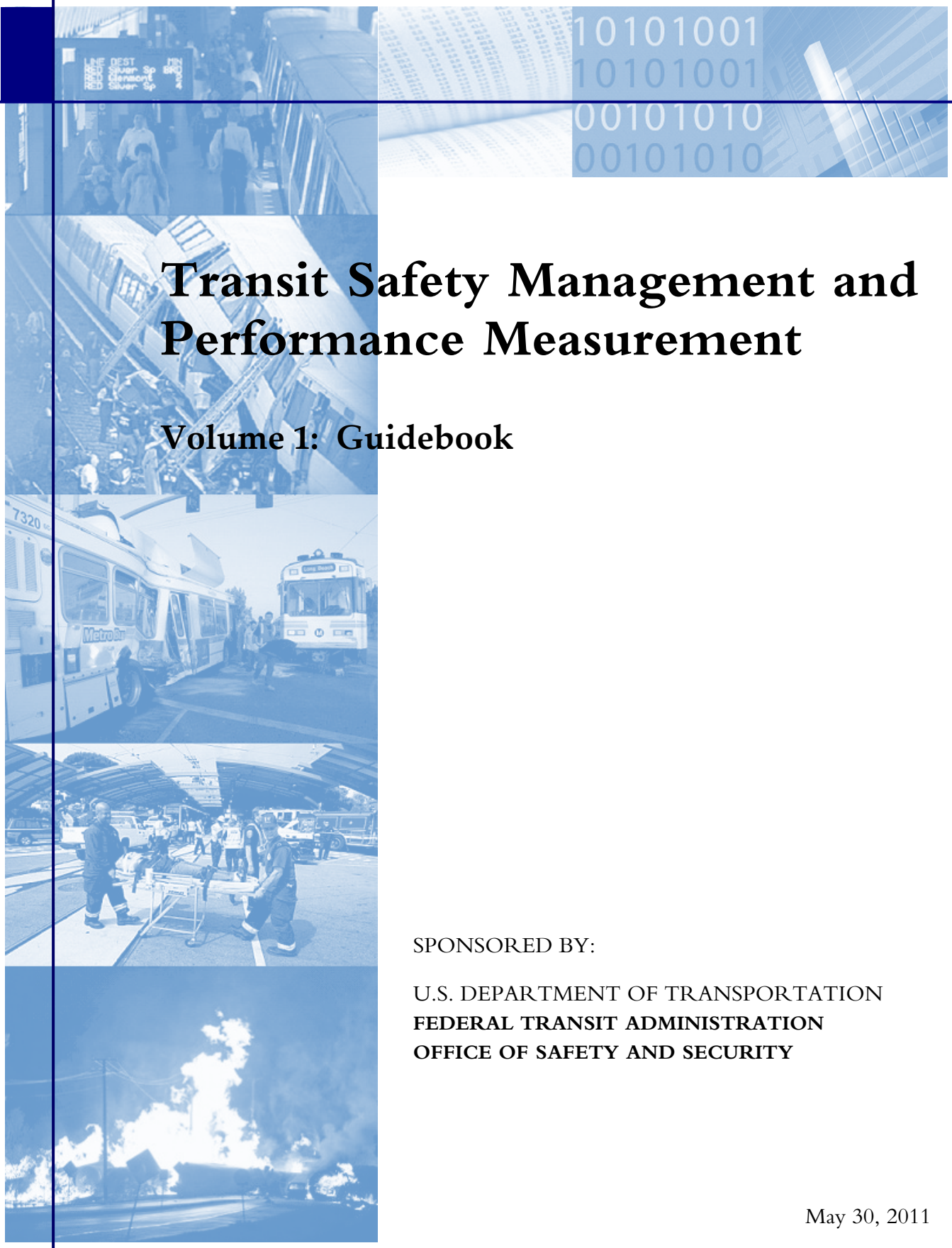

Transit Safety Management and Performance Measurement

Volume 1: Guidebook

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FEDERAL TRANSIT ADMINISTRATION
OFFICE OF SAFETY AND SECURITY

May 30, 2011

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Volume 1: Guidebook

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This guidebook was prepared with the objective of providing resource information for transit agencies and the FTA regarding the development and implementation of Safety Management Systems (SMS) and Safety Performance Measurement Systems (SPMS). SMS offer the most promising means of preventing public transportation accidents by integrating safety into all aspects of a transit system's activities, from planning to design to construction to operations to maintenance. Safety management is based on the fact that there will always be hazards and risks in public transportation. Therefore, systematic and proactive management is needed to identify and control these risks before they lead to mishaps. Transitioning to safety management will require a cultural transformation on the part of both the transit industry and FTA. Performance measurement is a key component of safety management. Measurement brings clarity to vague concepts, helps transit agencies identify gaps in safety performance, and forces management and governing boards to take action to improve performance.

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Table of Contents

List of Figures

List of Tables

Executive Summary

Transit ridership continued its 5-year record increase reaching 10.7 billion trips in 2008, the highest level of ridership in 52 years. Meanwhile, the public transportation fatality rate, expressed in fatalities per 100 million passenger-miles, has leveled-off in recent years. Therefore the statistical reality is that as the industry grows and the passenger-miles increase, the total numbers of fatalities and serious accidents will also increase. While the current rates of fatalities and accidents are low compared to other modes of surface transportation, any appreciable increase in the number of fatalities would be detrimental to an industry that for years has prided itself on its safety record. To avoid this situation, the transit industry needs to reduce the current low accident and fatality rates even further.

It is widely accepted that most public transportation accidents result from a combination of human, technical and organizational factors. Recent research and in-depth accident investigation reports suggest that most of the links in an accident chain are under the control of the organization, and accidents can best be prevented when the underlying causal factors are addressed at the organizational or system level. Human errors and technical failures are symptoms of the lack of organizational focus, accountability and communications. Addressing the root causes of public transportation accidents has become especially urgent in light of the recent high-profile rail transit accidents.

This guidebook was prepared with the objective of providing resource information for transit agencies and the FTA regarding the development and implementation of Safety Management Systems (SMS) and Safety Performance Measurement Systems (SPMS). SMS offer the most promising means of preventing public transportation accidents by integrating safety into all aspects of a transit system's activities, from planning to design to construction to operations to maintenance. SMS build on the four elements identified in the "System Safety Program Requirements" [53], which has its origins in the defense and space industries:

- A planned approach to system safety program tasks;
- Qualified personnel to accomplish the tasks;
- Authority to implement the tasks through all levels of management; and
- Appropriate financial and personnel resources to accomplish the tasks.

Safety management is based on the fact that safety is not an absolute condition -- there will always be hazards and risks in public transportation. Therefore, systematic and proactive management is needed to identify and control these risks before they lead to mishaps. Small problems should be fixed before they turn into major ones. Isolated incidents should be investigated to see if they are systemic. When accidents occur, the lessons learned should be documented and actions should be taken to prevent similar accidents from occurring. Safety should become a common theme permeating the organization, and affecting all individuals working there.

In the most basic form, safety management involves:

- Defining clear levels of responsibility and accountability for safety within the organization;
- Setting safety performance goals and actively pursuing them;
- Reporting and analyzing hazards, incidents and accidents and taking corrective actions to prevent their recurrence;
- Managing safety risks systematically and proactively, including learning and continuous improvement;
- Developing a workforce that is knowledgeable, flexible, dedicated, and efficient; and
- Monitoring and evaluating safety performance towards established goals.

Transitioning to safety management will require a cultural transformation on the part of both the transit industry and FTA in adopting a proactive management approach for delivering on safety objectives and continuously improving public transportation safety. Safety management requires developing and sustaining a strong safety culture where the following practices and behaviors become 'the way we do business around here' at each transit property:

- Management is accountable and responsible for safety;
- Everyone in the organization takes an active role in safety;
- Open communications and discussions of safety hazards and risks are encouraged;
- Safety hazards and close-calls are reported;
- Risk management continues despite everything looking safe;
- Human errors and unsafe acts are treated as symptoms of organizational problems;
- Safety redundancies are introduced to ensure resiliency to unplanned events;
- Investment in safety is made even in times of financial constraint;

- Industry, oversight agencies and FTA work together to make the system safer;
- Practices and procedures are regularly reviewed and improved;
- Activities and decisions are risk-based;
- Safety data are analyzed to identify systemic causes;
- Investment is made in proactive activities;
- The safety office is a proactive partner to the other departments;
- Safety performance is measured;
- Safe practices, continuous learning and improvement are the norm, even during times of financial problems and labor pressure;
- Safety information is shared;
- The safety management system is audited; and
- Safety information is shared internally and externally

In addition to developing and sustaining a safety culture, SMS has the potential of bringing other benefits. Many organizations have already adopted SMS and realized benefits such as:

- Increased direct and indirect cost savings due to accident/loss prevention and reduction in insurance premiums;
- Increased competitive business advantage through a marketable record of safe operations;
- Logical prioritization of safety needs based on the level of risk involved;
- Continuous improvement of operational and maintenance processes;
- Demonstrated due diligence when accidents occur;
- Improved communications and employee morale;
- Enhanced relationships and partnerships with other transit properties as a result of collaboration and information sharing; and
- Increased collaboration between stakeholders on safety initiatives to mitigate risk, especially in emergency preparedness activities.

Performance measurement is a key component of safety management. Measurement brings clarity to vague concepts, helps transit agencies identify gaps in safety performance, and forces management and governing boards to take action to improve performance.

The process of building and sustaining a successful SPMS is iterative, and involves a sequence of ten steps:

1. Getting started -- conducting a readiness assessment;
2. Agreeing on outcomes & activities to monitor;
3. Selecting key metrics;

4. Identifying data needs;
5. Pilot testing and collecting baseline data on metrics;
6. Setting targets;
7. Monitoring performance and evaluating results;
8. Reporting findings;
9. Integrating findings into agency decision-making; and
10. Sustaining the performance measurement system.

Performance measures should be developed in consultation with the key stakeholders including transit agency's management, staff, customers, governing body, service contractors, and oversight organizations. Acceptance by these stakeholders is critical to the long term viability and success of the performance measurement program.

SPMS developers should be encouraged to shift their focus from output/process measures to outcome measures that focus on safety goals and long-term impacts. Performance targets should be realistic but, wherever feasible, should encourage progress beyond historical performance levels.

Sustained support and commitment of senior management are essential for the SPM effort to take hold and become a vehicle for continuous safety improvement. Senior managers should be actively engaged in creating a measurement-friendly culture by promoting performance measurement as a means of continuous improvement and using the resources and other tools at their disposal to accomplish such culture change. In addition, senior managers should set a personal role model by utilizing performance metrics in decision-making. When top managers insist on receiving and using performance indicators, and when the word is spread throughout the organization, attitudes change rapidly.

Investment in developing skilled human resources capacity is essential to sustaining the SPMS initiative. Both technical and managerial skills will be needed for data collection and analysis, and setting goals. Investment in modern data systems and analysis tools will also be required to ensure the long-term success of SPMS. The governing board and senior management must commit the financial resources required for building organizational capacity and maintaining the SPMS on a continuous basis.

The SPMS should be able to produce and report the true story -- both good and bad news. Performance information should be transparent, made available to all stakeholders, and be subject to independent verification. Messengers should be protected to preserve the integrity of the measurement system. The focus should be on opportunities for improvement rather than allocating blame.

There is little value in even the best-designed performance metrics unless they are used systematically to inform decision-making and drive safety improvement. Once the SPMS is in place, performance results should be evaluated carefully to gain insight into the success of past efforts and develop ideas for improving future performance.

Visible commitment to using metrics even when targets are exceeded reaffirms the message that performance measurement is a long-term initiative as opposed to an episodic effort for a short period. One way of demonstrating commitment to performance measurement is to institute a formal process of reporting performance results. Another useful strategy is to have safety performance as a standing item on the agenda of executive meetings and staff meetings.

Acknowledging and rewarding employees who use performance results to learn and improve safety is important to sustaining the SPMS effort. This can be done through a variety of cost-effective methods.

Separating the impacts of the transit agency's activities from those of external factors beyond the agency's control can be complex and challenging. For example, collisions involving a bus are influenced by many factors besides the actions of the bus driver. The impacts of weather, risky behaviors of pedestrians and other vehicle drivers should be understood and accounted for in evaluating the agency's safety performance. In reporting performance results, it is important to explain any limitations of the performance evaluation process and caution the audience about interpreting the results in ways that may not be valid.

Recommendations

Following are recommendations regarding transit safety management systems, safety performance measurement, workforce development, safety data, and future research. Implementing these recommendations presents a variety of challenges to the transit industry and FTA, and one should not underestimate the difficulties involved. Yet, the effort required to bring about fundamental cultural changes is not only well-justified by the significant safety benefits that can be realized, but is in fact necessary to enable the transit industry to adapt and grow with current and future changes and challenges.

Recommendations Regarding Safety Management Systems

1. Ensure that transit properties develop and implement safety management systems.
2. Develop and sustain a positive safety culture.

3. Promote practicing risk management in all activitiesDemonstrate the feasibility of a Confidential Close Call Reporting System.

Recommendations Regarding Safety Performance Measurement

1. Promote the adoption of standard terminology and uniform safety performance metrics in the public transportation industry.
2. Advocate the need for clearly articulated safety goals and accountability for safety performance.
3. Ensure that transit properties consistently measure and analyze safety performance.
4. Encourage transit properties to consistently analyze and report performance trends and gaps.

Recommendations Regarding Transit Workforce Development

1. Implement findings of the 2007 international Transit Studies Program "Innovative Practices in Transit Workforce Development".
2. Encourage partnerships between transit industry and educational institutions to develop and offer curricula for certification and degree programs for transit-based occupations.
3. Establish transit-based occupational standards at the national level.
4. Executive and management training.
5. Web-based distribution of materials related to safety management and safety performance measurement including reports, presentations, and best practices.
6. FTA, in collaboration with APTA and other stakeholders, should plan and implement conferences and meetings specifically oriented to exchange of information about safety management and safety performance measurement.

Recommendations Regarding Transit Safety Data

1. Identify gaps and establish quality standards for safety data.

Recommendations Regarding Future Research

1. Produce a synthesis of best practices in developing and implementing safety management systems and safety performance measurement systems in the transportation industries.
2. Develop a central clearinghouse for public transportation safety risk mitigation techniques by mode.

CHAPTER 1

Introduction

1.1 Background

The U.S. transit industry has achieved a remarkably high level of safety compared to other modes of surface transportation. According to the National Safety Council, passengers on the nation's bus, rail, or commuter rail systems are 40 times less likely to be involved in a fatal accident, and 10 times less likely to be involved in an accident resulting in injury compared to traveling by automobile [3]. Sustaining this successful safety record will prove challenging as the number of people using transit increases. The American Public Transportation Association reported that transit ridership continued its 5-year record increase reaching 10.7 billion trips in 2008, the highest level of ridership in 52 years. Yet, the fatality rate, expressed in fatalities per 100 million passenger-miles, has leveled-off in recent years. Without reducing the current low fatality and accident rates even further, the statistical reality is that as the industry grows and the passenger-miles increase, the total numbers of fatalities and serious accidents will also increase. Any appreciable increase in the number of fatalities would be detrimental to an industry that for years has prided itself on its safety record.

Without reducing the current low fatality and accident rates even further, the statistical reality is that as the industry grows and the passenger-miles increase, the total numbers of fatalities and serious accidents will also increase.

There is a growing concern that the traditional approach of *reacting* to accidents by prescribing measures to prevent recurrence may no longer be sufficient for sustaining and improving public transportation safety. The need for a new approach to addressing public transportation safety has become especially urgent in light of the several, recent high-profile rail transit accidents. Modern safety management practices that *systematically* and *proactively* identify the factors that contribute to unsafe events and prevent or minimize the likelihood of their occurrence have proven effective in addressing similar concerns in other transportation industries. Such practices call for setting safety goals and objectives, defining clear levels of accountability and responsibility for safety, establishing proactive approach to managing risks and hazards in the day-to-day activities, risk-based resource allocation, monitoring and evaluating performance towards goals, and continuous learning and improvement. To that end, the FTA in partnership with the transit industry is working to promote the adoption of safety management concepts and transform the safety culture within the industry in order to make progress on the safety objectives.

Figure 1.1 illustrates the framework for modern safety performance management. It begins with setting clear goals and objectives for system safety and formulating a safety policy. Next is establishing programs for identifying and reporting hazards, and managing risks in the day-to-day activities. The third step is developing and implementing effective strategies to eliminate hazards and control risks to an acceptable level. Performance measurement and evaluation, step 4, involves constructing performance metrics to measure progress, setting targets that reflect the safety objectives, collecting reliable performance data, identifying performance gaps and trends, evaluating program effectiveness, and communicating performance results to the stakeholders. Finally, step 5 deals with integrating performance results into the decision-making process, allocating the needed resources for closing the gaps in safety performance, and investing in proactive activities.

Figure 1.1 Safety Performance Management Framework

SMS does not involve imposing an additional layer of regulations on transit agencies.

Safety performance management has much in common with quality management in that they both require planning, performance monitoring, communication, and the participation of all stakeholders. Its implementation does *not* involve imposing an *additional* layer of regulations on transit agencies. Rather, it is an organizational shift that is seamlessly integrated into the routine day-to-day operations. The good news for transit agencies is that many of the procedures and practices they have been using to comply with the current regulations and requirements (e.g., SSPP, DAMIS, 49 CFR

Part 659) will serve as a basis for establishing safety performance management systems.

1.2 Need for Safety Management Systems

It is now widely recognized that the underlying causal factors of most accidents can be attributed to human or organizational issues, and that organizations are best positioned to control those factors that are known to lead to accidents. But the question is how? Safety Management Systems (SMS) offer the most effective means of preventing public transportation accidents by integrating safety into all aspects of a transit system's activities, from planning to design to construction to operations to maintenance. SMS build on the four elements identified in the "System Safety Program Requirements" [53], which has its origins in the defense and space industries:

- A planned approach to system safety program tasks;
- Qualified personnel to accomplish the tasks;
- Authority to implement the tasks through all levels of management; and
- Appropriate financial and personnel resources to accomplish the tasks.

"A safety management system necessitates a cultural change in an organization so that the safety of operations is the objective behind every action and decision by those who oversee procedures and those who carry them out." -- Mark Rosenker, Chairman of the NTSB

The transportation safety literature differentiates between safety programs and safety management systems as follows:

- A ***safety program*** is an integrated set of activities and regulations aimed at improving safety.
- A ***safety management system (SMS)*** is an organized approach to managing safety, including the necessary organizational structures, safety goals and performance targets, responsibilities and authorities, accountabilities, policies, and procedures fork for integrating safety into day-to-day operations.

An effective SMS has three defining pillars: 1) a ***comprehensive corporate approach to safety*** that sets the tone for the management of safety, embraces the organization's safety goals, objectives and policies, and, most importantly, senior management's commitment to safety, 2) ***effective organizational structure and tools*** to deliver the necessary activities and processes to advance safety, and 3) a formal system for ***safety assurance*** to provide feedback and confirm the organization's continuing fulfillment of its safety goals, objectives, policy, and standards.

Safety management is based on the fact that safety is not an absolute condition -- there will always be hazards and risks in public transportation. Therefore, systematic and proactive management is needed to identify and control these risks before they lead to mishaps. An SMS establishes processes to identify hazards, improve communication about their risks, and take action to mitigate these risks. In addition, an SMS calls for a systems

approach to addressing safety where every aspect of the organization must become part of a safety culture that promotes and practices risk reduction.

SMS spreads responsibility for safe operations throughout all levels and segments of the organization.

Because SMS spreads responsibility for safe operations throughout all levels and segments of the organization, the number of people watching for safety increases, making it less likely for a hazard to go undetected and possibly lead to an accident. This is depicted in Figure 1.1, where each "slice" represents a different segment or layer of the organization. In this figure, a hypothetical transit agency is represented by four segments: facilities, operations, maintenance, and management. Each slice has holes that symbolize individual weaknesses in that layer of the system and the potential for a safety hazard to go unnoticed because the layer does not deal with that type of hazard, or due to human error. However, when these layers are unified by an SMS, it becomes less likely that a hazard makes it through all the layers without being identified and mitigated. In the real world, each SMS implementation will have its own customized set of layers that define the particular transit property under consideration.

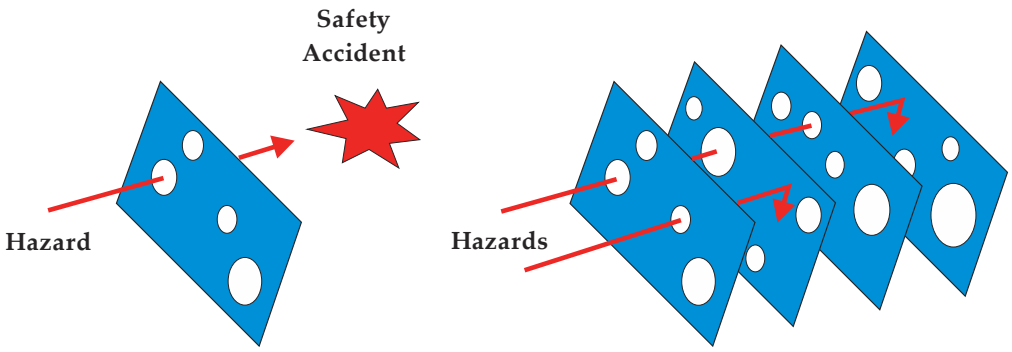

Figure 1.2 SMS Layers (Adopted from [5, 24])

Like financial management, safety management must also be a core business function in successful transit agencies. If properly implemented, safety management not only increases safety in terms of fewer accidents and injuries but also enhances the operational effectiveness of the organization. Other SMS benefits include:

- Reduction of the direct and indirect costs of accidents -- fines, repair costs, damage claims, increased insurance premiums, and so forth;
- Improved employee morale and productivity -- promoting communication between management and the rest of the organization regarding safety issues prevents frustration and lifts morale;
- Establishing a marketable record of safe operations;
- Logical prioritization of safety needs -- SMS emphasizes risk mitigation actions that provide the biggest impact on both safety and the bottom line;

- Compliance with legal and regulatory responsibilities for safety – legal and regulatory requirements mandate a number of safety processes and standards that can be included in an organization's SMS;
- More efficient maintenance scheduling and resource utilization -- effective hazard reporting in SMS allows proactive scheduling of maintenance tasks when resources are available; increasing the likelihood that maintenance is performed on time and more efficiently;
- Avoiding service disruptions -- improved communication and risk mitigation will prevent many accidents from ever occurring; and
- Continuous improvement of operational and maintenance processes -- SMS allows for lessons learned to be incorporated into the system and lead to superior operations.

1.3 Need for Safety Performance Measurement

Continuous improvement in the safety of public transportation systems requires monitoring of safety performance and taking active steps toward achieving established safety goals. The key elements to this process include: 1) agreeing on outcomes that are critical to safety performance, 2) selecting metrics for monitoring outcomes, 3) gathering baseline data on current conditions, 4) setting specific targets and dates for reaching these targets, 5) collecting data on a regular basis to assess whether the targets are being met, 6) analyzing performance data and reporting results, and 7) integrating performance results in decision-making.

Measuring performance is part of striving for excellence and its utility goes beyond generating measures.

Performance metrics (also known as performance measures or indicators) are means of gauging the safety performance or safety health of a transit agency or contractor. They are used to summarize the current position, and the direction and rate of progress towards a particular goal or objective. By comparing the values of a metric over time, one can tell whether performance has improved, deteriorated, or remained the same.

A performance target (also called goal or standard) is a specification of an acceptable/desired level of a particular metric to be accomplished by a particular future date or over a period of elapsed time. Safety targets should be measurable, acceptable to stakeholders, and consistent with those set by federal and state transportation organizations. Simply calling for improvement over time is not sufficient. An example of acceptable format of an agency's safety target is: "reduce the rate of fatalities to 0.25 per 100 million passenger-miles by the year 2012." Although targets represent acceptable levels of safety, their specification does not replace legal, regulatory, or other established requirements, nor does it relieve the transit agency from its obligations to the traveling public regarding safety.

Measuring performance is part of striving for excellence and its utility goes beyond generating measures. Organizations can use performance metrics for a number of reasons including:

- Improving accountability -- provide feedback regarding expectations and communicate results with various stakeholders;
- Decision-making -- inform and facilitate the decision-making process through quantitative performance information; and
- Attention-focusing -- send signals throughout the organization regarding critical safety issues.
- Enhancing efficiency and effectiveness -- help focus resources on priorities, e.g., proactive safety measures that can prevent accidents from happening in the first place;
- Identifying best practices – through benchmarking, the organization can compare its performance against that of peer agencies with similar conditions to identify and share effective practices.

Historically, performance measurement in the public sector evolved from monitoring of money spent (***inputs***) to monitoring of what the money bought (***outputs***, e.g., number of passengers served, hours of operations, revenue vehicle-miles), and more recently, the emphasis has switched to monitoring ***outcomes***, i.e., the end state that we wish to move towards (e.g., less transportation-related injuries) [37].

Inputs and outputs can be used to measure *efficiency*, i.e., how much each unit of output costs. Outcomes indicate the quality and *effectiveness* of that output, i.e., how well did the output achieve the desired goals? Both efficiency and effectiveness are important. But the public and their elected officials are becoming increasingly interested in outcomes -- the difference that a program or service has made in the quality of lives of citizens.

Performance measurement tells only *what* the outcomes were, not *why* those outcomes resulted. W. Edwards Deming, father of the total quality management philosophy, argues that once we learn about poor performance (or quality), we do not necessarily know what is causing it. In the Deming's approach, detailed analysis of performance data is required to pinpoint problems, isolate their root causes, and develop solutions. Program evaluation tools (e.g., before-and-after studies) complement performance measurement in assessing the effectiveness of individual programs or countermeasures. They can also be used to address the attribution question, i.e., the extent to which a particular program was the cause of the observed outcomes. Figure 1.3 illustrates how safety performance measures can be integrated with program evaluation to support the decision-making process.

Although performance measurements do not alone demonstrate the causal link between a program or intervention and the observed outcomes, they can help focus attention on whether progress is being made toward achieving goals and objectives. As Peter Scholtes, author of the "Team Handbook" explains, "numerical measures ... guide the search for better performance, and are recognized as a means rather than an end. They lead the way to a deeper understanding of the organization, and are not used as criteria for judging individuals," [22].

"Numerical measures ... guide the search for better performance, and are recognized as a means rather than an end. They lead the way to a deeper understanding of the organization, and are not used as criteria for judging individuals." -- Peter R. Scholtes (1988)

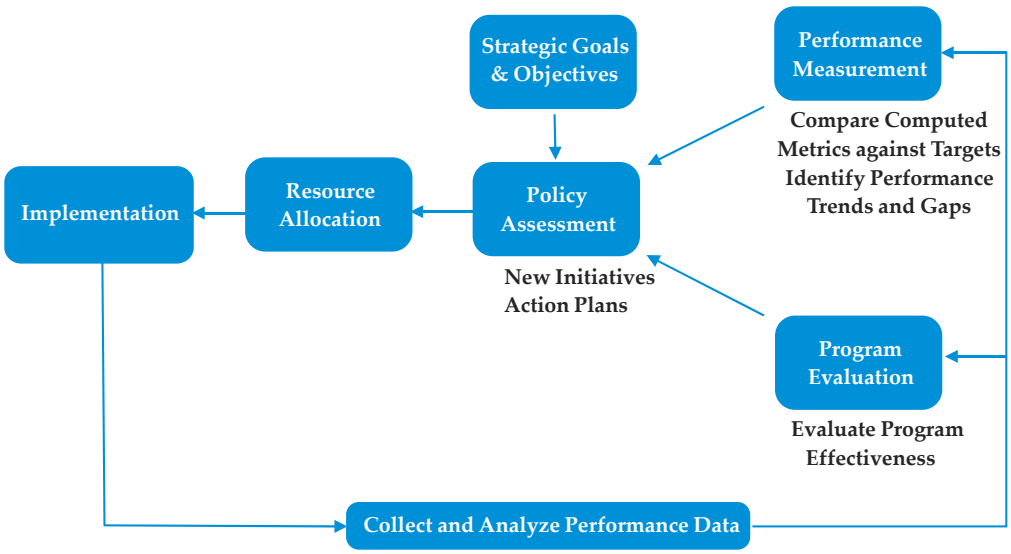

Figure 1.3 Integration of Performance Measurement and Program Evaluation in Decision-Making

Much has been written about the benefits of applying performance measurement in government agencies and the public and private sectors. Osborne and Gaebler summed it up well in their landmark work, *Reinventing Government* [11]:

- **What gets measured gets done.**
- **If you don't measure results, you can't tell success from failure.**
- **If you can't see success, you can't reward it.**
- **If you can't reward success, you are probably rewarding failure.**
- **If you can't see success, you can't learn from it.**
- **If you can't recognize failure, you can't correct it.**
- **If you can demonstrate results, you can win public support.**

One of the major findings of a 2004 FHWA/AASHTO/NCHRP international scan on performance measurement was the impressive application of

performance measurement in the area of transportation safety [9]. Safety was viewed as a strategic use of performance measurement that has resulted in a significant decline in fatalities and injuries in the four countries visited by the scan team (Australia, Canada, Japan, and New Zealand). A great deal can be learned from this application of performance measurement to enhance the safety of the U.S. public transportation systems.

