

TABLE OF CONTENTS

Chapter 8: Operation and Maintenance of Ramp Management Strategies	8-1
8.1 Chapter Overview.....	8-1
8.2 Role of Ramp Operations and Maintenance.....	8-2
8.2.1 How Operations and Maintenance Fits in with Overall System Operations.....	8-3
8.2.2 Impact on Performance Monitoring and Reporting.....	8-3
8.2.3 Ramp Operations and Maintenance Issues	8-4
8.3 Operational Policies and Procedures.....	8-5
8.3.1 Ramp Metering Operations.....	8-5
8.3.2 Ramp Closure Operations	8-8
8.3.3 Special-Use Treatment Operations	8-8
8.3.4 Ramp Terminal Treatment Operations	8-9
8.3.5 Unique and Emergency Operations	8-9
8.3.6 Staffing.....	8-9
8.3.7 Operational Support Tools and Procedures.....	8-10
8.4 Maintenance of Ramp Management Strategies.....	8-13
8.4.1 Maintenance Needs.....	8-14
8.4.2 Maintenance Procedures.....	8-14
8.4.3 Staffing.....	8-19
8.4.4 Training	8-21
8.4.5 Spare/Backup Equipment.....	8-22
8.4.6 Evaluation	8-22
8.5 Chapter Summary	8-22

This Page Left Blank

LIST OF FIGURES

Figure 8-1: Example of General Operator Responsibilities Outlined in an Operator's Handbook.....	8-7
Figure 8-2: Example of Detailed Operational Responsibilities Provided in an Operator's Handbook	8-7
Figure 8-3: Example of an Agency/Jurisdictional Contact List.....	8-11
Figure 8-4: Example Media Procedures from an Operator's Handbook.....	8-12

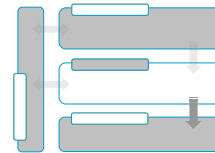
LIST OF TABLES

Table 8-1: Preventative Maintenance Procedures for Ramp Metering (Signals and Controller Assembly)	8-16
Table 8-2: Preventative Maintenance Procedures for Ramp Metering (Detectors).....	8-17
Table 8-3: Preventative Maintenance Procedures for Ramp Closure (Gates and Barriers)	8-18

This Page Left Blank



OPERATION AND MAINTENANCE OF RAMP MANAGEMENT STRATEGIES



Decision Making

Chapter 5: Ramp Management Strategies

Chapter 6: Developing and Selecting Strategies and Plans

Chapter 7: Implementing Strategies and Plans

Chapter 8: Operation and Maintenance of Ramp Management Strategies

8.1 Chapter Overview

This chapter concludes the four-step ramp management decision-making process. After providing a detailed overview of ramp management strategies in Chapter 5, how to select ramp management strategies in Chapter 6, and how to implement the selected strategies in Chapter 7, this chapter discusses operational and maintenance considerations for keeping the ramp management strategies operating effectively throughout their designed life cycles. This chapter also sets the stage for Chapter 9 by providing information on how ramp management strategies should perform. For instance, ramp meter operators may need to monitor ramp queues to ensure that ramp metering does not cause queues to spill into ramp/arterial intersections. Together, Chapters 6, 7, and 8 provide the basis for understanding the ramp management elements that need to be planned for and designed in capital projects (Chapter 10).

Ramp management strategies can only meet their intended goals and objectives if they are operated and maintained properly. Failure to properly operate and maintain strategies will result in inefficient investment and can result in unnecessary congestion and delays. In some cases, malfunctioning equipment might confuse or inadvertently misguide the public, which adversely affects driving behavior. Therefore, if ramp management strategies cannot be properly maintained, they should not be implemented. Equally important, ramp management strategies need to fit in with the overall operational strategies of the transportation man-

Chapter Organization

- 8.2 Role of Ramp Operation and Maintenance
- 8.3 Operational Policies and Procedures
- 8.4 Maintenance of Ramp Management Strategies
- 8.5 Chapter Summary

agement system. The integration of ramp management strategies with other transportation management elements will offer the best possible means of maximizing benefits from regional transportation investments.

This chapter begins by defining the role of ramp management with respect to overall transportation management operations and maintenance activities (Section 8.2). Additionally, the reasons for and importance of integrating ramp management into the overall transportation management program are discussed. The difference between designed and actual ramp management performance is described, and strategies to address this difference are provided. Finally, operations and maintenance activities are identified and discussed at a high level. Sections 8.3 and 8.4 discuss ramp management specific operations and maintenance activities in greater detail, beginning with operational policies and procedures and concluding with maintenance needs and procedures.

To help facilitate reader's understanding of this chapter, several objectives were developed. These objectives are outlined below.

Chapter 8 Objectives:

- | | |
|--------------|---|
| Objective 1: | Understand the role of ramp operations and management in overall transportation systems management. |
| Objective 2: | Identify operational policies and procedures that should be considered related to various ramp management strategies. |
| Objective 3: | Determine typical operations and maintenance needs associated with ramp management strategies. |
| Objective 4: | Understand staffing needs related to operating and maintaining ramp management strategies. |

8.2 Role of Ramp Operations and Maintenance

The ramp management strategies selected in Chapter 6 and implemented in Chapter 7 cannot simply be implemented then forgotten. Instead, ramp management strategies must be effectively operated and maintained if they are to deliver expected outcomes and benefits. Over the long term, the operation and maintenance of systems that support ramp management strategies will improve the performance and reliability of freeway ramps and other surface transportation components. Failure to actively operate and maintain systems will needlessly waste agency efforts and resources that were expended to deploy these strategies.

Practitioners responsible for the day-to-day operation of ramp management strategies should actively seek cooperation and input from the regional stakeholders (e.g., motorists, decision makers, transportation engineers and planners, enforcement agencies, emergency responders, and transit managers) affected by the implementation of ramp strategies. This input could include how to improve system performance and the reliability of implemented ramp management strategies. Where possible, practitioners should integrate ramp management strategies with other transportation functions. Doing so will maximize return on ramp management investments and will lead to considerable long-term cost savings.

