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Measuring and Communicating the Effects of Traffic Incident Management Improvements

This digest presents the results of NCHRP Project 20-7/Task 173, "Measuring and Communicating the Effects of Incident Management Improvements." The research team (composed of Richard Margiotta and Kenny Voorhies of Cambridge Systematics and Tim Lomax of the Texas Transportation Institute) reviewed current practice around the United States and convened a workshop of several progressive state DOTs to determine the best performance measures for traffic incident management. Recommendations for improving the state of the art and practice are included.

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1 INTRODUCTION

1.1 Background to the Problem

State Departments of Transportation (DOTs) are actively engaged in traffic incident management, and this activity is expanding. It is widely believed by the profession that traffic incident management provides substantial user benefits in terms of both decreased delay and improved safety (due to removing conditions that lead to secondary crashes). However, the profession has not been able to articulate and demonstrate the magnitude of these benefits (absolute and relative to other programs, especially capital ones) to users and decision makers.

The inability to communicate the benefits is caused by three basic problems. First, little agreement has been reached on the data, performance measures, and analysis methods to document traffic incident management effects. The effects of incidents are often difficult to assess because they are confounded with other sources of congestion (e.g., recurring bottlenecks and weather). In contrast, other program areas with which traffic incident management must compete for fund allocation (e.g., pavement maintenance, bridges, and capital construction) have long-standing histories of providing condition and performance information, as well as expected benefits to upper DOT management and lawmakers. Second, actual measurement of benefits is not taking place. Although some DOTs have started the process, data and methodological problems have yet to be resolved, and little consistency in these items exists between areas. Third, once technical hurdles are overcome, the marketing or "packaging" of traffic incident management programs has usually been ineffective, even though several factors reinforce the significance of traffic incident management in addressing congestion:

- Traffic incident management represents the only short-term means of producing measurable freeway service (and safety) improvements. Traffic incident management programs can be implemented quickly and cheaply compared with highway expansion (i.e., construction) projects.
- Traffic incident management activities highlight the importance of nonrecurring congestion and its effect on both total delay and reliability. Reliability is a concept that is growing in importance to transportation agencies. The most workable definition of "reliability" is how travel conditions vary over time. Because incidents are the dominant source of variable traffic conditions in urban areas, reliability – or lack thereof – is directly linked to them.
- Traffic incident management ties in with the increased focus of DOTs on overall emergency transportation operations and security. Effective traffic incident management programs coordinate the activities of a variety of agencies, including transportation, police, fire, emergency medical, and specialized response units. These agencies must be involved in coordinating response to natural and non-natural disasters. By involving these agencies in routine traffic incident management activities, institutional barriers to cooperation are overcome.

1.2 Purpose of this Digest

The purpose of this digest is to develop the best short-run strategy using available data to document and communicate the benefits of traffic incident management. Specifically, three issues are addressed:

1. Report the results of the workshop convened in Seattle, Washington, December 2-3, 2003. The structure of this report – and much of the information presented – can be traced to the discussions at the workshop.
2. Compile current practices in (a) developing traffic incident management benefits and (b) communicating the benefits to upper DOT management, decision makers, and the public.
3. Recommend a framework for moving forward.

This report cannot be expected to reconcile many of the institutional difficulties that confound the interagency cooperation needed for sound traffic incident management. The content was purposely prepared from the perspective of transportation agencies, primarily state DOTs, yet many more entities must be involved. In particular, the viewpoints of personnel from public safety, law enforcement, fire, emergency medical services, hazardous material teams, and private towing operators must all be considered. Such coordination is beyond the scope of the current effort, but can be taken up in several of the forums and other recommendations referenced herein. Providing the perspective of transportation agencies is an important first step in this process – it provides a way to communicate what is important and what is needed in an ideal environment. However, transportation agencies must recognize that it may be necessary to deviate from the ideal to reflect the viewpoints of other agencies involved in traffic incident management.

1.3 Project Workshop

The primary inputs for this report came from discussions at the December 2-3, 2003, workshop. The workshop had two parts: (1) presentations on the current state of the practice and (2) discussions of the issues needing resolution. The initial presentations given were the following:

- Purpose of Workshop (Doug MacDonald)
- State of Practice Review
- Practitioner Experience #1: Washington
- Practitioner Experience #2: California
- Practitioner Experience #3: Maryland/CHART
- Practitioner Experience #4: FHWA and National Perspectives

Appendix A contains the presentations made by several of the participants. Topics of discussion following the presentations included the following:

- Modeling and Measurement Methods for Developing Metrics
    - What definition of an incident and what incident timeline (e.g., detection, verification, on-scene arrival, clearance, departure, etc.) should be used?
    - What is the right mix of modeling and measurement?

  - What is required to quantify the various sources of congestion?
  - Should standard procedures be developed to ensure consistent reporting?
- Impacts of Various Incident Management Strategies
  - How should they be measured?
  - Can national standards or benchmarks for incident management performance (e.g., delay reduction, response times, etc.) be established and are they even desirable from the profession's perspective?
  - Do the incident management strategies cause a measurable change in the selected performance metrics?
- Ways to Communicate the Benefits of Incident Management
  - How should the media be used?
  - How should education campaigns for the public and decision makers be used?
- Metrics to Use
  - What resonates with the profession, decision makers, and the public?
  - Are there performance measures for output, outcome, or both?
  - Are there metrics for total/average congestion and reliability?
  - Are there multiple metrics (e.g., local versus national)?
  - Are there standard definitions for incident, other congestion sources, recurring congestion, nonrecurring congestion, delay, and free flow?

As a result of the workshop, an annotated outline was developed and revised based on feedback from the participants. The annotated outline served as the basis for this digest.

2 SUMMARY OF CURRENT PRACTICE

2.1 Estimating the Benefits of Traffic Incident Management Programs

Several traffic incident management programs were surveyed to identify good practices in benefit estimation and communication. The seven responders in Table 2.1 represent 12 different regions; the Caltrans response from the Traffic Operations Division includes six regions (Los Angeles, San Francisco, San Diego, Orange County, Sacramento and San Bernardino). A significant share of the benefits that traffic incident management programs provide relate to the ability to respond to an event, communicate the situation, and clear the problem.

2.1.1 System Patrol and Communication Description

The survey includes a few key identifiers of the actions taken on three important elements studied in this report (see Table 2.1):

- Response - A range of miles must be covered by each service patrol vehicle. Most areas use a roving patrol system rather than a dispatch-only system. Most responses indicate that the peak travel hours are covered with roving operating vehicles, but overnight and weekend operations are more typically operated as a dispatch-type operation.
- Communication – While there are many communication mechanisms, the survey only identified the number of message signs. Radio traffic reporting is relatively ubiquitous, but for travelers who choose not to listen, message signs can assist in route changes. The miles between each dynamic message sign for the urban freeway system is relatively consistent, ranging from 3 to 7 miles.
- Clearance - Five responders have official information campaigns to reinforce the need to clear collisions and vehicle breakdowns off the road quickly, but the California systems and the Twin Cities do not. There are official agreements between the DOT and State Patrol or Police agencies among most survey respondents. These agreements can greatly help sort out issues of incident scene control and clearance.

2.1.2 Performance Data

Table 2.2 shows the information collected by the agencies to estimate the traffic incident management program benefits and the amount of that information that is archived. Traffic volume, lane occupancy, and point speed data are collected by most agencies, while travel time data and vehicle classification are less frequently obtained. Incident location and time, and the key time points within the traffic incident management 'chain' (i.e., detection, response, and clearance) are not collected by all agencies and many only have such data for major incidents. Explanatory data (e.g., road and weather conditions and work zone location) are also not universally collected.

Table 2.1 System and Service Patrol Information

Traffic Incident Management Service Aspect	Baltimore	California	Cincinnati	Milwaukee	Minneapolis-St. Paul	Orlando	Seattle
No. of vehicles	9	326	5	8	8	9	21
No. of miles covered by service patrol	100	1,550	88	212	170	53	160 both directions
Miles per vehicle	11	5	18	27	21	6	16.8
Operating hours	Weekdays, 5a-9p	Peak hours; Other hours vary	Mon-Fri, 6a-7p	All days	5a-7:45p, M-F 9a-3p, S,S (1 vehicle on S,S)	24 hours, All days	6a-7p, M-F Express Lanes 7 days
Type of dispatch	Roving patrol	Roving patrol	No response	No response	Roving patrol	Roving patrol	Roving/call out
Message signs	40	524	40	25 Fwy/ 11 Street	66	35	150
Miles of urban freeway system	290	1,570	180	110	320	160	172 both directions
Miles per sign	7	3	5	4 (freeway)	5	5	4
Information campaign for clearing collisions quickly?	Yes	No	Yes	Yes	No	Yes	Yes
Agreements with law enforcement responders?	Yes	Yes	Informal	No	No	Yes	Yes

Table 2.2 System and Service Patrol Information

Data Collection Element	Baltimore		California		Cincinnati		Milwaukee		Minneapolis-St. Paul		Orlando		Seattle	
	Coll	Arch	Coll	Arch	Coll	Arch	Coll	Arch	Coll	Arch	Coll	Arch	Coll	Arch
Speed data from point-source detectors	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Travel time information from probes or electronic toll collection tags			✓[1]	✓[1]	✓		✓	✓					✓	✓
Traffic volume data (please include data collection technology used)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lane occupancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vehicle classification	✓	✓	✓	✓			✓	✓					✓	✓
Incident locations and time of day			✓[2]	✓[2]	✓	✓	✓	✓	✓		✓	✓	✓	✓
Detection, clearance and response times			✓[3]	✓[3]	✓	✓	✓	✓	✓				✓	✓
Road conditions	✓	✓	✓	✓					✓	✓			✓	✓
Weather conditions	✓	✓	✓[4]						✓	✓			✓	✓
Work zone locations	✓		✓	✓	✓	✓	✓	✓	✓				✓	✓

[1]San Francisco-Oakland only.
[2]Districts 3, 4, 7, 8, 11 and 12.
[3]Historical data is inconsistent; major incident details collected recently.
[4]Minor coverage.
Note: Coll – Collected; Arch – Archived

2.1.3 Incident Information

A variety of information is collected for the type and severity of freeway incidents. The number of incidents and type or severity is collected for all responding systems, but not in the same way or with the same level of detail (Table 2.3). The information is better on the more severe incidents such as those that block lanes, but there could be significant improvements in the consistency and level of detail provided. A set of major timeline elements and guidance on consistent definition of terms would assist agencies that wish to benchmark their operations for future improvements.