1.4 Stakeholders in Safety

Many groups have a stake in improving and managing the safety of public transportation systems. The principal stakeholders include:

- The traveling public;
- Transit properties and service providers;
- Federal Transportation organizations (e.g., USDOT, FTA, FRA);
- State and local transportation and safety oversight organizations;
- Industry associations (e.g., APTA, CTAA);
- Investigative agencies (e.g., NTSB);
- Transit systems planners and designers;
- Transportation research organizations (e.g., TRB, ITE); and
- Equipment manufacturers.

1.5 Using This Guidebook

Purpose

The purpose of this guidebook is to provide resource information for transit agencies regarding the development and implementation of Safety Management Systems (SMS) and Safety Performance Measurement Systems (SPMS). The guidebook consists of two volumes. Volume-I (this document):

- Explains basic concepts related to safety management and performance measurement;
- Describes a ten-step process for developing and implementing an SMS; and
- Presents a ten-step framework for creating and sustaining an SPMS.

Volume-II includes an assessment of the state of the practice used by large, medium, and small transit agencies regarding safety performance measurement and the utilization of performance results in decision-making. The assessment was based on a survey of approximately 430 transit agencies which was conducted in coordination with APTA and CTAA. The 86 responding agencies represent different transit modes, different size systems and different operating environments.

Target Audience

The concepts and methods described in this guidebook have been compiled from an extensive review of the published literature. The utility of this material is not limited to safety mangers and personnel. Rather, it should be relevant to all employees in transit agencies including senior management. Other stakeholders in transit safety will also find this resource guidebook helpful in improving safety.

Guidebook Contents

Volume-I of this guidebook includes five chapters and Appendices A through D. Following this introductory chapter, Chapter 2 summarizes key concepts and definitions including the contemporary meaning of "safety" used in safety management, the concept of risk and the process of safety risk management, near miss events as precursors to major accidents, human errors in accident causation and the Human Factors Analysis and Classification System (HFACS), the concept of safety culture, and the factors that affect the quality of safety data.

Chapter 3 describes the basic safety process and provides an overview of the ten steps involved in establishing a safety management system (SMS). It also presents practical considerations for the successful implementation of each step. The chapter highlights the flexibility and scalability of the process of launching an SMS to suit the unique characteristics and operating environment of each transit property. Transit properties are encouraged to build on existing safety procedures and practices, particularly the System Safety Program Plan (SSPP).

Chapter 4 discusses the types of performance measures, definitions of basic terms used in safety performance measurement (SPM), and good practices in designing a safety performance measurement system ((SPMS). The focus of this chapter is on a comprehensive ten-step framework for developing, implementing, and sustaining an SPMS. Each of these steps is discussed in detail with practical tips for ensuring the success of the performance measurement effort. The chapter also includes a discussion of the key findings of the survey of the U.S. transit industry regarding the use of safety performance measurement.

Chapter 5 summarizes the major conclusions drawn from this project and makes recommendations regarding safety management systems, safety performance measurement, transit workforce development, transit safety data, and future research. Appendix A presents a questionnaire that can be used to determine the safety culture of the organization. Appendix B includes a sample safety policy statement. Appendix C provides a sample

job description for the safety manager. Appendix D presents a sample policy on non-punitive hazard reporting.

Volume II presents results of the safety performance measurement survey of the U.S. transit industry.

CHAPTER 2

Basic Concepts

This chapter presents key concepts and definitions that are important to safety management and safety performance measurement. The classical definitions of "safety" are described along with the contemporary meaning used in safety management. The concept of risk is addressed and the process of safety risk management (hazard identification, risk assessment, and risk mitigation) is discussed. The chapter highlights the importance of learning from near miss events in order to avoid major accidents. The concept of safety culture is presented. Finally the factors that affect the quality of safety data are examined.

2.1 Concept of Safety

Depending on one's perspective, the concept of public transportation safety may have different connotative meanings, such as:

1. Zero accidents and serious incidents, a view widely held by the public;
2. The freedom from danger or risks, i.e., those factors which cause or are likely to cause harm;
3. The attitude of transit agency employees towards unsafe acts and conditions which defines the corporate safety culture;
4. The degree to which the inherent risks in public transportation are "acceptable"; and
5. The process of hazard identification and risk management.

While the elimination of accidents and serious incidents would be desirable, a one hundred percent level of safety is an unachievable goal. Failures and errors will occur, in spite of the best efforts to avoid and prevent them. No system where humans and technology interact can be guaranteed to be absolutely safe, i.e., free from risk. Safety, therefore, is a relative notion whereby some level of inherent risks is acceptable in a "safe" system.

No system where humans and technology interact can be guaranteed to be absolutely safe, i.e., free from risk.

In contemporary safety management, safety is viewed as the identification of hazards and risk factors, and the management of risk. Thus, for the purposes of this guidebook, safety is considered to have the following meaning:

> *Safety is the state in which the risk of injury to persons or damage to property is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management.*

2.2 Concept of Risk

Both the likelihood of occurrence of harmful events and the severity of potential consequences must be considered in evaluating risks.

Risk is the assessed potential for undesirable consequences resulting from a hazard. It is often expressed as the likelihood (probability) that the hazard will cause some harm. The concept of risk, however, involves more than just probability. To help illustrate, suppose that the probability of the supporting cable of a 120-passenger aerial commuter tram failing and allowing the car to fall was assessed as being the same as the probability of the supporting cable of a 12-passenger elevator failing and allowing the elevator to fall. While the probabilities of the two events occurring may be the same, the potential consequences of the aerial tram accident are much more severe. Risk is therefore two-dimensional. Evaluation of the acceptability of a given risk must always take into account both the *likelihood* of occurrence of harmful events and the *severity* of potential consequences. In safety engineering, risk equals the probability of occurrence of an event multiplied by the severity of the consequences.

As shown in the carrot diagram of Figure 2.1, risks may be classified as *unacceptable*, *tolerable*, or *acceptable*. Risks that are so high that they are unacceptable and must be reduced are at the top region, and risks that are so low that they are acceptable are at the bottom region. The region in between is called the tolerable region; risks in this region may be tolerated, if they cannot practically be reduced, based on various trade-offs between risks and benefits resulting from the system or installation that causes the risks.

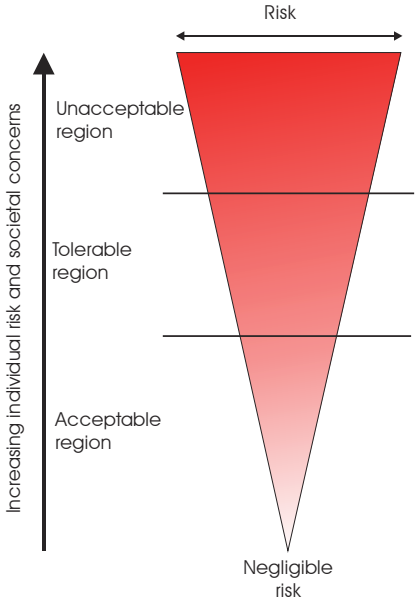

Figure 2-1 Tolerability of Risk

The level of risk deemed "acceptable" is determined on the basis of the agency's safety performance criteria, industry standards, public opinion

regarding such risk, and political and legal considerations. If the risk does not meet the acceptability criteria, an attempt must always be made to reduce it to a level that is acceptable using appropriate mitigation procedures. If the risk cannot be reduced to or below the acceptable level, it may be regarded as "tolerable" if all of the following three conditions are satisfied:

- The risk is less than the predetermined unacceptable limit;
- The risk has been reduced to a level that is as low as reasonably practicable; and
- The benefits of the proposed system or operation are sufficient to justify accepting the risk.

Even though a risk may be classified as acceptable or tolerable, measures should always be sought to further reduce the level of such risk. Risks beyond the tolerable level are unacceptable.

The level of risk deemed "acceptable" is determined on the basis of the agency's safety performance criteria, industry standards, public opinion regarding this risk and political and legal considerations.

The acronym ***ALARP*** is used to describe a risk that has been reduced to a level that is "as *low as reasonably practicable*." In determining the threshold for what is *"reasonably practicable"* in this context, consideration should be given to both the technological feasibility of further reducing the risk and the associated cost.

The ALARP principle makes use of the law of diminishing marginal returns to identify the point beyond which the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained. Additional investments begin to have a declining degree of impact on risk reduction.

It should be noted that when a transit agency "accepts" a risk, this does not mean that the risk is eliminated; some level of risk still remains. However, the agency has accepted that such risk is sufficiently low that it is outweighed by the benefits of the existing operation.

2.3 Safety Risk Management

Public transportation faces numerous safety risks on a daily basis. Not all risks can be eliminated, and not all conceivable risk mitigation measures are economically feasible. The risks inherent in public transportation necessitate a logical process for objective decision-making. This process is known as *safety risk management, (SRM)*. SRM facilitates the balancing act between assessed risks and viable risk mitigation measures. Risk management is an integral component of safety management.

Figure 2.2 presents an overview of the SRM process. As shown, SRM includes three elements: *hazard identification*, *risk assessment*, and *risk mitigation*. Following is a brief description of each element.

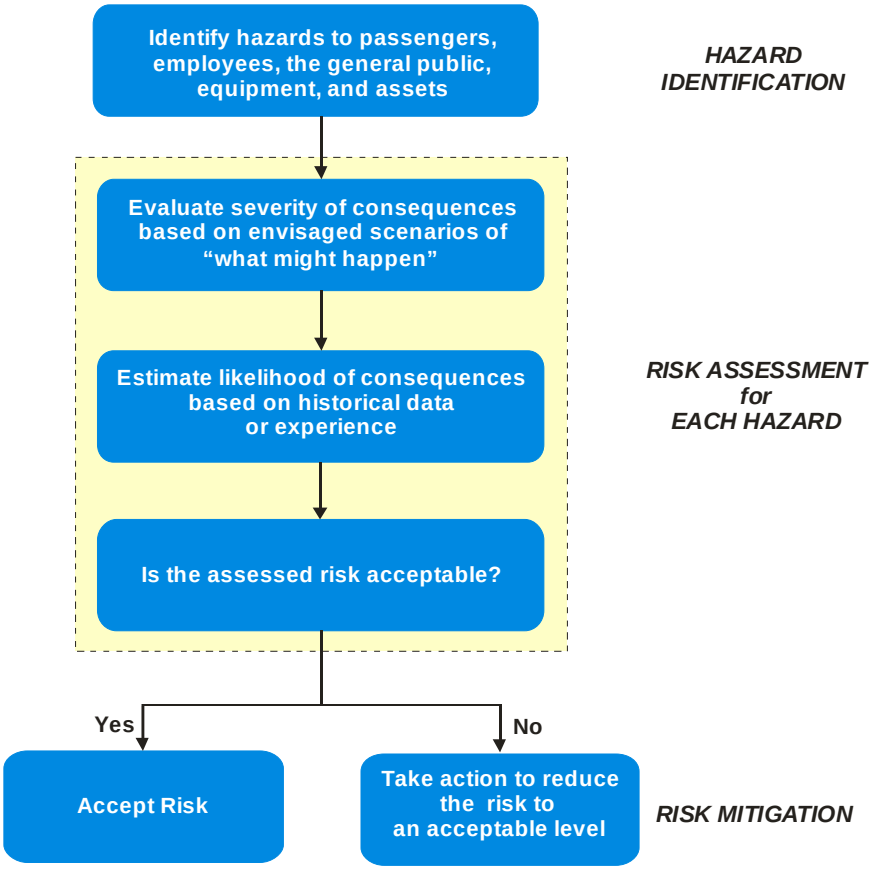

Figure 2.2 Safety Risk Management Process

Hazard Identification

Given that the term "hazard" refers to any situation or condition that could potentially cause adverse consequences, the scope of hazards in public transportation is wide. Examples of hazards include:

1. ***Design factors:*** vehicles, tracks, equipment, etc.;
2. ***Operating procedures and practices:*** documentation, checklists, etc.;
3. ***Communications:*** medium, terminology and language;
4. ***Personnel factors:*** agency policies for recruitment, training and remuneration;
5. ***Organizational factors:*** corporate safety culture, resource allocation, operating pressures, etc.;
6. ***Physical defenses:*** adequate detection and warning systems, traffic control devices, signaling, barriers, etc.; and
7. ***Regulatory and oversight factors:*** application and enforcement of regulations; certification of equipment, personnel and procedures; and adequacy of safety audits.

Hazards may be identified through investigations of actual safety events (accidents/incidents), or they may be identified through proactive processes aimed at identifying hazards before they precipitate an occurrence. In practice, both reactive measures and proactive processes provide effective means of identifying hazards.

Accidents and incidents are clear evidence of problems in the system and therefore provide an opportunity to learn valuable safety lessons. Safety events should therefore be investigated in detail to identify their root causes. This involves investigating all the factors, including the organizational factors and the human factors that could have played a role in the event.

The purpose of safety risk management is to focus safety efforts on those hazards posing the greatest risks and correctly direct resources for improvements.

Accident investigations document the circumstances surrounding individual accidents, often pointing out one or more factors that are seen as causal to the event. However, some of the factors that influence the likelihood of an accident can be difficult to discern in the context of a single accident. These factors emerge only after statistical analysis of the characteristics of many accidents that have occurred in comparison with the characteristics of similar non-accident operations.

In effective safety management systems, hazards are identified using a variety of proactive means as an ongoing process. Examples of the tools that can be employed to actively identify safety hazards include:

1. Hazard and incident reporting systems that promote the identification of latent unsafe conditions;
2. Safety surveys to elicit feedback from front-line personnel about areas of concern and unsatisfactory conditions that may have accident potential; and
3. Operational inspections or audits of all aspects of operations to identify vulnerable areas before accidents or incidents confirm that a problem exists.

In addition to identifying hazards, it is also important to examine the *risk factors* associated with different types of accidents/incidents. Risk factors are characteristics of people, vehicles, or the environment that are related to the increased incidence of collisions, injuries, fires, and so forth. Statistical techniques can be used to identify patterns and analyze the strength of the relation between specific risk factors and harmful outcomes.

Risk Assessment

Once hazards have been identified, they must undergo an assessment to determine their potential consequences. Typically, this assessment involves three considerations:

- The ***likelihood*** of the hazard precipitating an unsafe event;
- The ***severity*** of the consequences of the unsafe event if the hazard is allowed to remain; and
- The ***exposure*** to the hazard, (e.g., number of passengers-miles per day, number of pedestrians using a grade crossing during the peak-hour, number of vehicles per hour, etc .; and the characteristics of transit users and vehicles). The probability of adverse consequences becomes greater with increased exposure to the unsafe conditions.

In performing hazard assessments, a risk assessment matrix (RAM) like the one shown in Figure 2.3 could be used in the analysis. The columns of this matrix represent the likelihood of an accident/incident occurring, and the rows of the matrix, the severity of the consequences of that accident/incident. Numerical values may be assigned to the different levels of severity and probability. In Figure 2.3 for example, a scale from 1 to 5 is used to indicate increasing severity, and a similar scale for increasing likelihood. Each cell, corresponding to a particular level of severity and probability, is assigned a risk value that is calculated by multiplying the severity and probability.

Consequences					Likelihood				
Severity	People	Assets	Environment	Reputation	1	2	3	4	5
					Practically impossible (never heard of in the industry)	Remote, not likely to occur	Could occur, or heard of it happening	Likely, known to occur or has happened before	Common, or occurs frequently
1	First aid or no injury	No/Slight damage	No/Slight effect	No/Slight impact	L	L	L	L	M
2	Slight injury, medical treatment	Minor damage	Minor effect	Limited impact	L	L	M	M	H
3	Serious Injury, hospitalization more than 7 days	Moderate damage	Moderate effect	Local area impact	L	L	M	H	H
4	Permanent total disability, or one fatality	Major damage, unit level	Major effect	Major statewide impact	L	M	H	H	H
5	Multiple fatalities	Major damage, multiple units	Massive effect	Major national impact	M	M	H	H	H

Low risk, Continuous improvement

Medium risk, Monitor and control to ALARP

High risk, Unacceptable/Intolerable, immediately introduce further control measures

Figure 2.3 Risk Assessment Matrix (RAM)

Assessing the risk of a particular hazard should be done in sequence, first the potential consequences are identified and estimated, and then the likelihood of such consequences occurring is determined. The consequences are those of credible scenarios of what might happen if the hazard persists, taking the

prevailing conditions into consideration. Fault tree or event tree techniques can be used in the analysis. The potential consequences rather than the actual ones are used. These can be thought of as the consequences that could have resulted from the hazard if things went out of control.

After assessing the consequences, the likelihood is estimated based on historical evidence or experience that such consequences have materialized under similar conditions in the industry or the organization. Since historical data may not be available on all kinds of past accidents/incidents, transit agencies can rely on best educated opinions and the published literature as sources of information. As the safety management system matures, more data will become available for refining the estimates of probability and severity.

Risk Mitigation

The assessment process may indicate that certain hazards have an acceptable level of risk, while others require mitigation to an acceptable or tolerable level. The assessment matrix can help prioritize the hazards most warranting attention; the higher the risk the greater the urgency. The level of risk can be lowered by reducing the severity of the potential consequences, by reducing the likelihood of occurrence and/or by reducing the exposure to that risk. In general, safety actions can be categorized into three broad categories:

Physical defenses: These include objects and technologies that are engineered to discourage, warn against, or prevent inappropriate action or mitigate the consequences of events (e.g., traffic control devices, fences, safety restraining systems, train controls/signals, automatic train monitoring systems, safety redundancies, equipment crashworthiness, etc.);

Administrative defenses: These include procedures and practices that mitigate the likelihood of accident/incident (e.g., safety regulations, standard operating procedures, personnel proficiency, supervision, inspection, training, etc.); and

Behavioral defenses: These include behavioral interventions through education and public awareness campaigns aimed at reducing risky and reckless behavior of motorists, passengers and pedestrians; factors outside the control of the transit agency. The Operation Lifesaver campaign is an example.

2.4 Incidents as Precursors of Accidents

Major accidents, those that result in fatalities, serious injuries or substantial damage, present the strongest evidence of a breakdown in the system's safety defenses. Usually, these accidents are highly publicized and are investigated

in depth to determine how and why the accident occurred, and if a similar accident can happen again. Too often, latent unsafe conditions exist before the time of the accident and only become evident with hindsight. Had these precursors been identified earlier, the major accident could have been prevented.

For each major accident involving fatalities, there are as many as several hundred unreported incidents and occurrences that, if properly investigated, might have identified an underlying problem in time to prevent the accident.

The Heinrich pyramid depicted in Figure 2.4 has been widely accepted by the safety community in studying the safety of many systems including transportation. 1n 1932, Dr. H. W. Heinrich estimated that for every 300 unsafe conditions/acts that go unreported, there are 29 incidents involving minor injuries or property damage, and one major accident resulting in serious injury or fatality [23]. A more recent study by the insurance industry revealed a similar pattern but with different ratios: for each serious injury accident, there were 10 minor injury incidents, 30 property-damage incidents and 600 near-miss incidents that did not cause injury or property damage [52].

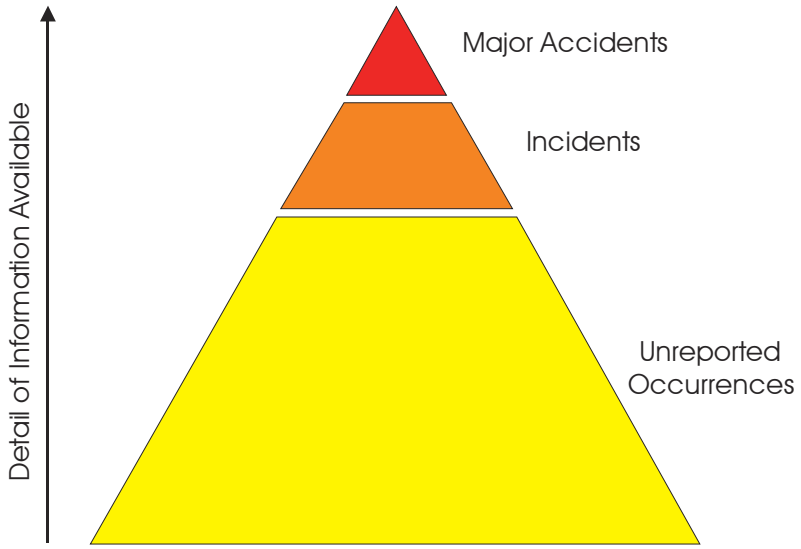

Figure 2.4 Heinrich Pyramid [23]

By themselves, most unreported events and near misses do not result in mishaps. However, the risks involved in these incidents form the building blocks of major mishaps. When the conditions are ripe, i.e., building blocks from the "unreported occurrences" part of the pyramid combine with each other, they may result in a serious accident.

Although the exact ratios of major accidents, incidents and other occurrences vary by industry, the morale of the Heinrich pyramid is valid. By allowing unsafe conditions and minor incidents to occur without intervention, one can expect some serious accident at some point in time. Alternatively, an

opportunity to improve safety will be wasted if investigations are focused only on those rare occurrences at the tip of the pyramid. It is likely that many of the same conditions and practices that contribute to serious accidents may be present in hundreds of minor incidents and close calls. Sometimes the difference is only a matter of inches or seconds. The more safety problems one can identify and correct at the bottom of the pyramid, the better is the chance of mitigating or completely eliminating harmful outcomes. Effective safety management requires investigating accident precursors and documenting the lessons learned.

Two recent reports: "*Improving Railroad Safety through Understanding Close Calls*" by the Volpe Center [8], and "*Accident Precursor Analysis and Management: Reducing Technological Risk through Diligence*" by the National Academy of Engineering [21], provide excellent discussion of accident precursors in transportation and other industries.

2.5 Human Factors in Accident Causation

It is widely accepted that most accidents result from human error. While it may be easy to dismiss these human errors as acts of carelessness or incompetence, recent research and accident investigation reports suggest that most accidents cannot be attributed to a single cause and that human error is merely the last link in a chain of events that leads to an accident. From Heinrich's axioms of industrial safety [23] to Bird's "Domino theory" [58] and Reason's "Swiss cheese" model of human error [24], a sequential theory of accident causation has been embraced by most in the field of human error [62]. Particularly useful in this regard has been the work by Jim Reason describing active and latent failures within the context of his "Swiss cheese" model of human error. In his model, Reason describes four levels of human failure, each one influencing the next: "*organizational influences* often lead to instances of *unsafe supervision* which in turn lead to *preconditions for unsafe acts* and ultimately the *unsafe acts of operators*." The latter level, the unsafe acts of operators, represents active failures and has been the focus of most accident investigations.

While Reason's work changed the way accident investigators view human error, it was largely theoretical and did not provide the level of detail necessary to apply it in the real world. It wasn't until Shappell and Wiegmann developed a comprehensive human error framework — the Human Factors Analysis and Classification System (HFACS) — that Reason's ideas were cast into the applied setting [59, 60, 61].

HFACS was originally developed for the U.S. Navy and Marine Corps as an accident investigation and data analysis tool. Other organizations such as the FAA and NASA have explored the use of HFACS as a complement to

preexisting systems and found it to be a viable tool in analyzing civil aviation accidents.

As shown in Figure 2.5, the HFACS framework includes 19 causal categories within the Reason's four levels of human failure. A brief description of each causal category is given in Table 2.1. Although all of the 19 causal categories are equally important, this section will only address the causal categories associated with the unsafe acts of operators and the preconditions for these unsafe acts. A complete description of all 19 HFACS causal categories can be found in a book entitled "*A human error approach to aviation accident analysis: The Human Factors Analysis and Classification System*," by Shappell and Wiegmann [59]. The HFACS framework is versatile and can be adapted, albeit with some modifications, to studying human factors in public transportation accidents.

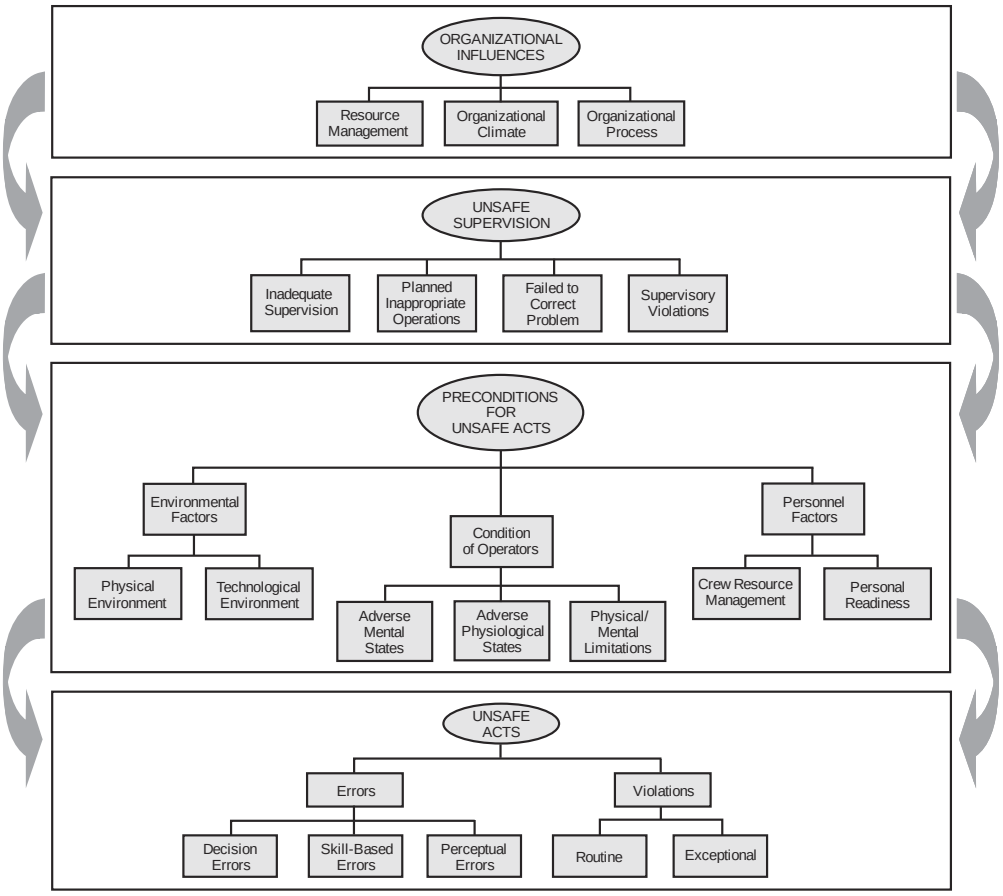

Figure 2.5 The HFACS Framework [60]

Unsafe Acts of Operators

Going back in time from the moment the accident occurred, the first level of HFACS describes the unsafe acts of operators that lead to the accident. These

unsafe acts may be classified as either errors or violations [24]. While both are common within most settings, they differ markedly when one considers the rules and regulation of the organization. Errors may be described as those "legal" activities that fail to achieve their intended outcome, while violations are commonly defined as behavior that represents the willful disregard for the rules and regulations. HFACS includes three types of errors (decision, skill-based, and perceptual) and two types of violations (routine and exceptional).

Errors

Decision errors. This type of error represents intentional behavior that proceeds as intended, but the plan proves inadequate or inappropriate for the situation. Often referred to as "honest mistakes," decision errors typically manifest in one of three forms: procedural errors (poorly executed procedures), choice errors (improper choices among multiple response options), or problem solving errors.

Skill-based errors. These errors occur with little or no conscious thought. For example, little thought goes into turning one's steering wheel or shifting gears in an automobile. The difficulty with these highly practiced and seemingly automatic behaviors is that they are particularly vulnerable to attention and/or memory failures. As a result, skill-based errors such as the inadvertent activation/deactivation of switches, forgotten intentions, and omitted items in checklists often occur when the operator is distracted, stressed, fatigued or in a hurry.

Perceptual errors. Perceptual errors occur when the sensory input is degraded as is often the case when operating in a visually impoverished environment. With imperfect or less information, operators run the risk of misjudging distances, speeds, and presence of stationary or mobile objects.

Violations

Routine violations. Routine violations are habitual by nature and often enabled by a system of supervision and management that tolerates such departures from the rules ([24]. The classic example is that of the individual who drives consistently 5-10 mph above the speed limit. While clearly against the law, the behavior is, in effect, sanctioned by local authorities who often will not enforce the law until speeds in excess of 10 mph over the posted limit are observed.

Exceptional violations. These violations are isolated departures from authority, neither typical of the individual nor condoned by management [24]. For example, an isolated incident of driving at 100 mph in a 55 mph zone is

considered exceptional violation. It is important to note, that while most exceptional violations are appalling, they are not considered "exceptional" because of their extreme nature. Rather, they are regarded as exceptional because they are neither typical of the individual nor condoned by authority.

Preconditions for Unsafe Acts

Simply focusing only on the unsafe acts of operators is an overly simplistic approach to accident causation. It is like focusing on a patient's symptoms without understanding the underlying disease that caused it. Therefore, investigators must dig deeper into the preconditions for unsafe acts. HFACS includes three major subdivisions of preconditions: environmental factors (physical environment and technological environment), condition of operators (adverse mental states, adverse physiological states, and physical/mental limitations), and the personnel factors (crew resource management and personal readiness).

Environmental Factors

Physical environment. This category includes the prevailing environmental factors that can affect the operator's ability to complete the required tasks accurately and in a timely manner. Examples of such factors include heat, lighting, vibration, noise, toxins and weather.

