Genesee Transportation Council

TRAVEL TIME DATA COLLECTION ASSESSMENT

FINAL REPORT

JANUARY 2007

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EXECUTIVE SUMMARY

GTC

OVERVIEW AND OBJECTIVES

This study evaluated the potential use of candidate Intelligent Transportation Systems (ITS) technologies to collect travel time data, in support of the Federally-mandated Congestion Management Process (CMP) in the Greater Rochester region.

The Congestion Management Process (CMP, formerly known as the Congestion Management System, or CMS), requires Metropolitan Planning Organizations (MPOs) to perform an ongoing analysis of congestion in their regions, identifying where it occurs and diagnosing its causes. The CMP also influences the planning and programming decisions made by an MPO, specifically with regard to the cost effectiveness of investments. A higher burden of proof is placed on expansions of single-occupant vehicle capacity.

Implementing the CMP is resource intensive, especially with respect to data collection needs along travel corridors of interest. For the MPO to diagnose congestion problems and to differentiate recurring from non-recurring congestion, it is necessary to go beyond model-based calculations of volume-to-capacity (V/C) ratio, as has been the practice at many MPOs around the country.

Furthermore, with increasing attention to travel time delay and reliability as superior metrics of congestion and system performance, the data needs have also become more complex. The need to understand congestion on arterials as well as freeways poses a unique challenge with respect to data collection.

GTC Congestion Management Process: Proposed Performance Metrics

- Minutes of excess delay/trip
- Average travel speed by corridor
- Average travel time by corridor
- Transit load factor by corridor and system wide
- Level of service
- Travel time reliability (e.g., variance in travel time)

The goal of this project was to evaluate candidate technologies to determine their suitability for CMP travel time data collection in the Greater Rochester region, specifically the Rochester Transportation Management Area (TMA), encompassing Monroe County and adjacent parts of Livingston, Ontario, and Wayne counties.

The study was commissioned by the Genesee Transportation Council (GTC), the MPO for the Genesee-Finger Lakes Region that includes Rochester. The study was guided by a multi-agency Steering Committee consisting of representatives of the New York State Department of Transportation (NYSDOT) – Region 4, the Monroe County Department of Transportation (MCDOT), and GTC. The study, conducted by a consultant team on behalf of GTC, commenced in May 2006 and concluded in January 2007.

CANDIDATE TECHNOLOGIES

GTC identified four primary travel time data collection methods of interest:

- **Archived ITS/Operations Data:** Uses existing transportation operations data and technologies deployed for other purposes such as incident detection or travel time information in order to 'mine' travel time information or other performance data.

- **Automated Toll/Fare Data:** Leverages existing electronic toll collection (ETC) infrastructure and transponder-equipped vehicles deployed by the New York State Thruway Authority and other toll agencies in the Northeast. Paired antenna readings between fixed upstream and downstream points can be used to obtain a statistically-valid travel time calculation, by calculating the elapsed time between detection of transponder-equipped vehicles at each location.
- **Global Positioning Systems (GPS) Data:** GPS-equipped 'probe' vehicles use low-cost, on-board equipment to measure travel times anywhere on the roadway network. While extremely flexible and low in capital costs, the drawback of this method is the labor-intensive nature of data collection (i.e., probe vehicle drivers) required to collect a representative sample.
- **Wireless Device Location Technology (cell phone/PDA):** The use of third-party data from mobile electronic devices has generated significant publicity recently, particularly in the realm of traveler information, following the growing success of 911 caller location identification for cellular phones. Such a system would allow pervasive monitoring of travel time conditions from thousands of ''probe' devices all across the region.

Additionally, **hybrid approaches**, using a combination of technologies for specific sub-regional needs, were taken into consideration by the study team.

METHODOLOGY

The Travel Time Data Collection Assessment study consisted of the following activities:

- **Project Initiation (Task 1):** The project commenced with an initiation teleconference on May 12, 2006 to confirm mutual project objectives and expectations, and to begin familiarizing the consultant team with existing CMP/data collection practices and related ITS infrastructure.
- **Methodology Review (Task 2):** This task consisted of an initial evaluation of the four technologies available in the marketplace, resulting in a Technical Memorandum that evaluated the technologies' overall strengths and weaknesses, data outputs, reliability, costs, and other factors.
- **Methodology Assessment (Task 3):** This task provided a comparative assessment of the above technologies in light of needs and conditions in Greater Rochester specifically. A major component of this task was an on-site workshop (held July 12, 2006) to discuss specific regional requirements and existing ITS systems. At the workshop, the consultants reviewed the findings of the Methodology Review Technical Memorandum with the Steering Committee and facilitated a roundtable discussion on the region's requirements.
- **Recommended Preferred Methodology (Task 4):** Based upon the results of the preceding tasks and consultations with the Steering Committee, the consultant team worked with GTC to select a preferred technology approach. A teleconference to discuss the preferred approach was held on September 18, 2006, and the consensus alternative has been documented in this Final Report.
- **Develop Final Report (Task 5):** The recommendations of the study, including an actionable implementation plan based upon the project committee's preferred data collection approach from the preceding task, were presented in a written Final Report (available from GTC).

REGIONAL TRAVEL TIME DATA COLLECTION NEEDS

The study took into account the fact that best practices from other regions may not necessarily be best suited to the local needs, operational conditions, and ITS infrastructure of Greater Rochester. Therefore, in performing the evaluation of candidate technologies, the study team identified key local requirements, which are summarized in Table ES-1.

PLANNING REQUIREMENTS	OPERATIONAL REQUIREMENTS	OTHER REQUIREMENTS
▪ Direct measurement of travel time variance to support CMP process ▪ Aggregate samples of travel time data okay, but capturing non-recurring congestion is critical ▪ Easy to use, 'clean' data ▪ Low burden on staff resources ▪ Can be implemented in the short-term ▪ Has a broad geographic reach ▪ Can be focused on congestion "hot spots"	▪ Support incident detection and traveler information functions ▪ Real-time, constant data collection at finer resolution ▪ Measures other than direct travel time (e.g. speed, volume) are useful ▪ In-house technician and operations resources ▪ Locate detection along major travel corridors ▪ Deployment of field technology for operations is not imminent	▪ Cost-effectiveness ▪ Reliability/Maintainability ▪ Technological maturity/ practical experiences of other MPOs ▪ Suitability to climate ▪ Affordable within available funding/cost sharing opportunities

Table ES-1: Summary of Regional Travel Time Data Collection Requirements

The needs evaluation process determined that the corridors of greatest interest are the region's limited-access expressways and a few other high-priority arterial streets. This is because these facilities are the region's primary congestion "hot spots," and present travelers with few alternative routes for effectively bypassing incidents or congestion.

Another key finding of this analysis was that there is a need to draw a distinction between the optimal **short-term strategy** (0-3 years) focused on the immediate CMP planning requirements, and a **longer-term strategy** (3+ years) which might leverage future ITS deployments to realize broader operational and planning benefits.

COMPARATIVE TECHNOLOGY EVALUATION

Based on the requirements identified, the study team performed a comparative evaluation of technology alternatives that are feasible in both the long and short terms. The results of this analysis for the short-term and long-term are summarized in the tables and discussion that follow.

SHORT-TERM RECOMMENDATION AND IMPLEMENTATION PLAN

In light of the above factors, the Steering Committee has recommended a **Global Positioning Systems (GPS)-based** travel time data collection system in the Short-Term (Table ES-2). This approach offers numerous advantages in meeting GTC's short-term CMP data collection needs, including: low implementation cost; proven, reliable, accurate technology; proven peer MPO experiences; and flexibility in technology deployment. The details of the recommended short-term implementation activities are detailed in Table ES-3.

Short-Term Technology Alternative	Evaluation Findings
GPS Data Collection	*Pros:* Meets immediate needs of CMP data collection program; proven experience in other CMP applications (e.g., Hartford, CT); flexible implementation on any roadway in the transportation network; direct measurement of travel time; low capital cost; can complement long-term strategy. *Cons:* Data collection is labor intensive, as a driver is needed for each probe measurement; data collection is intermittent rather than continuous
Portable Toll Data Collection	*Pros:* Direct measurement of travel time; continuous data collection as long as field antennas are deployed; leverages existing ITS infrastructure; low ongoing labor costs; can be used to test locations for permanent installation and to supplement other long-term infrastructure. *Cons:* Can only be located at suitable locations; deployment for CMP data collection is novel and thus has higher technology implementation risks; higher capital and maintenance costs.
Fixed Detection Pilot Project	*Pros:* provides a test-bed for long-term data collection strategies using fixed detection equipment; provides continuous direct or derived travel time measurement; extensive national experience with the technology. *Cons:* High capital cost; only covers a limited portion of the roadway network; requires active participation of other regional partners (e.g. MCDOT, NYSDOT) in system operations and maintenance.

Table ES-2: Summary of Short-Term Technology Evaluation

Short-Term Implementation Activity	Anticipated Outcome	Responsible Entity
Refine the regional Congestion Management Process (CMP)	Provides a framework for the travel time data collection program; identifies performance criteria and regional objectives	Genesee Transportation Council (GTC)
Identify critical corridors for short-term data collection activity	Identifies the congestion 'hotspots' where data collection will take place; provides for the development of a statistically valid data collection program and data collection resourcing plan.	Genesee Transportation Council (GTC)
Contract for third-party GPS data collection services	Supplements existing GTC staff resources to collect travel time data using GPS-equipped probe vehicles according to a data collection protocol prescribed or approved by GTC.	Genesee Transportation Council (GTC) Third-party data collection contractor
Evaluate and interpret GPS field data	Translate travel time measurements into performance measures for further regional model analysis and/or CMP reporting.	Genesee Transportation Council (GTC)
Implement Pilot Project to test a preferred long-term approach	Design and deploy a pilot implementation on a limited-access highway segment using fixed detection, in order to evaluate the long-term potential of a fixed infrastructure approach.	Genesee Transportation Council (GTC) Operating Agencies (NYSDOT, MCDOT)

Table ES-3: Short-Term Implementation Activities

FIXED DETECTION PILOT PROJECT

The Implementation Plan also recommends deployment of a **Short-Term Fixed Detection Pilot Project** examining the effectiveness of fixed travel time data collection infrastructure along a critical highway segment. One promising alternative is to coordinate with the NYS Thruway Authority and the TRANSMIT program to use existing E-Z Pass toll tags and systems infrastructure to obtain direct travel time measurements. Preliminary investigations suggest that such a pilot project could be performed cost-effectively leveraging existing TRANSMIT servers and software operated by the NYS Thruway Authority in the Buffalo-Niagara (NITTEC) region. Another option is to test an alternative fixed sensor technology along a corridor to accomplish the same travel time data collection function. A proposed ITS sensor technology deployment project for the I-490 Western Gateway corridor could make an ideal pilot project test-bed.

LONG-TERM IMPLEMENTATION STRATEGY

Two technologies with long-term potential were evaluated in the study (Table ES-4). However, due to the uncertainties involving technology maturity and regional operating goals, ongoing discussions about planning and traffic operations objectives for ITS are necessary to articulate a preferred long-term strategy.

The study team recommends a comprehensive review of regional strategic ITS goals in the forthcoming Regional ITS Strategic Plan prior to implementing a long-term strategy. The purpose of this review is to better understand potential collaboration and cost-sharing opportunities for fixed infrastructure deployment in support of both the GTC travel time data collection program and traffic operations initiatives performed by NYSDOT and MDOT, through the Regional Traffic Operations Center (RTOC).

Long-Term Technology Alternative	Evaluation Findings
Permanent Detector Installation	*Pros:* Allows continuous data collection on key roadway segments; provides numerous potential operating benefits to partner agencies (e.g., incident detection, travel time information for motorists) *Cons:* High capital cost; only covers a limited portion of the roadway network; requires active participation of other regional partners (e.g. MCDOT, NYSDOT) in system operations and maintenance.
Wireless Device Location Technology	*Pros:* Promises pervasive travel-time measurement capabilities at virtually any location on the transportation network; direct travel time measurement possible. *Cons:* Technology is immature and rapidly evolving; no market-ready providers; potential privacy concerns; costs uncertain.

Table ES-4: Summary of Long-Term Technology Evaluation

The study team also recommended that GTC continue to **monitor the evolution of emerging travel time data collection technologies**, such as Wireless Device Locator Technology, to determine if its implementation will become more practical within the next 3-5 years.

1. INTRODUCTION

1.1 Overview

This document is the product of a study to evaluate the possibility of using Intelligent Transportation Systems (ITS) technology to collect travel time data in support of the Federally-mandated Congestion Management Process (CMP) in the Greater Rochester region.

This study was commissioned by the Genesee Transportation Council (GTC), the Metropolitan Planning Organization (MPO) for the Genesee-Finger Lakes Region that includes Greater Rochester. The study was conducted in cooperation with two of GTC's regional partners, the New York State Department of Transportation (NYSDOT) and the Monroe County Department of Transportation (MCDOT). The study was conducted by a consultant team[1] under the direction of a steering committee comprised of these three agencies and chaired by GTC.

1.2 Background

1.2.1 THE CONGESTION MANAGEMENT PROCESS (CMP)

The federally-mandated Congestion Management Process, formerly Congestion Management System (CMS), requires Metropolitan Planning Organizations to perform an ongoing analysis of congestion in their regions, identifying where it occurs and diagnosing the causes. The CMP also influences the planning and programming decisions made by an MPO, specifically with regard to the cost effectiveness of investments. A higher burden of proof is placed on expansions of single-occupant vehicle capacity.

Implementing the CMP is resource intensive, especially with respect to data collection needs along travel corridors of interest. For the MPO to diagnose congestion problems and to differentiate recurring from non-recurring congestion, it is necessary to go beyond model-based calculations of volume-to-capacity (V/C) ratio, as has been the practice at many MPOs around the country.

Furthermore, with increasing attention to travel time delay and reliability as superior metrics of congestion and system performance, the data needs have also become more complex. Finally, the need to understand congestion on arterials as well as freeways poses a unique challenge with respect to data collection.

1.2.2 APPLYING TECHNOLOGY TO CMP DATA COLLECTION

This situation has led GTC and its peers around the country to contemplate the possible use of advanced technology to supplement, automate, or otherwise improve CMP travel time data collection, while reducing the resource requirements to fulfill this mandate.

In many instances, transportation operating agencies (both roadway and transit) generate large quantities of traffic data that is suitable for planning analysis as a 'byproduct' of their

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transportation system management activities. However, it is unlikely that archived ITS data will alone suit the needs of a CMP data collection program without an overarching assessment of CMP requirements and the coverage, quality, and format of data being generated. Traffic detection technology in general, and travel time data collection techniques specifically, has advanced considerably in recent years with the proliferation of metropolitan Advanced Traffic Management Systems and a Federal push to use traveler information infrastructure (e.g., Dynamic Message Signs (DMS), 511 telephone systems, etc.) to provide travel time estimates as their default mode of operation. Rochester's peer city of Milwaukee, Wisconsin has been an early leader in this latter regard.

Other MPOs have taken a different approach by using technology to collect new travel time data specifically in support of CMP, rather than 'mining' operational data. The Capital Region Council of Governments (CRCOG) in Hartford, Connecticut, through its use of low-cost portable GPS technology, is an example of such an agency. Thus the pre-existence of regional traffic management infrastructure is not a pre-requisite for collecting travel time data, though there are clearly efficiencies in leveraging existing or planned traffic management ITS systems where possible.

1.2.3 EXISTING CMP ACTIVITIES IN GREATER ROCHESTER

The Greater Rochester region does not currently have a formal Congestion Management Process in place. Additionally, there is also no freeway travel time data collection being performed within NYSDOT Region 4.

In the past, the existing regional transportation model has been used to generate data to determine congestion threshold metrics, such as V/C ratios. This travel time data collection assessment is part of a larger GTC effort to develop a CMP that meets federal requirements while also providing useful travel time information to public agency personnel and the general public.

GTC has already identified seven (7) performance measures for use in its future CMP. These performance measures are:

- Minutes of excess delay/trip;
- Average travel speed by corridor;
- Average travel time by corridor;
- Transit load factor by corridor and system wide;
- Level of service; and
- Reliability (e.g., variance in travel time).

This study shall focus on identifying the region's best data collection options for both the short-term and the long-term.

1.3 Candidate Technologies

GTC has identified four primary travel time data collection methods of interest:

1.3.1 ARCHIVED ITS/OPERATIONS DATA

This method leverages existing transportation operations data and technologies deployed for other purposes such as incident detection or travel time information in order to 'mine' travel time information or other performance data. Philosophically, the use of operations infrastructure to support a planning function is a prudent approach provided data coverage and quality are acceptable. Such cooperation may also provide additional value to regional partners, as equipment investments can fulfill the needs of several agencies simultaneously.

1.3.2 AUTOMATED TOLL/FARE DATA

Because of the use of electronic toll collection (ETC) by the New York State Thruway Authority and other toll agencies in the Northeast, it is reasonable to assume that there is a large market penetration of in-vehicle transponders in Greater Rochester. The Inter-Agency Group (IAG) overseeing the EZ-Pass program has authorized the use of many alternative applications of transponder data in the past, ranging from parking fees for transit and airports to service plaza fuel purchases. Privacy is a concern that always has to be addressed in such situations. In any case, paired antenna readings between fixed upstream and downstream points can be used to obtain a statistically-valid average travel time calculation for many roadways.

