

A MANAGEMENT PERSPECTIVE ON DEVELOPING AND IMPLEMENTING SAFETY MANAGEMENT SYSTEMS

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ABSTRACT

The New York State Department of Transportation (NYSDOT) is in the process of implementing a safety management system (SMS). This paper describes several issues which must be addressed by management if an SMS is to be successfully deployed. The paper focuses on development issues such as early definition of system scope, use of goals to drive system objectives, and the importance of integrating safety management with an agency's other management systems. It presents an overview of the NYSDOT goal-driven safety management process, and shows how the emerging SMS builds upon existing technical tools and procedures. Lastly, the paper describes management issues which should be addressed during SMS implementation and operation. These issues include the benefits of staged implementation and early institutionalization, possible effects of system deployment on organizational harmony, and the importance of training staff in the use of the SMS.

INTRODUCTION AND PURPOSE

For over two decades, the Federal Highway Administration (FHWA) has successfully focused attention of highway safety officials on a systematic approach to identifying, analyzing and treating identified high accident locations. Through what came to be called the Highway Safety Improvement Program (HSIP), FHWA encouraged and assisted the states in developing the methodology and analytical tools necessary for conducting an empirical approach to treating identified accident locations. Highway agencies have, as a consequence, been able to pinpoint and describe accident locations, perform requisite analytical accident studies to determine the causes and appropriate treatment of accident problems, and evaluate the performance of safety programs, projects, and specific accident countermeasures.

No longer will a state highway agency be able to define its highway safety program solely in terms of the FHWA sponsored Highway Safety Improvement Program. The Intermodal Surface Transportation Efficiency Act of 1991 requires that state highway

agencies examine the way they do business from the perspective of management systems. State highway agencies will need to design and implement systematic approaches to accomplishing well defined goals as they relate to their pavement, bridge, congestion, Intermodal transportation, and highway safety responsibilities.

The purpose of this paper is to describe the work being done in the New York State Department of Transportation (NYSDOT) in developing a safety management system (SMS). The paper focuses on management issues which must be addressed prior to and during system development, the current NYSDOT goal-oriented approach to safety management, and issues to consider during system implementation and operation.

ISSUES TO CONSIDER IN SYSTEM DEVELOPMENT

A safety management system should assist decision makers in identifying opportunities, analyzing options, developing strategies, setting priorities, and implementing cost effective safety improvements. Development of a system to meet all these objectives is a very large undertaking. Highway agencies should not make the mistake of "biting off more than they can chew" and developing massive data intensive systems which will eventually fall under their own weight. Thus, one of the most important issues to address early in system development is defining the scope of the SMS.

Definition of a Management System

Management systems are often thought of as just the technical tools and procedures essential to a systematic attack on an interrelated set of problems. However, management has to consider a much broader definition of a management system; it must recognize that administrative problems impede success as surely as technical inadequacies. Thus, NYSDOT includes the administrative side along with the more traditional technical considerations in its definition of a safety management system. NYSDOT believes an effective management system makes clear the interdependence of the many organizational functions and activities that do

or could contribute to accomplishing a particular management priority. A good system promotes effective and efficient coordination of resources for a common goal. It makes explicit the following key elements of "common-ground". Defining what is to be managed:

- Setting measurable objectives;
- Defining major contributing functions;
- Assigning roles and responsibilities;
- Clarifying appropriate linkages between responsibilities and authority; and
- Establishing controls for implementation (1).

The Scope of the System

Scoping the development of an SMS begins with determining the focus of the agency in providing safe transportation to the motoring public. Some state highway agencies are responsible for the Highway Patrol and the Motor Vehicle Licensing and Registration function, in addition to the responsibility to operate, maintain, rehabilitate and reconstruct, the highway system. Therefore, in such an agency the scope of the SMS should encompass the 3 E's of Safety-Engineering, Enforcement, and Education. In these agencies, the system should address safety issues related to the roadway, the driver, and the vehicle. In an agency such as NYSDOT, where the responsibility of the highway agency is limited to the roadway, the scope of the system would primarily be limited to the Engineering function.