2.1.4 Performance Measures

Almost all areas have some performance measures or information that is used to communicate the amount of time to respond to an incident, as noted in Table 2.4. The level of detail on these measures and the ease of access to the data, however, vary widely. The amount of delay, speed, and travel time is captured or estimated in most systems, but the terms that are used vary somewhat from area to area. The timeline elements identified in Section 3.2.1 could be incorporated into the performance measures in a way that might not require significantly more data collection effort, but would allow a greater set of response information to be communicated. The timeline elements would include the definition of terms such as detection, response, and clearance.

Caltrans uses an additional concept of "return to normal conditions" that incorporates the amount of time needed for the effects of incidents to be completely dissipated. These statistics will also draw upon the broader archived traffic database system. They represent the product of significant effort in addition to providing access to a computerized dataset and, as such, require time, effort, and some notion of who the customers are and what they are looking for.

2.1.5 Benefit Assessment

Some of the traffic incident management systems have an ongoing evaluation program that tracks both agency and system performance, such as the Baltimore metropolitan area's evaluation performed by Maryland State Highway Administration's Coordinated Highways Action Response Team (CHART) program, which has been performed annually since 1999. Most traffic incident management systems do not have such an ongoing program, but they have benefit assessment components (see Table 2.5). The agencies surveyed for this report are among the most highly regarded for their operations and communications efforts. Goals are mostly common and are relatively simple clearance or response time targets rather than a broad set of measures. The evaluations are not always performed annually, and only Milwaukee and Baltimore (among the respondents) have estimated secondary incident reductions. The evaluations are a product of both field data and computer simulation models. California is developing a broad set of system and agency measures, but the master plan has been under review for more than 1 year.

Table 2.3 Incident Information

Incident Information	Baltimore[1]	California	Cincinnati	Milwaukee	Minneapolis-St. Paul	Orlando	Seattle
Number	✓	✓	✓(~1100 per month)		✓	✓	1957 per month
Rate	✓				✓	✓	Not yet
Type[2]	✓	✓	✓		✓		Fatal, injury, property damage
Severity	Shoulder – 80.3% 1 lane – 8.6% 2 lanes – 6.4% 3 lanes – 2.2% 4 lanes – 2.4%	Only track major; motorist delayed 30+ minutes from normal		50+ types 1 to 5 scale	✓	✓	15 min or less 15-90 min over 90 min
Weekday or Weekend	94% weekday						Mostly weekdays (Express Lanes 7 days)
Peak or Off-peak	43% peak						Mostly daytime hours (both am and pm peaks)
Lanes Blocked	Shoulder – 80.3% 1 lane – 8.6% 2 lanes – 6.4% 3 lanes – 2.2% 4 lanes – 2.4%			5 codes: 1 – no lanes blocked 2 – 1 lane blocked 3 – 1 or more lanes, injury, road damage 4 – all lanes blocked 5 – freeway closed	Number blocked and time to clear is recorded	Number blocked is recorded	Direction (N/B, W/B, E/B, S/B) lanes—single, multiple, all, total closure, shoulder/ median, HOV lane, ramp, other

[1]Also report statistics by route and location.
[2]Cause of incident (collision, disabled, debris, etc.) and primary or secondary.

Table 2.4 Performance Measures

Measure	Baltimore	California	Cincinnati	Milwaukee	Minneapolis-St. Paul	Orlando	Seattle
Response Time	Call received to response vehicle arrival.	Caltrans notified to on-scene arrival.	No common measure.	Notified to on-scene.	Detected by transportation management center to arrival.	—	Time notified to time arrived (for notified responses)
Time	13.1 minutes	Goal—30 minutes.	—	—	—	—	Monitor trend but no goal set
Clearance Time	Arrival to complete clear.	Caltrans notified to all lanes open.	No common measure but ARTIMIS has "time stamp" data.	Verified to complete removal.	Detected to completely clear freeway.	Lane blocked to lane open.	Start time of incident to time cleared (incident response unit leaves the scene)
Time	14.6 minutes	Goal—90 minutes	—	—	—	—	Goal—90 minutes
Other Response/ Clearance	—	Return to normal conditions	—	—	—	—	—
Detection to Broadcast	Not reported.	Caltrans notified to appropriate action.	—	—	Detection to media notified	—	—
Time	—	—	Less than 2 minutes.	—	Estimated as 1 minute.	—	—
Travel Time and Reliability	Travel time, delay	Recurring congestion -Speeds below 35 mph for 15 minutes or more; measured for miles of road and number of hours.	Speed and travel time.	Speed and travel time.	—	Delay, extra travel time through incident.	Annually monitor 9+ major commute routes; 95% reliable travel time for peak travel times. Also monitor state's national ranking of average commute time.

Note: "Time stamp" refers to a record of key events within an incident.

Table 2.5 Benefit Assessment Components

Benefit Component	Baltimore	Cincinnati	Milwaukee	Minneapolis-St. Paul	Orlando	Seattle
Delay Reduction	Added delay due to incidents is calculated.	Estimated using ITS Deployment Analysis System (IDAS); hours of delay reduced and value of time; 2000 am peak mobility benefit-$187,000.	Estimated in three studies using field data and computer simulation.	None	Unknown	Delay reduction, estimated to be over $7,000 for time, $5,800 for fuel, plus other operating costs, totaling $40,000 to traveling public.
Reliability Improvements	No current metric.	2000 am peak travel time reliability benefit - $108 million.	No current metric.	None	Unknown	2 years of data analyzed to date. Four major commutes showed improved average peak travel times.
Safety Benefits	Primary incidents reduced; Secondary—2 miles and 2 hours; in opposite direction – half hour and half mile. CHART estimates 28.6% reduction in secondary incidents.	$1.7M benefits from accidents; 2.5% fatality reduction; analyze major closures.	Secondary incidents from two studies crashes upstream and later in time from initial event were identified (2 miles and 1 hour).	None	Unknown	Research to come (May 04).
Fuel Savings	Estimated fuel savings due to incident management – 5.06M gallons	$823,000 in fuel benefits; $33.9M in emissions reduction.	Used FRESIM computer model to estimate fuel savings.	None	Unknown	One disabled vehicle study is $5,800—no goals to date.
Goals	Management and board set goals. Objective: Improve mobility—reduce congestion delay due to incidents by 1% annually.	ARTIMIS goals: Improve safety, Reduce accidents, Improve air quality.	Policy and technical group developed a goal to: 1. Improve traffic incident management 2. Improve freeway safety 3. Enhance efficiency	Statewide goal: 35 minutes average clearance time, based on 10-year trend (2002 value – 36.3 minutes)	Statewide goal: Clear the road within 90 minutes of first officer arrival on scene; based on statewide committee and Washington State.	1. Improve travel times on major commutes 2. Efficient incident response program management—based on data 3. Reduce incidents over 90 minutes 4. Improve freeway safety

Note: California is in the process of completing a transportation management systems (TMS) master plan that will contain performance indicators for external stakeholders, management and practitioners.

2.2 Marketing Traffic Incident Management Programs

Appendix B presents several specific examples of efforts undertaken by state DOTs to market traffic incident management and operations in general. These efforts have a common theme: produce benefit estimates that have been verified, communicate them in simple terms that laypersons can understand, and rely on graphic presentations of technical material. Pat Irwin, Director of Transportation Operations of the San Antonio District of Texas DOT, has summarized the marketing process for operations as follows:

- Believe in the value of your actions. This belief will be apparent to your audiences.
- Relate the benefits of your programs at a personal level so that your audience knows how the programs affect them directly.
- Court the media. Low-cost solutions to congestion and the use of advanced technologies are strong selling points for the press.
- Be sensitive to intra-agency and interagency partners. Involve them in your processes.