8.2.1 How Operations and Maintenance Fits in with Overall System Operations

Ramp management is only one element of a freeway operations and management program. Ramp management should work in concert with other transportation management activities, to support the overall performance of the transportation management program and accomplish the goals and objectives of the transportation management system. When operating ramp management strategies, practitioners should ensure that ramp management and other freeway management program elements complement each other. Ramp management should be integrated with these other freeway management elements in order to maximize long-term benefits and cost effectiveness. For example, ramp management strategies may be deployed in concert with arterial traffic management strategies to reduce impact at the ramp/arterial intersection when ramp meters are installed. Adjustments to signal timing and/or the addition of lanes may help hold arterial traffic that cannot enter the ramp due to the length of the queue from the ramp meter. Ramp management strategies need to be operated with these interactions in mind in order to accomplish the goals set forth.

8.2.2 Impact on Performance Monitoring and Reporting

Successful operations require that agencies not only consider how systems and strategies will be operated on a day-by-day basis, but also account for future uncertainties such as system upgrades, budgetary requirements, and staffing needs. At a minimum, agencies should have a configuration management plan to help prepare them for this process. According to the Federal Highway Administration (FHWA)'s *Configuration Management (CM) for Transportation Management Systems Handbook*, a configuration management plan is defined as a "holistic approach for effectively controlling system change. It helps to verify that changes to subsystems are considered in terms of the entire system, minimizing adverse effects. Changes to the system are proposed, evaluated, and implemented using a standardized, systematic approach that ensures consistency. All proposed changes are evaluated in terms of their anticipated impact on the entire system. CM also verifies that changes are carried out as prescribed and that documentation of items and systems reflects their true configuration. A complete CM program includes provisions for the storing, tracking, and updating of all system information on a component, subsystem, and system basis."¹

8.2.3 Ramp Operations and Maintenance Issues

Operators and/or practitioners responsible for the operation or maintenance of ramp management strategies need to be aware of all the internal and external dependencies that may either positively or negatively affect operations on ramps, freeways and adjacent arterials. Operators also need to understand that their actions directly influence the success of ramp management strategies, and as such they must remain cognizant of the policies and procedures that dictate how ramp management strategies are to be operated.

Ramp Metering

From time to time, it is likely that ramp meters or associated equipment will not function as intended. Therefore, it is critical that ramp meters be routinely monitored to ensure that these systems are functioning correctly and that traffic on and adjacent to ramps is not affected. In situations where ramp meters are functioning properly, but perhaps not producing desired effects, ramp meter parameters may be adjusted until desired results are observed.

Part of ramp meter monitoring should focus on queues that form on ramps as a result of ramp meter operations. When a ramp meter is installed on a ramp, the potential exists for queues to spill back to the ramp/arterial intersection. When this happens, operations on the arterial may be affected, resulting in delays and reduced safety. If queues do spill back onto the arterial and affect arterial operation, operators or the system itself should adjust metering rates in an effort to quickly resolve queue-related problems.



Ramp Closure

Similar to ramp metering, the performance of ramp closures need to be evaluated to determine the effectiveness of the ramp closure in satisfying expected goals and objectives. Methods selected to close a ramp should make it apparent to motorists that the ramp is closed. Any uncertainty in motorists' minds may result in attempts to use closed ramps.

Closing a ramp can be a labor-intensive effort, depending on the selected method of ramp closure, the geometry of the ramp, and the traffic demand on the ramp. Methods that employ staff to physically place and remove barriers to close a ramp are only practical for a small number of closures or for temporary closures. For systems where many ramps will need to be closed, the staff levels needed to perform manual closures will likely not be available. Manual ramp closures may also pose a serious safety threat to employees responsible for conducting these actions.

Special-Use Treatments

Wherever possible, motorists should be alerted to and advised of activities pertaining to the construction of new ramps or the addition of new lanes, such as those dedicated for high-occupancy vehicles (HOV) or public transit vehicles only. Such projects, which provide benefits to specific vehicle types, may be negatively perceived by drivers of single-occupant vehicles or other vehicle types not permitted to use the ramp. Signing posted immediately upstream of where construction activities are taking place may be used in part to mitigate the adverse reaction of motorists who oppose construction. In this case, signing will provide ad-

vance notification of construction activities, helping to diffuse the potential negative impact of construction activities on normal driving behavior.

Special-use treatments should be monitored to assess their effectiveness in providing benefits to targeted vehicle types and to determine their operational performance. Areas where dedicated lanes merge with traditional traffic on the ramp are potential trouble spots that may need to be addressed.

Ramp Terminal Treatments

Ramp terminal treatments should be monitored to assess the effectiveness of selected treatments in satisfying goals and objectives. Turn restrictions implemented at the ramp/arterial intersection should be monitored through site visits to determine their effectiveness in improving conditions. Similarly, adjustments may need to be made to signal timing to ensure that queues are being cleared each cycle.

8.3 Operational Policies and Procedures

Operational policies and procedures state how, and under what conditions, ramp management strategies should be operated. All staff responsible for the operation of ramp management strategies should be familiar with policies and procedures relevant to ramp management and should be able to reference the operational policies and procedures manual when needed. These policies and procedures are often consolidated into a single operations manual.

This section describes the policies and procedures that should be considered when planning ramp management strategies.

8.3.1 Ramp Metering Operations

On a day-to-day basis, ramp meter operation should focus on monitoring freeway traffic conditions and conditions on and adjacent to the ramps affected by the strategies implemented. Monitoring ramp management strategies that have a high impact on normal traffic operations (e.g., ramp metering) should take precedence over monitoring ramp management strategies that have little immediate impact. The following subsections outline operational procedures common to ramp metering that should be defined before meters are activated and operated.