Another important requirement in determining the scope of the SMS is the early identification and definition of the products of the system. Different levels of management have different information requirements. Top managers are planning oriented, and the information required must be strategic in nature. Strategic information assists the executive in establishing policies to govern the acquisition, use, and disposition of resources to achieve organizational objectives, developing strategies, setting priorities, and initiating programs. Strategic information consists of highly aggregated data and is generally presented to executive management in summary reports. Examples of strategic information include the system wide trend in fatal accidents, or the number of high accident locations either Statewide or by Region.

Products needed by operating staff are much more specific and technical. Traffic engineers and analysts may need detailed reports on accident rates and severity by facility type, while designers may need information on accident type for a particular highway section. Thus, the SMS must be capable of supplying the information

required by the different levels and functional units within an organization. Determination of the exact nature of the system outputs and products is one of the most important tasks in defining the scope of an SMS or for that matter any management information system. For it is these outputs which determine the exact nature of the system inputs.

Data is a valuable corporate commodity. It is extremely expensive to collect and maintain. Thus data should only be collected if it is used in the safety decision-making process. The developer of the SMS should avoid the tendency to collect all information possibly collectable "just in case we may need it some day." Inputs are defined by output requirements. Understanding this is the key to successful scoping of a safety management system.

Process considerations in scoping are also critical to management. The processes selected must be within the agency's resources and must be compatible with the agency's other policies and procedures. Processes use resources, mainly people and money. Management has to be sure the scope of the processes will and can be borne by the agency. Otherwise the scope must be changed until the planned processes and commitments match.

Use of Goals to Drive System Objectives

The FHWA recently issued a memo describing good practices in implementing a management approach to highway safety (2). This compilation lists the establishment of safety goals within an agency as a key element. Clearly, definition of a safety goal, and use of goals to drive system objectives are issues which must be addressed during SMS development. There are several issues important to the goal setting process.

First, since safety is a consideration in much of what a highway agency does, the identification of a safety management goal will require the approval of top management. In addition, it requires the proactive involvement and cooperation of middle managers from other functional areas. This approach not only offers opportunities to improve the goal, but more importantly, it also begins the process of getting managers throughout the agency to understand and eventually to buy into the goal.

Second, the goal must be simply and clearly defined such that it is understood by agency personnel. Furthermore, the goal must be S-M-A-R-T - specific, measurable, achievable, relevant, and timely.

Third, it is important that economic efficiencies be part of a highway agency's safety goal. Management

needs this information in order to define, compare, and select from among a number of competing agency program and project actions. For example, should the agency engage in a program to upgrade all of its guiderail to standards, or should it focus its attentions on sign maintenance or replacement. In a climate of limited resources and competing needs, management needs to know the costs and benefits of alternative uses of those resources.

Lastly, a safety management system goal must include a measure of effectiveness. The measure of effectiveness should be defined in terms of the ultimate goal of the management system, e.g., accidents reduced or accident locations addressed/treated. By incorporating a measure of effectiveness into the agency's safety goal statement, the goal becomes more than a simple statement of good intentions. Since the agency's highway safety performance will be measured against it, agency decision makers will be strongly encouraged to address safety issues as part of the decision-making process.

Integration with Other Management Systems

Another issue which should be considered in the development of an SMS is the integration of safety management with other management systems. To a systems analyst the phrase "integration with other systems" means the development of computerized linkages which allow for the transfer of information between two or more data sets. Compatibility of data systems is certainly an important and difficult technical issue which must be addressed during SMS design. Care must be taken throughout the design phase to assure linkages with other management system inventories, both existing and planned. To management, however, the phrase means more than just computer linkages; integration means the development of policies and procedures to assure different programs are coordinated in order to promote effective and efficient deployment of resources to achieve the agencies' mission. For instance, all systems that perform economic analyses of project proposals should be bound to the same policy premises. Thus, all benefit-cost work should use the same discount rate for invested funds, the same values for motorist delays, and so on. Additionally, if lowest life cycle cost is a corporate investment policy, then all systems' procedures should be able to provide such assessments.