Technological environment. Included in this category are the design of equipment and controls, display/interface characteristics, checklist layout, and automation.

Conditions of the Operator

Adverse mental states. This category includes those mental conditions of operators that adversely affect performance. Principal among these are mental fatigue due to sleep loss or stress, loss of situational awareness, and attitudes such as overconfidence, complacency, and misplaced motivation that negatively impact decisions and contribute to unsafe acts.

Adverse physiological states. Particularly important in this category are conditions such as intoxication, illness, and a whole host of pharmacological and medical abnormalities known to affect performance and operational safety.

Physical and/or mental limitations. The final category of substandard conditions includes those instances when necessary sensory information is either unavailable, or if available, operators simply do not have the aptitude, skill, or time to safely deal with it. An example of the former is the situation

when the operator can not see other vehicles or obstacles due to the size, contrast, and/or location of the object in the visual field. Likewise, there are occasions when the operator is required to respond quickly and accurately, yet the operator's processing or reaction time exceeds that required to complete the task safely. In addition, even when favorable visual cues or an abundance of time is available, there are instances when an operator simply may not possess the necessary physical ability or proficiency to operate safely.

Personnel Factors

Crew resource management. Good communication skills and team coordination are critical to safety. As such, this category includes the failures of communications among operators, as well as communication with the automated control center personnel and other maintenance personnel. This category also includes those instances when personnel do not work together as a team, or when individuals directly responsible for the conduct of operations fail to coordinate activities.

Personal readiness. This category accounts for those instances when established rules such as operator rest requirements or alcohol restrictions are disregarded. Furthermore, this category includes behaviors that do not necessarily violate existing rules or regulations (e.g., running ten miles before operating a train or not observing good dietary practices) but have the potential of reduce the operating capabilities of the individual.

Table 1: Brief Description of HFACS Causal Categories [63]

Organizational Influences
Organizational climate: Prevailing atmosphere/vision within the organization, including such things as policies, command structure, and culture.
Operational process: Formal process by which the vision of an organization is carried out including operations, procedures, and oversight, among others.
Resource management: How human, monetary, and equipment resources necessary to carry out the vision are managed.
Unsafe Supervision
Inadequate supervision: Oversight and management of personnel and resources, including training, professional guidance, and operational leadership, among other aspects.
Planned inappropriate operations: Management and assignment of work, including aspects of risk management, crew pairing, operational tempo, etc.
Failed to correct known problems: Those instances in which deficiencies among individuals, equipment, training, or other related safety areas are "known" to the supervisor yet are allowed to continue uncorrected.
Supervisory violations: The willful disregard for existing rules, regulations, instructions, or standard operating procedures by managers during the course of their duties.

Table 1: Brief Description of HFACS Causal Categories (continued) [63]

Preconditions for Unsafe Acts
Environmental factors
Technological environment: This category encompasses a variety of issues, including the design of equipment and controls, display/interface characteristics, checklist layouts, task factors, and automation.
Physical environment: Included are both the operational setting (e.g., weather, altitude, terrain) and the ambient environment (e.g., as heat, vibration, lighting, toxins).
Condition of the operator
Adverse mental states: Acute psychological and/or mental conditions that negatively affect performance, such as mental fatigue, pernicious attitudes, and misplaced motivation.
Adverse physiological states: Acute medical and/or physiological conditions that preclude safe operations, such as illness, intoxication, and the myriad pharmacological and medical abnormalities known to affect performance.
Physical/mental limitations: Permanent physical/mental disabilities that may adversely impact performance, such as poor vision, lack of physical strength, mental aptitude, general knowledge, and a variety of other chronic mental illnesses.
Personnel factors
Crew resource management: Includes a variety of communication, coordination, and teamwork issues that impact performance.
Personal readiness: Off-duty activities required to perform optimally on the job, such as adhering to crew rest requirements, alcohol restrictions, and other off-duty mandates.
Unsafe Acts
Errors
Decision errors: These "thinking" errors represent conscious, goal-intended behavior that proceeds as designed, yet the plan proves inadequate or inappropriate for the situation. These errors typically manifest as poorly executed procedures, improper choices, or simply the misinterpretation and/or misuse of relevant information.
Skill-based errors: Highly practiced behavior that occurs with little or no conscious thought. These "doing" errors frequently appear as breakdown in visual scan patterns, inadvertent activation/deactivation of switches, forgotten intentions, and omitted items in checklists. Even the manner or technique with which one performs a task is included.
Perceptual errors: These errors arise when sensory input is degraded, as is often the case when flying at night, in poor weather, or in otherwise visually impoverished environments. Faced with acting on imperfect or incomplete information, aircrew run the risk of misjudging distances, altitude, and descent rates, as well as of responding incorrectly to a variety of visual/vestibular illusions.
Violations
Routine violations: Often referred to as "bending the rules," this type of violation tends to be habitual by nature and is often enabled by a system of supervision and management that tolerates such departures from the rules.
Exceptional violations: Isolated departures from authority, neither typical of the individual nor condoned by management.

2.6 Safety Culture

Organizational culture, or corporate culture, is a broad term used to define the personality or character of an organization. It comprises the organization's core values and beliefs, attitudes, corporate ethics and standards of behavior in the workplace. An organization's corporate culture provides the foundation for managerial and employee decision-making — *"This is how we do things around here!"* According to Edgar Schein, an MIT Sloan School of Management professor, a positive organizational culture is "the residue of success" [51]. It outlasts the products, services, founders, leadership and all other physical attributes of the organization.

A positive organizational culture is "the residue of success. It outlasts the products, services, founders, leadership and all other physical attributes of the organization.

Safety culture is that aspect of corporate culture that reflects the shared beliefs, practices and attitudes towards safety. Some of the practices that define a strong safety culture are:

- Management is accountable and responsible for safety;
- Everyone in the organization takes an active role in safety;
- Open communications and discussions of safety hazards and risks are encouraged;
- Safety hazards and close-calls are reported;
- Risk management continues despite everything looking safe;
- Human errors and unsafe acts are treated as symptoms of organizational problems;
- Safety redundancies are introduced to ensure resiliency to unplanned events;
- Investment in safety is made even in times of financial constraint;
- Industry, oversight agencies and FTA work together to make the system safer;
- Practices and procedures are regularly reviewed and improved;
- Activities and decisions are risk-based;
- Safety data are analyzed to identify systemic causes;
- Investment is made in proactive activities;
- The safety office is a proactive partner to the other departments;
- Safety performance is measured;
- Safe practices, continuous learning and improvement are the norm, even during times of financial problems and labor pressure;
- Safety information is shared;
- The safety management system is audited; and
- Safety information is shared internally and externally.

Table 2.2 summarizes the characteristics of three safety cultures: poor, bureaucratic or indifferent, and positive.

Table 2.2 Characteristics of Different Corporate Safety Cultures [4]

Safety Issues	Poor Safety Culture	Bureaucratic Safety Culture	Positive Safety Culture
Hazard information	Suppressed	Ignored	Actively sought
Safety messengers	Discouraged or punished	Tolerated	Trained and encouraged
Responsibility for safety	Avoided	Fragmented	Shared
Dissemination of safety information	Discouraged	Allowed but discouraged	Rewarded
Failures lead to	Cover-ups	Local fixes	Inquires and systemic reform
New ideas	Crushed	Considered as new problems (not opportunities)	Welcomed

The price of safety is chronic unease. Complacency is the worst enemy. There are no final victories in the struggle for safety.

Developing a positive safety culture is the key to improving safety of the U.S. transit systems. The overall goal is for safe practices to be demonstrated and reflected in all activities, at all organizational levels, in everyday work. The tone for safety culture must be set and nurtured by example from the words and actions of senior management. Managers who value safety will instill those same values in their employees. And when employees value safety, they will naturally choose safe operating procedures, report hazards and make safety suggestions. Safety culture therefore is an environment created by management that shapes workers' attitudes towards safety. The degree to which directors and senior management accept responsibility for safe operations and risk management establishes the safety ethos of the agency. Trust and respect between management and staff are essential; staff must believe that they will be supported in any decision made in the interests of safety. Workers must also understand that intentional violations of safety will not be tolerated.

How front-line managers and staff deal with the day-to-day activities is fundamental to positive safety culture. Are the correct conclusions being drawn from line experiences and the appropriate actions taken? Is the affected staff constructively involved in this process? Are the learnt lessons adequately documented? The answers to these questions depend on employee training, competency, supervision, motivation, and "buy-in".

In addition, the relationship that front-line management and staff have with representatives of the oversight/regulatory authority is indicative of the health of the safety culture. This relationship should be marked by

professional courtesy and cooperation, but without compromising accountability. Openness leads to better safety communications than strict enforcement of rules and regulations. The former approach promotes constructive dialogue, whereas the latter encourages concealing or ignoring the real safety problems.

As discussed in Chapter 1, a positive safety culture is essential for an SMS to function effectively. However, the safety culture of an organization is also shaped by the presence of a formal SMS. Because of this interdependency, transit agencies should not delay implementing an SMS until they have achieved an ideal safety culture. Positive safety culture will develop over time as exposure to, and experience with, safety management increases.

To find out if a particular organization has or is well on its way to having a good safety culture, Dr. James Reason of Manchester University in the United Kingdom prepared a checklist of twenty questions. This checklist is included in Appendix-A and can be viewed on-line at:
http://www.tc.gc.ca/civilaviation/systemsafety/Brochures/Tp13844/menu.htm

Depending on the numerical score, the safety culture of the organizations is classified as:

- Score 16-20: So healthy as to be barely credible,
- Score 11-15: You're in good shape, but don't forget to be uneasy,
- Score 6-10: Not at all bad, but there's still a long way to go,
- Score 1-5: You are very vulnerable,
- Score 0: Jurassic Park.

2.7 Data Quality

The quality and completeness of accident/incident data reported by transit agencies affects our understanding of the safety of the U.S. transit industry and consequently how safety resources are targeted. The reported data usually come from accident, incident, or police reports and are used to complete the major incident report form (S&S-40) and the non-major incident summary report form (S&S-50) required by the Federal Transit Administration's (FTA) Office of Safety and Security. The information contained in these forms is entered into the National Transit Database (NTD) which also contains financial and operating data for public transportation systems in the U.S.

Figure 2.6, adopted from Elvik and Vaa [27], illustrates the sources of error and loss of data in accident records. Starting with all accidents that occur in transit properties, the first loss of information has to do with the definition of "reportable" accident. Some of the accidents that occur do not meet the

thresholds for being reportable. Furthermore, the thresholds of reportable transit accidents change over time. For example, the limit of reportable property-damage-only (PDO) accidents was adjusted beginning January 2006 from $1,000 to $25,000 ($7,500 for a collision at a grade crossing). The limits for reportable non-fatal injury accidents (except those that take place at grade crossings or rail right-of-way) were also changed from "any physical harm reported at the time and place of occurrence and requiring immediate medical attention away from the scene" to "two or more injuries requiring immediate medical attention away from the scene." As a result, some accidents that would have been reportable before the change are no longer reportable with the higher thresholds in place.

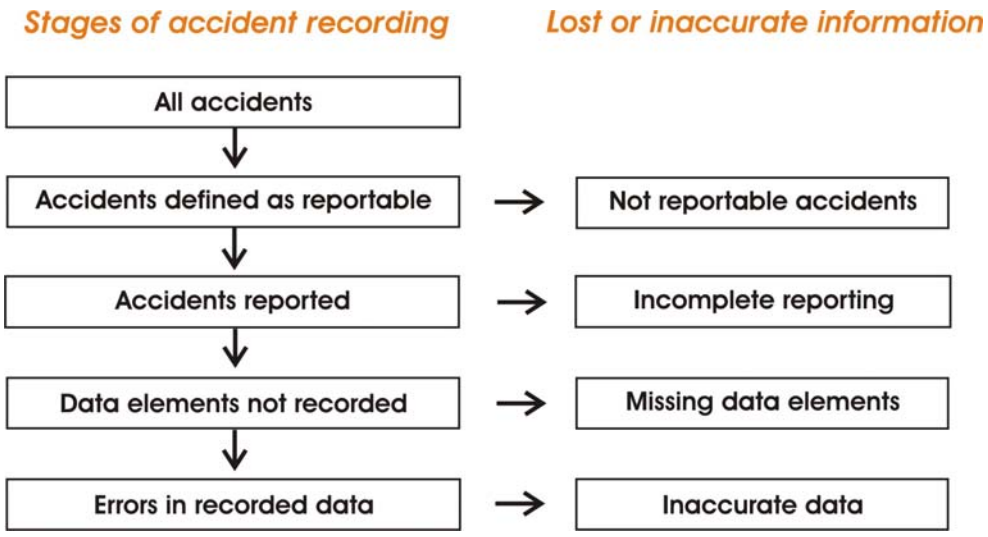

Figure 2.6 Sources of Errors and Data Loss in Official Accident Records [27]

The second source of information loss is incomplete reporting, that is, not all accidents that meet the reporting thresholds end up being reported. In an analysis of 49 studies of road accident reporting in official accident statistics made in 13 countries, Elvik and Mysen concluded that "reporting injuries in official accident statistics is incomplete at all levels of injury severity" [28]. Hauer and Hakkert found that the inclination to report an accident to or by police depends on severity of the outcome, age of victim, his/her role (driver, occupant, etc.) in the accident, number of vehicles involved, and other factors [26]. The tendency to report an accident increases with the age of the injured person, and with the number of vehicles involved. Injuries to non-occupants are less completely reported than injuries to drivers or passengers. The authors concluded that "as a ballpark average, police records miss some 20 percent of injuries that require hospitalization and perhaps up to half of the injuries that do not. Perhaps 60% of reportable PDO accidents are not

reported." An important implication of incomplete accident reporting is that it makes safety problems appear to be smaller than what they actually are and increases the uncertainty in the estimated effects of safety treatments.

Missing data elements is the third source of errors. Elvik and Mysen found that a large number of potentially important data elements, related to human factors in particular, are not recorded in official accident reports [28]. An assessment of the FTA's S&S-40 form revealed that basic data elements (e.g., vehicle speed, grade crossing geometry, type of right-of-way, pedestrians) are not included.

Finally, inaccuracies and missing information are bound to be present in some of the recorded data elements due to errors in data coding and computer entry. In a study of 124 accidents, data contained in police records were compared to detailed information collected by multidisciplinary accident investigation teams [29]. It was found that the most reliable data in police records were those concerned with the accident location, date, and number of drivers, passengers, and vehicles involved; and the least reliable were information about vertical alignment, road surface and accident severity. Except for driver age, sex and vehicle model, police reports were not informative with respect to driver and vehicle characteristics.

Data on near-miss events are not reported by transit agencies. Since accidents are rare events, valuable safety information regarding accident precursors can be gleaned if such data are recorded and analyzed. A Confidential Close Call Reporting System similar to the one developed by the Volpe National Transportation Center and the Bureau of Transportation Statistics (BTS) for the Federal Railroad Administration should be valuable to the transit industry. Such voluntary system can encourage transit employees to disclose safety-critical information and report and analyze close calls.

Another data quality issue has to do with the limitations of available exposure measures. Exposure data are not adequately detailed to support the analysis of risk factors for transit accidents. A 2002 report by the National Transportation Safety Board examined several national transportation safety databases to evaluate data quality issues [19]. The NTSB study found that "the FTA collects transit exposure data including passenger-miles traveled, vehicle-miles traveled, vehicle hours, and unlinked passenger-trips, but FTA exposure data contain little or no information about the population of transit users. Without detailed information about the people and vehicles involved in transportation activities, and the conditions under which such activities take place, it is difficult to assess the degree to which various factors may influence the likelihood and severity of transportation accidents. This circumstance lessens the usefulness of the relatively detailed data collected

for transportation accidents as a tool for monitoring and improving transportation safety," [19].

CHAPTER 3

Safety Management Systems

This chapter provides an overview of the basic elements of a safety management system (SMS) and practical considerations for their implementation. It draws from practices that have proven effective in other transportation industries [4, 8, 54]. Recognizing that "one size does not fit all," the process of launching an SMS is flexible and scalable. It is structured to allow each transit property to implement the SMS with the available resources, and to focus on those elements that are most appropriate for the agency's size, type of operation, and unique environment. All transit agencies should benefit from a formal SMS. However, some agencies may implement most of SMS functions but with a less structured approach.

3.1 What Is 'Safety Management'?

'Safety Management' is the systematic and comprehensive management of the safety hazards and risks associated with transit system operations and related maintenance activities to achieve high levels of safety performance.

3.2 What Is An SMS?

A 'Safety Management System' is an explicit element of the corporate management responsibility which sets out the transit property's safety policy; defines how it intends to identify safety hazards and control risks; and provides for goal setting, planning, and measuring performance. Established at the corporate level, the SMS then devolves out into the individual departments of the agency whose activities contribute to safety performance. These departments will have their own processes and procedures under the umbrella of the corporate SMS.

Continuous safety improvement and adoption of 'best practice' standards must be the goal.

In addition to the traditional reactive procedures and practices, SMS has built-in proactive measures to anticipate and prevent or reduce safety risks. Continuous safety improvement and adoption of 'best practice' standards must be the goal. The SMS must be woven into the fabric of the establishment; it becomes part of the culture, the way people do their jobs.

3.3 SMS Drivers

Public transportation has been experiencing a leveling off of the rates of serious mishaps. As shown in Figure 3.1, the rate of transit-related fatalities

per 100 million passenger-miles has leveled off in recent years. If the upward trend in ridership and the number of passenger-miles of travel continues, the public transportation industry will face significant increases in the number of fatalities and serious injuries. To improve on existing levels of safety in light of the forecast growth of the industry, additional measures are needed. One such measure that has proven effective in other transportation industries is to encourage individual transit properties to introduce their own SMS.

The rates of transit-related fatalities and injuries have leveled off in recent years.

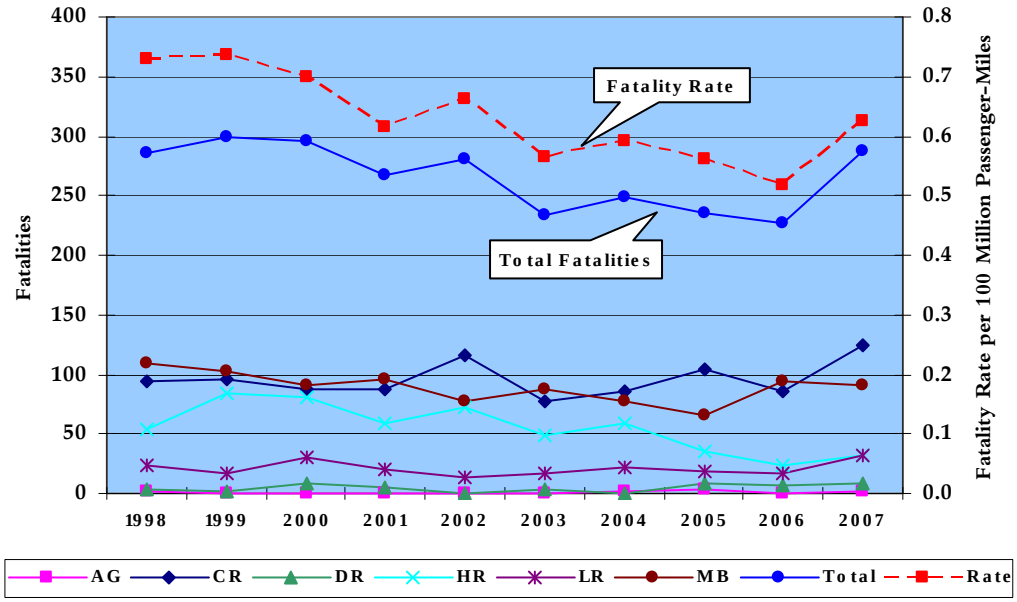

Figure 3.1 Fatalities and Fatality Rates by Transit Mode and Year

SMS is as important to business survival as a financial management system; each is a means of systematically managing a vital business function.

An SMS is as important to business survival as a financial management system; each is a means of systematically managing a vital business function. The features of a financial management system are well recognized; financial targets are set, budgets are developed, levels of authority are established, etc. The structure of a financial management system includes 'checks and balances' and a monitoring element so that corrections can be made if performance falls short of set targets. The information obtained from a financial management system is usually shared across the organization. Risks are still taken but the built-in management procedures should ensure that there is no surprise business loss. If there is, it can be devastating for a small company. For the larger company, unwelcome publicity and media attention usually follows an unexpected loss.

3.4 The Basic Safety Process

In its simplest, most stripped-down form, safety management follows the basic safety process depicted in Figure 3.2. The basic safety process is accomplished in the following five steps:

1. A safety issue or concern is raised, a hazard is identified, or an accident/incident happens;
2. The concern or event is reported or brought to the attention of management;
3. The event, hazard, or issue is analyzed to determine its cause or source and the associated risks are assessed;
4. Corrective actions and mitigation measures are developed and implemented; and
5. The corrective action is evaluated to make sure it is effective. If the safety issue is resolved, the action can be documented and the safety enhancement maintained. If the problem or issue is not resolved, it should be re-analyzed until it is resolved.

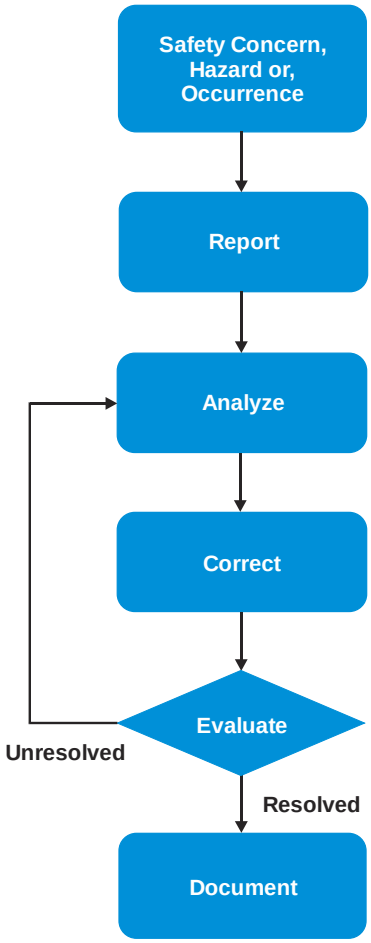

Figure 3.2 The Basic Safety Process
(Adopted with modifications from reference 54)

Transit properties that manage safety most successfully practice several common activities including:

- ***Organization***. They are organized to establish a safety culture and defined safety policy, responsibilities, and accountabilities;
- ***Occurrence reporting***. They have established formal procedures for reporting safety occurrences, near misses, and other unsafe conditions;
- ***Hazard identification schemes***. They employ both reactive and proactive schemes for identifying safety hazards throughout their organization, such as incident reporting, safety surveys, operational safety audits, and safety assessments;
- ***Investigation and analysis***. They follow up on reported occurrences and unsafe conditions and, if necessary, initiate competent safety investigations and safety analyses;
- ***Safety assessments***. They systematically analyze proposed changes to equipment or procedures to identify and mitigate weaknesses before implementing such changes;
- ***Safety promotion***. They actively disseminate the results of safety investigations and analyses, sharing safety lessons learned both within the organization and outside; and
- ***Safety assurance and performance measurement***. They measure safety performance, monitor trends, and perform audits to ensure that the SMS is functioning as intended.

The above activities are discussed in more detail in this chapter.

3.5 Cornerstones of Safety Management

Effective SMS implementation builds upon three cornerstones or pillars [4]. These pillars and the features that define them are listed below:

1. ***A comprehensive corporate approach to safety*** that provides for:
    - A clearly articulated philosophy for safety with supporting safety policy, safety goals, and a management plan for meeting these goals;
    - Top-down commitment to safety with the ultimate accountability for corporate safety being assigned to the Chief Executive Officer and Governing Board;
    - Well-defined roles and responsibilities with specific accountabilities for safety that are published and available to all personnel involved in safety;
    - Demonstrable evidence of a positive safety culture throughout the organization;
    - Non-punitive and just policy for voluntary reporting of hazards and unsafe conditions;

- Commitment to a safety assurance process which is independent of line management;
- A system for documenting policies, procedures and practices related to safety, and making such documents readily available to all affected personnel; and
- Formal safety review processes to assess proposed changes to equipment or procedures and identify any new risks before implementing such changes.

2. ***Effective organizational structure and tools to advance safety*** including:
   - A requirement for an independent safety manager;
   - Establishing a formal safety office;
   - Corporate definition of specific competencies and safety training requirements for all personnel with safety-sensitive functions, including contractor's personnel;
   - Effective programs for training and development of safety personnel, and safety awareness training for management and staff;
   - Application of hazard identification programs, risk assessment, and effective management of resources to control identified risks;
   - Mechanisms for enabling staff to communicate safety concerns to the appropriate level of management for resolution and feedback on actions taken;
   - Implementation of standard operating procedures developed in cooperation with affected personnel;
   - Defined standards for, and auditing of, procured assets and contracted services;
   - Controls for the early detection of, and action on, any deterioration in the performance of safety-critical equipment, systems or services;
   - Application of information technology tools to manage safety data and documents;
   - Systematic review and adoption of best safety practices from other organizations; and
   - Emergency response planning and simulated drills to test the plan's effectiveness.

3. ***A formal system for safety Assurance*** that includes such elements as:
   - A comprehensive system for external safety audits which has the flexibility to focus on specific safety concerns as they arise;

- A system for conducting internal safety audits and investigations, implementing corrective actions, and disseminating safety information to all affected personnel;
- A system for the effective use of safety data to monitor and assess safety performance;
- Periodic review of the effectiveness of the SMS by an independent body; and
- Arrangements for ongoing safety promotion and improvement based on measured safety performance.

3.6 Ten Steps to Establishing SMS

The process of launching an SMS is both flexible and scalable.

Launching all the functions of a full-fledged SMS simultaneously can seem daunting at the outset. To simplify this task, the process of developing and implementing an SMS is broken down into ten individual steps as shown in Table 3.1. These steps reflect the evolutionary nature of SMS and allow the transit property to adapt to, and become acquainted with, the requirements and results of each step before proceeding. The material presented in this section draws from the aviation industry's SMS literature [4, 54].

Table 3.1 Ten Steps to Establishing SMS

Step 1:	Planning
Step 2:	Safety Policy
Step 3:	Organizational Structure
Step 4:	Safety Promotion and Training
Step 5:	Hazard Identification and Risk Management
Step 6:	Occurrence Investigation and Analysis
Step 7:	Safety Documentation and Information Management
Step 8:	Emergency Preparedness and Response
Step 9:	Safety Assurance
Step 10:	Management of Change

Transit properties are encouraged to take a pragmatic approach to establishing an SMS.

Transit properties are encouraged to take a pragmatic approach to establishing an SMS, building where possible on existing safety procedures and practices, particularly the System Safety Program Plan (SSPP). Most transit properties will find that their existing safety processes can be linked to the elements of a formal SMS. Where safety sensitive functions are outsourced, contractual agreements should identify the need for equivalent, auditable SMS in the supplier.

The ten steps to establishing an SMS are described below. While there is certain logic to the sequence of the steps as outlined, it is not prescriptive.

Particular steps may be delayed pending a more suitable time. As the various steps are implemented, progress may be monitored using the confirmation checklist provided at each step to highlight the necessary actions.

Step 1: Planning

Careful planning is an essential stepping stone to the development of successful SMS -- the old saying "if you fail to plan, you plan to fail" applies. Typically, the planning effort will be carried out by a team comprised of experienced line managers and the person likely to be designated as the organization's safety manager (SM). Although the scope and details of the planning process will vary from one agency to the other, the following activities are common to most SMS planning efforts:

Review of Existing Capabilities. The planning team may be able to build upon existing safety management capabilities including experience, knowledge, processes, procedures, and so forth. Flaws and weaknesses experienced in existing safety management activities must be recognized, and the resources needed for developing SMS must be identified.

Procedures may already be in place for incident/accident investigation, hazard identification, safety monitoring, and the like. These should be reviewed and perhaps modified for integration with the SMS. It is important that the SMS utilizes as many existing procedures as practicable, as there is no need to replace known and effective procedures and processes. By building on such an experience base, the development of an SMS will be less disruptive. During this review process, the planning team should also examine best industry practices for safety management by consulting with other transit properties of similar size and mission.

Safety assessment. The planning team should systematically question and challenge all aspects of the organization's current and planned approach to safety management. This should reduce the risk of surprises in implementing the SMS, enhance the group's knowledge of existing practices and requirements, and pave the way for effectively implementing the change.

Safety performance metrics and safety targets. The planning team should be involved in defining metrics for measuring safety performance, and setting safety performance targets and timelines for meeting these targets. Performance metrics provide the means for evaluating the success of SMS. Performance targets and timelines must be realistic taking into account the transit agency's size, modes of service, operating environment, resource base, etc. Detailed discussion of safety performance measurement is given in Chapter 4.

Safety strategy. The next task in the planning process is to develop a realistic strategy for meeting the safety performance targets. The strategy should include the types of safety processes and activities that will be addressed in the following steps. Depending on the number of new initiatives and programs being considered and the available resources, a phased approach may be desirable. Senior management's input should be sought during the development of the safety strategy.

The SMS plan. The end result of the planning phase is a detailed plan for the development and implementation of the SMS. Typically, the planning time frame will be one to three years. The plan should consider such aspects as safety objectives, safety strategy, safety management processes and activities, resource implications and time lines.