Hours of Operation

Most agencies operate ramp meters during peak periods only. In some systems that have congestion outside the peak commute hours, meters may be operational for longer periods, during mid-day, evenings, or on weekends. It is good practice for an agency to operate ramp meters only during peak commute hours when ramp metering is first implemented, in order to get staff experienced in operating metering, make the system predictable, and reduce motorist confusion or frustration. Operating at predictable times, especially when metering is first implemented, allows the public to know with relative certainty when ramp meters will be on and off.

As motorists and operators become more familiar with the operation of the system and if congestion occurs outside the peak commuting hours, metering times can be expanded. For instance the Washington State Department of Transportation (WSDOT) operated meters in the City of Seattle from about 6:00 to 8:30 a.m. and 3:30 to 6:30 p.m. on Monday through Friday when the system was first implemented. Over the years, the window for metering expanded in the morning and evening and now includes the weekends in some areas of the region.

In certain situations, such as when congestion occurs at unpredictable times, mature ramp metering systems (i.e., those that have been in operation for a significant amount of time) may be turned on at any time of the day on any day of the week when conditions warrant their use. Operating ramp meters in off-peak hours, however, is not recommended for relatively newer systems where residents are not familiar with ramp metering. It is important for residents to get used to driving through ramp meters before expanding the times of day that meters could operate.

Mature ramp meter systems may also be activated outside scheduled time frames when emergencies occur or in unique situations. In some systems, meters may be activated automatically during off-peak periods when traffic congestion occurs because of collisions or other incidents.

Practitioners responsible for operating ramp meters should be well trained and familiar with the ramp metering system. They also need to have a strong understanding of typical traffic patterns and problems. Operators should monitor real-time traffic conditions to determine when it is most beneficial to turn on or off particular ramp meter(s).

Ramp Meter Monitoring and Operation

As mentioned previously, most ramp meter systems are turned on at the same times every day. In others, operators monitor conditions and modify the times accordingly. In either case, it is important for operators or operations staff to monitor the operation of the system.

When meters are active, operators should periodically monitor each ramp meter to confirm that meters are functioning correctly and adjust operating parameters when appropriate. Closed-circuit television (CCTV) cameras located on the freeway or local arterial streets may be used to visually monitor metered ramps. If metering is not centrally controlled and if there are no cameras that allow operators to monitor the metered ramps, operations staff should schedule routine field visits to observe the metering operation to determine if adjustments are needed. Operator responsibilities like these need to be documented for quick reference when needed. The operator manual or handbook that documents responsibilities can also be used for training. Figure 8-1 provides an example of general operator responsibilities as they pertain to ramp meter operations. The handbook in which these responsibilities are outlined also provides more specific operational procedures that the operators can reference when needed. An example of more detailed operational procedures pertaining to ramp metering is provided in Figure 8-2.

Operational plans and procedures also need to be developed that dictate how ramp meters are to be controlled during incidents and major emergencies. For instance, if smoke from a brush fire has limited the flow of traffic in all lanes of a freeway, operators need to know if they should turn off meters, and when metering should resume.

Responsibilities of Flow Operators (continued)

Control Ramp Meters to Maximize Freeway Efficiency

- Activate and deactivate ramp meters at selected freeway on-ramps, based on time of day and need. Adjust fuzzymeter parameters to minimize delay and optimize efficiency on both the ramps and freeway (more on this in the Ramp Metering section). Ramp meters often require special attention when there is a blocking incident nearby that disrupts the merge, so when dealing with incidents, don't forget to pay attention to nearby ramp meters.

Figure 8-1: Example of General Operator Responsibilities Outlined in an Operator's Handbookⁱⁱ

Controlling Ramp Meters (continued)

When meters are activated, it is the operator's responsibility to verify that each meter is functioning. Though some locations require more attention than others, all meters should be inspected with the cameras, if possible, at least once during the time in which they are activated. Following is a list of what a functioning ramp meter should look like:

AM Peak

Generally during the morning, the heaviest traffic will be heading towards Seattle, but there are other commute areas (such as I-90 EB, SR 520 EB, SR 167 NB, and I-405) that must also be considered. Metering must never begin prior to 5:30 AM, no matter the situation.

During the PM peak, both directions of I-5, both directions of I-405, eastbound SR-520, and eastbound I-90 traffic must be closely monitored. The operator must weigh local mainline occupancy as well as downstream conditions in deciding if, when and where to meter.

All ramp meters must be deactivated by 8:00 PM

Weekend Peak

Gauging local mainline occupancy and downstream effects, the operator must use engineering judgment to determine when to activate and deactivate ramp meters. Due to the unpredictable nature of some weekend congestion, ramps should be more closely monitored for unusual congestion, and ramp meters should be turned on or off as required. Some ramps near malls such as 196th St SW near Alderwood Mall is a good example.

**Figure 8-2: Example of Detailed Operational Responsibilities
Provided in an Operator's Handbook**

8.3.2 Ramp Closure Operations

Several unique procedures need to be implemented in order to safely and effectively close ramps. Depending on the type of ramp closure to be initiated, the procedures will differ. However, the general guiding principles inherent to each are the same. With all types of ramp closures, equipment must be deployed in the field to physically restrict access to the ramp. The type of equipment deployed in the field will depend on the method used to close the ramp. For permanent closures, the equipment may only need to be deployed once (typically with a construction project).

