

**Intelligent Transportation Systems**  
**Measures of Effectiveness**

**Final Report**

*prepared for*  
**New Jersey Department of Transportation**



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RESEARCH

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## **Executive Summary**

The New Jersey Department of Transportation (NJDOT) Integrated Transportation Management Strategies (ITMS) Master Plan proposes using various Intelligent Transportation Systems (ITS) strategies and technologies to deliver services to New Jersey's transportation system customers. The purpose of this report is to develop quantitative and qualitative evaluations of customer service delivery that can measure achievement of the results intended, such as lower overall trip time, reduced incident-related delay, better knowledge of travel options and conditions, etc.

The ITMS Master Plan recommends that the following ITS customer services be given high priority for deployment in the near- to medium-term of the next five to ten years.

- 1. Incident Management**
- 2. Traffic Control**
- 3. Pre-Trip Traveler Information**
- 4. Route Guidance/En-Route Traveler Information**

Accordingly, this report has focused on these services and has developed a series of quantitative and qualitative techniques that can be used to measure the results these services will achieve for New Jersey transportation customers. For each customer service at least two measurement techniques have been defined, one employing a lower-cost, simpler approach and the other a higher-cost, more complex approach. Additionally, for each measurement technique proposed, a detailed estimate of the hours of labor needed and the expenses which may be expected to be incurred is presented in the Appendix.

## **1.0 Introduction**

The New Jersey Department of Transportation (NJDOT) Integrated Transportation Management Strategies (ITMS) Master Plan proposes using various Intelligent Transportation Systems (ITS) strategies and technologies to deliver services to New Jersey's transportation system customers. The purpose of this report is to develop quantitative and qualitative evaluations of customer service delivery that can measure achievement of the results intended, such as lower overall trip time, reduced incident-related delay, better knowledge of travel options and conditions, etc. Accordingly, this report will employ the following steps in developing those evaluations:

**Step 1** - Describe the purpose of each customer service recommended in the ITMS Master Plan, how it is envisioned to work and the general positive effects and benefits typically associated with it, as well as an inventory of the strategies and technologies proposed in the ITMS Master Plan to deliver the service. Since the ITMS Master Plan determined two levels of priority for customer services, with the first level describing those services planned to be deployed in the near- to medium-term of the next five to ten years, the development of measurement techniques will focus on these higher priority services.

**Step 2** - Identify specific benefit characteristics associated with the higher priority services, based on the information from Step 1 above, including data requirements necessary to quantify their achievement.

**Step 3** - Recommend two methods for evaluating the results achieved by delivering each of the higher priority services, incorporating the general parameters and data requirements described above, with one using fairly simple, low-cost techniques and the other using more complex, higher-cost techniques. Included in this step will be a description of required resources for implementation of each evaluative technique. This is intended to give a planning level estimate of the commitment needed to pursue the program recommended.

## **2.0 ITMS Master Plan Customer Service Prioritization**

Following the results of the benefit-cost analyses contained within the ITMS Master Plan, NJDOT has selected five of the eleven recommended customer services from the plan for higher priority deployment in the next five to ten years. The remaining customer services have been assigned lower, longer term priority for general implementation (although retaining the possibility for demonstration projects of an isolated nature). Hence, this report will devote more attention, particularly in terms of defining evaluative techniques, to the higher priority customer services that are anticipated to be generally deployed in the near term.

### **2.1 Higher-Priority, Early Deployment Customer Services**

These customer services have been assigned higher priority for early deployment by NJDOT.

- 1. Incident Management**
- 2. Traffic Control**
- 3. Pre-Trip Traveler Information**
- 4. Route Guidance/En-Route Traveler Information**

For each of these five customer services, the following sections describe their purpose, how they work and help, and the strategies and technologies to make them happen.

## **2.1.1 Incident Management**

*Purpose* - Helps public and private organizations in New Jersey quickly identify incidents and implement a response to minimize their effects on travel.

*How It Works and Helps* - This service enhances existing capabilities for detecting and verifying incidents, in both urban and rural areas, and then responding appropriately. The service would use advanced sensors, such as radar detectors on freeway sections and loops from arterial signals, data processing, and communications, such as fiber optic, to improve the incident management and response capabilities of transportation and public safety officials, the towing and recovery industry, and others involved in incident response. The service will help these groups to quickly and accurately identify a variety of incidents, and to implement a response which minimizes the effects of these incidents on the movement of people and goods. Through improved information and data about operations characteristics and practices, this service will also help transportation officials to predict traffic or highway conditions so that they can take action in advance to prevent potential incidents or minimize their impacts. While the direct users of this service are the public and private entities responsible for incident detection and response, the ultimate beneficiaries are commercial and transit operators, and the traveling public.

### Strategies and Technologies to Make It Happen

Table 1 below lists all the functions required to deliver the incident management customer service and the strategies and technologies that have been identified to perform them. It should be noted that some strategies and technologies have a primary role in performing the functions, such as incident detection directly via radar detectors or indirectly via signal system loop detectors (a change in timing plans initiated by the system may be indicative of an incident), whereas others, such as weather stations, provide information that is supplemental and thus have a secondary role. Primary and secondary roles for strategies and technologies in performing required functions to deliver the customer service are indicated by a (P) or an (S), respectively, at the end of each descriptive bullet.

**Table 1**  
**Incident Management Customer Service**  
**Functions Required and Recommended Strategies and Technologies to Perform Them**

<b>Function</b>	<b>Recommended Strategies and Technologies</b>
<i>Surveillance</i>	<ul style="list-style-type: none"> <li>- Incident detection (includes radar detectors as above, secondary information from inductive loops associated with arterial signal systems, etc.) (P)</li> <li>- Closed circuit television (incident detection and verification, vehicle counts and classification) (P)</li> <li>- Weather stations/ice detection (S)</li> <li>- Emergency Service Patrols (P)</li> <li>- Cellular call-in (P)</li> <li>- Call boxes (P)</li> </ul>
<i>Communications</i>	<ul style="list-style-type: none"> <li>- Fiber optic communications (P for interconnection of individual agency operations centers, S otherwise)</li> <li>- Telecommunications company facilities (includes leased lines: dial-up lines, ISDN, T1 lines, etc.) (P)</li> <li>- Wireless media (microwave, spread spectrum radio, etc.) (S)</li> </ul>
<i>Traveler Interface</i>	<ul style="list-style-type: none"> <li>- Traveler information systems (includes variable/changeable message signs, highway advisory radio, highway/transit advisory telephone, kiosks, etc.) (P)</li> <li>- Internet/World Wide Web homepage (P)</li> </ul>
<i>Control Strategies</i>	<ul style="list-style-type: none"> <li>- Incident management plans (P)</li> <li>- Individual agency operations centers (e.g., NJDOT Traffic Operations Center - North) (P)</li> <li>- Alternative routes (includes traffic control/computerized signal systems, variable/changeable message signs, highway advisory radio, surveillance, etc.) (P)</li> </ul>
<i>Navigation/Guidance</i>	<ul style="list-style-type: none"> <li>- Highway advisory radio (P)</li> <li>- Variable/changeable message signs (P)</li> <li>- One-tenth mile-markers (S)</li> </ul>
<i>Data Processing</i>	<ul style="list-style-type: none"> <li>- System software (e.g., MIST for NJDOT) (P)</li> <li>- Traffic signal masters/controllers (P)</li> <li>- Variable/changeable message sign controllers (P)</li> <li>- Highway advisory radio system controllers (P)</li> <li>- Weather station/ice detection controllers (S)</li> <li>- Traffic monitoring system (includes video processors, weigh-in-motion processors, etc.) (S)</li> <li>- Multi-Agency Clearinghouse for Information Integration and Dissemination (P)</li> </ul>

### **2.1.2 Traffic Control**

Purpose - Manages traffic movement with computerized traffic signal systems and other control devices on New Jersey's State Highway System.

