

2.0. MONITORING APPROACH

Performance monitoring, evaluation and reporting should be a continuous process that occurs throughout the life cycle of a ramp meter. In other words, evaluating the effectiveness of ramp meters (or any freeway management strategy for that matter) should not be considered a one-time activity, but should be part of a periodic review of the effectiveness of the component and of the overall system. With that said, the monitoring approach will need to be reviewed and revised as needed to reflect changes to ramp meter status and implementation.

Before NDOT and RTC begin the process of monitoring and evaluating the performance of ramp meters, several questions need to be answered and decisions need to be made to develop an effective approach for conducting these tasks. Questions that need to be answered include:

- ▶ What are the objectives of the ramp metering program?
- ▶ What impacts will be measured?
- ▶ How will impacts be measured?
- ▶ What types of data will be collected?
- ▶ Where will data collection occur?
- ▶ Who will be responsible for collecting data?
- ▶ How will the results be reported?

Answers to the above list of questions will help develop an effective approach to monitor the network of ramp meters.

2.1. Program Goals and Objectives

The monitoring approach should be linked to the goals and objectives of the ramp metering program so the results of ramp meter evaluations are as meaningful as possible and that the time and effort used to conduct these evaluations is used effectively.

The first question that must be answered is “What are the objectives of the ramp metering program?” This paves the way for selecting performance measures so measured impacts can be tied back to objectives. The objectives of ramp metering in the Las Vegas area are as follows:

- ▶ Reduce the crash rate in the metered sections of freeway.
- ▶ Increase mainline speeds in metered freeway sections.
- ▶ Keep ramp queues contained on the ramps, except in extreme situations like severe incidents.

For each objective associated with the ramp metering program (i.e., reduce the crash rate or increase mainline speeds), the appropriate measure(s) of effectiveness should be identified, along with the desired threshold level of change that will be used to determine if the facility has met the objective. Measures of effectiveness that may be applicable for NDOT /RTC’s ramp metering program are identified and discussed in greater detail in Section 3.

2.2. Selecting the Type of Analysis to be Performed

Monitoring ramp metering operations is more than a simple process of visually observing the impacts ramp meters have on traffic flow, but rather one that involves the collection and thorough analysis of data to determine if ramp metering is producing desired results. The type

of analysis to be performed is largely defined by the objectives of the evaluation and type of feedback that is desired. In other words, NDOT and RTC must first answer the question “How are we going to use performance information” before an approach to monitor ramp meters can be developed. Ramp management evaluations may be performed prior to implementation, conducted as “before” and “after” snapshot views of performance, or implemented as a continuous monitoring and evaluation process. The evaluation efforts may also be narrowly focused to analyze one specific performance impact, or may be more broadly defined to capture the comprehensive region-wide benefits of the metering application. Further, these analyses may be intended to isolate the impacts of the ramp metering by itself, or to evaluate the performance these systems as part of a combination of operational strategies.

This section summarizes the basic types of analysis NDOT and RTC may use to measure ramp metering performance. This section also discusses the implications of how each type of study has different needs that substantially influence the analysis procedures to be performed. Since ramp meter implementations are new to Nevada, and little is known about the impacts of these systems, it is recommended that monitoring approach that NDOT and RTC select begins with a system impact analysis to gain an understanding of ramp meter impacts on US 95 and I-515, and to use this understanding to adjust metering operations to maximize benefits. Upon the completion of the system impact analysis, NDOT and RTC may elect to perform a benefit/cost analysis to determine how effective ramp metering is compared to other regional freeway management initiatives. In the future, NDOT and RTC may elect to monitor ramp metering performance in real-time. This requires that I-515 and US 95, along with corridors that will be metered in the future, be equipped with systems in the field (e.g., loop detectors, signals and processors) and TMC software programs that allow performance monitoring in real-time.

2.2.1. System Impact Analysis

System impact studies are performed to identify the impact that ramp meters have on one or more particular performance measures. These studies typically involve the comparison of conditions “before” the deployment of ramp meters with conditions “after” meters are deployed. NDOT and RTC may use system impact studies to provide system operators with direct feedback on ramp meter effectiveness. For example, a system impact study may be implemented to determine how well a ramp meter improves a particular system deficiency, such as higher than expected crash rates in a merge area. Technical and operational staff may communicate the results of the system impact study to decision makers and/or the traveling public to help justify and promote ramp metering as an effective ramp management strategy. Since the deployment of ramp meters has already taken place on US 95 southbound, the system impact analysis for this implementation must rely on the limited data that was collected in the before condition. A full system impact analysis should be considered for future ramp meter deployments.

2.2.2. Benefit Cost Analysis

In many regards, benefit/cost analyses are similar to system impact studies in that both provide assessments of the impacts related to the implementation of ramp metering. Whereas system impact studies may focus on one or more particular performance measures, a benefit/cost analysis is broader and attempts to fully account for the comprehensive, multi-modal impacts of ramp metering. Benefit/cost analysis weighs the complete observed impacts of the system – including both positive impacts such as reduced travel time on the mainline facility and negative impacts such as increased emissions associated with queues on the ramp – with the cost of implementing and operating ramp meters.