On the other hand, temporary ramp closures may need to be conducted on a daily basis. Temporary ramp closure, therefore, can incorporate some degree of automation or can be a completely manual process. Manually closing ramps implies that staff will erect cones or barriers to physically restrict access to the ramp. Although this process has little or no capital cost, it is much more labor-intensive than automated means and may not be practical for situations where staff are not available or where there may be a relatively large number of ramps being repeatedly closed over an extended period of time. Additionally, the safety of staff responsible for conducting the closure must be taken into consideration. Automated gate systems can also be used to close ramps and can be much safer than their manual counterparts. Automated gates can be closed or opened by an operator in the Traffic Management Center (TMC), but are often operated in the field to make sure there are no traffic or roadway conditions that should affect the closure that may not be viewable by the camera system. The safety of both the operator and the motoring public needs to be the primary concern in determining the method used for temporary ramp closures.

Permanent ramp closures may necessitate additional measures to emphasize that ramps will no longer be used. For instance, the actual ramp itself may need to be physically removed to make certain that motorists do not mistake the ramp as being temporarily closed. For either permanent closures or for regularly-occurring temporary closures (e.g., peak period closures), clearly marked permanent signing in advance of the closure is needed. For temporary closures that are not regularly occurring, temporary signing can be used but still requires sufficient advance signing. For specific information about advance signing for ramp closures, please refer to the *Manual on Uniform Traffic Control Devices* (MUTCD)ⁱⁱⁱ or the *Caltrans Ramp Meter Design Manual*.^{iv}

8.3.3 Special-Use Treatment Operations

Operational policies and procedures for special-use treatments are usually more straightforward than for ramp metering and ramp closure. These strategies are not influenced by daily traffic patterns and are therefore less dynamic in nature. Special-use treatments such as dedicated lanes for HOVs are typically implemented in a fixed fashion and cannot be manipulated to improve conditions on the ramp or freeway. Strategies that are fixed require few policies and procedures to operate.

As is the case with all ramp management strategies, special-use treatments should be closely monitored to determine whether treatments are successful in accomplishing the goals and objectives they target. In the

case of HOV bypass lanes, field observations are needed to determine if merging between HOV and non-HOV vehicles is acceptable. If the special-use treatment is in force by time of day, monitoring will be needed to verify that times of operation are correct for meeting the goals of the treatment. Monitoring is also needed to track usage of the lane or ramp to verify that treatment is neither under- nor over-utilized. In the case of HOV bypass lanes or dedicated ramps, the usage results may lead to decisions about the definition of carpools (generally 2+ or 3+ people) for the facility, corridor, or region. Refer to the FHWA's *Freeway Management and Operations Handbook* and the NCHRP's *HOV Systems Manual* for more information on HOV strategies, including HOV bypass ramps.^{v,vi} Signing is needed near affected ramps to advise motorists of the ramp restrictions employed. Motorists should be informed of the vehicle types that are able to use ramps and any other operating rules, such as the number of occupants required to be considered an HOV.

8.3.4 Ramp Terminal Treatment Operations

From an operational standpoint, most ramp terminal treatments will not require attention, other than periodic monitoring or observation, to make sure intended goals are being met or determine whether additional treatments are needed.

8.3.5 Unique and Emergency Operations

As was the case with ramp metering, operational plans and procedures also need to be developed that dictate if and how ramps will be closed when unique incidents or emergencies occur. For instance, if a major incident occurs at or immediately downstream of a ramp, it may be beneficial to close the upstream ramp to limit additional traffic from entering the affected area. Improvements are not limited to just the affected area on the mainline, but also extend to the adjacent arterial where queues waiting to enter the freeway may extend, preventing the smooth flow of traffic through the ramp/arterial intersection. By closing the ramp, a portion of the traffic that would normally use the ramp will divert to downstream ramps, where mainline conditions are no longer affected by the incident. Using this same example, closing a ramp to all vehicles except emergency vehicles may speed the response to individuals involved in the incident who are seeking medical treatment.

Procedures for closing a ramp when unique incidents or emergencies occur should be a collaborative effort among regional traffic and emergency management agencies. Together, agencies need to discuss different scenarios when ramp closure is warranted and establish procedures and responsibilities for closing ramps.

8.3.6 Staffing

Agencies implementing or expanding a ramp management program need to actively plan how staff will be used to perform all the transportation management functions associated with a TMC, including operations related to ramp management and control. This process includes analyzing staff duties and availability, staffing levels and shifts, and budgetary requirements; and identifying special needs (e.g., planned special events). See Section 4.4 for more detail on staffing considerations.

Staff need to be available to operate ramp meters as well as other transportation management functions throughout the year. When staff call in sick, take vacation, or quit, their duties must shift to other staff or additional staff must be hired to assume their roles. Typically, there is at least one staff position responsible for operating and addressing issues associated with ramp meters when they are active. This staff person(s) may be assisted by other support staff in a TMC.

8.3.7 Operational Support Tools and Procedures

Several tools and procedures are available to support and ensure successful operation of the four ramp management categories discussed in this handbook. These tools and procedures support the day-to-day system operation and may be largely based on documentation furnished by system suppliers. These documents may also include specific agency policies and procedures. Applicable software manuals could be referenced. These tools and procedures are identified and described in the following sections.

Operations Checklist

An operations checklist lists all of the tasks an operator will perform to accomplish a given function. There is often a routine (i.e., daily) checklist, as well as checklists for a variety of unusual or emergency tasks. Checklists are based on the specific functions and equipment included in the system and the operating policies and procedures adopted by the agency.

After Hours On-Call Roster

An after hours on-call roster containing the names and contact information (phone, mobile, pager, fax, etc.) of individuals to call in case of an emergency should be made available to all operators. The on-call roster should have a schedule of when staff members are on duty and the general types of problems each member is able to address.

Operations Logs

Operations logs are records of system activity that include descriptions of unusual or noteworthy events, when the events occur, and if any manual intervention was needed.

Agency and Jurisdictional Contacts

Contacts for partner agencies affected by or that operate systems that affect ramp management should be documented and easily accessible to staff and operators. An example of a contacts list is provided in Figure 8-3.