Unfortunately, highway agencies do not live in a universe of unlimited resources. Executive management is continually faced with difficult decisions on allocating funds among competing programs. Certainly, in order to

get a fair share, outputs of an SMS must clearly show the benefits of implementing safety improvements. However, if opportunities to improve safety are to be fully realized, safety issues must be considered in the development of all programs within an agency, in particular, the pavement, bridge, and capacity programs. Thus, communications with all relevant functional areas are a must during SMS design. Functional barriers, created by history and sustained by rivalry and assumed incompatibility, must be replaced with trust and mutual respect for competing concerns and goals.

At NYSDOT, good progress has been made in breaking down organizational barriers and coordinating the Department's infrastructure programs. The Department's Goal Oriented Capital Programming (GOCP) process has enabled functional groups representing various interests to better explain their needs, establish goals to address their needs, and define measures of effectiveness to determine how well they are doing. This process was developed to foster the recognition and balancing of legitimate competing needs, and by doing so has helped to reduce the tendency toward compartmentalization into insulated functional areas. The GOCP process as well as examples of how NYSDOT has integrated different programs are described later in this paper.

Recognition of the Agency's Organizational Structure

Successful deployment of a safety management system requires the system be tailored to an agency's organizational structure, at least during initial stages of implementation. Introduction of an SMS, or for that matter any management system, will cause a change in the way an organization does business. This change should be slow enough to allow all functional groups involved to buy into the new processes and systems. Thus the developers of an SMS should consider the agency's existing decision-making culture and shape the architecture of the system around this environment. This will increase the chance that the system will be immediately embraced by agency management and serve as an integral role in the safety decision-making process.

In addition, an organization's existing technical tools, systems, and procedures must be considered during SMS design. It is much easier and economically doable to build upon technologies and administrative processes already indigenous to a highway agency, than to start from scratch. The NYSDOT approach to developing an SMS follows this direction.

THE NYSDOT APPROACH TO SAFETY MANAGEMENT

The New York State Department of Transportation is a large organization responsible for managing a complex 15,000 mile highway system which accommodates over 50 billion vehicle miles of travel annually. The Department consists of a central office called the Main Office, and eleven regional offices which are geographically located throughout the State. The Department functions in a decentralized decision-making environment, where safety programs are developed in the regional offices based on policy guidance, goals, and allocations from the Main Office. Accountability of the regional offices is assured through the Department's unique Goal-Oriented Capital Programming Process.

The Goal-Oriented Capital Programming Process

The NYSDOT Goal-Oriented Capital Programming Process is a method to manage a capital program through establishing goals, setting clear, measurable objectives and then measuring program performance in the attainment of those goals and objectives. It is the extension of goal-oriented, or strategic management into the development and management of a capital program. The process creates the focus needed to sharpen the decision making involved in developing and carrying out a capital program (3).

The NYSDOT's capital program is a five-year plan of highway, bridge, and related transportation projects annually incorporated into the State Executive Budget. It is a rolling plan, updated as new needs are identified, old needs are met, and funding sources change. The product of the GOCP process is a capital program that explicitly balances needs, priorities and resources. The Goal-Oriented Capital Programming process serves as the framework for the Department's SMS. The Department's traditional Highway Safety Improvement Program functions within this framework.

The Department's HSIP

The Highway Safety Improvement Program has been at the center of the Federal Highway Administration's endeavors to improve state highway safety programs. The HSIP provides a comprehensive and systematic approach to improving highway safety through the identification of high accident locations, the treatment of those locations with proven cost effective accident

countermeasures, and the evaluation of safety projects and programs with the goal of improving project/program performance. In New York State, the HSIP has evolved over the years into a very sophisticated set of technical tools used extensively by each regional office in safety program development. The Department's SMS builds upon this highly successful system, and expands the traditional steps in the process to include both the use of safety goals to guide program development, and an integration process to assure coordination of safety management with the outputs from the Department's other infrastructure management systems.

