Management Perspective on the Integration of Transportation Planning Information

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ABSTRACT

The Management Systems Integration Committee (MSIC) is a group of state, local, and federal agencies formed to provide a means of sharing expertise and providing guidance to all agencies interested in the integration of transportation planning information. Formed in 1995 with FHWA funding, the Committee delivered its final report in 1998.

Viewing the prime objective of management systems as providing objective information to support the decision-making process, the Committee explored frameworks for bringing together the outputs of the seven systems described in the Intermodal Surface Transportation Act of 1991 (ISTEA), to support the major planning processes of a transportation agency. By comparing their diverse experiences with ISTEA implementation, MSIC members found broad commonality in the decision-making issues but wide divergence in the technical and organizational means of providing information.

Even though the ISTEA management system requirements have been rescinded, the need for objective planning information remains. In its Final Report, the Committee has developed a model of the generic decision-making processes to be supported, and summarized, in capsule form, how each of its members has tried to address the needs of decision-makers. The framework of the generic business process model was found to be a very useful way of organizing the implementation activities in a wide range of agencies.

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BACKGROUND

The Management Systems Integration Committee (MSIC) is a group of state, local, and federal agencies formed to provide a means of sharing expertise and providing guidance to all agencies interested in the integration of transportation planning information. Its primary mandate is to promote the integration of objective information into the decision making process. To accomplish this, the Committee set out to:

- Share knowledge and experiences of key states and Metropolitan Planning Organizations (MPOs), and identify issues and challenges regarding the integration of the transportation planning systems.
- Deliberate and resolve integration issues, and identify best practices, for recommendation to other states and MPOs.
- Foster cooperative and joint development relating to the integration of Management and Monitoring Systems.
- Identify the areas of need for integration work at the national level.

A Management System is a decision support tool that examines the primary components of the transportation system in an effort to monitor, manage and optimize the system's current and projected performance.

Management systems are utilized for the physical assets and behavioral components of a transportation system. Asset examples include pavement, bridges, transit fleets, intermodal facilities, and those physical elements that affect travel safety. Behavioral components involve the movement, flow, and safety of persons and goods.

While six systems (i.e., pavement, bridge, safety, congestion, intermodal facilities, and public transportation management systems, and the traffic monitoring system) were mandated by the 1991 ISTEA legislation, the National Highway System Act of 1995 made most of the management system requirements optional, largely at the urging of the states. Subsequent 1996 research by the US General Accounting Office (1) found that 24 states were still moving forward with the six management systems, and all of the rest were planning to continue implementation of at least three of them. Although removal of the mandate has in many cases adversely affected the level of resources and priority given to management system implementation, it has had the positive effect of allowing transportation agencies to mold the management systems into the tools most suited for the needs of their states.

Integration strategies typically need to address many inter-related issues, including:

- compatible outputs that allow cross-program comparison
- compatible analysis methodologies
- consistency of data used by multiple systems
- impact of one system's changes on the other systems
- data interfaces are linked (including GIS, common referencing system)
- common timelines and consistency of reports and outputs
- effective utilization of outputs in local and statewide planning and other decision making processes
- performance measures that allow agencies to measure system performance across functional classes, modes, and jurisdictions

The Committee explored, through dozens of case studies, how agencies have approached these and other integration issues. This resulted in a synthesis of best practice as presented in the Committee's Final Report (2).

THE DECISION MAKING CONTEXT

If a primary goal of management systems is to provide objective information to decision makers, then it follows that many of the requirements of the systems should follow from the needs of the decision making processes of transportation agencies. Based on a large number of case studies, the Committee developed an organizing framework that should be applicable to a large majority of transportation agencies at the state, metropolitan and local levels, across the scope of all seven ISTEA-defined management systems. Because of its relevance to all seven systems, this framework can form the basis for identifying specific integration requirements. These can then be used in the design of organizational processes and technical tools within the management systems. According to this framework, the major components of the decision making process are:

- **Long-range planning**
  - Set system goals
  - Determine long-range investment levels
  - Identify system-level problems
  - Prioritize long-range strategies and actions
- **STIP/TIP development**
  - Determine investment levels: project or program level
  - Identify and refine specific problems and solutions
  - Prioritize STIP/TIP strategies and actions
- **Project Design/Construction/Maintenance or Program Implementation/Operations**
  - Accomplish detailed design
  - Construct project or implement program
  - Maintain infrastructure or operate program
- **Evaluation of implemented actions**
  - Monitor project/program to compare performance with intended results
  - Reassess applicability of strategies and actions given findings

The following sections summarize the processes and findings for each component of the framework. Reference (2) provides numerous case studies and examples.