Key Personnel: District 6 TMC

First Name	Last Name	Title	Phone	E-Mail
Jane	Doe	Program Manager	555-555-5555 ext. 12	doe@usa.state.gov
John	Smith	Engineer	555-555-5555 ext. 6	smith@usa.state.gov
George	Anderson	ITS Engineer	555-555-5555 ext. 14	anderson@usa.state.gov
Joe	Doe	Maintenance	555-555-5555 ext 23	joedoe@usa.state.gov

Figure 8-3: Example of an Agency/Jurisdictional Contact List**Media Procedures**

Local media may significantly affect the success of ramp management strategies. The impact, however, can be either positive or negative depending on the level of interaction with the media. If local media are not actively involved, the benefits of ramp management strategies may not be publicly disseminated to the extent they would have been if there were greater interaction with the media. Where possible, every reasonable effort should be made to alert the media to activities associated with the implementation of ramp management strategies.

The procedures for communication and dissemination of information to media sources should be clearly documented and made available to all operators who have direct contact with the media. Procedures related to media event notification and responses to media inquiries should be outlined in the operator's handbook. Figure 8-4 shows an example pulled from an operator's handbook that details typical media procedures.

Sending Incident Messages

Incident messages are one of the key tools we have for getting incident information out to the media and the public. The incident message provides information that appears on television and radio traffic reports, on web sites, including WSDOT's incident page, the Seattle Times web site, and others.

Sending Messages to the Media and Other TMS98 Users

The Flow Operator is responsible for sending messages to our media Winflow software users (i.e. traffic reporters at radio or TV stations) and the Internet. These messages should contain information of traffic-related incidents gathered from different sources available to us, i.e. the incident may have been observed from CCTV, reported by the Radio Operators, or from the WSP's CAD Log.

Anytime you can visually verify an incident that has a noticeable and enduring traffic impact you should send a text message describing the incident. Also send a message when the incident status changes, for example, a blocking accident becomes a non-blocking incident that is cleared off to the shoulder.

IMPORTANT: Here are a few guidelines to always keep in mind:

- Keep in mind that the TSMC personnel are restricted from sending any non-traffic related details of an incident(s).
- Never include fatalities or the medical status of injured individuals in the messages.
- Do not report any non-traffic related incidents such as TSP (traffic stop) or ROB (robbery) in the messages.
- In most cases, hit-and-run accidents are "standing by" somewhere, and are not affecting traffic whatsoever, and should not be reported. If there's any doubt, check the inquiry page (move cursor to the incident line and press F5).
- We are not responsible for reporting incidents off the state highways and interstate freeways. These are listed on CAD as "NA" in the "HIWAY" column. BUT, every now and then an incident occurs on a busy city street, and it's good to report it, so keep your eyes open.

Figure 8-4: Example Media Procedures from an Operator's Handbook

8.4 Maintenance of Ramp Management Strategies

Systems and devices that support ramp management strategies should be routinely maintained to sustain adequate levels of service and ensure operational stability. When systems or devices fail, staff should be available to fix problems in a timely manner, to reduce the impacts on and exposure to the public. Delays in fixing problems may erode public support for and confidence in ramp management strategies.

As mentioned previously in Chapter 6, if ramp management strategies cannot be adequately maintained due to lack of funding or available staff or for other reasons, they should not be implemented. Additionally, if strategies are implemented and they are not routinely maintained, the potential for equipment malfunction will increase. This in turn would result in a greater likelihood that the public will be negatively affected, lessening support and acceptance of ramp management strategies.

Maintenance activities include:

- ▶ Replacing defective or broken components.
- ▶ Updating software and system inventories.
- ▶ Logging repairs.
- ▶ Testing equipment.
- ▶ Cleaning system components.

Maintenance helps agencies maximize returns on their investments and offers the best chance for systems to be operated up to and possibly beyond their design life span. This saves the time, effort, and funding needed to purchase new systems before deployed systems reach their designed life span. Failure to maintain ramp management equipment results in disruptions or failure of the strategies or systems that the equipment supports, and makes it difficult to achieve the goals set out for these strategies.

Agencies that implement ramp management strategies should create a maintenance plan that outlines the specific requirements and responsibilities for maintaining equipment and systems. Some of the key issues that should be discussed in an agency's maintenance plan that pertain specifically to ramp management strategies and systems are discussed throughout the remainder of this chapter.

The maintenance plan should cover two categories of maintenance activities: response maintenance and preventative maintenance.

Response Maintenance

Most, if not all, public agencies provide maintenance in response to alarms, customer requests, or identified problems, either with in-house or contracted staff. Response maintenance is defined as the repair of failed equipment and its restoration to safe, normal operation. It requires action based on the priority of the subsystem that has failed and takes precedence over preventative maintenance activities for the duration of the emergency.

“Maintenance needs should be prioritized based on the importance of each system in meeting the overall goals and objectives of the transportation management system.”

Response maintenance is a critical element of a comprehensive maintenance plan. The importance stems from an agency's responsibility to keep traffic systems operating safely at all times. Preserving the safety of the traveling public and minimizing the agency's exposure to liability represent the two strongest reasons for establishing a sound approach to response maintenance. Typically, response maintenance requires that a qualified technician be on-call to receive notice of any and all problems that arise with field equipment.

Preventative Maintenance

Although most, if not all, public agencies provide response maintenance, fewer agencies provide preventative maintenance on a regular, routinely-scheduled basis. Preventative maintenance, or routine maintenance, is defined as a set of checks and procedures to be performed at regularly scheduled intervals to ensure that equipment functions properly. It includes checking, testing, inspecting, record keeping, cleaning, and replacement based on the function and rated service life of the device and its components. Preventative maintenance is intended to ensure reliable mechanical, electrical, and electronic operation of equipment, thereby reducing equipment failures, response maintenance, road user costs, and liability exposure. The emphasis in preventative maintenance is on checking for proper operation and taking proactive steps to repair or replace defective equipment, thus ensuring that problems are not left until the equipment fails. However, preventative maintenance is often neglected because of staffing limitations.

