SUMMARY

The Texas Medical Center, located in Houston, Texas, is the largest medical center in the world. In 2002, the TMC adopted a Transportation Master Plan to serve as a guide to developing the area’s transportation system. Phase Two of the Transportation Master Plan includes the creation of a performance monitoring plan as part of an effective transportation management strategy.

The develop the conceptual monitoring plan, system issues were observed and combined with the goals and objectives of the Transportation Master Plan to select performance measures that help identify correctible operational breakdowns. The research also developed an implementation plan for the real-time monitoring which included monitoring recommendations, functions of a proposed TMC Mobility Management Center, and a prototype section of a transportation management handbook.
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INTRODUCTION

The Texas Medical Center (TMC) is located south of downtown Houston, Texas. With more than 800 acres, the TMC is the largest such medical district in the world. The transportation system in and around the Medical Center is very expansive and incorporates many different modes of travel. In 1999, the Texas Medical Center recognized the need for a long term strategic plan and created *A Vision For Growth: A 50 Year Master Plan*. To meet the strategic goals of this plan, a transportation master plan was created in 2002. Phase Two of this plan calls for the development of an effective transportation management strategy for the TMC area, including real-time system monitoring to ensure efficient performance (1).

LITERATURE REVIEW

Before developing the performance monitoring plan, a review of literature available on performance measurement in transportation was conducted. To grasp an understanding of the TMC and its transportation system, the Transportation Master Plan and other information on the TMC were also reviewed.

Introduction to Performance Measurement

Performance measurement is the use of statistical evidence to determine progress toward specifically-defined organizational objectives. Although the use of performance measurement in the private sector is well-established, it was not until the mid-1990s when public agencies began adopting similar policies. The National Performance Review, initiated in 1993, began the process of uniting government agencies towards a goal of performance-based management. The capstone report of the National Performance Review, *Serving the American Public: Best Practices in Performance Measurement*, outlined a strategy for agencies at all levels of government to achieve this goal (2). The document also provided an alternative definition of performance measurement:

> A process of assessing progress toward achieving predetermined goals, including information on the efficiency with which resources are transformed into goods and services (outputs), the quality of those outputs (how well they are delivered to clients and the extent to which clients are satisfied) and outcomes (the results of a program activity compared to its intended purpose), and the effectiveness of government operations in terms of their specific contributions to program objectives.

There are several reasons why a public agency would adopt performance measures, as described by Pickrell and Neumann (3):

- accountability: performance measurement provides a means by which the agency can be held accountable for its resources,
- efficiency: performance measures help keep the agency’s actions in line with their goals, and will cut down on waste in the process,
- effectiveness: Performance measures help the agency shift its focus from output to outcome,
- communications: the use of performance measures gives the public a better means by which an agency can be evaluated,
- clarity: when properly selected, performance measures will give the user clear information about the agency’s performance, and
- improvement: the performance measures can be tracked over time to show improvements or areas that need additional resources dedicated to them.
Organizations which choose to adopt performance measures will usually follow the same general procedure. This procedure includes the goal or objective identification, performance measure selection, data collection, analysis, and action.

To execute a performance-based planning process, transportation agencies must first set the goals and objectives they hope to meet. These goals and objectives fall into eight broad categories (4):

- accessibility,
- mobility,
- economic development,
- quality of life,
- environmental and resource conservation,
- Safety,
- operational efficiency, and
- system condition and performance.

Upon the selection of specific goals and objectives, the agency must then decide what measures should be used to gauge their progress toward achieving the goals. In general, a good measure will have the following characteristics (1):

- meaningful and useful to the user,
- measures progress towards the stated goal or objective,
- clearly defined and simple to understand,
- able to measure trends, and
- can be collected economically.

Often, the best group of performance measures will allow the agency to measure progress towards multiple goals with the same method of collection. Once the data is collected, it can be analyzed and trends can be established. These trends can help indicate where improvements need to be made in the system, whether it is a transportation system or another type of system.