LONG RANGE PLANNING

Long range planning encompasses much of the functionality that, in individual management systems, might be called network-level or system-level policy analysis. This part of the decision-making process establishes long-range goals and monitors the accomplishment of these goals. The sub-components of this process are:

Set system goals. Decision makers set system goals, often called policies, for various components of the transportation system. Many agencies set quantified goals for the capital assets of their transportation system in order to maintain their infrastructure at some desired level. More and more agencies are beginning to quantify goals for the system-wide performance of their transportation system, such as the safety or mobility of the system.

Determine long range investment levels. Investment levels are then set which will achieve the system goals within a prescribed time frame. Funding is typically allocated to certain categories of projects, such as resurfacing, safety, public transportation, capacity, etc. Ideally, these decisions should be from a total “system” approach, looking at the implications of changes from one to another part of the total transportation system.

Identify system level problems. The third step is usually to look at where the problem areas are--where are the poor bridges, high congestion, bottlenecks, etc. This step pares down the areas of focus for evaluating long term actions.

Prioritize long range strategies and actions. Finally, long term strategies and actions are determined to focus in the problem areas. Carrying out these strategies and actions should result in achievement of the system goals if the appropriate funding (investment level) has been set and implemented.

Transportation agencies have often found it difficult to provide integrated, objective information for long-range planning, because it is complex in several ways: it involves inputs from several engineering and planning disciplines; it requires well-digested, high level data; and it requires making predictions about the long range future. From its research, the Committee documented nineteen separate findings that represent a sample of best practices undertaken by agencies to try to overcome these difficulties.

1. A basic piece of information useful from all management systems is the "state of the system." Management systems should answer the these questions:

- How well is system performing?
- How well are the transportation assets being maintained?
- What is the physical condition of the system?

These "state of the system" reports should be available in multiple levels of aggregation, depending on the level of decision making. There should ultimately be the capability to summarize system performance and condition into generic, non-technical categories such as percents of "good, fair, and poor" or "acceptable/unacceptable." With the national trend toward increased flexibility in transportation funding, decision makers require "state of the system" reports that cover the major components of the transportation system so that they can make informed decisions about the allocation of funding.

2. In order to define and use categories of system performance, an underlying implication is that management systems are inherently based on standards or objectives. Questions such as "how well is the system performing" can only be answered if there are accepted standards and/or objectives for physical condition or performance. Standards may range from clearly articulated quantitative measures to simply deviations from past trends. These standards should be clearly articulated and understood by users of the management systems' information. Agreement on standards and objectives can be difficult when there will be funding allocation implications. Management and major stakeholders must understand the standards/objectives and agree to them. For example, often decision makers and users misinterpret information from an asset-based management system as applying only to the maintenance needs and conditions. However, often such systems measure condition relative to current design or functional standards (such as the width or load capacity of a bridge).

3. Management systems should include the ability to assess the financial implications of altering assumptions and standards. What if the schedule for replacing assets is extended--what will be the financial implications? If pavement is maintained at 90% fair or better, what will be the cost over a certain number of years?

4. What-if analyses are more useful in long-range planning if they can optimize the results. Optimization reflects a value structure. A system optimized to preserve the transportation system, for example, will yield different results than one optimized to stimulate economic development. Optimization can be based on

- performance or level of service (What is the optimal level of service?) or
- budget constraints (How should funds be allocated among competing needs in the same inventory or among different inventories?)

The results can be optimized

- by using a benefit/cost analysis (How can we get the most benefit for a given investment?) or
- by using non-dollar measures of effectiveness (What actions, at what cost, should be taken to achieve a performance goal?)

For example, we can achieve 90% fair or better pavement conditions on statewide roads and 66% fair or better on district roads for $80 million a year. Alternately, in order to achieve 90% fair or better pavement conditions on all state jurisdiction roads we need to invest $100 million a year.