How It Works and Helps - This service will provide for the integration and adaptive control of the freeway and surface street systems to improve the flow of traffic, give preference to public safety, transit or other high occupancy vehicles, and minimize congestion while maximizing the movement of people and goods. Through appropriate traffic controls, the service will also promote the safety of non-vehicular travelers, such as pedestrians and bicyclists. This service

requires advanced surveillance of traffic flows, analysis techniques for determining appropriate traffic signals and ramp metering controls, and communication of these controls to the wayside infrastructure. This service gathers data from the transportation system, organizes it into usable information, and uses it to determine the optimum assignment of right-of-way to vehicles and pedestrians. The real-time traffic information collected by the Traffic Control service also provides the foundations for many other services.

Strategies and Technologies to Make It Happen

Table 2 below lists all the functions required to deliver the traffic control customer service and the strategies and technologies that have been identified to perform them. It should be noted that some strategies and technologies have a primary role in performing the functions, such as surveillance via signal system loop detectors, whereas others, such as wireless media, have a secondary role. Primary and secondary roles for strategies and technologies in performing required functions to deliver the customer service are indicated by a (P) or an (S), respectively, at the end of each descriptive bullet.

**Table 2**  
**Traffic Control Customer Service**  
**Functions Required and Recommended Strategies and Technologies to Perform Them**

<b>Function</b>	<b>Recommended Strategies and Technologies</b>
<i>Surveillance</i>	<ul style="list-style-type: none"> <li>- Traffic signal system detection (may include radar detectors, inductive loops, etc.) (P)</li> </ul>
<i>Communications</i>	<ul style="list-style-type: none"> <li>- Fiber optic communications (P for interconnection of individual agency operations centers, S otherwise)</li> <li>- Telecommunications company facilities (includes leased line, ISDN, T1 lines, etc.) (P)</li> <li>- Wireless media (microwave, spread spectrum radio, etc.) (S)</li> </ul>
<i>Control Strategies</i>	<ul style="list-style-type: none"> <li>- Semi-actuated arterial traffic signal systems with bus preference where applicable as determined by NJDOT/NJ TRANSIT interagency coordination (P)</li> <li>- Variable/changeable message signs (P)</li> <li>- Highway advisory radio (P)</li> <li>- Individual agency operations centers (e.g., NJDOT Traffic Operations Center - North) (P)</li> </ul>
<i>Data Processing</i>	<ul style="list-style-type: none"> <li>- System software (e.g., MIST for NJDOT) (P)</li> <li>- Signal system masters/controllers (P)</li> <li>- Multi-Agency Clearinghouse for Information Integration and Dissemination (S)</li> </ul>

**2.1.3 Pre-Trip Traveler Information**

Purpose - Provides information for selecting the best transportation mode, departure time, and route.

How It Works and Helps - Pre-trip travel information allows travelers to access a complete range of intermodal transportation information at home, work, and other major sites where trips originate. Real-time information on transit routes, schedules, transfers and fares, and ride matching services are available to encourage the use of alternatives to the single occupancy vehicle. Information needed for long, interurban or vacation trips would also be available. Real-time information on accidents, road construction, alternate routes, traffic speeds along given routes, parking conditions, event schedules, and weather information is also included. Based on

this information, the traveler can select the best route, modes of travel and departure time, or decide not to make the trip at all.

Strategies and Technologies to Make It Happen

Table 3 below lists all the functions required to deliver the Pre-Trip Traveler Information customer service and the strategies and technologies that have been identified to perform them. It should be noted that some strategies and technologies have a primary role in performing the functions, such as traveler interface via kiosks, whereas others, such as performing the communications function via wireless media, have a secondary role. Primary and secondary roles for strategies and technologies in performing required functions to deliver the customer service are indicated by a (P) or an (S), respectively, at the end of each descriptive bullet.

**Table 3**  
**Pre-Trip Traveler Information Customer Service**  
**Functions Required and Recommended Strategies and Technologies to Perform Them**

<b>Function</b>	<b>Recommended Strategies and Technologies</b>
<i>Surveillance</i>	<ul style="list-style-type: none"> <li>- Vehicle detection (includes radar detectors, inductive loops, etc.) (P)</li> <li>- Closed circuit television (incident verification) (P)</li> <li>- Weather stations/ice detection systems (P)</li> </ul>
<i>Communications</i>	<ul style="list-style-type: none"> <li>- Fiber optic communications (P for interconnection of individual agency operations centers, S otherwise)</li> <li>- Telecommunications company facilities (includes leased line, ISDN, T1 lines, etc.) (P)</li> <li>- Wireless media (microwave, spread spectrum radio, etc.) (S)</li> </ul>
<i>Traveler Interface</i>	<ul style="list-style-type: none"> <li>- Kiosks (P)</li> <li>- Internet/World Wide Web homepage (P)</li> <li>- Print/television/radio (S)</li> <li>- Computers/electronic bulletin boards (S)</li> </ul>
<i>Data Processing</i>	<ul style="list-style-type: none"> <li>- System software (e.g., MIST for NJDOT) (P)</li> <li>- Kiosk Servers (P)</li> <li>- Weather station/ice detection controllers (P)</li> <li>- Multi-Agency Clearinghouse for Information Integration and Dissemination (P)</li> </ul>

**2.1.4 Route Guidance and En-Route Driver Information**

Purpose - Route guidance provides customers with simple directions on how to best reach their destinations. En-Route Driver Information supplies driver advisories for convenience and safety.

How They Work and Help - The route guidance service provides a suggested route to reach a specified destination. Early route guidance systems will be based on static information about the roadway network, transit schedules, etc. When fully deployed, route guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system. The route guidance service will consider traffic conditions, status and schedule of the transit systems, and road closures in developing the best route. Directions will generally consist of simple instructions on turns or other upcoming maneuvers. Users of the service include not only drivers of all types of vehicles, but also non-motor vehicle travelers, such as pedestrians or bicyclists. En-Route Driver Information conveys real-time information to travelers underway about traffic conditions, incidents, construction, transit schedules, and weather conditions to drivers of personal, commercial, and public transit vehicles. This

information allows the driver to select the best route, or shift to another mode in mid-trip if desired.

Strategies and Technologies to Make Them Happen

Table 4 below lists all the functions required to deliver the En-Route Driver Information and Route Guidance customer services and the strategies and technologies that have been identified to perform them. It should be noted that some strategies and technologies have a primary role in performing the functions, such as traveler interface and navigation/guidance via Highway Advisory Radio (HAR) and Variable Message Signs (VMSs), whereas others, such as performing the communications function via wireless media, have a secondary role. Primary and secondary roles for strategies and technologies in performing required functions to deliver the customer service are indicated by a (P) or an (S), respectively, at the end of each descriptive bullet.

**Table 4**  
**Route Guidance/En-Route Traveler Information Customer Services (Including**  
**Alternate Routes)**  
**Functions Required and Recommended Strategies and Technologies to**  
**Perform Them**

<b>Function</b>	<b>Recommended Strategies and Technologies</b>
<i>Surveillance</i>	<ul style="list-style-type: none"> <li>- Vehicle detection (includes radar detectors, inductive loops from arterial traffic signal systems, etc.) (P)</li> <li>- Closed circuit television (incident verification) (P)</li> <li>- Weather stations/ice detection systems (P)</li> </ul>
<i>Communications</i>	<ul style="list-style-type: none"> <li>- Fiber optic communications (P for interconnection of individual agency operations centers, S otherwise)</li> <li>- Telecommunications company facilities (includes leased line, ISDN, T1 lines, etc.) (P)</li> <li>- Wireless media (microwave, spread spectrum radio, etc.) (S)</li> </ul>
<i>Traveler Interface</i>	<ul style="list-style-type: none"> <li>- Traveler information systems (includes variable/changeable message signs, highway advisory radio, etc.) (P)</li> <li>- In-vehicle displays (S)</li> <li>- Cellular telephone (S)</li> <li>- Highway advisory telephone (S)</li> </ul>
<i>Control Strategies</i>	<ul style="list-style-type: none"> <li>- Individual agency operations centers (e.g., NJDOT Traffic Operations Center - North) (P)</li> </ul>
<i>Navigation/Guidance</i>	<ul style="list-style-type: none"> <li>- Highway advisory radio (P)</li> <li>- Variable/changeable message signs (P)</li> <li>- In-vehicle displays (S)</li> <li>- One-tenth mile-markers (S)</li> </ul>
<i>Data Processing</i>	<ul style="list-style-type: none"> <li>- System software (e.g., MIST for NJDOT)</li> <li>- Traffic signal masters/controllers</li> <li>- Variable/changeable message sign controllers (P)</li> <li>- Highway advisory radio system controllers (P)</li> <li>- Weather station/ice detection controllers (P)</li> <li>- Multi-Agency Clearinghouse for Information Integration and Dissemination (P)</li> </ul>

**2.2 Lower-Priority, Later Deployment Customer Services**

In addition to the customer services described in detail above, NJDOT has assigned a lesser priority and later date for general deployment (although certain individual projects may be pursued on a demonstration basis) for the following six customer services also recommended in the ITMS Master Plan:

- 1. En-Route Transit Information**
- 2. Demand Management and Operations**
- 3. Public Transportation Management**
- 4. Commercial Vehicle Electronic Clearance**
- 5. Freight Mobility**
- 6. Electronic Payment**

The next sections provide similar information to the tables above, albeit with less detail owing to the lower priority and later deployment, concerning the purpose of these customer services, how they work and help, and the strategies and technologies to make them happen.