**The Texas Medical Center**

The TMC is the largest medical district in the world. Here are some facts about the complex (5):

- The 800-acre campus south of downtown Houston, Texas includes more than 100 permanent buildings.
- There are over 40 member institutions, including hospitals, outpatient facilities, specialized treatment clinics, research centers, and educational institutes.
- There are two Level I trauma centers in the TMC; both are on the north side of the TMC and are accessed from MacGregor Drive.
- When all the member institutions are combined, they employ over 65,000 people – the most of any Houston-area employer.
- In 2004, 5.2 million patient visits occurred at the Medical Center, including more than 10,000 international patients.

As would be expected, a vast transportation network is required to service the TMC. The TMC transportation network is very unique in the fact that it not only serves the world’s largest medical district,
but it also supports several other high-traffic areas including Houston’s Museum District, Hermann Park, and the Reliant Park complex. Here is a short description of the TMC transportation network (5):

- There are more than 18 miles of public and private roadways serving the TMC. Major north-south streets through the TMC include Main Street and Fannin Street. Primary east-west streets include Holcombe Boulevard and Old Spanish Trail. Additionally, the complex has nearby access to three of Houston’s major freeways: South Freeway (State Highway 288), Southwest Freeway (US Highway 59), and South Loop West (Interstate 610).
- There are close to 45,000 parking spaces that serve the institutions of the TMC. There are 17 parking garages and 22 surface lots, some owned by the member institutions and others that are owned by the Texas Medical Center. For employees of the TMC, parking is usually done in large parking areas south of the main campus area. Visitors of TMC institutions can park in the parking garages on an hourly basis or purchase passes of varying durations. Valet parking is also available to visitors.
- The Metropolitan Transit Authority of Harris County, Texas (METRO) serves the TMC with 13 transit bus lines. METRO light rail’s Red Line also serves the Center with four stations nearby: North MacGregor, Dryden/TMC, TMC Transit Center, and Smithlands.
- METRO also operates three shuttle bus routes within the TMC. These shuttles connect member institutions with parking and other transit options. During peak hours, the shuttles run every 4-10 minutes, depending on the route.

TMC Transportation Master Plan

The Transportation Master Plan, created in 2002, provides a strategic plan for the transportation growth of the TMC. The Master Plan describes the goals, objectives, and outcomes for transportation in the area, as well as supporting information. The Master Plan Summary Report defines the extent of the Master Plan in terms of two study areas, the primary and the secondary. The primary study area includes all of the TMC institutions as well as transportation facilities critical to accessing the Center. The secondary study area consists of additional regions that would be affected by travel demands from the primary study area. Table 1 shows the boundaries of the two study areas.

<table>
<thead>
<tr>
<th>Boundaries</th>
<th>Primary Study Area</th>
<th>Secondary Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>Bissonnet-Binz</td>
<td>US-59</td>
</tr>
<tr>
<td>South</td>
<td>IH-610</td>
<td>IH-610</td>
</tr>
<tr>
<td>East</td>
<td>SR-288</td>
<td>SR-288</td>
</tr>
<tr>
<td>West</td>
<td>Main-Kirby</td>
<td>Kirby Drive</td>
</tr>
</tbody>
</table>

The Master Plan also contains projections for growth and development in the TMC area. The report anticipates that there will be a 60 percent increase in vehicle traffic and a 75 percent increase in transit usage over the next 25 years (6). Future needs were assessed and reported in a separate technical memorandum for the areas of roadway traffic, parking, pedestrians, and transit. Several of the most important areas that were identified in the needs assessment are being improved at the present time or are scheduled to be improved in the near future.
RESEARCH OBJECTIVES

The goal of the research was to assist the TMC in implementing their Transportation Master Plan by identifying correctible system issues and developing a conceptual performance monitoring plan to detect and identify these issues. The scope of the research included:

- identification of system issues,
- selection of appropriate performance measures,
- development of a conceptual real-time performance monitoring plan, and
- development of a prototype sample transportation management handbook for TMC area.

TMC AREA TRANSPORTATION ASSESSMENT

The performance of the Texas Medical Center’s transportation system is affected by several issues, both of a recurring and non-recurring nature. The issues were identified by mode either through past studies or by field observations taken in July 2005.