Table 3.2 Checklist 1 -- Planning

1. A safety planning team and safety manager have been designated.
2. The SMS planning team:
   - Possesses an appropriate experience base;
   - Meets regularly with senior management; and
   - Receives resources (including time for meetings).
3. The planning team develops a realistic strategy and implementation plan for the SMS that will meet the organization's safety targets.
4. Senior management endorses the SMS development plan.

Step 2: Safety Policy

The safety policy is a written document that reflects the organization's philosophy of safety management and outlines the methods and processes that the transit property will implement to achieve desired safety outcomes. A safety policy may take different forms but will typically include statements concerning:

- The safety objective(s) of the organization;
- A commitment by the organization to make the SMS one of its top priorities and to provide the necessary resources for the effective management of safety;
- Senior management's commitment to ensuring that all aspects of the operation meet safety performance targets; and
- The transit agency's policy concerning responsibility and accountability for safety at all levels of the organization.

In developing the safety policy, senior management should consult with and seek input from key staff members in charge of safety-critical areas. This gives them a sense of ownership. The safety policy should be communicated to all staff.

A sample corporate safety policy statement is included in Appendix 2. An alternative to this type of safety policy is a statement by the Chief Executive Officer expressing the organization's commitment to maintaining the highest standards of safety. Topics that are typically covered in statements of corporate safety commitment include the following:

- **Fundamental safety beliefs.** Our fundamental safety beliefs include:
  1. Safety is a core business value;
  2. Safety excellence is a key component of our mission;
  3. Safety is a source of our competitive advantage; our business will be strengthened by making safety excellence an integral part of all our public transportation activities; and
  4. Accidents and serious incidents are preventable and do not occur out of the blue; they are preceded by precursors (events, behaviors, and conditions) that were ingredients of the recipe for such accidents and serious incidents.

- **Basic elements of our safety approach**. The basic elements of our safety approach are:

  1. ***Top management commitment to safe operations:***

  - We are committed to developing, implementing, and improving strategies, management systems, and processes to ensure that all our public transportation activities uphold the highest level of safety and meet national and industry standards;
  - The ultimate accountability for our safety performance rests with the Chief Executive Officer and the Governing Board;
  - We will provide the necessary training to build and maintain meaningful safety leadership skills;
  - We will involve relevant staff in the decision-making process; and
  - We are committed to encouraging employees to report safety issues without reprisal.

  2. ***Responsibility and accountability of all employees:***

  - Senior management will hold line management and all employees accountable for safety performance;
  - Each of us will be expected to accept responsibility and accountability for our own behavior and actions;

- Safety performance will be an important part of our management and employee evaluation system;
- Before any work is done, we will ensure that each employee is aware of safety standards and processes, as well as his/her personal responsibilities toward safety; and
- We will recognize and reward excellent safety performance.

3. ***Clearly communicated safety goals:***
   - We are committed to the management of safety risk and the continual improvement in the level of safety;
   - We will have formal written safety targets, and we will ensure that everyone understands and accepts these targets;
   - Each of us will have an opportunity to participate in developing safety standards and procedures; and
   - We will have a communications and motivation system in place to keep our employees focused on our safety goals.

4. ***Responsibility of all employees:***
   - We will openly communicate information about safety incidents and hazards;
   - We will share the lessons learned with others; and
   - Each of us will be concerned for the safety of our customers, the general public, and other employees in our organization.

5. ***Safety assurance and measuring performance for improvement:***
   - Management will ensure that regular safety audits are conducted;
   - We will communicate the audit results and any corrective actions to all affected employees;
   - We will have clear safety metrics for measuring the safety performance of our organization, and
   - We will perform periodic reviews of our SMS to insure it remains relevant and appropriate to our organization.

Table 3.3 Checklist 2 -- Safety Policy

1. Senior management is committed to, and involved in, the SMS.
2. Senior management has approved the organization's safety policy, safety objectives, the SMS implementation plan, and operational safety standards. These are communicated to all staff, with visible endorsement by senior management.

Table 3.3 Checklist 2 -- Safety Policy (continued)

3. The safety policy:
   - Enjoys the commitment and involvement of all staff;
   - Aligns with other operational policies;
   - Provides direction for implementing the policy;
   - States the responsibilities and accountabilities for directors, managers, and employees;
   - Is reflected in the actions and decisions of all staff;
   - Has been communicated to all staff; and
   - Is reviewed periodically.
4. Safety objectives and goals are practical and achievable, and they are regularly reviewed for relevance.
5. Performance standards including acceptable behavior are established.
6. Responsibilities for actions and behaviors are clearly understood.
7. Managers follow through and hold those responsible to account for their progress towards the safety goals.
8. Appropriate resources are allocated to support the safety manager.
9. Senior management commits resources to correct hazards posing unacceptable risks.
10. Senior management has established an appropriate reporting chain for safety issues.
11. Senior management actively encourages participation in the various safety programs of the SMS.
12. Senior management promotes a positive safety culture whereby:
    - Safety information is actively sought;
    - Personnel are trained for their safety responsibilities;
    - Safety is a shared responsibility;
    - Safety-related information is disseminated to all affected personnel;
    - Potential system failures and hazards lead to prompt managerial inquiries and any necessary reforms;
    - A formal program is in place to regularly assess safety performance; and
    - New ideas related to improving safety are welcomed.

Step 3: Organizational Structure

A well-defined organizational structure aimed at facilitating safety management is crucial to accomplishing the objectives stated in the safety

policy. Considerations that support the SMS include appointing a safety manager, establishing a safety office, documenting safety responsibilities and accountabilities, and creating a safety committee. The organizational structure should be appropriate to the size, complexity and operating environment of the transit agency.

Safety manager (SM)

Regardless of the size of the transit agency, a safety manager (SM) should be designated as the focal point for implementing and maintaining the SMS. The SM's responsibilities include:

- Promoting safety awareness throughout the organization;
- Ensuring that safety documentation is current and accessible to all employees;
- Communicating changes in safety documents to all personnel;
- Monitoring the effectiveness of corrective actions;
- Providing periodic reports on safety performance;
- Rendering independent advice to the CEO, senior managers, and other personnel on safety-related matters; and
- Ensuring that safety management has a high priority throughout the organization.

Preferably, the SM should have no responsibilities other than safety. This would generally be the case in medium- and large-size transit agencies where a full-time SM position can be justified. In small agencies, safety management may be assigned to a manager who also has other duties. In such cases, in order to avoid possible conflicts of interest, it would be preferable that the person responsible for safety management does not also have direct responsibility for any of the operational, maintenance, or engineering areas.

Whether the SM position is a full-time one or forms only part of the responsibilities of the designated manager, the SM should be a member of the overall management team of the organization. Furthermore, the SM should be at a sufficiently high level in the management hierarchy of the organization to be able to communicate directly with the CEO and other senior managers. Figure 3.3 illustrates the recommended reporting hierarchy for an effective SMS.

Senior management must not hold the SM accountable for line managers' responsibilities or the safety performance of the organization. Rather, the SM is accountable for any deficiencies in the SMS itself and providing effective support to all line managers and staff to ensure the success of the organization's SMS. Top-level accountabilities may not be delegated, but

should be cascaded throughout the agency so that all aspects of safety are covered without gaps.

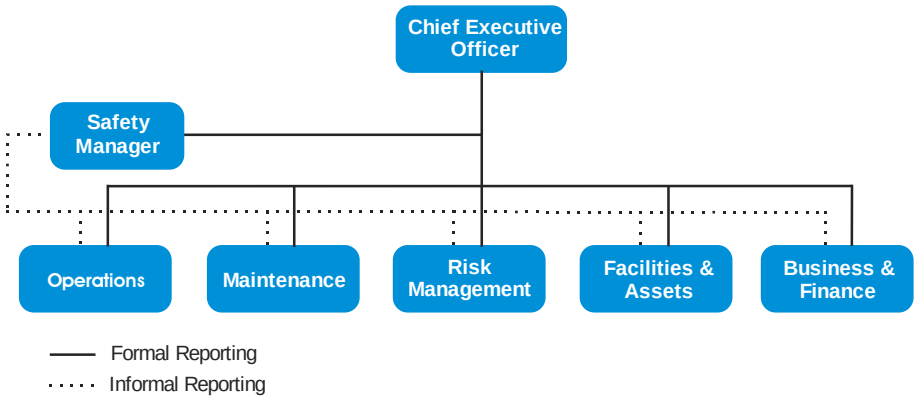

Figure 3-3 Reporting Lines to the CEO

To be successful, the SM is expected to have: 1) relevant operational or maintenance experience, 2) safety management and accident investigation training, 3) respect of the organization, and 4) leadership skills. Important attributes of the SM include:

- ***Personal example***. The SM must set an example for all employees, contractors, and management by upholding the highest standards of safety at all times.
- ***Courage of convictions***. The SM must be willing to stand up for safety and go against the tide if necessary. The need for change will not always be popular, either to management or to the affected employees.
- ***Consensus builder***. The SM must be capable of building consensus among key players and convincing them of the need for change. Often this will require compromise and conflict-resolution skills.
- ***Adaptable***. The SM needs to steer a fine course through ever-changing circumstances and priorities, judging when to speak out and when to accommodate.
- ***Self-starter***. The effective SM does not wait for accidents and serious incidents to happen. Consistent with a proactive safety culture, initiative is required to search out hazards, assess the associated risks, and provide argument for change.
- ***Innovative***. The SM must find innovative approaches to deal with problems of complacency, short cuts, and "work around".
- ***Firm but fair***. Effective leadership treats all people equitably and acts firmly in terms of what is required, but fairly in being sensitive to unique circumstance.

A sample job description for a safety manager position is included in Appendix-C.

Safety Office

A dedicated, suitably equipped office for the SM sends a message about the importance that senior management attaches to safety management and the role of the SM in the organization. The safety office serves as the focal point for safety-related activities, acts as a repository for safety reports and information, and provides expertise on safety management to line managers.

Regardless of its location within the organization, the safety office fulfils a variety of safety functions including:

1. Advising senior management on safety-related matters such as:
   - Defining responsibilities and accountabilities for safety;
   - Recommending resource allocations to support safety initiatives; and
   - Disseminating public communications on safety issues.
2. Overseeing hazard identification systems, for example:
   - Accident and incident investigations; and
   - Incident and hazard reporting.
3. Assisting line managers in:
   - Assessing identified risks; and
   - Selecting the most appropriate risk mitigation measures for those risks deemed unacceptable.
4. Managing safety databases.
5. Conducting safety analyses and monitoring of performance metrics.
6. Providing training on safety management methods.
7. Coordinating safety committee meetings.
8. Promoting safety by:
   - Sustaining awareness and understanding of the organization's safety management processes across all functional areas of the organization;
   - Disseminating safety lessons in-house; and
   - Exchanging safety information with other transit agencies and industry associations.
9. Reporting on safety to meet the requirements of:
   - Management (e.g. annual/quarterly review of safety trends and identification of unresolved safety issues); and
   - Federal, state and local agencies.

Safety committee

In large transit agencies with several modes of public transportation, safety issues often require inputs from several departments. Interdepartmental

communications and coordination can be enhanced by a safety committee that meets regularly and includes the SM as well as other senior managers. The committee may also include representation from key transportation safety stakeholders in the community including engineering, law enforcement, emergency services, and education.

The safety committee provides a forum for discussing safety-related issues from a broader viewpoint, identifying creative solutions to mitigate safety hazards, and assessing safety performance from a "system" perspective. Furthermore, the safety committee ensures the active involvement of senior management of the organization in the SMS. During the initial implementation phase of an SMS, the safety committee will also review progress of the implementation process.

The structure and charge of the safety committee should be documented in the organization's safety management manual.

Safety Responsibilities and Accountabilities

A formal statement of safety responsibilities and accountabilities of individual staff members is prudent, even in small transit agencies. This statement clarifies the formal and informal reporting lines on the organizational chart and specifies accountabilities for particular safety activities with no overlap or omission. The contents of the statement vary depending on the size and complexity of the organization.

Responsibilities for safety should be assigned based on the level of competence and training of the staff member concerned. The appropriate experience and training requirements for safety-related positions must be defined, monitored, and recorded. Line managers should be accountable for ensuring the continuing competence of the personnel in safety-related positions within their areas of responsibility.

All training, including that of contractor's staff, should explain the company's safety culture, how the SMS operates, and those aspects of the SMS and associated procedures that are relevant to the position in question.

Although individual staff members must be accountable for their own behaviors and actions, managers and supervisors are accountable for the overall safety performance of the group that reports to them.

Accountability is a two-way street. Managers are also accountable for ensuring that their subordinates have the resources, training, and experience needed for the safe completion of their assigned duties.

Table 3.4 Checklist 3 -- Organizational Structure

1. A safety manager with appropriate competencies, training, and capacity has been appointed.
2. The organizational structure facilitates:
   - Lines of communication between the SM, CEO, and middle/line managers; and
   - A clear definition of authorities, accountabilities and responsibilities of the management team, thereby avoiding misunderstanding, overlap, and conflict (e.g., between the SM and line management).
3. The roles and responsibilities of the individual staff members are clearly defined and documented.
4. Staff and management understand and support the roles of the SM.
5. A safety committee meets regularly to review safety issues, evaluate safety performance, and make recommendations to senior management.

Step 4: Safety Promotion and Training

Safety promotion is critical to the success of SMS by ensuring that the entire organization fully understands and trusts the SMS policies, procedures, and structure. It involves establishing a culture that recognizes safety as a "core value", training employees in safety principles, and allowing open communications of safety issues.

Safety Culture

The primary goal of safety promotion is to develop a "positive safety culture" that allows the SMS to succeed. Typically, a positive safety culture is:

1. **An informed culture**
   - Employees understand the hazards and risks involved in their areas of operation;
   - Employees are provided with the necessary knowledge, training and resources; and
   - Employees work continuously to identify and overcome threats to safety.
2. **A just culture**
   - Employees know and agree on what is acceptable and unacceptable behavior; and

- Human errors must be understood but negligence and willful violations cannot be tolerated.

3. **A reporting culture**
   - Employees are encouraged to voice safety concerns and to share critical safety information without the threat of punitive action; and
   - When safety concerns are reported they are analyzed and appropriate action is taken.
4. **A learning culture**
   - Learning is valued as a lifetime process beyond basic-skills training;
   - Employees are encouraged to develop and apply their own skills and knowledge to enhance safety; and
   - Employees are updated on safety issues by management and safety reports are fed back to staff so that everyone learns the pertinent lessons.

Positive safety culture must be generated from the top-down. Senior management must maintain a relentless drumbeat that safety-related activities are an inextricable part of everything we do. The actions, attitudes, and decisions at the policy-making level must demonstrate a genuine commitment to safety. Safety must be recognized as the responsibility of each employee with the ultimate responsibility for safety resting with the CEO and Governing Board. Employees must trust that they will have management support for decisions made in the interest of safety while recognizing that intentional breaches of safety will not be tolerated.

Training

During the initial implementation of an SMS, specific training will be required for all employees, including contract staff, to explain the agency's safety culture and describe how the SMS works. The SM is the logical resource person for providing a corporate perspective on the organization's approach to safety management. Once the SMS is fully implemented, safety training needs will depend on the safety responsibilities of the individual staff members and the nature of the tasks performed. Table 3.5 lists the topics to be included in safety management training.

Table 3.5 Safety Management Training

Initial safety training for all staff
1. Basic principles of safety management including the integrated nature of SMS, risk management, safety culture, and so forth;

Table 3.5 Safety Management Training (continued)

2. Corporate safety philosophy, safety goals and objectives, safety policy, and safety standards;
3. Importance of complying with the safety policy and SMS procedures, and the approach to disciplinary actions for different safety issues;
4. Organizational structure, roles and responsibilities of staff in relation to safety;
5. Transit agency's safety record, including areas of systemic weakness;
6. Requirement for ongoing internal assessment of organizational safety performance (e.g. employee surveys, safety audits, and assessments);
7. Reporting accidents, incidents, and perceived hazards;
8. Lines of communication for safety matters;
9. Feedback and communication methods for the dissemination of safety information; and
10. Safety promotion and information dissemination.

Safety training for operations personnel

1. Unique hazards facing operational personnel;
2. Seasonal safety hazards and procedures (e.g., winter operations);
3. Procedures for hazard reporting;
4. Procedures for reporting accidents and incidents; and
5. Emergency procedures.

Safety training for management

1. Principles of the SMS;
2. Management responsibilities and accountabilities for safety; and
3. Legal issues (e.g., liability).

Training for Safety manager

1. Familiarization with different transit modes, types of operation, routes, and so forth;
2. Understanding the role of human performance in accident causation and prevention;
3. Operation of SMS;
4. Investigating safety occurrences;
5. Crisis management and emergency response planning;
6. Safety promotion;
7. Communication skills;
8. Performing safety audits and assessments;
9. Monitoring safety performance;
10. NTD incident reporting requirements; and
11. Computer skills such as word-processing, spreadsheets, database management, and statistical analysis.

Transit agencies should have processes for monitoring, maintaining, and improving upon the competency of its staff and managers in relation to safety. The appropriate experience and training requirements for safety-related posts must be defined, monitored, and recorded.

Competency and subsequent refresher training can be provided through formal safety courses and/or structured development in the workplace. Regardless of their experience level, all employees benefit from feedback on hazards identified, safety actions taken, safety lessons learned, and the like.

Table 3.6 Checklist 4 -- Safety Promotion and Training

1. Senior management emphasizes that safety is paramount to everything we do.
2. Management recognizes that all levels of the organization require training in safety management principles.
3. Job descriptions reflect competency requirements.
4. Staff is aware of the elements of SMS that are pertinent to their duties.
5. Staff understands that safety management has nothing to do with attributing blame.
6. Employees understand that SMS is not an added burden; it is an important tool for business survival.
7. All personnel receive specific ongoing training depending on their job responsibilities.
8. The organization has an effective program for the timely promotion of safety issues.

Step 5: Hazard Identification and Risk Management

As discussed in Chapter 2, managing the risks associated with safety hazards involves three essential elements: hazard identification, risk assessment, and risk mitigation. This requires the analysis and elimination (or at least reduction to an acceptable level) of those hazards that threaten the safety of passengers, employees, and the general public.

Establishing effective hazard identification programs is fundamental to safety management. Hazard identification can be reactive or proactive in nature. Occurrence reporting, incident investigation and trend monitoring are essentially reactive. Other hazard identification methods actively seek feedback by observing and analyzing routine day-to-day operations. Common hazard identification activities include:

- Safety assessments;
- Trend monitoring;
- Hazard and incident reporting;
- Safety surveys;
- Safety audits; and
- Evaluating customer suggestions and complaints.

The practice of reporting and learning from accident precursors is a valuable complement to other hazard identification practices.

According to the Heinrich pyramid discussed in Chapter 2, the number of near-miss incidents, known as precursors, is significantly greater than the number of accidents for comparable types of events. Because the causal and contributory factors associated with close calls can culminate in serious accidents, every precursor event is, therefore, an opportunity to develop and apply knowledge to avoid accidents. Unfortunately, precursor incidents may not be known to those responsible for eliminating the hazard or reducing its risks. Too often, after an accident occurs, hands-on employees note that they "knew about that unsafe condition." For some reason, however, they did not report the perceived hazards, perhaps because of fear of self-incrimination or retaliation, not being sufficiently motivated to report incidents, or lack of effective reporting system. The practice of reporting and learning from accident precursors is a valuable complement to other hazard identification practices.

To be successful, hazard identification must take place within a non-punitive and just safety culture.

To be successful, hazard identification must take place within a non-punitive and just safety culture. Management's interest should be in systematic safety improvements by discovering and learning of potential weaknesses in the system's safety. If employees operate in a climate of fear of punishment for normal slips, lapses and mistakes in their daily duties, errors and unsafe conditions are likely to remain hidden. Blame is only an issue when individuals are culpable of reckless or negligent behavior. A sample company policy on non-punitive hazard reporting is shown in Appendix-D.

Once hazards have been identified, they must undergo an assessment to determine their potential consequences. Factors to be considered are the likelihood of occurrence, the severity of the consequences should there be an occurrence, and the level of exposure to the hazard. Risks may be assessed subjectively by experienced personnel using a risk assessment matrix similar to the one shown in Figure 2.3. Alternatively, they may be assessed using more analytical, objective techniques which are beyond the scope of this report. The chosen method must be clearly documented in the safety management manual.

Results of the risk assessment process will help determine whether the risk is being appropriately managed or controlled. If the risks are acceptable, the hazard needs to be monitored. If the risks are unacceptable, steps should be taken to lower the risk to an acceptable or tolerable level, or to remove or

avoid the hazard. As discussed in Chapter 2, the agency may choose from a range of risk control measures (physical, administrative, and/or behavioral). Having decided upon a course of action, management must then communicate the safety concerns and planned actions to all affected persons.

The hazard identification and risk assessment log shown in Figure 3.4 can be used to provide a record of the identified hazards and the actions that should be taken. The recommended action must be addressed by a specified individual, typically the appropriate line manager responsible for addressing that particular risk, and a target date for completion must be given. Entries in the log should not to be cleared until the required action is completed. The hazard log and action completion records should be retained permanently by the SM.

Risk Code	Generic Risk Type	Risk Description	Current Measures to Reduce Risk	Risk Rating[1] L	Risk Rating[1] S	Risk Rating[1] Value	Further Actions Required to Reduce Risk	Responsibility
C-5	Human Error	Non-compliance with agency maintenance procedure.	1. Minimum competency requirements. 2. Effective safety culture in agency (maintenance department). 3. Effective task planning 4. Availability of procedures 5. Procedure reviews and simplification into tasks 6. Recurrent training	5	4	20	1. Introduce compliance monitoring 2. Effective supervision including work compliance assessment 3. Competency assessments 4. Maintenance policy to reinforce need for compliance	Safety Assurance Line Manager Maintenance Manager Maintenance Manager

1. L = Likelihood, S = Severity, Value = L x S

Figure 3.4 Hazard Identification and Risk Assessment Log

Legal concerns may deter transit agencies from collecting reports about safety problems and inhibit the use of precursor data. For example, showing that an organization knew about a particular precursor but did not take corrective action could increase the organization's liability in the event of an actual accident. Under current law, precursor reports generated prior to an accident are often considered discoverable evidence after an accident. As a result, some organizations may be reluctant to establish formal precursor reporting programs. For example, they may rely on oral, rather than written, notification of observed precursors. A recent collaborative project between the Federal Railroad Administration (FRA), the Volpe Center, and the Bureau of Transportation Statistics has been designed to demonstrate the feasibility of Confidential Close Call Reporting System (C3RS) [53].

Incentives to encourage precursor management could include monetary or other rewards for transit properties that institute programs for identifying and collecting data on precursor events. For example, insurance companies could reduce premiums for companies that try to manage their risk through the systematic use of precursor information.

Failure to take notice of the safety lessons learnt at other transit properties is a sign of trouble ahead.

Finally, sharing of safety information across transit agencies is important because serious accidents in some transit systems are likely to be preceded by similar but less-serious precursor events in other transit systems. Because of a lack of effective information exchange, the organization that experiences the eventual accident is often unaware that others have learned from and acted upon related precursor events. Failure to take notice of the safety lessons learnt at other transit properties and to build a strong knowledge-management system is a sign of trouble ahead.

Table 3.7 Checklist 5 -- Hazard Identification and Risk Management

1. Formal mechanisms for the systematic identification of hazards (such as safety assessments and safety audits) are in place.
2. An occurrence reporting system is in effect.
3. Management has provided adequate resources to support hazard identification programs including staff training.
4. Competent personnel administer the hazard identification programs.
5. Management fosters a non-punitive and just environment -- employees involved in reported incidents are aware that they will not be penalized for normal errors.
6. Hazard identification data are systematically analyzed and saved.
7. Criteria are established for assessing identified safety risks.
8. Risks are analyzed and ranked by competent personnel.
9. Viable risk control measures are evaluated.
10. Management takes action to mitigate the risks.
11. Actions taken to eliminate or mitigate identified hazards are communicated to staff.
12. Procedures are in place to confirm that the actions taken are working as intended.
13. Significant safety concerns potentially affecting other transit agencies are shared across industry.

Step 6: Occurrence Investigation and Analysis

Knowledge-based safety management is dependent on the investigation and analysis of safety issues and occurrences (accidents, hazards and precursor incidents). The knowledge obtained from these investigations can be thought of as fuel for the safety-improvement engine.

Identifying the lessons to be learned from a safety occurrence requires an understanding of not just *what* happened, but *why* it happened. Safety

investigations should, therefore, look beyond the obvious causes and focus on identifying all the contributing factors, some of which may be related to organizational issues. The knowledge gained from safety investigations is proportional to the quality and rigor of the investigative effort.

The knowledge gained from safety investigations is proportional to the quality and rigor of the investigative effort.

Serious accidents are often investigated by experienced accident investigation teams from federal and state agencies. The NTSB is an example. The team examines the evidence, performs analysis of probable and contributory causes, and prepares a final report with recommendations.

Non-serious accidents and close calls do not warrant investigations by either federal or state investigative authorities. Nevertheless, such occurrences should be properly investigated in-house. Depending on the nature of the occurrence being investigated, the in-house investigating team may require the assistance of specialists such as maintenance engineers for incidents involving material or vehicle failures, smoke or fire, etc.

Safety investigations and the various hazard identification programs will result in safety data that must be checked for accuracy and completeness; and analyzed to identify trends and monitor safety performance. Many of the analytical techniques and tools used in safety analysis are based on statistical procedures and concepts. For example, risk analysis utilizes the concepts of statistical probability. Statistics help quantify situations by providing insight through numbers. However, data reduction to simple statistics (e.g., average, percentiles, etc.) serves little useful purpose without evaluation of the practical significance of these statistics in order to provide convincing arguments for change.

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Most statistical analysis procedures are available in commercial software packages (e.g., Microsoft Excel). Although these software packages do not require detailed knowledge of the statistical theory behind the technique, the analyst should understand what the procedure does and what the results are intended to convey.

When misused, statistics can lead to erroneous conclusions. Care must be taken in the selection and use of statistical analysis methods.

Table 3.8 Checklist 6 -- Occurrence Investigation and Analysis

1. Key members of operational staff have received formal training in safety investigations.
2. Each hazard and incident report is evaluated with further safety investigation as necessary.

Table 3.8 Checklist 6 -- Occurrence Investigation and Analysis (continued)

3. Management supports the acquisition and analysis of safety data.
4. Safety data are subjected to quality control checks.
5. Management takes an active interest in the findings of safety investigations and applies risk management procedures to identified hazards.
6. Safety lessons learned from safety investigations are widely disseminated.
7. The SM is experienced in analytical methods or has access to competent safety analysts.
8. Analytical tools (and specialist support) are available to support safety analyses.
9. Other information sources (e.g., maintenance records) are accessible.
10. Safety performance data are routinely monitored and analyzed.
11. Safety analyses are subject to peer review to ensure that appropriate analysis methods are followed.
12. Safety recommendations are made to management, and corrective actions are taken and tracked to ensure that they are appropriate and effective.

Step 7: Safety Documentation and Information Management

Safety information represents a valuable asset that requires careful management to serve the SMS activities across the organization.

Operating an SMS generates large amounts of information on a routine basis, some as documents and some as data in paper or electronic format. This information represents a valuable asset that requires careful management to serve the SMS activities across the organization. Without the proper tools and skills to organize, catalog, store, maintain, secure, and retrieve the necessary information, such information is essentially useless and its collection is a waste of time.

A well-maintained safety database is an essential tool for managing safety data. The sophistication of the database depends on the amount of data collected; which in turn depends on the agency size and the number of service modes operated. A simple spreadsheet may be adequate for rural and small urban systems, while a more sophisticated database will likely be needed for a medium-sized system. Large transit systems may require an information management system to integrate the data collected by various agency departments.

A safety management manual (SMM) is required to document safety management procedures and how they relate to the organization's safety policy. The manual should provide the guidance necessary for incorporating the organization's safety activities into a coherent, integrated safety system. The SMM should be kept as short and concise as possible.

The SMM should be a living document, reflecting the current status of the SMS. Significant changes to the SMS will require an update of the SMM. In addition, the SMM should specify procedures for controlling changes to safety documents (e.g., periodic reviews of documents) and the means for communicating these changes to all personnel. Any information that changes regularly should be put into appendices (e.g., names of personnel assigned specific safety responsibilities).

It is important that the organization maintains records of the measures taken to fulfill the objectives of the SMS (e.g., actions taken to control risks or ensure that adequate levels of safety are maintained). These records should be maintained by the SM in sufficient detail to ensure traceability of all safety-related decisions.

Table 3.9 Checklist 7 -- Safety Documentation and Information Management

1. Management supports the need for safety documentation and information management.
2. The SMS is well documented in a safety management manual.
3. Documents are updated regularly and are readily available to those who need them.
4. Procedures for controlling changes in safety documents are implemented and obsolete documents are promptly removed.
5. A safety database has been developed to organize, catalog, store, maintain, and retrieve safety-related data.
6. The safety database is used to support safety analyses and performance monitoring.
7. Staff has received the necessary training for using and maintaining the safety information management system.
8. Appropriate staff has access to safety databases.
9. Credible measures have been taken to protect and secure sensitive safety information.
10. Computers, software, equipment, and technical support are available for managing safety information.