The purpose of benefit/cost analysis is typically to identify the relative effectiveness of investment in one strategy by providing a common point of comparison with other potential strategies. The comparison is often used in prioritizing funding for future applications. The information generated by benefit/cost analyses are also often used to communicate the relative benefits of the system to decision makers and the traveling public.

Benefit/cost analyses are also typically based on comparisons of conditions both with and without the application of the strategy. The compared conditions may represent a snapshot view or may be based on longer-term trends, depending on the needs of the particular study. Due to the more comprehensive nature of benefit/cost analyses, these studies often make more substantial use of analysis tools and models to generate estimates of the full-range of possible impacts. Although it is too late to compare conditions before the initial deployment of ramp meters in the southbound US 95 corridor, I-515 and other metered corridors can be analyzed when metering is implemented.

While intended to provide a comprehensive quantitative analysis of the benefits and costs of ramp metering, there are many impacts that are difficult or impossible to quantify, such as traveler perceptions. No benefit/cost analysis can fully encompass all of the possible impacts of a ramp metering system, so it is important to recognize that benefit/cost analysis provides only a partial view of the overall picture that should be evaluated in assessing the success of the strategy.

Similar to the other types of analysis, a benefit/cost analysis can be designed to isolate the particular impacts and benefits related specifically to ramp metering, or may be utilized as part of a broader evaluation designed to capture the benefits of a selected combination of traffic management strategies.

2.2.3. On-going System Monitoring and Analysis

The purpose of on-going system monitoring and analysis is to provide system operators with direct, real-time feedback on the performance of individual ramp meters allowing for more active management of the entire system. The data collected through this monitoring effort should be appropriately archived using the FAST data archive so that additional analysis may be performed to identify trends of how the impacts of ramp metering may change over time or vary under different traffic conditions.

On-going monitoring efforts typically depend on automated data sources including: loop detector data, radar or acoustic based speed detectors, closed circuit cameras, and automatic vehicle location systems, among other systems. Often times, these automated data sources may be deployed as part of a ramp metering system or a general freeway management system. Reliable access to accurate data sources such as these is a prerequisite of implementing a successful monitoring and analysis program. NDOT and RTC have access to some automated data sources on US 95 or I-515, primarily detectors and closed circuit television cameras.

Although these on-going monitoring and analysis efforts are intended to provide performance data to the system operations personnel, it is important to note that the data generated by these efforts may be utilized in other evaluation efforts. For example, automated system data, collected by the Minnesota DOT for use in monitoring the real-time performance and making operational decisions, was used extensively in the benefit/cost analysis of the Twin Cities metering system. This historical volume and speed data was used to extrapolate impacts observed during a limited data collection window to other time periods and traffic conditions.

2.3. Defining Geographic Scope

The study area selected can have significant implications on the analysis data requirements, evaluation techniques, resource requirements, and even the results. These implications are discussed in the following section to help identify the appropriate study area suitable to particular needs.

Ramp management applications can have impacts far beyond the local area in which they're implemented. Depending on travel pattern changes, impacts may be observed at freeway bottleneck locations far downstream from the ramp itself; arterial intersections located many miles from the interchange; or even on alternative modes such as transit. Failure to define the study area broadly enough may result in critical impacts not being captured and an over- or understatement of reported benefits. Meanwhile, defining the study area too broadly may result in the inefficient use of evaluation resources if efforts are diverted towards analyzing inconsequential impacts. Therefore, it is critically important to identify an appropriate study area prior to the implementation of the evaluation effort to ensure the proper assessment of system impacts.

There are no firmly established guidelines for identifying the appropriate study area; however, the decision is usually based on:

- ▶ Purpose of the study – Is the evaluation effort being undertaken to identify the ability of the ramp management strategy to mitigate a specific deficiency in a particular location, or does it intend to provide a comprehensive accounting of the region-wide benefits and costs?
- ▶ Extent of the ramp management application – Is the evaluation being focused on a single or a very limited number of ramps, or does the application involve multiple ramps?
- ▶ Knowledge of local traffic conditions – Local operations personnel usually maintain a close familiarity with the traffic conditions and should be involved in any decision regarding the extent of the study area. In addition to operations personnel, the manager of the freeway management system (FAST) will have detailed information related to regional freeway operation that others don't, and therefore should be involved in all decisions regarding the installation and operation of ramp meters.

Furthermore, factors such as the particular performance measures being evaluated, the proposed analysis tools, and the evaluation resources available have a symbiotic relationship with the determination of the appropriate study area. The intended performance measures, analysis tools and resource availability should be considered in the determination of the study area. Likewise, the identified study area may also determine the possible performance measures, the appropriate analysis tool and the evaluation resources required.

Study areas can be generalized into three categories: localized, corridor, or region-wide. These categories are discussed below with examples of when they should be used.