Motor Vehicle

Conditions that limit mobility:

- Intersection congestion: Master Plan Technical Memorandum 2 reports that many intersections within the TMC area are operating at level of service D or worse. Additionally, some of the analysis from the master plan was conducted with data that was up to 10 years old and conditions may have worsened significantly since that time (7).
- Traffic incidents: Houston-Galveston Area Council (HGAC) reports that the risk of a serious motor vehicle crash is 30 percent higher in the TMC than the regional average (8). Accidents can block lanes of a roadway or entire intersections until they are cleared, leading to additional congestion and problems.
- Capacity deficiency: some streets in the TMC are configured for outdated traffic volumes. However, in some places, the roadway cannot be widened due to the proximity of buildings.
- Driver familiarity: many drivers in the TMC do not know exactly where they are going, so they are looking for street names, buildings, or parking garages and driving slow and being inattentive of roadway conditions. Distractions caused by a sick or injured passenger could also make the driver less attentive of the roadway. Either condition creates a safety hazard for drivers in the TMC. Recently, the TMC has installed wayfinding signs to direct drivers to institutions and parking (see Appendix A, Figure A3). However, field visits revealed many of these signs are difficult to read because they are located so far off the roadway, are too small, or are covered up by trees or brush.
- Poor signal timing: signals may not be timed properly due to improper maintenance or lack of an existing timing plan. One consequence of poor signal timing is vehicles from one intersection queuing into the previous intersection.
- Stopped vehicles: normally caused by either delivery vehicles or private vehicles dropping off passengers. Vehicles block the lane of traffic during stopped time.

Possible solutions include:

- Incident management program: implementing an incident management program has been proven to reduce congestion by decreasing the amount of time an incident is blocking the flow of traffic on a roadway. Presently, the TMC has a motorist assistance program which is run by its security staff. In 2004, the TMC motorist assistance program helped over 6,000 people with various vehicle related problems (9). However, no formal incident management plans exist for the TMC area.
• Street reconfiguration: streets in the TMC should be evaluated for possible improvement or reconfiguration to better serve the driving public (i.e. conversion of two streets into a one-way pair for example).
• Improved signage: assess the newly installed wayfinding signs for visibility as well as compliance with the Manual on Uniform Traffic Control Devices (MUTCD) sign guidelines.
• Signal retiming/monitoring: routinely inspect the signal system in the TMC area to ensure smooth traffic flow on major arteries.
• Increased enforcement of stopped-vehicle ordinances: work with delivery companies or other companies which do business that involves a pick-up and drop-off service to reach an understanding on the problems caused by stopping in traffic lanes. After this, increase enforcement with off-duty police officers writing citations to violators.
• Centralized delivery points or drop-off lanes: locate areas of the TMC that could be used exclusively for service vehicles away from high volume streets. Much of this has already been done in the Master Plan. To alleviate problems associated with passengers who are being dropped off, areas where this practice is common could be located and a special drop off lane be constructed.

Parking

Conditions that limit mobility:

• Parking availability: certain parking garages in the TMC may operate at or near capacity on a daily basis. This problem means that drivers could potentially drive around inside a garage that does not have adequate space for their vehicle.
• Garage entrance queues: some garage driveways will have a queue line of vehicles waiting to enter which backs into the street, causing problems on that street. This condition is particularly prevalent outside of the valet garages (see Appendix A, Figure A1).

Possible solutions include:

• Provide “garage full” signs and directions to alternate parking areas at the entrances of parking garages (see Appendix A, Figure A2).
• To relieve parking demand in the TMC core, work with TMC institutions to encourage their visitors to use remote parking or alternate modes of transportation.
• Work with valet services to mitigate the driveway queuing problems by adding more valet drivers, raising prices, or increasing the capacity of the driveway.

Pedestrians

Condition that limits mobility:

• Pedestrian crossing time: at some intersections, the pedestrian “walk” phase lengths are very short. They are also very infrequent because of the length of the signal cycle. This leads to a high occurrence of jaywalking. This is especially true on Fannin Street, where pedestrians will jaywalk in order to reach the light rail platform in time for the next departure. Additionally, jaywalking puts pedestrians at a higher risk of an accident with a motor vehicle or light rail vehicle.
Possible solutions include:

- Conduct crosswalk analyses for major intersections to determine if the “walk” phase times are appropriate.
- Increase enforcement of jaywalking/light rail trespassing ordinances using off-duty police.
- Place fencing or other barriers along the edge of the sidewalks.
- Accelerate the pedestrian bridge program implementation.
- Ensure that new development and construction is aligned with the principles of the TMC’s Pedestrian Circulation Master Plan.