Step 8: Emergency Preparedness and Response

Although emergency preparedness and response are usually associated with managing disasters, the concept is also applicable to major accidents and critical incidents experienced in day-to-day operations. In this context, an emergency is considered to be an event that could cause major harm or disruption to normal operations (e.g., weather, fires, power outage, loss of communications, computer system failure, train derailments, major collisions, and the like).

An Emergency Response Plan (ERP) is required to outline what should be done when an emergency event occurs, what to do after the occurrence, and who is responsible for each action. The ERP must be readily available at the work stations of those who may be the first to be notified or required to respond. The plan should assign responsibilities to specific individuals; provide emergency procedures; control the notification of outside agencies; nominate channels and centers of communication; provide for in-house emergency response; and outline effective liaison with accident investigators and outside emergency services. In addition, methods for communicating with the public in the event of a critical incident should be covered in the plan.

Once the ERP has been formulated, it is important to ensure that the staff is adequately trained in the procedures that will be employed in the event of a serious accident or critical incident. The ERP should be rehearsed regularly to familiarize staff and to reveal any problems. There should also be routine testing of emergency systems; and all testing, training and rehearsals should be recorded and appropriate action taken if deficiencies are identified.

Table 3.10 Checklist 8 -- Emergency Preparedness and Response

1. An emergency response plan is in place and available at work stations.
2. Employees have been briefed on the plan and their responsibilities.
3. Staff received training on how to respond to emergencies.
4. Emergency response plan is periodically tested.
5. Emergency systems are tested on a regular basis.

Step 9: Safety Assurance

Safety assurance, one of the cornerstones of safety management, provides the necessary feedback for ensuring that the SMS is functioning effectively and that the transit agency is meeting or exceeding its safety objectives. This is

achieved through safety audits, surveys of employees, and analysis of safety performance metrics.

Safety auditing involves a systematic and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled. The audit process subjects each area of the transit property's safety system to critical, objective examination including management policy and practices, operating procedures, training, hazard identification, emergency procedures, etc. The aim is to disclose the strengths and weaknesses, as well as the main areas of vulnerability and risk. Auditing goes beyond inspection, which is limited to an examination of actual conditions, and is typically considered to be a line management responsibility.

Safety audits may be conducted internally by the transit property, or by an external safety auditor. The audit should be carried out by a team of people who are competent, objective, and with a reasonable degree of independence from the department or unit being audited.

Internal safety audits should be performed on a regular basis in accordance with an established safety audit program. The program should follow a cycle that ensures each functional area with safety responsibilities is audited as a part of the organization's safety assurance plan. The audits include formal or informal observations and inspections of day-to-day activities in all safety-critical areas, workplace safety, reviews of progress made on safety action plans, training, and surveys of employees' views on safety. The criteria against which the audit will be conducted should be specified in advance. Checklists may be used to identify what is to be reviewed during the audit in sufficient detail in order to ensure that all intended tasks and functions are covered. The extent of the checklists will depend on the size and complexity of the transit agency being audited.

External safety audits may be performed by the State Safety Oversight Agency (SSOA), or by a professional organization such as APTA. Audits may be scheduled or unscheduled and they provide means for ensuring that:

- The structure of the SMS is sound in terms of appropriate staffing levels; compliance with approved procedures and instructions; and a satisfactory level of competency and training to operate equipment and facilities and to maintain their levels of performance;
- Safety-sensitive employees and contractors are compliant with workplace safety policies including drug and alcohol polices, fatigue management, and medical fitness;
- Equipment performance is adequate from a safety standpoint;

- Safety occurrences are reported;
- Identified safety issues are addressed promptly;
- Effective processes exist for promoting safety and monitoring safety performance; and
- Adequate plans and arrangements exist to handle foreseeable emergencies.

For an external audit to be successful, the cooperation of the personnel of the unit or department being audited is essential. The safety audit program should be based on the following principles:

- The objective of the audit is to gain knowledge for continuous improvement; any suggestions of blame or punishment will be counterproductive;
- The audited agency should make all relevant documentation available to the auditors and arrange for staff to be available for interview as required;
- Facts should be examined in an objective manner;
- A written audit report describing the findings and recommended corrective actions should be presented to the subject unit or department within a specified period (e.g., 30-45 days);
- The staff of the unit or department, as well as the management, should be given an opportunity to provide feedback regarding the findings of the audit;
- While deficiencies must be identified, negative criticism should be avoided to the extent possible. Positive feedback should be provided by highlighting in the report the good points observed during the audit; and
- The need to develop a plan to resolve deficiencies within a specified time period should be required.

Corrective actions should be agreed upon with senior management. Implementation of the action plan must be monitored, and follow-up audits should focus on the adequacy of the implemented actions.

In addition to audits, safety assurance relies on safety performance metrics to validate the effectiveness of SMS in achieving the organization's safety objectives. These metrics can be used to evaluate trends in safety performance in terms of the number or rate of accidents, incidents or casualties over a given time frame.

Performance measurement and metrics are discussed in greater detail in Chapter 4 of this report.

Safety assurance does not need to be extensive or complex in order to be effective. Smaller organizations may find available tools such as the Internal Evaluation Program Audit tools produced by the Medallion Foundation (http://www.medallionfoundation.org) to be a good foundation for their organization's safety assurance processes.

Table 3.11 Checklist 9 -- Safety Assurance

1. Internal and external safety audits are conducted regularly in all safety-critical areas of the organization including the activities of contractors.
2. Staff input is sought through safety surveys without fear of repercussion.
3. Audit findings are communicated to staff, and corrective actions are implemented as required to strengthen the system.
4. A safety performance measurement system is implemented and adequate resources are allocated to safety performance monitoring functions.

Step 10: Management of Change

Change is constant in transit properties; introduction of new equipment and technologies, system expansion and modification, changes in operational requirements and maintenance procedures, and organizational changes are examples. Management of change (MOC) is the process of evaluating and controlling modifications to the configuration, design, operation, maintenance, or organization of a transit property prior to implementing such changes. The objective of MOC is to ensure that no new hazards are inadvertently introduced and that the risks of existing hazards are not unknowingly increased. MOC entails thoughtful planning and consultation with, and involvement of, the staff affected by the changes.

The objective of MOC is to ensure that no new hazards are inadvertently introduced and that the risks of existing hazards are not unknowingly increased.

MOC reviews should be performed by qualified personnel who are knowledgeable of safety standards and risk assessment procedures. Based on this review, and after addressing any additional requirements, an authorized party either approves, amends, or rejects the change.

Prior to implementation, potentially affected personnel should be made aware of the change, and if needed, provided with more detailed training. Affected safety documents and training records should be modified to reflect the change.

Table 3.12 Checklist 10 – Management of Change

1. Levels of management with authority to approve changes are designated.
2. Changes in system configuration, design, equipment, operating conditions, or maintenance procedures are analyzed.
3. Potential hazards associated with a proposed change are identified, and their risks are assessed and managed.
4. Maintenance and operations manuals are updated with latest changes.
5. Personnel are made aware of, and understand, any changes.
6. Affected personnel received necessary training.

3.7 Summary

Safety Management is at the forefront of methods by which transit properties can make public transportation, already the safest form of surface travel, even safer. The key feature is the move beyond the traditional reactive processes to those which try to identify potential hazards through objective assessment of risks in operations, maintenance and construction activities, and applying operational knowledge and professional judgment to mitigate these risks. Launching and sustaining a successful SMS requires a positive safety culture and senior management commitment to safety. Hazard identification must take place in a non-punitive and just culture to encourage employees to communicate safety concerns freely. Management's interest should be in the systematic safety improvements by learning of potential weaknesses in the system's safety.

CHAPTER 4

SAFETY PERFORMANCE MEASUREMENT SYSTEMS

As discussed in Chapter 3, safety assurance is a critical component of the safety management process; it provides feedback for assessing the system's performance so that necessary actions can be taken to affect the desired levels of safety. This, however, requires a clear understanding of how safety performance will be evaluated, i.e., what metrics will be employed to assess system safety and determine if the safety management system is working properly? Having decided on the metrics by which success will be measured; safety management requires embedding these metrics in the organizational culture and encouraging their use for ongoing performance improvement.

While it is possible to improve safety performance without measurement, for example, by gut feel, by experience, and so on, one cannot do so reliably and repeatedly.

Transit agencies have been collecting safety-related data for more than three decades to report on their safety performance to local, state, and federal agencies. Over 650 of the nation's public transportation providers submit safety data to the National Transit Database (NTD) program routinely by service mode [2]. These data are used by the FTA to construct metrics, and track trends in the overall safety performance of the transit industry.

Nevertheless, there appears to be widespread consensus that most transit properties do not make effective use of the data they collect to measure their own performance and improve their bottom line on safety. While it is possible to improve performance without measurement, for example, by gut feel, by experience, and so on, one cannot do so reliably and repeatedly. Performance measurement is an essential ingredient for sound performance management. Measurement is the antidote to ambiguity; it brings clarity to vague concepts, helps transit agencies identify performance gaps, and forces management and governing boards to take action to improve performance.

Measurement is the antidote to ambiguity; it brings clarity to vague concepts.

This chapter begins with a discussion of the types of performance measures and definitions of basic terms used in safety performance measurement (SPM). Good practices in designing a safety performance measurement system ((SPMS) are presented based on extensive literature review. The focus of this chapter is on a comprehensive ten-step framework for developing, implementing, and sustaining an SPMS. Each of these steps is discussed in detail with practical tips for ensuring the success of the performance measurement effort. The chapter also includes a discussion of

the major findings of a survey of the U.S. transit industry regarding the use of safety performance measurement.

4.1 Types of Performance Measures

Performance can be measured in terms of inputs, outputs, outcomes, and efficiency among many other criteria. Following are brief descriptions of basic terms used in performance measurement:

Input: Resources (expenditures or employee time) used to produce outputs and outcomes. Some organizations mistakenly equate the availability of resources with success. Although data on program inputs are of interest for comparing resources across departments or organizations, they do not provide information on performance or what was accomplished with these resources.

Most transit properties don't make effective use of the data they collect to measure their own performance and improve their bottom line on safety.

Output (or process): Amount of work completed or services delivered by the organization or by its contractors (such as vehicle-hours of operation, miles of track inspected, maintenance jobs completed, number of customers receiving safety information, number of transit vehicle operators who completed specific type of training, etc.).

Outcome: An event, occurrence, or condition that is outside the activity or program itself and is of direct importance to program users or the public (such as fatalities, injuries, property damage, etc.).

Intermediate outcome: An outcome that is expected to lead to a desired end result but is not an end result in itself (such as reduction in risky behavior, decrease in operational errors, etc.). A program may have multiple intermediate outcomes.

End outcome: The end result that is sought (such as reduced incidence of fatalities or serious injuries resulting from transit vehicle collisions). A program may have more than one end outcome.

Efficiency: The ratio of input to output.

Goal: Description of a desired, long-term, widespread impact of an activity or program (e.g., provide safe and secure public transportation across all transit modes).

Objective: Specific, quantifiable statement clearly related to a goal and stating a desired direction (e.g., "reduce the rate of injuries").

Performance measure (metric): A numerical indicator that is used to gauge one aspect of program performance. Performance metrics can be either *outcome* or *output* measures.

Performance measurement: The regular systematic collection, analysis and reporting of data that track resources used, work produced, and whether specific outcomes were achieved. In other words, it is a tool to quantify and improve performance, and engage and communicate with agency staff and external stakeholders. Performance measurement has two core functions: monitoring and evaluation (M&E).

Performance Targets: The quantifiable levels of performance metrics that an organization wants to accomplish by a given time in order to realize performance goal and objectives. For example, the target for transit fatalities might be 0.448 per 100 million passenger miles by the year 2011. Performance targets can be stated for either outcomes or outputs.

Figure 4.1 illustrates the input-output-outcome chain. The use of performance measurement as a means to inform performance management has evolved from a monitoring of money spent (*inputs*) to monitoring of what the money bought (*outputs*), and more recently, the emphasis has shifted to monitoring *outcomes*, i.e., the end state that we wish to move towards (e.g., less traffic casualties) [37].

Performance measurement has evolved from a monitoring of money spent (inputs) to monitoring of what the money bought (outputs), and more recently, the emphasis has shifted to monitoring outcomes, i.e., the end state that we wish to move towards.

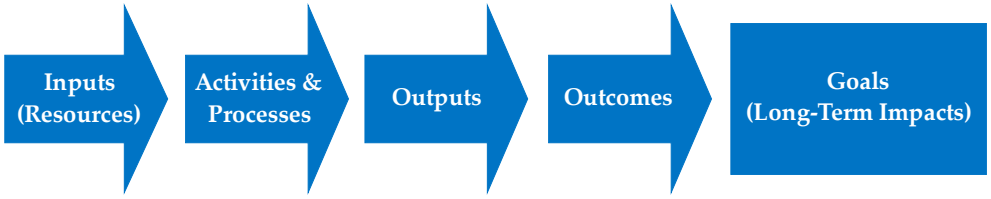


Figure 4.1 The Input-Output-Outcome Chain
(Adopted with modifications from reference 7)

Osborne and Gaebler noted two basic lessons that have been learnt by organizations that developed performance measurement systems. First, when public agencies set out to measure performance, managers tend to focus on what their agencies do, that is, the level of output of a certain process [11]. Although process measurement can be useful, *outputs* do not guarantee *outcomes*.

The second lesson has to do with distinguishing between measuring *efficiency* and measuring *effectiveness*. Efficiency is a measure of how much each unit of output costs; whereas effectiveness is a measure of the quality of that output, i.e., how well did it achieve the desired outcomes that are both controllable by the organization and important to program users. Both efficiency and effectiveness are important. The problem arises when organizations measure only outputs and efficiency – as too many do. People may be pleased that their public transportation system costs less per passenger than comparable

systems in other cities, but if their system has a poor safety record, they are not likely to be pleased for long.

A blend of outcome measures and output measures may be preferable to using either type alone.

With the growing experience in performance measurement, it appears that a blend of *outcome* measures and *output* measures may be preferable to using either type alone. The rationale for this argument stems from balancing customers' expectation for outcome-related performance metrics with the agency's need for useful output measures that can help managers make decisions. For example, the public is more likely to notice and relate to outcome measures such as system-wide accident or casualty rates. But the transit agency needs to know specific information on such things as high-accident locations, track condition, vehicle maintenance, violations of established operating policies, and so forth. Transit agencies can, therefore, use a mix of outcome, output, and efficiency measures that are tailored to meet their safety management information needs.

Some have argued that safety is an outcome that public transportation agencies can influence but do not have full control over. For example, they cannot control other driver behavior in a shared right-of-way, pedestrian actions at a grade crossing, or the weather – important contributors to collisions. Is it fair to hold the transit agency accountable when such external factors can influence system safety? In such cases, performance measures should be defined to reflect those aspects of safety that are controllable by the agency, for example, accidents caused by operational errors, deficiencies in safety-related operating practices, design factors, etc.

4.2 Good Practices in Designing SPMS

Designing an effective safety performance measurement system requires adherence to some basic principles, listed in Table 4.1 [1, 10, 11, 33, 37]:

Table 4.1 Characteristics of Effective SPMS

• Stakeholder involvement and acceptance
• Focus on agency goals and activities
• Clarity and precision
• Credibility and robustness
• Variety of measures
• Number of measures
• A hierarchy of measures
• Forward-looking measures
• Integration into agency decision-making
• Timely reporting
• In context
• Realism of goals and targets

The following sections provide more detail on these principles.

Stakeholder Involvement and Acceptance

Performance measures should be developed in consultation with key stakeholders and decision-makers including transit agency's management, staff, customers, governing body, service contractors, and oversight organizations. Acceptance by these stakeholders is critical to the long term viability and success of the performance measurement program.

A performance measurement program initiated without input from and support of those who will be held accountable for meeting targets is likely to fail or, at a minimum, the metrics will not be used effectively.

Experience shows that a performance measurement program initiated without input from and support of those who will be held accountable for meeting targets is likely to fail or, at a minimum, the metrics will not be used effectively. The best way to deal with the fear and resistance surrounding performance measurement is to bring employees, middle managers, and contractors into the process of selecting and defining the appropriate measures. To take performance metrics into heart, employees have to buy into the value of these metrics -- to feel that they provide useful, relevant information that will help improve the safety of the transit system.

Focus on Agency Goals and Activities

Performance metrics should reflect the goals and objectives articulated in the agency's safety policy and strategic and business plans. The point of performance measurement is not just to measure but to help gauge the degree of success in achieving these goals, identify performance gaps that require attention, and facilitate fact-based decision-making. The selected metrics should be appropriately balanced between those measures of outcome, output, and input.

Clarity and Precision

The meaning of performance metrics should be clear and their linkage to goals should be easily recognized. This will help their acceptance by stakeholders al all levels. Developers of performance measures should avoid complex analytical constructs when simpler ones would suffice.

When a metric is not unambiguously defined, different audience will interpret it the way that works well for them.

Precision refers to how carefully and exactly a metric is defined so that there will be no doubt or dispute about it. This is important so that employees responsible for collecting and analyzing performance data know precisely what to do. For example, "vehicle-hours" or "vehicle-miles" can be interpreted in more than one way depending on whether the vehicle is in revenue service. Similarly, for rail transit, "vehicle- miles" can be directional route miles or track miles. Experience shows that when a metric is not unambiguously defined, different audience will interpret it the way that

works well for them. The units of measure should also be included in the definition of a metric.

Credibility and Robustness

The designers of performance measures should be objective in the selection of metrics, that is, avoid the temptation of using metrics that will inevitably make the organization, its people and managers look good. The selection of metrics should be based on how accurately and fairly those metrics assess agency performance and gauge the level of success in achieving goals.

Employees in charge of gathering performance data and analyzing performance should not permit their self-interests to affect the accuracy of the results.

Another aspect of credibility is the extent to which a metric can be manipulated or gamed by people with something at stake. Those involved in developing performance measures should be conscious about this type of undesirable behavior. Employees in charge of gathering performance data and analyzing performance should not permit their self-interests to affect the accuracy of the results.

The integrity of performance measures is linked to the agency's credibility which is critical in the political process. It takes a long time and a lot of effort to establish credibility with the public, policy makers, and other external stakeholders. Credibility can be lost quickly if inaccurate metrics are presented or if attempts are made to cover up problems.

Variety of Measures

An effective tactic to avoid undesirable behaviors and manipulation of performance measures is to institute multiple metrics rather than just a single metric. For instance, measuring just the "number of fatalities resulting from preventable collisions" can lead to classifying pedestrians as trespassers; measuring just the "percent of total safety audit/review findings for which approved corrective actions have been successfully implemented" can lead to documenting only those findings that are easy to implement. The individual metrics used by the transit agency must be viewed as part of a system of related measures and competing operational metrics (such as "on-schedule" and "speed violations") should be balanced.

Number of Measures

One of the challenges that face developers of performance measures is separating the vital few measures from the trivial many. Although there are no hard and fast rules about the right number of measures, experience shows that relying on the smallest set of well-targeted metrics that provides the necessary performance information for decision-making generally is better. The need for a variety of measures must be balanced to avoid confusing the

end users about priorities and overloading them with superfluous data to sift through to find the key drivers of safety improvement.

A Hierarchy of Measures

The level of detail about safety performance should be tailored depending on the type of audience and the expected use of performance information. For example, the information needs of staff or program managers will differ from those of the governing body or the public.

It is best to employ a small set of core, high-level performance metrics that focus on performance outcomes and key safety-related activities as the backbone of a hierarchical measurement system. These select metrics will be shared by stakeholders at all levels and used for external reporting. More detailed, operational measures will be available for diagnostics and decision-making at the mid-management and staff levels. Ideally, the few high-level measures should be linked to the more detailed operational measures with a drill-down capability to provide the supporting details as needed. For instance, the rate of serious injuries resulting from collisions might be reported to senior management, governing board, and the public, but operations and maintenance departments will have more detailed measures that relate to their department's influence on collisions. This hierarchy of measures helps all employees in the transit property see themselves in the big picture.

It is best to employ a small set of core, high-level performance metrics that focus on performance outcomes and key safety-related activities as the backbone of a hierarchical measurement system.

Desktop database, spreadsheet, and GIS tools as well as more specialized analysis software can be utilized to summarize performance measures for different parts of the transit system (e.g., bus, light-rail, etc.). In addition, they can provide a drill-down capability to allow the user to explore conditions at different levels of geographic aggregation (e.g., different bus routes, rail stations, grade crossings, etc.). Furthermore, breakdown of performance metrics by key classes of accidents and incidents (e.g., collisions involving other vehicles, pedestrians, etc.) can be easily produced.

In developing an SPMS, it is not necessary to begin with a comprehensive program. Many organizations have been successful in beginning with a few metrics, then building slowly on initial successes.

Forward-Looking Measures

A well-designed SPMS should include forward-looking metrics that provide early warnings of potential deterioration in future safety performance. Metrics that tell fatality rate for last month are helpful in establishing trends and comparing actual performance against targets, but this is after-the-fact information; discovering that a target has been missed does not allow

preventing it. Therefore, it is critical to include metrics that capture near misses and precursor events to help predict future performance and develop countermeasures. For example, finding out that there has been an increase in operational errors in a given month allows measures to be implemented to minimize serious incidents during the following month.

Integration into Agency Decision-Making

There is little value in even the best-designed performance metrics unless they are used systematically to inform decision-making and drive safety improvement.

There is little value in even the best-designed performance metrics unless they are used systematically to inform decision-making and drive safety improvement. Once the SPMS is in place, performance results should be evaluated carefully to gain insight into the success of past efforts and develop ideas for improving future performance.

Allocating the organization's limited resources -- people and money -- makes priorities real. Setting priorities without allocating sufficient resources to achieve them tells staff and middle managers that the organization was not serious about those priorities in the first place. In addition, if employees are unmotivated or lack the skills needed to act on the priorities, they will not deliver the performance required to achieve the targets.

Timely Reporting

Timely analysis and reporting of performance results is important to managing safety. When the goals are not met, performance data should be carefully examined to identify and react to problem areas as quickly as possible.

In Context

In reporting performance results, it is desirable that the metrics be accompanied by contextual information that provide fair and balanced explanation of the results and allow the reader to reach an informed conclusion. For instance, exogenous factors beyond the agency's control could lower performance below target levels.

Realism of Goals and Targets

The designers of SPMS should be cautious in setting performance targets to make sure that they are neither too ambitious nor too easy to achieve. Unrealistic targets can impact the usefulness of the program and frustrate managers and employees, since no reasonable amount of effort can raise performance to the target level. This is particularly important when external factors that are not under the agency's control have a substantial impact on performance results. For example, even the best executed safety

management program probably cannot eliminate serious injuries in a given transit property.

Conversely, performance is not likely to improve when targets are easy to achieve based on historical performance levels. Being ambitious and introducing a "stretch" factor has benefits to encourage managers and employees to find ways to continually improve performance.

4.3 Ten Steps to Building and Sustaining an SPMS

The process of building and sustaining a successful safety performance measurement system involves a sequence of ten steps as shown in Figure 4.2. These steps, in order, are:

1. Getting Started -- Conducting a Readiness Assessment;
2. Agreeing on Outcomes & Activities to Monitor;
3. Selecting Key Metrics;
4. Identifying Data Needs;
5. Pilot Testing and Collecting Baseline Data on Metrics;
6. Setting Targets;
7. Monitoring Performance and Evaluating Results;
8. Reporting Findings;
9. Integrating Findings into Agency Decision-Making; and
10. Sustaining the Performance Measurement System.

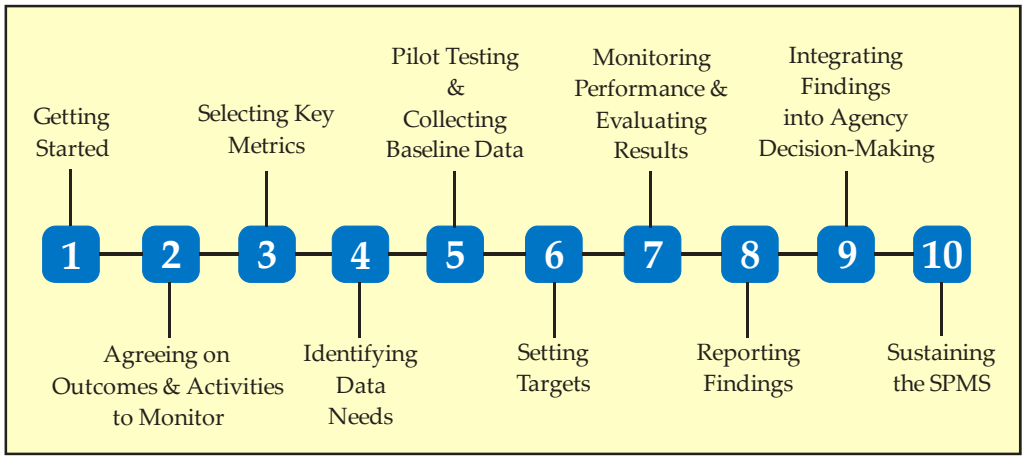


Figure 4.2 Ten Steps to Building and Sustaining an SPMS
(Adopted with modifications from reference 6)

Although the process presented in Figure 4.2 visually appears as linear, in reality it is iterative and involves feedback loops. The results from virtually all of these steps will influence the others, and one will inevitably go back

and forth along the steps, or work on several steps simultaneously. For instance, if a transit property encounters problems in step-5 "Pilot Testing and Collecting Baseline Data on Metrics," there should be a feedback loop that directs the SPMS developers back to steps 3 and 4.

Step 1: Getting Started

Building an SPMS requires some preparatory work to assess the organization's readiness. The objective of this initial step, shown in Figure 4.3, is to remove any barriers that can potentially stand in the way of effective SPMS implementation. Key questions to consider include:

- Does the agency's leadership understand the need for an SPMS? Is management committed to supporting the SPM effort?
- Who will champion the SPM initiative?
- Who will use safety performance data? Who will own the SPMS?
- Where does capacity exist within the organization to support the SPMS?

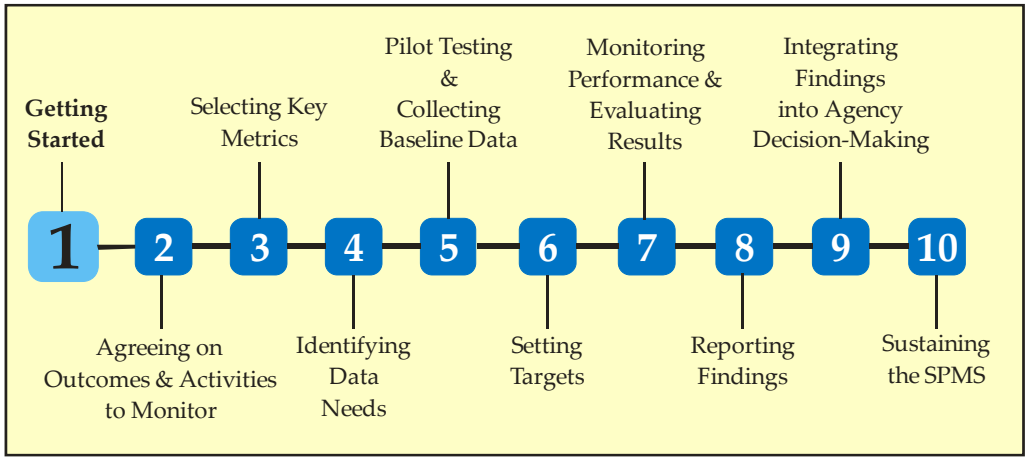


Figure 4.3 Step-1: Getting Started

Sustained support and commitment of senior management are essential for the SPM effort to take hold and become a vehicle for continuous safety improvement.

Generating Management Support

Sustained support and commitment of senior management are essential for the SPM effort to take hold and become a vehicle for continuous safety improvement. Filling performance gaps will require outcome-linked decision-making and allocating the resources needed to implement the safety improvement strategy.

Educating senior management and the governing board about the power of and the driving forces for measuring safety performance will provide a solid foundation for building a sustainable SPMS. The transit agency's leadership

must understand the role that performance measurement plays in safety assurance and the value of performance metrics to inform decision-making.

A particularly effective tactic to get management "on-board" is to have senior managers and the board members involved in developing and shaping the SPMS. By keeping them informed and soliciting their feedback throughout the different phases of the 10-step process, they will have a better understanding of performance measurement.

Finding High-Level Champion(s)

Having high-level individual(s) within the organization who will champion the SPM initiative is critical to the success and sustainability of SPMS. The champion(s) will advocate the need for performance-based decision-making and help overcome any internal resistance. To be viable, the champion must be in a position close to the center of decision-making. The safety manager should be one of the SPM champions.

Identifying Users and Stakeholders

Understanding the concerns, priorities, and perspectives of stakeholders will help tailor an approach that gains their acceptance and support.

Identifying the users of safety performance data will help design an SPMS that is responsive to their needs. The SPMS will eventually affect employees, managers, customers, members of the governing body, service contractors, and oversight organizations. Understanding the concerns, priorities, and perspectives of these stakeholders will help tailor an approach that gains their acceptance and support.

Assessing Existing Organizational Capacity

The organization's readiness for building an SPMS depends on the available resources, data systems, skills, and experience. Senior management must publicize their support for the SPM initiative and the move toward results-based decision-making. Internal and external data sources that will be available to the program must be identified and the quality of existing data must be understood. Some transit properties may lack the technical skills needed for building an SPMS. However, this is not an insurmountable obstacle. Industry organizations, universities, and training centers can assist with developing the necessary technical capacity.