5. While asset-based management systems typically directly calculate the financial implications of action (or lack of action), performance-based systems do not necessarily provide such a calculation. Such systems may only act as a means to signal the responsible agency to take a closer look at the performance of the system or sub-area. The financial implication, as well as the non-financial implications, may only be understood after further examination of the performance problem and the examination of alternative mobility or safety strategies.

6. To help ensure integration among systems, the following should be done:

- Clearly articulate and document the underlying assumptions, objectives, and standards used in the different systems.
- Ensure that standards that are common to diverse inventories are the same.
- Ensure that data and analysis methodologies that are common to different systems have common data definitions and are consistent.
- Where management systems are used to calculate a single numeric score or rating, test and evaluate the various components that go into that score for consistency among systems.

7. Generally there is consensus throughout the transportation industry on the design standards underlying asset based systems. There is less consensus for performance-based systems such as congestion management systems. "Good performance" or mobility objectives are more reflective of the particular concerns of individual regions and states. Such concerns, for example, often vary between rural and urban regions. Some regions may focus on reducing congestion, while others may focus on accessibility, cost effectiveness, or other goals. However, as with asset-based systems, clearly articulated performance objectives or standards are critical no matter what the performance objective and should be set by policy makers. Standards and objectives are a way of articulating to the customers (public) what the policies of the agency are, and a way of delegating authority to agency staff.

8. At a system level, performance based measures, whether called management systems or not, have proved useful to measure how performance of the system varies depending upon alternative investment strategies. This would be a desirable use and practice for MPOs and states. For example, regional plans of larger MPOs will often develop alternative regional investment strategies and measure how the performance of these strategies may vary. State of the system reports help the MPO select a preferred investment strategy for implementation in the regional plan. A similar process is typically used at a corridor level to measure the performance of alternative investment strategies.

9. The introduction of objective performance-based information into transportation decision making helps delineate the discreet components of decisions to be made so that each component of decisions can be debated and decided upon individually, then weighted against other components for a comprehensive decisions. Transportation decision making in the public arena is very complex, with numerous conflicting and competing needs. Those needs (decision making components) that lend themselves to objective analysis, which can be quantified with a reasonable degree of confidence and credibility, are directly supported by the provision of management system information. Along with these objective components of decision making are many subjective components, such as social equity, political pressures, public sentiment, windows of opportunity, etc. These subjective components are completely valid and should be fully considered. One of the main benefits of management system information is that it helps force subjective components into open debate, since the objective components speak for themselves. This helps keep the debate clear, thus limiting the potential for exaggerated claims of infrastructure condition, safety, or mobility.

10. In order for objective information to be fully considered in the transportation decision making process, long range system goals should be quantified. Without quantification, measuring the attainment of goals is difficult or impossible, and quantified information has much less potential for improving decision making. Principles espoused by experts on total quality management emphasize use of numeric goals and a

data-based systems approach rather than a project-by-project approach. Finally, the quantification of goals allows the staff of the agency to carry out the achievement of the goals in the most efficient way with relatively little interference while still being completely consistent with the desired outcomes of decision makers.

11. Transportation decisions are made every day without adequate information about the transportation system. Without good information, goals can be unrealistic or less meaningful. Setting goals should be an iterative approach where decision makers can evaluate the consequences of proposed goals on the total system given available revenues. Management systems can play a key role in projecting scenarios and monitoring the effects of long range decisions.

12. Traditional analysis methods for transportation assets are based primarily on physical condition (e.g. depth of pavement rutting, percent spalling of concrete girders.) This is very useful for engineers for use in project scoping and design. Higher level decision makers are typically concerned with broad funding decisions that require a different type of information. A needs-based analysis is much more useful to them because it addresses the financial implications of various scenarios of overall asset physical condition. A needs-based analysis considers deterioration rates in determining the financial “needs” of a given piece of the inventory. State-of-the-art computerized asset management systems put this ability at the fingertips of management systems professionals.

13. The process of long range planning requires significant cooperation among numerous stakeholders. Many partnerships have been initiated by the management systems process. For example, in the development of safety management systems, diverse professionals representing traffic engineering, driver behavior, enforcement, and emergency services often sat down together for the first time to try to begin to coordinate ways to save human lives, reduce injuries, and minimize property damage.