Section 3 presents a more in-depth look at this and several other marketing-related issues. In addition to the information presented in Appendix B, useful materials may be found at the following locations:

- Florida DOT
  - http://www.dot.state.fl.us/planning/library/library_incident.htm
  - http://www.floridaits.com/PDFs/benefits_analysis.pdf

- Vancouver, Washington: Vancouver Area Smart Trek
  - http://www.vastrek.org/initiatives/IM.htm

- AASHTO Success Stories: Connecticut DOT
  - http://www.transportation.org/aashto/success.nsf/allpages/13-CTIncidentManagement?opendocument

- Oregon DOT
  - http://www.tfhrc.gov/pubrds/03sep/03.htm
  - http://www.odot.state.or.us/its/BenefitsOfITS/trafficMgmt.htm

- Arizona DOT
  - http://www.aztech.org/react/benefits.htm

- Caltrans (safety orientation)
  - http://www.tibco.com/resources/customers/successstory_caltrans.pdf

- Indiana DOT
  - http://www.in.gov/dot/motoristinfo/trafficwise/about_benefits.html

- Maryland CHART
  - http://chartinput.umd.edu/

3 RECOMMENDATIONS[1]

3.1 Marketing, Outreach, and Education

3.1.1 Who Are our Customers?

The overall market of groups that receive benefits from improvements of a traffic incident management program is large. Potential market segments of those receiving benefits from traffic incident management activities include the following:

- Public Interests
  - National Government – U. S. Congress
  - State Government – Governors, State Legislators, State and Local Transportation Agencies
  - State and Local Emergency Responders - State Patrol or Police Departments, Local Police Departments, Local Fire Departments, Emergency Medical Services, Emergency Management Agencies, Local Coroners Offices, Local Hazardous Materials Agencies
  - State and Local Planning Agencies – Metropolitan Planning Organizations, Regional Operating Organizations, State and Local Planning Agencies, State Environmental Authorities
- Private Interests
  - Environmental Advocacy Groups
  - Freight Users and Freight Carriers
  - Vehicle Fleet Managers
  - Tourists
  - Commuters
  - Media
  - Towing and Recovery
  - Hazardous Materials Contractors
  - Private Emergency Medical Services

For those involved directly in traffic incident management activities, the stake that each of these groups has is obvious. However, it is often difficult to make the case for traffic incident management with these groups because of competing concerns and the elusiveness with which incidents occur. For example, given that incidents vary by location, time, and severity, travelers do not experience their effects every day in the same way they would a recurring bottleneck like an overwhelmed interchange or a bridge crossing.

But in order to build support for traffic incident management activities with the widest possible base, all of these potential customers should be targeted to some degree. To do this,

[1] Specific recommendations are noted in bold italics throughout this section.

- ***We recommend that a fundamental message be crafted and then tailored to each of the potential customer groups. This fundamental message should come in the form of a NATIONAL VISION, as discussed below.***

3.1.2 Creating a National Vision for Operations in General and Traffic Incident Management in Specific

The strong, simple message to communicate the benefits of improving traffic incident management programs should be aligned with a National Vision for Operations. A process to develop a National Vision for Operations is being initiated by the transportation community. This process will be consensus building, and traffic incident management must be a major component of the vision.

The National Vision for Operations should be far reaching and must include not only traffic incident management but traveler information, congestion management, transit operations, managed work zones, operations during inclement weather, special event management, and emergency operations during natural and non-natural disasters. This wide range of situations invites an equally broad spectrum of stakeholders to the visioning process - not only state and local DOTs, but also emergency response agencies, other transportation modal operators, and private entities such as freight carriers and the media.

The visioning process must set goals that capture the imagination of the public safety and the transportation communities. An example of such a goal was the Interstate Highway System's goal of linking every major city with grade-separated, high-capacity roadways by 1976. Another example was President John F. Kennedy's call for the United States to have an American walk on the moon by the end of the 1960s. These goals galvanized entire industries and provided a means for measurable success of those programs. Potential overarching visions have been discussed at this workshop and in other venues.

- ***The recommended Operations Vision is "No Unexpected Delays on the National Highway System."***

This far-reaching goal has many implications. The reference to the National Highway System (NHS) not only includes the entire Interstate system, but also numerous critical non-express (i.e., arterial) roadways. Most current traffic incident management and state DOT operations programs have only included freeways. This goal requires costly increases in the traffic incident management program coverage areas. Most freeway service patrol programs operate in urban areas; outside these areas, achieving acceptable detection and response times will be a significant challenge. In these rural areas, public safety agencies will be the primary responders to incidents. Of course, public safety agencies have significant funding and staffing problems of their own. In addition, the term "unexpected" implies a heavy component of traveler information, so that even if delay occurs (which inevitably will happen), travelers can be made aware of it beforehand.

A primary focus of this vision should include the notion that the United States cannot build itself out of the congestion problem. A recent analysis conducted as part of the Urban Mobility Study indicates that in the 75 largest metropolitan areas, it would require 1,200 additional freeway lane-miles plus 1,230 additional arterial lane-miles to achieve 200 million hours of delay reduction (approximately 1.5 percent of total delay). There is a broad range of alternatives to providing additional roadway capacity that have been shown to rank very highly in benefitcost analyses. These alternatives include improved transit, land use changes, travel demand management, freeway and arterial operations improvements, weather management, and work zone management. Another focus of this vision will be travel time reliability. Congestion is often cited as a major concern, but customer interviews with travelers have indicated that reliability of travel time for trips is becoming as important as congestion itself.

The success of the highway safety community is a great example of translating a vision into actions and getting the message across to decision makers and the public. Highway safety advocates began to be noticed in the 1960s; highway safety programs are now a part of every state government; and U.S. DOT has created the National Highway Traffic Safety Administration (NHTSA) to address highway safety issues. A number of advocacy groups such as the Insurance Institute for Highway Safety, the Highway Loss Data Institute, Mothers Against Drunk Drivers, Advocates for Highway and Auto Safety, and the Governors Highway Safety Association are now a major influence on federal and state legislation. This influence has led to the development of the *Highway Safety Manual* (the safety version of the *Highway Capacity Manual* [HCM]) and Highway Safety Strategic Plans developed by both AASHTO and individual state DOTs. Highway safety has been incorporated into the design process for roadways as well as for vehicles. A "culture of operations" is the desired outcome of the National Vision for Operations, just as a "culture of safety" has already been fostered in transportation agencies. To promote traffic incident management in a similar fashion, the following recommendations are made:

- ***Increase the emphasis on evaluating operations (especially traffic incident management) in the Highway Capacity Manual. This may even take the form of a companion volume to the traditional HCM as a way to highlight the importance of operations in maintaining the maximum capacity provided by the physical infrastructure.***
- ***Undertake an AASHTO-supported National Operations Strategic Plan, following the model set by the AASHTO/NCHRP "Strategic Highway Safety Plan." Alternately, reduce the scope to just cover a National Traffic Incident Management Strategic Plan as one piece of a larger operations initiative.***
- ***Encourage the development of Operations Strategic Plans (or Traffic Incident Management Strategic Plans) at the state and regional levels. These plans would be an effective way to improve the visibility of operations and provide guidance to highway planners and programmers. To start, one or two states can be selected as prototypes for future plans. The process of developing such documents will help foster the institutional relationships and discussions that must take place to promote operations – both peer-to-peer and sharing information between agencies and within agencies.***
- ***Promote the integration of the Operations Strategic Plan into the Statewide Transportation Plan. The integration process educates agencies about operations activities and also provides a mechanism to further include operations programs and projects into the programming process.***

Part of the difficulty in communicating the value of operations to a wide variety of audiences is defining the value in terms that are easily understood. Of particular concern is having a basis for comparing traditional capital improvements and operations on equal terms. Therefore,

- ***It is recommended that translating the effect of traffic incident management (and operations) on traffic flow into equivalent lane-miles of new capacity should be used in discussing the benefits of traffic incident management programs***. This tactic plays into the mindset that most transportation agencies and the public have: both can easily relate to what the effect of adding new lanes or new highways will be. This tactic could be as simple as identifying the percentage increase in vehicle or person throughput and multiplying by the amount of lane-miles of roadway that are treated.

The important role of traffic incident management in the National Vision for Operations is further enhanced by the recent emphasis on emergency preparedness. An agency that successfully conducts traffic incident management activities by necessity has developed the institutional awareness and interagency relationships needed to prepare for traffic and transportation operations during natural and non-natural disasters. A successful traffic incident management program also promotes an "operations philosophy" in regional and state public safety and emergency management partner agencies.

- ***The link between routine traffic incident management and emergency preparedness should be used as a selling point for traffic incident management programs.***

As the process to craft the National Vision for Operations proceeds, specific target goals (or "benchmarks") should be developed. One approach is to develop the steps that occur in the traffic incident management process. Goals should be developed for incident detection – or, in case of a natural disaster, for a warning of forecasted locations and severity of damage - for response time by the responding agencies and for the roadway clearance time. Target goals for incident detection may need to vary by location. In urban areas where freeway detection devices are available, a goal of detection within 1 minute of an incident seems achievable, whereas in rural areas a 15-minute detection goal may be more reasonable. Response time (i.e., time between incident detection and arrival on the scene by a responding agency) will also vary by location, with urban areas having a higher goal (i.e., shorter response time) than rural areas. Clearance time (i.e., time between incident detection and clearance of all roadway travel lanes) has received considerable attention across the United States already. Several states have adopted policies to meet a goal of a specific clearance time. For example, Florida has adopted the "Open Roads Policy," which states that any incident in Florida will be cleared from travel lanes within 90 minutes. Similar programs in California and Washington have also chosen a 90-minute clearance time. A primary task in the development of the National Vision for Operations is to achieve consensus on a set of target goals that will be adopted across the nation.

- ***The vision should include specific targets for different aspects of traffic incident management activities.*** (Several potential targets can be found in Table 3.1.)

Along with the development of goals must be a continuous performance measurement program for operations. The goals mentioned previously must be measured and reported in order for national, state, and local agencies to progress toward meeting those goals. Development and reporting of operations performance measures on a national basis will generate focus and public interest in operations just as the national report on congestion by the Urban Mobility Study has brought considerable national attention to the congestion issue. The transportation community should consider a partnership in this effort with associations representing the other partners in the traffic incident management process, including the public safety and emergency management agencies. One candidate for this partnership is the International City/County

Management Association (ICMA[2]). ICMA already provides performance measurement comparisons between local governments in various standard service areas such as fire, police, and emergency services response time. A specific recommendation flows from this discussion:

- ***Guidelines for establishing ongoing performance monitoring programs should be developed and promoted by FHWA, AASHTO, or both. This digest provides much of the background needed to develop these guidelines, but a more formal process is needed to ensure completeness and acceptance by the transportation community.***

Table 3.1 Possible Structure of a National Traffic Incident Management Strategic Plan

Element	Goals and Targets
1. Field Response	1. Clearing 80% of lane blockages within 10 minutes 2. Clearing minor traffic incidents within 20 minutes 3. Clearing major traffic incidents within 90 minutes 4. Training incident responders in traffic control techniques
2. Organization and Coordination	5. Establishing regional multiagency traffic incident management programs 6. Establishing protocols for incident scene management 7. Linking routine traffic incident management with emergency preparedness and security
3. Planning, Detection, and Deterrence	8. Detecting incidents within 60 seconds 9. Warning travelers of incidents within 5 minutes 10. Improving the uniformity, quality, and timeliness of incident- and delay-related data 11. Monitoring the performance monitoring of traffic incident management activities 12. Reducing the occurrence of secondary incidents by 25%
4. Infrastructure and Equipment	13. Improving equipment for multiagency communications to promote the integrated two-way exchange of voice, data, and video information. 14. Identifying and securing equipment resources for traffic incident management activities

Note: Implementation guides to be developed around each goal/target.