### **2.2.1 En-Route Transit Information**

Purpose - Provides information to public transportation customers after they begin their trip.

How It Works and Helps - This service provides information to assist the traveler once public transportation begins. Real-time, accurate transit service and traffic information on board the vehicle helps travelers make effective transfer decisions and itinerary modifications after the trip is underway.

Strategies and Technologies to Make It Happen

- On-board vehicle display system.

### **2.2.2 Demand Management and Operations**

Purpose - Provides support for customers to use high occupancy vehicles and to use rail transit as an alternative mode, both of which are designed to mitigate the environmental and social impacts of traffic congestion.

How It Works and Helps - This service generates and communicates management and control strategies that support the implementation of programs to reduce the number of individuals who choose to drive alone, especially to work; increase the use of transit and high occupancy vehicles; and provide a variety of mobility options for those who wish to travel in a more efficient manner, for example in non-peak periods.

Strategies and Technologies to Make It Happen

- High Occupancy Vehicle Lane Treatments
- Rail Transit as an Alternative Mode
- Electronic Cottage; Telecommuting

### **2.2.3 Public Transportation Management**

Purpose - Automates operations, planning, and management functions for NJ TRANSIT and other public transit providers in New Jersey.

How It Works and Helps - This service provides computer analysis of real-time vehicle and facility status to improve transit operations and maintenance. The analysis identifies deviations from schedule and provides potential solutions to dispatchers and drivers. Integrating this capability with traffic control services can help maintain transportation schedules and assure transfer connections in intermodal transportation. Information regarding passenger loading, bus running times, and mileage accumulated will help improve service and facilitate administrative reporting. Automatically recording and verifying performed tasks will also enhance transit personnel management.

Strategies and Technologies to Make It Happen

- Automatic Vehicle Locator (AVL) System
- Transit Vehicle Maintenance Information System
- Transit Vehicle Fluids Management System

## **2.2.4 Commercial Vehicle Electronic Clearance**

Purpose - Helps trucking customers in New Jersey travel at weigh stations at border crossings and within the state by weighing their vehicles on the mainline without stopping or reducing speed.

How It Works and Helps - This service will enable commercial vehicles to have their weight checked at mainline speeds. Vehicles of legal weight will be allowed to pass the weigh station without delay.

Strategies and Technologies to Make It Happen

- Weigh In Motion
- Credential Verification via Wayside Reader

## **2.2.5 Freight Mobility**

Purpose - Provides real-time communications between customers driving commercial vehicles, their dispatchers, and traffic operations centers in New Jersey.

How It Works and Helps - The availability of real-time traffic information for commercial vehicles would help dispatchers to better manage fleet operations by helping their drivers avoid congested areas and would also improve the reliability and efficiency of carriers' pickup-and-delivery operations. The provision of real-time information from commercial dispatchers to traffic operations centers would significantly expand their surveillance capability at low cost.

Strategies and Technologies to Make It Happen

- Two-way Communication with Trucks
- Dispatcher Communication with Traffic Operations Center

## **2.2.6 Electronic Payment**

Purpose - Allows customers using toll facilities in New Jersey to pay their tolls electronically.

How It Works and Helps - As proposed in the Master Plan, this service will permit commercial vehicle tolls to be paid electronically without stopping at toll plazas. This will help achieve operational, accounting and financial efficiency for both the customer and toll agency. Eventually, as it is deployed to a broader customer base, this service will foster intermodal travel by providing a common electronic payment medium for all transportation modes and functions, including tolls, transit fares, and parking. The service provides for a common service fee and payment structure using "smart cards" or other technologies. Such systems could be truly multi-use, allowing personal financial transactions on the same medium. The flexibility that electronic payment services offer will also facilitate travel demand management, if conditions warrant. They could, if local authorities so choose, enable application of road pricing policies which could influence departure times and mode selection. A further application is the use of tagged vehicles to monitor traffic flow conditions.

Strategies and Technologies to Make It Happen

- Electronic Toll Collection

### **3.0 Policy Goals, Customer Needs and Customer Service Delivery**

The process of measuring the results achieved by delivering ITS customer services, to be of greatest possible value to NJDOT, must necessarily be prefaced by two key pieces of information. First, the relative policy importance of achieving the goals and objectives to be attained by delivering the particular customer service must be known. Second, it must also be known, from the customer's point of view, how important it is to satisfy the needs and wants that the particular customer service is intended to address. The policy priorities are ones which NJDOT must define as part of its overall managerial effort and the ITMS Master Plan has provided direction in this area. The New Jersey customer's viewpoint about ITS, initially investigated and presented in the ITMS Master Plan and additionally researched in several other efforts, notably the TRANSCOM report titled "The Public's Interest In and Willingness to Pay For Enhanced Traveler Information as Provided by IVHS" and I-95 Corridor Coalition Project No. 6 - User Needs and Marketability, should be monitored on an ongoing basis.

One possible way to present evaluation results that gives due emphasis to the policy and customer perspectives is to use a matrix method with a composite score for outcomes that presents both their policy and customer importance along with the outcome of the evaluation process that shows measurement of results achieved. This will help maintain a sense of proportion that achieving 90% performance for a goal of 10% importance is not as important as achieving 20% performance for a goal of 90% importance.

Even if the antecedent questions regarding policy and customer importance have been answered (thus providing a context for the information to be obtained by measuring the results achieved from customer service delivery), caution still must be observed to yield a useful analysis. This is true for two reasons. First, any measurement of results achievement for a particular customer service must recognize the strong interrelationships among the various technologies to deliver customer services such that there may be more than one technology option by which to deliver the desired service and its related components (e.g., the incident detection element of incident management may be done by Cellular Call-In, Call Box, Inductive Loop, Radar, Machine Vision, etc.) and that a single technology option can serve multiple customer services (e.g., detection can serve both incident management and traffic control). Second, there is a great deal of similarity in the types of benefit amongst the different customer services. Consequently, a particular element of benefit data may carry with it the effects of several different customer services (presuming delivery is occurring simultaneously). Of course, to the degree possible, it would be desirable to measure only those benefits accruing to one particular customer service. To help understand the effects resulting from the delivery of individual customer services, Table 5 presents the categories of benefit in the ITMS Master Plan for which data are most readily available for measurement (congestion reduction and air quality) and relates these two categories to the eleven different customer services.