Step 2: Agreeing on Outcomes & Activities to Monitor

Setting safety goals and objectives is part of strategic planning and establishing safety policy. All transit agencies have safety goals, although not all define their goals clearly. Goals are generally descriptions of desirable long-term impacts, such as the U.S. DOT safety strategic goal "Enhance the

Public Health and Safety by Working toward the Elimination of Transportation-Related Deaths and Injuries." Having clearly defined safety goals is crucial to establishing SPMS.

From goals we move to outcomes; the critical success factors that show us what success looks like. For example, the U.S. DOT has two key safety outcome statements: reduction in transportation-related deaths and reduction in transportation-related injuries.

The second step in building an SPMS is to reach an agreement among stakeholders on the outcomes and processes that will be monitored. This is shown in Figure 4.4. As discussed earlier, performance measurement should go beyond a mere summary of program activities and focus on the outcomes of these activities. Having a blend of both outcomes and outputs will serve the needs of the different stakeholders.

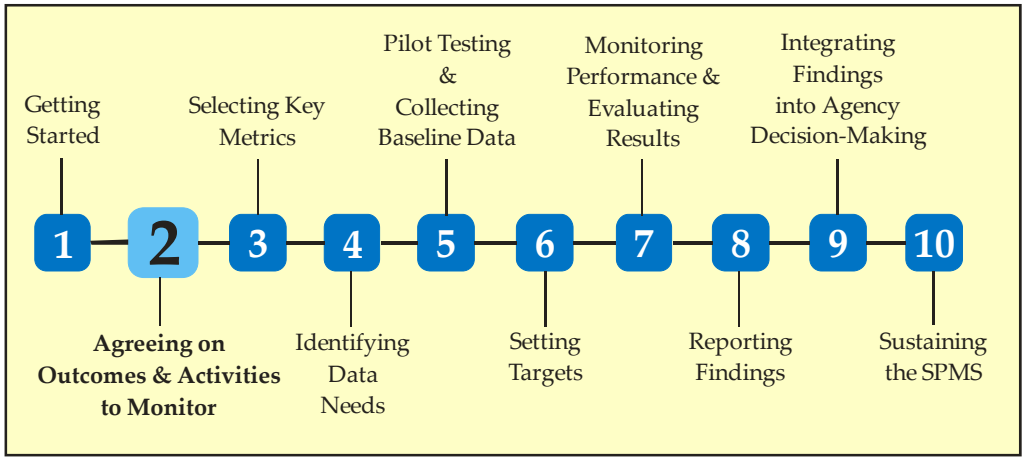


Figure 4.4 Step-2: Agreeing on Outcomes & Activities to Monitor

Tips for Choosing Outcomes and Activities to Monitor

- Build a collaborative and participatory process involving key stakeholders. This can be accomplished by holding meetings with agency staff and managers, convening a focus group with representatives of different transit stakeholders, working with an established citizen's advisory committee, and conducting public meetings to gather information on community concerns. While meeting with agency's employees and other stakeholder groups, stress the importance of active participation by everyone. Brainstorm effectively to generate as many ideas as possible without judging them. List all ideas and concerns exactly as they are expressed on a flip chart or pieces of paper that are tacked to a pin board.

- Translate safety concerns and issues into statements of possible outcome improvements**.** Frame outcome statements positively by using action verbs such as "Increase," "Reduce," "Initiate," "Improve," "Become," "Achieve," and so on. This helps distinguish the action-oriented nature of outcome statements from the simple reiteration of the problem. An outcome-oriented statement guides one to identify the road and destination ahead. Keep outcome statements simple and avoid jargon. Ensure a shared understanding of the meaning of outcome statements among employees and stakeholders.

- Disaggregate outcome statements to capture the key desired outcomes. Work with employees and stakeholders to distill the key outcomes from each outcome statement. This will identify the critical success factors to be monitored, and eliminate confusion later when one develops performance metrics.

- Verify the relevance of the selected outcomes to the agency's goals and objectives**.** How consistent is each outcome with the transit property's safety goals? Can these outcomes be linked to the core safety objectives and values?

- Ensure that the relevant transportation safety outcomes included in the U.S. DOT strategic plan are included in the safety outcomes of the transit property.

- Identify the key activities and processes that impact safety. In keeping with the internal needs for information to manage safety, work with agency staff and managers to reach a consensus on the critical activities and processes to be monitored.

Deciding on the outcomes to be monitored is the first phase in constructing the performance matrix. Table 4.2 illustrates the performance matrix after populating it with example safety outcomes. Performance metrics, baselines, and targets will all follow this initial phase of establishing outcomes.

Table 4.2 Performance Matrix -- showing selected outcomes

Outcomes	Metrics	Baselines	Targets
Reduce transit-related fatalities			
Reduce transit-related injuries			
Reduce risks of injuries to employees			

Table 4.2 Performance Matrix -- showing selected outcomes (continued)

Outcomes	Metrics	Baselines	Targets
Accelerate development of safety culture			
Improve workforce core competencies and skills			

Step 3: Selecting Key Metrics

Having agreed on the outcomes and activities to be monitored, the next step (Figure 4.5) is to develop a set of measurable performance metrics that will be used to assess the progress made toward achieving the desired outcomes. These metrics can also be utilized to measure the changes in performance connected to specific action or intervention.

The selected metrics should be well-thought through and there should be no doubt or dispute about the logic and rationale for each metric.

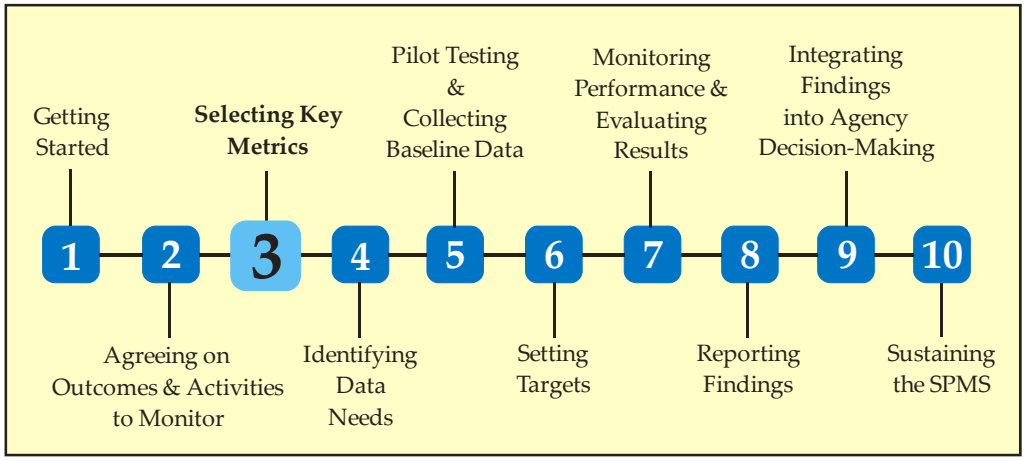


Figure 4.5 Step-3: Selecting Key Metrics

As shown in Figure 4.5, metric development drives subsequent data collection, target setting, analysis, and reporting. Therefore, the selected metrics should be well-thought through and there should be no doubt or dispute about the logic and rationale for each metric. Performance metrics should not be changed often, as this can cause problems in data collection and make it difficult to evaluate performance trends.

As with agreeing on outcomes, the interests of all stakeholders should be taken into account when selecting metrics. At a minimum, there should be metrics that directly measure the desired outcomes. Metrics that are intended for monitoring activities and processes have to be relevant to the

employees and managers, because the focus of SPMS is on performance improvement.

By monitoring performance metrics on a regular basis, managers and employees can determine whether the results of their programs and processes are on track or off track in terms of reaching set targets and achieving outcomes. Performance information presents an opportunity for the transit property to detect performance shortfalls early and implement corrective actions.

Analytic Forms of Performance Metrics

The three most common forms of performance metrics are:

- A number -- for example, total number of collisions, total number of fatal accidents, average time to implement the findings of safety inspections, etc.
- A rate -- for example, fatalities per 100 million passenger-miles traveled, crashes per 100 million vehicle-miles, etc.
- A ratio or percentage -- for example, ratio of fatal to nonfatal collisions, preventable accidents to non-preventable accidents, percent of collisions occurring at rail grade crossings, etc.

Designers of performance metrics should consider including two forms of metrics: 1) number and 2) rate or percentage. According to Hatry [43], "the number of successes (or failures) in itself does not indicate the rate of success (or failure). The percent by itself does not indicate the size of the success. Assessing the significance of an outcome typically requires data on the number and percent."

As shown in Table 4.3, knowledge of either the number or rate of preventable fatalities alone is not sufficient to describe the problem. Both the number and rate are needed to assess performance.

Table 4.3 Using Number and Rate of Fatalities to Describe Performance

Transit Agency	Number of Preventable fatalities	Passenger-miles traveled (millions)	Fatalities/ million passenger-miles traveled
A	5	10	0.50
B	5	100	0.05

Tips for Developing Performance Metrics

Developing performance metrics should be guided by the principles discussed earlier in section 4.2 "Good Practices in Designing SPMS." Many

of the points made bear repeating because ignoring them will lessen the effectiveness of SPMS.

Deciding what to measure

- Start with the desired outcomes. For each outcome, list two or three key metrics that would best describe the progress made toward achieving that outcome. Include both number and rate/ratio forms of each metric.
- There may be dozens of programs, activities, and processes that a transit agency must undertake to meet its safety goals. Identify the five to ten programs and processes that are absolutely vital to ensure safety of customers, employees and the public.
- Disaggregate metrics as appropriate. Provide breakouts of performance metrics by key classes or categories. For example, collisions can be disaggregated into collisions with pedestrians, collisions with other vehicles, and collisions with other objects. Limit the number of classes to the two or three that are most important for each metric.
- Include forward-looking metrics that capture accident precursors. This can provide useful information regarding future performance.
- Consider availability and reliability of data. A performance metric is useless unless up-to-date and accurate data can be gathered at reasonable cost to calculate the value of that metric on regular basis.
- Include the safety performance metrics developed by the U.S. DOT and the FTA in the transit agency's metrics. This ensures consistency and harmonization across the transit industry, and permits comparisons with peer transit agencies.
- Account for external, uncontrollable factors that can affect outcomes.
- Keep the number of metrics to the minimum required to manage toward the desired outcomes.

Measuring the right way

- Phrase your performance metrics in clear and specific language -- such as "number of bus collisions per month." Different users should interpret the metric in the same way.
- Establish well-defined procedures and guidelines for the data collection process (what data elements to collect and how to collect them) and the calculation methodologies.
- Use multiple metrics to avoid undesirable behaviors and manipulation of performance data.

Examples of Safety Performance Metrics

TCRP Report 88 "A Guidebook for Developing a Transit Performance-Measurement System" includes discussion of performance metrics for a variety of transit-related subjects ranging from operating efficiency to safety and security [1]. Although the report does not focus on safety performance measurement in particular, it presents good examples of safety performance metrics as shown in Table 4.4.

Table 4.4 Examples of Safety Performance Metrics [1]

Category	Examples of Metrics
Passenger safety	• Number of fatalities and fatality crashes per specified time period. • Number of injuries and injury crashes per specified time period. • Fatal accidents per million passenger-miles/vehicle-miles traveled.[1,2, 3] • Injury accidents per million passenger-miles/vehicle-miles traveled. [1,2, 3] • PDO accidents per million passenger-miles/vehicle-miles traveled.
Workplace safety	• Employee work days lost to injuries (by injury type) per specified time period. • Work-related fatalities per specified time period. • Workers compensation payments per specified time period.
Accident Potential	• Percent of positive drug/alcohol tests per specified time period. • Number of traffic tickets issued to bus (or paratransit vehicle) operators per specified time period. • Percent of buses (or paratransit vehicles) exceeding the speed limit per specified time period. • Number of rail station overruns per specified distance or time period. • Number of unplanned revenue service road calls per specified distance or time period.
System Safety	• Number of vehicle defects reported by operators per specified time period. • Number of infrastructure defects reported by operators per specified time period. • Number of fires per specified time period (measured by location: stations, vehicles, or guideways; by cause: faulty electrical wiring, arson, etc.; and in terms of severity). • Liability losses (by category of loss) per specified time period. • Customer satisfaction ratings (measured through well-designed market surveys).

Table 4.4 Examples of Safety Performance Metrics [1] (continued)

Category	Examples of Metrics
Maintenance	• Percent of preventive maintenance inspections completed within 10% of scheduled mileage.
Other	• Miles between traffic accidents. • Accidents per 100,000 vehicle-hours

1 Metric can be disaggregated by cause (e.g., injuries resulting from collisions vs. slips and falls).

2 Accident rates can also be expressed in terms of passenger boardings.

3 Use of fatality rates and injury rates per 100 million passenger-miles traveled is recommended for consistency with U.S. DOT metrics.

Table 4.5 illustrates the performance matrix discussed in the previous step after adding the performance metrics.

Table 4.5 Performance Matrix -- showing selected metrics

Outcomes	Metrics	Baselines	Targets
Reduce transit-related fatalities	• Fatalities per 100 million passenger-miles traveled.		
Reduce transit-related injuries	• Injuries per 100 million passenger-miles traveled.		
Reduce risks of injuries to employees	• Employee work days lost to injuries (by injury type) per month.		
Accelerate development of safety culture	• Number of safety improvement ideas submitted by employees per quarter. • Number of employees attending weekly safety meetings. • Number of close calls reported per month.		
Improve workforce core competencies and skills	• Percent of employees scoring 85% or higher on standardized competency tests.		

Step 4: Identifying Data Needs

After selecting the metrics that will be used to monitor performance, the next step (Figure 4.6) is to identify the data required for calculating and updating the metrics. The effectiveness of SPMS hinges on the availability of quality data. If performance data are unreliable, then the conclusions drawn by converting such data into performance metrics also will be unreliable and will have reduced value in managing safety. For this reason, great care should be taken in the collection and management of performance data to ensure accuracy, completeness, and consistency.

If performance data are unreliable, then the conclusions drawn by converting such data into performance metrics also will be unreliable and will have reduced value in managing safety.

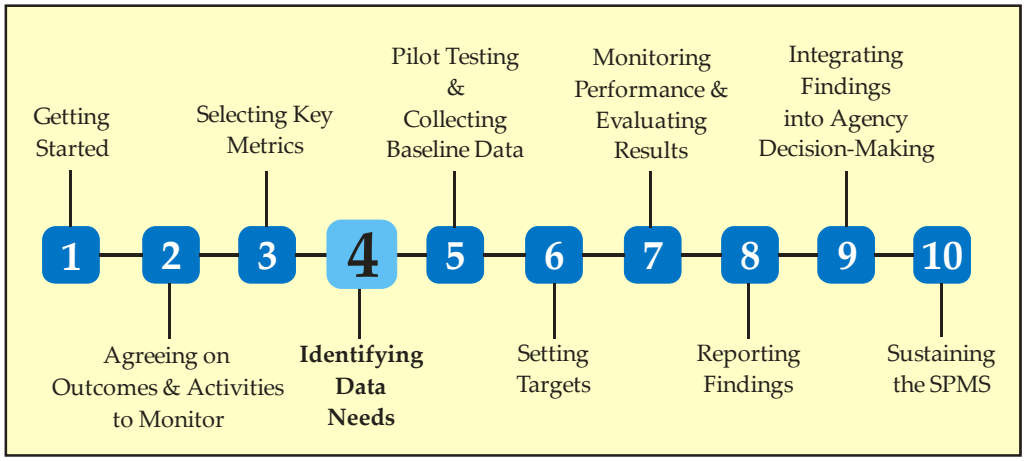


Figure 4.6 Step-4: Identifying Data Needs

To streamline the data collection process, a clear data collection plan should be developed to address the following questions:

1. What are the data elements required to calculate each metric?
2. What are the sources of data?
3. What are the data collection methods and instruments?
4. Who will own (collect and manage) the data?
5. How often will the data be collected to update performance metrics?
6. What are the known issues or concerns related to data quality, cost, or difficulty to collect the data?
7. What specific actions are needed to ensure data quality both initially and on an ongoing basis?
8. Who will analyze the data? What are the types of charts and graphs to be used? What are the types of comparison to be made and the calculation methodology?
9. Who will use the data?

Table 4.6 is a convenient method for summarizing the answers to the above questions for each metric.

Table 4.6 Data Collection Plan Summary

Metric	Data Elements	Data Source	Data Collection Method	Data Owner	Schedule for Updating	Known Issues	Actions Required	Who will analyze data?	Who will use data?
1	1 2 3								
2									
3									

Converting Metrics to Data Elements

Data elements are the individual pieces of data that are required to calculate the value of a metric. In most cases, the name of the metric will identify the data elements involved such as the "number of injuries per million passenger-miles traveled" during a specified time period. In this case, the data elements are "number of injuries" and "number of passengers- miles traveled." Yet, clear definitions of terms (such as the threshold defining "injury"), and clear explanation of how "passenger-miles" are determined will be needed to ensure consistency in data collection and reporting.

Standardization helps minimize subjectivity, maximize objectivity, and ensure accuracy and repeatability.

To promote consistency in reporting to the National Transit Database (NTD), standard definitions of data elements have been developed by the FTA and are included in a "data dictionary." Transit agencies should strive to adhere to these standard definitions in data collection efforts. Furthermore, precise procedures and guidelines should be instituted for the calculation methodologies. Standardization helps minimize subjectivity, maximize objectivity, and ensure accuracy and repeatability. Standardized data also are necessary for finding comparable peer agencies.

Identifying Data Sources

For most metrics, written or computerized records kept by the transit agency are likely to be the primary source of information. Nevertheless, some data may be needed from the records of other outside entities. When identifying data sources, one should consider the ease of accessing the data source on a regular and timely basis and the quality of the data available.

In-house data systems include accident and incident records, maintenance records, operations logs, schedule data, system maps, performance audits, alcohol and drug testing reports, training completion reports, competency test results, complaint records, and results of interviews and surveys with system users and agency's employees.

For NTD electronic reporting purposes, transit operators collect data on four major categories of transit accidents: 1) collisions, 2) derailments/buses going off the road, 3) personal casualties, and 4) fires. These major categories are

divided into subcategories. For example, the collisions category comprises collisions with vehicles, objects, and people (except suicides). Transit agencies report fatalities, injuries, accidents, incidents, and property damage in excess of a specified dollar amount. Certification from the agency's Chief Executive Officer must accompany NTD reports along with an independent auditor's statement. Although data submitted to the NTD are generally considered accurate, the reliability of these data varies because some transit properties cannot obtain accurate information or misinterpret data.

Outside the transit agency, departments of public safety, police departments, city/county/state transportation and traffic departments, and universities may also provide some of the necessary data. For instance, local public works departments and state departments of transportation are good sources of traffic data (traffic volumes, traffic speeds, inventories of traffic control devices, traffic signal timing information, and so forth). The geographic information systems (GIS) maintained by local planning organizations can be very helpful in analyzing data spatially.

Developing Data Collection Procedures and Instruments

Well defined procedures for gathering the necessary data from each source will be needed to guide the data collectors. Ideally, these procedures should be standardized throughout the transit industry to ensure consistency and facilitate comparisons with peer agencies.

According to Fielding, the reliability of in-house data varies depending on the type of data; financial data are the most reliable, whereas passenger-miles are the least reliable [20]. The reliability of manually-collected data depends on the training of data collectors and the amount of time they devote to collecting the data.

Data collection instruments should be prepared to facilitate recording the collected data properly. These instruments can be paper forms or computerized templates. For each data element, there should be a fixed amount of precision and a schedule for updating its value.

When computers are used to record the various data elements, performance metrics can be computed automatically from these data. Computer-generated checks of the keyed information should be programmed to ensure validity of the data.

Managing Performance Data

Performance data must be managed as any other asset. Each data element must have an owner who is responsible for collecting, checking, reporting and updating the information.

The different data elements need to be organized in a database for analysis, reporting, and archiving. An Excel spreadsheet should be adequate for rural and small urban transit systems, while a more sophisticated database will likely be needed for medium-sized and large systems.

Performance measurement is not synonymous with data collection.

Performance measurement is not synonymous with data collection. While quality data are prerequisite for effective SPMS, there are many agencies that have plenty of data but cannot or do not put the data to good use. The success of SPMS depends on a host of other activities including integrating data from different sources for analysis and mapping, transforming raw data into meaningful metrics, examining trends, identifying gaps in performance, and providing such information to decision makers in a useful and timely manner.

Transit agencies should take advantage of available visualization technology. For example, digital photos and video clips can be integrated with GIS-based inventory of assets to identify damaged or missing assets. This system can also be used to identify accident hot spots and analyze accidents in context with the built environment, traffic control devices, and so forth.

Step 5: Pilot Testing & Collecting Baseline Data

The data sources and data collection methods developed in step-4 should be pilot tested to identify and remedy potential problems prior to the full deployment of SPMS. Pilot testing helps ensure that the data elements are available from the identified sources, the right data will be collected, and the data collection methods and instruments will work as intended. Figure 4.7 illustrates this step.

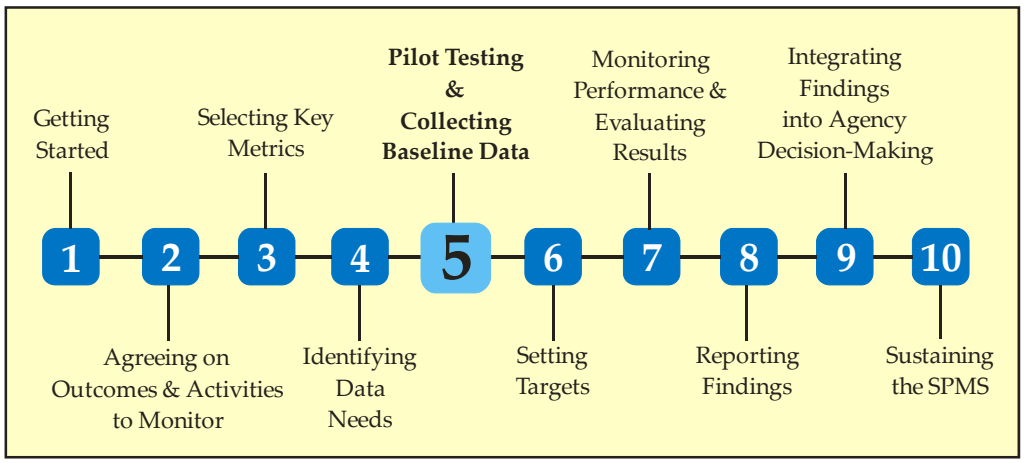


Figure 4.7 Step-5: Pilot Testing and Collecting Baseline Data

Once the agency is confident that their data collection program works properly, baseline performance data should be collected to establish a reference point for each metric. The baseline is the initial measurement of a metric. It sets the present levels of performance and conditions which are needed for determining performance targets and measuring progress made toward achieving desired outcomes.

The baseline is the initial measurement of a metric.

Table 4.7 illustrates the performance matrix discussed in earlier steps after adding the baseline data.

Table 4.7 Performance Matrix -- showing baseline data

Outcomes	Metrics	Baselines	Targets
Reduce transit-related fatalities	• Fatalities per 100 million passenger-miles traveled.	0.74 in 2009	
Reduce transit-related injuries	• Injuries per 100 million passenger-miles traveled.	3.96 in 2009	
Reduce risks of injuries to employees	• Employee work days lost to injuries (by injury type) per month.	8 on average for injury type xyz in 2009	
Accelerate development of safety culture	• Number of safety improvement ideas submitted by employees per quarter. • Number of employees attending monthly safety meetings. • Number of close calls reported per month.	1 in 4th quarter, 2009 3 on average in 2009 0 on average in 2009	
Improve workforce core competencies and skills	• Percent of employees scoring 85% or higher on standardized competency tests.	50% in 2009	

Step 6: Setting Performance Targets

After deciding on the metrics that will be used and gathering baseline data on them, the next step is to establish performance targets – the quantifiable levels of the metrics that a transit property wants to achieve by a particular

date or period of elapsed time. Unlike the use of continuous but nonspecific improvement goals over time, the use of performance targets helps identify performance gaps, which can then be analyzed to determine their root causes. This step is shown in Figure 4.8.

Each indicator is expected to have only one target over a specified time frame, [6].

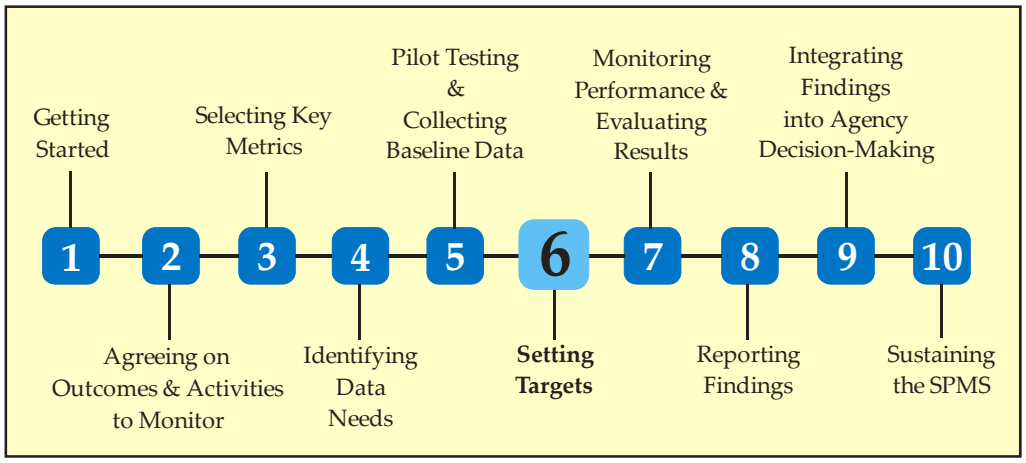


Figure 4.8 Step-6: Setting Performance Targets

Targets are interim steps (milestones) on the way to an outcome and eventually to a longer-term goal, [6].

Most targets are established on an annual basis, but some could be set for a shorter time period (e.g., quarterly), and yet others for a period longer than a year. However, setting targets more than five years in advance is not recommended because there are many unknowns that could affect performance (e.g., demographic trends, technological developments, future resources available, etc.).

Multiyear targets usually include an annual increment in addition to the cumulative value. For example, the U.S. DOT Strategic Plan 2006-2011 specifies a cumulative level for transit fatalities of 0.448 per 100 million passenger-miles traveled by 2011. In addition, the 2006, 2007, and 2008 targets were set at 0.477, 0.473 and 0.468 fatalities per 100 million passenger-miles traveled, respectively [3].

Targets may be expressed either in absolute or relative terms. The U.S. DOT targets for transit fatalities are examples of absolute targets. Relative targets incorporate a desired percentage reduction in a baseline value of accidents or particular types of safety occurrences within a defined time period. For instance, a transit property may determine that an acceptable level of safety will be achieved by specifying such safety performance targets as: reduce passenger injuries by x% in the next 12 months against the baseline; reduce the number of operational errors by y% in the next 12 months against the baseline; and so forth.

Performance measurement experts agree that targets should be "SMART", where the SMART acronym stands for some variant of Specific, Measurable, Achievable, Relevant, and Time-based:

Specific: Targets spell out precisely what is to be achieved;

Measurable: One should be able to prove that the target has, or has not, been reached. The metric for which the target has been set must use data that can be easily collected and updated over the duration of the target's timeframe;

Achievable: Targets should be realistic with a "stretch" factor built into them to encourage managers and employees to search for ways to continually improve performance. People will loose confidence in the performance measurement system if no reasonable amount of effort can raise performance to the target level. Being realistic in setting targets is particularly important during the first year, since measurement program will provide data for the next round of targets;

Relevant: Targets should take into consideration the particular operating and political environment of the transit property, available resources, and the impacts of external factors that are beyond the agency's control;

Time-Related: Targets must have deadlines for accomplishing them.

The success of a target should be measured not simply in terms of the achievement of the nominated value of the specified indicator, but in light of the progress achieved towards fundamental objectives, [6].

Tips for setting performance targets

Practical tips for establishing performance targets include the following:

- Consider past and present performance data and performance trends in setting targets. Historical data on a particular metric can be analyzed to establish a baseline and determine trends that can be utilized for setting targets for future performance. It is important to have a clear definition of the baseline; for example, last year's performance, an average of the last three years' performance, average trend, and so forth. Having decided on the baseline for a given metric, one can determine the target by including the desired level of improvement over a specified time period, that is,

  $T_i = B_i \pm \Delta P_i$

  Where:
  T_i = target for performance metric i,
  B_i = baseline value for performance metric i, and
  ΔP_i = desired level of improvement in performance metric i.

  For example, suppose a transit agency wants to set a target for buses exceeding the speed limit over the coming twelve months, and the percent of bus operators who exceed the speed limit climbed from 8% to 15% over the previous two years. Using last year's performance as a baseline, an appropriate target in this case could be to reduce the percent of buses exceeding the speed limit from 15% to 10% in the next year.

- Involve employees and others who will be held accountable. Acceptance by those closest to the action is critical since they are in the best position to provide information on the possible improvements in their work and the resources needed to accomplish these improvements. Involvement of these stakeholders will help gain their buy-in as they feel a sense of ownership in the process of setting the target levels.

  However, it is important not to rely completely on these sources alone since they may underestimate what can be achieved. Employees and middle managers may be timid of "setting the bar too high" and not being able to meet an ambitious target.