[2] http://www2.icma.org/main/bc.asp?bcid=107&hsid=1&ssid1=50&ssid2=220&ssid3=297

3.1.3 Mechanisms for Outreach, Marketing, and Education

As the strong, simple message on the benefits of improving roadway operations and traffic incident management is developed, mechanisms for promoting this message should also be developed. A wide-ranging set of outreach, marketing, and education techniques should be conducted to promote the operations message. Some of the techniques that are recommended include the following:

- ***There should be case studies – examples of successful traffic incident management programs, institutional partnerships, and regional operations organizations.***
- ***There should be a peer-to-peer network – a roster of experts in operations and traffic incident management available to provide guidance to agencies.***
- ***There should be scanning tours for decision makers – a listing of successful operations programs that can be toured by decision makers to learn how successful operations are conducted.***
- ***There should be an education campaign for senior DOT officials (AASHTO committees) – special emphasis for DOT officials not involved in operations.***
- ***There should be training courses for DOT employees outside of operations – the National Highway Institute (NHI) has been sponsoring traffic incident management training for several years, and many operations personnel have had the training. DOT personnel who are not involved in operations need an overview course that provides the benefits of operations and traffic incident management and describes how their jobs may be affected.***

3.1.4 Content of Outreach, Marketing, and Education Materials

As an outreach program is being developed, it is important to develop the content of the outreach materials properly. The materials describing the benefits of operations and traffic incident management must be clear and concise, as well as usable for a wide audience. Operations and traffic incident management must be defined clearly, and the benefits described must relate to and be understood by the audience. Proper development of the outreach materials' contents will likely lead to materials for a range of targeted audiences. The benefit data must also be a product of rigorous technical analysis; "junk" or unsubstantiated data must be avoided. Communications specialists should also participate in the development of outreach materials because not only must the content be correct, but the message should be worded in a fashion that connects with the targeted audience.

- ***The data, statistics, and analysis used to develop benefits for traffic incident management programs should be evaluated by independent reviewers prior to release.*** This will ensure that believable numbers are used to justify the programs. Most state DOTs have research relationships with universities in their states, and these relationships are a good mechanism for review, provided that the universities did not produce the benefits in the first place.
- ***The outreach program must incorporate the need for funding agency and interagency activities such traffic incident management, coordinated planning, joint operations, and resource sharing.*** The current funding process emphasizes capital projects development and implementation, and the funding normally is provided by mode. When operations

activities require funding, it is difficult for these activities to fit into the existing funding programs. The capital projects related to traffic incident management (e.g., intelligent transportation systems [ITS] devices, vehicles, or a transportation management center [TMC] building) can only provide a means to communicate or detect. Activities are required to produce a response or a coordinated plan. Activities requiring coordination among modes and with agencies not in the transportation community do not usually fit into existing funding categories at the federal or state level. An outreach program should suggest new or modified methods to obtain resources to accomplish traffic incident management.

3.1.5 Customized Public Relations Materials

The workshop identified several specific public relations tools that should be developed and promoted. These tools would target potential customers individually and would be in addition to press releases, newspaper and magazine articles, and radio and television news spots.

- ***There should be a "Best Practices Guide" for marketing and estimating benefits of traffic incident management programs.*** The guide will be a template for state DOTs to follow in preparing marketing materials, estimating benefits, and implementing a performance monitoring program. The discussion in this digest and the examples in the appendixes present a framework for the guide.
- ***Agencies should strive for "the Perfect Incident/Collision."*** The best collision is one that does not happen, but there will be problems on the road system. The "perfect collision" concept identifies the elements of agency response, driver and responder actions, and the resulting benefits to the travelers.
    1. The collision occurs on the middle lane of a three-lane freeway section.
    2. The event is identified in less than 60 seconds by a combination of cell phone calls and camera confirmation.
    3. The drivers of the vehicles see that they cannot move their vehicles because of the damage; if damage had been light, the drivers would have moved their vehicles off the freeway to a shoulder or to a place completely off the freeway.
    4. Other travelers are warned within 2 minutes of the incident about the possible effects and their alternate routes if the backup will be severe enough to warrant. Travelers who have yet to depart can decide to choose other modes that may be less affected by the incident (e.g., high-occupancy vehicle lane) or departure times.
    5. Travel in the opposite direction is not affected by the incident thanks to visual screens in the median that prevent "rubbernecking."
    6. Responders arrive within 5 minutes with all the appropriate equipment needed to address the incident. The Highway Helper Patrol is first on the scene and confirms equipment and personnel needs. The heavy-duty tow truck is turned around part way to the scene when the cameras determine that light-duty tow trucks will be sufficient. And the responding fire truck that remains in case it is needed is well off the traveled path.

7. Emergency medical services personnel treat any injuries that have been sustained.
8. Law enforcement personnel, by standing agreement of local agencies, are in charge once they arrive at the scene and are tasked to remove lane blockages as quickly as possible.
9. Only one lane is blocked when the responders arrive, and in the course of the event one other lane (between the collision scene and the outside shoulder) is closed for 2 minutes while the tow trucks attach to the vehicles with enough security to drive to the shoulder. Enforcement officers take pictures of the scene with digital cameras, and, if available, a helicopter also takes video or still photos of the scene.
10. After the damaged vehicles reach the shoulder, the tow trucks attach all safety devices so that the vehicles may be towed away from the freeway. Clean-up crews quickly sweep debris from the travel lanes while the attachment takes place.
11. Further collision investigation and citations are issued after the vehicles are removed to an area away from the freeway.
12. The incident scene is cleared in about 15 minutes, resulting in a back-up of only 1.5 miles, and conditions return to normal for that time period in about 60 minutes. There are no collisions in the unexpected queue thanks to the rapid clearing of the scene, communication via radio and message signs, and heightened awareness of the travelers in the area.

- ***Vignettes should target specific audiences.*** Vignettes are small "slices of reality" that follow specific events from the perspective of a representative from the target audience. Target audiences are as follows:
    1. ***DOT staff.*** Benefits are accrued for planners who have real-time, continuous data that were previously unavailable; field staff will benefit from improved safety; infrastructure staff will benefit from improved asset monitoring; operations staff will be able to provide better traveler information to the public and to partnering agencies; and management benefits from expanded performance measurement systems.
    2. ***Long-haul truckers.*** Rural emergency responders – police, fire, emergency medical services, coroner, and hazardous material specialists – are the target audience for this vignette. Successful traffic incident management practices provide improved agency coordination, verification of exact incident location, and safer incident scene management. All of these attributes provide for safer, more efficient services for the responding agencies.
    3. ***Metropolitan emergency responders***. Evacuation planning and operations during an evacuation will be the topic of this vignette. Emergency managers benefit from established working relationships among agencies when planning for evacuation. When agencies regularly work together in traffic incident management, each agency's capabilities are known by the other agencies, and resources to be shared among agencies have been pre-determined.
    4. ***Commuters trying to reach appointments on time during an "unreliable" (unexpected incident) evening rush hour.*** This vignette will feature a commuter

on a tight schedule – getting to a meeting on time, getting to daycare in time to pick up a child, etc. Improved operations and traffic incident management provides a more predictable travel time, thus allowing people to adhere to their personal schedules better.

3.2 Technical Aspects of Incident Performance Measurement and Benefits Assessment

3.2.1 Uniform Reporting of Incident Performance Data

This section presents preliminary ideas on how the definition, collection, and reporting of incident performance data can be made more uniform. It borrows ideas from two existing ITS data dictionary standards: (1) *P1512.2 Standard for Public Safety Traffic Incident Management Message Sets for use by Emergency Management Centers,* developed by the Institute of Electrical and Electronics Engineers (IEEE), and (2) *Traffic Management Data Dictionary* (TMDD), developed by the Institute of Transportation Engineers (ITE).

Incident Definition

The P1512.2 standard defines an incident as "a non-reoccurring or planned event impacting transportation services." The TMDD classifies incidents under the general heading of "events." In the TMDD, an incident "event" is defined as "situations arising from roadway crashes and other unplanned roadway incidents, including disabled vehicles" and considers the following categories (which have also been used in P1512.2):

1=accident;
2=serious-accident;
3=injury-accident;
4=minor-accident;
5=multi-vehicle-accident;
6=numerous-accidents;
7=accident-involving-a-bicycle;
8=accident-involving-a-bus;
9=accident-involving-a-motorcycle;
10=accident-involving-a-pedestrian;
11=accident-involving-a-train;
12=accident-involving-a-truck;
13=accident-involving-hazardous-materials;
14=earlier-accident;
15=medical-emergency;
16=secondary-accident;
17=rescue-and-recovery-work-in-progress;
18=accident-investigation-work;
19=incident;
20=stalled-vehicle;
21=abandoned-vehicle;
22=disabled-vehicle;
23=disabled-truck;
24=disabled-semi-trailer;
25=disabled-bus;
26=disabled-train;
27=vehicle-spun-out;
28=vehicle-on-fire;
29=vehicle-in-water;
30=vehicles-slowing-to-look-at-accident;
31=jackknifed-semi-trailer;
32=jackknifed-trailer-home;
33=jackknifed-trailer;
34=spillage-occurring-from-moving-vehicle;
35=acid-spill;
36=chemical-spill;
37=fuel-spill;
38=hazardous-materials-spill;
39=oil-spill;
40=spilled-load;
41=toxic-spill;
42=overturned-vehicle;
43=overturned-truck;
44=overturned-semi-trailer;
45=overturned-bus;
46=derailed-train;
47=stuck-vehicle;
48=truck-stuck-under-bridge;

49=bus-stuck-under-bridge;
126=accident-cleared; and
127=incident-cleared.