Overview of the NYSDOT Safety Management System

The SMS being developed in New York State is tailored to the Department's decentralized decision-making environment. The system design builds upon existing analytical tools and methodology, and assures accountability through the goal-setting and the monitoring of performance of the eleven regional offices. Care is being taken during system development to encourage other functional groups, in particular those responsible for pavement and bridge management, to influence SMS design so they too may benefit from system deployment.

Figure 1 presents a macro flowchart of the emerging NYSDOT SMS. The solid process boxes indicate the steps in the traditional HSIP while the dashed lines represent enhancements added by NYSDOT as part of the Goal-Oriented Capital Programming Process. Each step in the NYSDOT safety management system is described as follows (4):

Problem Identification (HSIP)

In cooperation with the State Police, local police agencies, and the New York State Department of Motor Vehicles, NYSDOT operates accident surveillance systems which use recorded accident histories to pinpoint suspect locations with statistically high accident rates. The State Accident Surveillance System (SASS) identifies such locations on the 15,000 miles of State highways, while the Centralized Local Accident Surveillance System (CLASS) informs local highway agencies of problem locations on the 95,000 miles of non-State highways. Data from SASS is used in the establishment of the Department's safety goal.

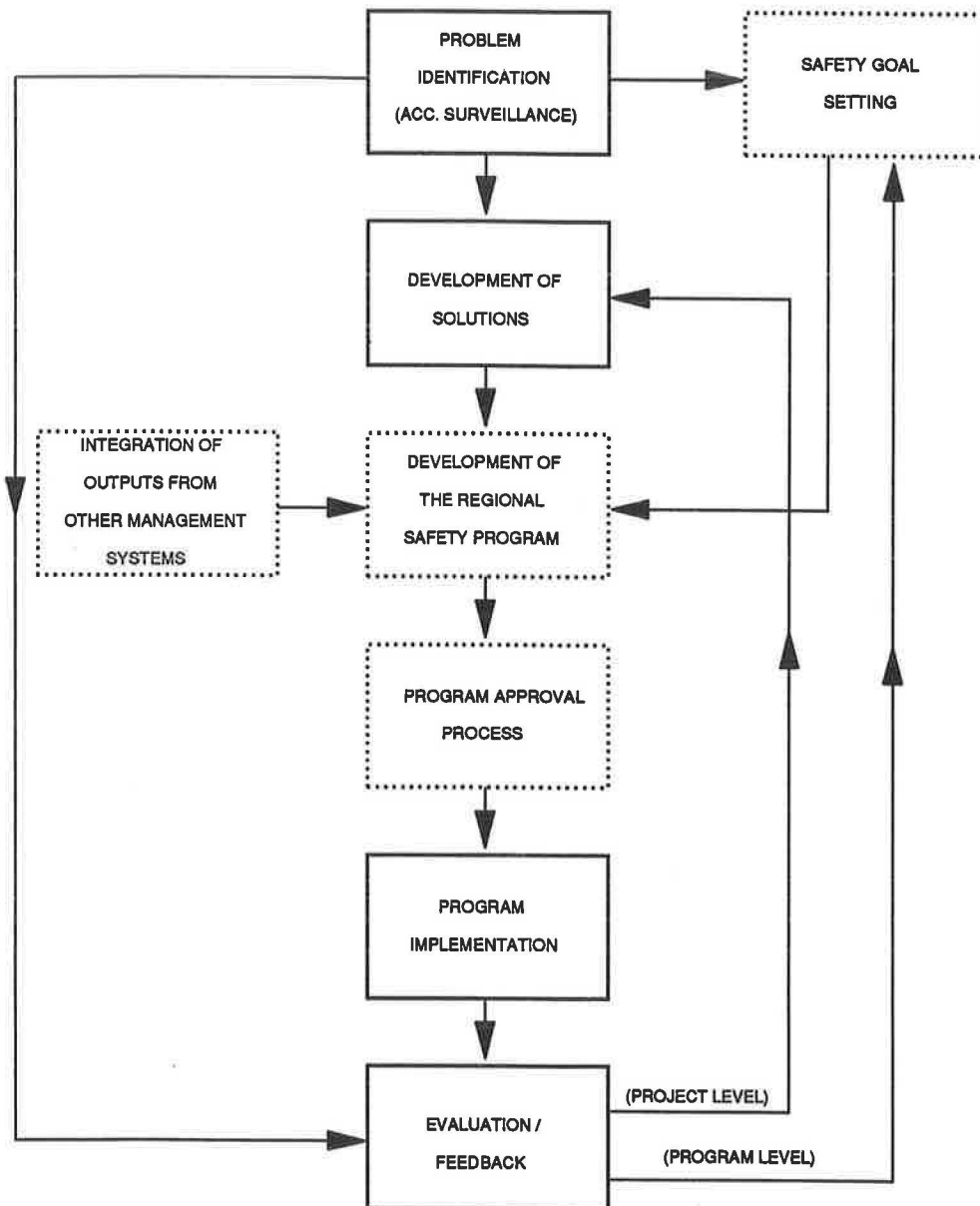


FIGURE 1 Macro flowchart of the NYSDOT Safety Management System.

Development of Solutions (HSIP)

Solutions to identified accident problems are developed by researchers, traffic engineers, designers, transportation analysts, and technicians in accordance with systematic safety investigation procedures. Solutions may range from low-cost measures such as signing or simple striping to larger capital projects. Safety improvement projects usually tend to be of smaller scale than the Department's typical capital project, allowing

more projects per dollar than other construction program projects.

Implementation of Solutions (HSIP)

Small scale safety improvements are usually implemented by agency maintenance forces. Large scale capital projects are let to private contractors. Federal and State funds are used to finance capital projects with