- Consider industry standards. A survey of the performance standards and performance statistics (averages, percentiles, etc.) published by the transit industry organizations will provide useful information regarding the safety performance expectations.

  For instance, if industry standards for a particular mode of transit call for 100% of preventive maintenance completed within 5% to 10% of scheduled mileage, those figures may serve as a reasonable target for the preventive maintenance metric.

- Consider peer comparisons. Benchmarking or comparison with similar peers can provide useful information on the levels of performance that are being achieved by these agencies. For a given metric, the target can be set based on the average value of the peer agencies, or alternatively, some percentile value (e.g., 85th percentile performance level).

  For benchmarking purposes, transit agencies should be classified into peer groups for which comparisons are meaningful. Agencies in a given peer group should have similar operating and political environments (e.g., city sizes, demographics, climate, transit modes, labor costs, etc.). The Florida Transit Information System (FTIS) software, developed by the Lehman Center for Transportation Research at Florida International University, can be used to help identify potential peer agencies [48]. When reviewing the standards of other agencies, it is important to understand how these agencies define their metrics. For instance, the rate of passenger injuries could be defined as *passenger injuries per 100,000 passenger boardings*, *passenger injuries per million passenger-miles of travel*, or *passenger injuries per million vehicle-miles of travel*. Furthermore, how peer agencies define "injury" can affect comparisons.

- Consider national targets. The U.S. DOT has been praised for its work in establishing national objectives, metrics, and targets for transportation safety performance, particularly transportation-related fatalities. Aligning agency targets with these nationally-based targets is highly desirable

because of their political significance; there are political ramifications for not meeting these targets. The federal government finances a significant share of the capital investment in the nation's transit systems. Therefore, it makes sense for Congress and U.S. DOT to seek ways to measure the effectiveness of these investments in terms of safety and service quality.

- Consider a range instead of a single value in setting targets for new metrics. When good baseline data are not available for a particular metric, it is recommended to use a range instead of a firm value for the target. The target does not have to be a single numerical value.

- For instance, in 2009, one might set a target for enforcing operating rules that states "by 2010, 85 to 90 percent of all vehicles will be equipped with crash-proof video and voice recorders."

- Gather feedback from customers and other stakeholders. Information regarding the expectations of these groups might yield insights that can help in establishing performance targets.

- Identify safety improvement initiatives. While considering targets, the organization might introduce new programs or other initiatives that support achieving the targets. Examples include training, engineering improvements, education campaigns, vehicle design changes, etc.

  For example, to meet a target of "30% reduction in collisions between light-rail vehicles and pedestrians in the coming 12 months," the transit agency may launch an educational campaign in coordination with "Operation Lifesaver".

Table 4.8 illustrates the performance matrix discussed in earlier steps after adding performance targets.

Table 4.8 Performance Matrix -- showing performance targets

Outcomes	Metrics	Baselines	Targets
Reduce transit-related fatalities	• Fatalities per 100 million passenger-miles traveled.	0.74 in 2009	0.445 by 2012
Reduce transit-related injuries	• Injuries per 100 million passenger-miles traveled.	3.96 in 2009	2.15 by 2012
Reduce risks of injuries to employees	• Employee work days lost to injuries (by injury type) per month.	8 on average for injury type xyz in 2009	4 on average by 2012

Table 4.8 Performance Matrix -- showing performance targets (continued)

Outcomes	Metrics	Baselines	Targets
Accelerate development of safety culture	• Number of safety improvement ideas submitted by employees per quarter.	1 in 4th quarter, 2009	N/A
	• Number of employees attending monthly safety meetings.	3 on average in 2009	75% of all employees by 2012
	• Number of close calls reported per month.	0 on average in 2009	N/A
Improve workforce core competencies and skills	• Percent of employees scoring 85% or higher on standardized competency tests.	50% in 2009	80% by 2012

Step 7: Monitoring Performance & Evaluating Results

Having completed the performance matrix discussed in earlier steps, the transit property is ready to collect and analyze safety data on a regular basis in order to monitor performance and inform the decision-making process. This is shown in Figure 4.9. Senior management should ensure that middle managers and staff have the resources (human, financial, and technical) needed to carry out the performance measurement activities.

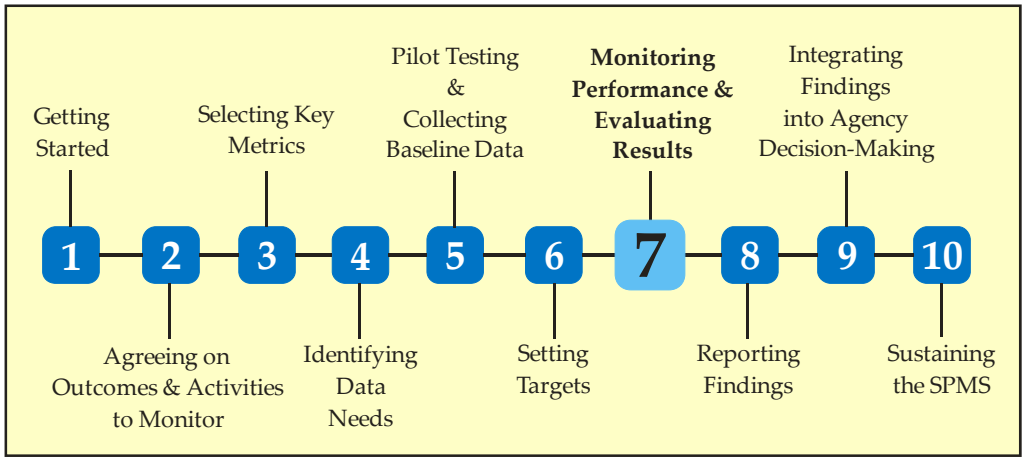


Figure 4.9 Step-7: Monitoring Performance and Evaluating Results

Data Preparation

Before transforming performance data into metrics, the data should be recorded and checked for accuracy, completeness and consistency. Incoming data should be entered into a computer database with a well-thought-out structure to facilitate analysis and evaluation. Software programs such as Microsoft Excel and Microsoft Access can be used for this purpose, although this requires familiarity with such programs. The original data records should be retained for a reasonable time period (at least 5 years) and stored in a data archive kept in the safety manager's office.

As discussed in Chapter 2, errors can be introduced into data in many ways including data recording. Data checking should be performed soon after data entry into the computer. This will provide an opportunity to go back to the data collection forms to clarify any questions or errors. In addition, quality control checks should be carried out periodically on all accumulated performance data. Quality control checks are typically done on random basis.

Simple descriptive analyses can also be performed to provide summaries and ensure that the data elements are within expected limits. For example, such summaries can help detect data entry errors like a pedestrian whose age is 422, a collision that occurred on February 38, or a 9 entered where the response should be between 1 and 4.

Analysis and Evaluation of Results

The process of analyzing data focuses on comparing actual performance against targets and identifying the underlying trends and patterns in performance. Descriptive statistics can be used to describe the basic features of the data such as frequencies of safety occurrences, percentage change, mean (average) value, range, and standard deviation. Together with statistical charts and graphics, they transform the data into information that can be grasped and acted upon.

Comparing performance data over time is a valuable tool for distinguishing random (common) causes of variation from assignable (special) causes that warrant further evaluation. It also helps identify trends that can serve as early warnings of potential safety problems. For instance, Figure 4.10 illustrates a line graph of the occurrence rate of a particular type of safety incident over some defined time period. The calculated trend line and the desirable target levels are also shown. Although the trend line indicates a general reduction in the rate of occurrence over the time period, the rate of occurrence remained above the target levels -- an undesirable state. The graph also shows a new upward trend in recent quarters that requires further investigation to identify the causes. For instance, there may have been

several new hires in the 2nd quarter of 2008, new equipment was introduced, training budget was cut, and so forth.

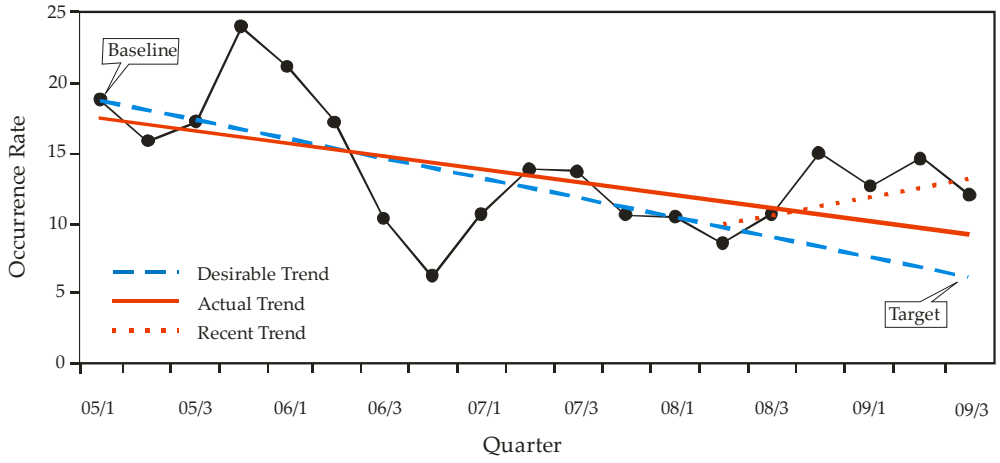


Figure 4.10 Performance Comparisons over Time

Figure 4.11 illustrates the concept of performance gaps; the undesirable state when actual achievements fall short of set targets. The graph to the left shows the case when the transit agency is falling behind, i.e., there is a gap, whereas the graph to the right indicates that the agency is doing very well and exceeding the desired target. In either case, managers should ask why their agency performed that way. When gaps are present, the root causes of such gaps should be identified, and countermeasures should be developed and implemented. A performance gap should be viewed as an opportunity for improvement. For instance, a new initiative may be needed to improve employee skills or correct faulty processes. Likewise, when the agency is doing very well (the graph to the right), management should understand the reasons for such superior performance and document the lessons learned.

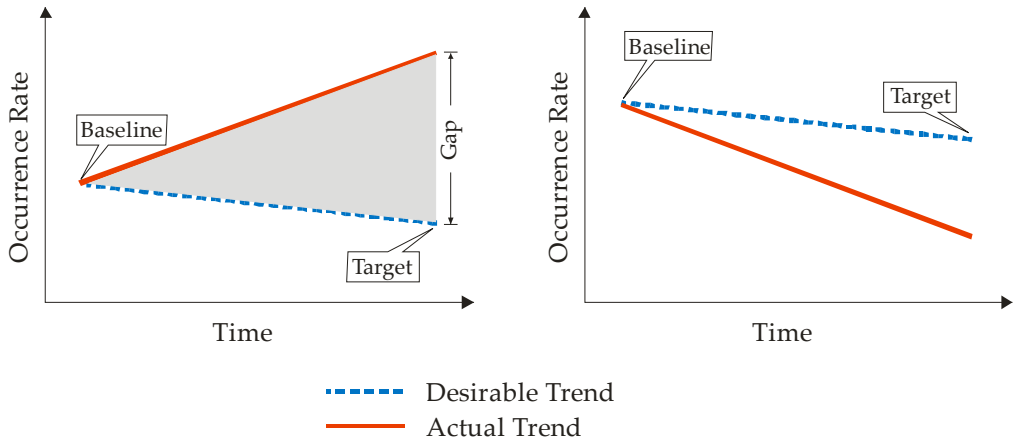


Figure 4.11 Performance Gaps

Attribution

Separating the impacts of the transit agency's activities from those of external factors beyond the agency's control can be complex and challenging. For example, collisions involving a bus are influenced by many factors besides the actions of the bus driver. The impacts of weather, risky behaviors of pedestrians and other vehicle drivers should be understood and accounted for in evaluating the agency's safety performance.

One approach to addressing the "attribution" issue (i.e., distinguishing the agency's influence on outcomes) is to collect data on explanatory variables such as traffic volume, travel demand, weather conditions, and changes over time in driver and pedestrian behavior that affect safety performance. Analysis of these explanatory variables can be used to supplement performance metrics.

Before-and-after studies can also be used to evaluate the impacts of safety improvement initiatives and projects, although this requires training in statistical analysis methods. For instance, the results of such studies provide an understanding of whether the reductions in fatalities and injuries are attributed to the implementation of a particular safety improvement or are the result of chance causes.

Unintended Consequences

Undisciplined use of performance metrics can result in unintended changes in employees' behaviors, particularly when the metrics are used as tools for assigning blame and subsequent punishment. Gloria Grizzle points to unintended consequences in test scores, crime reports, corporate earnings, and the practice of "creaming" clients or customers [45]. In order to meet targets, some employees may deliberately alter performance data. In other cases, they may purposely lower the targets to close performance gaps. Both behaviors are unethical; employees are following the path of least resistance without giving serious thought to the reason behind measurement -- enabling performance improvement.

Step 8: Reporting Findings

Effective and timely communication of safety performance results to stakeholders is central to safety assurance and management. This step is shown in Figure 4.12. The objective is to provide continuous performance feedback to quickly identify and react to safety problem areas and assess the benefits that resulted from safety improvement actions.

There are three main considerations in reporting performance results: 1) the level of detail that is relevant to each target audience, 2) the form in which

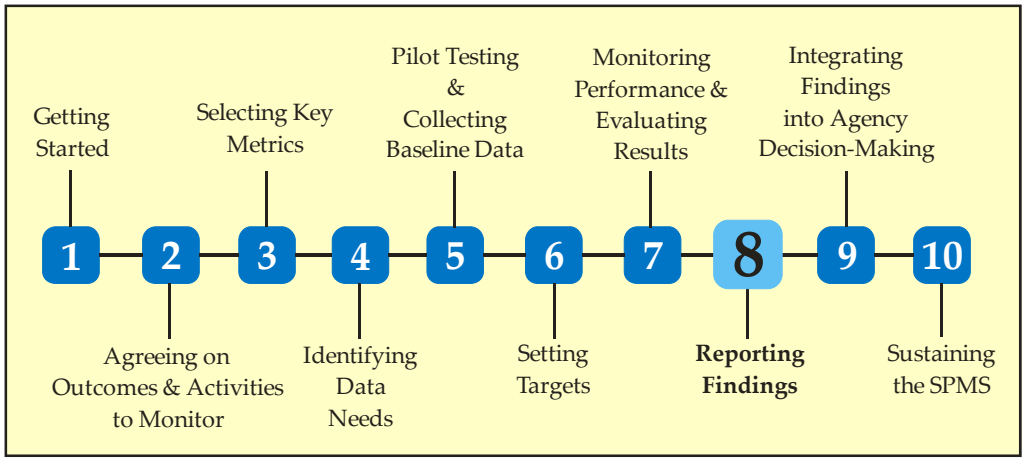


Figure 4.12 Step-8: Reporting Findings

Performance results should be communicated in a clear and concise manner, and be timely and relevant to the different stakeholders.

the information will be most useful, and 3) the frequency of reporting. Performance results should be communicated in a clear and concise manner, and be timely and relevant to the different stakeholders: operating personnel, line managers, agency executives, board members, and the general public. Otherwise, the intended message would not be delivered and the effectiveness of the performance measurement effort will diminish.

Figure 4.13 illustrates the relationship between the level of stakeholder responsibility, amount of detail, and the frequency of reporting (Adopted with modification from TCRP 88 [1]).

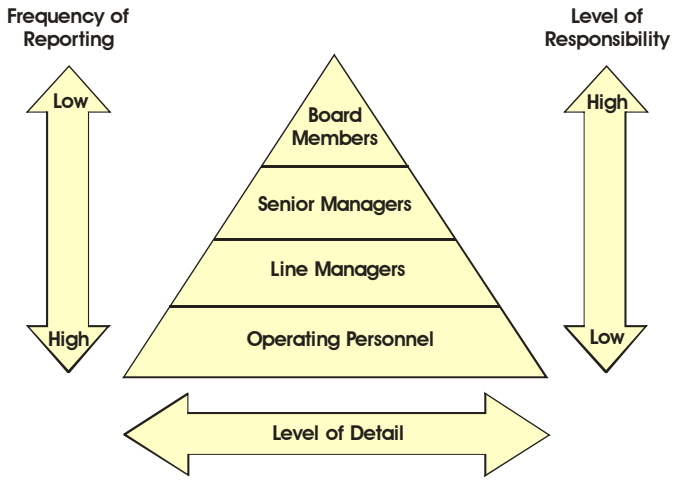


Figure 4.13 Stakeholder Reporting Needs
(Adopted with modifications from TCRP 88 [1])

Typically, the lower the level of responsibility, the more need there is for detailed safety performance data. Operating personnel and line managers need reports that are diagnostic in nature and provide as much detail as

possible. Furthermore, reporting must be more frequent for operating personnel than for board members and the general public.

Further up the responsibility chain, less detail and explanation will be needed. Aggregated summaries will be more appropriate. Senior managers need succinct reports that are relevant to the specific issues, while the agency's board members may desire executive summaries that are even less detailed. Passengers and the general public need brief summary of performance results communicated in a clear, understandable manner, preferably using graphics and dashboards.

Means of Reporting Performance Results

There are three primary means of reporting performance results: written reports, oral presentations, and the internet. The target audience will often dictate the reporting method, and a communications strategy should be developed accordingly.

Typically, a written report with an executive summary focusing on key performance metrics is most appropriate for agency's board members and senior managers. The executive summary can include reference to the report for more details. At the line managers and staff level, a detailed report of all safety performance metrics and the supporting data will be needed.

Visual presentation tools help communicate the information clearly and effectively, add interest, increase memory retention, and help present the big picture.

Oral and PowerPoint presentations can be used either alone or in conjunction with written reports to highlight the major findings and recommendations.

Graphics and visual presentations are powerful techniques for getting the message across to the audience. Data charts (line graph, bar graph, pie graph, and so forth), data tables, GIS maps, and photographs should be considered in both written reports and oral presentations. These visual presentation tools help communicate the information clearly and effectively, add interest, increase memory retention, and help present the big picture.

Good graphics should be simple yet effective; they should be clearly labeled, convey information without needing text, and illustrate patterns that can be easily recognized. Data charts and tables can be set up in an Excel spreadsheet so that they will be updated automatically as new data are provided for each reporting period.

Tips for Reporting Performance

- Compare actual outcomes to targets and highlight any gaps or overachievements in performance, and provide this information in an easy-to-understand visual display.

- Communicate progress toward reaching targets at the monthly or quarterly management meetings to help create a cultural shift toward more performance-based decision-making.
- Current levels of performance metrics should be compared to past data to identify patterns and trends -- reporting results on a specific month, quarter, or year by itself is not useful.
- Reporting should cover all important results, both positive and negative. A good performance measurement system is intended to identify performance gaps and trigger in-depth examination of problem areas -- not just bring good news.
- Performance reports should offer valid reasons for poor or disappointing outcomes, to the extent that such reasons are known, and document any steps already underway to address them.
- Explain any limitations of the performance evaluation process and caution the audience about interpreting the results in ways that may not be valid.
- Performance results should be supported by data and subject to independent verification.
- Be sure to invite feedback from the different stakeholders regarding performance results and the possible improvement actions.

Step 9: Integrating Findings into Decision-Making

The crux of an SPMS is not in generating performance-based metrics, but in using this information to learn, inform decisions, and make positive changes. The main objective is continuous improvement. When performance goals are not met, the causes should be identified and actions must be taken to close the performance gaps. Conversely, when goals are consistently exceeded, targets may have to be re-examined to see if the par can be raised. Figure 4.14 illustrates this step.

Continuous improvement can take place when three conditions are present. First, employees must be sufficiently motivated to continually seek improvement in the safety of their transit system. This is at the heart of a healthy safety culture. Second, employees must have the resources, skills and tools to improve performance. Third, the management styles and systems of the organization must be reengineered in harmony with the concept of never-ending improvement. Otherwise, insights are likely to be underused or inconsistently used in decision-making. Performance gaps must be viewed as opportunities rather than threats, and the link between safety performance and resource allocation decisions must be made clear.

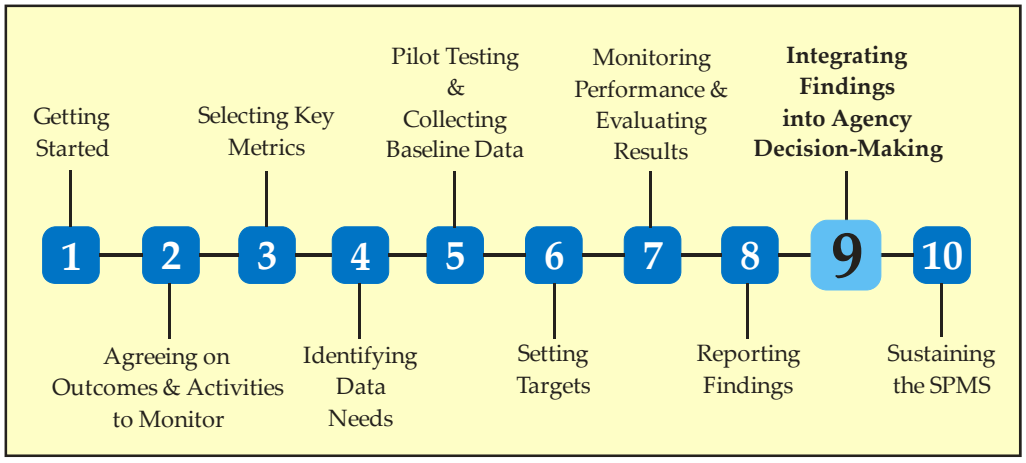


Figure 4.14 Step-9: Integrating Findings into Decision-Making

Uses of Performance Results

Organizations use performance measurement and evaluation results for a number of reasons, including [43]:

- Focus attention on performance gaps and trigger in-depth investigations of what performance problems exist;
- Help make informed resource allocation decisions;
- Identify needs for staff training or technical assistance;
- Help motivate employees to continue making program improvements;
- Support strategic planning efforts by providing baseline information for tracking progress;
- Identify best practices through benchmarking, i.e., comparing the performance results achieved by similar agencies using differing practices, approaches, or processes; and
- Respond to the elected officials and the public's demands for accountability.

What Influences the Use of Performance Results?

The extent to which performance results are used in a particular organization is influenced by a number of factors, including:

- ***Relevance of results to decision makers' needs.*** It is important to understand the information needs of the different stakeholders. Performance results are more likely to be used if they are relevant to decision makers' needs and related to their job responsibilities.
- ***Reporting procedures.*** In addition to being relevant, performance results must be reported in a way that is easy to understand and provides an

appropriate level of detail. As discussed in step-8, different reporting formats must be tailored to the needs of different types of users. Middle managers, for example, are likely to need a much greater level of detail than the agency's board members.

- ***Validity and timeliness of results***. The better the quality of performance data and the evaluation procedures used, the more likely that performance results will be utilized. The timeliness of reporting results is also critical.
- ***Clarity of program goals***. Performance data are most likely to be used where there is clear consensus on program goals among the different stakeholders.
- ***Level of stakeholder involvement in developing performance metrics and setting targets***. Decision makers and other users are generally most supportive of performance measurement systems that they have helped to develop themselves. Not only are such systems most likely to address their information needs, but they are also less "threatening" by nature.

Step 10: Sustaining the Performance Measurement System

As the safety performance measurement system takes shape, it is important for the transit agency to be aware of the organizational, political, and technical challenges that could affect the survival of this kind of initiative over the long run. This step is shown in Figure 4.15.

Sustaining the SPMS is not an easy task; it requires continuous commitment, champions, and resources – but it is doable.

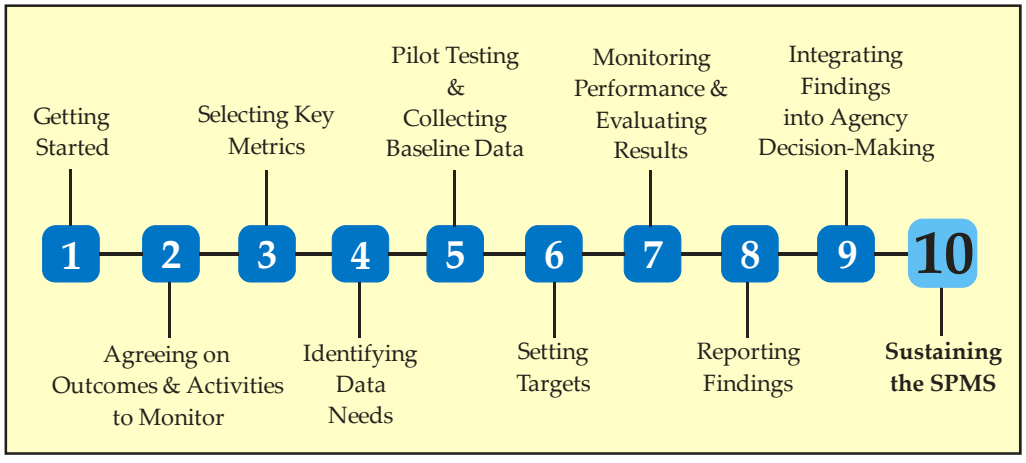


Figure 4.15 Step-10: Sustaining the SPMS

Changes in leadership, loss of talented personnel, financial shortfalls, and organization's cultural factors are examples of challenges that must be

overcome. Sustaining the SPMS is not an easy task; it requires continuous commitment, champions, and resources – but it is doable. And it is certainly worthwhile given the power of performance measurement in safety assurance and continuous improvement.

Tips for Sustaining the SPMS

- ***Create measurement-friendly culture***. Senior managers should be actively engaged in creating a measurement-friendly culture by promoting performance measurement as a means of continuous improvement and using the resources and other tools at their disposal to accomplish such culture change. In addition, senior managers should set a personal role model by utilizing performance metrics in decision-making. As Albert Einstein wrote, "Setting an example is not the main means of influencing others; it is the only means." When top managers insist on receiving and using performance indicators, and when the word is spread throughout the organization, attitudes change rapidly.

- ***Build organizational capacity***. Investment in developing skilled human resources capacity is essential to sustaining the SPMS initiative. Both technical and managerial skills will be needed for data collection and analysis, and setting goals. Investment in modern data systems and analysis tools will also be required to ensure the long-term success of SPMS.

  The governing board and senior management must commit the financial resources required for building organizational capacity and maintaining the SPMS on a continuous basis.

- ***Reliability and transparency of performance results***. The SPMS should be able to produce and report the true story -- both good and bad news. Performance information should be transparent, made available to all stakeholders, and be subject to independent verification. Messengers should be protected to preserve the integrity of the measurement system. The focus should be on opportunities for improvement rather than allocating blame.

- ***Demonstrate continuous commitment to measurement***. Visible commitment to using metrics even when targets are exceeded reaffirms the message that performance measurement is a long-term initiative as opposed to an episodic effort for a short period. One way of demonstrating commitment to performance measurement is to institute a formal process of reporting performance results. Another useful strategy is to have safety performance as a standing item on the agenda of executive meetings and staff meetings.

- ***Recognize and reward success***. Acknowledging and rewarding employees who use performance results to learn and improve safety is important to sustaining the SPMS effort. This can be done through a variety of cost-effective methods.

4.4 Survey of U.S. Transit Industry

One of the objectives of this study was to assess the state of the practice used by large, medium, and small transit agencies regarding safety performance measurement and its utilization in decision making. To accomplish this objective, a survey questionnaire was developed in collaboration with the FTA Office of Safety and Security and a select group of State Safety Oversight Agency (SSOA) leaders. The survey questionnaire included sixty questions and was divided into seven sections:

1. Transit agency characteristics;
2. Strategic and safety planning;
3. Categories of accidents and probable causes;
4. Use of quantitative measures to assess safety performance;
5. Safety data acquisition and analysis;
6. Safety performance measurement and decision-making; and
7. Safety reporting.

A copy of the survey questionnaire is included in Appendix-A of Part-II of this report.

The survey was converted to a web-based questionnaire using a computer program prepared by the research team. The software was designed to validate the responses as they are entered, and to allow skip and branching patterns that depend on responses to previous questions. Respondents were asked to call the research staff if they encountered difficulty in answering any of the questions.

The American Public Transportation Association (APTA) and the Community Transit Association of America (CTAA) assisted in identifying a

sample list of 430 transit agencies that were included in the survey. An e-mail with the APTA letterhead was sent to all 430 agencies inviting them to participate. The sample represented different transit modes, different size systems, and different operating environments. The response rate for completed surveys was approximately 20% (86 of the 430 invited agencies completed the survey).

Figures 4.16 and 4.17 present the distribution of the responding agencies by size and modes of transit service offered. Table 4.9 shows the geographic distribution of responding agencies by FTA region. Figure 4.18 is a map of the FTA regions.