Even though P1512.2 borrows the data element and the valid values (coding) from the TMDD, there is still an inconsistency in the basic definitions: P1512.2 seems to allow for planned events, while the TMDD considers an incident "unplanned" and defines "planned" events separately. This inconsistency highlights the difference in the purpose of each – P1512.2 is based on emergency response (which could include planned events) while the TMDD is primarily aimed at actions that manage traffic flow. Therefore,

- ***For the purpose of marketing and performance monitoring of traffic incident management activities, the TMDD definition of an "incident" is preferred ("a non-reoccurring or planned event impacting transportation services"). This definition includes specifying the type of incident using the TMDD data element "EVENT_DescriptionTypeIncident_code."***

Incident Reporting

A major problem with collecting incident data is that different agencies investigate and manage incidents; thus, no single database contains all incidents that occur in a region. For example, police and fire computer-aided dispatching (CAD) systems will contain information on incidents reported to and managed by them. Transportation personnel will frequently work the same incidents as police and fire personnel, so there is an overlap in incident data collection. However, transportation personnel do not investigate all incidents worked by fire and police, and vice versa. (An example of the latter is a vehicle breakdown worked exclusively by freeway service patrols.)

- ***Transportation agencies should endeavor to collect incident information for incidents in which their personnel are not directly involved. This may include tapping into the CAD system operated by 911 agencies or the point at which the initial incident detection is made.***

Incident Characteristics – Required Data

For the purpose of establishing an ongoing performance monitoring program, the following data types related to incident characteristics are required.

Incident Location. Geolocation is a complex topic in the transportation industry. There are many competing reference systems and technical difficulties with applying them to highway features. Further, integration of different information systems to use a single referencing system is a very intensive task. Two options are available for the basic location of an incident (or any other event or highway feature):

1. Traditional linear referencing. This option is constructed by combining several data items (usually route, direction, and milepost).
2. Geospatial coordinates (latitude, longitude, and altitude). This system is used by the TMDD. However, the TMDD also specifies a "linear distance offset" for event locations from the beginning point of a road, route, or link. In addition, the TMDD also uses "nearest cross-streets" at the beginning and end of an event as well as the nearest

upstream freeway entrance and exit ramps. Apparently, the specification of multiple georeferencing systems was done to allow flexibility.

Supplemental information can be appended to these basic structures to indicate if the event (incident) is located on ramps and other positions off of highway mainlines. For example, in the TMDD, the data element "EVENT_LocationRelationToJunction_code" specifies where the incident has occurred relative to intersections and interchanges.[3] For the purpose of this application, the following recommendations are made concerning the coding of incident location.

- ***The location of an incident should be coded using the prevailing georeferencing system used by the state DOT or the specific traffic management center. Whichever system is used, it should be able to be matched directly or "cross-walked" with the system used to identify several other important features for performance monitoring, especially the location of traffic surveillance sensors and the cross-section character (e.g. lanes, shoulders, median, etc.).***
- ***Because incidents can be spread out over linear distance, it is recommended that the linear extent (beginning point/end point) of the incident be captured. For incidents that consume less than 0.1 mile of linear distance, only a single value need be coded.***
- ***In addition to coding the "point" on the roadway system where the incident occurs, the location coding should also encompass additional information on the location to facilitate performance monitoring and other analyses:***
  - ***The location relative to the highway cross section should be coded. This includes specifying***
    - ***i. The lateral location (i.e., in-lane, shoulder, median, gore, and combinations of these);***
    - ***ii. The type of lanes affected (see TMDD "EVENT_LanesType"); and***
    - ***iii. The number of lanes affected (see TMDD "EVENT_LanesAffected_code").***
  - ***The location relative to key geometric features that influence traffic flow should be captured.*** At a minimum, the TMDD's "EVENT_LocationRelationToJunction_code" can be used. More advanced applications would include the actual distance to these features.

Incident Timeline. Decomposing total incident duration into discrete "sub-events" is very useful for performance monitoring; tracking the duration of the sub-events can help identify areas that require improvement. The TMDD identifies several date/time points on the event timeline that may be used:

[3] This data element was actually adopted by the TMDD from the Model Minimum Uniform Crash Criteria (MMUCC) specification.

1. Start time of the event (time of detection for an incident).
2. Time the event was confirmed and response was initiated. (These two sub-events are actually separate, but the TMDD treats them as one.)
3. Time of the first arrival at the event scene.
4. Time a roadway event was cleared, activities were completed, and roadway is recovering. (Time of clearance and time all activities are completed can be two separate sub-events, but the TMDD treats them as one.)
5. "The actual end time of a roadway event" (TMDD definition). It is unclear how this data element relates to the element described immediately above.

For monitoring the performance of traffic incident management programs, the TMDD provides a basic structure for the incident timeline. However, a slightly more detailed structure is offered for agencies wishing to expand on the TMDD. ***Specifically, the following points on the incident timeline should be captured:***[4]

1. ***Incident Start Time – an estimate of the actual start time of an incident, allowing for gap between when the incident actually occurred and when it was detected. This estimate will be subjective.***
2. ***Incident Detection/Report Time – the time an incident was detected by or reported to the first agency involved in a coordinated traffic incident management program. (This point corresponds to TMDD's "EVENT_TimelineStart_date/utc".)***
3. ***Incident Verification Time – the time that an incident was verified by an agency involved in a coordinated traffic incident management program.***
4. ***Incident Response Dispatch Time – the time the first responder was notified of the incident. (This time and incident verification time require that TMDD "EVENT_TimelineConfirmedAndResponding_date/utc" be spilt into two elements.) Dispatch times for additional responders may also be included. If so, data identifying the type of responders may also be added.***
5. ***Incident Scene Arrival Time – the time the first responder arrived at the incident scene. This responder does not have to be the first one dispatched. (This time matches TMDD data element "EVENT_TimelineFirstArrivalAtScene_date/utc".) Arrival times for additional responders may also be included. If so, data identifying the type of responders may also be added.***
6. ***Incident Lane Blockage Clearance Time – for incidents that block lanes or a partial lane, the time that the blockage was either completely removed or moved out of the way (e.g., to the shoulder) so that the full width of the lane is available for traffic.***
7. ***Incident Clearance Time – the time that the incident has been physically removed from the roadway environment. (This time roughly matches TMDD data element "EVENT_TimelineClearedAndRecovering_date/utc".)***

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[4] These recommednations borrow heavily from Caltrans' definitions.

8. ***Incident Scene Departure Time – the time the last responder leaves the scene of an incident.***

9. ***Time of Return to Normal Conditions (optional) – this data element is highly subjective, given that "normal" conditions may be difficult to determine in the field. For example, if the incident has occurred during the peak period, "normal" conditions might be congestion (queues present). If properly matched to traffic sensor data, this time can be determined analytically.***

From these points on the incident timeline, the duration of several different time intervals can be calculated, including total incident duration, TMC response time, and on-scene time.

Traffic Effects of Incidents

In addition to the timeline information, agencies may find it desirable to monitor what happens to the highway cross section at the incident scene. This monitoring accounts for conditions that may change during the course of clearing an incident. For example, a rear-end collision may block a single lane initially. When responders arrive, they may close an additional lane in order to manage the incident. Finally, once cleared, emergency vehicles may remain on the shoulder for some time. All of these discrete events have a widely different impact on traffic flow.

The data would allow more refined analyses to be performed as well as to track how well responders are managing incident scenes (from the perspective of traffic flow). The data are structured as the times that lane or shoulder blocking events begin. Every time the nature of the blockage changes, a new entry is made. These data are optional, since some agencies lack the resources to collect them. Following are the data required to record the traffic effects of incidents:

- Begin Time of Blockage.
- Number of Lanes Blocked/Right Shoulder Blocked/Left Shoulder Blocked.
- Nature of Blockage (e.g., emergency vehicles, incident-involved vehicles, debris, solid cargo, liquid cargo, fuel spill).

Staged Implementation and Data Harmonization

In preparing this section, it became apparent that the data required for monitoring and promoting traffic incident management programs from the transportation agency perspective are quite different from what currently exists in nontransportation agency data systems. These systems are likely to be a major source of information for developing traffic incident management performance measures. However, immediate and seamless integration is unrealistic to expect. Therefore, the following two recommendations are made:

- ***In order to provide basic data needed for overall performance monitoring, it is recommended that the above data definitions be implemented in a staged approach. Specifically, implementation of the detail provided on the incident timeline should be postponed until the data definitions across all of the involved agencies can be reconciled. Until the data definitions can be reconciled, the most important information***

to collect is total blockage time measured from Point 1 to Point 7 on the recommended timeline.