1.3.3 GLOBAL POSITIONING SYSTEMS (GPS) DATA

The use of GPS-equipped 'probe' vehicles takes advantage of the fact that this technology can monitor the translation of a vehicle through space without defined cordons or measurement locations as in the transponder approach. This provides greater flexibility to measure anywhere on the network, but there are practical challenges related to obtaining an adequate probe sample to create statistically valid results. The use of AVL-equipped transit vehicles as probes has been attempted in several places, but generally requires frequent service headways to account for travel time distortions caused by passenger boardings and other factors unique to transit operations.

1.3.4 WIRELESS DEVICE LOCATION TECHNOLOGY (CELL PHONE/PDA)

The use of third-party data from mobile electronic devices has generated significant publicity recently, particularly in the realm of traveler information, following the growing success of 911 caller location identification for cellular phones. Like transponder-based systems, there are privacy concerns and some providers (depending on their business model) may assess fees to access data of interest. Certain regulatory bodies (e.g., public utilities commissions) can help to facilitate access to such data, but the practical hurdles can quickly escalate this approach to an impractical level.

1.4 Alternative or Hybrid Approaches

The above categories do not represent an exhaustive list of available technology approaches. For example, license plate capture, which uses optical character recognition to compare plate readings at upstream and downstream locations, is a different technology approach to the ETC transponder concept. There are also algorithmic techniques for deriving travel time information based upon 'spot' measurements of traffic characteristics, such as speed, volume, and occupancy, as could be collected using microwave, acoustic, or loop detection technology.

Finally, hybrid approaches, using a combination of technologies and/or conventional methods for specific sub-regional needs, can be considered provided that the practical ramifications regarding data type and quality, maintainability, etc. are fully considered.

1.5 Study Area

The study area for this project consists of the Rochester Transportation Management Area (TMA), including Monroe County and the adjacent portions of Livingston, Ontario, and Wayne counties. The study focused primarily on the limited-access freeway and arterial street system within the TMA. Further discussion of the study area and roadway network is presented later in this document.

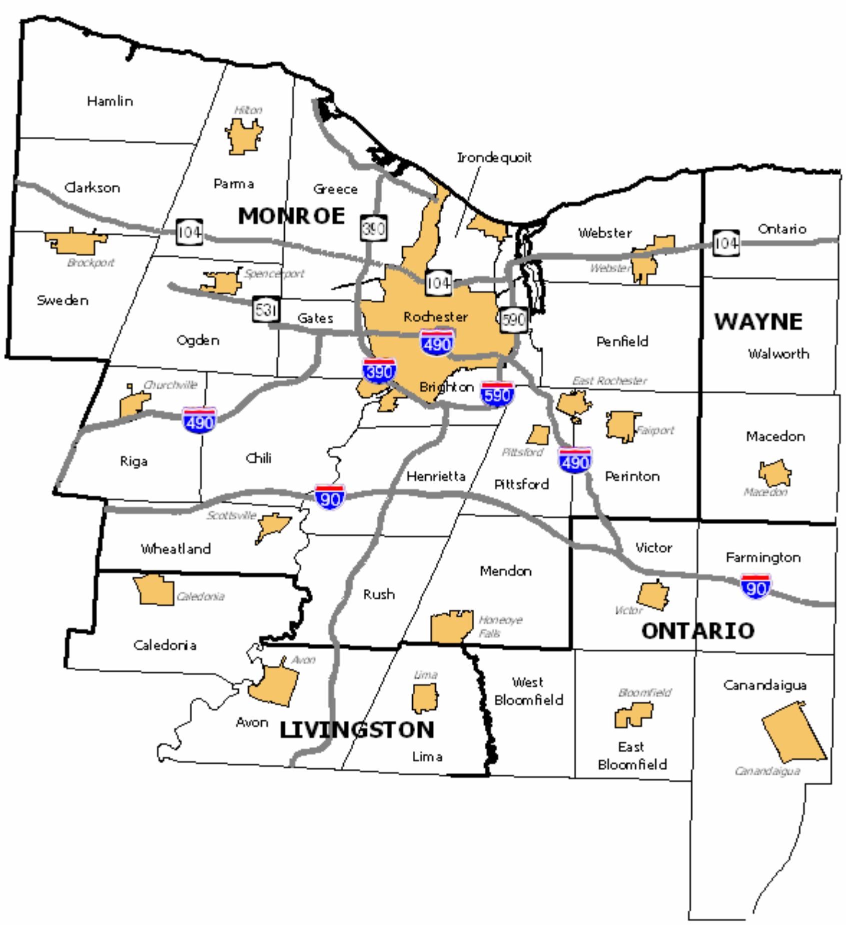

Figure 1: Study Area (Rochester TMA)[2]

[2] Source: Genesee Transportation Council

1.6 Study Methodology

TASK 1: INITIATION TELECONFERENCE

The project commenced with an initiation teleconference on May 12, 2006 to confirm mutual project objectives and expectations, and to begin familiarizing the consultant team with existing CMP/data collection practices and related ITS infrastructure. GTC staff reviewed project objectives and background, while the consultant team reviewed the proposed methodology, the technologies to be investigated, and upcoming project milestones.

TASK 2: METHODOLOGY REVIEW

The Methodology Review consisted of an initial evaluation of four technologies available in the marketplace: Archived ITS/Operations Data; Automated Toll/Fare Data; GPS Data; and Wireless Device Location Technology. An overview of each technology was provided in a Technical Memorandum, along with a comparative framework that evaluated the technologies' overall strengths and weaknesses, data outputs, reliability, costs, and other factors.

TASK 3: METHODOLOGY ASSESSMENT

This task provided a comparative assessment of the above technologies in light of needs and conditions in Greater Rochester specifically. A major component of this task was an on-site workshop (held July 12, 2006) to discuss specific regional requirements and existing ITS systems. At the workshop, the consultants reviewed the findings of the Methodology Review Technical Memorandum with the Steering Committee and facilitated a roundtable discussion on the region's requirements.

TASK 4: RECOMMENDED PREFERRED METHODOLOGY

Based upon the results of the preceding tasks and consultations with the Steering Committee, the consultant team worked with GTC to select a preferred technology approach. A teleconference to discuss the preferred approach was held on September 18, 2006, and the consensus alternative has been documented in this Final Report.

TASK 5: DEVELOP FINAL REPORT

The final recommendations of the study, including an actionable implementation plan based upon the project committee's preferred data collection approach from Task 4, are incorporated into this Final Report. The Final Report was presented to the Steering Committee in draft format for review and comment prior to finalization.

1.7 Project Timeline and Milestones

This study commenced in May 2006 and was completed in January 2007. The following is a summary of major project milestones:

Project Initiation Teleconference	May 15, 2006
Methodology Review Memorandum	July 5, 2006
Stakeholder Workshop	July 12, 2006
Methodology Assessment Memorandum	August 31, 2006
Technology Evaluation Teleconference	September 18, 2006
Submission of Final Report to Steering Committee	December 2006
Final Report Issued	January 2007

1.8 Steering Committee

The project was directed by a Steering Committee comprised of the following individuals:

<u>Genesee Transportation Council</u>

Erik Frisch, Program Manager (Study Project Manager)

Kevin Beers, Program Manager – Travel Demand Modeling and GIS

<u>New York State Department of Transportation</u>

Dan McCusker, Manager, Regional Traffic Operations Center, Region 4

<u>Monroe County Department of Transportation</u>

Jim Pond, Associate Traffic Engineer

2. TECHNOLOGY REQUIREMENTS IN GREATER ROCHESTER

2.1 Introduction

Identifying the best technology solution to travel time data collection in Greater Rochester requires consideration of a variety of local factors, among them the local operating environment, available resources, and the intended use(s) of collected data.

Exploration of these locally-significant issues was the subject of a half-day Travel Time Workshop held on July 12, 2006 at the Regional Traffic Operations Center (RTOC) on Scottsville Road in Rochester.

This chapter presents a summary of the key local factors influencing the selection of a travel time data collection technology, namely:

- Travel time infrastructure **functional requirements**, which describe what the participating agencies intend to accomplish using the technology and how it will fit into the local operating environment;

- The **critical travel time measurement corridors** and roadway functional classification, where travel time data collection is desired; and

- **The existing and planned ITS infrastructure** in the region that could possibly be leveraged to support infrastructure deployment.

2.2 Travel Time Workshop Overview

The Travel Time Workshop provided the project committee with an opportunity to discuss the findings of the global technology scan conducted during Task 2 (Methodology Review), and to begin to tailor the evaluation process to include requirements and decision factors specific to Greater Rochester. From this discussion the consultant team was able to refine evaluation criteria that were subsequently used to assess the regional suitability of each methodology.

The following individuals participated in the Travel Time Workshop:

- Erik Frisch, Genesee Transportation Council (Project Manager)

- Kevin Beers, Genesee Transportation Council

- Jim Pond, Monroe County Department of Transportation

- Bill Robinson, New York State Department of Transportation - Region 4

- Randy Knapick, IBI Group (Consultant)

- Tom Shannon, IBI Group (Consultant)

- James Sorensen, IBI Group (Consultant)

2.3 Functional Requirements

The first key question pertains to the intended usage of the travel time data collection equipment from a functional perspective. In other words, what do participating agencies intend to do with the travel time infrastructure and the data collected?

The principal objective of this study is to facilitate planning data collection in support of the Genesee Transportation Council's Congestion Management Process. However, it is important for strategic reasons (such as cost-effectiveness and interoperability) to consider the broader two-way implications of the technology selection on regional ITS deployment and traffic management activities of other agencies.

This leads to three sets of functional requirements:

- **Planning Criteria:** These are, first and foremost, the functional objectives that are critical to meeting the principal aims of GTC in collecting Congestion Management Process travel time data;
- **Traffic Management Criteria:** Acknowledging the potential long-term linkage between traffic/incident management and planning data collection, these are factors that are important in choosing a technology that can provide operational benefits as well;
- **Other Criteria:** These are additional pragmatic and environmental factors that should be taken into consideration when choosing a preferred technology approach, based upon the local operating environment and the region's past experiences in technology deployment and operations.

2.3.1 PLANNING REQUIREMENTS

For planning purposes, the ultimate goal is to collect travel time data to support GTC's travel time reliability measure, one of seven identified Congestion Management Process (CMP) performance measures.

Less than 5% of the region's TIP is devoted to capacity expansion, so reliable measures of Transportation System Management and Operations (TSM&O) needs and improvements are critical to regional transportation investment decision-making.

The value of direct field measurement of travel time conditions is evidenced by GTC's current reliance on predicted values derived from its regional travel demand model which do not necessarily reflect real-world conditions.

Planning Requirements Summary:

- **Direct measurement of travel time variance to support CMP process**
- **Aggregate samples of travel time data okay, but capturing non-recurring congestion is critical**
- **Easy to use, 'clean' data**
- **Low burden on staff resources**
- **Can be implemented in the short-term**
- **Has a broad geographic reach**
- **Can be focused on congestion "hot spots"**

To be useful to GTC staff, this data is required in an aggregate form that provides a representative sample of prevailing traffic conditions.

Data collected for planning purposes does not necessarily need to be collected constantly in real-time, nor does GTC require real-time connectivity to field equipment (data transfer by CD, for example, is acceptable). There are, however, two important qualifications:

- Because travel time reliability is typically measured by *variance* in travel time, the sample size must be large enough to effectively capture this metric; and

- As in many medium-sized metropolitan areas, planners and operators agree that the region's principal concern is *non*-recurring congestion, rather than recurring peak hour congestion. Because non-recurring congestion is by definition unpredictable in timing and location, the sampling schema must be pervasive enough to capture a representative sample of incident activity. (Highway incident response logs from RTOC or NYSDOT HELP vans could be useful in gauging the frequency and duration of these events.)

Since GTC is a small MPO, direct staff resources available for travel time data collection and processing are limited. Reduction of the overall data collection burden is a primary goal of the technology deployment. If field equipment generates vast quantities of raw field data, GTC will require a simple and efficient method of "cleaning up" and distilling this field data into discrete samples that are more directly useful for CMP and other planning purposes. In the workshop, the consultants noted the possibility of completing such a transformation using a simple and inexpensive software tool designed for this purpose.

Direct technology support and field equipment maintenance will likely require the participation of RTOC personnel (or possibly another third-party entity) due to the lack of in-house technician capabilities at GTC.

Short-term implementation of a data collection method is critical to advancing recommendations contained in GTC's 2005 Joint FHWA/FTA Certification Review in the near future.

In terms of coverage, the travel time data collected for planning purposes will ideally have a broad geographic reach, covering the critical corridors throughout the region. The data collection method should be able to focus in on congestion "hot spots;" critical links in the transportation network that are subject to congestion.

2.3.2 OPERATIONS REQUIREMENTS

Both NYSDOT and MCDOT provide regional traffic operations services in the region from the jointly-operated, County-owned Regional Traffic Operations Center (RTOC). From an operations point of view, the travel time data collected would primarily be used to assist in two areas: 1.) traffic incident detection and management, and 2.) provision of traveler

Operations Requirements Summary:

- **Support incident detection and traveler information functions**
- **Real-time, constant data collection at finer resolution**
- **Low burden on staff resources**
- **Measures other than direct travel time (e.g. speed, volume) are useful**
- **In-house technician and operations resources**
- **Locate detection along major travel corridors**
- **Deployment of field technology for operations is not imminent**

information to the public.

Operating agencies also have an interest in "point" detection measurements, such as speed, occupancy, and volume, which in many ways are as useful for operational purposes as travel time measurement. Travel time measurement can be inferred from such point measures for operational and planning purposes.

Unlike the CMP planning application, constant and real-time data collection is generally required to support traffic operations, incident detection, and traveler information. Data must be collected in fine enough resolution to allow operators to isolate incidents on specific links. Thus permanent field data collection installations are required, rather than temporary, portable data collection systems or probe vehicle measurements.

Operational data collection infrastructure, if deployed, would be focused on the region's limited access expressways where traffic volumes and incident frequencies are highest.

Workshop participants expressed interest in providing real-time data to the public on a website, similar to a website recently deployed by NITTEC in Buffalo[3] or the New York State Transportation Federation statewide.[4]

NYSDOT has plans to deploy additional new traffic technologies in the region, such as along Interstate 390 (additional camera sites) and the Interstate 490 Western Gateway corridor. However, further regional discussion about long-term technology priorities may be necessary to evaluate the feasibility of large-scale deployment of non-video traffic detection technology across the region.

2.3.3 OTHER REQUIREMENTS

The following general requirements were expressed during the course of the workshop, taking into account local conditions and agencies' past experience with ITS technology deployment, operations, and maintenance:

Other Requirements Summary:

- **Cost-Effectiveness**
- **Reliability/Maintainability**
- **Technological Maturity**
- **Suitability to Climate**
- **Affordable within available funding/cost sharing opportunities**

- **Cost-Effectiveness** – The project committee is committed to a solution that provides an excellent return on their investment and the greatest overall value for the region. As such, assessing relative capital and operations and maintenance costs will be an important consideration.
- **Reliability/Maintainability** – The preferred methodology should be a reliable system that can be easily maintained, ideally within the capabilities of GTC's and RTOC's in-house staff.

[3] NITTEC Real-Time Traffic Map: http://maps.nittec.org/mappage.aspx
[4] NYS Transportation Federation Travel Information Gateway: http://www.travelinfony.com

- **Technological Maturity** – There is always risk associated with being an early adopter of an unproven technology. These risks would have to be carefully weighed against expected benefits prior to methodology selection. Technologies that have been proven in other regions with similar operational conditions are preferred to those technologies which are unproven.

- **Suitability to Climate** – The solution should not be unduly affected by snow and other cold weather events experienced in Rochester.

- **Funding Opportunities** – For certain approaches, there may be funding opportunities associated with pilot deployments or leveraging multiple planning operations, and/or security applications with a single infrastructure investment.

2.4 Critical Corridors for Travel Time Measurement

Citing the Genesee Transportation Council's Long Range Transportation Plan (LRTP)[5], workshop participants identified the region's critical corridors for travel time data collection. The primary area of interest for Congestion Management Process (CMP) data collection is the region contained within the boundaries of the Transportation Management Area (TMA; Figure 1).

These correspond to the corridors that the GTC travel demand model identified as having links that are either currently experiencing or are forecasted to experience congestion in the PM peak by the year 2025 under a no-build scenario. In this case, a "congested" link is defined as any link having a volume-to-capacity (v/c) ratio of 0.9 or higher (Figure 2). Recurring congestion in Greater Rochester on limited access facilities peaks between 4-6 PM. The AM peak is more spread out between approximately 7 and 9 AM. Peak periods on many arterial roads occur on Saturdays, approximately 12-2 PM.

Among these "congested" corridors, the roads of primary interest for travel time data collection in the **short-term** are the region's limited access Interstates and Urban Principal Arterial Expressways. This is because those facilities are responsible for the most significant non-recurring congestion delays in the region and travel time reliability is a critical CMP performance criterion. Also, the impact of such delays tends to be magnified by the volume of traffic affected and the relative scarcity of alternate routes to avoid such delays.

