Congestion Management Process

Procedures and Responsibilities Report

Durham-Chapel Hill-Carrboro

Metropolitan Planning Organization

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1. Introduction

The Congestion Management Process (CMP), which is required by Federal law, is a systematic approach to managing new and existing transportation systems for relieving congestion and maximizing the safety and mobility of people and goods. The measured system performance and defined strategies should be incorporated in the process of the long range transportation plan (LRTP) and the transportation improvement plan (TIP).

The Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC MPO) is responsible for transportation planning in the urbanized areas of Durham and Orange counties and parts of northern Chatham County. As part of the planning process, the DCHC MPO is required to develop and implement a CMP for monitoring traffic congestion, evaluating system performance, and incorporating mitigation strategies into the LRTP and TIP.

This Procedures and Responsibilities Report describes how the CMP will be implemented and used on a continuing basis to comply with federal requirements. It will include congestion management objectives; the monitored coverage area and networks; performance measures; performance monitoring plan; identifying & evaluating strategies, and implementation & management.

1.1. Background

a) Legislative Background

The Safe, Accountable, Flexible, and Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU)[1] is the Federal authorization of funding for surface transportation programs for highways, highway safety, and transit. The act was in place from August 2005 to September 2009 and was extended until the end of 2010.

SAFETEA-LU requires that "the transportation planning process in Transportation Management Areas (TMA – urban areas over 200,000 populations) shall address congestion management through a process that provides for safe and effective integrated management and operation of the multimodal transportation system, based on a cooperatively developed and implemented metropolitan-wide strategy, of new and existing transportation facilities eligible for funding through the use of travel demand reduction and operational management strategies [23 CFR 450.320]."

The Congestion Management Process evolved from the Congestion Management System (CMS), which was required by previous surface transportation authorization laws: the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the Transportation Equity Act for the 21st Century (TEA-21). The CMP differs from the CMS primarily in mandating the incorporation of CMP within metropolitan transportation planning, rather than as a stand-alone program or system. The CMS has been described as a "7 Step" process, but the CMP is an "8 Step" process with the addition of a new "first step - Develop Congestion Management Objectives."

[1] Public Law 109–59, 109th Cong., August 10, 2005

b) Requirements

Federal rules define congestion as "the level at which transportation system performance is no longer acceptable due to traffic interference. The level of system performance deemed acceptable by State and local officials may vary by type of transportation facility, geographic location (metropolitan area or subarea, rural area), and/or time of day."

An effective CMP is defined as "a systematic process for managing congestion that provides information on transportation system performance and on alternative strategies for alleviating congestion and enhancing the mobility of persons and goods to the levels that meet State and local needs. The CMP results in consideration and implementation of strategies that provide the most efficient and effective use of existing and future transportation systems."

A CMP will provide planners, policy makers and the public with a clearer understanding of congestion problems and the most cost-effective means for addressing them. In order to accomplish this mission, USDOT recommends that the following key elements be part of a CMP:

- Congestion management objectives;
- identification of the CMP coverage area;
- transportation system definition, including modes and network;
- performance measures;
- performance monitoring plan;
- identification and evaluation of strategies;
- monitoring of strategy effectiveness; and
- implementation and management.

The SAFETEA-LU planning rule states that the CMP shall include the definition of congestion management objectives and performance measures to assess the extent of congestion, and support the evaluation of the effectiveness of congestion reduction and mobility enhancement strategies for the movement of people and goods.

1.2. Outreach

Although the CMP is the responsibility of the DCHC MPO, it is an interagency multidisciplinary approach that seeks to optimize the performance of infrastructure through the implementation of multimodal, intermodal, and cross-jurisdictional systems, services and projects. As such, the expertise of a diverse team is needed that can provide input on transportation operations, the availability of existing and new data sources, and policy issues related to the development and update on the CMP. To assure this multidisciplinary approach, the DCHC MPO recommends working with the three groups described below, in the development of a CMP that addresses congestion through shared goals.

a) Stakeholders

The stakeholder group will be involved in all elements of the CMP program including discussing ideas, identifying improvement strategies, and working towards consensus on key elements. The stakeholder group includes representatives from the following organizations:

- DCHC MPO member agencies,
- NC DOT,
- Transit agencies,
- Federal Highway Administration,
- Federal Transit Administration, and
- Others as deemed necessary

b) Technical Steering Committee

The Technical Steering Committee is a technical advisory group. The committee will be made up of a diverse set of specialists. The committee members provide guidance on the availability of existing and new data sources that are necessary to identify recurring and nonrecurring congestion. The committee members also provide substantial guidance on the selection and use of performance measures, the review of the technical analysis methodologies and the results, and the identification of an improvement strategy. The committee members include:

- DCHC MPO planners and engineers,
- Transit planners,
- Bicycle & pedestrian specialists,
- Congestion management engineers,
- Traffic signal, operation, ITS engineers, and
- Others as deemed necessary.

c) Public

Citizens will have opportunities for involvement throughout all stages of the CMP process including development, update, monitoring and implementation. To increase public understanding of both the CMP and congestion issues, all documented reports, statistics, and maps will be uploaded to an interactive WEB tool or web-based map.

1.3. CMP Goals and Objectives

a) Goals

In order for the MPO, State and local governments to respond to growing demands for maintaining and improving our mobility needs, these agencies must cost-effectively manage existing facilities. In order to maximize our return on transportation investments, we must effectively manage congestion. A primary purpose for the CMP is to provide a systematic approach for a better understanding of existing and projected system performance and the effectiveness of various management strategies.

b) Objectives

CMP objectives should be consistent with regional goals and plans. To develop the congestion management objectives, the list of 2035 LRTP goals, objectives, and the measures of effectiveness (MOE) were reviewed for application to the CMP. The goals and objectives which are related to the CMP are shown in Table 1.1.

Table 1.1 LRTP Goals and Objectives that Relate to the CMP

Goals	ID	Objectives	MOE
Overall Transportation System	L-1.1	- Establish performance standards that will measure the effectiveness of the urban area's overall transportation system in supporting access to goods, services, activities, and destinations.	N/A
	L-1.2	- Select and program transportation projects, which are consistent with community goals and are a cost-effective use of funds.	Benefit-Cost Ratio
	L-1.3	- Develop and maintain a multi-modal regional transportation model that reflects travel patterns and incorporates innovative techniques for evaluating the impacts of proposed transportation investments on travel and land use patterns.	N/A
	L-1.4	- Develop cooperative strategies with employers to reduce congestion and increase the efficiency of the transportation system.	Person-to-Capacity ratios, by facility and mode
Multi-Modal Street and Highway System	L-2.1	- Establish performance standards and report on the condition and effectiveness of the multimodal street and highway system.	N/A
	L-2.2	- Develop and implement level of service (LOS) standards for the urban area that are based on a cooperative agreement between state and local agencies.	N/A
Public Transportation System	L-3.1	- Establish performance standards and report on the condition and effectiveness of the public transportation system.	N/A
	L-3.2	- Develop and implement alternatives to the use of single occupant vehicles, including high occupancy vehicle (HOV) facilities and regional rail services.	N/A
Pedestrian and Bicycle System	L-4.1	- Establish performance standards and report on the condition and effectiveness of the pedestrian and bicycle system.	N/A
	L-4.2	- Maintain and implement a Regional Pedestrian Plan and a Regional Bicycle Plan.	N/A
	L-4.3	- Provide greater safety for pedestrians and bicyclists of all levels of ability, and safer interaction with users of other modes of transportation.	N/A
Public Involvement	L-7.1	- Educate the public and elected officials, in order to increase public understanding of both the options and the constraints of transportation alternatives.	Number of Meetings and Contacts
Safety and Security	L-8.1	- Reduce fatality, injury, and crash/incident rates on all modes.	Fatality & Crash Rates, Local transit crashes, Bike/Ped incidents/injuries
Freight Transportation and Urban Goods Movement	L-9.1	- Relieve congestion on heavily-traveled truck routes.	Percentage of truck VMT under congested conditions / in off-peak

In order to achieve the regional goals and objectives that relate to the CMP, seven CMP objectives are selected: the objectives and the associated measurements are described in Table 1.2.

Table 1.2 CMP Objectives

CMP ID	Objectives	Possible Support Measurements	Related LRTP Goals & Objectives (ID)
C-1	Improve accessibility and mobility for people and freight	Travel Time Index – Ratio of actual travel time to uncongested travel time during peak-hour and daily Duration of Congestion – the congested time length Control Delay – the average vehicle delay at intersection during peak-hour	L-1.4
C-2	Maintain productivity and efficiency of the transportation facilities	Volume-to-Capacity Ratio during peak-hour	L-1.4
C-3	Identify and implement transportation safety enhancements	Number of Crashes and Incident Severity by intersection, by corridor	L-8.1, L-4.3
C-4	Increase transit service to reduce dependency on single occupant auto travel	Number of transit routes / frequency Ridership	L-3.1, L-2.1, L-2.2
C-5	Increase bicycle/pedestrian facilities to promote the use of non-motorized mode	Center line miles Pedestrian/Bicyclist count during weekday	L-2.1, L-2.2, L-4.1, L-4.2
C-6	Provide system operational status to public using a state-of-the-art technology, and maintain system reliability	Travel Time and Standard deviation of travel time or 85 percentile of travel time during peak-hour and daily Number of web visitor during weekdays	L-7.1
C-7	Develop and maintain a multi-modal regional operation model to evaluate and estimate the system performance	N/A	L-1.1, L-1.3

1.4. Study Area

a) Geographic Coverage

The geographic area will cover the Metropolitan Area Boundary (MAB) as shown in Figure 1.1. This coverage includes all of Durham County, the City of Durham, Carrboro, Chapel Hill, Hillsborough, and the MPO planning jurisdiction portions of Orange County and Chatham County. This wide coverage is more beneficial in identifying existing and future congestion locations, evaluating systemwide effects of management strategies, and providing perspective for the extent and degree of congestion throughout the area. This coverage and transportation facilities within the area will dictate data needs for both system performance and strategy effectiveness.

b) CMP Network

Since congestion is an interacted result between the supply and demand of the transportation system and its operation, congestion management is associated with most transportation systems. The selected network should be able to achieve the goals and objectives, and the existing facilities and financially committed projects in the transportation plans will be considered. Recommendations from the stakeholders, technical steering committee, and public will be included in the selection of the networks. The transportation systems, which are related to our CMP goals and objectives, are highways, public transportation, pedestrians and bicycles, safety and security, freight and goods movement, and ITS.