14. As experience using the systems increases, the boundaries among the systems begin to evaporate. The SMS, CMS and PMS, for example, might locate problems/needs in the same highway segment. Planning and project selection processes can then focus on the problem area. Those involved in developing strategies to solve the problem, possibly a cross-functional team, need compatible data for the segment from each of these management systems. The data could appear on a geographic information system (GIS) application that integrates the information and changes the focus from the individual systems to the performance of the transportation system as a whole.

15. One stop shopping can greatly facilitate sharing of data throughout a transportation agency. It saves time and effort for those seeking information, greatly increasing the likelihood that the information will be used. Putting transportation information into silos should be avoided as much as possible by combining management systems information with all other relevant information needed for decision making. One stop shopping does not necessarily mean that all transportation information is stored in an enterprise database or accessible via a GIS. The key is to make data conveniently accessible, which can be done with contact persons, distributed processing, intranets, etc. The bulk of asset management data consists of engineering detail that may not be suitable for widespread sharing.

16. Mock up reports should be developed as part of establishing user requirements for the management systems. They are one of the most effective ways for users to describe what information is needed from a management system and how it should be presented. Mock up reports have been very successfully used in software development. They are also very successful for hardcopy reports to be given to decision makers. Producing comprehensive mock up reports also emphasizes the benefits of uniformity and compatibility between systems.

17. Although many state DOTs recognize the important role of technology in developing management systems, they have not fully used or optimized the benefits of such systems. Deterioration and prediction models, computer aided design/drafting (CADD), geographic information systems (GIS), and other systems are well underway as separate efforts in many states. States are beginning to recognize that some of the needed data are nonexistent, duplicative, difficult to retrieve, or incompatible. As statewide transportation planning becomes more complex and processes change accordingly, it becomes imperative to migrate to a better integrated and planned transportation system.

18. Performance objectives and standards should be set by policy makers. Management system professionals should offer appropriate categories of performance measures, their professional judgment of

the impact of various performance standards, and decide the technical measures appropriate to assess these performance objectives. Management systems should provide evaluated, viable alternatives.

19. Management systems should be policy driven. For example, the relative importance of infrastructure preservation vs. safety vs. mobility is policy level and should not be buried in the analytics of individual management systems. Management systems should not set priorities in project selection process, but should help policy makers evaluate different policy focuses, and provide policy makers performance information related to their priorities. Management systems should provide information that improves the sophistication of selection processes and forces policy decisions into open debate.

STIP/TIP DEVELOPMENT

STIP/TIPs (state and metropolitan transportation improvement programs, respectively) are practical sets of projects and programs designed to achieve the goals and objectives established in long-range plans. STIP/TIPs are derived from long-range plans that differ between metropolitan and state jurisdictions.

STIPs and TIPs can generally be distinguished from long-range plans by their greater degree of project/or program specificity, readiness and prioritization, and funding constraints. Additionally, STIPs/TIPs are a shorter-range programming of projects (minimum three years of projects) and are the intermediate step between the long-range plan and ultimate project delivery. The sub-components of STIP/TIP development are:

Determine investment levels at the project or program level. Because STIPs/TIPs have financial constraints, decision makers have to trade off investing at varying levels within and across program areas. For some states and all MPOs, this step is part of long-range planning. However, knowing the financial constraints, many states use the shorter range STIP to refine the investments into program areas. In addition to these program-level refinements, they make project-specific allocations.

The consequences of tradeoffs among program areas currently are not usually well understood in terms of the impact to the performance and preservation of the transportation system. Additionally, the reasonableness of projected costs and revenues becomes crucial in order to optimize a financially constrained STIP/TIP.

Identify and refine specific problems and solutions. Projects and programs eligible for inclusion in a STIP/TIP need to have been identified in the metropolitan long-range plan or linked to the goals and objectives established in a state's long-range plan if that plan is not project specific. At the STIP/TIP stage, specific investment strategies can begin to address problems with the transportation system. However, given financial constraints the universe of potential solutions must be pared down since only a small subset can be selected for inclusion in the STIP/TIP. The management systems can contribute to the refinement of problems and the identification and evaluation of potential solutions.