**Table 5  
ITS Customer Services and Benefit Parameters**

ITS Customer Service	Benefit Parameter	
	Congestion Reduction	Air Quality Improvement
Incident Management	Faster detection; more efficient processes and appropriate resources at the site speed clearance; alternate routes lessen load on impacted facility	Reduced Person-Hours Traveled (PHT); reduced CO hotspot intensity; increased speeds
En-Route Driver Information	Better informed drivers will select less congested routes	Reduced PHT and/or Person-Miles Traveled (PMT)
Traffic Control	Improved flow and responsiveness to conditions	Reduced PHT; reduced CO hotspot intensity; increased speeds
Electronic Payment Services	Faster processing and less delay for tagged vehicles; possible delay reduction for other vehicles	Reduced PHT; reduced CO hotspot intensity; increased speeds
Commercial Vehicle Electronic Clearance	No delay for legal weight trucks	Reduced truck idling at weigh stations
Freight Mobility	Better informed drivers will select less congested routes	Small reduction in PHT for commercial vehicles
Pre-trip Travel Information	Better informed travelers will select less congested routes, modes and times	Reduced PMT and PHT, principally from mode shift, some from route and time shift
Demand Management and Operations	Less congestion by less road vehicles and mode shift to rail	Reduced PMT and PHT from more efficient vehicle use and mode shift
Route Guidance	Better informed travelers will seek less congested routes	Reduced PMT and PHT from more efficient route selection
Public Transportation Management	Transit more efficiently managed will encourage use	Reduced PMT and PHT from mode shift
En-Route Transit Information	Transit more market-oriented will encourage use	Reduced PMT and PHT from mode shift

#### **4.0 Data Development for Evaluation**

Delivering customer services to achieve the benefits described in Table 5 preceding revolves around two issues, performance of management and operations tasks and delivery of information. To assess whether or not the management and operations tasks are succeeding requires operations data about the day to day functioning of the transportation system. To assess information delivery requires market data that can be obtained by querying the target customers to find out if they are receiving the information and whether they are using it. The following discussion is intended to provide an example of the varying types of operations and management data and their attributes.

With respect to raw management and operations data, Table 6 following summarizes key data sources in terms of data cost, accessibility and quality.

**Table 6**  
**Management and Operations Data**  
**Data Sources and Associated Cost, Accessibility and Quality Characteristics**

<i>Source of Raw Management and Operations Data</i>	<i>Incremental Cost of Data Collection</i>	<i>Ease of Data Collection</i>	<i>Regularity of Data Gathering</i>	<i>Repeatability/Uniformity of Data Gathering</i>	<i>Timeliness - Historic and Current Data</i>
Permanent Count Station	Low	High	High	High	High
Quarterly Counts	Low	High	High	High	High
Spot ATR Counts	Medium	Medium	Low	Medium	Low
Classification Counts	Medium	Medium	Low	Medium	Low
Aerial Surveillance	High	Low	Low	High	Medium
NJDOT ESP Reports	Low	Medium	Medium	Medium	Medium
NJDOT Accident Records	Low	Medium	High	High	Low
Individual Police Agency Accident Reports	High	Low	Low	Low	Low
NJDEPE Hazmat Incident Reports	High	Low	High	High	High
TRANSCOM Log	Low	High	High	High	High
NJ Turnpike Authority Log	Low	Medium	High	High	High
NJ Highway Authority Log	Low	Medium	High	High	High

In the event that control sites are used to establish comparative norms for reference in future evaluation efforts, it is important that data include certain descriptors to characterize sites appropriately to enable valid comparisons. The following categories are recommended:

1. Urban, Rural
2. Freeway/Interstate/Other Limited Access, Divided Arterial, Undivided Arterial
3. Shoulders/No Shoulders (for assessing Incident Management)
4. For arterials, number of curb cuts/access points per mile
5. For arterials, signal density (spacing less than 2 miles)
6. For freeway/interstate/other limited access, average miles between interchanges

## **5.0 Evaluation Methodology**

The following discussion will present methods for evaluating the high-priority customer services: incident management, traffic control, pre-trip traveler information, route guidance, and en-route traveler information. When these evaluation techniques are employed, it is important that the following guidelines be observed with respect to: (1) control sites to be used to evaluate sites where no "before" data exists; and (2) interpretation of results. Regarding control sites, since there is no existing documentation about specific criteria to establish control sites using typical parameters such as volume or level of service for any of the techniques discussed, it is recommended that control sites be selected according to experienced operations engineering judgment. This judgment will be based on many factors but should particularly include documentation of what is occurring both upstream and downstream (especially downstream) of the site chosen. The reason to account for behavior in adjacent areas is that many strategies also contain the possibility of shifting the location of the problem in addition to solving it. In terms of interpretation of results, for every evaluation performed, a necessary final step will be such an interpretation of the outcome and data obtained including a conclusion and recommendation for action. Of course, depending on the findings of the evaluation, the conclusion may be that everything is working and that the recommended action is to do nothing (with the possibility of follow-up investigations at some future time or interval).

Estimates of labor and expense resources necessary to execute these methods are included in the appendix.

### **5.1 Incident Management Evaluation**

The principal quantifiable customer benefit that will accrue to incident management is delay reduction. Incident management can reduce delay in five important ways:

- 1.** By employing automatic detection equipment, incident management can reduce the time required for incident detection.
- 2.** Incident management can take less time for incident verification, frequently making it coincident with detection where cameras are in place that can provide views of the scene.
- 3.** Incident management can lessen the time needed to bring appropriate resources to the scene and facilitate their use in a planned and organized manner.
- 4.** Improved traffic management procedures at the scene, integrated as part of the overall incident resolution process, can help queue dissipation begin sooner and occur more efficiently.
- 5.** Finally, incident management can reduce queue build-up by clearing the traveled way more quickly, by using alternate routes to divert traffic and by warning off potential travelers with advance information.

These possible delay reductions, coupled to the amount of traffic affected by them, result in a benefit that can be expressed in either vehicle-hours or person-hours (assuming that average vehicle occupancy is known or can be reasonably estimated).

It is relatively easy to measure or estimate the amount of traffic affected by an incident and the associated geometric characteristics for a section of roadway impacted by an incident. This is due to the fact that a high quality database exists and can be readily supplemented by straightforward additional data gathering. However, it is much more difficult, time consuming and expensive to directly measure the operational performance characteristics and the amount of resultant delay associated with a particular incident. Since obtaining this type of data is costly and complex, the recommended lower cost, simpler approach for incident management evaluation will focus on a process whose analyses do not require its direct input but rather can be driven by more easily acquired traffic and geometric data. To do so will entail a modeling process that uses fairly standardized national data to estimate the potential operational effects of

incidents and incident management. Accordingly, the lower-cost, simpler approach recommended here for evaluation of incident management will employ this type of modeling process. On the other hand, the higher-cost, more complex approach recommended here will combine better traffic information with procedures designed to identify incident-related operational characteristics and delay behavior more precisely with respect to specific New Jersey conditions.

### **5.1.1 Incident Management Evaluation - Lower-Cost, Simpler Approach**

This section will be presented in two parts. The first part will describe application of the evaluation technique and the results it is expected to produce. The second part will describe the resources required to implement the evaluation technique.

#### **5.1.1.1 Evaluation Technique Application and Results**

A recent Federal Highway Administration study developed an empirical computerized model of incident occurrence and severity intended for estimating the incident impacts expected for particular urban freeway segments and traffic volumes, and for quantifying the expected changes in incident impacts corresponding to improvements to freeways, traffic management, and incident management procedures. The computerized model is called "IMPACT." The study also made recommendations about national guidelines for incident data collection to enable more comprehensive and consistent treatment of key variables with respect to planning and operations issues in incident management. The following is a brief description of the process used to develop "IMPACT."

The "IMPACT" model considered incidents that:

1. occurred on urban freeways;
2. affected traffic flow; and
3. were amenable to impact mitigation by intervention of incident response agencies.

The "IMPACT" study made the following conclusions and recommendations about data gathering. Data gathering should:

1. handle incident types now reported (accidents, fires, disabled vehicles, debris) as well as those now often unreported (enforcement, construction, maintenance activities)
2. provide better information about traffic conditions at the incident time and location as well as traffic/incident management actions performed

Specific incident data uses identified in the model development process included justification and management of incident response capabilities, assessment of urban traffic operations improvements, and planning and programming of traffic improvements at all levels.