The selection criteria for the CMP network differ by transportation system as shown in Table 1.3. Figure 1.2 illustrates some examples of the identified facilities.

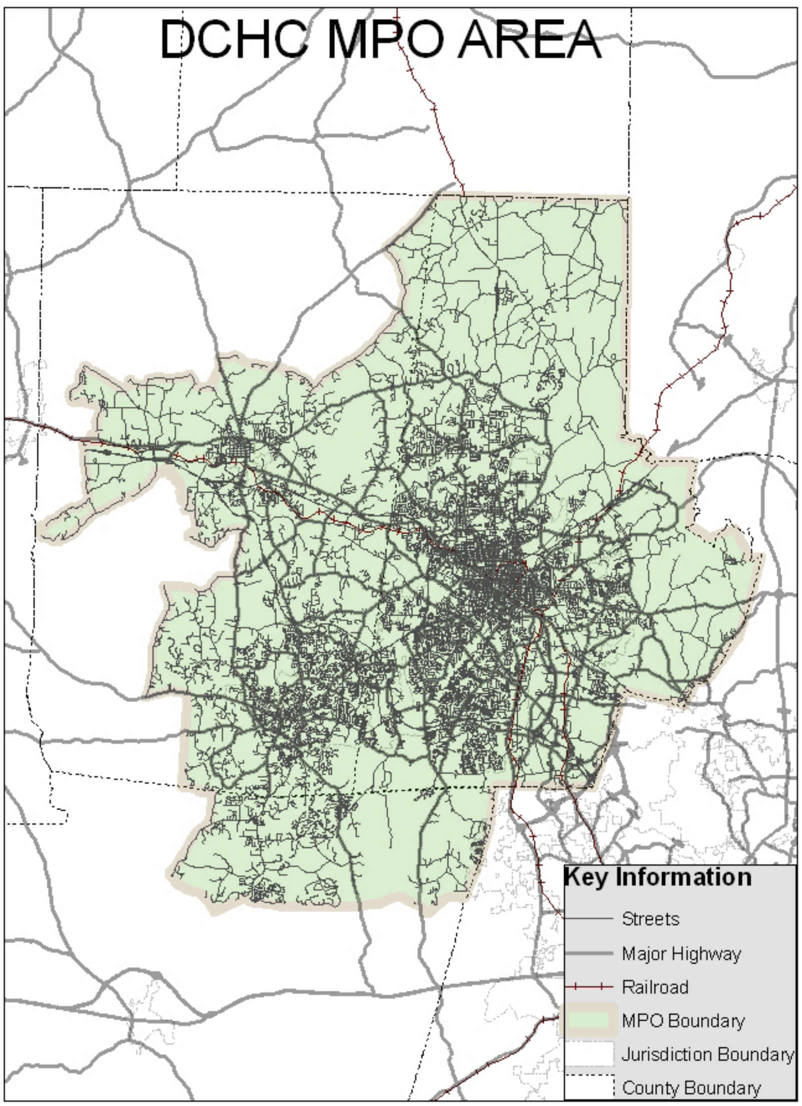


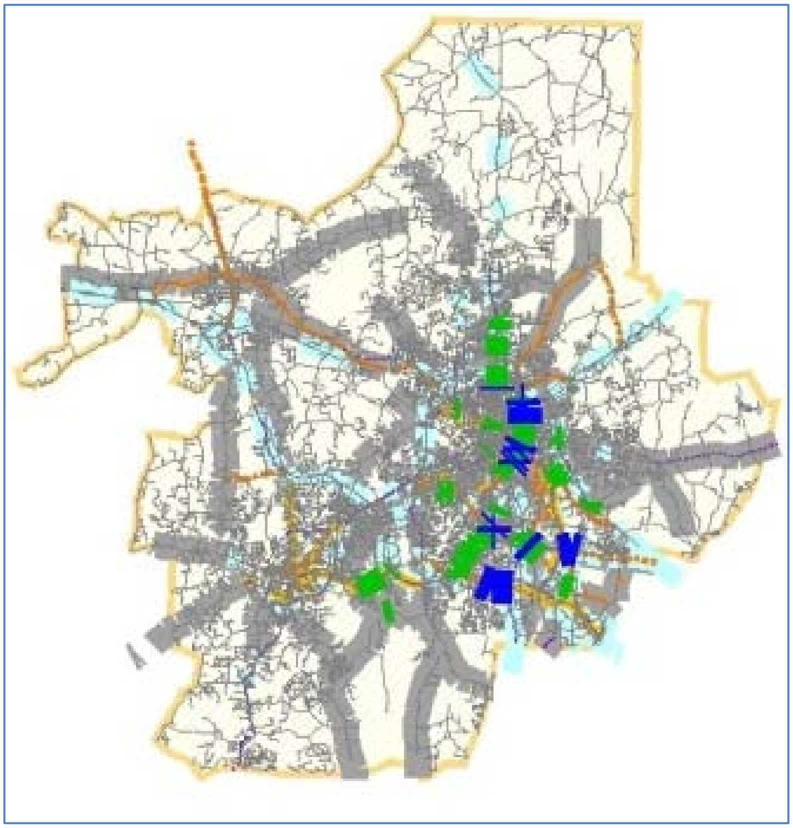
Figure 1.1 CMP Geographic Coverage

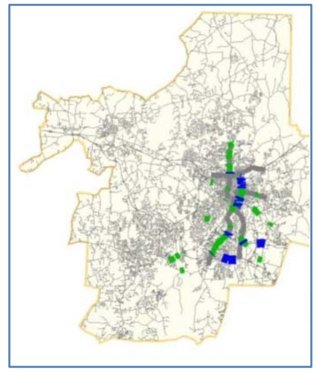
Table 1.3 Network Selection Criteria and CMP Network

System Area & Networks	Criteria	Description
1) Highway	All roads in the Triangle Regional Model (TRM) base year highway network	Interstate Highway, Expressway, Arterial, Collector, and Local roadways
	plus the committed highway network, which will be completed within three years and the alternative routes of the network	Before-After analysis for monitoring the implemented strategy effectiveness.
	plus roadways with a fixed transit route	Durham Area Transit (DATA), Chapel Hill Transit (CHT), and Triangle Transit (TTA)
	plus Designated evacuation routes and emergency management networks	Security
	plus Major road alternative routes	Incident Management
2)Public Transportation	Fixed routes in TRM transit network	Bus, LRT, and Commuter Rail
3)Pedestrian	Pedestrian path and sidewalks/Walkways	Pedestrian facilities that provide regional connectivity with destinations to schools, major trip generators, and high activity density and land use
4)Bicycle	Bicycle paths and greenways	Bicycle facilities that provide regional connectivity with destinations to schools, major trip generators, and high activity density and land use
5)Safety	Crash rate	More than 120 crashes per million entering vehicles at intersections and segments for nonrecurring congestion.
6) Freight	Major freight route	Designated truck routes. Connectivity to land use density activity centers

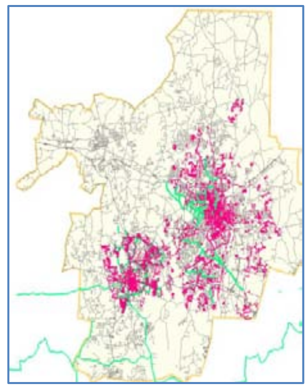
c) CMP Tier System

Two main considerations in decisions regarding CMP are data availability and cost. Since data collection represent the biggest portion of costs in CMP effort, a CMP data collection tiered system is recommended. The CMP tiered architecture designed to match the data collection effort to the specific system components is a cost effective approach given the financial constraints and the MPO funding situation. Each component of the transportation system will be identified as either Tier 1, Tier 2, or Tier 3. A description of the three tiers and the recommended monitoring cycle are described in Table 1.4.





(b) Examples of High Crash Sites



(a) Example of Highway Network (c) Examples of Pedestrian/Bike Networks

Figure 1.2 CMP Network

Table 1.4 CMP Three Tier-Systems

Level	Tier-1: High priority corridors and networks of regional significance	Tier-2: Most Congested/Unsafe Corridors or Areas – Group I	Tier-3: Congested/Unsafe/Other Corridors or Areas – Group II
Purpose	Monitoring system trend	Monitoring the congested corridors including the Tier-1 group and new facilities for a Before-After evaluation	Monitoring the other corridors including the Tier-1 group
Selection Criteria	-More than 4 network selection criteria duplicated in Table 1-3 -Recommendation from the stakeholders, technical steering committee, and public	-More than 3 network selection criteria duplicated in Table 1-3* -Newly implemented strategy (projects) and the alternatives within two years, or the alternatives of the planned projects in LRTP, TIP, or etc. within 2 years	-Other corridor or area identified in Table 1-3
Monitoring Cycle	Every year	Every two years	Every four years

* More detailed selection criteria are explained in Appendix B.

2. CMP Steps

The CMP is a process; therefore, the CMP steps form a feedback loop. The CMP will continually be revised based on findings from the monitoring process and from other planning efforts.