the Federal Title II Program historically the most helpful.

Evaluation of Solutions (HSIP)

It is absolutely essential that an SMS contain an aggressive evaluation function. Evaluation data is the primary source of feedback used to both gauge project performance and to guide future program development. In NYSDOT, evaluations are performed at two levels, project-level and the program level.

Project-level evaluations are performed by the Department's Post Implementation Evaluation System (PIES), a computerized system used to assess the effectiveness of specific safety treatments. Data from PIES provides feedback to the "development of solutions" element of the HSIP, in particular the selection of the most cost-effective accident countermeasure.

Program-level evaluations are performed by the State Accident Surveillance System. Data from SASS is used to monitor the effectiveness of safety program implementation and to provide feedback to the annual safety goal-setting activity.

Safety Goal Setting (GOCP)

Goal-setting is at the heart of the Department's capital program development process. Goals are used to underscore priorities and as such guide the regional safety program development. Goal-setting at the Statewide level, starts with consideration of:

- The Department's mission;
- The State's transportation requirements;
- Anticipated resource levels; and
- The existing and historical condition of the transportation system and past funding levels in support of each element of the system (5).

Staff from the Department's Office of Planning and Program Management annually evaluate these considerations and develop tentative statewide goals for pavement and bridge condition, safety, and capacity for review by Executive Management. Based on this review, Executive Management establishes statewide program emphasis, sets statewide goals, and provides each region with their tentative requirements. Since a goal must be S-M-A-R-T, each region has an opportunity to negotiate with Executive Management prior to the adoption of the final goal statement.

Safety goals are supplied to the regions during the early fall for use in updating the five-year GOCP. The goal instruction package consists of a goal statement, measures of performance, and project selection criteria. Typically, the Department's safety goal addresses a reduction in the number of high accident locations as identified by the HSIP.