Prioritize STIP/TIP strategies and actions. Projects nominated for inclusion in the STIP/TIP must be selected in accordance with established procedures or funding eligibility requirements. Project selection can encompass many factors, including the degree to which a project meets threshold requirements; project readiness; and its ranking among similar projects or among unrelated projects that are eligible for the same funding sources. The management systems can assist in project selection as well as help rank similar projects, or distinguish among the priorities of the various components of the transportation system. Information from the management systems can also be used as criteria in establishing threshold requirements.

This phase of the decision making process includes network-level budgeting by program category when hard budget constraints are involved. It also includes project-level needs identification. When funding constraints and project needs are inconsistent (i.e. not enough money available to satisfy all needs), a priority-setting process must be conducted in order to reconcile the two levels of concern. The result of priority-setting is usually that needed projects, and their accompanying performance benefits, are delayed. Much of the engineering functionality of existing asset management systems is directed toward providing information to support these decision making processes. Sometimes the process also results in renewed efforts to increase or accelerate agency funding, such as through tax increases or borrowing. The Management System Integration Committee identified eight findings related to STIP/TIP development.

1. When multiple decisions are inter-related, as is always the case in STIP/TIP development, it has often been useful to isolate each individual decision, and use an automated process such as optimization or prioritization to show how the decision of interest might affect other decisions. For example, if funding is decreased, how many projects could be delayed before transportation system performance declines below a critical level? Asset management systems often provide this capability, as a type of “what-if” analysis. Unfortunately, this type of feature is often misunderstood as a decision-making, rather than decision-support, feature. It is important to recognize that priority-setting and budgeting decisions should always be made by human decision makers, using management systems only to provide feedback on the possible implications of alternative decisions.

2. Development of TIPs and STIPs necessarily requires the sharing and exchange of information within individual agencies, as well as between agencies of different jurisdictions and responsibilities. Further, agreement on the meaning and relative importance of analyses performed on data combined from many sources is necessary if STIP and TIP documents are to obtain the necessary agreement among the affected parties. There are both technical and definitional aspects of data that affect the ability to be shared among dissimilar systems. It is often necessary to have a process for ongoing negotiation and consensus-building in order to maintain a set of data sharing capabilities.

3. As the use of management system data becomes more widespread through an agency or more important to decision making, the need for accurate and complete data becomes more apparent. Staff who may initially see data management issues as tedious or unnecessary generally gain a greater appreciation for them over time as implementation proceeds.

4. Tools or measures to determine policy or performance are easier to develop and integrate into transportation business practices if they are developed for cross-functional purposes. For example, bridge engineers have historically provided bridge condition information in a technical format. This was insufficient for managers to understand the economic implications and did not enable them to make appropriate policy decisions. In recent years, bridge management systems have developed the ability to express project outcomes in terms of economic benefits and performance measures that are relevant to a wider audience. A primary result is improved communication: inspectors, engineers, planners, programmers, budget analysts, and managers all gain a better understanding of physical condition and performance, funding needs, project scope and cost, policies, and transportation system performance. As a structured method for negotiating a specific program of projects, the STIP/TIP process can be a major beneficiary of this improved communication.

5. As transportation funding in the public arena becomes more flexible at the state and local levels, competition for that funding will undoubtedly increase. Decision makers faced with a plethora of needs for funding usually look to objective information to substantiate these public expenditures. As requests for projects pour in, those armed with credible and objective data are often at a considerable advantage. Infrastructure management system tools have become very powerful, making sophisticated projections of deterioration and complex benefit/cost calculations that can prove to decision makers that their money will be well spent.

6. However, agencies must not make decisions about the infrastructure in a vacuum of information about other parts of the transportation system. The technology and professional knowledge that exists today allows agencies to make proactive tradeoffs between various components of the transportation system for overall balance.

7. Management systems offer the opportunity to improve the comprehensive planning process by demonstrating all the potential needs by type of program on the same segment (enabled by GIS), so economies can be realized by coordinating projects from multiple systems at one time. During the design and development of management systems, this outcome needs to be kept in mind.

8. State of the art practice is to publish criteria for project selection so everyone knows how and why projects are selected in advance, specifically when objective matrixes or formulas are used.