Incident data analyses of the modeling effort showed regular, logical incident patterns on urban freeways consistent with the traffic environment and existing management systems. These regularities and patterns permitted development of an incident impact methodology, implemented in the "IMPACT" computer model, applicable to a wide range of US urban conditions. The "IMPACT" model considers seven incident types (abandoned vehicle, accident/fire, debris, mechanical/electrical, stalled, tire, other) and then identifies four sets of relationships which join together in a process to predict and assess incident impacts. The four sets of relationships are:

1. Incident rate "models," to estimate the number of incidents by type.
2. Incident severity "models," to estimate the likelihood that incidents of a given type block one or more lanes, or occur on the shoulder (with the corresponding capacity reduction implications).

3. Incident duration "models," to estimate resolution time for incidents of given types and severities depending, among other things, on local incident detection and response capabilities.
4. An incident impact "model," to estimate the delays due to incidents of given types, severities and durations. Although delays depend on the time distribution of traffic demand, local short-term demand management capabilities (principally diversion plans and real-time traveler information services) and the road network configuration (determines alternate route availability), the developed model employs only demand distributions. The remaining factors have been excluded because available data and theory are inadequate to establish meaningful quantitative relationships sensitive to demand management capabilities.

The "IMPACT" model produces output which quantifies expected delay due to freeway incidents, as determined by roadway conditions, traffic conditions, and existing or proposed incident management capabilities. The remaining discussion summarizes the inputs required by the "IMPACT" model and the outputs it produces.

With respect to inputs, the "IMPACT" model design maximizes the use of default parameters so that it can be employed even when detailed data on traffic and road conditions are unavailable. Table 7 shows the inputs required, ranging from a general header to specific data about the freeway section or sections under evaluation. Since model calibration data were inadequate to explore the relationships concerning the effect of weather on incidents and the effect of the local definition threshold of a "major" incident (and thus the impact of having a "major" incident response team available), they have been reserved for future use when these two empirical relationships become available.

**Table 7**  
**"IMPACT" Model Input Data Requirements**

Data Item	Description
<b>General Information</b>	
Header	Text used to label printed output.
Climate Code (future use)	Code indicating days per year of precipitation.
Major Incident (future use)	Local definition of "major" incident.
<b>Freeway Section Characteristics</b>	
Centerline length	Section length in miles.
Number of lanes	Mainline width (one direction).
2-way AADT	Annual average daily traffic (vehicles per day).
Peak hours per day (model has default value)	Sum of morning and evening peak period lengths.
K-factor (model has default value)	Percent of weekday ADT occurring during the design hour (the typical peak hour)
D-factor (model has default value)	Percent of total peak hour traffic in the heavier direction.
Percent trucks	The percentage of peak hour traffic that consists of trucks; used to estimate capacity.
AAWT/AADT (model has default value)	Ratio of average weekday traffic to AADT.
Shoulder type	Left side, right side, both sides or none (8 foot shoulders or greater).
Traffic Management	Type of incident detection and response system: None, Traffic Management Center only, "Major" Incident Response Teams, Freeway Service/Motorist Assistance Patrols, or User-Defined.

The "IMPACT" model produces four specific outputs as below:

1. The estimated capacities for all freeway sections.
2. The peak and off-peak sectional traffic volumes and the number of incidents per year, for each of the seven incident types within the model and the total.
3. For each section, the proportions of incidents by type occurring on shoulders or in-lane, by severities of the lane blockages, with estimates of the remaining capacities.
4. For each section, the total annual peak and off-peak vehicle hours of delay, for the seven incident types and the total.

Beyond the normal input data, the "IMPACT" methodology has several sets of quasi-permanent data which the user can access and modify. These data include various components of the four calibrated incident impact submodels as well as another group of data termed "assumptions."

The four incident impact submodels with elements that can be adjusted by the user are the incident rate submodel; incident severity submodel; incident duration submodel; and delay submodel. For example, within the duration submodel are estimated detection and response times for accidents and all in-lane incidents and all other incident types for each type of incident management (none, traffic management center, "major" incident response team, freeway service/motorist assistance patrols, user-defined) with the user-defined category defaulting to the values used for no incident response capability in place and intended to be modified by the user. Similar types of adjustments can be made elsewhere in the submodels.

Beyond various factors in the submodels, certain assumptions are also able to be changed. These include:

**Capacity Parameters.** The "IMPACT" model estimates section capacities using the method of Chapter 3 in the 1985 *Highway Capacity Manual*. The model uses a number of assumed parameter values, such maximum service flow rate (MSF), population factor, width factor, and truck equivalency factor. These values are user-adjustable, if desired.

**Volume Distribution Parameters.** These parameters contain default values as noted previously for peak period length, K and D factors, and AAWT/AADT ratio, as well as the number of non-holiday weekdays per year (initially set to 250 days).

**Traffic Volume Polynomial Parameters.** These parameters are the time-of-day traffic volume distributions adapted from the FREWAY program, fit to 9th degree polynomial functions.

**Polynomial Evaluation Times.** These values are the times of day for which the traffic volume polynomials are evaluated, and the portion of incidents associated with each evaluation time (initially set proportional to the amount of traffic represented each evaluation time on the grounds that the number of incidents are roughly proportional to the vehicle-miles of travel). This information is required by the delay submodel.

The assumptions data can be accessed and adjusted, if necessary, to specific New Jersey conditions. Due to the comprehensive national database used in the model development and the consistency of relationships noted, it is unlikely that this adjustment would be needed. However, if adjustments prove necessary, to do so would require specialized expertise. This is because, except for the straightforward capacity and volume distribution parameters, making changes to other parameters requires intimate knowledge of the internal logic of the delay model.

### **5.1.1.2 Required Resources for Evaluation Technique Implementation**

Implementing the "IMPACT" model evaluation technique will require allocation of both initial, start-up resources as well as an ongoing resource commitment so that the process can produce useful output over time. Among the initial costs are software installation (the software is supplied by FHWA and is in the public domain, so this should be minimal), training personnel to use the software, and any modifications to the Highway Performance Monitoring System (HPMS) and Federal Aid Primary (FAP) files maintained by NJDOT as may be required to facilitate automated data input. The ongoing costs include data input (either manual or automatic), actual implementation of the application, updates and refinements to the software, and, finally, development, interpretation and presentation of results to appropriate units within NJDOT and external agencies. The actual staffing and equipment levels needed will depend upon the intensity with which this technique is pursued. This could range from a part-time effort from a single individual to several persons.

### **5.1.2 Incident Management Evaluation - Higher Cost, More Complex Approach**

Similar to the foregoing, this section will also have two parts. The first part will describe application of the evaluation technique and the results it is expected to produce. The second part will describe the resources required to implement the evaluation technique.

#### **5.1.2.1 Evaluation Technique Application and Results**

This approach involves creation of baseline incident performance data for facilities of various types (multiple lane freeway, arterial, etc.) without incident management systems in place which can then be used as a basis for comparison with incident performance data for facilities which have incident management systems. The objectives of the approach are to document total response time, resolution time, traffic flow rates at the scene, and queue build-up and dissipation. Total response time is the total time required to deploy personnel, equipment and strategies to respond to the incident. Resolution time is the total amount of time that responders of any kind are at the scene, from the moment the first arrives to the moment the last departs. Queue flow rates are determined by established calculation procedures relating the number of open lanes at the site to the total number of lanes available; these procedures account for the extra "friction" induced by the presence of an incident scene. Queue build-up and dissipation is accounted for by comparison of the flow rates that occur during an incident from the beginning of the incident to the complete dissipation of the queue to the total traffic demand experienced by the roadway. Alternate route use and delay of travel because of the incident are two key factors that will reduce the level of demand. The following describes the methods to be used in developing the baseline data.

Baseline data development will consist of selecting roadways and facilities and then documenting their existing incident performance. Roadways and facilities should be selected according to the presence of non-recurring congestion in the ITMS Master Plan, high levels of traffic volume, and the absence of incident management systems. At the minimum, one freeway each of two, three and four lanes should be selected along with one single lane and one double lane arterial.

For each roadway or facility to be included in development of the incident performance baseline, as well as for any roadway or facility for which incident management is being evaluated, the data gathering below should be performed.