**Light Rail**

Conditions that limit mobility:

- Light rail accidents: data from METRORail accidents show that about 20 percent of the crashes involving METRORail have occurred in the TMC area, making it the second-most dangerous segment of the light rail line. \(^{(10)}\).
- Blocking of tracks/intersections by motor vehicles or pedestrians, especially with left turn conflicts: Fannin Street in the TMC is the only area on the Main Street light rail line where a lane is shared between the light rail and motor vehicles \(^{(11)}\). Additionally, the light rail could prevent motor vehicles from entering the left turn lane causing those waiting vehicles to block through lanes.
- Crowd vehicles between the TMC main campus and the Smithlands parking area station during TMC employee shift changes or other peak periods.

Possible solutions include:

- Coordinate efforts between METRO and TMC institutions to educate drivers on the proper interactions between the light rail and personal vehicle.
- Work with METRO to provide an adequate amount of capacity on its vehicles during peak times.

**PERFORMANCE MEASURE SELECTION**

The goal of the performance measure selection was to combine the observed system issues with the transportation-related goals established by the TMC to produce a set of measures that will detect system breakdowns in real time.

**Selection Process**

The first step in the selection process was to identify the transportation-related goals and objectives of the TMC area. The transportation goal of the TMC area is defined in the *Transportation Master Plan Technical Memorandum 3: Goals, Objectives, and Guiding Principles*. The goal is as follows \(^{(12)}\):

> Improve transportation system conditions within the study area by providing improved access during both normal and flood conditions, circulation, and parking, that are appropriate to each sub area, through improvements in infrastructure, operations, policies, and practices to reduce the dependency on personal vehicles and effectively utilize available transportation resources.

The overall goal of the Master Plan is supplemented by several related objectives. These objectives were matched with the objective categories described in \(^{(4)}\) and are listed in Table 2 below.
Table 2. TMC Transportation Master Plan Objectives and Categories (12)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve access to trauma centers, major activity centers, and redevelopment areas.</td>
<td>Accessibility, Safety</td>
</tr>
<tr>
<td>Improve activity area circulation by all modes of transportation.</td>
<td>Mobility</td>
</tr>
<tr>
<td>Increase activity center parking in accordance with demand and locate major parking facilities on approach routes.</td>
<td>Accessibility</td>
</tr>
<tr>
<td>Balance the transportation system to reduce dependence on personal motor vehicle travel.</td>
<td>Operational Efficiency</td>
</tr>
<tr>
<td>Protect neighborhood character and conditions and local area cultural, educational, and recreational amenities as transportation services are improved.</td>
<td>Quality of Life</td>
</tr>
<tr>
<td>Provide emergency access during flood conditions and develop transportation improvements associated with flood remediation projects.</td>
<td>Accessibility, Safety, Mobility</td>
</tr>
<tr>
<td>Use available transportation resources effectively and efficiently.</td>
<td>Operational Efficiency</td>
</tr>
</tbody>
</table>

After identifying the goals, objectives, and categories, the next task was to select performance measures. The performance measures were selected from the NCHRP’s Guidebook for Performance-Based Transportation Planning, which lists performance measures used by transportation agencies across the United States by category. Performance measures were selected from the following categories: accessibility, mobility, safety, and operational efficiency. These performance measures are summarized in Table 3 by travel mode.

**Discussion of Selected Measures**

**Motor Vehicle Travel Time**

Use: the travel time data will be useful to travelers in the TMC area because it will allow them to know how long specific segments of their trip will take. Travel time significantly above normal might indicate the presence of congestion or an incident and that an alternate route may be faster.

Collection method: the automated vehicle identification (AVI) tags sold by the Harris County Toll Road Authority (HCTRA), more commonly known as “EZ-Tags,” have the capability to be read to collect travel time and, via calculation, speed data. However, since this method of data collection is only effective for long segments of roadway, the AVI tags will only be recommended for the major approach streets and emergency routes to the TMC.