Data collection along other Principal Arterials, Minor Arterials, and Collectors are of longer-term interest, but the general consensus is that these facilities are of secondary importance compared to the limited access routes. This is partly because the effect of incidents and delays on these routes is less due to the multi-path nature of the arterial street network.

Furthermore, there is recognition of the increased challenges in accurate automated travel time measurement on congested, signalized arterial streets with multiple entry and exit points. That said, the arterial network does include "hot spots" that are candidates for future travel time monitoring, such as the Victor-Farmington-Canandaigua corridor in the south-eastern portion of the Rochester TMA.

[5] Genesee Transportation Council. *Long Range Transportation Plan for the Genesee-Finger Lakes Region: 2005-2025*. December 2004.

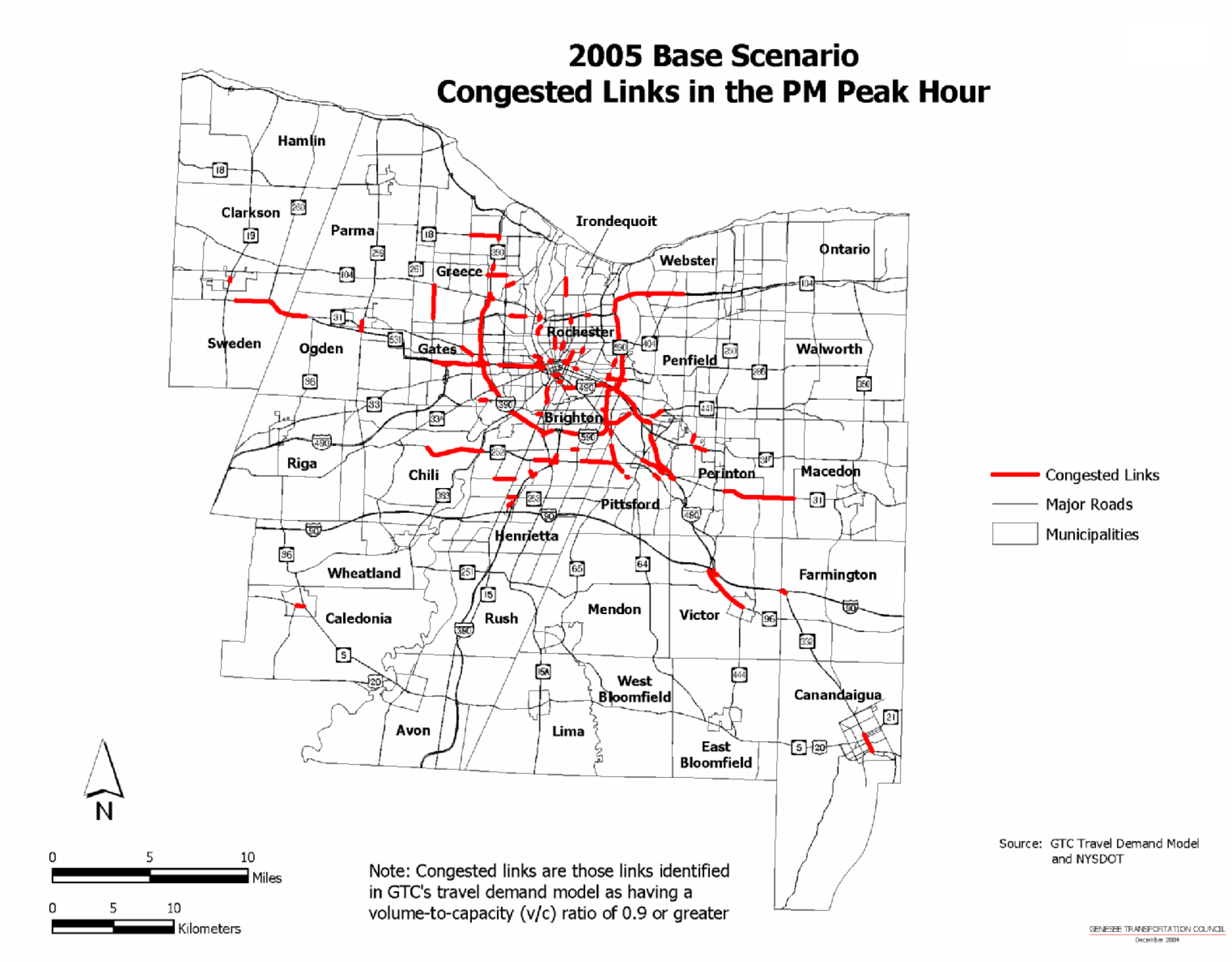

Figure 2: Congested Regional Transportation Links (2004)[6]

2.5 Existing and Planned Intelligent Transportation Systems (ITS) Infrastructure

The functionality and coverage of the region's existing and planned Intelligent Transportation Systems (ITS) infrastructure is a critical factor in evaluating travel time technologies because of the potential opportunities to leverage such supporting infrastructure for travel time data collection purposes. Thus, workshop participants discussed current and future ITS systems envisioned by NYSDOT, MCDOT, and others in the region.

[6] Genesee Transportation Council. *Long Range Transportation Plan for the Genesee-Finger Lakes Region: 2005-2025*. December 2004.

Workshop participants noted the existing (2004) and future (2015) ITS network build-out vision identified in the Long Range Transportation Plan (Figures 3 and 4). The principal features of this expansion plan include:

- Significant expansion of CCTV monitoring capability along most major expressway and arterial corridors in the TMA;
- Continued build-out of regional fiber-optic networks, which already runs along several key travel corridors in the region. Since the development of the LRTP, plans have been made for even further expansion of the fiber optic network; and
- An approximate doubling of the number of Dynamic Message Signs (DMS) in the region, primarily along expressways, to provide traveler information to motorists.

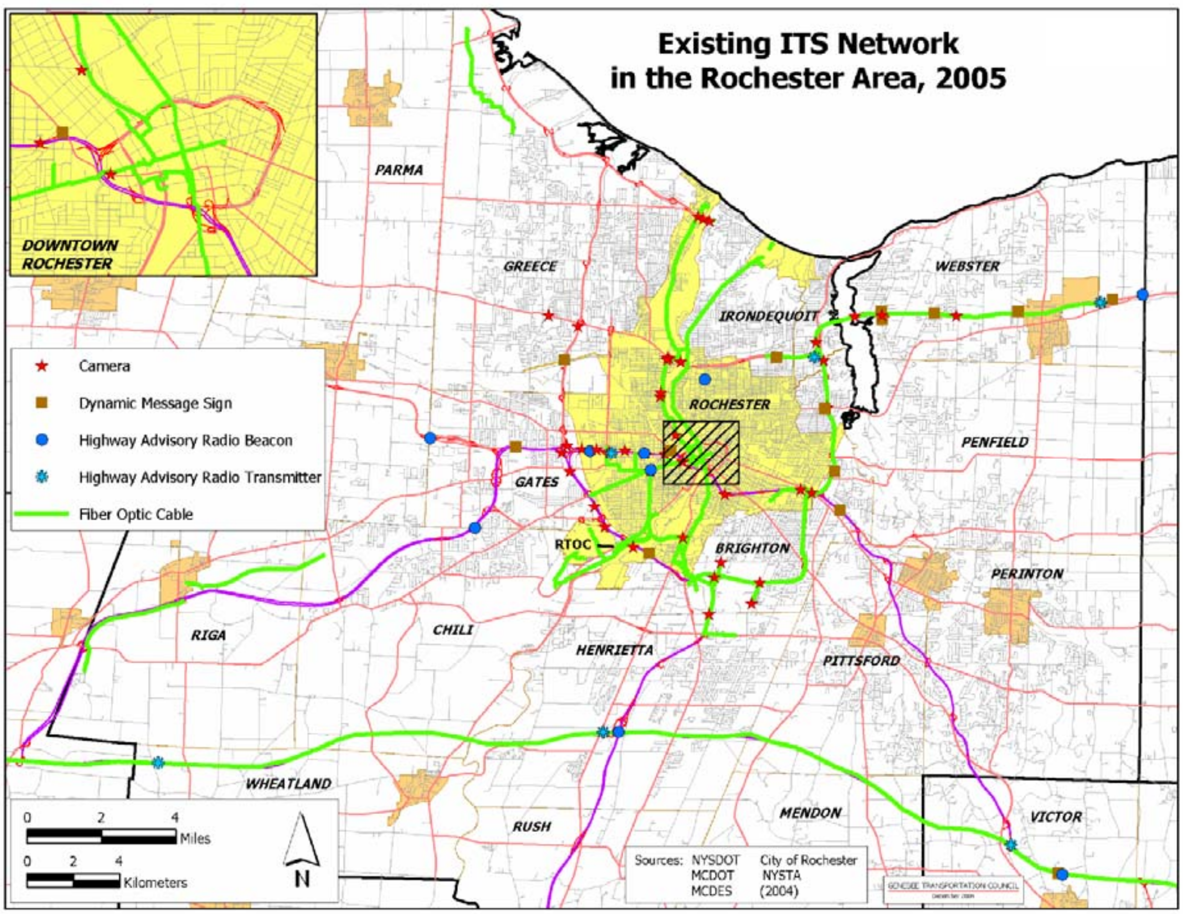

Figure 3: Existing ITS Infrastructure in Greater Rochester (2004)[7]

[7] Ibid.

The LRTP identifies the Regional Traffic Operations Center (RTOC) as "the backbone of the region's growing ITS capabilities." RTOC is a multi-jurisdictional facility that houses members of NYSDOT, Monroe County DOT, and New York State Police. RTOC capabilities include: traffic signal coordination, dynamic message signs (DMS), highway advisory radio (HAR) components, and incident management capabilities.

RTOC personnel receive information and data from police, 911 dispatch, and CCTV cameras. NYSDOT currently operates 24 cameras in the region, and has plans to add 3-4 cameras per year. Over the next few years, Monroe County plans to add 30 more CCTV cameras to the region.

RTOC personnel operate two types of dynamic message signs (DMS): LED Full Matrix Daktronics and Hybrid Flip-Disc Vultron signs to provide traveler information. These signs are accessed from RTOC via T-1 dial-up lines and fiber optic links.

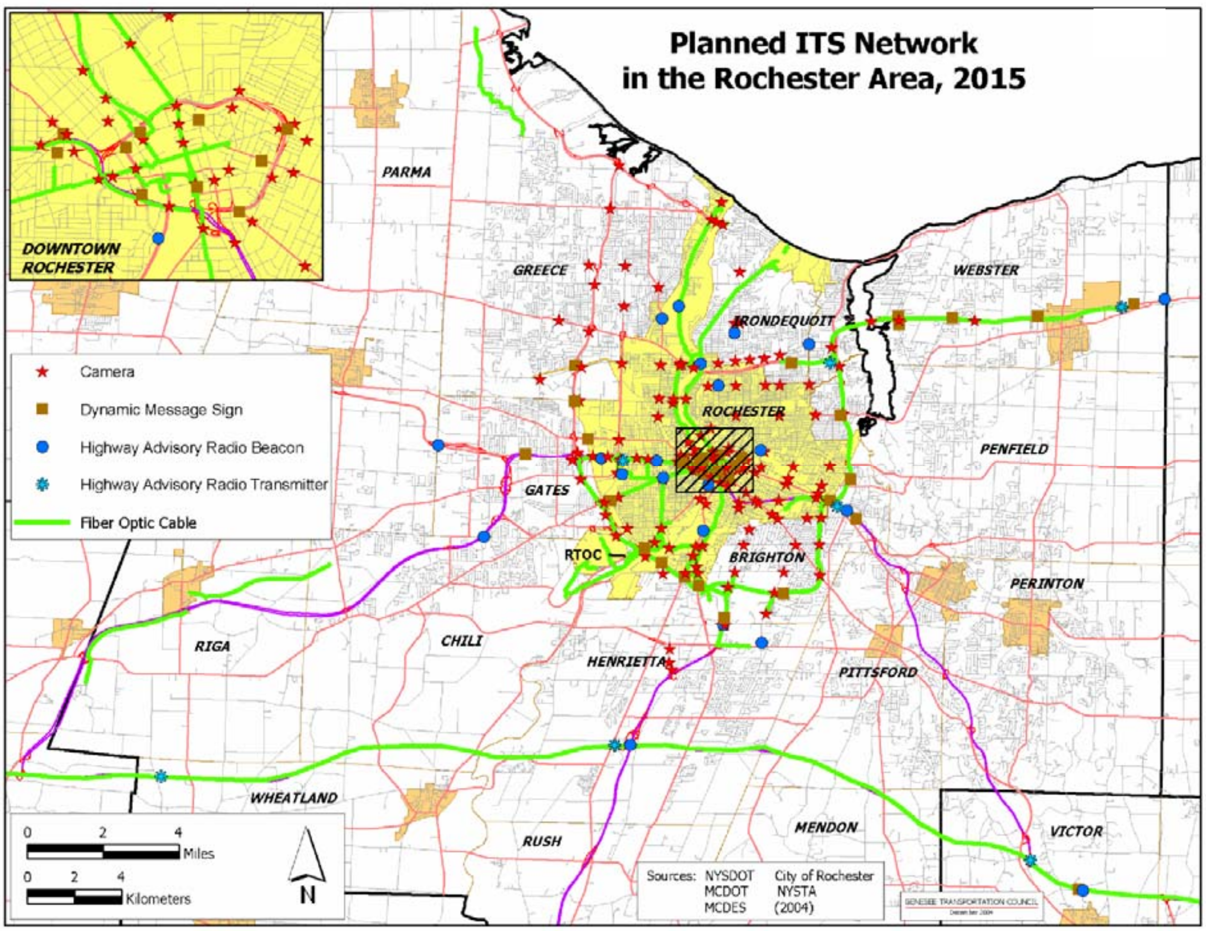

Figure 4: Planned ITS Infrastructure in Greater Rochester (2015)[8]

[8] Ibid.

2.6 Implications of Regional Factors for Evaluating Data Collection Technologies

The review of regional needs and conditions through the Travel Time Workshop and subsequent analysis points to a number of key considerations for selecting the most advantageous data collection strategy for Greater Rochester. They are summarized below.

2.6.1 LEVERAGING TRAFFIC/INCIDENT MANAGEMENT INFRASTRUCTURE FOR PLANNING

The Greater Rochester region is at a crossroads in its traffic and incident management strategy for the future. The region's high level of interagency coordination and information exchange leaves the region well-positioned to capitalize on future technological investments. Because the more expensive travel time data collection methods also require operational justifications for investment in ITS technology, communication, and supporting infrastructure, the future direction of the regional ITS program has direct implications on the selection of an optimal travel time data collection strategy for the region.

Currently, traffic and incident management along limited access expressways in Greater Rochester by RTOC is conducted primarily by 'visual' means – namely CCTV cameras. This approach has functioned well to date because of the relatively small number of cameras deployed. However, in the future, operators will have difficulty simultaneously monitoring every deployed camera site in the region, and may desire assistive incident detection technologies using non-visual forms of detection or video queue detection. This is a key consideration in evaluating long-term travel time data collection techniques because it creates an operational motivation for deployment (and funding) of traffic data collection that complements the planning function under study.

In the long-term, it is plausible that travel time data collection may be a 'by-product' of the massive flow data generated by incident detection equipment on the region's roadways. As the region formalizes its plans for expansion of RTOC's ITS capabilities, the ability to collect travel time data for planning and operations purposes should be given consideration.

2.6.2 REGIONAL COMMUNICATIONS INFRASTRUCTURE

The region's ongoing investment in communications infrastructure is a positive development for keeping open a wide variety of travel time data collection options. For the more expensive travel time data collection strategies, supporting communications infrastructure represents the primary cost consideration. If this communications infrastructure is already in place and ongoing operations and maintenance expenses can be shared with other uses, the barriers that render planning data collection alone infeasible rapidly diminish.

2.6.3 NECESSITY OF SHORT- AND LONG-TERM STRATEGIES

GTC has immediate data collection needs related to the implementation of its Congestion Management Process, the optimization of limited staff resources, and the advancement of recommendations from its 2005 federal MPO re-certification. These more pressing needs must be balanced against the pursuit of a “global optimum” solution involving long-term collaboration with operating agencies.

Deployment of long-term pervasive roadway monitoring systems for operational purposes will take significant time and resources and may require a broader dialogue about the region’s ITS vision, concept of operation, deployment priorities, and funding. Therefore consideration of an interim or short-term strategy specifically for CMP travel time data collection, with lower implementation costs and more immediate benefit to GTC, must also be considered.

In crafting an implementation strategy, the short-term approach will not preclude migration towards a more comprehensive, multi-functional long-term solution based on the gradual deployment of more permanent roadway detection infrastructure for operations purposes across the region.

2.6.4 PLANNING FUNDING FOR DEMONSTRATION PROJECTS

From an implementation perspective, it is noteworthy that there is potential for pilot projects that support planning data collection to be included among GTC’s annual Unified Planning Work Program (UPWP) projects. Such projects are typically small, ranging from $40,000 to $120,000, but could support small-scale technology pilot projects.

These planning funds could provide the means to deploy a short-term data collection solution and/or a ‘proof-of-concept’ pilot project in the image of a candidate long-term solution.