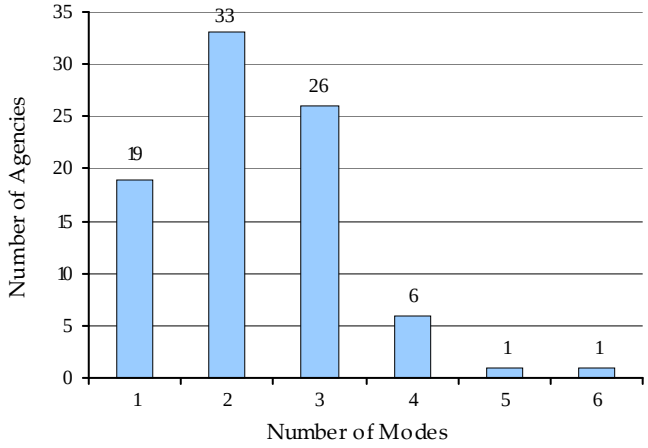


Figure 4.16 Distribution of Responding Agencies by Size

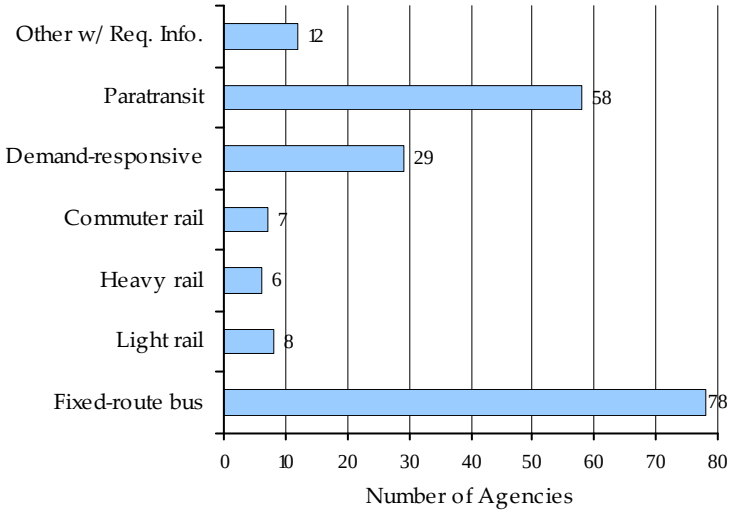


Figure 4.17 Distribution of Responding Agencies by Modes Offered

Table 4.9 Responding Transit Agencies by FTA Region

FTA Region	No. of Agencies Responding
I	2
II	6
III	13
IV	9
V	17
VI	9
VII	1
VIII	4
IX	21
X	4
Total	86

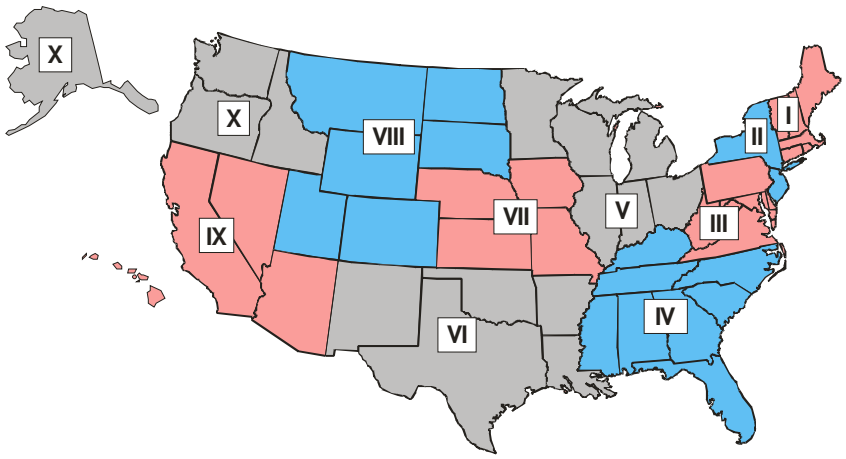


Figure 4.18 Map of FTA Regions

The survey results are presented in Part-II of this report. Major conclusions from the survey include the following:

- Seventy-two of the 86 respondents (84%) have strategic plans and/or business plans that include vision and mission statements. Fifty-two of those 72 agencies indicated that safety is included as a core value in their strategic or business plans.
- The survey asked, "Does your agency have a System Safety Program Plan (SSPP) for any of the modes provided?" and "Are safety goals and objectives established in the SSPP?" Fifty-one of the 86 responding agencies (59%) noted that they have an SSPP. Forty-two of the 51 agencies (82%) that have an SSPP indicated that safety goals and objectives are included in their SSPP.

- Sixty-one of the 86 responding agencies (71%) indicated that they use quantitative measures to evaluate safety performance. The number of performance metrics used varies widely among transit agencies that responded to the survey.

- Respondents cited numerous sources of information for collecting safety data. Accident investigation reports, results from safety reviews and audits, customer complaints, vehicle defect reports, "unusual occurrence" reports, claims/worker's compensation information, and reports from ride-along and employee observations were the most commonly cited information sources.

- The survey asked, "What type of data management system or information technology do you use to manage and analyze safety data?" Manual, Microsoft Excel, and customized database software were the most commonly cited tools. Customized GIS and statistical software were noted by few of the responding agencies.

- Forty-six of the 86 responding agencies (53%) indicated that personnel who work with safety data had received some training in the development and use of safety performance measures.

- Identifying areas in need of improvement, determining trends in safety performance, assessing the effectiveness of safety actions, and benchmarking safety performance against that of peer group agencies were the most cited motives for using safety performance measures by the responding transit agencies. On closer examination of the results, it was discovered that 22 of the agencies that cited motives for measuring performance had indicated in an earlier question that they do not use quantitative measures to evaluate safety performance.

- The survey asked, "Has your agency been able to use safety performance measures to justify investment decisions?" Forty-six of the 86 responding agencies (53%) responded "Yes".

- A follow-up question asked, "Has your agency been able to use safety performance measures to justify changes in design, operating procedures or allocating personnel?" Fifty-two of the 86 responding agencies (60%) responded "Yes".

- The survey asked, "Do you feel that adequate resources have been made available to support safety performance measurement at your agency?" Forty-nine of the 86 responding agencies (57%) responded "Yes", 26 agencies (30%) responded "No" and 10 agencies (12%) responded "Do not know". A follow-up question asked, "What resources would you like to have?" Full-time personnel to handle safety issues, funds to

purchase safety-critical items, training, better safety management tools and software, and hiring a safety manager were among the needs identified by those agencies that stated they do not have adequate resources to support safety performance measurement.

CHAPTER 5

SUMMARY FINDINGS AND RECOMMENDATIONS

Transit ridership continued its 5-year record increase reaching 10.7 billion trips in 2008, the highest level of ridership in 52 years. Meanwhile, the public transportation fatality rate, expressed in fatalities per 100 million passenger-miles, has leveled-off in recent years. Therefore the statistical reality is that as the industry grows and the passenger-miles increase, the total numbers of fatalities and serious accidents will also increase. While the current rates of fatalities and accidents are low compared to other modes of surface transportation, any appreciable increase in the number of fatalities would be detrimental to an industry that for years has prided itself on its safety record. To avoid this situation, the transit industry needs to reduce the current low accident and fatality rates even further.

It is widely accepted that most public transportation accidents result from a combination of human, technical and organizational factors. Recent research and in-depth accident investigation reports suggest that most of the links in an accident chain are under the control of the organization, and accidents can best be prevented when the underlying causal factors are addressed at the organizational or system level. Human errors and technical failures are symptoms of the lack of organizational focus, accountability and communications. Addressing the root causes of public transportation accidents has become especially urgent in light of the recent high-profile rail transit accidents.

This guidebook was prepared with the objective of providing resource information for transit agencies and the FTA regarding the development and implementation of Safety Management Systems (SMS) and Safety Performance Measurement Systems (SPMS). SMS offer the most promising

means of preventing public transportation accidents by integrating safety into all aspects of a transit system's activities, from planning to design to construction to operations to maintenance. SMS build on the four elements identified in the "System Safety Program Requirements" [53], which has its origins in the defense and space industries:

- A planned approach to system safety program tasks;
- Qualified personnel to accomplish the tasks;
- Authority to implement the tasks through all levels of management; and
- Appropriate financial and personnel resources to accomplish the tasks.

Safety management is based on the fact that safety is not an absolute condition -- there will always be hazards and risks in public transportation. Therefore, systematic and proactive management is needed to identify and control these risks before they lead to mishaps. Small problems should be fixed before they turn into major ones. Isolated incidents should be investigated to see if they are systemic. When accidents occur, the lessons learned should be documented and actions should be taken to prevent similar accidents from occurring. Safety should become a common theme permeating the organization, and affecting all individuals working there.

In the most basic form, safety management involves:

- Defining clear levels of responsibility and accountability for safety within the organization;
- Setting safety performance goals and actively pursuing them;
- Reporting and analyzing hazards, incidents and accidents and taking corrective actions to prevent their recurrence;
- Managing safety risks systematically and proactively, including learning and continuous improvement;
- Developing a workforce that is knowledgeable, flexible, dedicated, and efficient; and

- Monitoring and evaluating safety performance towards established goals and developing action plans to address any performance gaps.

Transitioning to safety management will require a cultural transformation on the part of both the transit industry and FTA in adopting a proactive management approach for delivering on safety objectives and continuously improving public transportation safety. Safety management requires developing and sustaining a strong safety culture where the following practices and behaviors become 'the way we do business around here' at each transit property:

- Management is accountable and responsible for safety;
- Everyone in the organization takes an active role in safety;
- Open communications and discussions of safety hazards and risks are encouraged;
- Safety hazards and close-calls are reported;
- Risk management continues despite everything looking safe;
- Human errors and unsafe acts are treated as symptoms of organizational problems;
- Safety redundancies are introduced to ensure resiliency to unplanned events;
- Investment in safety is made even in times of financial constraint;
- Industry, oversight agencies and FTA work together to make the system safer;
- Practices and procedures are regularly compared, reviewed and improved;
- Activities and decisions are risk-based;
- Safety data are analyzed to identify systemic causes;
- Investment is made in proactive activities;
- The safety office is a proactive partner to the other departments;
- Safety performance is measured;
- Safe practices, continuous learning and improvement are the norm, even during times of financial problems and labor pressure;
- Safety information is shared;

- The safety management system is audited; and
- Safety information is shared internally and externally

In addition to developing and sustaining a safety culture, SMS has the potential of bringing other benefits. Many organizations have already adopted SMS and realized benefits such as:

- Increased direct and indirect cost savings due to accident/loss prevention and reduction in insurance premiums;
- Increased competitive business advantage through a marketable record of safe operations;
- Logical prioritization of safety needs based on the level of risk involved;
- Continuous improvement of operational and maintenance processes;
- Demonstrated due diligence when accidents occur;
- Improved communications and employee morale within the organization;
- Enhanced relationships and partnerships with other transit properties as a result of collaboration and information sharing; and
- Increased collaboration between stakeholders on safety initiatives to mitigate risk, especially in emergency preparedness activities.

Performance measurement is a key component of safety management. Measurement brings clarity to vague concepts, helps transit agencies identify gaps in safety performance, and forces management and governing boards to take action to improve performance.

The process of building and sustaining a successful SPMS is iterative, and involves a sequence of ten steps:

1. Getting started -- conducting a readiness assessment;
2. Agreeing on outcomes & activities to monitor;
3. Selecting key metrics;
4. Identifying data needs;
5. Pilot testing and collecting baseline data on metrics;
6. Setting targets;
7. Monitoring performance and evaluating results;
8. Reporting findings;
9. Integrating findings into agency decision-making; and
10. Sustaining the performance measurement system.

Performance measures should be developed in consultation with the key stakeholders including transit agency's management, staff, customers,

governing body, service contractors, and oversight organizations. Acceptance by these stakeholders is critical to the long term viability and success of the performance measurement program.

SPMS developers should be encouraged to shift their focus from output/process measures to outcome measures that focus on safety goals and long-term impacts. Performance targets should be realistic but, wherever feasible, should encourage progress beyond historical performance levels.

Sustained support and commitment of senior management are essential for the SPM effort to take hold and become a vehicle for continuous safety improvement. Senior managers should be actively engaged in creating a measurement-friendly culture by promoting performance measurement as a means of continuous improvement and using the resources and other tools at their disposal to accomplish such culture change. In addition, senior managers should set a personal role model by utilizing performance metrics in decision-making. When top managers insist on receiving and using performance indicators, and when the word is spread throughout the organization, attitudes change rapidly.

Investment in developing skilled human resources capacity is essential to sustaining the SPMS initiative. Both technical and managerial skills will be needed for data collection and analysis, and setting goals. Investment in modern data systems and analysis tools will also be required to ensure the long-term success of SPMS. The governing board and senior management must commit the financial resources required for building organizational capacity and maintaining the SPMS on a continuous basis.

The SPMS should be able to produce and report the true story -- both good and bad news. Performance information should be transparent, made available to all stakeholders, and be subject to independent verification. Messengers should be protected to preserve the integrity of the measurement system. The focus should be on opportunities for improvement rather than allocating blame.

There is little value in even the best-designed performance metrics unless they are used systematically to inform decision-making and drive safety improvement. Once the SPMS is in place, performance results should be evaluated carefully to gain insight into the success of past efforts and develop ideas for improving future performance.

Visible commitment to using metrics even when targets are exceeded reaffirms the message that performance measurement is a long-term initiative as opposed to an episodic effort for a short period. One way of demonstrating commitment to performance measurement is to institute a

formal process of reporting performance results. Another useful strategy is to have safety performance as a standing item on the agenda of executive meetings and staff meetings.

Acknowledging and rewarding employees who use performance results to learn and improve safety is important to sustaining the SPMS effort. This can be done through a variety of cost-effective methods.

Separating the impacts of the transit agency's activities from those of external factors beyond the agency's control can be complex and challenging. For example, collisions involving a bus are influenced by many factors besides the actions of the bus driver. The impacts of weather, risky behaviors of pedestrians and other vehicle drivers should be understood and accounted for in evaluating the agency's safety performance. In reporting performance results, it is important to explain any limitations of the performance evaluation process and caution the audience about interpreting the results in ways that may not be valid.

Recommendations

The remainder of this chapter presents recommendations with regard to transit safety management systems, safety performance measurement, workforce development, safety data, and future research. Implementing these recommendations presents a variety of challenges to the transit industry and FTA, and one should not underestimate the difficulties involved. Yet, the effort required to bring about fundamental cultural changes is not only well-justified by the significant safety benefits that can be realized, but is in fact necessary to enable the transit industry to adapt and grow with current and future changes and challenges.

Recommendations Regarding Safety Management Systems

1. *Ensure that transit properties develop and implement safety management systems*. Require that transit properties submit to the FTA and the State

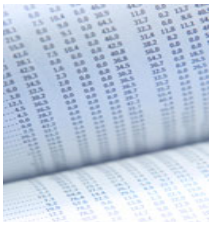
Safety Oversight Agencies plans for developing and implementing safety management systems.

2. *Develop and sustain a positive safety culture*. FTA, in partnership with the transit industry and other stakeholders, must take a leadership role to transform the prevailing safety culture to one where safe practices are the norm, where people at all levels of the public transportation system proactively and systematically manage risks and hazards in their day-to-day activities, and where continuous safety improvement and learning are core business values. This transformation represents a major cultural shift, and will require substantial effort and time to be realized, but is doable.

3. *Promote practicing risk management in all activities*. FTA, in partnership with the transit industry and other stakeholders, must persuade transit agencies to apply of risk management in the selection, design, construction, operation, and maintenance of all the systems and subsystems that comprise the total transit system.

4. *Demonstrate the feasibility of a Confidential Close Call Reporting System*. FTA is urged to sponsor a demonstration project for a Confidential Close Call Reporting System that transit industry employees can use to confidentially report safety-related concerns. The proposed demonstration project can be tailored after a similar collaborative project between the Federal Railroad Administration (FRA), and RITA's Volpe Center and Bureau of Transportation Statistics (BTS). The FRA's Confidential Close Call Reporting System (C^3RS) has been designed so railroad employees can voluntarily and confidentially report "close call" events or unsafe conditions that could have resulted in an accident but did not. The reported data are analyzed to develop methods and tools to help railroads better identify hazards and manage risk. The BTS' statutory authority to protect the confidentiality of information collected for statistical purposes helps protect the reported information from attorneys (as part of discovery), punitive use, and the media.

Recommendations Regarding Safety Performance Measurement



1. *Promote the adoption of standard terminology and uniform safety performance metrics in the public transportation industry*. FTA, in collaboration with the State Safety Oversight Agencies (SSOAs), APTA, CTAA, and other stakeholders should standardize safety performance terminology and identify a set of core metrics to foster uniformity in measuring safety performance. Transit properties should be encouraged to adopt these core metrics in setting their performance

measurement systems and reporting on their performance. This will enhance benchmarking among transit properties, and facilitate tracking the transit agencies' progress toward safety goals.

2. *Advocate the need for clearly articulated safety goals and accountability for safety performance*. Transit properties should be required to develop clear goals and objectives for the safety of their systems, and management and staff should be encouraged to shift their focus from output/process indicators to outcome indicators that address the long-term safety impacts of the transit system.

3. *Ensure that transit properties consistently measure and analyze safety performance*. Require that transit properties submit to the appropriate State Safety Oversight Agencies annual performance reports that describe their progress in meeting safety goals and targets by using agreed upon core performance metrics.

4. *Encourage transit properties to consistently analyze and report performance trends and gaps*. FTA, in collaboration with industry organizations, should promote analyzing performance trends and projecting trend lines to upcoming target milestones to allow a determination of whether the transit property is on track to meet its safety goals.

Recommendations Regarding Transit Workforce Development

1. *Implement findings of the 2007 international Transit Studies Program "Innovative Practices in Transit Workforce Development"*. FTA, in collaboration with the transit industry, should implement the findings of the 2007 international Transit Studies Program [56] regarding the practices of respected transit organizations abroad. These practices should prove valuable to U.S. transit property managers in their efforts to attract competent candidates and retain as much of retiring workers' knowledge as possible.

2. *Encourage partnerships between transit industry and educational institutions to develop and offer curricula for certification and degree programs for transit-based*

occupations. These joint programs can offer an efficient mechanism for the initial training and continuing development of transit employees.

3. *Establish transit-based occupational standards at the national level*. The transit industry should develop and implement a nationally based, shared perspective of job requirements and duties and performance standards. Such a shared perspective can set the stage for joint union/labor-management acceptance at the local level and eliminate the costly duplication of effort.

4. *Executive and management training*. FTA, in collaboration with APTA and RITA's Transportation Safety Institute (TSI), should develop training courses and arrange workshops aimed at transit property executives, governing board members and midlevel managers to learn about safety management systems and performance measurement systems. Topics could include: development and use of safety management systems, development and use of safety performance measurement systems, safety culture, and best practices.

5. *Web-based distribution of materials*. Designate a logical Web-based home (FTA, APTA, or a university) for disseminating technical materials related to safety management and safety performance measurement including reports, presentations, and best practices.

6. *Conferences and meetings*. FTA, in collaboration with APTA and other stakeholders, should plan and implement conferences and meetings specifically oriented to exchange of information about safety management and safety performance measurement.

Recommendations Regarding Transit Safety Data

1. Identify gaps and establish quality standards for safety data. FTA, in collaboration with APTA, RITA's Bureau of Transportation Statistics (BTS), Transportation Research Board and other stakeholders, should establish a program to identify information gaps and to set data quality standards.

Recommendations Regarding Future Research

1. *Produce a synthesis of best practices*. Research is needed to survey and document the best practices available in developing and implementing safety management systems and safety performance measurement systems in the transportation industries. The synthesis should include case studies that show how SMS and SPMS are being used to manage risks and identify gaps in safety performance.

2. *Develop a central clearinghouse for public transportation safety risk mitigation techniques by mode*. A web site should be developed for managing proven safety risk mitigation techniques so that those engaged in risk-mitigation projects can learn from the experience and knowledge accumulated by other transit properties.

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Appendices

APPENDIX A

SCORE YOUR SAFETY CULTURE

The following checklist was written by Professor James Reason and presented at the fifth Australian aviation psychology symposium which was held in Manly, Sydney, November, 2000.

SCORING:

YES = This is definitely the case in my organization (scores 1);
? = "Don't know," "maybe" or "could be partially true" (scores 0.5);
NO = This is definitely not the case in my organization (scores zero).

1. **MINDFUL OF DANGER:** Top managers are ever mindful of the human organizational factors that can endanger their operations.
   - ○ Yes
   - ○ ?
   - ○ No

2. **ACCEPT SETBACKS:** Top management accepts occasional setbacks and nasty surprises as inevitable. They anticipate that staff will make errors and train them to detect and recover from them.
   - ○ Yes
   - ○ ?
   - ○ No

3. **COMMITTED:** Top managers are genuinely committed to transportation safety and provide adequate resources to serve this end.
   - ○ Yes
   - ○ ?
   - ○ No

4. **REGULAR MEETINGS:** Safety-related issues are considered at high-level meetings on a regular basis, not just after some bad event.
   - ○ Yes
   - ○ ?
   - ○ No

5. **EVENTS REVIEWED:** Past events are thoroughly reviewed at top-level meetings and the lessons learned are implemented as global reforms rather than local repairs.
   - ○ Yes
   - ○ ?
   - ○ No

6. **IMPROVED DEFENCE:** After some mishap, the primary aim of top management is to identify the failed system defenses and improve them, rather than to seek to divert responsibility to particular individuals.
   - ○ Yes
   - ○ ?
   - ○ No

7. **HEALTH CHECKS:** Top management adopts a proactive stance toward safety. That is, it does some or all of the following: takes steps to identify recurrent error traps and remove them; strives to eliminate the workplace and organizational factors likely to provoke error; brainstorms new scenarios of failure; and conducts regular "health checks" on the organizational process known to contribute to mishaps.
   - ○ Yes
   - ○ ?
   - ○ No

8. **INSTITUTIONAL FACTORS RECOGNIZED:** Top management recognizes that error-provoking institutional factors (under-staffing, inadequate equipment, inexperience, patchy training, bad human-machine interfaces, etc.) are easier to manage and correct than fleeting psychological states, such as distraction, inattention and forgetfulness.
   - ○ Yes
   - ○ ?
   - ○ No

9. **DATA:** It is understood that the effective management of safety, just like any other management process, depends critically on the collection, analysis and dissemination of relevant information.
   - ○ Yes
   - ○ ?
   - ○ No

10. **VITAL SIGNS:** Management recognizes the necessity of combining reactive outcome data (i.e., the near miss and incident reporting system) with active process information. The latter entails far more than occasional audits. It involves the regular sampling of a variety of institutional parameters (scheduling, budgeting, fostering, procedures, defenses, training, etc.), identifying which of these vital signs are most in need of attention, and then carrying out remedial actions.
    - ○ Yes
    - ○ ?
    - ○ No

11. **STAFF ATTENDS SAFETY MEETINGS:** Meetings relating to safety are attended by staff from a wide variety of department and levels.
    - ○ Yes
    - ○ ?
    - ○ No

12. **CAREER BOOST:** Assignment to a safety-related function (e.g., risk management) is seen as a fast-track appointment, not a dead end. Such functions are accorded appropriate status and salary.
    - ○ Yes
    - ○ ?
    - ○ No

13. **MONEY VS. SAFETY:** It is appreciated that commercial goals and safety issues can come into conflict. Measures are in place to recognize and resolve such conflicts in an effective and transparent manner.
    - ○ Yes
    - ○ ?
    - ○ No

14. **REPORTING ENCOURAGED:** Policies are in place to encourage everyone to raise safety-related issues (one of the defining characteristics of a pathological culture is that messengers are "shot" and whistleblowers dismissed or discredited).
    - ○ Yes
    - ○ ?
    - ○ No

15. **TRUST:** The organization recognizes the critical dependence of a safety management system on the trust of the workforce - particularly in regard to reporting systems. A safe culture - that is, an informed culture - is the product of a reporting culture that, in turn, can only arise from a just culture.
    - ○ Yes
    - ○ ?
    - ○ No

16. **QUALIFIED INDEMNITY:** Policies relating to near miss and incident reporting systems make clear the organization's stance regarding qualified indemnity against sanctions, confidentiality, and the organizational separation of the data-collecting department from those involved in disciplinary proceedings.
    - ○ Yes
    - ○ ?
    - ○ No

17. **BLAME:** Disciplinary policies are based on an agreed (i.e., negotiated) distinction between acceptable and unacceptable behavior. It is recognized by all staff that a small proportion of unsafe acts are indeed reckless and warrant sanctions but that the large majority of such acts should not attract punishment. The key determinant of blameworthiness is not so much the act itself - error or violation - as the nature of the behavior in which it was embedded. Did this behavior involve deliberate unwarranted risk-taking or a course of action likely to productive avoidable errors? If so, then the act would be culpable regardless of whether it was an error or a violation.

- Yes
- ?
- No

18. **NON-TECHNICAL SKILLS:** Line management encourages their staff to acquire the mental (or non-technical) as well as the technical skills necessary to achieve safe and effective performance. Mental skills include anticipating possible errors and rehearsing the appropriate recoverable recoveries. Such mental preparation at both individual and organizational levels is one of the hallmarks of high-reliability systems and goes beyond routine simulator checks.

- Yes
- ?
- No

19. **FEEDBACK:** The organization has in place rapid, useful and intelligible feedback channels to communicate the lessons learned from both the reactive and proactive safety information systems. Throughout, the emphasis is upon generalizing these lessons to the system at large.

- Yes
- ?
- No

20. **ACKNOWLEDGE ERROR:** The organization has the will and the resources to acknowledge its errors, to apologize for them and to reassure the victims (or their relatives) that the lessons learned from such accidents will help to prevent their recurrence.

- Yes
- ?
- No

Your Organization's Score:

Your Score = (Number of "YES") + (Number of "?" × 0.5)

Interpreting your score:

16-20	So healthy as to be barely credible.
11-15	You are in good shape, but don't forget to be uneasy.
6-10	Not at all bad, but there's still a long way to go.
1-5	You are very vulnerable.
0	Jurassic Park.

SAFETY HEALTH WARNING

High scores on this checklist provide no guarantee of immunity from accidents or incidents. Even the "healthiest" institutions can still have bad events. But a moderate to good score (8-15) suggests that you are striving hard to achieve a high degree of robustness while still meeting your other organizational objectives. The price of safety is chronic unease: complacency is the worst enemy. There are no final victories in the struggle for safety.

APPENDIX B

SAMPLE SAFETY POLICY STATEMENT

Safety is paramount in all our activities. We are committed to developing, implementing, and improving strategies, management systems and processes to ensure that all our public transportation activities uphold the highest level of safety performance and meet national and industry standards.

Our commitment is to:

a) Develop, embrace and embed a safety culture in all our public transportation activities that recognizes the importance and value of effective safety management and acknowledges that safety is the first priority in everything we do;

b) Clearly define for all staff their accountabilities and responsibilities for the development and delivery of public transportation safety strategy and performance;

c) Minimize the risks associated with our transit system operations to a point that is as low as reasonably practicable/achievable;

d) Ensure that externally supplied equipment, systems and services that impact the safety of our operations meet appropriate safety standards;

e) Actively develop and improve our safety processes to conform to national and industry standards;

f) Comply with and, wherever possible, exceed national and industry requirements and standards;

g) Ensure that all staff are provided with adequate and appropriate safety information and training, are competent in safety matters and are only assigned tasks that fit their skills;

h) Ensure that resources including skilled and trained staff are available to implement our organization's safety strategy and policy;

i) Establish performance metrics and measure our safety performance against realistic targets;

j) Continually improve our safety performance;

k) Conduct safety and management reviews and ensure that relevant corrective actions are taken; and

l) Ensure that the application of effective safety management systems is integral to all our public transportation activities, with the objective of achieving the highest levels of safety standards and performance.

APPENDIX C

SAFETY MANAGER

(Sample Job Description)

ABC Transit is seeking outstanding applicants to fill the position of Safety Manager (SM). The SM is responsible for providing guidance and direction for the operation of the organization's safety management system. The SM acts independently of other managers within the organization and reports directly to the CEO and Board of Directors.

Responsibilities include:

1. Interact with operational personnel, senior managers and Chief Executive Officer/Director;
2. Provide information and advice to senior management on matters related to the safety of customers, employees and the general public;
3. Conduct safety audits of any aspect of the operation;
4. Convene an inquiry into an accident, incident, or unsafe behavior in accordance with the procedures specified in the safety management manual;
5. Provide training on safety management employees and management; and
6. Foster positive relationships with regulatory authorities, oversight agencies and service providers outside the organization.

The successful applicant must have:

1. Broad operational knowledge and experience in the functions of the organization;
2. Sound knowledge of safety management principles and practices;
3. Good written and verbal communication skills;
4. Well-developed interpersonal skills;
5. Computer literacy;
6. The ability to relate to all levels, both inside and outside the organization;
7. Organizational ability;
8. Capable of working unsupervised;
9. Good analytical skills;
10. Leadership skills and an authoritative approach; and
11. Worthy of respect among peers and management.

APPENDIX D

SAMPLE POLICY ON NON-PUNITIVE HAZARD REPORTING

ABC Transit Non-Punitive Reporting Policy:

1. ABC Transit is committed to the safest flight operating standards possible. To achieve this, it is imperative that we have uninhibited reporting of all incidents and occurrences which may compromise the safe conduct of our operations. To this end, every employee is responsible for communicating any information that may affect the integrity of flight safety. Such communication must be completely free of any form of reprisal.
2. ABC Transit will not take disciplinary action against any employee who discloses an incident or occurrence involving flight safety. This policy shall not apply to information received by the Company from a source other than the employee, or which involves an illegal act, or a deliberate or willful disregard of promulgated regulations or procedures.
3. The primary responsibility for flight safety rests with line managers; however, flight safety is everyone's concern.
4. Our method of collecting, recording and disseminating information obtained from Air Safety Reports has been developed to protect, to the extent permissible by law, the identity of any employee who provides flight safety information.
5. I urge all staff to use our flight safety program to help ABC Transit become a leader in providing our customers and employees with the highest level of flight safety.

Signed: _____
CEO