*Determine Traffic Volume and Composition* - ATR counts should be performed on the designated section for development of the incident performance baseline. In the case of evaluating incident management systems performance, the counts should be performed at the

incident location after the incident. The reason for performing the counts after the incident is that it may shed light on possible alternate route or other traffic diversion behavior during the incident. For example, given the processing rate and queue data from the incident, it is possible to derive the arrival rate, or the level of traffic on the road, at the time of the incident. This can then be compared to usual traffic levels at the incident location in the same time interval under non-incident conditions. If there is a significant difference in the derived and post-incident measured value, it will indicate likelihood that a diversion occurred. Finally, if possible, these counts should be supplemented by vehicle classification counts and, if possible, a vehicle occupancy survey, to assist with impact determination.

*Determine Response and Resolution Time* - These two data elements are important because they show how long it takes to bring appropriate resources to the scene and how long they are at the scene (even if they are not actively engaged in the resolution process, their mere presence has an impeding effect on traffic). This data can be obtained by direct observation at the site or by investigation of responder logs and reports after the incident concludes.

*Determine Incident Site Traffic Capacity and Possible Alternate Route Use* - The next step should be to determine the status of roadway operations and available capacity at the incident site as the incident is being cleared and the use of alternate routes. These tasks can be accomplished by either review of individual agency logs or by direct observation of performance when incidents occur. It is recommended that direct observation be used (especially for determining the processing or flow rate at the incident site) because this will help achieve data uniformity and reliability. Direct observation can be accomplished by an observer/auditor at the site or by aerial surveillance during daylight hours. Where possible, aerial surveillance should be used since this will permit observation of alternate route usage.

*Identify Queue Build-Up, Length and Dissipation Time* - The final step is to determine the amount of queue build-up, queue length and subsequent dissipation. This can be done by direct observation at the site or by aerial surveillance during daylight hours. It is important that queues in both directions, in the incident direction and in the non-incident direction due to "gapers" be accounted.

## **Analysis Design**

The data collected will permit estimates of the processing rate, or road capacity, under incident conditions for the incident and non-incident direction as well as the time it takes for the processing rate or capacity to be restored. These can then be compared to the arrival rates for traffic, which are the measured ATR volumes, and relationships can then be constructed for different types of facilities, under different types of incident conditions. This will serve as the basis for comparison for implementation of incident management which has the capability to increase the processing rate at the incident site and speed return of the pre-incident processing rate due to more efficient allocation of appropriate resources. Since incident management can also affect the arrival rate by implementation of alternate routes and by informing travelers who will choose to defer their trips, this factor can also be measured under incident conditions when incident management has been put into place. On the other hand, it may be true that the change in arrival rate could be less than the day to day variation under "usual" traffic conditions. If this is so, a useful comparison may be achieved by comparing the after incident traffic levels to the same time interval for days when the before traffic levels are similar but no incident occurred. In any case, the end result will be a determination of the incident management delay reduction in terms of person-hours (using average occupancy data) and the delay reduction for freight based on the vehicle mix. If desired, an hourly average dollar value can be assigned for person-hours and an average value for freight can also be derived, with value assigned in terms of regional inventory valuation data with respect to an established interest rate or time value of money.

### **5.1.2.2 Required Resources for Evaluation Technique Implementation**

Conducting a field survey of incident performance to develop a database of at least five sites on representative control sections will require a combination of scheduled and on-call activities. For the scheduled activities, once the sites have been selected, traffic and geometric data for each site can then be collected including 24-hour (with 1/4-hour summaries) Automatic Traffic Recorder (ATR) counts for at least a one week time period, with a manual classification and vehicle occupancy count performed during the same time frame. The unscheduled activities will be based upon responding on-call to incident occurrences within a specific time period of between two and four weeks in the spring or fall, when traffic is unperturbed by vacation, holiday or winter weather anomalies. The individuals involved in the response will observe and record traffic flow and operating conditions at the incident site as well as using vehicular and/or aerial surveillance to determine queue behavior. On-site traffic and operating conditions monitoring will be done by at least two individuals at the scene. One person will be responsible for monitoring and recording traffic flow and the other will be responsible for monitoring and recording operating conditions such as lane and shoulder blockages. It may be advisable to use a bucket truck on-site so that these workers can get an improved visual perspective. Investigating and recording queue behavior will require at least two individuals with vehicles, one to check the queue in the incident direction and the other in the non-incident direction.

## **5.2 Traffic Control Evaluation**

Evaluation of arterial signal system performance can be done using three parameters: delay, average speed, and number of stops. Various lower-cost, simple and higher-cost, complex approaches can be used in the determination of each parameter. Regardless of which approaches are chosen however, it is important that this evaluation be conducted on a before and after basis and that consistent techniques be used for both time frames.

### **5.2.1 Traffic Control Evaluation - Delay Measurement**

A good evaluation parameter for a signalized arterial is stopped-delay. This strategy measures the typical stopped delay at key traffic signal locations along the subject arterial. The following process can be employed using either a lower-cost, simple approach with counting personnel or a higher-cost, complex approach using aerial surveillance. While field personnel would suffice in many instances, there will be cases where observation of the entire queue during the peaks would be very difficult. In those cases, more complex data collection efforts are needed.

#### **5.2.1.1 Delay Measurement - Lower Cost, Simpler Approach**

This exercise employs two to four field personnel per signalized intersection to measure the queuing. Since the objective of most arterial signal systems is to optimize traffic operations on the arterial mainline, the mainline lanes are the subject of the data collection program. It is assumed that the signal timing adequately serves the side streets. However, if the side street traffic volumes are very high, data coverage may be appropriate for all approaches.

Prior to the initiation of the field data collection, the signalized arterial should be examined to determine "critical" intersections. The "critical" intersections will be subject of all data collection activities. Intersections with state highways or other arterials would be included in the list of critical intersections.

The data is to be collected at regular intervals during the peak period. A timing interval of 20 seconds is recommended for the data sampling. It is not necessary to pick an interval which intentionally does or does not divide evenly into the cycle length. The possibility of introducing error by using the same point in each cycle (as evenly divisible intervals would suggest) could be significant if the count interval were very large. However, given the frequency of data sampling (every 20 seconds), the reliability of the data is quite high. In addition, because the

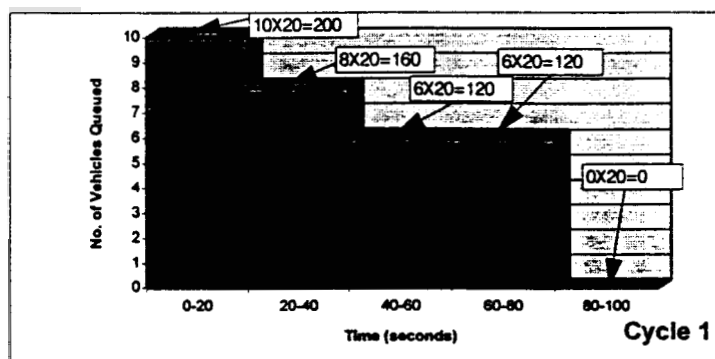
timing interval is not dependent upon cycle length, the method is applicable to arterial signal systems that have variable cycle times, as with adaptive or semi-adaptive signal systems.

Turning movements may affect the evaluation for a signal, particularly if the timing and/or the phasing is revised under the new signal plans. In order to quantify this affect, data is to be collected separately for each intersection lane group on the mainline approach. For example, if there are two through-lanes, a right turn lane, and a left-turn lane at an approach, three separate data sets are to be collected: through stopped-vehicles, right-turn stopped-vehicles, and left-turn stopped-vehicles. In instances where there are shared lanes, data is to be collected for the shared movement. For example, if there is one through and left-turn lane, along with one through and right-turn lane at an approach, two separate data sets are to be collected: shared through/left stopped-vehicles, and shared through/right stopped-vehicles.