PROJECT AND PROGRAM IMPLEMENTATION AND OPERATIONS

As projects and programs reach their implementation phase, decision making tends to have a shorter timeframe and becomes more narrowly focused. Nevertheless, a systems approach to implementation activities, assisted by management systems, can have great value in helping to improve the operational decisions that are made. This phase is defined by three elements:

- Accomplish detailed design;
- Construct project or implement program;
- Maintain infrastructure or operate program.

The strategies chosen in response to transportation needs can be loosely categorized in two groups: operational strategies, often referred to as Transportation System Management; and capital strategies, such as new construction or functional improvements.

The tradeoffs between these categories are normally evaluated during the STIP/TIP process, where the broad outlines of the strategies are defined. At the same time, both types of strategies have a tradeoff to be considered between start-up costs (program implementation, or design and construction) and ongoing costs (operations and maintenance). Although these decisions are made before the implementation phase begins, they rely heavily on experience and metrics that can be captured during implementation. An effective system of recording actual work accomplishments and operational decisions can become an essential element of an organizational memory, allowing the agency to become increasingly competent in its STIP/TIP decision-making over time. The systems aspect of implementation and operational decision-making is evident in several ways:

- Operational decisions made at one location affect other locations. Examples include traffic signal timing and maintenance scheduling.
- The existence of substantial fixed costs introduces economies of scale. For example, the existence of a construction traffic control scheme for a pavement project may make it more attractive to take care of other needs, such as safety improvements and bridge work, at the same time at that location.
- Application of consistent standards for the design of both capital facilities and operational strategies, tends to adjust driver expectations, which in turn tends to reduce safety and maintenance problems.

The Committee documented the following findings related to project and program implementation and operations:

1. The planning capabilities of management systems are inextricably linked to the processes of project and program implementation, maintenance, and operations. All of these areas benefit in similar ways from a more comprehensive approach to management systems. Work accomplishment and incident data that can only be captured at the maintenance and operations level of the organization are essential to the long-term credibility of the planning models in management systems.

2. Transportation agencies have made substantial progress on the implementation of traffic management systems for signal coordination and are on the verge of additional success in the field of Intelligent Transportation Systems. For example, a transportation agency can relate traffic flow data obtained through GPS technology to signal timing programs to pinpoint intersections at risk of air quality ‘hot spots’ violations.

3. Benefit/cost analysis and similar quantitative tools can incorporate the number and types of accidents per year and examine the cost of preventing accidents for a host of different countermeasures. This allows an agency to select those countermeasures that provide the highest benefit, and helps to cost effectively incorporate safety enhancements into projects designed to achieve other goals, like pavement rehabilitation.

4. From a single source of information (e.g., bridge maintenance reports), numerous levels of reports can be produced to address the needs of the audience. For example, a higher end report can summarize regional bridge maintenance needs by activity, so managers can get a snapshot of major emphasis areas in a region. At the more detailed end, maintenance needs can be summarized for each bridge structure so that a maintenance crew can effectively address all of the needs of a bridge.

EVALUATION OF IMPLEMENTED ACTIONS

The philosophy of continuous improvement can readily be extended to management systems, manifesting itself in a feedback loop where the planning process outputs are compared to real-life outcomes, with planning inputs adjusted accordingly. The purpose is to make planning processes and modeling more realistic, so future outcomes will be closer to what was intended.

In order for this feedback loop to work, the agency must have an effective system of recording work accomplishments, that documents and quantifies the exact actions which were taken, the resources which were used, and the exact inventory items (facilities, vehicles, market segments, etc.) which were acted upon. The agency must also have an ongoing process of monitoring system condition and performance. This is the same data collection activity that was discussed in the context of long-range planning and STIP/TIP development, repeated on a regular basis in a consistent way so before-and-after comparisons are possible. There are two important aspects of evaluating implemented actions:

- To monitor a project or program to compare performance with intended results; and
- To reassess the applicability of strategies and actions, and to identify the magnitude and direction of needed changes, if any.