**Intersection/Non-Intersection Delay**

Use: measuring intersection delay will aid TMC traffic managers in identifying system issues as they occur at intersections. Since the distance between intersections in the “core” of the TMC is so short, intersection delay can be used as an indicator of mid-block problems as well.
### Table 3. Selected Performance Measures

<table>
<thead>
<tr>
<th>Travel Mode</th>
<th>Measure</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Vehicle</td>
<td>Travel Time</td>
<td>Accessibility</td>
</tr>
<tr>
<td></td>
<td>Intersection Delay</td>
<td>Mobility</td>
</tr>
<tr>
<td></td>
<td>Non-Intersection Delay</td>
<td>Mobility</td>
</tr>
<tr>
<td>Parking</td>
<td>Parking Occupancy</td>
<td>Accessibility/Operational Efficiency</td>
</tr>
<tr>
<td></td>
<td>Queue Line Length</td>
<td>Mobility</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>Crossing Volumes</td>
<td>Safety</td>
</tr>
<tr>
<td></td>
<td>Accident/Violation Locations</td>
<td>Safety</td>
</tr>
<tr>
<td>Transit</td>
<td>Light Rail Travel Time</td>
<td>Mobility</td>
</tr>
<tr>
<td></td>
<td>Load Factors</td>
<td>Operational Efficiency</td>
</tr>
</tbody>
</table>

Collection method: a combination of upstream traffic signal detectors (pavement loop detectors or cameras located on traffic signal mast arms) will be able to detect delay based on a comparison between the signal phase and presence of upstream queues and/or the movement of the traffic stream.

**Parking Occupancy**

Use: collecting this data will enable TMC traffic managers to automatically or manually tell motorists if space is available or direct them to an alternative location. The data can also be used to track patterns in parking demand over a longer time period.

Collection method: TMC parking garages currently employ a counting device called the McGann Automatic Count System to determine the occupancy of the garages (13).

**Parking Garage Queue Length**

Use: measuring the length of the queue will help detect if the queue line has extended beyond the length of the driveway and into the street. If a queue is detected, the garage operator can be notified to either expedite the flow of vehicles into the garage or close the driveway.

Collection method: video detection located at garage entrances.

**Pedestrian Crossing Volumes**

Use: can be used to identify high volume crosswalks and analyze crossing times.

Collection method: this measure would be extremely difficult to monitor on a real time basis. Alternatively, occasional manual counts would be used to collect the required data.
Pedestrian Violations and Accidents

Use: used to determine frequent jaywalking or unsafe locations.

Collection method: cannot be directly measured in real time. Researchers would use accident, police, or TMC security reports instead.

Light Rail Travel Time

Use: measuring the light rail travel time or headways will confirm normal movements of light rail vehicles. Similar to the motor vehicle travel time, if the measured light rail travel time exceeds the normal travel time, the light rail vehicle may have been involved in an incident which is affecting efficient operations in the TMC area.

Collection method: measured by the Train Control System.

Transit Load Factors

Use: measuring the load factors on both light rail and TMC shuttles will show how well METRO bus and rail capacity is serving demand. This will allow adjustments to be made in available capacity of each.

Collection method: this cannot be collected continuously in real time. However, a manual count can be taken during the peak period to get the necessary data. Alternatively, measuring or observing the number of riders left at the platform or bus stop after a departure indicates insufficient capacity.

TMC MOBILITY MANAGEMENT CENTER

Once the performance measures and collection methods were selected, the research focus shifted to the data collection and performance monitoring process. As part of the Transportation Master Plan Phase Two, the TMC hopes to create a Mobility Management Center (MMC) as the primary system performance monitoring center. The proposed MMC will have several functions as described below.

Real-Time System Monitoring

The principal function of the MMC will be to monitor the performance of the TMC area transportation system on a real-time basis. In the real-time monitoring strategy, data will be collected and if the measured data indicates a problem, the MMC operator will follow a set of guidelines to correct the situation. The following places were determined to be ideal locations for real-time monitoring.

Major intersections: major intersections need to be monitored for delay and incidents. Monitoring will be conducted using detection camera or loop detectors as required and discussed above. Additional studies and stakeholder discussions will be necessary to select priority intersections for adding new equipment.

