocating the use of personal digital assistants (PDA's). Previously the owner/agency had implemented a process whereby laptop computers were issued to all field inspection teams, with the express purpose to allow field based reporting for later uploading to the agency database.

This previous effort failed for a variety of reasons, one being that basic inspection workflow process was neither investigated, nor documented as a necessary aid to overall process improvements. It was discovered after deployment, that even though new computer capabilities were added, work processes never changed. Therefore, a charge for this investigation was to not repeat this mistake.

It has become evident upon completion of the initial research that specific process improvements can still be derailed through organization structures that fragment improvement processes. The charge of not repeating a past mistake is proving easier said, than done. This was apparent during the research proposal stage and was later reinforced by the Bridge Inspection Division's decision to implement a "hardware first" direction.

2.1. VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)

To further improve transportation research the state maintains the Virginia Transportation Research Council (VTRC) as a state-sponsored center for innovation in advanced transportation-related engineering technology and for improvements in state agency management and operational practices. These objectives are intended to be met by conducting a broad-based program of applied and basic research, including support for technology transfer to the VDOT. In this capacity as innovator the VTRC is a coordinating agency that assists in interfacing between agency needs and university researchers to address innovative research issues (VTRC, 2004).

Although the VTRC acts as a catalyst, many of the research activities are internally linked back to a specific VDOT organizational unit. In the instance of inspection improvements the direction and focus is being provided by the BSD. This mechanism of yielding major research direction to an operational arm of the agency adds to process fragmentation, yet allows for a broader user led and initiated research. This fragmentation was, to a certain extent, obvious in the initial research proposals and further reinforced by the BSD post research decisions and the VTRC's weakness in redirecting these decisions.

2.2. FRAGMENTED RESEARCH STRATEGIES

The VTRC had previously discussed strategies with researchers to improve the inspection processes it took the BSD to make the initial call through the VTRC for process improvement proposals. Upon receipt of the call an initial proposal was prepared that addressed only inspection process improvements through; 1) research on work processes, 2) defining optimum user needs; 3) developing process improvement strategies, 4) proposals for specific hardware/software solutions, 5) the implementation of prototype trials, 6) development of implementation procedures, and 7) measuring and assessing improvements. Upon proposal review the BSD countered that only hardware/software solutions are proposed with a particular desire to target a specific hardware solution set.

This "hardware first" solution was indicative of the previously mentioned laptop implementation failure. Preconceived notions without process understanding are doomed to failure. A second proposal was prepared to address this owner-driven approach. Fortunately, the VTRC recommended otherwise. The VTRC recommended that agency work processes must be researched and understood before any hardware solution could be proposed. This lead to a third proposal that addressed a simple work processes investigation within a transformation strategy of incorporating wearable/handheld computers into the inspection process.

3. RESEARCH APPROACH

The strategy for this research was to map the work flows as described and then observe how field personnel actually proceeded with their work tasks. To quote Anjard (1996), "A processes map prompts new thinking about how work is done." Additionally as Symonds and Jacobs (1997) have shown in their work, multi-level process maps can produce higher levels of detail and hence higher levels of understanding and opportunity for innovative process improvements. Thus the use of simple mappings to understand and analyze workflow can be quite successful in identifying change opportunities.

Due to the uniqueness, diversity, and locations of the states asset inventory it was determined that several bridge inspection teams or districts operational processes would be observed and mapped. To find out how different people and different teams approached and conducted similar inspections, and to get reliable and transportable mappings, bridge inspectors from four different districts were interviewed and then physically observed in the field and office as they implemented the inspection process. Not unexpectedly the observations of the different inspection teams identified a common work process. Although the processes had commonality in accomplishment and outputs the actual procedures were sequenced and implemented differently by each of the different teams. This validated the need for a modernization strategy that could incorporate mobile computing technology into standard operating procedures but also allow different teams to work in self-defined sequences.

4. RESULTS

Most if not all states, including Virginia provides its inspectors with standardized training through comprehensive courses based on the FHWA's "Bridge Inspector's Training Manual" and NBIS. This commonality in training is intended to standardize the process by minimizing the variability in inspection observations and reports. Although inspector training and reporting requirements are standardized to comply with FHWA requirements, each state is free to develop its own inspection and reporting methodologies. Therefore, each state has a unique inspection, collection, internal reporting, and archiving methodology.

In general, the different inspection teams accomplished their basic inspection tasks using similar but not identical procedures. From the research, see Figure 1, it was determined that the inspection process operates within three distinct and sequential functions, 1) Inspection Management, 2) Inspection, and 3) Reporting.