The primary focus areas of the CMP are summarized in the following steps and displayed in Figure 2.1:

1. Develop Performance Measures: Performance measures are determined through a cooperative effort. The measures are used in all steps of the process. In this step, guidelines are also identified for determining congestion in terms of extent, intensity and duration and congestion-based ranking.

2. Collect and Analyze Data: A coordinated data collection program is to be established, using existing data sources when possible.

3. Quantify Performance, Identify and Evaluate Alternatives: Develop data summaries, graphics, and maps that quantify the performance of the system based on previously defined measures and associated data analysis. Expected benefits of the congestion management strategies are identified and evaluated based on the established performance measures.

4. Select Projects: Appropriate improvement strategies are selected. Consideration should be given to demand management, traffic operational improvements, public transportation improvements, Intelligent Transportation Systems (ITS) improvements, and where necessary, additional system capacity. Implementation schedules and responsibilities are to be identified.

5. Monitor Improvements: Compare before and after conditions using performance measures. Learn from the results and apply the appropriate findings to subsequent projects.

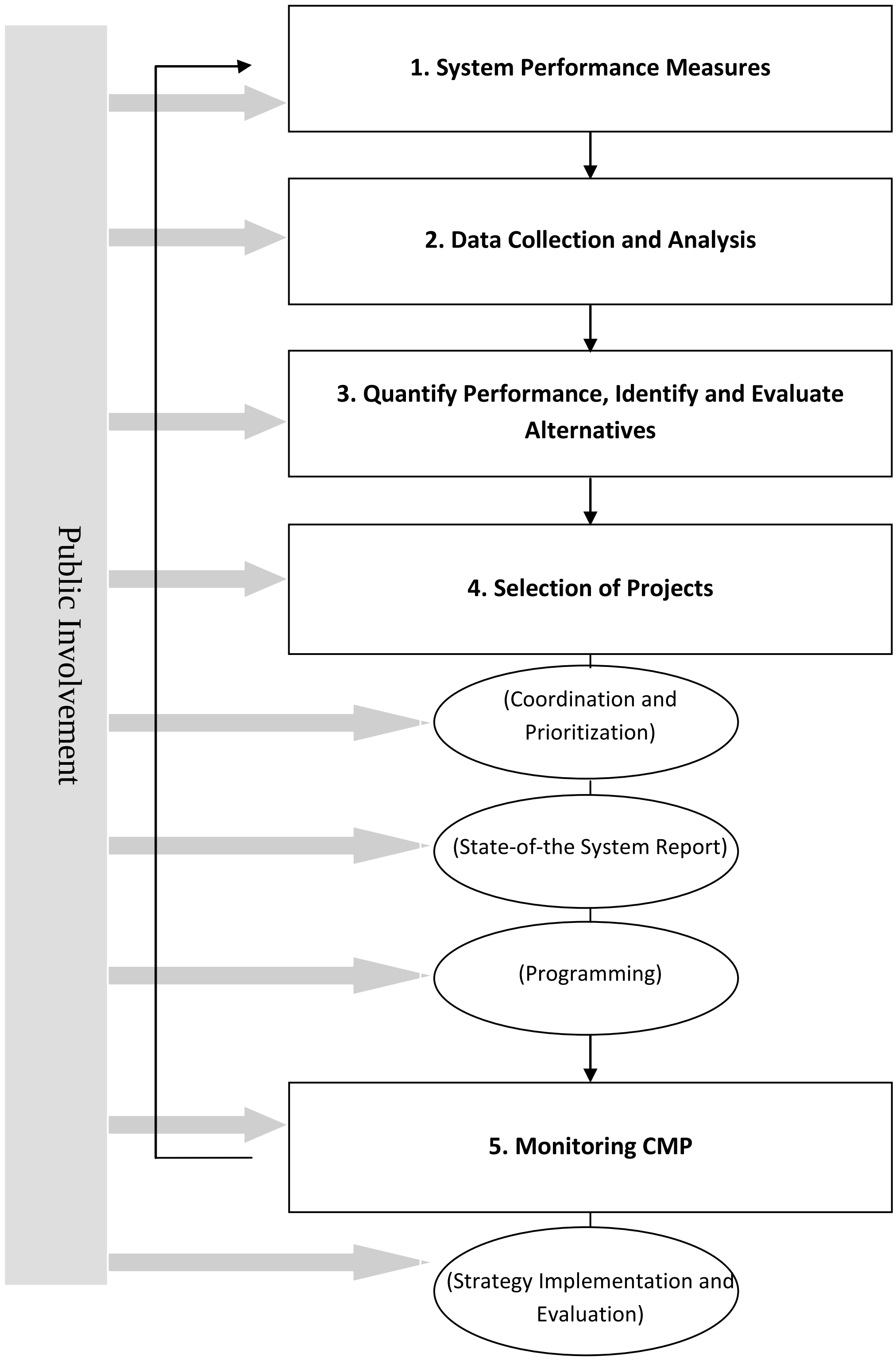


Figure 2.1 Congestion Management Process (CMP) Structure

3. Performance Measures

The performance measurements should be identified, evaluated, and selected properly to monitor system performance effectively. This chapter discusses potential measures and the initially identified performance measures. The final measures will be selected by the technical steering committee.

3.1. Identification and Evaluation of Performance Measurements

Many potential measures were considered to identify effective performance measures that fit our region. Efforts were made to adapt the various potential performance measures to the needs of our region. Table 3.1 provides a summary of the various performance measures reviewed.

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Table 3.1 Performance Measures

Performance Measures	Definition	Units of Measurement	Benefits	Constraints	Data Type (Observed / Estimated)	Goals & Objectives (ID)	Application Level	Recommendation
Volume to Capacity (v/c) ratio	Measurement of average volume compared to adopted service volume or capacity.	• Roadway v/c ratio (daily and/or peak hour). • Intersection movement v/c ratio.	• Can indicate congestion. Can be flexible for multiple time periods and area types. Daily v/c can be determined using existing data by combining AADT and service volumes. Daily v/c can be used as first screen of congestion, providing a cost-effective use of limited resources.	• Daily v/c may limit the identification of certain types of improvements, additional data sources are needed to determine peak-hour v/c.	Estimated	C-2	Major Corridors, Intersections	Yes
Vehicle delay	Measurement of average vehicle delay of all of the movements, or average vehicle delay of an individual movement(s) during a specified time period	• Average control delay (sec/veh)	• Can indicate congestion and may highlight potential safety issues.	• Difficult to measure. • Forecast data will be useful.	Estimated	C-1	Corridor, Intersection	Yes
Number of lane miles that are congested	Miles of roadway that can be classified as "congested". The definition of "congested" can be customized for a particular area or facility type.	• Lane miles of congested roadways. • Percent of congested roadways (congested/total x 100%).	• Indicator of severity of congestion. Can be used to determine percentage of total lane miles that are congested.	• Difficult to measure. There are no existing data sources. While this is a useful areawide indicator, it does not identify specific constraints, or causes.	Observed	C-1, C-2	System wide	No
Duration of Congestion	Time duration where pre-defined sections can be classified as "congested".	• Hours of congestion.	• Indicator of severity of congestion, can be used to determine percentage of time that a facility is congested.	• Difficult to measure. There are no existing data sources. Does not identify specific constraints, causes, or needed improvements.	Observed	C-2	Interstates	Yes
Percent of daily miles traveled under congested conditions	The percentage of travel distance that is spent under congested conditions.	• Percent of congestion.	• Indicator of severity of congestion.	• Difficult to measure. While this is a useful areawide indicator, it does not identify specific constraints, causes, or needed improvements.	Estimated	C-2, C-7	Major Corridors, Interstates	For future consideration

Performance Measures	Definition	Units of Measurement	Benefits	Constraints	Data Type (Observed / Estimated)	Goals & Objectives (ID)	Application Level	Recommendation
Daily vehicle miles	Miles traveled throughout the region.	• Miles traveled per average vehicle. Total miles traveled.	• Can be derived from AADT or TRM	• Takes more effort than AADT, but is not more informative.	Estimated	C-1, C-7	Systemwide	For future consideration
Average Delay – recurring	Average vehicle delay that occurs at a typical time-of day and day-of-week.	• Vehicle-hours.	• Indicates average congestion. Can be measured over different area types, time periods, and facilities.	• Delay is difficult to calculate when v/c ratios are exceeded.	Observed / Estimated	C-1, C-7	Systemwide, Major Corridors	For future consideration
Average Speed	Average travel speed.	• Miles per hour.	• Indicates average congestion. Can be measured over different area types, time periods, and facilities. Easily understood.	• Speed is difficult to calculate when congestion exists.	Observed / Estimated	C-1, C-7	Systemwide, Major Corridors	Yes
Person Miles of Travel	Total miles traveled per person (miles per vehicle times occupancy).	• Miles per person.	• Provides a region-wide indicator of transportation demand.	• Does not identify mode split, potential for demand management, or congested locations.	Estimated	C-1, C-7	Systemwide	For future consideration
Travel Time Index (TTI)	Ratio of actual travel time to uncongested travel time.	• Unitless; the measurement is an index. 1.0 indicates no congestion. • Travel Time • Speed Limit	• Qualifies average travel time data. Can be used to calculate average travel speed as a percent of the speed limit (or 15 percentile of free flow speed).	• Requires travel speed data.	Observed	C-1	Systemwide, Major Corridors	Yes
Buffer Index (BI)	Buffer Index measures the amount of time added to an average trip to ensure on-time arrival for 95% of trips. Buffer Index indicates predictability.	• Unitless; the measurement is an index. 0.0 indicates no volatility.	• Can indicate instability and areas with higher potential for nonrecurring congestion.	• Difficult to measure. Needs extensive data collection and processing.	Observed	C-1, C-2	Systemwide, Major Corridors	No
Planning Index (PI)	This measurement is an indicator of the total time required to arrive on time. It is calculated by combining TTI and BI.	• Unitless; the measurement is an index. 1.0 indicates no congestion.	• Indicates areas with recurring and nonrecurring congestion.	• Difficult to measure. Needs extensive data collection and processing.	Observed	C-1, C-2	Systemwide, Major Corridors	No
Roughness Index for pavement	A measurement of the quality of pavement conditions.	• Unitless; the measurement is an index. •	• Can identify potential contributing factor of congestion.	• Additional factors are more likely to cause congestion.	Observed	-	Systemwide, Major Corridors	No