Emergency corridors: the following streets are access routes from major highways to the Level I Trauma Centers in the TMC: Fannin Street, Holcombe Boulevard, MacGregor Way, and Main Street. Monitoring along the corridors will allow emergency vehicle drivers to be notified of delays so alternate routes can be used, if necessary.

Parking garages: monitoring on the total occupancy of the garages as well as entrance queues. A future study is planned to be conducted to determine locations and corresponding critical entrance queue length.

Light rail movements: in a cooperative effort between the two agencies, the MMC will monitor METRO’s Train Control System to observe normal movements of the light rail.
Information Dissemination

The MMC will serve as the primary information distribution center for traffic in the TMC area. If any conditions are detected that need to be reported to the public, such as heavy congestion or an incident, it will be done so via a highway advisory radio (HAR) frequency based at the MMC. Additional information dissemination could come in the form of strategically placed dynamic message signs (DMS), with the locations and messages to be determined by future study. Additionally, the data collected would be shared with Houston TranStar for additional distribution.

Incident Management and Security

The MMC would also serve as the dispatch center for TMC security. The TMC’s successful motorist assistance program would also be based out of the MMC. At the present time, the motorist assistance program does not have a vehicle dedicated specifically to it. If funds become available, investing in a vehicle equipped exclusively for motorist assistance will free up TMC security and increase the efficiency of the motorist assistance program.

Special Event Traffic Management

As previously mentioned, the TMC area transportation system is unique because of the diverse traffic needs that it serves. To ensure that areas north of the TMC core are performing efficiently, the MMC will have the task of monitoring large traffic demands from events at Hermann Park and the Museum District. Additionally, working with Reliant Park and their traffic management plan will allow the MMC to monitor conditions on the southern half of the TMC area.

Flood Monitoring

The disastrous events of Tropical Storm Allison in 2001 led to the creation of the Brays Bayou Flood ALERT System, a cooperative effort between the TMC and Rice University to monitor flood conditions in Brays Bayou (14). The MMC could potentially serve as the infrastructure headquarters for the flood monitoring system, and would allow flooding-related messages or warnings to be distributed quickly and efficiently.

SAMPLE MANAGEMENT HANDBOOK

The final portion of the research was to create a prototypical section of a sample management handbook that will be used by TMC traffic managers. This handbook will be a guide for responding to measured or observed system problems when they are detected. The handbook will represent a portion of the operations manual for the Mobility Management Center, and will consist of an observed condition and a corresponding action plan for that condition at each monitoring location. This report has provided several examples. Technical details about each monitoring location will be determined in future study.

Intersection

A sample section from the management handbook for a typical intersection will be fairly large so as to cover the wide range of scenarios that could be detected at an intersection. The typical monitoring setup for an intersection will be to measure the amount of delay at that location. Table 4 is a prototype page from the handbook for an intersection located in the “core” of the TMC.
Table 4. Prototype Management Handbook, Intersection

<table>
<thead>
<tr>
<th>Condition: Measured Delay Exceeds Threshold. Use CCTV to Visually Confirm Cause of Excessive Delay</th>
<th>Motor Vehicle Incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Condition from CCTV:</td>
<td><strong>Dispatch TMC Security Officer to intersection for traffic control purposes.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Call Houston City Police.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>If there is an appearance of personal injury, dispatch ambulance to intersection.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>If vehicles do not appear to be able to be driven from the scene, dispatch tow truck to intersection.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>If a light rail vehicle or transit bus is involved, notify METRO police.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Stalled or broken down single vehicle</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Dispatch TMC Security Officer and motorist assistance to intersection for traffic control and vehicle assistance.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Dispatch tow truck to intersection as required.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Apparent congestion or other queuing from downstream intersection or cross street</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Investigate conditions at downstream intersection or cross street.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Pedestrians conflicting with traffic flow (extended condition)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Attempt to identify cause of conflict.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Dispatch TMC Security Officer to scene.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Continue to monitor for possible problems.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Cause cannot be visually confirmed</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Dispatch TMC Security Officer to scene for further reporting.</strong></td>
</tr>
</tbody>
</table>

Emergency Corridor

In emergency corridors, travel time will be monitored in such a way that if the measured travel time rises above a certain value, an alternative route will be recommended for emergency vehicle travel. Table 5 shows a prototype page for emergency corridors.