- ***An effort should be undertaken to harmonize the data requirements specified here, existing ITS standards (especially the TMDD and 1512 "family"), and standards used in the data systems of nontransportation agencies (especially police CAD systems).***

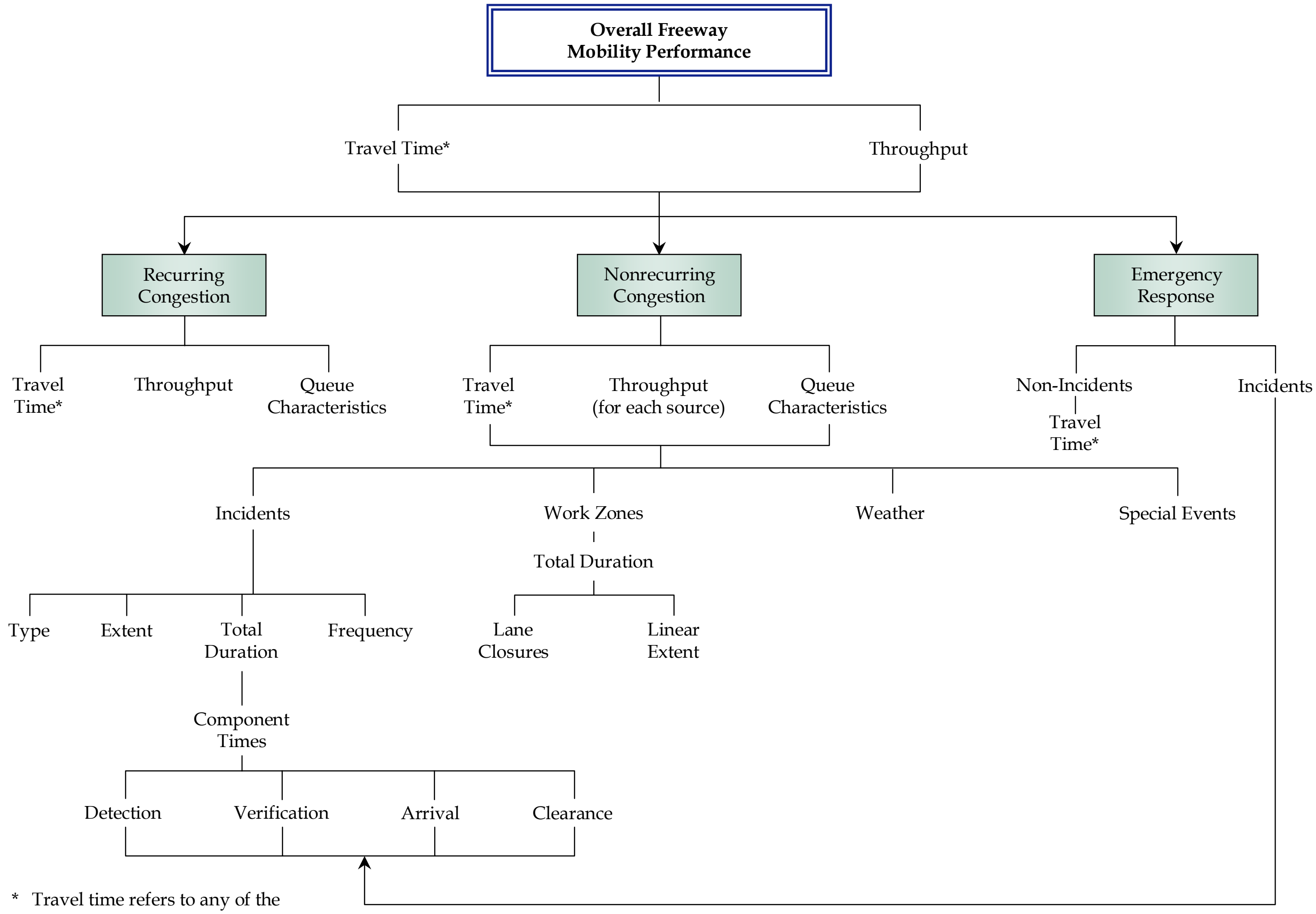
3.2.2 Recommended Performance Measures (Metrics)

The set of performance measures that are used to evaluate or prioritize traffic incident management efforts must include a range of considerations. Ideally, the process would start at the vision end of the scale; identify goals and objectives; develop some sample messages, themes, or analytical processes that the measures should support; identify the measures; and produce the data or analysis components that are needed. In practice, the process is more chaotic or iterative and involves several agencies and departments as well as the process elements. The components are outlined below, and some key steps are described in the subsequent sections.

- Vision – The measures should identify key effects or considerations in the broader context of transportation and quality of life.
- Goals and objectives - There should be specific measures that are targeted to key steps in the process and measures for individual modes or operations, but there must also be broad measures to link the outcomes together.
- Sample messages or themes – Develop some sample commercials, press releases, or analyses that you wish to conduct. They should be written in a way that technical audiences get the full amount of detail. The messages should also be written in ways that work for nontechnical audiences. There will typically be overlap among the measures that satisfy the range of needs and audiences, but there may also be a need to estimate some measures strictly for one audience.
- Data collection – Directly collected data are usually the highest priority when it comes to performance measures. There will always be a need for estimation tools, however, and if the analysis chain is sound and the assumptions can be supported, the resulting measures are valuable.
- Analytical processes – The estimation processes need to calculate the measures and supplement the data that can be collected. These processes are particularly important for future analyses or alternative scenario analysis.

The data and measures will be used for several purposes that will also affect the recommended set of measures. Annual monitoring or evaluation, daily communication in real time, and accountability for funding programs should be the expected targets. These measures will allow evaluations of the effectiveness of programs and comparisons between programs. One aspect of the decision process is to get the planners/designers at metropolitan planning organizations and DOTs to recognize the benefits of operations. Figure 3.1 shows a general structure for how traffic incident management performance measures fit into the larger picture of mobility and congestion monitoring.

Figure 3.1 General Taxonomy of Mobility-Based Performance Measures



* Travel time refers to any of the travel time-based metrics discussed in this report.

The measures used in this digest were designed for road travel, but many of them also work for bus travel and fixed-guideway service. There may need to be some adaptation to get the best set of measures and procedures for transit analyses, but at the conceptual level the measures in this digest appear to work very well. The measures also seem to apply to other transportation elements such as Internet service, sidewalks, and bike routes.

Identifying the Messages

Three categories of benefits might provide a framework on which to build. These categories target the community benefits as well as agency benefits. They may be viewed as a series of concentric rings. Message development starts in the middle and accesses the most readily available data; the data are verified for accuracy; and the measures are developed. Expansion on this base then provides additional benefit information. Messages can be placed in three general categories:

1. Travel Inconvenience – congestion-related delay and reliability.
2. Safety.
3. Emergency Preparedness.

There are any number of message types, but as a start, the various audiences might be targeted with some of the following. It will be important to view these from both the system performance and system user perspectives. The system performance is an important accountability issue, but the user perspective will be the one that frequently controls the real-time and daily communications. Simple and direct personnel-focused messages can also guide the daily actions of the field staff in ways that broader or user-focused measures cannot. Examples include the following:

- Every day there are *A* incidents on the National Highway System. This causes *X* more hours of travel time, consumes *Y* percent of capacity, and causes *Z* shipment arrival times to be missed.
- *X* lane-miles or lane-mile hours are lost every day due to work zones, incidents, and other sources of nonrecurring congestion. This much of the resource that cost a significant amount to construct is not able to be used.
- *Y* percent of the arterial capacity is lost due to poor signal timing or uncoordinated signal timing.
- With operational treatments and communication technologies, we can improve on-time arrivals for *Z* trips each day.
- *X* percent of the incidents are cleared within 90 minutes compared with *X*+ percent 1 year ago.

Identifying the Performance Measures

As stated above and mentioned several times in the workshop, the measures and analysis procedures have several targets. In general, there are both system measures and user or traveler measures. These are used for communications in several time frames. The messages discussed above can be computed using these performance measures as a base.

- ***The real-time websites, radio reports, and phone systems attempt to communicate current and near-future conditions. Travel times for specific commutes or corridor measures seem to be the most useful.***
- ***Daily monitoring reports can summarize the key corridor or urban area statistics as well as agency responses to events. Travel times have a role here, but index measures and average areawide or corridor measures also can be useful.***
- ***Annual reports can provide agency and system performance information for accountability, government performance reporting, and budget discussions.***
- ***Before-after analyses and alternative scenario analyses must estimate conditions that are not in existence.***

Measures that satisfy one or more of these needs are recommended below.

Traffic Incident Management System (Efficiency) Measures (Using the Timeline Points Recommended in Section 3.2.1)

- ***Average detection time – Point 1 to Point 2.***
- ***Average verification time – Point 2 to Point 3.***
- ***Average response time – Point 3 to Point 5.***
- ***Average clearance time – Point 5 to Point 7.***
- ***Effect of incident on traffic conditions – Point 1 to Point 8 (includes the visual effects of responders remaining on scene after traffic lanes are re-opened).***

User Measures (based on travel times)

- ***Travel time index - the ratio of actual travel conditions for the time period being considered to free-flow conditions. Travel conditions are defined in terms of the travel rate (the inverse of speed) weighted by vehicle-miles traveled (VMT) for ease of computation. As an example for both freeways and principal arterials in the peak period:***

$$\text{Peak Period Travel Time Index} = \frac{\left(\dfrac{\text{Freeway Travel Rate}}{\text{Freeway Free-Flow Rate}} \times \text{Freeway Peak Period VMT}\right) + \left(\dfrac{\text{Principal Arterial Street Travel Rate}}{\text{Principal Arterial Street Free-Flow Rate}} \times \text{Principal Arterial Street Peak Period VMT}\right)}{\left(\text{Freeway Peak Period VMT} + \text{Principal Arterial Street Peak Period VMT}\right)}$$

The index can be applied to various system elements with different free-flow speeds. Index values can be related to the general public as an indicator of the length of extra time spent in the transportation system during a trip.