Performance Measures	Definition	Units of Measurement	Benefits	Constraints	Data Type (Observed / Estimated)	Goals & Objectives (ID)	Application Level	Recommendation
Customer Satisfaction (User Surveys) – Bike/Ped	A qualitative measure of the opinions of people using the transportation system. This can be specific to areas.	• Very satisfied. • Somewhat satisfied. • Neutral. • Somewhat dissatisfied. • Very dissatisfied. • Not applicable.	• Projects determined with user input are desirable to users.	• Collection and processing of data is relatively difficult.	Observed	C-5	Systemwide, Major Corridors	For future consideration
Incident Duration	The time elapsed from notification of an incident until all evidence of the incident has been removed from the scene.	• Minutes per incident.	• Indicator of non-recurring congestion. Great indicator of conditions before and after improvements.	• Difficult to collect data.	Observed	C-1, C-3	Systemwide, Major Corridors	For future consideration
Incident Severity	A quantitative measurement of the cost of an incident. Assumed injury costs vary by injury severity.	• Cost per incident.	• Indicator of potential safety concern that can lead to long incident durations	• Additional data is needed to prioritize locations, such as number of crashes per million vehicles.	Observed	C-3	Major Corridors, Intersections	For future consideration
Number of crashes	Measurement of the total number of crashes at a certain location per unit of time.	• Crashes per year.	• Indicator of nonrecurring congestion. Can identify problem areas to help focus limited resources. Can be determined using existing data sources.	• Ignores type, cause, severity, etc. To be more useful, there is a need to determine the relationship with total volume entering the location. Additional data needed to evaluate causes.	Observed	C-3	Major Corridors, Intersections	For future consideration
Crash Rate	Measurement of the total number of crashes at a certain location, compared to the total volume at the location. This measurement allows for the identification of locations that have a disproportionate number of crashes (compared to intersections with similar volumes).	• Crashes per million entering vehicles at intersections • Crashes per million entering vehicles at segments	• Indicator of nonrecurring congestion. Can identify problem areas to help focus limited resources. Can be determined using existing data sources.	• Ignores type, cause, severity, etc. • Additional data is needed to evaluate causes.	Observed	C-3	Major Corridors, Intersections	Yes

Performance Measures	Definition	Units of Measurement	Benefits	Constraints	Data Type (Observed / Estimated)	Goals & Objectives (ID)	Application Level	Recommendation
Air quality analysis	A measure of the concentration of vehicle emissions.	• Emissions – kg, kg per year.	• Indicator of congestion.	• Secondary indicator; low travel speeds and excessive delay will result in poor air quality.	Estimated	-	Systemwide, Major Corridors, Intersections	Yes
Office Parking	Parking lot utilization data	• Ratio of Occupied / available parking lots	• Indicator of parking strategy • Can divert SOV user to transit	• Regarding to development of a jurisdiction's policy	Observed	C-1	Areawide	For future consideration
Bike parking	Bike parking utilization data	• Bike racks • Bike parking lots	• Can promote bike user	• Secondary indicator	Observed	C-5	Systemwide	For future consideration
Pedestrian Facilities	Sidewalk length	• Sidewalk length • Sidewalk length within transit service area	• Important for transit mobility and pedestrian safety	• Ignores connectivity and Pedestrian density or connectivity and density of population	Observed	C-5	Systemwide, areawide	Yes
Pedestrian Activity	A measure of the number of pedestrians	• Pedestrian count	• what level of pedestrian activity is being experienced • where pedestrian activity is occurring in order to better understand the reasons why there may or may not be pedestrian activity in different areas	• Difficult to understand a function for land use, facility presence, and facility design. • Difficulty of count	Observed	C-5	Systemwide, areawide	Yes
Centerline miles of bike path	Total miles of bike path	• Length of facilities	• Indicator of bicycle network	• Data does not consider demand. Does not identify specific corridors or routes that should be improved.	Observed	C-5	Systemwide, areawide	Yes
Bike Activity	A measure of the number of bicyclists	• Number of bicyclist	• what level of bicyclist activity is being experienced • where bicyclist activity is occurring	• Difficult to understand a function for land use, facility presence, and facility design. • Difficulty of count	Observed	C-5	Systemwide, areawide	Yes
Non-motorized traffic safety	Measurement of the total number of crashes related with pedestrian or bicyclist	• Number of pedestrian/bicycle accidents	• Indicator of safer route • Indicator of nonrecurring congestion	• Ignores type, cause, severity, etc.	Observed	C-5, C-3	Systemwide, major routes	For future consideration

Performance Measures	Definition	Units of Measurement	Benefits	Constraints	Data Type (Observed / Estimated)	Goals & Objectives (ID)	Application Level	Recommendation
Transit Ridership	Number of people on a transit route per unit of time.	• Riders per hour	• Key performance measure when determining which routes to expand or reduce service on.	• It can be difficult to forecast ridership for proposed routes.	Observed	C-4	Systemwide, major routes	Yes
Schedule Adherence	Ability of transit to adhere to the planned schedule. This is typically used to determine how to operate a route.	• Percentage of stops that are on-time	• Can use adherence to identify LOS. Can be used to help determine how to run a route.	• Not used to determine whether or not to increase or reduce service.	Observed	C-4	Systemwide, major routes	For future consideration
Subsidized Cost of Transit	This measurement identifies the amount of money it costs to operate a route. This is the cost to the transit agency, not the cost paid by the user.	• Cost per rider	• The subsidized cost per route is used to make decisions about whether a route should be run or not. Critical element in decision making process.	• Cost is not a stand-alone measure. This must be used in combination with other measures.	Observed	C-4	Systemwide, major routes	For future consideration
Transit Service	Measurement of transit service availability	• Annual service hours of operation • Geographical coverage • Population coverage	• Indicates whether transit service is available	• Does not consider demand.	Observed	C-4	Systemwide	Yes
Availability of transit within congested corridor	Presence of a transit route or system within or adjacent to a congested corridor.	• Available/Not available. Type and frequency of transit should be specified.	• Indicates whether modal split options are available.	• Does not consider demand.	Observed	C-4, C-1	Systemwide	For future consideration

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3.2. Selection of Performance Measures

All of the listed performance measures have the potential to provide useful information for managing congestion. Some are most useful in certain area types, and some are most useful at certain levels of analysis. The selection of performance measures should consider a) the availability of data from existing sources, b) the applicability of those measures in quantifying system performance, and c) the ability of the performance measure to identify future system deficiencies.

In order to select a manageable list of performance measures that are customized to the unique characteristics of the DCHC MPO Area, the Technical Steering Committee will be consulted in the process of review, selection, and approval.

While a number of different performance measures were identified in Table 3.1, not all of them are applicable to each type of facility. Also, availability of data for some of the measures is limited at the current time, thus some will be phased in at a future time as the data becomes available. The performance measures, which can be selected for the DCHC CMP, are as follows:

a) Recurring Congestion

The following recurring congestion performance measures will be selected:

- TTI (peak-hour: AM, Noon, PM),
- Volume / capacity ratio for through movement at downstream boundary intersection (peak-hour: AM, Noon, PM),
- Extension of congestion[2]: spatial, temporal (daily),
- Segment volume / capacity ratio (daily, peak-hour: AM, Noon, PM),
- Average pedestrian space(peak-hour: AM, Noon, PM),
- LOS Scores for pedestrian, bicycle, and transit modes(peak-hour: AM, Noon, PM),
- Transit Ridership (including Peak passengers/seat ratio),
- Signal control delay (including retiming cost/benefit)

b) Non-Recurring Congestion

The following nonrecurring performance measures will be selected:

- High crash intersections: by crash rate (crashes per million vehicles entering) and by the number of crashes
- High crash corridors: by crash rate (crashes per million vehicles miles)
- Incident duration
- Customer or Expert survey

[2] Available data is limited currently; interstate only.

4. Monitoring Plan

The monitoring plan includes overview and data sections; the overview includes the identification of data source, the development of a data management system, and the definition of a reporting procedure. The data section will cover data collection and analysis.

4.1. Monitoring Plan Overview

a) Data Source

Identifying existing data sources and databases that may be used as part of a performance monitoring system is important to maximize the utilization of available resources and to develop a cost-effective data collection program. The existing data sources identified for potential application and new data collection efforts are shown in Table 4.1. The existing sources have established programs for a specific purpose focused on a limited number of facilities or specific geographic coverage. The challenges or barriers of obtaining the data are described in Table 4.2.

b) Data Management

Integration and coordination of the data collection activities will create data management issues and responsibilities. Currently, there is no existing data management system. DCHC MPO will develop an appropriate data management tool using the GIS. It can be used for data management activities as well as for analysis and presentation purposes. Once the analysis is completed, tables and maps of links, corridors, or the entire system can be generated to provide spatial and temporal contexts for the discussion of congestion and mobility. It is also expected that the management tool will be connected with the DCHC MPO Web site to facilitate its use and the efficient flow of information between agencies and the public.

DCHC MPO will take an active role in ensuring that the necessary data is made available and passed forward for use in the CMP. The member agencies are responsible for the flow of data between the agencies and the MPO.