3. TECHNOLOGY REVIEW

The technology review focused on four major data collection methods identified by the Genesee Transportation Council, namely:

- **Archived Intelligent Transportation Systems (ITS)/Operations Data**
- **Automated Toll/Fare Data**
- **Global Positioning System (GPS) Data**
- **Wireless Device Location Technology**

This section summarizes and compares each of these travel time data collection techniques. A fifth method that was examined but not noted above is an alternative or hybrid approach which may utilize other technology or multiple complementary technologies.

3.1 Archived ITS/Operations Data

3.1.1 DESCRIPTION

This data collection method leverages any of a number of traffic detection technologies deployed for other purposes to generate travel time information. Deploying fixed ITS data collection systems on a regional scale for the sole purpose of planning studies is unrealistic. Beyond the cost of the traffic monitoring devices themselves, there are highly significant communications backbone (fiber network), installation, calibration, integration, and support and maintenance costs. These capital costs are typically not justified if used solely for planning purposes, but rather, planning needs should be included as part of a regional vision for traffic monitoring and management. Therefore, using existing operations infrastructure to support a planning function is a prudent approach, provided data coverage and quality are acceptable, because it results in greater value from ITS infrastructure with little or no additional cost.

Typically, archived ITS/operations data is collected from traffic monitoring devices deployed to support real-time operations (e.g., signal optimization or incident management). These devices collect traffic count and speed data from passing vehicles. Algorithms can then be used to translate this data into travel time estimates.

Since there is currently no freeway travel time data collection within NYSDOT Region 4, the use of archived ITS/operations data is principally a longer-term “value added” strategy once such equipment has been deployed to support regional traffic management.

There are a wide variety of traffic monitoring devices utilizing different technologies and with different advantages and disadvantages. These devices include intrusive sensors (sensors are installed within or across the pavement on roads and bridges) and non-intrusive sensors (sensors are installed above or on the sides of roads and bridges with minimum disruption to traffic flow):

- Intrusive sensors;
  - Inductance loop detectors;
  - Piezoelectric sensors;
  - Magnetic sensors;
- Non-intrusive sensors;
  - Active and passive infrared sensors;
  - Vehicle image detection systems;
  - Microwave sensors;
  - Passive acoustic sensors; and
  - Pulse ultrasonic detectors.

In the region, a recently prepared addendum to the ITS Report for Interstate 490[9], evaluated a variety of intrusive and non-intrusive sensor technologies. The addendum recommended acoustic detection systems (ADS) or microwave radar detection systems (MRDS) instead of inductor loop detection systems (ILDS) or video image detector systems (VIDS) since:

> "For this project, taking into account climate, geography, and availability of power, it appears ADS and MRDS have an advantage because of the installation flexibility, higher tolerance for weather conditions, low power requirements and low installation and maintenance costs. In addition, it is likely that the cost of installing ADS and MRDS will be slightly lower than represented, where the cost of installing ILDS and VIDS may increase depending on the availability of power."

There are also a variety of algorithms that may be used to translate sensor measurements into travel time estimates. These algorithms include:

- Spot-speed algorithms: Estimates travel times based on spot-speeds of vehicles. They include algorithms such as: the Average Speed Algorithm, the Vehicle Trajectory Algorithm, and the Iterative Travel Time Algorithm.
- Stochastic Queuing Methods: Uses only vehicle count data and does not require speed measurements. Average travel times are estimated based on the cumulative arrivals and cumulative departures curves. These methods require a "closed" system.
- Section Density Algorithms: Estimates speeds and travel times using measured traffic volumes and average section density estimated on the basis of cumulative vehicle counts.

[9] Addendum to ITS Report (issued June 2001). Updated Sensor Technology Analysis Prepared for NYSDOT – Region 4 as part of ITS Route I-490. Dunn Engineering. April 2006.

- Multi-Regime Algorithms: Separate travel time estimation methods are used for each of three traffic states such as (1) lane closures, (2) incident conditions, and (3) normal operations.

The accuracy of the travel time data collected from these devices depends on both the accuracy of the sensor measurements and the robustness of the algorithm being employed to translate these measurements into travel times. Additionally, the accuracy of travel time data estimated from sensor measurements is often diminished during periods of heavy freeway congestion and when used for arterial streets.

Another consideration to be taken into account when considering this approach is data management. Typically, ITS operations generate a tremendous quantity of raw data that requires manipulation, formatting and 'cleaning' in order to be useful for planning purposes. Data storage capacity may also be a concern.

3.1.2 LOCATIONS DEPLOYED

The following locations have used archived ITS/operations data to develop travel time information:

Portland, Oregon: In the Portland area, the Oregon Department of Transportation (ODOT) calculates travel times based on inductive loop detector data (collected once every 20 seconds). This data is spot checked by ODOT staff for accuracy and posted on area dynamic message signs (DMS). ODOT has reported difficulties in losing loop detectors during road repaving operations. ODOT has also reported difficulties detecting congestion using loop detectors located near ramps. ODOT has also been working with a local transit agency to conduct a probe vehicle test using approximately 750 buses on limited access and arterial roadways.

Nashville, Tennessee: In Nashville, the Tennessee Department of Transportation (TDOT) uses non-intrusive side-fire radar sensors installed at ¼ mile intervals to collect average speed data. This average speed data is then used to generate travel times estimates. Travel time information is then posted on local DMS. TDOT checks system accuracy by regularly calibrating radar sensors. TDOT also regularly uses CCTV cameras to determine a unique vehicle's travel time and compares this value to the travel time estimates generated using the radar sensor data.

Connecticut: ConnDOT has deployed the CRESCENT Advanced Traffic Management System (ATMS) in the greater Hartford area. CRESCENT allows the operators in ConnDOT's Newington Operations Center to respond to events throughout the State of Connecticut. Phase I of the project included Event Declaration, Automatic Response Generation, and VMS control. Phase II of the system included Traffic Data Collection and Incident & Queue Detection.

The real-time data is collected every 30 seconds from 139 stations. This large amount of data is used to update a congestion map for the operators as well as the detection algorithms. When congestion is detected by the system, the operator receives an alarm, which they can verify with their cameras. The real-time data is also used for travel-time calculations. These travel times are currently used to assist the operations staff but may eventually be displayed on the VMS.

This massive volume of real-time data has been transformed into a manageable resource for the local MPO, the Capitol Region Council of Governments (CRCOG). Data mining techniques can be performed on the real-time data for the purpose of planning studies. The volume, occupancy, and speed for each lane are averaged together to get station values. Time averaging the data converts it from 30-second samples to 5-minute, 15-minute or hourly samples. Long-term historical averages are also computed to help identify recurring vs. non-recurring congestion. The resulting information can then be presented on a GIS map to assist in identifying problematic locations and times of congestion.

3.1.3 STRENGTHS & WEAKNESSES

Strengths:

- Utilizes proven detector technology.
- Large quantities of data can be gathered automatically.
- Costs can be shared between planning and operations agencies.

Weaknesses:

- Accuracy is diminished during periods of heavy congestion and on arterial streets.
- Certain devices have significant capital and operation and maintenance costs.
- Significant data storage and processing requirements.
- Permanent installations limit flexibility in terms of route selection.

3.1.4 REPRESENTATIVE VENDORS

The following are suppliers of traffic sensors in the U.S.:

- **Inductance loop detectors:** Eberle Design Inc.; Reno A&E; 3M/Canoga
- **Piezoelectric sensors:** International Road Dynamics, Inc.; Measurement Specialties, Inc.; Kistler Instruments Corporation
- **Active infrared sensors:** Schwartz Electro-Optics, Inc.
- **Passive infrared sensors:** ASIM Technologies, Ltd.; Siemans; Eltec Instruments, Inc.; Eagle Traffic Control Systems
- **Magnetic sensors:** 3M, Intelligent Transport System; Midian Electronics, Inc.
- **Video image detection systems:** Image Sensing Systems; Quixote Traffic Corporation; Traficon USA; Iteris; Nestor Traffic Systems
- **Microwave sensors:** Microwave Sensors, Inc.; Whelen Engineering Company; Electronic Control Measurement, Inc.; Naztec, Inc.; Electronic Integrated Systems, Inc.

- **Passive acoustic sensors:** International Road Dynamics, Inc. (IRD); SmarTek Systems, Inc.

- **Pulse ultrasonic detector:** Novax Industries Corp.; Microwave Sensors, Inc.

3.1.5 SUMMARY OF TECHNICAL CHARACTERISTICS

Technical Characteristics	Information
Data	• Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns.
Maturity	• Proven technologies.
Accuracy	• Refer to Exhibit 1 for error rates in detector devices used in freeway applications. • Accuracy is dependent on sensor type, proper installation, regular calibration, and algorithm robustness. • Accuracy is often diminished during periods of heavy congestion or when queuing occurs. • Accuracy is also diminished when used for arterial street applications.
Reliability	• Reliability of intrusive sensors is often diminished by improper installation, pavement deterioration, and weather-related effects. Repaving and utility activities often damage detectors, affecting reliability. • Reliability of non-intrusive sensors depends on sensor type, mounting height and location, vehicle mix, road configuration, and sensor viewing angles.
Flexibility	• Requires permanent installation.
Costs	• **Sensor Costs:** o Inductance loop detectors: \$200-\$300 per loop o Piezoelectric sensors: \$300 -\$600 per unit o Magnetic sensors: \$600 -\$1000 per unit o Active infrared sensors: \$6000 -\$7500 per unit o Passive infrared sensors: \$750 -\$1400 per unit o Vehicle image detection systems: \$4000 -\$15000 per unit o Microwave sensors: \$750 -\$3300 per unit o Passive acoustic sensors: \$3500 -\$5000 per unit o Pulse ultrasonic detectors: \$500 -\$700 per unit • **Installation Costs:** Installation costs vary by sensor type. Intrusive

Technical Characteristics	Information
	sensors typically require closing lanes of traffic and pavement cuts. Non-intrusive sensors require mounting on poles or overhead structures, a significant initial deployment cost. Installation costs may be defrayed by mounting sensors on existing infrastructure, if suitable. • **Communications and Power Costs:** There are significant cost implications associated with supplying communications and power to sensor installations. These costs often represent the majority of implementation costs since the required communications and power infrastructure may not exist or may require substantial improvements. For example, providing fiber optic cable to each installation may prove to be cost prohibitive. Utilizing existing infrastructure, if available, may defray some of these costs. Communication costs might also be reduced if data was collected only periodically (weekly) rather than requiring constant communication with field equipment.
Maintenance	• Intrusive sensors are often damaged and require regular repair and replacement. Maintenance often requires closing down lanes of traffic. • All sensors require regular calibration and maintenance.
Other Functions	• Can be used for incident detection, real-time congestion management, and traveler information systems.
Institutional Factors	• Costs could be shared between freeway operations and regional planning agencies, such as between NYSDOT and GTC. • There are sometimes safety and aesthetic concerns with overhead- and pole-mounted sensors.

Exhibit 1: Error Rates for Detector Devices in Freeway Applications[10]

Sensor	Mounting Location	Count Data	Speed Data	Evaluation Organization
Inductive Loop				
Saw-cut	Pavement	3%	1.2% - 3.3%	MNDOT
Saw-cut	Pavement	2%	5%-10%	TTI
Preformed	Pavement	2%	2% - 5%	TTI
Magnetic				
3M microloop	Pavement	2.50%	1.4% - 4.8%	MNDOT
3M microloop	Bridge	1.20%	1.80%	MNDOT
3M microloop	Pavement	5%	µ : -0.25 mphs, δ: 3.6 mph	TTI
SPVD	Pavement	1% (Phoenix), 10%-12% (Florida)		HAC
Active Infrared				
Autosense I	Overhead	2.40%		MNDOT
Autosense II	Overhead	0.70%	5.80%	MNDOT
Passive Infrared				
ASIM IR 224	Overhead	1%		MNDOT
ASIM IR 254	Overhead	10.00%	10.80%	MNDOT
Siemens PIR - 1	Overhead	10%		TTI
Microwave Radar				
Accuwave 150LX	Overhead	10%		TTI
TDN 30	Overhead	2.5% - 13.8%	1%	MNDOT
RTMS	Overhead	2%	7.90%	MNDOT
RTMS	Sidefire	3% - 5%		ODOT
RTMS	Sidefire	3%		SDDOT
RTMS	Sidefire	2.4% - 13.6%	2.6% - 5.9%	TTI
Ultrasonic				
TC 30	Overhead	2%		MNDOT
Lane King	Overhead	1.20%		MNDOT
Passive Acoustic				
SAS - I	Sidefire	8% - 16%	4.8% - 6.3%	MNDOT
SAS - I	Sidefire	4.0% - 6.8%	3.4% - 4.8%	TTI
SAS - I	Sidefire	10%	µ : -0.5 mphs, δ : 4.8 mph	TTI
Smartsonic TSS-1	Overhead	4%		MNDOT
Smartsonic TSS-1	Overhead	15%	µ : 4 mph	TTI
Video Image Detector Systems				
Autoscope 2004 (1)	Sidefire	5%	Difference range: 5mph	ERAU
Autoscope 2004	Overhead	2.2% - 10.6%		MNDOT
Autoscope solo	Sidefire	5%	8%	MNDOT
VideoTrak 900 (1)	Overhead	1.6% - 4.8%		MNDOT
VideoTrak 900	Sidefire	10%	µ : +1.4 mphs, δ : 6.9 mph	TTI
Traficon	Sidefire	5% (45 feet), 10%-15% (25-30 feet)	2% -12%	MNDOT
Traficon	Overhead	2.7% - 4.4%	3% - 7.2%	MNDOT
Traffic Vision		1.8% - 4.8%		TTI

[10] Source: Martin, Peter T., Yuqi Feng, and Xiaodong Wang. “Detector Technology Evaluation.” Department of Civil and Environmental Engineering, University of Utah. November 2003. Accessed online at: http://www.ndsu.nodak.edu/ndsu/ugpti/MPC_Pubs/html/MPC03-154/index.html

3.2 Automated Toll/Fare Data

3.2.1 DESCRIPTION

Automatic vehicle identification (AVI) technology is used in many regions as a method for electronic tolling and traffic management (ETTM). This technology involves installation of electronic transponders (often called 'tags') with unique identification (ID) numbers in vehicles. Roadside readers are installed at key locations such as toll plazas. As these transponder-equipped vehicles pass these locations, the unique transponder ID number is read.

Because of the use of electronic toll collection (ETC) by the New York State Thruway Authority and other toll agencies in the Northeast, it is possible that using automated toll/fare data might be an appropriate data collection method for Greater Rochester. The Inter-Agency Group (IAG) overseeing the EZ-Pass program has authorized the use of many alternative applications of transponder data in the past, ranging from parking fees for transit and airports to service plaza fuel purchases. Privacy is a concern that always has to be addressed in such situations. In any case, paired antenna readings between fixed upstream and downstream points can be used to obtain a statistically-valid average travel time calculation for many roadways. Discussions with the New York State Thruway Authority indicate that there is a market penetration rate of 18% in Monroe County (versus an assumed minimum threshold of 12%).

3.2.2 LOCATIONS DEPLOYED

The following locations have deployed automated toll/fare technology for collecting travel time data, including:

New York/New Jersey: The TRANSCOM System for Managing Incidents and Traffic (TRANSMIT) system operates on the New York State Thruway and Garden State Parkway in New York and New Jersey. TRANSMIT uses overhead E-ZPass AVI transponder readers installed at regular intervals along the roadway. As vehicles pass these AVI readers, the transponder tag information is sent to a central site, where the information is processed to calculate travel times. This system has been successfully used to monitor traffic congestion and detect incidents.

TRANSMIT data from 20 E-ZPass readers has also been successfully incorporated into the Crossroads ATMS in Buffalo, NY. This data provides real-time travel time information within the ATMS. NITTEC operations staff use this information to determine if a specific link is

Screen Capture from NITTEC.org Public Travel Information Website

performing at or below expected travel times. The TRANSMIT data is also used in Crossroads to populate travel time maps on the NITTEC.org website (shown in the screen capture to the right).

Houston, Texas: The TranStar Traffic Monitoring System uses automated toll data to monitor traffic on Houston's main freeways. TranStar's travel time data collection system uses vehicles equipped with transponder tags as vehicle probes. The main source of vehicle probes is commuters using the "EZ-Tag" automatic toll collection system installed by the Harris County Toll Road Authority (HCTRA). Transponder tag readers are placed at 1 to 5 mile intervals along Houston freeways. As probe vehicles pass through successive readers, average travel times and speeds are calculated for the roadway segment. This travel time information is then available for posting to local DMS. To address privacy concerns, TranStar strips individual identification information from its recorded tag reads so that TranStar can track, but not identify, vehicles on the freeway. Data accuracy is confirmed using CCTV cameras to determine a unique vehicle's travel time and comparing it to the travel time calculated using the automated toll data.

3.2.3 STRENGTHS & WEAKNESSES

Strengths:

- Continuous, automatic data collection.
- Highly accurate data collection.
- Costs can be shared between planning and operations agencies.
- Existing transponder-equipped vehicle population

Weaknesses:

- Requires significant initial deployment effort.
- Significant capital and operation costs.
- Requires commitment from operating agencies/RTOC staff to maintain interface with field equipment.
- Privacy issues.
- Possible sample bias due to including only transponder-equipped vehicles.
- Significant data storage and processing requirements.