The steps in the process are:

1. Select an observation point at the subject intersection where the stop line for the surveyed lane group is clearly visible. The reference point will be the stop-line. Vehicles which pass beyond this point are no longer counted as part of the counted queue.
2. Begin a stopwatch at the beginning of the analysis period and, as accurately as safe field practices will permit, record the number of stopped-vehicles, (vehicles queued at the approach) for each turning movement at the regular timing interval of 20 seconds.
3. Note any unusual events which may have an effect on delay: buses, stalled vehicles, or unloading trucks.
4. Volume counts may maintained for each approach so that delay can be directly related to the *Highway Capacity Manual*. Volume counts can be done with automatic traffic recorders (ATR's) and should be placed far enough before the intersection stop line so as to measure vehicles prior to joining the queue. It is recommended that volume data be collected at a minimum 15-minute intervals.
5. The field data can be reduced in a number of ways to determine total delay. The histogram method provides a graphical display of delay. For each analysis period, plot the number of stopped-vehicles versus time on a histogram where the x-axis is time and the y-axis is the number of stopped-vehicles. The resulting area under the curve is the total delay at the intersection for the analysis period. An example is shown below. The total delay for the subject lane group during the analysis period (for this example, Cycle 1) is  $200+160+120+120+0$  seconds = 600 seconds, or 10 minutes. An average value of delay can be calculated for the peak hour and peak 15-minute period. Values for intersections along an arterial route can be summed to indicate the total average delay for a potential signal system installation.

**Figure 1**  
**Example of Delay Histogram**



6. The data can also be reduced by using a spreadsheet program. Delay (in vehicle-seconds) can be calculated for each timing interval as (number of vehicles queued) X ( 20 seconds). The delay can than be summed for the analysis period.
7. If traffic volume counts are performed along with the stopped-vehicle counts, average delay per vehicle can be calculated and directly related to the *Highway Capacity Manual* level of service (LOS) determinations. A value of average delay per vehicle of 40 to 60 seconds is classified as LOS E. Average delay per vehicle greater than 60 seconds is LOS F.

### 5.2.1.2 Delay Measurement - Higher Cost, More Complex Approach

A more complex approach using aerial surveillance can also be done, particularly in areas where the congestion is very great. While this method is expensive, it can provide valuable data where field collection is difficult. Aerial cameras can collect data with time imprinted to the nearest second. Generally, a zoom angle photo of the intersection would be taken at the beginning of a cycle, and then the camera would pan out to take several more photos during the cycle length in order to track the queue lengths. This would be repeated for several cycles during the peak period. The data collected via this method would probably use a longer count interval (time between images). In addition, in order to be cost-effective, it is recommended that the aerial surveillance cover the entire system during one peak period, so less data per intersection would be collected. Still, the amount of information collected and the accuracy of this method make it very good for very congested areas.

### 5.2.2 Traffic Control Evaluation - Average Speed Measurement

This evaluation involves collection of speed and delay data. For a given arterial route, it is necessary to designate certain intersections as "critical" to the system. The actual timing point is generally located at the stopbars of the critical intersections. In addition, notes are kept between each intersection listing the time spent in queue, or stopped-delay and the cause, if evident. A summary of the steps is presented below:

1. Designate the route and identify critical intersections as timing points. The limits of the arterial travel route should stretch just beyond all traffic signals which are being considered as a candidate for an arterial signal system.
2. Begin a stopwatch when passing over the stopbar of the first intersection. Note the duration and nature of any stops encountered between timing points. Record the time on the stopwatch every time you pass over the stopbar of a timing point intersection. Try to make at least four runs during the peak hour. An example of the type of data collected is shown below. Other information collected includes a reason for the delay, i.e. signal, pedestrian, or left-turning vehicle. It is also important to note any grade-separated interchanges which are included in the route. This type of interchange may disperse the progression of platoons, and must be considered in the viability of a signal system.

**Table 8**  
**Example of Speed and Delay Data Collected in the Field**

Timing Point	Distance (miles)	Time Begin 8:01:00	Time Begin 8:14:34	Time Begin 8:34:56
		AM Run 1	AM Run 2	AM Run 3
Start intersection "A"	0	0	0	0
duration of stops	N/A	—	8 sec	6 sec + 3 sec

<i>Intersection "B"</i>	0.53	50 sec	55 sec	64 sec
<i>duration of stops</i>	N/A	2 sec	--	2 sec
<i>Intersection "C"</i>	1.00	101 sec	119 sec	125 sec

3. The total time required to move between the two timing points divided by the distance between them will be considered the average travel speed. The total duration of stops during a run is the stopped-delay. Actual operating speed is computed by subtracting the stopped delay from the travel time and then dividing by the distance. Delays can be categorized as fixed and variable.

It is possible, but not necessary, to associate the delay value with a time value of money or to use the speed data to support emissions calculations.

### 5.2.3 Traffic Control Evaluation - Number of Stops Measurement

The number of "stops" a vehicle encounters while traveling an arterial is a significant measure of the quality of flow. This evaluation identifies the number of vehicles encountering a "stop" in the system. This includes vehicles arriving on a red phase as well as vehicles arriving during a green phase before queue dissipation occurs.

#### 5.2.3.1 Number of Stops Measurement - Lower Cost, Simpler Approach

This process measures the number of "stops" encountered along the arterial route. The vehicles arriving during the red phase and very early in the green phase must come to a complete stop before proceeding. This is counted as one "stop". However, if a vehicle arrives during the green phase when the queue is nearly dissipated, the vehicle does not come to a complete stop, but rather, just slows a bit before proceeding. This situation is counted as a partial stop. For simplicity purposes, it is acceptable to equate all partial stops to one-half of a stop. Keep in mind that if a traffic signal is operating at over-saturated conditions, than it could produce more than one stop for an individual vehicle.

On a lower-cost, simple basis the number of stops evaluation can be done by field personnel who ride the arterial route and record stops at critical intersections. Because the data collection method of stops is very similar to the measurement of average speed, the two data sets can be collected at the same time (see Section 5.2.2). A summary of the steps is presented below:

1. Designate route. The limits of the arterial travel route should stretch just beyond all travel signals which are being considered as a candidate for an arterial signal system.
2. It is recommended that two field personnel be used to collect data: one driver and one recorder. This data collection effort can also be done by one person using a tape recorder to record number of stops, and passing over the stopbar timing points.
3. Note when you pass over the stopbar of each intersection. Record the number of any stops or partial stops encountered as a result of delay at the traffic signals. Do not record other stops which are not a result of the signals, i.e. left-turning vehicles before or after the signalized intersection or pedestrians. Try to make at least four runs during the peak hour. An example of the type of data collected is shown below.

**Table 9**  
**Example of Number of Stops Data Collected in the Field**

<b>Location</b>	<b>Number of stops</b>			
	<b>1</b>	<b>2</b>	<b>3</b>	<b>&lt;-- Run No</b>

'A'	1.0	1.0	0.0	
'B'	1.5	2.0	1.0	
'C'	0.0	0.5	1.0	
sum	3.5	5.5	5.0	

4. If there are shared lane operations, it may be necessary to record stops separately by lane. For example, shared left and through lanes will operate differently than an exclusive through-lane. Try to make at least four runs during the peak hour for each different lane group.

The number of stops is a measure used by a popular signal optimization program, TRANSYT-7F, which minimizes the number of stops (and delay) as its objective function. Stops and delay may also be used to estimate fuel consumption.

#### **5.2.3.2 Number of Stops Measurement - Higher Cost, More Complex Approach**

The higher-cost, more complex basis to determine the number of stops would employ the same logic and process as the manual effort described above, but would use aerial surveillance to gather data.

### **5.3 Pre-Trip Traveler Information and Route Guidance Evaluations**

Evaluating these two customer services can be done from two perspectives for each service: determining the number of people who are using the service and finding out how valuable the service is to them. The first perspective lends itself to being evaluated using a lower-cost, simple approach while the second requires a higher-cost, complex method.

#### **5.3.1 Pre-Trip Traveler Information and Route Guidance Evaluations - Lower-Cost, Simpler Approach**

The technologies principally used to provide these services -- Transit Information Telephone, Highway Advisory Telephone, Kiosks, and On-Line Services -- all have the ability to electronically track the amount of usage to which they are subjected. Additionally, kiosks and on-line services can also track the types of information that have been requested. It is recommended that all installations of this type include software and hardware requirements that will enable such tracking to be done. As a part of the installation procedure, uniform reporting guidelines can be established and implemented for each of these services to allow for simplified comparisons and evaluations.