Table 4.1 Data Sources and Hierarchy

Data Type	Source	Primary	Secondary	Innovative Strategy
Travel Time	I-95 Corridor Coalition / INRIX®	X		
	Traffic .com	X		
	NCDOT Operations Center	X		
	MPO Data Collection		X	
	City of Durham – speed warning signs			X
	Downstream loop detector data			X
	Transit agency data		X	
Traffic Count	NCDOT Count Program	X		
	Municipal Signal System Count Programs	X		
	MPO Data Collection		X	
	Municipal Detector Data Counts			X
	Data collected for TIA studies	X		
Turning Movement Count	Municipal Signal System Count Programs	X		
	MPO Data Collection		X	
	Local Consulting Firm Data			X
Control Delay	Regional Operational Model			X
Ped/Bike count & survey	UNC sponsored Data	X		
	Volunteer Data Collection		X	
	MPO Data Collection		X	
Transit ridership & survey	Transit Agencies	X		
Crash rate, count, & severity	NCDOT TEAAS	X		
Public and expert survey results	MPO Survey			X
	MPO WEB survey system			X

Table 4.2 Data Collection Challenges and Barriers

Data Type	Source	Challenge	Barrier
Travel Time	I-95 Corridor Coalition/ INRIX®	Real-time acquisition	Interstate only
	Traffic .com	Real-time acquisition	Interstate only
	NCDOT Operations Center	Data acquisition ability	Interstate only
	MPO Data Collection	A detailed plan	Budget, Staff
	City of Durham – speed warning signs	Calibration	Only 2 locations
	Downstream loop detector data	Calibration	
	Transit agency data	Data acquisition & process	
Traffic Count	NCDOT Count Program		Two year program State Rd only
	Municipal Signal System Count Programs		Paused (?)
	MPO Data Collection	A detailed plan	Budget, Staff
	Municipal Detector Data Counts	Calibration	
	Data collected for TIA studies	Cooperation	
Turning Movement Count	Municipal Signal System Count Programs		Paused (?), Few locations
	MPO Data Collection	A detailed plan	Budget, Staff
	Local Consulting Firm Data	Cooperation	Legal agreement
Control Delay	Regional Operational Model		
Ped/Bike count & survey	UNC sponsored Data	Cooperation	
	Volunteer Data Collection	Identifying groups	
	MPO Data Collection		Budget, Staff
Transit ridership & survey	Transit Agencies	Cooperation	
Crash rate, count, & severity	NCDOT TEAAS	Pedestrian /Bicycle accident report acquisition	
Public & expert survey	MPO Survey		Budget, Staff
	MPO WEB survey system		Budget, Staff

c) Reporting Procedure

CMP Status Report

The main product of this activity will be the State of the System Report. The report will summarize the performance of the region's transportation system including the benefits of the strategies as related to the performance measures discussed earlier. Results will be presented using tables, graphs, or maps. This report will also include an analysis of results by: identifying performance trends; highlighting performance changes resulting from the implemented projects; and identifying system deficiencies or areas of concern. This report will be documented on a biannual basis, staggered with development of the LRTP since these results will help inform the development of the LRTP. Project, corridor, and subarea reports may also be generated if needed.

<u>WEB Based GIS Database Report</u>

The summarized system performance results and data will be published through the DCHC MPO Web system. It will improve the public accessibility to the congestion information, educate the public on MPO activity and planning, and improve communication between agencies as well as the public. The system will include the following information: TMC, volume (AADT), speed, safety (accident spot, number, severity), network (existing and future routes – committed), network (existing and future routes – planned), and relevant other agencies' web-address (NCDOT, CAMPO, etc).

4.2. Coordinated Data Collection

Data should be collected in a coordinated manner between the MPO and member agencies. The corridors or areas where data should be collected would consist of a 3 tier system: 1st-benchmark corridors or areas, 2nd- congested/unsafe corridors or areas, and 3rd-other corridors or areas. The total number of corridors or areas will not exceed more than 50. Data collection methodologies for the identified measurements are described in this section, and the methodologies are focused on the MPO's data collection efforts.

a) Travel time and travel speeds

The data will be collected mainly using a GPS device (GeoLogger) if existing resources such as downstream loop detectors, ITS facilities, and etc. are not applicable.

For quality control of the data, at least, 5 good travel time samples for each direction on the corridors will be required in each peak period- AM, Noon, and PM. For instance, the total number of runs per corridor should be more than 30 (3 peaks * 2 directions * (5+alpha)) if other resources are not available. A more detailed description of the travel time data collection methodology is shown in Appendix C.

b) Traffic volume

If traffic volume from downstream loop detector or other resources is feasible, no extra data will be collected since the detector can report 365 days and 24 hours ideally. The data from the loop detectors will be analyzed, and the results will be released every year.

If the downstream system detector is not practical, the segments on the corridors identified by the CMP Tier System will be considered to be selected and the number of the selected segments will not be more than 100 including segments in the NCDOT Count Program.

The criteria and weight point for the segment selection are described in Appendix B.

Based on the locations of the segments in the Tier system, it will be categorized as annual, bi-annual, and 4th year program. Data including the vehicle classification should be collected at least during 72 consecutive hours with 15 minute time periods using the tube counter. The data and traffic counts from various resources such as NCDOT- statewide planning branch, member agencies' traffic division and private consulting firms are analyzed, and the results will be released bi-annually.

c) Turning Movement Count

Initially, 20 intersections will be identified using GeoLogger's travel time data. Once travel time is collected, the travel time data can be geo-coded and the most congested 20 intersections in terms of travel time delay on both directions of a main approach can be recognized using the coded data within 200 feet at an upstream segment. Manual count using Jammar or tube counters can be applied to collect the TMC with 15 minute intervals.

The locations and others, where TMC was collected by various agencies' traffic divisions, will be coded into a regional operation model. The analysis results such as control delay, queue length, the optimized phasing & timing plan, and off-set parameters will be helpful to understand the causes of congestion and to create a mitigation strategy. The analyzed results will be released bi-annually.

d) Pedestrian and Bicyclist Count and Satisfaction Survey

Pedestrian and bicyclist counts will be taken using various resources. One idea is to utilize volunteers to collect this data in as much as possible. Another potential source of pedestrian crossing activity in the downtown area is the surveillance cameras already in place to support the traffic operation centers. Later the digital image can be analyzed manually or automatically. In lieu of these resources, temporary data collectors or consultant resources will be utilized for this effort. The results will be released bi-annually.

e) Transit ridership and satisfaction survey

DATA, Chapel Hill Transit, and the Triangle Transit each provide annual operating performance statistics to the Federal Transit Administration. The transit agencies also conduct a bi-annual customer satisfaction survey. These data sources will be used to monitor transit performance. It will be released biannually.

f) Crash rate, count, and severity

The Traffic Engineering Accident Analysis System (TEAAS) is a tool to analyze accidents that occur on the state's roads, and is maintained by NCDOT- Traffic Engineering and Safety Systems Branch. This tool will be used to monitor safety. The most dangerous 20 locations will be ranked by crash rate and another 20 locations will be ranked by crash frequency. The result will be released biannually.

g) Public and expert survey results

Experts' comments for CMP are mostly collected during the steering committee meeting. For hearing public comments, the MPO web-page will have a comment window and also a brief survey will be conducted biannually to the member agencies for what kind of public comments they have received.

4.3. Data Analysis

To describe congestion conditions and trends systemwide, the collected data will be analyzed and the following outputs will be summarized using tables, graphs, or maps. The Level-of-Service (LOS) criteria for the intersections and corridors in Table 4.3 and Table 4.4 will be applied to summarize the analysis results. These summaries will help identify overall congestion status and problematic areas. The LOS criteria for non-automobile modes are shown in Table 4.5 and 4.6.

- Recurring congestion performance measures
  - Travel time index and comparison result with historical data
  - V/C ratio and comparison result with historical data
  - Temporal and spatial extension of congestion, and comparison result with historical data
  - Control delay and queue length
  - Transit route/frequency, ridership, and peak-hour passenger/seat ratio
  - Bicycle/Pedestrian facilities information with counts and satisfaction survey
  - LOS Scores for pedestrian, bicycle, and transit modes
  - Key truck route, if possible
  - Evacuation route, if possible
- Nonrecurring congestion performance measures
  - High crash intersections by crash rate, the number of crashes, and incident severity
  - High crash corridors by crash rate, the number of crashes, and incident severity

Table 4.3 LOS for At-Grade Intersections

LOS	Signalized Intersection	Unsignalized Intersection
A	< 10 sec	< 10 sec
B	10~20 sec	10~15 sec
C	20~35 sec	15~25 sec
D	35~55 sec	25~35 sec
E	55~80 sec	35~50 sec
F	> 80 sec	> 50 sec

Table 4.4 LOS for Corridors (TTI)

LOS	Signalized Corridor (TTI =Posted Speed Limit / Avg. Travel Speed)	Freeway	Congestion Status
A	≤ 1.20	≤ 1.00	Not congested
B	1.20~1.50	1.00~1.08	Not congested
C	1.50~1.96	1.08~1.59	Not congested
D	1.96~2.50	1.59~2.17	Approaching congestion
E	2.50~3.46	2.17~3.25	Congested
F	> 3.46	> 3.25	Severely Congested

Table 4.5 LOS Criteria for Pedestrian Mode

Pedestrian LOS Score	LOS by Average Pedestrian Space (ft^2/p)*					
	> 60	40-60	24-40	15-24	8-15	≤ 8.0
≤ 2.00	A	B	C	D	E	F
2.00~2.75	B	B	C	D	E	F
2.75~3.50	C	C	C	D	E	F
3.50~4.25	D	D	D	D	E	F
4.25~5.00	E	E	E	E	E	F
> 5.00	F	F	F	F	F	F

Source: 2010 HCM

Table 4.6 LOS Criteria for Bicycle and Transit Modes

LOS	LOS Score*
A	≤ 2.00
B	2.00~2.75
C	2.75~3.50
D	3.50~4.25
E	4.25~5.00
F	> 5.00

Source: 2010 HCM

To identify the congested corridor or location and to develop strategies, the performance measurement results of corridors and locations will be analyzed.