Development of the Regional Safety Program

Each year, the State Accident Surveillance System is used to generate lists containing problem locations ranked in order of descending priority. The ranking algorithm is based on a "reduction index", a function of the accident rate in excess of the average statewide rate for the particular highway or intersection type. These locations are analyzed and treatments selected based on cost-effectiveness. It is important to note that the number of sections proposed for treatment always exceeds the available resources. It is the duty of the Regional Traffic Engineers to work within an allocation and develop the most cost-effective program of projects which best meets the safety goal. Once developed, the project lists are submitted to each Regional Capital Programming Committee, a formal committee chaired by the Regional Director, and consisting of all major regional functional group managers. This committee provides a forum for safety to influence other program areas, and vice versa. It is the responsibility of the Regional Director to weigh all the information, to make tradeoffs, and to decide upon the five-year program of projects to submit to the Main Office for review and approval.

Program Approval Process

This activity involves the Main Office review of the regional update of the five-year program. All programs (pavements, bridges, safety, and capacity) are reviewed annually to assure compliance with the program emphasis and goals established by Executive Management. The safety programs are detailed in descriptive materials prepared by each region. These materials consist of project lists, rationale used in, and any tradeoffs made in arriving at program choices, and summary statistics showing planned work accomplishments and forecasts of program impacts on safety.

Each program is evaluated against pre-established program criteria. The evaluation is performed by staff level representatives from several functional groups

within the Main Office. During this phase, the regions are kept informed of any concerns, in particular, shortcomings in goal attainment. Based on these concerns, the programs may be revised by the regions and resubmitted or the regions may choose not to revise the programs to reflect the concerns raised during the staff review.

Each Regional Director is then invited to make a formal presentation (and defense) of the proposed program before a special committee consisting of Executive Management and chaired by the Commissioner of Transportation. Unresolved concerns raised during the staff review must be addressed by the Regional Director at this time. The presentation results in program approval, or conditional approval which means that while the committee is in substantial agreement with the proposal, some minor issues still require discussion and resolution. After negotiations, final approval is obtained and implementation of the first year element of the five-year program commences.

Integration of Outputs from Other Management Systems

Traditionally, highway agencies have used their accident surveillance and evaluation systems to assess the effectiveness of accident countermeasures and apply that information to assist management in establishing cost-effectiveness options for treating accident problems as part of safety projects/programs. Managers of safety programs were generally unaware of any opportunities an SMS might present for accomplishing safety objectives in other than safety specific projects or actions pursued under their own direction. The NYSDOT capital programming process has begun to change the tendency to narrowly pursue functional responsibilities. The Department's mission statement explicitly cites safety as a priority and by encouraging agency functional managers to set goals to meet the Department's mission, it is becoming apparent that safety is considered in most, if not all Department activities.

This reality has manifested itself in the development of the Department's Safer Infrastructure Program (SIP) which has won a safety award from the FHWA. The objective of the SIP which consists of two elements is to integrate safety management with the outputs of the Department's pavement and bridge management systems. The first element called SAFEPAVE is based on safety evaluation findings which suggest that a simple resurfacing with high friction asphalt will reduce wet weather accidents by 50 percent at locations where wet

weather accident rates are significantly above the mean. Locations identified as candidates for simple resurfacing by the pavement management system are now matched to the high wet weather accident locations and project lists are developed which address both considerations.

The second element addresses bridge decks experiencing high proportions of snow/ice accidents. Safety evaluations have determined that overlaying these decks with Verglimit (C_aC_{12}), a permanent deicing material, will result in statistically significant reductions in snow/ice accidents. As with SAFEPAVE, bridges which are candidates for deck resurfacing are output from the Department's bridge management system and matched to the output of the SMS. Thus two functional areas benefit from the same set of projects.