2.3.1. Localized Analysis

This analysis, which focuses on the impacts observed on the facilities immediately adjacent to the ramp management application, is the most appropriate for limited scale deployments or for system impact evaluations focused on a narrowly defined set of performance measures. For example, an evaluation effort that was solely focused on identifying the ability of a ramp meter application to decrease the number of collisions occurring within the merge area might limit the study area to a short distance (maybe a quarter of a mile) upstream of the merge area to a short distance (maybe a quarter of a mile) downstream of the merge area.

2.3.2. Corridor Analysis

Expanding the study area to the corridor level is more appropriate when multiple ramp locations are involved, or when the deployment is anticipated to affect any of the selected performance measures outside of the immediate region. The study corridor extent should be based on the local street pattern and knowledge of local travel demand to determine the mainline, ramp, and arterial facilities to be included.

2.3.3. Region-wide Analysis

A region-wide study area is most appropriate when a comprehensive accounting of all possible impacts is required, or the deployments are scattered across a large area. Region-wide analyses can be the most costly analysis to conduct due to the significant data requirements. Therefore, this analysis will often use various large-scale traffic analysis tools, such as regional travel demand models, to estimate the impacts, rather than depend on observed before and after data.

Not all evaluation efforts will fit neatly into the study area definitions above. Some evaluations may use multiple study area definitions within the same effort based on the performance measures being evaluated or the availability of data.

2.3.4. Initial Operation

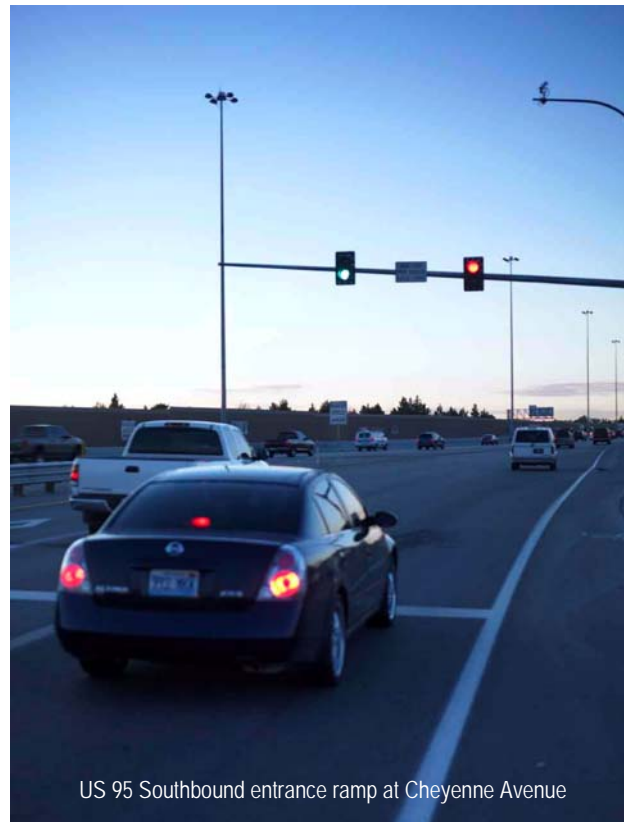
During the initial operation of ramp meters along US 95, ramp meter performance monitoring should focus on the stretch of US 95 that is currently metered.

- ▶ Cheyenne Avenue to southbound entrance ramp
- ▶ Eastbound Lake Mead Boulevard to southbound entrance ramp
- ▶ Westbound Lake Mead Boulevard to southbound entrance ramp

When metering is initiated on I-515, performance monitoring should focus on:

- ▶ Las Vegas Boulevard northbound entrance ramp
- ▶ Fourth Street/Casino Center Boulevard northbound entrance ramp
- ▶ Eastern Avenue northbound entrance ramp

In each of these cases, a corridor analysis should be undertaken. If there are specific areas with high collision rates, it may be appropriate to focus the safety analyses on those localized areas.



US 95 Southbound entrance ramp at Cheyenne Avenue

2.3.5. Subsequent Phases/ System wide

Subsequent phases of ramp metering have been discussed, but no firm plans are in place. Decisions on system expansion will be based, to a certain extent, on the results of the

performance monitoring effort for the US 95 and I-515 implementation. However, when two or more corridors are implemented with ramp meters, NDOT should consider starting a region-wide analysis of ramp metering performance.

2.3.6. On-going (Real-time)

The purpose of on-going system monitoring and analysis is to provide staff with direct, real-time feedback on the performance of the ramp metering system and to allow for more active management of it. On-going monitoring efforts must, therefore, rely on automated data sources including: loop detectors, radar or acoustic based speed detectors, closed circuit cameras, and automatic vehicle location systems, among other systems. Reliable access to data sources such as these is a prerequisite of implementing a successful monitoring and analysis program.

Currently, detector data and closed circuit television cameras are available on US 95 and I-515 eliminating the need to deploy additional devices. Data collected through these devices is currently archived in the FAST system. The FAST archive may be used to archive data from other sources, and used to identify trends of how the impacts of ramp meters may change over time. On-going system monitoring should be established as early in ramp metering as possible.