- ***Buffer Index - the amount of extra "buffer" time needed to be on time 95 percent of the time (late 1 day per month). As such, it is a measure of travel time reliability. Indexing the measure provides a time- and distance-neutral measure, but the actual minute values (i.e., the 95th percentile) could be used by an individual traveler for a particular trip length. The index is calculated for each road segment, and a weighted average is calculated using vehicle-miles of travel as the weighting factor.***

$$\text{Buffer Index} = \begin{array}{c}\text{Weighted}\\ \text{Average of}\\ \text{All Sections}\\ \text{Using VMT}\end{array}\left[\frac{\begin{array}{c}\text{95th Percentile Travel Rate}\\ \text{(in minutes per mile)}\end{array} - \begin{array}{c}\text{Average Travel Rate}\\ \text{(in minutes per mile)}\end{array}}{\begin{array}{c}\text{Average Travel Rate}\\ \text{(in minutes per mile)}\end{array}} \times 100\%\right]$$

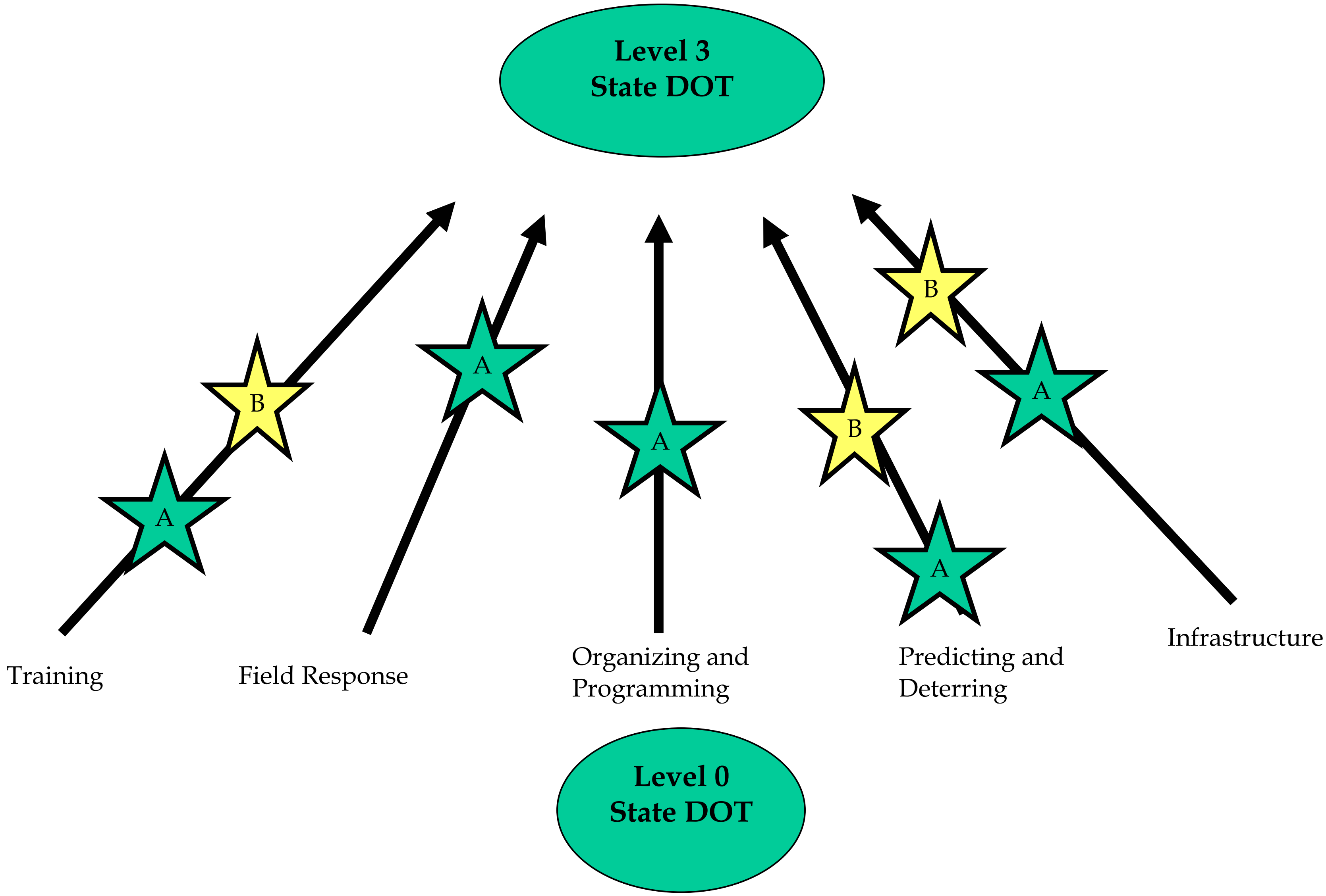
- ***Total delay – vehicle-hours (and possibly person-hours) lost because travel was adversely affected by a variety of sources. Delay is measured relative to free-flow conditions.***
- ***Delay due to incidents – the sources of the nonrecurring delay problem. There appear to be data to identify several components in some urban areas. The delay effects of weather, primary incidents, secondary incidents, roadwork, special events, and higher than normal traffic volumes can be identified in some data archives.***
- ***Fuel savings due to traffic incident management – an estimate of the fuel that is saved because traffic incident management improved traffic flow.***
- ***Safety benefits – reductions in primary and secondary incidents due to rapid response and identification of problem areas to be solved by geometric or operational improvements.***

3.2.3 Procedures for Developing Performance Measures

Archived data, computer models and estimation procedures will be needed for many analyses. It will be important to use the existing resources to create the best estimates of current performance to get discussion about what each measure communicates and how useful they are. There should be a discussion about the measure results and the confidence in each measurement or estimation procedure. The participants agreed with the statement that "the perfect should not crowd out the good," meaning that agencies should communicate the best estimates and refine them over time, rather than waiting for all uncertainties to be eliminated.

A key factor in developing traffic incident management performance measures is linking performance to the level of deployment or sophistication of traffic incident management activities. For example, the number of on-call service patrols and the highway mileage covered will have a significant impact on reducing incident durations. As shown in Figure 3.2, five categories of traffic incident management activities are relevant for capturing these deployment levels:

Figure 3.2 Levels of Deployment and Sophistication in Traffic Incident Management Activities



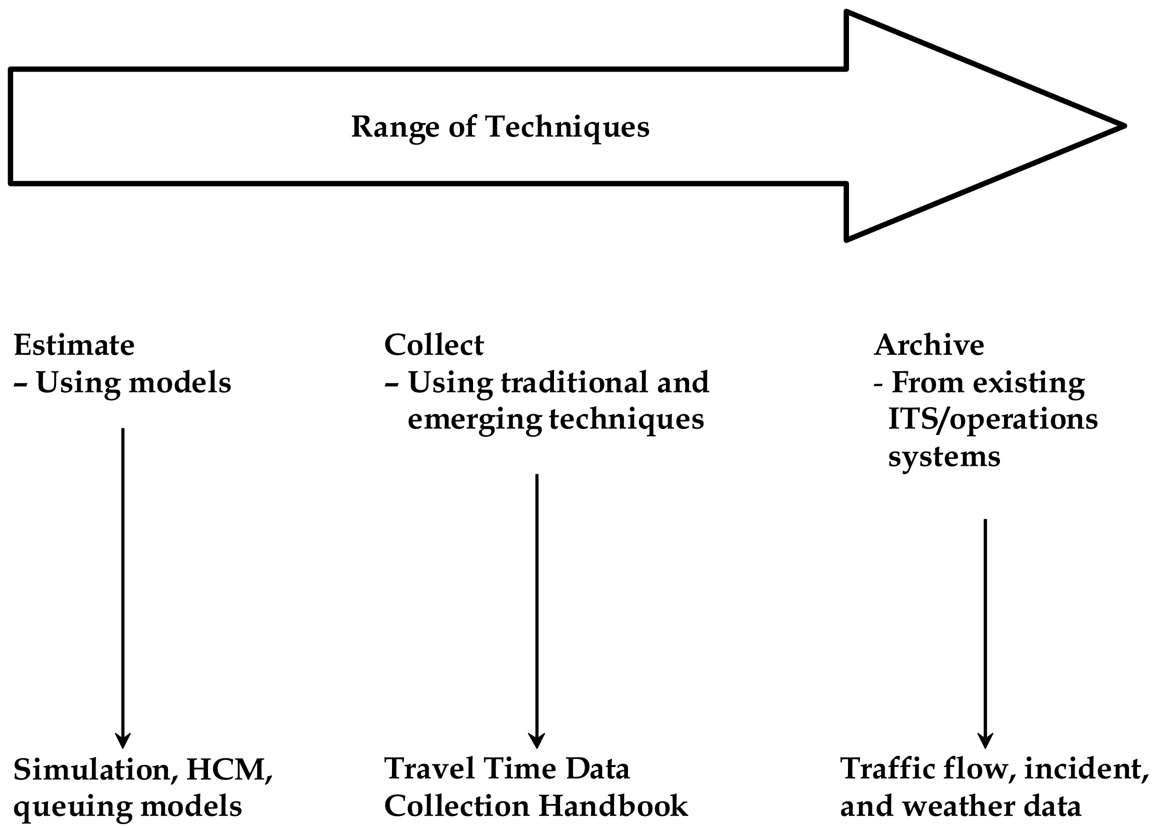
NOTE: The "A" stars reflect a low level of deployment within each vector and the point at which a state DOT may assess itself. This chart illustrates how this state DOT may choose to move toward "B" stars (more sophisticated levels of deployment) in Training, Predicting and Deterring, and Infrastructure vectors. This move would be achieved through one application of the final report of NCHRP Project 20-59(11), "Emergency Transportation Operations." The final report will probably be published in mid-2004.