3.2.4 REPRESENTATIVE VENDORS

The following are suppliers of AVI technology in the U.S.:

- TransCore

- Mark IV
- Sirit Technologies, Inc.
- Raytheon

3.2.5 SUMMARY OF TECHNICAL CHARACTERISTICS

Technical Characteristics	Information
Data	• Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns.
Maturity	• Proven technologies.
Accuracy	• Highly accurate. Tests have demonstrated 99% and higher accuracy.
Reliability	• Highly reliable.
Flexibility	• Requires permanent installation.
Costs	• Electronic transponder tags : $20 to $50 each • Roadside antennas: $1,500 to $3,000 • Roadside reader systems: $10,000 to $30,000 • Control facility computer: $2,000 to $5,000 • Data Storage: Varies by data usage. Typically $100 to $200 per GB • Power and Communication Connections: Varies by location • Analysis Software: Varies by vendor
Maintenance	• Annual operation and maintenance costs of AVI systems are often approximated at 10% of their capital cost.
Other Functions	• Transponders are used for ETTM. Other uses for tags may include parking fees, service plaza fuel purchases, and weigh station bypass.
Institutional Factors	• Costs could be shared between toll agencies and planning agencies. • Privacy issues are a concern.

3.3 Global Positioning Systems (GPS) Data

3.3.1 DESCRIPTION

In this methodology, GPS can be used to collect data using an active test vehicle method or a more passive probe vehicle method or some combination of the two. In the 'active' test vehicle method, vehicles are equipped with GPS and drivers then drive designated routes to collect travel time data. Drivers of these test vehicles then typically follow one of three driving styles:

- **Average Car:** this driving style means that the driver uses his/her judgment to match the average speed of the traffic stream.

- **Floating Car:** this driving style means that the driver "floats" with the traffic by attempting to pass as many vehicles as pass the test vehicle.

- **Maximum Car:** this driving style means that the driver drives the posted speed limit unless impeded by actual traffic conditions or safety considerations.

- **Chase Car:** this driving style randomly selects a unique vehicle in the traffic stream and follows it.

In practice, most test vehicles adopt a hybrid of the average and floating car techniques.

The 'passive' use of GPS-equipped 'probe' vehicles involves installation of GPS or automatic vehicle location (AVL) technology on a number of different vehicles and then collecting travel time data as these vehicles navigate the transportation network. A common strategy is to equip transportation agency personnel's vehicles with GPS. Agency personnel can then drive or alter their regular commute collect travel time data in the desired locations. AVL technology has also been installed to track the movements of a number of different vehicle fleets, including: emergency and public safety vehicles (i.e., police, fire, ambulance), maintenance vehicles, snow plows, taxis, and transit vehicles. The use of these vehicles as probes has been attempted in several places, but has encountered difficulties due to travel time distortions caused by the irregular travel behavior of these types of vehicles.

Use of GPS takes advantage of the fact that this technology can monitor the translation of a vehicle through space without defined cordons or measurement locations. This provides flexibility to measure anywhere on the network, but there are practical challenges related to obtaining an adequate probe sample to create statistically valid results.

Additionally, GPS technology can be utilized by GTC without the need for coordination or maintenance support from the operating agencies, MCDOT or NYSDOT, because GPS does not require any integration with those agencies' field ITS equipment.

3.3.2 LOCATIONS DEPLOYED

The FHWA Travel Time Data Collection Handbook[11] identified several locations that had deployed GPS for collecting travel time data. These locations included:

Louisiana State University (LSU): LSU's Remote Sensing and Image Processing Laboratory developed a methodology to use GPS in collecting, reducing, and reporting travel time data for congestion management systems. This methodology was used to collect travel time on 330 miles of urban highways in three metropolitan areas in Louisiana: Baton Rouge, Shreveport, and New Orleans.

Boston, Massachusetts: Boston's Central Transportation Planning Staff (CTPS) identified travel time as a performance measure for the Boston area congestion management system (CMS). Several techniques for travel time data collection were considered, but GPS was selected since it provided high potential for more accurate data at a reduced cost. Furthermore, CTPS selected the GPS technology since it may be utilized for analyses of queue lengths, stopped delay, and speed profiles for the CMS.

San Antonio, Texas: The Texas Department of Transportation (TxDOT) sponsored the Texas Transportation Institute (TTI) in using GPS technology for travel time data collection in San Antonio. The study used GPS data collection to provide an historical database of travel time information for approximately 150 centerline miles of freeway and arterial roadways in San Antonio.

Northern Virginia: TransCore conducted a study in Northern Virginia that investigated aspects of GPS travel time data collection including data processing and analysis.

Lexington, Kentucky: In Lexington, GPS was used primarily for the collection of personal travel survey data, but travel time data were collected as well.

A report[12] prepared for the New York State Association of Metropolitan Planning Organizations (NYSMPOs) identified the following example:

Hartford, Connecticut: The Capital Region Council of Governments (CRCOG) of the Hartford, CT area used a $12,000 Technology and Innovation Funding grant from FHWA to purchase GPS equipment to monitor travel times during peak hours on arterial roads. CRCOG selected a simple and cost-effective GPS unit that allows direct download of the data to a GIS. CRCOG utilized its own staff to collect data with the GPS units as part of their normal commute routines, with some deviations, along several key arterial corridors.

3.3.3 STRENGTHS & WEAKNESSES

Strengths:

- Utilizes proven technology.
- Active test vehicle method does not require remote communication and has low data processing and storage requirements (though collects less data).
- Passive probe vehicle method collects more data

[11] Travel Time Data Collection Handbook. Report No. FHWA-PL-98-035. FHWA and Texas Transportation Institute. May 1998.
[12] Congestion Management Process (CMP) Innovations: A Menu of Options. Prepared for NYSMPOs. ICF Consulting. February 24, 2006.

- Flexible in terms of routes examined.
- May be supplemented by AVL on other vehicle fleets.
- Can help control for individual driving styles, especially if using an active test vehicle approach.
- Minimal training is required for some applications.
- Advanced and detailed data can be collected.
- Relatively low operating cost following initial deployment.

Weaknesses:

- Some applications require expertise in GIS to graph data.
- Obtaining a statistically significant sample can prove difficult.
- Passive probe vehicle method requires remote communication with probe vehicles and requires more data processing and storage (though collects more data).
- May require significant initial deployment effort.
- Privacy issues.
- Significant data storage and processing requirements.
- Possible loss of signal due to “urban canyon” effect, geography, trees, etc.

3.3.4 REPRESENTATIVE VENDORS

There are a large number of suppliers of GPS technology in the U.S., including:

- Earthmate Blue Logger (GPS receivers and mapping software)
- SiRF (GPS chipsets and software)
- Garmin (handheld GPS and navigation)

The following are providers of integrated GPS traffic solutions:

- IBI Group
- TransCore
- Delcan/NET

3.3.5 SUMMARY OF TECHNICAL CHARACTERISTICS

Technical Characteristics	Information
Data	• Large quantities of data can be automatically generated. Data can be easily mapped into GIS software. Data processing, formatting, and storage are concerns. • Active test vehicle method collects less data; does not require remote communication; requires less data processing and storage. Passive probe vehicle method collects more data; requires remote communication with probe vehicles; requires more data processing and storage. • Obtaining an adequate sample for statistically valid results may be problematic.
Maturity	• Proven technologies.
Accuracy	• Sub-meter accuracy can be obtained. • Accuracy may be limited by topography and line-of-sight issues.
Reliability	• Reliability may be limited by “urban canyon” effect, geography, trees, etc.
Flexibility	• Highly flexible. Both active and passive techniques can look at different routes at different times.
Costs	• GPS Receiver: $300-$500 per unit • GPS Antenna: $100-$150 per unit • Signal Service Fee: $200 to $800 per unit per year • Data Storage Computer: $2,000-$5,000 per unit • GPS Logging Software: $25-$50 per license • GIS Software: $2,000-$3,000 per license • Driver Costs: Varies by method
Maintenance	• Relatively low maintenance costs.
Other Functions	• Passive probe vehicle information can be used for real-time congestion management and traveler information purposes.

Technical Characteristics	Information
Institutional Factors	• For the passive probe vehicle method, there may be privacy issues.

3.4 Wireless Device Location Technology

3.4.1 DESCRIPTION

The use of third-party data from mobile electronic devices, such as cellular phones or PDAs, has generated significant publicity recently, particularly in the realm of traveler information, following the growing success of 911 caller location identification for cellular phones. Like transponder-based systems, there are privacy concerns and some providers (depending on their business model) may assess fees to access data of interest. Certain regulatory bodies (e.g., public utilities commissions) can help to facilitate access to such data, but the practical hurdles can quickly escalate this approach to an impractical level.

In theory, this methodology would track wireless devices to collect travel time data and monitor freeway conditions. The system would geo-locate wireless devices operating on the freeway. In this manner, all vehicles with wireless devices would act as probes, collecting travel time information for the system.

3.4.2 LOCATIONS DEPLOYED

The FHWA Travel Time Data Collection Handbook[13] identified only one location that had tested wireless device location technology to collect travel time data.

Washington, D.C.: An operational test called the Cellular APplied to ITS Tracking And Location (CAPITAL) was conducted in the Washington D.C. area. Travel time data was collected by monitoring cellular phone call initiation, geo-locating these calls, mapping the calls to specific links on a GIS map, verifying vehicle direction and speed, and calculating travel times along the map link. The test experienced relatively low vehicle location accuracy due to topographic interference and line-of-sight problems.

A report[14] prepared for the New York State Association of Metropolitan Planning Organizations (NYSMPOs) identified the following example:

Baltimore, Maryland: Maryland DOT has partnered with Delcan/NET Corporation to implement a cell phone data collection system in the Baltimore area. The project will calculate traffic information using data from cell phone companies, without requiring new automated data collection infrastructure. The project will not track individual phones; instead, it will analyze anonymous data that cell phone companies already collect in order to calculate travel times and speeds based on movements between cells.

[13] Travel Time Data Collection Handbook. Report No. FHWA-PL-98-035. FHWA and Texas Transportation Institute. May 1998.
[14] Congestion Management Process (CMP) Innovations: A Menu of Options. Prepared for NYSMPOs. ICF Consulting. February 24, 2006.

Hampton Roads, Virginia: A recent study[15] performed by VDOT evaluated the AirSage technology deployed in the Hampton Roads region. The study concluded that it was incapable of providing reliable data; however, the author provides guidelines for public entities considering the purchase of third-party probe data for travel time purposes.

3.4.3 STRENGTHS & WEAKNESSES

Strengths:

- Advanced and detailed data can be collected.
- No in-vehicle equipment to install.
- Large amounts of data can be automatically generated.
- All vehicles with wireless devices become probe vehicles

Weaknesses:

- Technology remains unproven under a variety of conditions.
- Privacy issues.
- Significant data storage and processing requirements.
- Potential bias in travel times by not including vehicles without wireless devices.
- Dependent on consistent wireless device use.
- Accuracy tends to be lower than other methods.

3.4.4 REPRESENTATIVE VENDORS

There are numerous suppliers of wireless devices in the U.S. and two major providers of cell phone traffic data: Delcan/NET and AirSage.

3.4.5 SUMMARY OF TECHNICAL CHARACTERISTICS

Technical Characteristics	Information
Data	• Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns. • Data is dependent on wireless device usage.

[15] Smith, Brian L. "Investigation of Travel Time Data Service Requirements." University of Virginia Center for Transportation Studies. (UVACTS-05-0-108), 2005.

Technical Characteristics	Information
Maturity	• Relatively new application of these technologies.
Accuracy	• Low accuracy has been reported due to line-of-sight issues and topography.
Reliability	• Dependent on wireless device usage.
Flexibility	• Highly flexible. Different routes and different time periods can be examined.
Costs	Due to scarcity of published cost data for these types of systems, only the cost of equipment from the Washington D.C. CAPITAL project (see FHWA Travel Time Data Collection Handbook[16]) are presented here: • Transmission Alert System: $200,000 per unit • Geolocation Control System: $150,000 • Direction Finding System: $310,000 • Personal Computers: $2,000 to $5,000
Maintenance	• Maintenance needs are unknown.
Other Functions	• Data could be used for traveler information systems.
Institutional Factors	• Privacy issues are a primary concern. • Would require a partnership with wireless device service provider.

3.5 Alternative or Hybrid Methods

3.5.1 DESCRIPTION

In addition to the above methodologies, there are other alternative technologies that might be implemented to collect travel time data. For example, license plate capture, which uses optical character recognition to compare plate readings at upstream and downstream locations, is a different technology approach that might be implemented in the region.

Furthermore, hybrid approaches, using a combination of technologies and/or conventional methods for specific sub-regional needs, should be considered.

[16] Travel Time Data Collection Handbook. Report No. FHWA-PL-98-035. FHWA and Texas Transportation Institute. May 1998.

3.5.2 TECHNICAL CHARACTERISTICS

Technical Characteristics	Information
Data	• License Plate Capture: Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns. • Hybrid Approaches: Can provide data redundancy and independent verification.
Maturity	• License Plate Capture: Remains relatively new technology. • Hybrid Approaches: Varies by method(s) employed.
Accuracy	• License Plate Capture: Varies by vendor, location, application, installation, weather, etc. Vendors report accuracies as high as 95%. • Hybrid Approaches: Varies by method(s) employed.
Reliability	• License Plate Capture: Reliability is affected by occlusions, viewing angle, “open” or “closed” system, etc. • Hybrid Approaches: Varies by method(s) employed.
Flexibility	• License Plate Capture: Requires permanent installations. • Hybrid Approaches: Varies by method(s) employed.
Costs	• License Plate Capture: Varies by vendor. Typical system costs range between $25,000-$40,000 per installation. • Hybrid Approaches: Varies by method(s) employed.
Maintenance	• License Plate Capture: Regular calibration is required. • Hybrid Approaches: Varies by method(s) employed.
Other Functions	• License Plate Capture: Can be used for incident detection, real-time congestion management, and traveler information systems. Cameras could also provide public safety and security functions. • Hybrid Approaches: Varies by method(s) employed.
Institutional Factors	• License Plate Capture: Costs could be shared between operations and planning agencies, such as between NYSDOT and GTC. Privacy concerns and video image monitoring may be issues. • Hybrid Approaches: Varies by method(s) employed.

3.5.3 LOCATIONS DEPLOYED

The following locations have employed license plate capture or hybrid methods of travel time data collection:

Florida: A two-day trial of license plate capture technology was conducted over a 2.2 mile long section of SR-436. Cameras located at two sites (an upstream and a downstream site) were able to collect travel time information for 1538 vehicles over the two day period.

Also, preliminary results of a field test by Florida DOT in the Tallahassee region[17] found that license plate recognition technology has the potential to produce usable travel time data. The temporary camera installations read between 37.3% and 64.2% of the tags. Perfect matches of license plate numbers accounted for between 6.5 and 11.8% of the traffic stream. Florida DOT also noted that cameras placed too far apart on roads with multiple exit and entry points decreased the number of effective matches.

Chicago, Illinois: In the Chicago Metropolitan area, the Illinois State Toll Highway Authority (ISTHA) currently uses three sources of data to provide travel time estimates:

- Electronic toll data from readers located at local toll plazas.
- Data from the Illinois Department of Transportation's loop detector network.
- Radar sensor data provided by a private vendor as part of the USDOT's Intelligent Transportation Infrastructure Program (ITIP).

For roadway segments covered by more than one of these data sources, ISTHA staff can choose which travel time estimates to use based on application, experience, and judgment.

3.5.4 STRENGTHS & WEAKNESSES

Strengths:

- License Plate Capture:
    - Continuous, automatic data collection.
    - Costs can be shared between planning and operations agencies.
    - Passive technology; does not require installing equipment in vehicles.
- Hybrid Approach:
    - Provides data redundancy and independent accuracy verification.
    - Can be customized to fit regional needs and existing infrastructure

Weaknesses:

- License Plate Capture:
    - Requires significant initial deployment effort.

[17] Florida DOT. License Plate Reader Field Test Results Report. May 5, 2006. http://www.floridaits.com/PDFs/TWO57_LPR/060505-A36-LPR_FieldTestResults-V1.pdf

- Significant capital and operation and maintenance costs.
- Privacy issues.
- Significant data storage and processing requirements.

- Hybrid Approach:
  - Increased complexity.
  - Significant data storage and processing requirements.
  - Requires maintenance of multiple technologies and systems.
  - Requires ongoing integration and calibration work.