For the motorized traffic congestion analysis, a rank system will be applied to the existing and projected congestion. The severity of existing congestion will be 80 % of weight and the severity of projected congestion with financially committed improvements will be 20 % of weight in the rank system. The severity of projected congestion with committed improvements in the TIP will be drawn from a Regional operation model or the TRM model at a target year. The volume-to-capacity ratio can be applied if the travel time index is not available.

The rank system is as follows:

$$\text{Rank} = \text{ELOS} + \text{FLOS}$$

$$= \text{MAX}(\{ (TTI_E + CT_E + D_E)*.80 + (TTI_P + CT_P + D_P)*.20\}, \{ (CT_E + v/c_E + D_E)*.80 + (CT_P + v/c_P + D_P)*.20\})$$

Where:

ELOS = (Existing congestion)
FLOS = (Projected congestion from a operational model or TRM)
TTI_E = (Existing Travel Time Index, Free flow speed/travel speed)
CT_E = (Duration of existing congestion)

v/c_E = (Existing volume/capacity)
D_E = (Existing control delay / 120)
TTI_P = (Projected Travel Time Index, Free flow speed/travel speed)
CT_P = (Duration of projected congestion)
v/c_P = (Projected volume/capacity)
D_P = (Projected control delay / 120)

Once the congested corridors and locations are ranked, the top ranked 20 areas will be reported for problem identification, strategy review and project selection.

The high crash intersections and corridors for nonrecurring congestion will be ranked and the top ranked 5 corridors or locations will be reported for identifying the cause of problems.

The performance measurement in the area of pedestrian & bicycle, transit, freight, and security will be analyzed independently. Once the congested areas are identified, the corridors or locations should be reported for problem identification.

In further, the Multimodal Level of Service (MMLOS) analysis method will be considered to introduce in the CMP. The MMLOS method can address the perceived quality of service within the right of way of the urban street for passenger car driver, bus passengers, bicyclists, and pedestrians. It is noted that (a) the MMLOS method is not simple, (b) it cannot be applicable for the analysis of dynamic conditions such as the determination of the beginning and end times of congestion, and (c) the MMLOS analysis for the four modes requires various additional data, which are not defined in the previous sections, including the number of times a vehicle decelerates to a full stop, number of the exclusive left turn lanes, proportion of heavy vehicles, pavement surface condition rate, percentage of segment with occupied on-street parking, lane configuration and the width on segments, number of right-turn-on-red vehicles, etc.

5. Problem Identification

To identify the causes of the problem for the reported corridors or intersections, the results of the following analyses will be carefully reviewed:

- Existing facility analysis (lane configuration, signal-timing plan, bus loading bay, bicycle/pedestrian facilities, and driveway density),
- Capacity analysis (V/C ratio during a peak-hour and daily),
- Intersection LOS analysis (control delay during a peak-hour),
- Corridor analysis (intensity of travel time index during a peak-hour and daily),
- Temporal and spatial extension of congestion (V/C ratio or TTI during daily), and
- Collision analysis (crash types and incident severity during last 5 years)

This comprehensive analysis results will help to find the problem causes and lead to develop an improvement strategy.

6. Identification of Strategies

After the causes of congestion have been identified and evaluated, specific improvement strategies will be identified. During the identification of appropriate improvement strategies, the following contributing factors that affect the feasibility of the strategies should be assessed: estimated cost, right-of-way availability, technology infrastructure, and environmental and social constraints. Environmental Justice Analysis will be conducted in the assessment of environmental and social constraints. This analysis will prove to ensure that the candidate improvement strategy will not impact negatively on minority and low-income populations. For recurring congestion problems, improvement strategies will be focused on decreasing the travel time index, V/C, and control delay. It is noted that the mentioned performance measurements are projected numbers and they can be estimated from a regional operation model or TRM. Strategies for nonrecurring congestion problems will be evaluated in terms of their ability to decrease crash rates or decrease the incident severity. To quantify estimated crash rate, number of crashes, or incident severity, the development of a regional safety model is required. The detailed identification process of appropriate improvement strategies is shown in Figure 6.1.

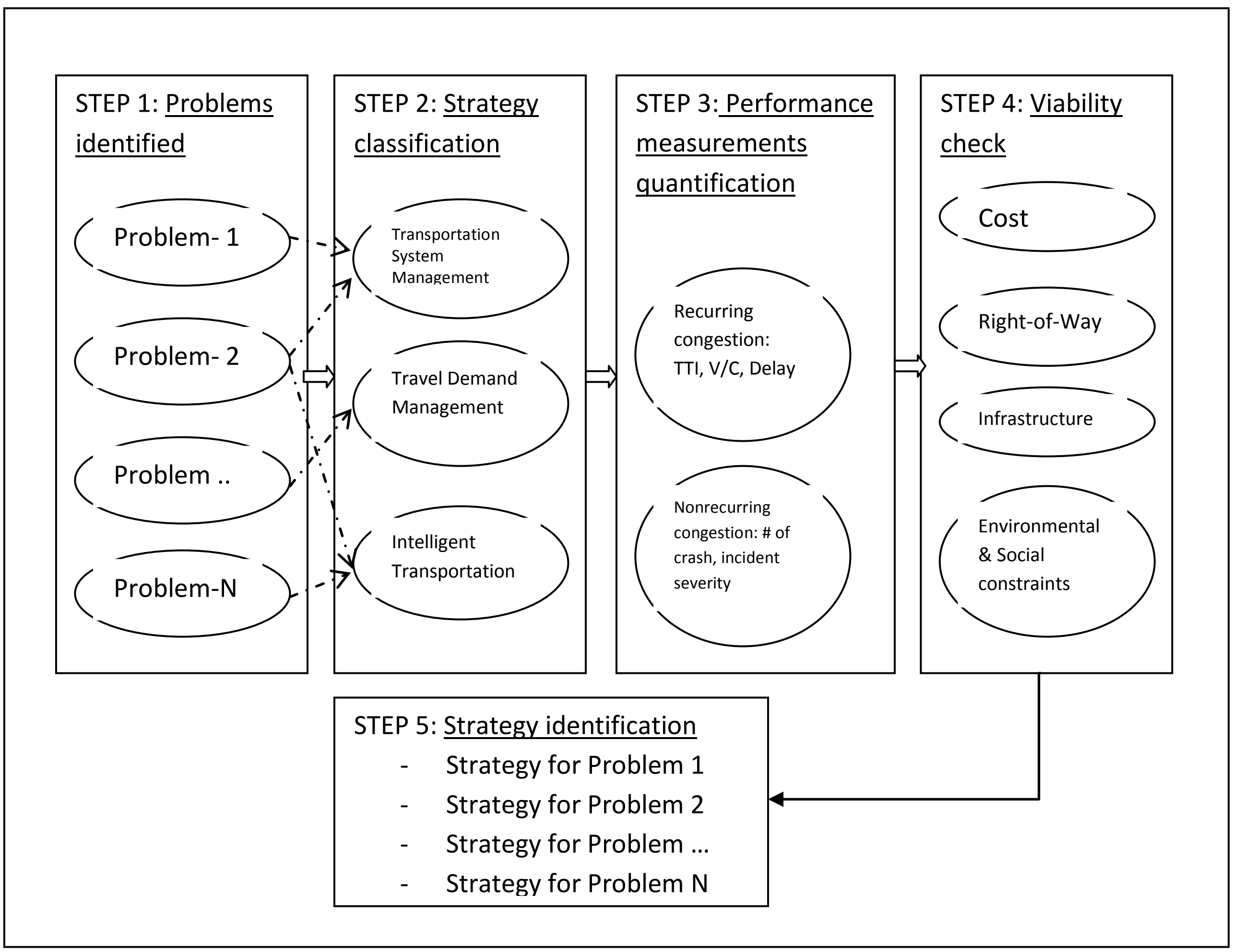

Figure 6.1 Strategies identification process

Some types of strategies are stated in SAFETEA-LU Sec. 450.320 (c) (4), and the strategies are reorganized for the following categories;

- Transportation System Management Strategies;

- Travel Demand Management Strategies; and

- Intelligent Transportation System Strategies;

Each congested area will have specific characteristics that that will lead to certain improvements. While every category of strategies will not be applicable for every situation, it is important to consider the alternatives when they are applicable. Some examples of the types of improvement strategies included in each category are shown in Table 6.1.