1. Training – across levels of DOTs.
2. Field Response – technical details of how incidents are managed on scene.
3. Organizational and Programmatic – institutional arrangements and funding.
4. Predicting and Deterring – analytic methods for predicting the impacts of incidents, monitoring performance, preventing incidents (safety enhancements), and alerting travelers to incident conditions.
5. Infrastructure – detection, verification, and communication equipment for traffic incident management.

The following recommendations are made:

- ***"Measure where you can; model everything else." Direct measurement is preferred, but is not also achievable. However, do what is possible with whatever data are available now – do not wait for the "perfect" data system to be in place. Rather, make improvements in the process as performance measure activities progress (Figure 3.3).***
- ***The best source of information for performance measurement is that generated by operations systems themselves – this implies that proactive management of archived data is conducted. Data should include the following:***
    - ***Incident data identified earlier in this section.***
    - ***Traffic flow data from roadway-based sensors (e.g., volumes, speeds, and occupancy) and probe vehicles (e.g., point-to-point travel times), where available.***
    - ***Weather (e.g., duration and type of precipitation) and road surface condition data, tied as directly to highway segments as possible.***
    - ***Quality control of data conducted by field personnel or TMC personnel***
- ***Use of data generated by operations systems for performance measurement also requires attention to the quality and accuracy of the data. An ongoing program to maintain quality data should be implemented, including the following:***
    - ***Proper installation and acceptance testing of field sensors.***
    - ***Detection methods for identifying poor-quality data.***
    - ***Maintenance procedures for fixing faulty field sensors.***

Figure 3.3 Getting Performance Data



- *Supplemental data may need to be collected, especially in cases where operations-generated data do not exist. The type of data will be dictated by the type of analysis method, but generally will fall into the incident, traffic flow, and weather categories discussed above.*
- *Estimate both delay and reliability – measure both totals for road system and individual corridors.*
- *Break out total congestion by its components, especially that part due to incidents.*
- *Document safety benefits, including both secondary and primary crashes that did not happen (e.g., lower crash rates with traffic incident management programs).*
- *Fuel savings should be estimated.*
- *Air quality changes should be estimated.*
- *Document the level of deployment or sophistication of traffic incident management activities, following the model in Figure 3.2. Relate changes in the level of deployment to changes in performance measures.*
- *Ensure that existing traffic incident management self-assessment tools are organized around capturing the levels of deployment in each category of Figure 3.2.*

- ***Translate user impacts (e.g., travel time, crashes, and fuel) into economic impacts wherever possible.***
- ***Have all benefit assessments independently reviewed for veracity.***
- ***Some consideration should be given to establish formal guidance on methods used to estimate the benefits of traffic incident management. A strict standard is probably undesirable, and some local flexibility is required due to unique circumstances and the availability of data. Rather, a set of guidelines on benefits estimation would be helpful.***

3.2.4 Procedures for the Routine Reporting of Incident Performance Measures

NCHRP Project 3-68 ("Guide to Effective Freeway Performance Measures") is investigating this topic and several other ones related to traffic incident management performance measurement. The study is in its early phases but should be monitored for best practices in reporting and displaying performance measures. In addition, the material in Appendixes A and B show examples of how several state DOTs are currently approaching this aspect of the problem.

One useful technique for presenting performance measures is the creation of a "dashboard" – a highly summarized, highly graphical display of key features for consumption by the public and decision makers. Missouri DOT's dashboard is included as Appendix D for reference.

3.2.5 Guidelines for Using Performance Measures in Making Decisions

Sufficient experience exists in identifying metrics and in developing the data and methods needed to create the metrics. There is also growing experience with producing "report cards" of performance to document conditions. However, linking performance measures to investment decisions and changes in operating practices has been elusive. Accordingly, ***it is recommended that guidelines be established on how agencies should use operations-based performance measures in the decision-making process. The guidelines should encompass the entire timescale of agency concerns:***

<u>Real-Time Operations</u>

- ***What is happening now and expected to happen shortly?***
    - ***How do we respond to travel/system conditions? What strategies do we implement?***
    - ***How do we respond to an incident? What information do we provide to travelers?***

<u>Operations Planning</u>

- ***What do we expect to happen next week/next month?***
    - ***How can we adjust our strategies to be more responsive?***
    - ***What are the new coordination plans, pre-deployment plans, and routing plans?***

Short-Term Planning and Programming - 1-5 years (Transportation Improvement Programs [TIPs], Intelligent Transportation Systems [ITS] Deployment Plans and Architectures); and Long-Term Planning - 5-20 years

- ***How are planning models made sensitive to performance measures, especially reliability and the ability to produce estimates by congestion source (e.g., recurring bottlenecks, incidents, weather, work zones, and special events)?***
- ***In what ways can expected impacts on performance measures help in deciding priorities and trade-offs?***

3.2.6 Funding and Programming of Traffic Incident Management Programs

Funding transportation programs in general has been somewhat of an uphill battle: identified investment needs almost always outstrip available funding resources. With the economic slowdown and resulting tighter state fiscal policies of the past few years, additional strain has been placed on transportation investment.

The traditional way to deal with funding shortfalls has been to defer improvements or increase taxes, primarily dedicated user taxes such as the fuel tax. Issuing bonds for specific toll facilities is another method that has been used. However, anecdotal evidence suggests there is currently a strong anti-tax sentiment among the public and legislators. Even in this environment, tax increases are possible – in the summer of 2003, Ohio succeeded in getting a 2-cent-per-gallon increase per year (for 3 years) in the state fuel tax. A copy of the testimony given by Ohio DOT's director to the Ohio House Finance Committee is included as Appendix C.

A similar approach may be possible with traffic incident management, and even operations in more general terms, if the package is communicated in a palatable manner. Something along the lines of a "Congestion Relief Package" that includes both infrastructure and operations improvements, preferably aimed at specific projects or corridors, might be acceptable. Clearly, such an effort would require a significant amount of advance work (as outlined in this digest), but would be tied to the much larger picture of general congestion. Given the contentiousness of tax increases, a specific recommendation is not being given here. Rather, this topic is for general consideration by transportation professionals.

Programming operational deployments has proven to be difficult. First, operational deployments must compete for initial capital funding with other transportation investments. Even more vexing is securing ongoing funds for operations and management (O&M) – which may exceed initial capital costs – in a corporate environment where funding is classified as either capital outlay or routine maintenance. In most states, these O&M costs would probably be classified as "routine maintenance" and would end up competing with traditional maintenance activities. Further, traditional maintenance personnel have little experience dealing with the advanced technologies often used in operational deployments. Three recommendations are offered to address this situation:

- ***An O&M "spending account" can be established at the time of initial capital outlay for operations deployments, especially traffic incident management activities. This account would be drawn down on an annual basis to support ongoing O&M activities. Estimation of annual O&M costs is critical for this approach, and each state should***

track life cycle costs of operations strategies in order to refine these estimates. In the interim, FHWA's ITS Benefits and Costs Database may be used.[5]

- ***Consideration should be given to establishing a categorical funding program aimed at improving interagency operations for safety and security. Interagency operations are absolutely vital during natural and non-natural disasters. However, these events are rare and agencies can only plan and anticipate them. However, as pointed out elsewhere in this report, by promoting routine cooperation for traffic incident management, most of the technical and institutional issues restricting cooperation during disasters are worked out as part of normal, everyday practice.***
- ***Increased training for routine maintenance personnel in advanced technologies used in operations should be achieved.***

3.2.7 Performance Measurement Self-Assessment

Self-assessments have been used successfully in the emerging fields of operations. Self-assessments are essentially expanded checklists that agencies can use to compare their current activities with a norm. Self-assessments are very useful in allowing agencies to identify areas that they have not considered; once identified, agencies can seek out additional guidance.

It is recommended that an operations performance measurement self-assessment process be developed for use by state and local transportation agencies. The self-assessment can be based on much of the work presented in this digest and should include several features:

- ***Identification of good, better, and best practices in monitoring the performance of transportation systems from an operations perspective. Monitoring should include the following:***
    - ***System performance from the user's perspective (i.e., "outcome" congestion/ mobility metrics based on travel time).***
    - ***System performance from the agency's perspective (i.e., "output" metrics such as the incident timeline presented in this report, work zone activities, and durations).***
    - ***Safety.***
    - ***Emergency preparedness.***
- ***Institutional relationships required for data collection and for improving field activities.***
- ***Measurement methods and models and data collection programs.***

3.2.8 Continuation of this Effort

This digest has laid out the issues associated with measuring and communicating the benefits of traffic incident management programs. The digest has made many specific recommendations for further actions. However, the need remains for a "champion" to continue overseeing efforts and to promote traffic incident management in the national forum. ***The National Coalition on***

[5] http://www.benefitcost.its.dot.gov/

Traffic Operations is well suited to this task, and it is recommended that the coalition adopt the concepts and philosophy outlined in this digest. As a framework for moving forward, the following process is recommended: (1) identify national programs and vision, (2) deliver the programs and vision to several levels of state DOTs, and (3) work to broaden national-level support from other groups (i.e., public safety, politicians, and industry) so that local representatives in these areas are more receptive to the traffic incident management programs.

APPENDIXES

The appendixes for this digest are not published herein; however, they are available online as *NCHRP Web Document 64*. To access this web document, go to http://www4.trb.org/trb/onlinepubs.nsf and click on "NCHRP Web Documents."

These digests are issued in order to increase awareness of research results emanating from projects in the Cooperative Research Programs (CRP). Persons wanting to pursue the project subject matter in greater depth should contact the CRP Staff, Transportation Research Board of the National Academies, 500 Fifth Street, NW, Washington, DC 20001.

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