3.5.5 REPRESENTATIVE VENDORS

The following are suppliers of license plate capture in the U.S.:

- PIPS Technology
- AutoVu Technologies
- Northrup Grumman

4. SUMMARY COMPARISON OF CANDIDATE TECHNOLOGIES

Based upon the review of the methodologies and other agency experience, the following table summarizes the key findings of each methodology:

	CANDIDATE METHODOLOGIES				
	Archived ITS / Operations Data	Automated Toll/Fare Data	GPS Data	Wireless Device Location Technology	Hybrid Approaches
Data	• Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns. • Burden of post-processing data falls to operations and/or MPO staff.	• Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns. • Requires partnership with tolling agency (e.g., TRANSCOM) to post-process data and generate travel times.	• Large quantities of data can be automatically generated. Data can be easily mapped into GIS software. Data processing, formatting, and storage are concerns. • Active test vehicle method collects less data; does not require remote communication; requires less data processing and storage. Passive probe vehicle method collects more data; requires remote communication with probe vehicles; requires more data processing and storage. • Obtaining an adequate sample for statistically valid results may be problematic.	• Large quantities of data can be automatically generated processing, formatting, and storage are concerns. • Data requires third-party post-processing to derive travel times. • Data is dependent on wireless device usage.	• License Plate Capture: Large quantities of data can be automatically generated. Data processing, formatting, and storage are concerns. • Hybrid Approaches: Can provide data redundancy and independent verification.
Maturity	• Proven technologies.	• Proven technologies.	• Proven technologies.	• Relatively new application of these technologies.	• License Plate Capture: Remains relatively new technology. • Hybrid Approaches: Varies by method(s) employed.
Accuracy	• Refer to Exhibit 1 for error rates in detector devices used in freeway applications. • Accuracy is dependent on sensor type, proper installation, regular calibration, and algorithm robustness. • Accuracy is often diminished during periods of heavy congestion or when queuing occurs. • Accuracy is also diminished when used for arterial street applications.	• Highly accurate. Tests have demonstrated 99% and higher accuracy.	• Sub-meter accuracy can be obtained. • Accuracy may be limited by topography and line-of-sight issues.	• Low accuracy has been reported due to line-of-sight issues and topography.	• License Plate Capture: Varies by vendor, location, application, installation, weather, etc. Vendors report accuracies as high as 95%. • Hybrid Approaches: Varies by method(s) employed.
Reliability	• Reliability of intrusive sensors is often diminished by improper installation, pavement deterioration, and weather-related effects. Repaving and utility activities often damage detectors, affecting reliability. • Reliability of non-intrusive sensors depends on sensor type, mounting height and location, vehicle mix, road configuration, and sensor viewing angles.	• Highly reliable.	• Reliability may be limited by "urban canyon" effect, geography, trees, etc.	• Dependent on wireless device usage.	• License Plate Capture: Reliability is affected by occlusions, viewing angle, "open" or "closed" system, etc. • Hybrid Approaches: Varies by method(s) employed.

	CANDIDATE METHODOLOGIES				
	Archived ITS / Operations Data	**Automated Toll/Fare Data**	**GPS Data**	**Wireless Device Location Technology**	**Hybrid Approaches**
Flexibility	• Requires permanent installation.	• Requires permanent installation.	• Highly flexible. Both active and passive techniques can look at different routes at different times.	• Highly flexible. Different routes and different time periods can be examined.	• License Plate Capture: Requires permanent installations. • Hybrid Approaches: Varies by method(s) employed.
Costs	• **Sensor Costs:** o Inductance loop detectors: $500-$1000 per loop o Piezoelectric sensors: $300 -$600 per unit o Magnetic sensors: $600 -$1000 per unit o Active infrared sensors: $6000 -$7500 per unit o Passive infrared sensors: $750 -$1400 per unit o Vehicle image detection systems: $4000 -$15000 per unit o Microwave sensors: $750 -$3300 per unit o Passive acoustic sensors: $3500 -$5000 per unit o Pulse ultrasonic detectors: $500 -$700 per unit • **Installation Costs:** Installation costs vary by sensor type. Intrusive sensors typically require closing lanes of traffic and pavement cuts. Non-intrusive sensors require mounting on poles or overhead structures, a significant initial deployment cost. Installation costs may be defrayed by mounting sensors on existing infrastructure, if suitable.	• Electronic transponder tags : $20 to $50 each • Roadside antennas: $1,500 to $3,000 • Roadside reader systems: $10,000 to $30,000 • Control facility computer: $2,000 to $5,000 • Data Storage: Varies by data usage. Typically $100 to $200 per GB • Power and Communication Connections: Varies by location • Analysis Software: Varies by vendor	• GPS Receiver: $300-$500 per unit • GPS Antenna: $100-$150 per unit • Signal Service Fee: $200 to $800 per unit per year • Data Storage Computer: $2,000-$5,000 per unit • GPS Logging Software: $25-$50 per license • GIS Software: $2,000-$3,000 per license • Driver Costs: Varies by method	Due to scarcity of published cost data for these types of systems, only the cost of equipment from the Washington D.C. CAPITAL project (see FHWA Travel Time Data Collection Handbook[18]) are presented here: • Transmission Alert System: $200,000 per unit • Geolocation Control System: $150,000 • Direction Finding System: $310,000 • Personal Computers: $2,000 to $5,000	• License Plate Capture: Varies by vendor. Typical system costs range between $25,000-$40,000 per installation. • Hybrid Approaches: Varies by method(s) employed.
Maintenance	• Intrusive sensors are often damaged and require regular repair and replacement. Maintenance often requires closing down lanes of traffic. • All sensors require regular calibration and maintenance.	• Annual operation and maintenance costs for AVI readers is typically estimated as 10% of the capital cost.	• Relatively low maintenance costs.	• Maintenance needs are unknown.	• License Plate Capture: Regular calibration is required. • Hybrid Approaches: Varies by method(s) employed.
Other Functions	• Can be used for incident detection, real-time congestion management, and traveler information systems.	• Transponders are used for ETTM. Other uses for tags may include parking fees, service plaza fuel purchases, and weigh station bypass.	• Passive probe vehicle information can be used for real-time congestion management and traveler information purposes.	• Data could be used for traveler information systems.	• License Plate Capture: Can be used for incident detection, real-time congestion management, and traveler information systems. Cameras could also provide public safety and security functions.

[18] Travel Time Data Collection Handbook. Report No. FHWA-PL-98-035. FHWA and Texas Transportation Institute. May 1998.

	CANDIDATE METHODOLOGIES				
	Archived ITS / Operations Data	**Automated Toll/Fare Data**	**GPS Data**	**Wireless Device Location Technology**	**Hybrid Approaches**
Institutional Factors	• Costs could be shared between freeway operations and regional planning agencies, such as between NYSDOT and GTC. • There are sometimes safety and aesthetic concerns with overhead- and pole-mounted sensors.	• Costs could be shared between toll agencies and planning agencies. • Privacy issues are a concern.	• For the passive probe vehicle method, there may be privacy issues.	• Privacy issues are a primary concern. • Would require a partnership with wireless device service provider.	• License Plate Capture: Costs could be shared between operations and planning agencies, such as between NYSDOT and GTC. Privacy concerns and video image monitoring may be issues. • Hybrid Approaches: Varies by method(s) employed.
Representative Vendors	• **Inductance loop detectors:** Eberle Design Inc.; Reno A&E; 3M/Canoga • **Piezoelectric sensors:** International Road Dynamics, Inc.; Measurement Specialties, Inc.; Kistler Instruments Corporation • **Active infrared sensors:** Schwartz Electro-Optics, Inc. • **Passive infrared sensors:** ASIM Technologies, Ltd.; Siemans; Eltec Instruments, Inc.; Eagle Traffic Control Systems • **Magnetic sensors:** 3M, Intelligent Transport System; Midian Electronics, Inc. • **Video image detection systems:** Image Sensing Systems; Quixote Traffic Corporation; Traficon USA; Iteris; Nestor Traffic Systems • **Microwave sensors:** Microwave Sensors, Inc.; Whelen Engineering Company; Electronic Control Measurement, Inc.; Naztec, Inc.; Electronic Integrated Systems, Inc. • **Passive acoustic sensors:** International Road Dynamics, Inc. (IRD); SmarTek Systems, Inc. • **Pulse ultrasonic detector:** Novax Industries Corp.; Microwave Sensors, Inc.	• TransCore • Mark IV • Sirit Technologies, Inc. • Raytheon	• Earthmate Blue Logger • TransCore	• None identified	• PIPS Technology • AutoVu Technologies • Northrup Grumman

5. EVALUATION OF ALTERNATIVE DATA COLLECTION STRATEGIES

This section evaluates the suitability of various travel time data collection methodologies identified in the Methodology Review (Task 2) to the requirements and conditions identified in the Greater Rochester region, as well as the needs of the regional agencies that will use and maintain these systems for planning and other purposes.

Recommended alternatives for both short-term and long-term strategies are presented. Key issues and decision criteria when comparing and evaluating the recommended strategies are also discussed.

5.1 Summary of Short- and Long-Term Objectives

Based on discussions with the project Steering Committee, the short- and long-term objectives for travel time data collection from the planning and operational perspectives are summarized in the table below.

Time Period	Planning Objectives	Operational Objectives
SHORT-TERM (0-3 Years)	• Implement a low-cost, proven, easy-to-use approach to support immediate CMP data collection needs • Collect manageable samples or 'snapshots' of prevailing conditions, realizing that it may not be possible to fully capture non-recurring congestion effects • Explore options for transition to long-term strategy leveraging regional ITS infrastructure for travel time data collection, up to and including a pilot project deployment	• Explore regional vision and future potential for expanded, non-CCTV traffic monitoring in the region • Pilot deployment of real-time travel measurement methods in limited areas
LONG-TERM (3+ years)	• More rigorous measurement of non-recurring congestion through increased surveillance/ sampling frequency • Utilize traffic data generated as a 'byproduct' of regional ITS infrastructure to expand reach and accuracy of the travel time data collection program	• Phased implementation of regional traffic detection technologies to support incident detection • Continuous, widespread provision of real-time travel time information to the public through DMS signs, website, and other media

Figure 5. Summary of Short- and Long-Term Objectives

5.2 Definition of Alternative Strategies

Using the above objectives as a guide, the consultant team identified the following long- and short-term strategies. The reader is referred to the Task 2 general technology evaluation for additional background about the candidate technologies contained in these strategies.

Section 4 of this report provides a side-by-side comparison of the short- and long-term options presented below.

5.2.1 SHORT-TERM STRATEGIES

Candidate short-term strategies focus on potential solutions that can be implemented quickly, at relatively low cost, and meet GTC's core planning objectives.

- GPS Data Collection
- Portable Toll Data Collection
- Fixed Detection Pilot Project

5.2.2 LONG-TERM STRATEGIES

Candidate long-term strategies incorporate a multi-functional, regional approach to planning and operational needs, with more pervasive coverage of the regional roadway network.

- Permanent Detector Installation
- Wireless Device Location Technology

Detailed descriptions of these strategies are provided in the following sections, along with a description of their respective strengths and weaknesses.

5.2.3 HYBRID APPROACHES

GTC may elect to implement a 'hybrid' approach that combines two or more of the above technology strategies to meet the region's total needs.

In particular, in the transition to a long-term strategy involving deployment of permanent fixed detector infrastructure on part of the region's limited access highways, a GPS or toll tag approach may be used to collect data in other 'hot spots' during the transition period or where the investment in fixed infrastructure investment cannot be justified.

Furthermore, within the permanent detection option, there is a high degree of latitude in selecting specific detector types depending on local conditions and traffic operations requirements. This constitutes another possible form of technological hybridization to achieve the most locally-advantageous solution.

5.3 Description of Short-Term Strategies

5.3.1 GPS DATA

The recommended strategy for using GPS data for travel time data collection emulates the strategy employed by the Capital Region Council of Governments (CRCOG) in Hartford, Connecticut for data collection on their arterial system. This strategy consists of purchasing inexpensive and easy to use GPS receivers and PDAs. This equipment is then used to manually collect data through sample travel time runs. This GPS data is then analyzed after the fact in an office environment using GIS software.

Advantages:

- Low Cost – Equipment can be purchased at low cost. CRCOG reported purchasing satisfactory GPS receivers for $180 per unit, and PDAs for $335 per unit. CRCOG was also able to use their existing GIS software for analysis. The labor costs associated with manual data collection will likely comprise the majority of the project costs.

- Ease of Use – This approach utilizes reliable, proven technology that is often extremely user-friendly. Certain GPS receivers have a “one button” data collection function that requires little to no training to use.

- Data Storage and Processing – Data storage and processing requirements are minimal and thus easier to consider handling in-house.

- Detail of Data – GPS captures trips in high detail, including stops, queuing, and speeds throughout the trip of the probe vehicle.

- Accuracy – GPS data is highly accurate and large amounts of detailed data can be easily collected. Typical GPS receivers can hold over 50,000 data points (more than 24 hours worth of data) without needing to be downloaded to a PDA and/or PC.

- Flexibility – The collection of GPS data can be extremely flexible. Data can be collected for different routes and time periods over a large geographic range. The GIS analysis allows for different definitions of roadway links or segments. Also, congestion “hot spots” can be easily targeted for additional study and analysis.

- Complementary Uses – GPS data can be supplemented by GPS or AVL installed on commercial vehicle fleets, public safety vehicles, and/or transit vehicles. Care should be taken when using this type of supplemental data since this data often exhibits distorted travel behavior. Furthermore, GPS data collection can be used to complement additional travel time data collection systems deployed in the long term. For example, CRCOG uses ConnDOT’s RTMS sensors to monitor travel times on Hartford area freeways and GPS data to monitor travel times on Hartford arterials.

Drawbacks:

- Labor Intensive – Manually collecting GPS data, transferring the data to PDA/PC, and performing analysis using GIS software is a very labor intensive strategy. Some of this labor can be minimized by creative data collection methods (e.g., taking advantage of employees' normal peak period commutes) and by selecting a GPS receiver that requires little training to use and has a simple data transfer method.

- Statistically Significant Sample Sizes – With the manual data collection process limiting the number of travel time samples collected, additional thought and effort must be expended in developing a statistically useful data sample.

- Measuring Reliability – One of the GTC CMP performance measures is reliability in terms of travel time variance. With a limited number of sample travel times being collected, assessing the travel time reliability of a specific corridor will be problematic. Theoretically though, GTC can choose to 'saturate' a corridor of interest with a high number of readings, which is more likely to capture non-recurring congestion events.

- Limited Operations Use – This strategy does not collect constant, real-time data and would therefore be of limited use to operations activities such as incident detection and traveler information services. Historic travel time data could be used to assist in isolating problem locations or establishing travel time baselines to assist operations personnel, but the expected usefulness of this data for operations purposes is minimal.

5.3.2 PORTABLE TOLL DATA

Based upon additional inquiry following the Travel Time Workshop, applications of portable transponder tag readers have been identified.

TRANSCOM in the New York metropolitan area has developed the TRANSCOM System for Managing Incidents and Traffic (TRANSMIT) system. This system is currently used by the New York State Thruway Authority and others in New York State for travel time monitoring purposes, and provides a springboard for Greater Rochester by leveraging existing E-ZPass toll tag equipped vehicles in the region. TRANSCOM in the metro New York area has been using a van equipped with a portable reader to monitor traffic for several years, and has also developed a portable trailer application that is used for evaluating potential sites for locating fixed antennas.

Additionally, the Rensselaer Polytechnic Institute (RPI) and NYSDOT have been collaborating on development of a trailer-mounted portable reader unit. Several of these portable reader units could be deployed throughout the Greater Rochester region for direct measurement of travel time between a pair of upstream and downstream readers.

Portable reader units could also be utilized in conjunction with the ground fixed readers deployed along the Interstate spurs leading to and from the NYS Thruway. An agreement or Memorandum of Understanding with the Thruway Authority regarding the use and exchange of data would need to be developed and signed.

<u>Advantages:</u>

- Accurate Data – Using toll data allows for extremely accurate travel time data of actual vehicles in the traffic stream. Lag time issues associated with two-reader travel time measurement during the early and clearing phases of traffic incidents are not problematic in planning data applications.

- Existing Population of Transponder Tag Vehicles – The existing market penetration in the Rochester region, estimated to be approximately 18%, is more than sufficient for collecting accurate travel time samples.

- Relatively Low Cost – A portable reader unit can be procured and deployed for considerably less than a permanent toll reader installation. Preliminary RPI cost estimates suggest that following development a portable reader unit would cost approximately $20,000 - $30,000.

- Flexibility – The deployment of portable reader units would allow for flexibility in terms of routes examined. It would also allow for the targeting of congestion “hot spots” for further study and analysis.

- Operations Uses – The portable reader units collect data in real-time and could be used by operations personnel to assist in incident detection and in traveler information services.

- Possible Demonstration Project Opportunity – With NYSDOT and RPI leading the development of the portable reader unit, there may exist an opportunity to participate in a potential demonstration project. As a demonstration project, cost sharing and/or grant opportunities may be available if Rochester is used as a field test location.

- Complementary Uses – Portable toll data collection can be used to complement fixed travel time data collection systems deployed in the long term, filling in ‘gaps’ in coverage.

<u>Drawbacks:</u>

- Reliability/Technological Maturity – With the portable reader unit still being under development, the operating experience with this type of unit in this particular application is sparse. While traditional readers are very reliable and accurate, there are inherent risks and obstacles associated with moving forward with an innovative application.

- Implementation Schedule – The development schedule of the portable reader unit involves significant risk. While the researchers at RPI plan to complete initial field testing of the units this winter, development of a commercially available unit may take years. It is therefore possible that this option would not be suitably developed in time for deployment in the short-term.