8.4.1 Maintenance Needs

Maintenance needs for ramp management strategies will depend on the strategies that are implemented and the extent to which ramp strategies have been deployed. Strategies implemented at one or a few ramps will obviously require much less maintenance than strategies implemented along an entire corridor or in multiple corridors. Similarly, strategies that require computer systems to be in place, such as ramp meters or automated gates for ramp closure, may require that software be updated or reconfigured when errors occur.

Maintenance needs should be prioritized based on the importance of each system in meeting the overall goals and objectives of the transportation management system. Response maintenance on devices deemed to be mission critical (i.e., those that are needed to keep the transportation system operating correctly) or critical to safety should be the highest priority. In these cases failed equipment needs to be replaced or repaired immediately. Response maintenance on non-mission-critical devices should be the next priority, followed by preventative maintenance.

8.4.2 Maintenance Procedures

Systems that are maintained according to vendor requirements will last longer than those that are minimally maintained or not maintained at all. Regularly scheduled preventative maintenance activities will allow agencies to use systems up to and beyond their design life, maximizing an agency's investment. However, system failures will likely happen at some point no matter what level of maintenance is performed. When unexpected failures occur, systems need to be repaired as soon as pos-

sible. In emergency situations, systems should be repaired immediately so operations can be restored.

Maintenance personnel should have a direct means of communications with operations staff to help identify and assess maintenance needs. Typically, communications occur via cell phone or two-way radio, however other means are available. Communication between operations and maintenance staff may also help troubleshoot maintenance issues by providing maintenance personnel with additional information on the problem.

System Inventory

An inventory of all implemented equipment and software should be developed and kept up-to-date as new equipment is installed and existing equipment is repaired or replaced. Inventories facilitate maintenance by tracking the numbers of devices that are currently in stock. This reduces the chance that devices will not be available when needed, which in turn reduces the amount of time devices must remain inoperable. The following minimum information should be included as part of the inventory:

- ▶ Date equipment was installed.
- ▶ Location of equipment.
- ▶ Equipment vendor.
- ▶ Vendor contact information.
- ▶ Equipment model or version.
- ▶ Serial number (or other unique identifier).

The system inventory also serves a logistical purpose in facilitating the purchase of spare parts in the quantities that are needed. It also helps determine the level of staff needed to perform maintenance tasks.

Maintenance Checklist

Maintenance checklists list the recommended steps and procedures for maintaining any given piece of equipment. The checklist serves as a means to track the completion of maintenance procedures and to ensure that each procedure is completed at the time that maintenance is performed. There should be a separate checklist for each type of device included in the system inventory.

Preventative Maintenance Procedures

Tables 8-1 through 8-3 provide typical preventative maintenance procedures for systems used for ramp meter and ramp closure applications.^{vii}

**Table 8-1: Preventative Maintenance Procedures for Ramp Metering
(Signals and Controller Assembly)**

Action	Timeframe
Check the operation of the Blank Out sign - replace any defective bulbs	Monthly
Check the operation of the Ramp Controller - repair as needed	Monthly
Check stop line and make sure that this is clearly visible - make notation for any line that is not visible and report immediately to road marking crew for remarking	Monthly
Check advisory signs to ensure accurate words and facing the motorist	Monthly
Check signal light head for correct operation	Monthly
Replace any burnt out bulbs	Monthly
Check and adjust signal head to face the correct direction	Monthly
Check and adjust where necessary the ramp meter time clocks in accordance with schedules	Monthly
Check the function of the queue loop	Monthly
Document all results on the ramp meter maintenance check list	Monthly
Request control center to send command to turn on or off and verify	Monthly

Table 8-2: Preventative Maintenance Procedures for Ramp Metering (Detectors)

Action	Timeframe
Disconnect loop	Quarterly
With LCR meter measure and record inductance of the loop	Quarterly
With LCR meter measure and record resistance	Quarterly
With a MEGGER meter measure and record the insulation resistance	Quarterly
If readings are outside specification, disconnect lead-in at the splice box and check all three parameters at that level	Quarterly
From the readings determine whether loop or the lead-in need repair	Quarterly
Check cracks in the asphalt at the shoulder	Annually
Check cracks in the sensor at the shoulder	Annually
Check cracks in the sensor at the wheel tracks	Annually
Check cracks at the sensor/asphalt interface	Annually
Using LCR meter measure capacitance	Annually
Use manufacturers recommended procedure for checking detectors	Annually

Table 8-3: Preventative Maintenance Procedures for Ramp Closure (Gates and Barriers)

Action	Timeframe
Open and close gate group from control cabinet	Monthly
Adjust gate opening and closing timing sequence	Monthly
Check isolators associated with the controller for damage and repair or replace if needed	Monthly
Perform visual inspection of the high voltage side of the cabinet (use extreme caution and observe all safety rules)	Quarterly
Check oil level - add oil if needed	Quarterly
Grease all grease nipples and wipe excess	Quarterly
Check for oil leaks in the gate housing	Quarterly
Verify that the lights on the gate flash when the gate arm moves between opening and closing.	Quarterly
Verify that the lights stop flashing and remain on solid when the gate arm is in closed position	Quarterly
Verify that the lights stop flashing and remain off when the gate arm is in the open position	Quarterly
Turn off power to the gate cabinet and use hand crank to open or close gate (this is to ensure that the gate can be opened or closed in the event of power failure)	Quarterly
Replace all burnt out bulbs	Quarterly
Perform physical inspection of the gate arm and replace broken or rotten wood	Quarterly
Check reflectors and replace where necessary	Quarterly
Check and adjust gate clearance (clearance measured from road surface to bottom of gate)	Quarterly
Check and adjust limit switches if needed	Quarterly

Maintenance Logs

After responding to a maintenance request, maintenance personnel should log all pertinent information associated with the maintenance issue, as deemed necessary by their supervisor. At a minimum, the log should contain the complaint or request in which the maintenance request was issued, date and time the issue was addressed and resolved, staff that performed the required work, and actions taken to resolve the issue. It is also good practice to report systems or parts that have been replaced, so additional systems or parts can be purchased to replace those that have been taken out of inventory.