Management systems can help in this important role, because they contain information on several key aspects of transportation system performance, both in an historical and a forecasted sense:

- Historic condition of transportation system infrastructure and fleets;
- Historic use of the system (e.g., traffic or ridership; composition of users; imposition of operational or structural loads on the system);
- Actions taken on the system or fleet (e.g., capital investments, routine maintenance, changes in operational policies such as speed limits or vehicle restrictions);
- Agency resources used to accomplish these actions, by category or class (e.g., labor, equipment, materials, contracted services);
- Costs, benefits, and other impacts of these actions based upon historical information;
- Updated inspection data or observations of actual system performance;
- Calibrated management system models or relationships based upon these data.

Application of these system data and results to the evaluation of implemented actions can be visualized at all management levels. The Committee documented eight findings related to the evaluation of implemented actions:

1. A feedback loop of evaluating and updating the decision making process is essential to establishing its credibility and improving it over time. The data collection required for this is the same as what is needed for long-range planning and STIP/TIP development, and has the same considerations regarding integration.

2. In some cases, a complete analysis of data collection needs can lead to a reduction of data requirements, especially in cases where a data collection resource can serve multiple purposes, or where the frequency of data collection is found to be more than what is required for management decisions.

3. The State-of-the-System report needs to be updated each year so decision makers and the public can see whether the desired systemwide changes have been achieved.

4. Few agencies have enough experience with management systems to have exploited the feedback loop on a systemwide basis so far, but some excellent tools are available when organizations are ready to use them.

5. Be careful of cause and effect relationships in evaluating implemented actions. Exogenous factors sometimes have a significant effect on specific project or policy outcomes.

6. In evaluating implemented actions, it is important to consider a “total systems” approach since the traveling public cares most about the efficiency of their trip and not about which entity has jurisdictional (i.e., operational) responsibility. Service to the public is enhanced by utilizing performance measures that are customer based, as well as those needed by transportation professionals. However, inter-jurisdictional cooperation in a “total systems” planning approach can be most challenging to achieve.

7. Safety is typically the most difficult of all performance issues to evaluate, because of the random nature of crash locations and human behavior factors.

8. For more subjective performance measures, periodic stakeholder surveys can help to evaluate decision outcomes from the customer standpoint.

MANAGEMENT SYSTEM TOOLS

Management systems offer a host of tools to assist decision makers and transportation practitioners in the various components of the decision making process. The use of objective performance-based information in transportation decision making helps delineate the discreet components of the decision to be made so that each decision component can be debated independently and then considered along with other, more subjective components for an overall decision.

For this work, committee members interviewed decision makers with a strict “customer focus” adherence and looking for specific direction regarding what information from the management systems is most useful for improved decision making. The survey of tools presented in Table 1 is not intended to be exhaustive, nor is it claimed to represent the state-of-the-practice. Instead, it is intended to spotlight the very practical and typical issues which arise in transportation agencies when attempting to use transportation information in an integrated fashion to provide objective information to decision-makers at all levels of the organization.

CONCLUSIONS AND NEXT STEPS

Even though the ISTEA mandate for management systems has been rescinded, a resurgence of interest is apparent as transportation consumers and practitioners call for more accountability from transportation decision makers. In response, transportation agencies are continuing to improve their ability to analyze and monitor the transportation system’s performance and responses to differing actions in an effort to make the best use of limited resources. As agencies continue to gain experience with management systems, they have found ways to achieve the benefits of integrated objective information while learning to avoid excessive complexity. The case studies and findings of the Management System Integration Committee could be considered to be the lessons learned from the first generation of management system integration. Future efforts will undoubtedly be able to learn from these experiences and produce even better ways to present objective information to decision makers.

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TABLE 1 Application of Management System Tools

Tools	Long-Range Planning	STIP/TIP Development	Implementation Operations	Evaluation of Actions
Inventory	×	×		×
Performance				
Measures	×	×		×
Monitoring	×	×	×	×
State of the System Report	×			×
Identify Need	×	×		
Predictive Capabilities	×	×		
Project Selection Methods		×		
Prioritization Criteria		×		
“What-If” Analysis	×	×		
Design Tools and Standards			×	
Secondary Needs Identification			×	
Resource Allocation and Scheduling			×	
Traffic Management Systems			×	
Intelligent Transportation Systems			×	
Stakeholder Survey				×
Statistical Updating of Model Parameters				×