5.3.3 FIXED DETECTION PILOT PROJECT

Another short-term strategy would be to deploy fixed detection equipment on a small segment of the regional transportation network as a pilot project or proof-of-concept to support evaluation of a longer-term candidate technology.

These technologies could be any of the variety of traffic sensors (e.g., microwave, acoustic, video, induction, etc.) or a permanent ground fixed transponder tag reader. By funding a pilot project, the region’s transportation agencies could better assess the costs and benefits of a particular technology. This could help in determining whether or not the region is interested in future large scale deployments for planning and traffic management purposes.

Advantages:

- Operations Uses – This small scale deployment would likely provide data in real-time that could assist operations personnel in incident detection and traveler information activities. It could prove useful in assessing the value of a broader regional strategy to deploy detection to support incident and traffic management prior to making large scale investments.

- Takes Advantage of Existing Infrastructure – By only initially funding a limited deployment, implementing agencies can take advantage of existing infrastructure, particularly communications infrastructure, in order to minimize costs. Existing infrastructure could include existing fiber optic cable, existing power connections, existing mounting poles, etc.

Drawbacks:

- Limited Coverage – A pilot project would have only limited network coverage and would therefore provide only a limited amount of information. It would have to be complemented by other forms of CMP data collection in most other parts of the region.

- Risk of Technology Failure – There is risk associated in selecting a technology for the pilot test. If the technology fails to meet the region's needs, the region is saved from a larger investment in the technology, but has still expended funds that could have been used elsewhere.

5.4 Description of Long-Term Strategies

5.4.1 PERMANENT DETECTOR INSTALLATION

This long-term strategy would involve the permanent installation of traffic monitoring devices to provide operations personnel with real-time travel time information that could also be mined for planning purposes. It would necessitate ongoing discussion and coordination between operations and planning personnel to determine which technology to invest in, how data would be managed and exchanged, and how costs could be shared. This investment could be an expansion of a pilot project or a separate investment.

It is assumed that the primary motive for permanent fixed detector deployment would be to support highway operations, with planning data collection being a side benefit of having this infrastructure in place. NYSDOT and MCDOT are therefore key partners in adopting this strategy, and it must take place within a broader dialogue about regional ITS investments for operational purposes.

Advantages:

- Operations Uses – Detector deployment would offer a more sophisticated set of tools to address traffic operations needs. As more video cameras are deployed throughout the region, it will become more and more difficult for personnel to monitor all video feeds simultaneously. This system could act as a filter, automatically alerting personnel when certain areas deserve additional attention when changes in traffic flow are detected.

- Data Quantity – A permanent installation will generate large quantities of data. This will allow for more rigorous analysis of regional congestion issues, including time-series analyses and inter-regional comparisons.

Drawbacks:

- Cost of Deployment – A large-scale fixed detection deployment would require expansion of regional infrastructure, procurement of field equipment, development or procurement of back-office software, etc. This is a large investment that will need to be carefully planned, coordinated, procured, and integrated, with the full support and material contributions of other agencies in the region.

5.4.2 WIRELESS DEVICE LOCATION TECHNOLOGY

The development of wireless device location technology is a “wildcard” in determining a long range strategy. This powerful technology appears to be on the cusp of broad commercial application, though not ready for immediate short-term usage. However, the use of wireless device location data from a third-party source would provide pervasive regional travel time information that might one day supplant other existing data collection methods.

In light of the technological immaturity, the study team recommends that GTC continue to monitor the development of this technology and assess its viability in a few years either through a pilot deployment or through an evaluation of peer MPO “early adopter” experiences.

Advantages:

- Geographic Coverage – Due to the nearly ubiquitous use of cell phones, this approach would provide better coverage than practically any other approach.

- Data Quantity – Large quantities of data could be collected in real-time for both operations and planning purposes.

- Flexibility – The number and location of routes examined could be highly flexible.

Drawbacks:

- Privacy Issues – There are numerous concerns over passively tracking random wireless devices. It is still uncertain at this point whether or not this will become more or less socially acceptable in the near future, as seen in the evolution of electronic tolling through the 1990s.

- Technological Maturity – Due primarily to the privacy issues involved, this approach remains unproven under a variety of different conditions.

6. SUMMARY OF CANDIDATE STRATEGIES

The following tables (Figure 6 and Figure 7) summarize the merits of the short- and long-term strategies against the region-specific functional criteria outlined in Section 2.

6.1 Comparison of Short-Term Strategies

Strategy	Key Planning Requirements				Key Operations Requirements				General Requirements				
	Ability to Meet Core Travel Time Data Collection Requirement	Data Character-istics	Geographic Coverage	GTC Staff Resource Requirements	Ability to Support Incident Detection Function	Ability to Support Traveler Information Function	RTOC Staff Resource Requirements	Cost Effectiveness/ Value	Reliability/ Maintainability	Technological Maturity	Suitability to Climate	Funding Opportunities	Suitability to Long-Term Use
GPS Probe Data Collection	High – Although likely to under-represent non-recurring congestion due to sampling infrequency	Direct travel time measurement with detailed profile of trip characteristics; Sample size a function of hours driven	Highly Flexible – can be used on any facility within the TMA	Moderate - Requires staff or volunteer time for all data collection plus data processing	N/A – no real-time connection to RTOC	N/A – no real-time connection to RTOC	Low to None – systems operated and maintained by GTC	Low capital cost, moderate operating cost due to labor requirements Single-function application	Reliable with low maintenance requirements	Proven and widely used technology	Data can be collected any time that it is safe to drive (may raise liability concerns during severe weather)	Possibly funded through UPWP	Fair – can supplement long-term strategy, but not an integral part of the long-term infrastructure
Portable Toll Tag Readers	High – Although likely to under-represent non-recurring congestion due to sampling infrequency	Direct travel time measurement; Provides a continuous sample as long as unit is deployed	Flexible - Limited only by physical placement constraints	Low - Passive collection – staff time limited to positioning, periodic data retrieval and processing	N/A – no real-time connection to RTOC	N/A – no real-time connection to RTOC	Low – device positioning and maintenance support may be required	Low capital cost; note portable units are not in regular commercial production; Low operating cost Single-purpose application	Reliable technology. Field units require periodic maintenance.	Concept is used widely though portable application may present early-adopter risks	Functional in virtually all weather conditions, though deployment in severe weather may be difficult for field personnel	Possibly funded through UPWP May be eligible for research/ field test funds	Good – can be used to test locations for permanent installation, and to supplement other long-term infrastructure using the same technology
Point Detection Pilot Project	Very Good – Partly dependent on spacing of detectors, traffic volumes, and environmental factors	Indirect travel time calculation using point data; Provides a continuous data sample	Coverage only on fixed corridor(s) where sensors are deployed Best suited to limited-access facilities	Low - Passive collection – staff time limited to periodic data retrieval and processing	Possible limited role in one corridor as a proof-of-concept	Possible limited role in one corridor as a proof-of-concept	Low – ongoing maintenance support may be required	Moderate capital and operating cost– minimized with use of existing comm. Infrastructure Multiple planning/ops applications	Reliable technology Field devices will require periodic maintenance	Proven and widely used technology	Functional in virtually all weather conditions	Possibly funded through UPWP	Excellent – Pilot project corridors become part of the long-term system

Figure 6. Summary Comparison of Short-Term Strategies

6.2 Key Short-Term Decision Factors

The alternatives presented above are intended to fulfill GTC's core travel time data collection requirements at relatively low cost and within a short deployment timeframe. Each is a viable alternative but there are variations among them in terms of agency participation, data type, resource requirements, lead time, technological maturity, and other criteria as identified in the table. Consideration of the following central questions may be useful in selecting a preferred short-term strategy:

- **ST1 Available Labor Resources:** What are the available labor resources, particularly with respect to the labor-intensive data collection of the GPS approach? This is a question to be asked of GTC as well as partner agencies that may have a role in field deployment and/or maintenance of certain technologies.

- **ST2 Implementation Schedule:** What is the region's target implementation schedule and its tolerance for experimentation with less proven but promising technologies? The GPS data approach can be implemented quickly. The trailer-mounted portable transponder tag reader technology is still under development and may require a longer start-up time. Developing and installing a fixed-instrument pilot project will likely require a longer lead time as well, and will not immediately meet all regional CMP data collection needs.

- **ST3 Hybrid Approaches:** Is the region willing to consider a 'hybrid' approach that uses multiple technologies to suit varying facility types and locations across the region? Such an approach may provide greater flexibility but also increases the overall complexity of the data collection program and variations in the output data generated by each method.

- **ST4 Suitability to Long-Term ITS Strategy:** How will the short-term strategy fit into the region's longer term ITS strategy? – In order to minimize costs and maximize usefulness, the short-term strategy should be designed to complement the region's long-term goals and priorities. By investing in a system that considers long-term objectives along with short-term necessities, the region reduces the risk of redundant investment and/or obsolescence.

- **ST5 Funding Sources:** How will potential funding sources impact the selection of a strategy? – The region should explore funding opportunities through inter-agency cost sharing or grants. For example, the CRCOG was able to procure a $12,000 grant from the federal Technology & Innovation Program to help fund their GPS travel time arterial monitoring system. Furthermore, research or grant funding may exist to participate as part of a demonstration project for portable transponder tag readers.

6.3 Comparison of Long-Term Strategies

Strategy	Key Planning Requirements				Key Operations Requirements			General Requirements				
	Ability to Meet Core Travel Time Data Collection Requirement	Data Character-istics	Geographic Coverage	GTC Staff Resource Requirements	Ability to Support Incident Detection Function	Ability to Support Traveler Information Function	RTOC Staff Resource Requirements	Cost Effectiveness/ Value	Reliability/ Maintainability	Technological Maturity	Suitability to Climate	Funding Opportunities
Permanent Detector Installation	High – Excellent continuous data collection and non-recurring delay capture; non-instrumented congestion "hot spots" may be excluded	Direct travel time measurement (e.g., toll tag readers) ; or point measurements (e.g. microwave or acoustic detectors); continuous data collection	Coverage only on instrumented facilities; may require alternative approach on other facilities of interest	Low/Moderate – data provided periodically to GTC by operating agencies; Possibly manipulation of large data volumes	High – Proven ability to support speed monitoring and/or automated incident detection	High – Proven ability to provide direct or calculated travel time estimates	Moderate – Ongoing field maintenance and operations staff requirements	Moderate capital cost – considerably less where there is existing capital cost. Moderate operating cost requiring periodic field maintenance Multi-application investment	Reliable with low maintenance requirements	Proven and widely used technology	Functional in virtually all weather conditions	Possible cost sharing among agencies due to multi-application nature of the infrastructure investment
Wireless Device Location	Very High – Excellent continuous data collection on essentially all roadway facilities in the region	Direct travel time measurement; Provides a continuous sample 24/7.	Pervasive – region-wide coverage	Moderate - Passive collection; will require administration of third-party contract and possibly manipulation of large data volumes	Moderate/High – Use to monitor link speeds and possibly incident detection; experience with this application is limited	Moderate/High – Can monitor speed; experience with this application is limited	Low/Moderate – operations staff requirements, liaison with third-party data provider	Costs and maintenance requirements dependent on arrangement with data provider; difficult to predict based upon limited experience Multi-application investment	Uncertain reliability and maintainability due to technological novelty and reliance on third-party sources	Promising but as yet unproven in traffic management applications	Functional in virtually all weather conditions	Possible cost sharing among agencies due to multi-application nature of the infrastructure investment Third-party data provider may offer alternative financing/ cost sharing/ public data usage arrangements

Figure 7. Summary Comparison of Long-Term Strategies

6.4 Key Long-Term Decision Factors

The long-term strategies presented above are premised on the emergence of one or both of the following conditions, which would signal to the region that a migration from the short-term strategy may be warranted:

LT1 Traffic Operations Objectives: A decision to deploy additional field detection equipment to support traffic operations functions on limited-access highways in the region would provide a new impetus for investment in fixed technology. In this instance, collection of planning data would become a 'byproduct' of the traffic data generated in the course of routine highway operations activities, which given the significant investment required would become the primary motivation for investing in field detection technology.

LT2 Technological Maturity: Further technological and commercial maturation of third-party wireless data services, obtained either for strict planning or planning/operations applications, that increase the feasibility of the Wireless Device Location strategy while decreasing GTC's and other's implementation risk.

Other central questions surrounding the migration to, and selection of, a long-term strategy include:

LT3 Value of Continuous Data Collection: What is the incremental value to GTC (planning function) and RTOC (operations function) of continuous travel time data collection to capture non-recurring phenomena?

LT4 Relation to Regional ITS Strategic Goals and Regional ITS Architecture: At what point does the transition to a combined traffic management/planning data collection approach become appropriate in terms of the region's overall transportation system management needs and resources?

LT5 Peer/Pilot Experience: What has been the experience of the region (and/or peer regions) with a pilot deployment of the candidate technology?

LT6 Leveraging Existing Infrastructure: How can the region coordinate and leverage its existing and future supporting ITS infrastructure investments, particularly with respect to communications infrastructure?

LT7 Cost-Sharing Arrangements: What cost-sharing arrangements are possible among participating agencies (and possibly, third-party data providers) to offset the higher costs of the long-term solutions in light of their more broadly-dispersed benefits?

7. CONSENSUS STRATEGY AND IMPLEMENTATION PLAN

7.1 Introduction

Based upon a discussion of the alternative strategies presented in the preceding sections of this report, the project Steering Committee convened a meeting/teleconference on September 18, 2006 to discuss preferences for the preferred approach to support the Congestion Management Process and long-term operations data needs in the Greater Rochester region.

Some of the central points raised in the Steering Committee discussion of alternatives include the following:

- The need to meet immediate planning requirements (i.e., CMP travel time data collection) in the near term, while in the long-term migrating to a more comprehensive or permanent solution that offers other advantages and functionality;

- The need to conduct an in-depth strategic review of operational requirements for any new permanent detection technology to be deployed primarily for highway incident/emergency management purposes, before committing to its full deployment in the region;

- A desire to leverage existing regional ITS resources, such as the NYS Thruway Authority's TRANSMIT toll tag data collection program, and the existing central hardware for this system that is operated by the Thruway Authority in Buffalo;

- A desire to remain open to the evolution of new technologies, such as wireless location, as they mature and become more practical solutions within the next few years.

7.2 Preferred Short-Term Approach and Implementation Plan

7.2.1 SHORT-TERM DECISION FACTORS

The review of local requirements against the key decision factors presented in the preceding section for the short-term resulted in the following evaluation that underpins the selection of a preferred alternative:

Short-Term Decision Factor	Regional Assessment
ST1: Available Labor Resources	Labor resources for data collection are limited, and it is unlikely that existing GTC staff could undertake a large-scale data collection program given current responsibilities and resource constraints. However, because any short-term approach is likely to be labor intensive, outsourcing of data collection has been suggested as a means to leverage additional labor.
ST2: Implementation Schedule	Implementation of the data collection program is contingent on finalizing the region's overall CMP strategy, though it is likely to occur within the next 12-24 months. Thus, it is unlikely that the technological landscape, either locally or nationally, will change significantly enough to present

Short-Term Decision Factor	Regional Assessment
	alternative approaches to the short-term strategies presented above.
ST3: Hybrid Approaches	In the short term, it is unlikely that a hybrid approach would be implemented, because of the lack of existing data collection field equipment to leverage, and the relatively small scale of the initial data collection effort. However, it is recognized that a pilot project using an alternative, more permanent data collection technology could be valuable in evaluating potential longer-term approaches.
ST4: Suitability to Long-Term Objectives	At present, there are no pending operational ITS investments by either NYSDOT or MCDOT that are likely to impact available infrastructure for data collection. A re-visitation of the region's ITS strategic plan has been proposed, and may in the future identify commonalities in planning and highway operations objectives that influence the long-term data collection strategy.
ST5: Funding Sources	The funding for a short-term data collection program is likely to be drawn from UPWP funds, limiting the amount of available funds (typically $40,000-$120,000). Because of the absence of regional partners for cost sharing in the short term, a premium is placed on keeping data collection costs down.

7.2.2 PREFERRED SHORT-TERM TECHNOLOGY APPROACH: GLOBAL POSITIONING SYSTEMS (GPS)

In light of the above factors, the Steering Committee has opted to pursue a **Global Positioning Systems (GPS)-based** travel time data collection system for the short-term. This approach offers the following advantages:

- Low implementation cost
- Proven, reliable, accurate technology
- Highly robust data providing significant trip detail across space and time
- Proven peer MPO experiences
- Ability to meet the immediate CMP planning objectives
- Very flexible in geographic coverage and intensity of data collection
- Retains flexibility in evaluating and adopting long-term technology approaches (low 'sunk cost')

- Can be used to supplement gaps in long-term coverage as part of a hybrid long term strategy

The principal limitation on the GPS approach is the high labor intensiveness of the data collection process itself. Every hour of field data collection is matched by an hour of field survey time by either GTC staff or an outside entity. However, compared to the alternative approaches (portable toll tag reader or limited fixed field detection), the strategy is best suited to meet the basic data collection needs of the regions while more extensive and sophisticated methods are being evaluated. GTC has expressed a preference for using a third-party contractor to collect the GPS field measurements in lieu of the agency's own staff.