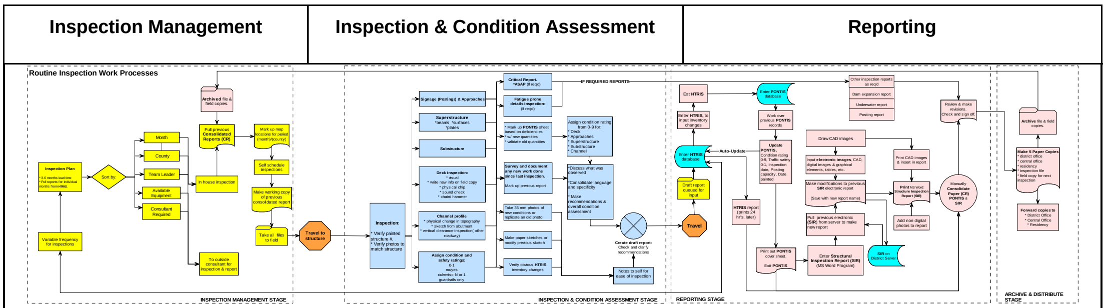

Figure 1 - Current Inspection Workflow

In all instances data collection by field inspectors was done by marking up, in red, the previous paper reports with any new data. Later the inspectors would return to the office and manually input the newly recorded data into three separate electronic applications and print out a paper archival report. The data collection and reporting systems used to complete an inspection was characteristically paper based with the results being manually transferred and archived into three separate and distinct software applications, 1) HTRIS, an older DOS-based asset inventory database; 2) Pontis, a Windows-based proprietary database application; and 3) a word processing document that contained text, graphics, and images. These three applications have limited interoperability and required a manually composed report combining paper outputs from all three applications to produce a final archival report.

4.1. WORK PROCESSES IDENTIFY INFORMATION FRAGMENTATION

It was determined that at the inspection level information was compiled, stored, and archived within three functionally independent information interfaces. Although these interfaces exist independently and have limited interoperability they are collectively used to record bridge/structure inspection data and to manage the state's bridge/structure assets. The three independent information archives having been previously described are; 1) HTRIS (DOS-based), 2) Pontis (Windows-based), and 3) SIR (text with graphics and images).

Table 1 is an example of the level of fragmentation in information accessibility that exists within the state's bridge/structure inspection process. Access to each of these information types is necessary to fully comprehend the condition of a bridge and to develop any MR&R strategy (Mills and Wakefield, 2004). As can be observed in Table 1 no single software application provides an assessment of the structure's condition that is usable and adequate for competent asset management.

Table 1 – Bridge/Structure Condition Data Fragmentation

Information Type	HTRIS	Pontis	SIR
Text commentary			√
Graphical data (sketches)			√
Photographs			√
Geometrical data	√		
Condition ratings	√	√	
Inspection frequencies	√	√	
Element conditions		√	
Maintenance & improvement cost		√	

From an analysis of the research data, it was determined that a modernizing of the inspection processes through the implementation of mobile computing devices could improve the processes within the inspection management, inspection, and reporting functions.

4.2. MODERNIZATION RECOMMENDATIONS

A series of recommendations were offered to the agency that described a deliberated and phased approach to the agency's goals of modernizing the inspection process by incorporating mobile computing devices and current information transfer mechanisms. Figure 2 is a workflow redefinition of the current work practices with an attempt to address redefinition by incorporating mobile computing technology. The recommendations proposed a tiered strategy for modernization that attempts to incrementally modernize the process by defining varying levels of internal improvements prior to any revolutionary hardware/software transformation.