Table 6.1 DCHC MPO CMP Improvement Strategies Tool Box

Main group	Sub group	Strategies
Transportation System Management Strategies	Traffic Signalization and Control	- new signal installation, - signal re-timing, - signal hardware upgrades, - signal interconnection, and - demand-responsive signal system
	System capacity and Intersection Improvements	- new travel lanes on major freeway and streets, - Intersection/street widening, - lane assignment changes, - installation of turn lanes, - land use restrictions, - bus loading bays, and - Bus on Shoulder System (BOSS)
	Bottleneck Removal	- re-striping, - installation of signage, - addition of lanes, - reduction of merging and weaving
	Special-Event Management	- traffic management plans, - signal timing plans, and - dynamic lane assignments
	Access Management	- turn lanes, - driveway closures - median treatment - implementation of superstreet design

Table 6-1 Improvement strategies (continue)

Main group	Sub group	Strategies
Travel Demand Management Strategies	Improve Transportation Options	- alternative work schedules, - vanpooling/carpooling, - park & ride, and - bike and pedestrian improvements
	Incentives to Use Alternative Modes	- parking management/shared parking, - congestion pricing/road pricing, and - guaranteed ride home programs
	Sustainable Development	- transit-oriented development, - land use density and clustering, and - bicycle parking facilities
	Policy and Institutional Reform	- car-free planning, - speed reduction, and - context sensitive design
	TDM Marketing and Education	- walking and cycling encouragement, and - transit and alternative mode encouragement
Intelligent Transportation System Strategies	Public Transportation	- transit vehicle tracking, - transit fixed-route operations, - transit passenger and fare management, and - transit traveler information
	Traffic Management	- network surveillance, - surface street control, - freeway control, - traffic incident-management system, - advanced railroad-grade crossing, - roadway closure management, and - Traffic Management Center improvement
	Commercial Vehicle Operations	- fleet and freight administration, - electronic clearance, - weigh-in-motion, - roadside commercial vehicle operations safety, and - freight assignment tracking
	Emergency Management	- emergency routing, - roadway service patrols, and - disaster traveler information
	Maintenance & Construction Management	- maintenance and construction vehicle and equipment tracking, - road weather data collection, and - work-zone management

7. Implementing Strategies and Monitoring Strategy Effectiveness

7.1. Implementation and Management

The previously identified improvement strategies should be incorporated into the long range transportation plan (LRTP) and the transportation improvement plan (TIP). The implementation processes of the defined strategies will be closely monitored if the improvements are adopted in the TIP or other program with the financial commitment. The implementation of the improvement strategies will be led by the operating agencies, and the progress should be reported to the MPO every month.

7.2. Monitoring Strategy Effectiveness

The implemented strategies will be monitored to assess their effectiveness. Monitoring techniques and schedules will be dependent on the type of improvement that is implemented, and the data availability. It may take years to assess the benefits of safety-type improvements that are intended to reduce crash rates, crash severity, or incidents. Conversely, the benefits of capacity improvements are relatively easy to measure and assess.

The benefits of the implemented strategies will be documented in the biannual report. For the improvements that may not be accurately measured in a two year time frame, results will be presented with a description of the limitations of monitoring. Capacity projects and other improvements that are implemented through non CMP methods will still be monitored to determine their benefits. Based upon the monitoring results, the learned facts will feedback for the CMP to verify and update the used performance measures, the applied data analysis techniques, and the considered strategies. If necessary, the CMP objectives and the CMP itself will be adjusted.

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Appendix A: TITLE 23--HIGHWAYS

CHAPTER I--FEDERAL HIGHWAY ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

PART 450—PLANNING ASSISTANCE AND STANDARDS

Subpart C—Metropolitan Transportation Planning and Programming

< http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e1e6fded77bb21ea5585c6420e6552eb&rgn=div8&view=text&node=23:1.0.1.5.11.3.1.11&idno=23 >

§ 450.320 Congestion management process in transportation management areas.

(a) The transportation planning process in a TMA shall address congestion management through a process that provides for safe and effective integrated management and operation of the multimodal transportation system, based on a cooperatively developed and implemented metropolitan-wide strategy, of new and existing transportation facilities eligible for funding under title 23 U.S.C. and title 49 U.S.C. Chapter 53 through the use of travel demand reduction and operational management strategies.

(b) The development of a congestion management process should result in multimodal system performance measures and strategies that can be reflected in the metropolitan transportation plan and the TIP. The level of system performance deemed acceptable by State and local transportation officials may vary by type of transportation facility, geographic location (metropolitan area or subarea), and/or time of day. In addition, consideration should be given to strategies that manage demand, reduce single occupant vehicle (SOV) travel, and improve transportation system management and operations. Where the addition of general purpose lanes is determined to be an appropriate congestion management strategy, explicit consideration is to be given to the incorporation of appropriate features into the SOV project to facilitate future demand management strategies and operational improvements that will maintain the functional integrity and safety of those lanes.

(c) The congestion management process shall be developed, established, and implemented as part of the metropolitan transportation planning process that includes coordination with transportation system management and operations activities. The congestion management process shall include:

(1) Methods to monitor and evaluate the performance of the multimodal transportation system, identify the causes of recurring and non-recurring congestion, identify and evaluate alternative strategies, provide information supporting the implementation of actions, and evaluate the effectiveness of implemented actions;

(2) Definition of congestion management objectives and appropriate performance measures to assess the extent of congestion and support the evaluation of the effectiveness of congestion reduction and mobility enhancement strategies for the movement of people and goods. Since levels of acceptable system performance may vary among local communities, performance measures should be tailored to the specific needs of the area and established cooperatively by the State(s), affected MPO(s), and local officials in consultation with the operators of major modes of transportation in the coverage area;

(3) Establishment of a coordinated program for data collection and system performance monitoring to define the extent and duration of congestion, to contribute in determining the causes of congestion, and evaluate the efficiency and effectiveness of implemented actions. To the extent possible, this data collection program should be coordinated with existing data sources (including archived operational/ITS data) and coordinated with operations managers in the metropolitan area;

(4) Identification and evaluation of the anticipated performance and expected benefits of appropriate congestion management strategies that will contribute to the more effective use and improved safety of existing and future transportation systems based on the established performance measures. The following categories of strategies, or combinations of strategies, are some examples of what should be appropriately considered for each area:

(i) Demand management measures, including growth management and congestion pricing;

(ii) Traffic operational improvements;

(iii) Public transportation improvements;

(iv) ITS technologies as related to the regional ITS architecture; and

(v) Where necessary, additional system capacity;

(5) Identification of an implementation schedule, implementation responsibilities, and possible funding sources for each strategy (or combination of strategies) proposed for implementation; and

(6) Implementation of a process for periodic assessment of the effectiveness of implemented strategies, in terms of the area's established performance measures. The results of this evaluation shall be provided to decisionmakers and the public to provide guidance on selection of effective strategies for future implementation.

(d) In a TMA designated as nonattainment area for ozone or carbon monoxide pursuant to the Clean Air Act, Federal funds may not be programmed for any project that will result in a significant increase in the carrying capacity for SOVs (*i.e.* , a new general purpose highway on a new location or adding general purpose lanes, with the exception of safety improvements or the elimination of bottlenecks), unless the project is addressed through a congestion management process meeting the requirements of this section.

(e) In TMAs designated as nonattainment for ozone or carbon monoxide, the congestion management process shall provide an appropriate analysis of reasonable (including multimodal) travel demand reduction and operational management strategies for the corridor in which a project that will result in a significant increase in capacity for SOVs (as described in paragraph (d) of this section) is proposed to be advanced with Federal funds. If the analysis demonstrates that travel demand reduction and operational management strategies cannot fully satisfy the need for additional capacity in the corridor and additional SOV capacity is warranted, then the congestion management process shall identify all reasonable strategies to manage the SOV facility safely and effectively (or to facilitate its management in the future). Other travel demand reduction and operational management strategies appropriate for the corridor, but not appropriate for incorporation into the SOV facility itself, shall also be identified through the congestion management process. All identified reasonable travel demand reduction and operational management strategies shall be incorporated into the SOV project or committed to by the State and MPO for implementation.

(f) State laws, rules, or regulations pertaining to congestion management systems or programs may constitute the congestion management process, if the FHWA and the FTA find that the State laws, rules, or regulations are consistent with, and fulfill the intent of, the purposes of 23 U.S.C. 134 and 49 U.S.C. 5303.

Appendix B: Tier-2 Selection Criteria

Travel Time

The selection criteria of corridors in the Tier-2 and the associated weight points are;

- Daily and peak-hour v/c ratio: if the ratio on a corridor is greater than 80 percentile in the predefined network, the weight is 4, else 0.
- Traffic volume: if the percentile of the volume on a corridor is greater than 80, the weight is 1, else 0.
- Transit route and service frequency: if a transit service is provided on a corridor, the weight is 1, else 0. If a transit service is provided and the service frequency percentile is more than 50, another two points of weight are given. In transit subject, maximum 3 points are available.
- Incident rate and numbers: the each subject has 1 weight point if each subjects of percentile is greater than 80. Maximum is 2 weight points.
- Truck route: if a corridor is designated as truck route, the weight is 2, else 0.
- Evacuation route: if a corridor is evacuation route, the weight is 2, else 0.
- Bypass or an alternative route of a committed project in LRTP (Metropolitan transportation Plan such as LRTP, TIP, or etc.): if a committed project in LRTP will be completed and was completed within 2 years, both the alternative corridor(s) and the completed project or the alternative corridor(s) alone will be selected in the 2^{nd} tier level regardless of the weight points.
- Newly implemented projects within three years or the alternative routes of the planned projects in LRTP, Tip, etc. within two years.
- Corridor suggested by this steering committee: the corridor will be selected, regardless of the weight points.

Traffic Count

The selection criteria of segments for traffic count and the associated weight points are;

- TTI(maximum weight: 5),
- Transit route and service frequency (max 3),
- Incident rate and numbers (max 2),
- Truck route (max 2), and
- Evacuation route (2).

A segment on the bypass or an alternative route of a committed project, and segments suggested by the Technical Steering Committee will be selected, regardless of the weight points.

Appendix C: Travel Time Data Collection Procedures

1. Sample Size Calculation
    a. Using Standard Deviation of Travel Time

$$n = \left(\frac{t \times s}{\varepsilon}\right)^2 = \left(\frac{t \times c.v.}{e}\right)^2$$

Where $n =$ Sample Size;
$t =$ Student's t statistics value from confidence interval for (n-1) degree of freedom;
$c.v. =$ Coefficient of variance – the relative variability in the travel times from empirical data, expressed as a percentage (%); and
$e =$ Relative error- the relative permissible error in the travel time estimate, expressed as a percentage (%).