ISSUES TO CONSIDER IN SYSTEM IMPLEMENTATION

A safety management system is the umbrella under which a highway agency will make important decisions regarding the safe operation of their highway network. Thus, implementation will involve staff from several functional groups and will cause a change in the way they do business. As previously mentioned, this change should be slow enough to allow staff to buy into the new technical tools and processes. However, at the same time, top management will want to see an immediate return on their investment. Successful development and operation of an SMS requires attention be paid to both of these concerns.

Staged Implementation

At NYSDOT, infrastructure and other management systems are being implemented in three stages - crawl, walk, and run. Throughout each stage, staff are kept informed of progress by the use of several media including presentations, newsletters, and bulletins. Potential users are encouraged to participate and offer suggestions to assist in system deployment. Communications with all relevant program areas must be maintained and nurtured to alleviate fears associated with organizational change.

Staging the implementation of an SMS will also permit the development of early products. Since the development and full scale implementation of an SMS may take several years, executive management may become concerned that they are pouring money into a

bottomless pit. It is important to recognize that successful operation of an SMS requires continued support of top management. Showing that the system provides early benefit to the organization will increase the chance of this continued commitment.

Institutionalization

The sooner an SMS is institutionalized the greater the likelihood of success. The decisions made using an SMS should be different (and better) than the decisions made before the system was implemented. Otherwise, executive management will question the reasons for committing time and resources to developing and implementing the system in the first place. Executive management must be convinced that a safety management system has become an integral part of the day-to-day operations of line decision-makers in the highway agency. The provisions, operating assumptions, and outputs of the safety management system should be understood and accepted as credible by both management and the agency's "in-house safety experts". Otherwise, confidence in the system will be lost. Furthermore, the operation of a safety management system cannot be confined to a small separate unit in one corner of the organization. Nor can it depend upon the knowledge and experience of one "highway safety manager", or the existence of a champion in executive management for its survival. Not only will the safety management system supporter's influence be limited, but someday that one person will leave and the SMS will be without critically needed support.

Organizational Harmony

Just as implementation of a safety management system may be perceived as a threat to some, it may be perceived as an opportunity to others. Unfortunately, implementation may even lead to "turf battles" within an organization. The highway safety related functional units may see a safety management system as an opportunity to increase their influence within the highway agency's decision-making process at the expense of other functional areas of the agency. On the other hand, other functional units may believe that the accomplishment of their goals are threatened by the infringement of safety management initiatives into "their territory". Thus, care should be taken throughout system implementation to maintain an atmosphere of cooperation and mutual respect among affected functional areas.

In NYSDOT, ongoing coordination in implementing emerging management systems has been assigned to one functional group. In this role, the Division of Strategic Planning and Management Systems acts as an arbitrator and sometimes referee in resolving any real or perceived organizational conflicts which may come about during systems deployment and operations. One of the objectives of the coordination function is to assure the interests of the agency are held above the interests of specific program areas.

Training

Formalized training is essential to the successful implementation of any new system. Training must be provided to all users of the system as well as to the first line and middle managers who must support the system on a daily basis. Many of the fears associated with organization change are allayed once affected staff are trained in the new procedures and technical tools. Training should also reinforce the fact that a safety management system is not a black box and that it should serve as a decision support system. Finally, training should stress the fact that outputs from an SMS should not be used to usurp engineering expertise, but rather to complement and enhance the decision-making process for the good of the organization.

SUMMARY

A safety management system is more than just a set of technical tools. Its scope must extend beyond the traditional Highway Safety Improvement Program. An SMS involves the establishment of goals and the implementation of policies and actions which will help to achieve those goals. System outputs must assist Executive Management in making program choices in an environment of limited resources and competing demands for those resources. Policies which govern the system must also seek out opportunities to gain safety objectives by influencing project selection and design under other agency management systems.

Deployment of an SMS will cause a change in the way a state highway agency does business. Therefore, successful development and implementation requires attention be paid to issues which affect organizational harmony. And importantly, the operations of a safety management system requires continued support and commitment by top-level management. Every effort should be taken throughout development and implementation to assure this support.

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