Table 5. Prototype Management Handbook, Emergency Corridor

<table>
<thead>
<tr>
<th>Measured Condition:</th>
<th>Corridor travel time exceeds acceptable value (based on time of day) for that corridor</th>
<th>Actions:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Recommend alternative route for emergency vehicles as outlined in accompanying plan.</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>If high travel times continue, investigate with intersection monitoring or TMC Security dispatch.</strong></td>
</tr>
</tbody>
</table>
Valet Parking Garage Driveway

For valet parking garages, the entrance queue length will be measured. Excess queue length will notify the MMC operator of a problem at the entrance of that garage. Table 6 shows a prototype handbook section for a valet parking garage driveway.

<table>
<thead>
<tr>
<th>Measured Condition:</th>
<th>Actions:</th>
</tr>
</thead>
</table>
| Excess queue detected | • Confirm visually with CCTV.  
• Notify valet garage operator, instruct operator to speed up vehicle processing to eliminate queue line within a given amount of time or close the driveway until the queue can be cleared.  
• If the queue is not eliminated within a given amount of time, dispatch patrol officer to scene to investigate situation and possibly write citations to valet operator or motorists waiting in queue.  
• Additional actions as required based on patrol officer reports. |

**CONCLUSIONS**

The goal of the research was to develop a conceptual performance monitoring plan for the TMC area transportation system. Field observations and information from past reports combined with the TMC’s Transportation Master Plan goals to develop a set of performance measures for mobility in the area. Using the selected measures, a conceptual plan for measurement was outlined including recommended initial strategies for real-time monitoring and other MMC functions.

**Implementation**

Due to their conceptual nature, many additional steps remain before the real-time monitoring and response plans can be initiated. Upon TMC management approval and funding, a detailed analysis of the major intersections in the TMC area should be done to determine the locations most suitable for real-time monitoring. This analysis should include, but not be limited to, operating speeds by time of day, traffic volumes, accident data, normal queuing, and other characteristics of that particular intersection which could cause congestion or other problems. Similarly, parking garage entrances should be investigated to find the distance from the entrance where a queue line at that location would adversely affect operations on the adjacent street or intersection.

**Future Studies**

To cover the issues that cannot be detected and corrected by the MMC monitoring system, several future studies are recommended:

- Signal retiming: for major corridors, signals should be retimed to ensure proper mobility. Retiming should be done regularly, at least every three years or when travel patterns are observed to have changed or expected to do so due to openings or closings of TMC facilities or adjustments to the
street system or crosswalk locations. Additionally, preventative maintenance should be done regularly to keep the signals working properly.

- Sign/signal visibility analysis: for proper visibility of traffic signals, wayfinding signs, and other informational signs, a program should be launched to maintain the visibility of these signs via trimming trees or other maintenance activities.
- Wayfinding sign analysis: the TMC recently installed a system of wayfinding signs on its streets (see Appendix A, Figure A3). Signs should be checked for compliance with the MUTCD as well as visibility, clarity, and usefulness.
- Alternate parking signs: on some TMC-owned garages, signs direct drivers to alternate parking if the garage is full, (see Appendix A, Figure A2). Installing these signs on all garages and making them more visible from the road would alleviate some stopping and queuing in front of garage entrances. Signs may also need to be placed in front of privately owned parking locations.

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REFERENCES

1. Scope of Work: Initiating Texas Medical Center Area Transportation Master Plan Implementation. Texas Transportation Institute, April 1, 2005.


APPENDIX A

All images were taken during a field observation visit to the Texas Medical Center on July 15, 2005.

Figure A1. Queue at the entrance of a valet parking garage owned by a TMC member institution. Note that the traffic signal is green and there is a vehicle blocking the intersection.

Figure A2. Sign located near the entrance of a TMC-owned parking garage. If the garage is full, the sign indicates where additional visitor parking is available. However, this is the only TMC-owned garage on the campus that has such a sign.
Figure A3. TMC Wayfinding sign