Coefficients of Variance for the Test Vehicle Technique on Freeway and Arterial Streets from Empirical data[1)]

Freeway		Arterial Streets	
Average Daily Traffic (ADT) Volume per lane	Average Coefficient of Variation (%)	Traffic Signal Density (signals per database)	Average Coefficient of Variation (%)
0 ~ 15,000	9	< 3	9
15,000 ~ 20,000	11	3 to 6	12
> 20,000	17	> 6	15

Source 1) Lomax, T. and e.t.c. "quantifying Congestion: User's Guide". NCHRP Report 398, Volume II. Transportation Research Board, Washington, DC, 1997.

Test Vehicle Sample Sizes on Freeways[1)]

Average Daily Traffic (ADT) Volume per lane	Average Coefficient of Variation (%)	Sample Sizes		
		90% Confidence, ± 10% error[2)]	95% Confidence, ± 10% error	95% Confidence, ± 5% error[3)]
< 15,000	9	5	6	15
15,000 to 20,000	11	6	8	21
> 20,000	17	10	14	47

Test Vehicle Sample Sizes on Arterial Streets1)

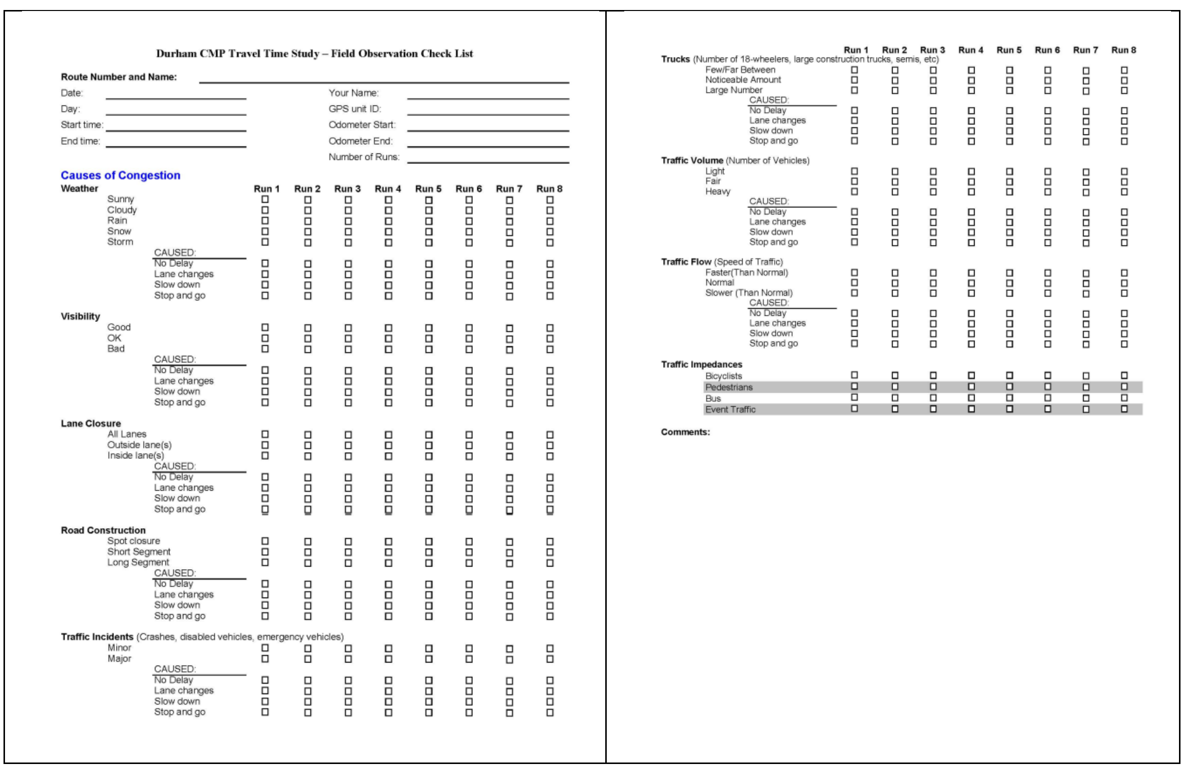
Average Daily Traffic (ADT) Volume per lane	Average Coefficient of Variation (%)	Sample Sizes		
		90% Confidence, ± 10% error[2)]	95% Confidence, ± 10% error	95% Confidence, ± 5% error[3)]
< 3	9	5	6	15
3 to 6	12	6	8	25
> 6	13	9	12	37

2) Planning purpose
3) Operational purpose

b. Budget restriction method (Common practice?)
   1. Typically 3 to 6 runs per routes
   2. In our plan, 5 runs/direction/peak-period/route are designed.

2. Procedures
   a. Safety considered highest priority. Do not attempt to fill out any forms while driving. Do not feel pressured to make unsafe lane changes, travel at unsafe speeds or drive in any unsafe manner in order to “keep up” with normal traffic speed. If fatigued, discontinue study. Become familiar with the route and turnaround locations well in advance of the study. If possible, make a practice run to familiarize yourself with the route.
   b. When it is safe to do so, driving should reflect the average speed of those around you. Try to keep up with a platoon if possible. Try not to accelerate or stop quickly. Unless there is a safety issue necessitating a stop or deviation from the specified route, drive the entire route from start to finish for each run without interruption.
   c. Install and turn on the GPS equipment at least a few minutes before driving is to start, as it can take a minute or two for the unit to pick up a signal. Make sure battery in unit is working (back of unit has instructions for determining whether battery is working, signal is received, etc.). Make sure unit is properly plugged into vehicle’s power source (red light indicates power source is connected properly).

The following sheet is used to record information about the travel time runs. The sheet should be filled out in a safe location *before and after* driving the runs, NOT while driving.



Durham CMP Travel Time Study – Field Observation Check List

Route Number and Name: ______________________

Date: ____________ Your Name: ____________
Day: ____________ GPS unit ID: ____________
Start time: ____________ Odometer Start: ____________
End time: ____________ Odometer End: ____________
Number of Runs: ____________

Causes of Congestion

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
Weather								
Sunny	☐	☐	☐	☐	☐	☐	☐	☐
Cloudy	☐	☐	☐	☐	☐	☐	☐	☐
Rain	☐	☐	☐	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐	☐	☐	☐
Storm	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Visibility								
Good	☐	☐	☐	☐	☐	☐	☐	☐
OK	☐	☐	☐	☐	☐	☐	☐	☐
Bad	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Lane Closure								
All Lanes	☐	☐	☐	☐	☐	☐	☐	☐
Outside lane(s)	☐	☐	☐	☐	☐	☐	☐	☐
Inside lane(s)	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Road Construction								
Spot closure	☐	☐	☐	☐	☐	☐	☐	☐
Short Segment	☐	☐	☐	☐	☐	☐	☐	☐
Long Segment	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Traffic Incidents (Crashes, disabled vehicles, emergency vehicles)								
Minor	☐	☐	☐	☐	☐	☐	☐	☐
Major	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
Trucks (Number of 18-wheelers, large construction trucks, semis, etc)								
Few/Far Between	☐	☐	☐	☐	☐	☐	☐	☐
Noticeable Amount	☐	☐	☐	☐	☐	☐	☐	☐
Large Number	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Traffic Volume (Number of Vehicles)								
Light	☐	☐	☐	☐	☐	☐	☐	☐
Fair	☐	☐	☐	☐	☐	☐	☐	☐
Heavy	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Traffic Flow (Speed of Traffic)								
Faster(Than Normal)	☐	☐	☐	☐	☐	☐	☐	☐
Normal	☐	☐	☐	☐	☐	☐	☐	☐
Slower (Than Normal)	☐	☐	☐	☐	☐	☐	☐	☐
CAUSED:								
No Delay	☐	☐	☐	☐	☐	☐	☐	☐
Lane changes	☐	☐	☐	☐	☐	☐	☐	☐
Slow down	☐	☐	☐	☐	☐	☐	☐	☐
Stop and go	☐	☐	☐	☐	☐	☐	☐	☐
Traffic Impedances								
Bicyclists	☐	☐	☐	☐	☐	☐	☐	☐
Pedestrians	☐	☐	☐	☐	☐	☐	☐	☐
Bus	☐	☐	☐	☐	☐	☐	☐	☐
Event Traffic	☐	☐	☐	☐	☐	☐	☐	☐

Comments:

3. Examples

Example of Schedule

a. Date (typically middle 3 days of week): Tuesday, Wednesday, Thursday
b. Time (Approximately 12.75 hours, 8 core hours)
   i. 6:15 ~6:45 (0.5hr): travel to target route
   ii. 6:45 ~8:45 (2.0hr): AM peak hour runs – inbound / outbound (2/2 times)
   iii. 8:45 ~9:30 (0.75hr): Break
   iv. 9:30 ~10:30 (1.0hr): Off-peak I runs – inbound / outbound (1/1 times)
   v. 10:30 ~11:30 (1.0hr): Break
   vi. 11:30 ~13:30 (2.0hr): Noon peak hour runs – inbound / outbound (2/2 times)
   vii. 13:30 ~14:30 (1.0hr): Break
   viii. 14:30 ~15:30 (1.0hr): Off-peak II runs – inbound / outbound (1/1 times)
   ix. 15:30 ~16:30 (1.0hr): Break
   x. 16:30 ~18:30 (2.0hr): PM peak hour runs – inbound / outbound (2/2 times)
   xi. 18:30 ~19:00 (0.5hr): Return
c. Prior to study, information about the route should be collected and organized as follows. A map should be prepared with the route as well as turnaround locations.

Example of pre-study information (MLK Blvd.)

Route	Apporx.Length (miles)	# of signals	Signal density	start point	end point	AADT	Speed limit (mph)
Martin Luther King Jr. Blvd.	5	11	2.2 (signal/ mile)	MLK and NC 55	MLK and University	15,000 to 23,000	35 to 45

Example of pre-study route map with turnaround points (Duke/Gregson)