8.4.3 Staffing

Trained staff must be available to replace or repair system components or devices when they fail. Similarly, staff are needed to perform regularly scheduled maintenance activities to reduce the probability that failures will occur.

When implementing new ramp management strategies, agencies need to remain cognizant of the fact that the implementation of new strategies also brings additional maintenance needs and requirements. In many cases, new staff need to be hired to support existing staff in handling these new needs and requirements.

There are no established, accepted guidelines that agencies can utilize to determine maintenance staffing levels by classification for the number and type of ramp management-related devices that it owns and operates. The Oregon DOT's statewide maintenance plan establishes guidelines for that agency based on experience within the department and discussions with equipment vendors. The plan identifies about 1,750 ITS devices such as emergency signal preemption systems, CCTV cameras, and road weather information systems. The plan identifies that eight positions are needed to maintain this inventory.

There are several agencies that maintain ITS devices that have staffing levels and/or practices that can be found in the literature.^{viii} As of 2000, The Maryland State Highway Administration (SHA) employs eight technicians to conduct both response and limited preventative maintenance for 35 permanent and close to 100 portable variable message signs (VMS). The Maryland SHA has another 11 technicians that are responsible for both response and limited preventative maintenance for 250 field devices, including CCTV cameras, road weather information systems, detectors, and traveler advisory radio units.

In 2000, the Virginia DOT's Northern Virginia Advanced Traffic Management System (ATMS) had seven technicians and one engineer employed on a full-time basis to conduct response maintenance for over 1,500 devices, including CCTV cameras, VMS, and detectors. The Virginia DOT rarely conducted preventative maintenance on the ATMS.

In 2001, the Washington State Department of Transportation (WSDOT)'s Northwest Region had about 1,150 ITS devices, including CCTV cameras, call boxes, and ramp meter systems. (Note: WSDOT does not define their devices down to the component level, such as *video detector* as some of the devices are defined in Oregon or *detectors* as defined in Northern Virginia). WSDOT also maintains over 100 miles of fiberoptic

Staffing Approaches:

- ▶ In-House.
- ▶ Outsourcing.
- ▶ Facilities Management.

cable system. Twelve maintenance staff employees worked for WSDOT to conduct both response and preventative maintenance for these devices.

These examples indicate that one maintenance staff person can maintain anywhere from 100 to 200 ITS devices. The higher number is for less complicated devices and systems, and the lower number for more complicated devices and systems.

There are three approaches that an agency can follow to provide the maintenance support outlined above: in-house, outsourcing, and facilities management. Each has its own distinct benefits and risks. Agencies should identify and select a course of action best suited to its needs, culture, and existing situation.

In-House Staffing

Using a staff comprised of all agency employees is often considered ideal, because managers and team leaders have a single personnel management system to deal with and team cohesiveness is easier to establish and maintain. However, given today's trends of downsizing and doing more with less, many agencies around the country have a difficult time finding, training, and retaining the required talented staff to maintain their field equipment. Maintaining the skills necessary to support the fast-changing technologies is a problem when utilizing in-house support. Where required, in-house support can be supplemented by outsourcing.

Outsourcing

It is becoming increasingly difficult for public agencies to fill highly technical positions that usually require special classifications and a high pay scale. Personnel departments within the public sector tend to resist creating special classifications and often follow a policy of setting pay scales by the number of persons supervised. Positions requiring highly specialized skills often do not supervise many people, if any at all, making it difficult to justify the pay scales necessary to attract qualified staff.

In an era of government downsizing, state and local agencies often face pressures to cut staffing and freeze existing vacancies. Leaving vacancies unfilled in maintenance positions that support ramp management will usually result in significantly reduced system effectiveness.

Outsourcing can often bypass these problems. Staffing through outsourcing does not result in more staff counted on the agency's payroll. The budgetary item for outsourcing is often treated by the agency administration like a line item for electricity to run the equipment, with none of the negative perceptions involved in financing new staff positions. It is also often easier for a private firm to fill vacancies with appropriately skilled personnel and to fire poorly performing employees.

Although outsourcing offers solutions to the types of staffing problems noted above, it is not without its own set of problems. Some of the problems with outsourcing include the necessity of continuing tight administration of performance under the contract, potential higher turnover rates in contractor personnel than in-house staff, the scarcity of private sector personnel with adequate experience, and friction with in-house staff. Outsourcing requires careful development of a detailed, clearly defined set of contractor requirements including task descriptions, schedules, performance standards, and payment terms.

Facilities Management

The third option is for agencies to engage a facilities management contractor in a public-private venture for the purposes of providing maintenance or operations and maintenance. Although facilities management shares some characteristics with outsourcing, it also provides a level of flexibility and incentives for both parties that a service contract does not.

Facilities management, or facilities outsourcing, involves using private-sector staff to perform traditional government services, working on a broad mission basis and targeting the standard of mission accomplishment. Although facilities management is a new concept in traffic management, it is a tried-and-true method for providing service in other high-technology environments including computer facilities, law enforcement dispatching systems, and telecommunications systems.

Facilities management is different than outsourcing, where the private contractor is required to follow the explicit directions of the government manager. With outsourcing, there is little incentive for the private contractor to control costs, because it is paid by the person-hour employed. Under facilities management, the private-sector firm and the public agency have congruent goals and the same incentive to succeed. Because it is paid for mission fulfillment, the private-sector contractor has the incentive to seek efficiencies and cost-effective techniques for achieving the contract objectives.