7.2.3 DESIGN OF A GPS-BASED TRAVEL TIME DATA COLLECTION METHODOLOGY

There is a rich academic literature[19] on the design of travel time data collection experiments using GPS units, and the associated strategies for pilot vehicle behavior in the traffic flow (e.g., average car, floating car, etc. – see Section 3.3 of this document). GTC will need to develop a data collection plan that articulates the data collection methodology, including factors such as:

- Probe vehicle driving style(s)
- Key corridors and routes to be monitored (presumably, elements of the limited-access highway network in the short term);
- Sample sizes that will provide results with statistically significant confidence levels;
- Frequency of data collection; and
- Required post-processing of raw GPS data, and their relationship to the performance measures prescribed in the regional Congestion Management Process.

The interrelated nature of these decisions suggests that the decision-making process may require an iterative process to balance data requirements against available resources.

In order to quickly implement a low-cost GPS-based travel time data collection strategy, GTC can benefit from the experiences of its peer agencies such as the Capital Region Council of Governments (CRCOG) in Hartford, CT. CRCOG employs an active method of using GPS equipment to monitor travel times during peak hours on arterial roads. CRCOG selected a simple and cost-effective GPS unit that allows direct download of the data to a GIS, and utilizes its own staff to collect data with the GPS units as part of their normal commute routines, with some deviations, along several key arterial corridors.

In selecting a GPS unit, factors to consider include: unit cost; quality of data; the ease of importing this data into the preferred GIS analysis software; the ease of managing the data and interpreting it for travel time purposes; the quality of technical support offered; and equipment warranties. Some equipment providers have developed systems that are geared specifically towards transportation data collection, including travel time surveys.

Alternately, the selection of the particular hardware and software can be left to the successful third-party data collection vendor, with GTC instead specifying performance-based outcomes for the

[19] For example, see Wu, Seung Kook et. Al, ***A Practical Procedure to Collect Arterial Travel Time Data Using GPS-Instrumented Test Vehicles*****,** Transportation Research Board Annual Meeting 2006 Paper #06-2971.

data collection methodology and the format of the raw data provided to the agency by the contractor.

7.2.4 SHORT-TERM IMPLEMENTATION PLAN

The elements of the preferred short-term travel time data collection approach are summarized below:

Short-Term Implementation Activity	Anticipated Outcome	Responsible Entity
Refine the regional Congestion Management Process (CMP)	Provides a framework for the travel time data collection program; identifies performance criteria and regional objectives	Genesee Transportation Council (GTC)
Identify critical corridors for short-term data collection activity	Identifies the locations where data collection will take place; provides for the development of a statistically valid data collection program and data collection resourcing plan.	Genesee Transportation Council (GTC)
Contract for third-party GPS data collection services	Supplements existing GTC staff resources to collect travel time data using GPS-equipped probe vehicles according to a data collection protocol prescribed or approved by GTC.	Genesee Transportation Council (GTC) Third-party data collection contractor
Evaluate and interpret GPS field data	Translate travel time measurements into performance measures for further regional model analysis and/or CMP reporting.	Genesee Transportation Council (GTC)
Implement Pilot Project to test a preferred long-term approach	Design and deploy a pilot implementation on a limited-access highway segment using fixed detection, in order to evaluate the long-term potential of a fixed infrastructure approach.	Genesee Transportation Council (GTC) Operating Agencies (NYSDOT, MCDOT)

7.3 Short-Term Fixed-Detection Pilot Project

7.3.1 PILOT PROJECT OBJECTIVES

Implementation of a fixed-detection pilot project is seen as an important short-term step towards a more permanent, geographically dispersed, and continuous travel time monitoring program. The objectives of the pilot project include:

- Demonstrating the effectiveness and benefits of continuous travel time data collection in support of GTC's CMP objectives;
- Gaining regional experience in data collection and manipulation from fixed-detection devices;
- Demonstrating the complementary operational benefits of fixed detection, such as incident detection and/or provision of real-time travel time information to the general public; and
- Building support for future investment in fixed technology based upon demonstration of tangible results.

GTC should work with its regional partners to identify cost-sharing and maintenance arrangements that pool resources to implement this pilot project. However, if necessary a basic pilot project could be developed and implemented within the range of typical GTC UPWP projects, approximately ($40,000-$120,000).

7.3.2 TRANSMIT PILOT PROJECT

This study recommends that GTC pursue a pilot project in coordination with the New York State Thruway Authority and the TRANSMIT program to use existing E-ZPass toll tag readers to also collect travel time data in the region.

This strategy leverages existing automatic vehicle identification (AVI) infrastructure and technology, provides direct measurement of travel time between reader locations, and offers a potential funding opportunity by coordination of efforts with the Thruway Authority and other regional transportation operating entities. Other metropolitan areas in upstate New York, including Buffalo, Syracuse, and Albany, either participate or plan to participate in the TRANSMIT program.

As described previously in this report, the TRANSCOM System for Managing Incidents and Traffic (TRANSMIT) system operates on the New York State Thruway and Garden State Parkway in New York and New Jersey. TRANSMIT uses overhead AVI transponder readers installed at regular intervals along the roadway. As vehicles pass these AVI readers, the transponder tag information is sent to a central site, where the information is processed to calculate travel times. This system has been successfully used to monitor traffic congestion and detect incidents.

TRANSMIT data from 20 readers has also been successfully incorporated into the *CROSSROADS* ATMS in the Buffalo-Niagara region. This data provides real-time travel time information within the ATMS. NITTEC operations staff uses this information to determine if a specific link is performing at or below expected travel times. The TRANSMIT data is also used in Crossroads to populate travel time maps on the NITTEC.org website.

Based upon preliminary discussions with the New York State Thruway Authority, additional TRANSMIT readers are planned for deployment in 2007, resulting in a reader at every Thruway exit. The Thruway Authority is also planning a pilot project with TRANSCOM for six (6) portable readers that the Thruway will be able to use at the ramps as well. The City of Syracuse is working with the Thruway Authority to share readers, data and server hardware. It is recommended that members of the project committee contact Syracuse to determine their short-term and long-term plans.

There are several ways in which a TRANSMIT pilot project could be implemented in the Greater Rochester region, leveraging existing infrastructure in the Buffalo-Niagara region. One cost-effective method is to deploy a single reader on an inbound route toward the city center from the Thruway, and measure the travel time between the Thruway's exit reader and this additional location. Alternately, a pair of new readers could be deployed at other locations on the regional highway network or other roadway segments that are deemed of greater interest.

To cost-effectively leverage the existing data processing capabilities of the TRANSMIT infrastructure in Buffalo, Rochester could establish a fiber connection to the Thruway's existing fiber network. This communications backbone investment could provide other operational benefits as well. If a fiber connection with the Thruway is deemed infeasible, "always on" ISDN phone connections set up by the local telecommunications provider could be used instead.

The data would then be sent to NITTEC's existing TRANSMIT servers in Buffalo to calculate travel times from the raw antenna data. The data could possibly be integrated into NITTEC's Crossroads interactive map interface, and be archived in the database for future planning analysis.

If Rochester was to deploy its own stand-alone system, an agency in the region would need to procure a TRANSCOM server and deploy TRANSMIT readers. Rochester would also need to establish all communications with the TRANSMIT readers (fiber or ISDN) and the TRANSCOM server. Rochester would also need to develop tools (or use the tools provided by TRANSCOM) to view and analyze the data. Further discussion with TRANSCOM would be required to fully articulate the issues and costs associated with a stand-alone approach.

7.3.3 ALTERNATIVE PILOT PROJECT APPROACHES

Another pilot project deployment option is to use an alternative sensor technology along a fixed corridor to accomplish the same data collection function. This approach may prove more attractive if, for example, further analysis of regional operations objectives indicates a desire to begin implementing point detectors to monitor vehicle speed or occupancy at specific locations along the limited access network, or if an alternative upstream/downstream monitoring system (i.e., license plate readers) is desired in lieu of the TRANSMIT toll-tag based approach.

An ITS sensor technology deployment project has been proposed for the I-490 Western Gateway corridor between the Erie Canal and Genesee River. This corridor, representing a major limited access highway into the metropolitan region for which fixed detector technology is proposed for operational purposes, could make an ideal pilot project test-bed if fixed detection technology is proposed, or if a head-to-head comparison of fixed detection and TRANSMIT technology is desired in this corridor.

In any situation, it is important that the placement of equipment is done in such a way as to maximize both the planning data and highway operations/incident detection benefits of the system. Thus selection of a high-incident, congested roadway of high importance in the region is recommended, provided existing infrastructure (e.g., communications, poles, complementary CCTV, etc.) is available to make the pilot installation cost effective.

7.4 Long-Term Decision Criteria

The identification of a long-term approach is more complex than the short-term approach because of the involvement of a wide array of additional variables in the decision-making process.

In general, there is regional agreement that movement toward a future strategy that is less labor intensive and more pervasive (in geographic coverage and continuous data collection) than the GPS-based approach prescribed for the short term. For example, continuous real-time data collection on major arterials will better capture the non-recurring causes of congestion caused by random incidents. Such non-recurring congestion is a major cause of overall congestion in the region, and it is the area that proactive regional traffic management strategies are likely to address.

However, it is not cost-effective to pursue such a large-scale data collection program without other operational objectives – and regional partners – to share in the burden of funding, implementing, operating, and maintaining the equipment. As has been stated previously, the field equipment in a typical metropolitan Advanced Traffic Management System (ATMS) is deployed to meet operational objectives, with copious volumes of planning data generated as a 'byproduct.'

In the case of the Greater Rochester region, however, it is clear from discussion with the Steering Committee (which included NYSDOT and MCDOT representatives) that the regional ATMS strategy is currently more focused on visual and field spotter incident detection and management than the use of the kinds of field detectors that would also yield travel time data for planning purposes. While MCDOT has implemented a large number of loop detectors as part of its signalized arterial management system, these detectors are not ideally suited to travel time data collection and do not address the need to collect data on regional limited-access highways.

The other 'X-factor' is the potential evolution of emerging technologies, such as wireless device location, that could usurp the field detector approach with low-cost, pervasive data that can be purchased from a third-party source. While there are significant technical, commercial, and legal (e.g., privacy) barriers that must be addressed before any such approach is implemented for CMP purposes, it is possible that such an approach will prove feasible by the time the region is ready to transition to a more permanent approach.

7.4.1 LONG-TERM DECISION FACTORS

The review of local requirements against the key decision factors presented in the preceding section for the short-term resulted in the following evaluation that underpins the future refinement of a long-term data collection strategy:

Long-Term Decision Factor	Regional Assessment
LT1: Traffic Operations Objectives	Regional highway operations, which currently rely exclusively on CCTV surveillance and field personnel for traffic detection, is approaching a crossroads as system coverage expands and operational needs evolve. The proposed Interstate 490 Western Gateway project may present the first real opportunity to leverage operational infrastructure for planning data collection; however future plans for widespread traffic detector deployment across the

Long-Term Decision Factor	Regional Assessment
	region remain uncertain.
LT2: Technological Maturity	The Steering Committee has expressed interest in pervasive data collection methods leveraging data provided by third party entities such as mobile phone providers or on-board automotive technology (e.g., General Motors' *OnStar*). While these technologies are not yet market ready for a CMP application, the Committee expressed a desire to revisit their feasibility at a future time.
LT3: Value of Continuous Data Collection	Continuous data collection at fixed sites provides obvious benefits in terms of data quality and cost reduction for the CMP program, but its wide-scale use is contingent on finding other complementary operational applications to defray the cost of installing and maintaining the field equipment.
LT4: Relation to Regional ITS Strategic Goals and Regional ITS Architecture	As stated previously, there are plans to update the region's ITS strategic plan which may identify commonalities in planning and highway operations objectives that influence the long-term data collection strategy.
LT5: Peer/Pilot Experience	Experience around New York State with the TRANSMIT transponder-based data collection program has shown great promise, and is likely to be feasible in the Rochester area because of the market penetration of E-ZPass toll tags. The use of other fixed traffic detection technology, including point detection or license-plate reader systems has also proven very successful and can be considered a 'mature' approach.
LT6: Leveraging Existing Infrastructure	TRANSMIT central servers located in Buffalo could potentially be used to support toll tag data processing in the Rochester region very economically. Additionally, the region has deployed a significant fiber communications network on the limited access highway network that could be used to support a travel time data collection pilot installation or a larger-scale, dual use planning/operations detector deployment on the region's major limited access corridors.
LT7: Cost-Sharing Arrangements	Cost-sharing with other agencies will be necessary to defray the cost of any large-scale fixed detection network. This in turn is directly related to the identification of complementary traffic operations applications of the hardware through a re-visitation of the region's ITS strategic deployment plan.

7.5 Towards a Long-Term Data Collection Approach

The ultimate goal of the long-term strategy is to provide improved data quality and coverage at a lower cost by leveraging an expanding network of detection infrastructure that will be deployed across the region in the coming years.

Because of the uncertainties identified in this project's exploration of the long-term data collection alternatives, ongoing regional discussions about planning and traffic operations objectives for ITS are necessary to articulate a preferred long-term approach.

The migration toward a long-term strategy should begin with an evaluation of the proposed pilot project(s), and an evaluation of the performance of the GPS systems employed in the short term, so that they can be refined and continued in the longer term to cover gaps in the fixed detection infrastructure network. The emergence of newer technology options, such as a refined vehicle probe data solution offered by a third party may present additional options that can be reconsidered in a few years' time.

In the meantime, there are two elements that GTC and its partner agencies can proactively pursue to attain a clearer understanding of the preferred long-term travel time data collection approach. These are:

- Consideration of CMP requirements in the forthcoming **Regional ITS Strategic Plan Update**; and;

- Evaluation of the **Short-Term Fixed Detection Pilot Project** to determine desirability for further deployment.

These two elements are discussed in the following sections.

7.6 Factors to Consider in the Regional ITS Strategic Plan Update

It is difficult to overstate the importance of the interplay of regional planning, highway operations, and traveler information objectives in the definition of a long-term strategy. The fundamental premise of the long-term strategy is to migrate towards an integrated, permanent infrastructure approach to both planning and operational needs.

This by definition requires a coherent regional strategy and an understanding of various stakeholders' requirements and their intentions regarding the deployment of future field hardware or supporting infrastructure (e.g., communications).

While this report begins to explore the interrelationships of operational and planning requirements and infrastructure, much hinges on the traffic management strategy to be pursued by NYSDOT and MCDOT, the two operating partners in the Regional Traffic Operations Center.

An update of the regional ITS strategic plan has been proposed. Currently the region has two comprehensive but aging ITS vision documents: the *Improved Mobility Areawide Guidance Evaluation (IMAGE)* report, circa 1996, and the *Rochester Regional ITS Architecture*, circa 2000.

A shift towards additional traffic detection technologies beyond CCTV presents clear opportunities for planning data collection as well as the provision of public travel speed information via DMS signs, the Internet, 511 telephone traveler information, etc.

All stakeholders participating in the future ITS strategic plan update are encouraged to consider the CMP planning requirements outlined in this document, and to identify opportunities for joint use of ITS infrastructure to accomplish multiple functional objectives. Assuming such commonalities are identified, some detailed issues to address in the plan include:

- Placement of future infrastructure to meet planning, incident management, and traveler information functions;
- Regional communications interconnectivity;
- Development of an interagency concept of operations for regional traffic data collection, archiving, field maintenance, etc.;
- Exploration of joint infrastructure funding opportunities; and
- Identification of discrete field detection deployment projects in a phased, prioritized manner.

8. CONCLUSION

This study has examined the suitability of four leading travel time measurement technologies to identify a technology approach that best meets the needs of the Genesee Transportation Council's Congestion Management Process. From the assessment of local needs and a state of practice evaluation, it is clear that at least two options, GPS Data Collection and Portable Toll Data Collection, meet the immediate needs of GTC to accomplish CMP planning in the short term. Based upon the ease of use and the success of other MPOs in its use, the project committee has recommended GPS data collection as the preferred approach in the short term.

As in many other areas of transportation planning and technology deployment, additional opportunities can be realized by taking a functionally broader, more regionalized approach to the issue. A key future consideration for the region is the extent to which fixed traffic detection technology will be justified to support traffic operations needs of GTC's regional partners, NYSDOT and MCDOT. Point measurement technologies may include loop detectors, acoustic sensors microwave sensors, paired E-ZPass toll tag readers, or other sensors as dictated by operational requirements. All of these devices generate vast amounts of archivable traffic flow data as a 'byproduct' of their operation.

While such fixed infrastructure is costly and can only realistically be deployed over several years, coordinated deployment in the region would allow for a migration towards a continuous, high-quality data collection system that operates at low cost and is ideal for capturing non-recurring congestion. Importantly, such a system could provide other regional operational benefits, such as public travel time information and incident detection. Thus, continued dialogue to articulate regional traffic detection/data collection deployment strategy, as well as identification of concrete pilot project alternatives such as the I-490 Western Gateway corridor and cost sharing approaches, is in the interest of all affected agencies.

In the future, promising emerging technologies, such as wireless device location, may provide pervasive data collection across virtually all roadways in the region. While this study concludes that such technology is not adequately mature for application to immediate CMP needs, it suggests that GTC, its partner agencies, and its peer MPOs should periodically re-examine developments in the industry.