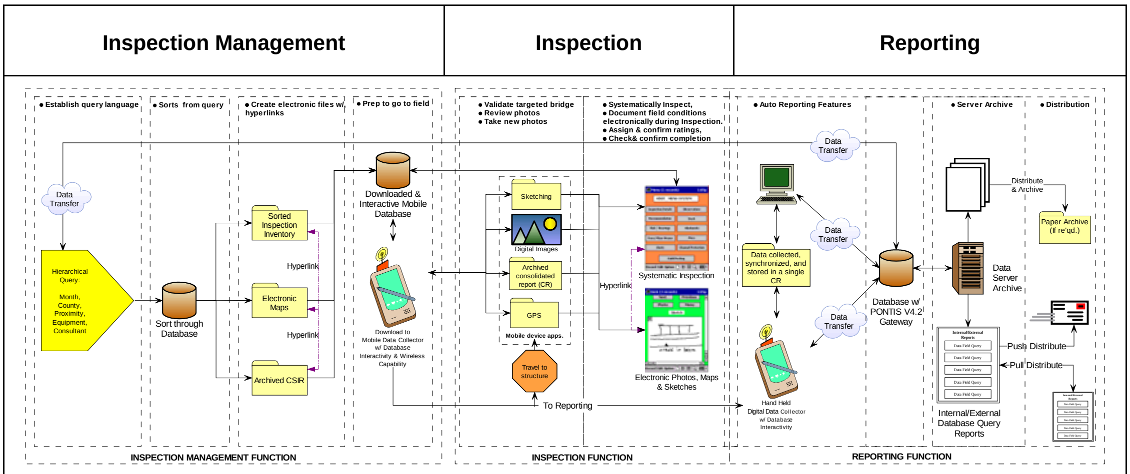

Figure 2 - Proposed Inspection Workflow

Tier One improvements are intended to foster an achievable level of internal agency action. This was to be accomplished by; 1) simple procedural adjustments that eliminated agency redundancies and minimized internal inefficiencies without any new hardware/software additions, and 2) adopting agency procedures that would aid in the standardization of upstream and downstream information transfers to improve the chances of a more successful transformation when mobile inspection tools were added to the process (Mills and Wakefield, 2004).

Tier Two work proposed an implementation sequence that mimicked the first research proposal and offered three alternative mobile computing solutions to the agency and the VTRC. Essentially the work proposed that the BSD; 1) establish its inspection modernization priorities through a facilitator led workshop, 2) that three proposed solutions be investigated, 3) that VTRC/BSD create a mobile field application pilot program with solution supplier support, and 4) that VTRC/BSD pilot the solutions and present the findings to the agency.

Upon a complete assessment of the pilot program a prototypical mobile inspection assistant could be compiled for actual field testing and benchmarking. Once this phase was completed a hardware/software solution could be established, followed by a procurement, implementation and adoption procedure. This last phase of the work was to implement a field monitoring assessment to monitor productivity improvement (Mills and Wakefield, 2004).

5. A FRAGMENTED STRATEGY FOR MODERNIZATION

Prior to completion of the Phase I work, the BSD was desirous of a quick solution and proceeded to initiate a “hardware first” solution. This effort was consistent with the BSD’s initial strategy to ignore the work processes and focus on a solution before understanding the existing work processes and how they could be modernized. Thus the BSD proceeded in designating an “affordable” Palm OS device as the pre-designated solution to integrating mobile computer assistance for modernizing the inspection process.

5.1. RAMIFICATIONS AND THE RETURN TO FRAGMENTATION

It is being discovered that the BSD “hardware first” solution is not meeting with much success. During this attempt to implement the solution before determining the problems, researchers of Phase I were not contacted nor consulted. The researchers are aware that the results of Phase I have been read by BSD and there has been discussion of continuing the research. What becomes apparent is that without a studied and careful effort to understand the problems, any solution is primed for failure. A research focused facility such as the VTRC has the vision to foresee this problem and as such initiated the Phase I research that yielded a reasonable strategy and excellent opportunity to modernize the processes much as proposed.

What is also evident is that by observing BSD’s desire for a quicker solution and VTRC’s mediated phase one proposal the fragmentation that exists reinforces an action versus research dilemma in transforming an organization’s operational processes. The acceptance of a reasonable proposal that staged the progression of deliverables and allowed research findings to be incorporated into action prior to report completion would have allowed fast-tracking and a quicker solution.

5.2. CONCLUDING LESSONS LEARNED

History has a unique way of repeating itself. The innovative VDOT laptop deployment that failed earlier has the opportunity to repeat itself during VDOT’s current efforts to modernize their antiquated inspection processes. Successful innovation requires an adequate understanding of the problem and the issues that make innovation possible and successful. Innovative solutions take understanding and understanding requires time. To be a successful innovator, an owner/agency must gather buy-in from all users and allow time for the process to develop. VTRC and VDOT dedicated research approach fosters buy-in through the very elements aid fragmentation. Any fragmentation within an organization hinders the organizations ability to quickly foster innovation and modernization.

When an organization is unclear on its internal roles and responsibilities, action or research, it will encounter difficulty in driving innovation. VDOT's efforts to modernize their inspection processes are resulting in multiple starts, stops, and redundancies that characterize the process with internal delays and failed successes. With regards to VTRC/BSD effort to modernize their inspection processes, the end users' (BSD) needs should drive the research and the research group should drive the investigative process.

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