8.4.4 Training

Systems and devices that support ramp management strategies can only be used to their furthest extent if staff are trained on how to maintain them. All staff responsible for operating and/or maintaining systems that support ramp management strategies, whether existing or newly hired, will need to be trained on the procedures specific to individual systems and devices, operational policies, and testing and calibration methods. Additionally, staff need to be trained on how to use special vehicles (e.g., bucket trucks) to maintain systems and devices that cannot be easily completed from the ground. Staff must be trained on typical and disaster-specific emergency procedures.

The first step in determining training needs and whether staff is adequately trained is to define the knowledge, skills, and abilities that are needed for each staff position within an organization. A training plan or program should then be developed to identify training opportunities to provide employees with the needed knowledge, skills, and abilities. The program or plan should focus on gaps between the minimum requirements for the position and the requirements to perform in the position at an optimal level. The plan is often developed and maintained in the Human Resources section of the organization. Some organizations include a formal training program to provide needed skills to their employees.

To help facilitate training, many agencies issue step-by-step instructions or handbooks that outline what and when maintenance ought to be performed. Although most agencies rely on in-house training, workshops, seminars, or other outside means are used to support training needs. When procuring a system or software from a third-party vendor, agencies should include a provision within the contract that requires vendors to fully train staff on how to maintain and operate purchased systems.



Ongoing staff training will be needed to keep staff up-to-date and to train new staff members.

8.4.5 Spare/Backup Equipment

Sufficient spare or backup equipment and/or parts are needed so maintenance personnel can keep systems that support the ramp management strategies operational. There must be documentation of the equipment and parts needed, including:

- ▶ Inventory of spare and backup equipment.
- ▶ Listing of suppliers' and vendors' contact information (e.g., phone, pager, e-mail) associated with equipment and software related to the system.

Additional information pertaining to the documentation of spare/backup equipment as well as other aspects of transportation systems can be found in the FHWA's *Configuration Management for Transportation Management Systems Handbook*.

8.4.6 Evaluation

Maintenance procedures and practices must be evaluated periodically to maintain efficiency in those activities. Evaluation in terms of ramp management maintenance refers to the routine collection and analysis of appropriate data and comparing this data to previously established performance measures. The results of this comparison can be used to assess the benefits or drawbacks of existing maintenance procedures and practices and can offer insights on how to improve them. Ramp management strategy evaluation is discussed in greater detail in Chapter 9.

8.5 Chapter Summary

Upon reading this chapter, it is easy to see the importance of properly operating and maintaining ramp management strategies. The strategies selected in Chapter 6 and implemented in Chapter 7 cannot be fully utilized if they are not effectively operated and properly maintained. To be successful, the practitioner responsible for ramp management and operation must first understand that ramp management is only one element of a freeway operations and management program. To maximize benefits and reduce overall operating costs, ramp management strategies must be integrated with other freeway management elements.

The practitioner responsible for ramp management strategy operation and maintenance must also be aware of the various day-to-day issues tied to these activities that may affect the success of the implemented strategy. This awareness allows practitioners to successfully operate strategies throughout their designed life cycles, achieving the maximum return on ramp management investments. Part of this activity is knowing the equipment, materials, and skills needed to operate and maintain implemented strategies. Such knowledge not only allows the practitioner to obtain needed resources in advance of actually needing them, but also provides time savings, which in turn equates to potential cost savings. Continued proper operation and maintenance of strategies also builds

public confidence and support of strategies and the agencies that implement them, making it easier for these agencies to obtain funding for future projects.

Successful operations and maintenance of ramp management strategies must also incorporate steps to actively monitor and document needs and requirements, so they can be tied into the next component of the ramp management implementation process - performance monitoring, evaluation and reporting. Tracking needs and monitoring performance of ramp management strategies will make it easier for practitioners to identify and acquire the resources (staffing, equipment, training, etc.) needed to operate and maintain strategies more effectively. Performance monitoring, evaluation, and reporting are discussed in detail in the next chapter of this handbook – Chapter 9.

REFERENCES

-
- ⁱ *Configuration Management for Transportation Management Systems Handbook*. Publication FHWA-OP-04-013. U.S. Department of Transportation, Federal Highway Administration (FHWA). September 2003. Available: http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13885.html
- ⁱⁱ *Flow Operator's Handbook*. Washington State Department of Transportation. December 2002.
- ⁱⁱⁱ *Manual on Uniform Traffic Control Devices for Streets and Highways*. 2003 Edition. U.S. Department of Transportation, Federal Highway Administration. Available: <http://mutcd.fhwa.dot.gov/pdfs/2003/pdf-index.htm>.
- ^{iv} *Ramp Meter Design Manual*. Caltrans Traffic Operations Program in cooperation with Design and Local Programs and the Department of California Highway Patrol. January 2000.
- ^v *Freeway Management and Operations Handbook*. Publication FHWA-OP-04-003. U.S. Department of Transportation, Federal Highway Administration. September 2003. Available: http://ops.fhwa.dot.gov/freewaymgmt/freeway_mgmt_handbook/index.htm
- ^{vi} *HOV Systems Manual*. Publication NCHRP Report 414. National Cooperative Highway Research Program. National Academy Press. Washington, D.C. 1998.
- ^{vii} *Guidelines for Transportation Management Systems Maintenance Concept and Plans*. Publication FHWA-OP-04-011. U.S. Department of Transportation, Federal Highway Administration. December 2002. Available: <http://ops.fhwa.dot.gov/docs/TMSMaintCptandPlans/toc.htm>
- ^{viii} *Silicon Valley ITS Strategic Plan. Technical Memorandum #3 - Operations and Maintenance*. Prepared by PB Farradyne and Kimley Horn and Associates. December 2000.