Each pre-trip traveler information guidance evaluation, with the use of uniform reporting procedures for the implemented services could be completed with minimal efforts. Additionally, some level of available pre-implementation base case corridor traffic characteristics (e.g. average annual daily traffic, peak hour volumes, congestion, delay, etc.) should be used to compare with after implementation corridor characteristics to assist in the assessment of the impacts attributable to pre-trip traveler information and route guidance systems. The availability of analysis data and effort to conduct the evaluations lends easily to monthly or quarterly evaluations. For purposes of personpower estimating, it is anticipated that 5 such evaluations will be conducted. The following tasks are anticipated for the lower-cost, simpler approach pre-trip traveler information and route guidance evaluations:

1. Establish Uniform Reporting Guidelines for Services
2. Establish Evaluation Performance Measures
3. Collect and Review Service Reports

4. Collect and Review Corridor Traffic Characteristics
5. Conduct Evaluation
6. Prepare Summary Report

### **5.3.2 Pre-Trip Traveler Information and Route Guidance Evaluations - Higher-Cost, More Complex Approach**

Although it may be reasonably easy, as discussed above, to determine how many people are using these types of services, it is somewhat more difficult to determine whether or not these people are getting the type of information that they can use and are actually using it. To procure this data, it is recommended that a telephone survey be conducted in the corridor in which the service has been implemented. The survey instrument should cover awareness and use of individual services, as well as specific questions about decisions made based upon information supplied by the services, the satisfaction or dissatisfaction with the information provided, and the likelihood of future reliance on the services. At an even greater level of cost and complexity, it is possible to conduct focus group research to discover more detailed information about service valuation and customer impressions.

#### **5.3.2.1 Telephone Surveys**

An initial telephone survey instrument format and questions will be designed to allow for some level of customization for specific corridor surveys. Standards will be established for determining adequate sample size based on corridor travel characteristics, coordination of the survey, and the format of the data records to be compiled from the survey information. Each pre-trip traveler information guidance evaluation will include all of the implemented services for the specific corridor under evaluation.

For purposes of personpower estimating, it is anticipated that 5 such telephone surveys will be conducted, each with an average person survey size of 100 persons. The following tasks are anticipated for the higher-cost, more complex approach pre-trip traveler information and route guidance evaluations:

1. Develop Survey Instrument
2. Develop Standards to Determine Sample Size and Data Record Format
3. Establish Evaluation Performance Measures
4. Collect and Review Corridor Traffic Characteristics
5. Conduct and Code Survey
6. Conduct Evaluation
7. Prepare Summary Report

To assist with executing steps 1 and 2 above, the following describes an overall approach to telephone interview survey development.

#### **Telephone Interview Survey Design and Implementation**

Survey data are collected from a sample of people, and a common method of collecting responses includes the telephone interview. Telephone interviews usually take less time than the other methods, but do not allow the presentation of visual stimuli. Telephone interviews generally have traits that are between the extremes of the personal interview and the mail-out and mail-back questionnaire, making them an attractive choice for many surveys.

The following is generally capsulized from the Institute of Transportation Engineers *Manual of Transportation Engineering Studies*, and provides guidance in the development and implementation of a telephone survey.

## **Sample Selection**

A major part of the work of survey design is the selection of a sample of people who will respond to the survey. The sample is intended to represent the population of interest. Sampling is necessary because it is usually too costly and too slow to survey the entire population of interest. Several common sampling techniques are discussed here.

### **Random Sampling**

With random sampling each member of the population of interest has some established probability of being selected as part of the sample to be surveyed. Random sampling is common and has several advantages over nonrandom sampling. Random sampling requires the analyst to regard the population under study as a collection of sampling units. The population under study can be quite specific and must be related to study objectives.

#### *Simple Random Sampling*

With this method, each sampling unit in the population has an equal chance of being chosen. The analyst chooses units to be sampled by assigning a number to each unit in the population and then drawing random numbers. Simple random sampling can be accomplished with replacement, when sampling units are eligible to be drawn more than once, or without replacement, when units cannot be drawn a second time. Some formulas for analyzing samples with replacement are simpler, but for most surveys there is no difference in the analysis. Therefore, to remove the possibility that a person is asked the same questions twice, sampling without replacement is standard.

#### *Stratified Random Sampling*

In this scheme, analysts divide the population into non-overlapping groups of units called strata. A simple random sample is then drawn from each stratum. Estimates of means, proportions, and other desired statistics are based on the samples in the strata. Analysts should select strata so that the characteristic of interest in the survey differs between them. For example, in a survey on the travel habits of households, it may be desirable to stratify by the number of automobiles owned by a household since auto ownership is strongly related to travel patterns.

#### *Cluster Sampling*

This random sampling scheme is best explained through an example. Instead of choosing individual people as the sampling unit for a travel survey of the residents of a town, the analyst chooses neighborhoods as the sampling unit. Then the individual people are known as the sampling subunits, and each subunit in a sampled neighborhood would be asked to respond to the survey. This sampling plan is known as cluster sampling because the sampling unit (a neighborhood) consists of a cluster of subunits. Cluster sampling is a very popular way to conduct surveys in transportation and many other fields.

### **Nonrandom Sampling**

Nonrandom sampling refers to schemes wherein each unit does not have an established probability of being selected. Engineers usually draw nonrandom samples from the most readily accessible units in the population in a haphazard way. An example of a nonrandom sampling plan would be an engineer surveying pedestrian habits in an area by stopping the first 100 people walking along a particular sidewalk. Most surveys by transportation engineers use nonrandom sampling.

### **Composing Questions**

Writing good survey questions is very difficult. The following provides guidance in composing questions so that major pitfalls may be avoided.

### **Number of Questions**

Several factors affect the length of a survey. First, the study objectives will affect the survey length. Complex and multiple objectives require longer surveys, while simple objectives require short surveys. Designers should include as many questions as needed to accomplish study objectives and should make sure that each question relates to the objectives. One way to ensure that each question is related is to state in writing its unique contribution to accomplishing the objectives. Second, the topic affects the survey length. Respondents will tolerate longer surveys on topics that are interesting or important to them. Analysts can ask more questions per respondent with personal or telephone interviews than with mail-back surveys. Finally, there is a trade-off with a fixed budget between the number of questions to be asked and the sample size, especially for personal and telephone interviews.

### **Question Order**

Research has shown that responses to a question can differ depending on placement of the question in relation to other questions. There are no rules on question order, but several general suggestions for obtaining higher-quality responses include:

1. place easier questions early in the survey to avoid discouraging respondents;
2. place questions that may be threatening (i.e., embarrassing or intimidating) to respondents in the middle of the survey;
3. place demographic questions at the end of the survey; and
4. avoid response set bias (a series of questions in a row with the same response).

In addition, designers should move questions likely to bias responses to later questions. For example, do not follow a question on traffic congestion with a question asking for "the worst suburban problems of our time" with "traffic congestion" as one possible response.

Begin the survey with an introduction explaining who is conducting the survey, the purpose of the survey, the subject matter to be covered by the survey, and information on the respondent's rights and privileges. After the last question has been asked, leave time for respondent comments. The comments may prove useful and the opportunity to make a comment helps the respondent feel that their opinion is important. Finally, the respondent should always be thanked and may be offered a summary of the survey results.

### **Types of Questions**

There are two basic types of questions. Closed questions present a fixed set of alternate answers to the respondent. Open questions allow the respondent to create his own answer. Closed questions take many forms.

"Yes or no" questions are common and simple to score. However, because "yes or no" questions are absolute, respondents may feel more intimidated by them and are more likely to misinterpret them. Distribute likely "yes" and "no" responses randomly on the survey form so that respondents do not discern a pattern. Checklist questions provide respondents with a list of possible responses, from which they may choose one or more items. The keys to constructing unbiased checklist questions include:

1. the list must include all possible answers;
2. the items must be mutually exclusive; and
3. there should be more variation between items than within individual items.

"No opinion" or "don't know" options should be offered on most checklists (and with most "yes or no" questions) to include all possible answers and to avoid bias. Closed survey questions may provide scales to the respondents so that they can choose positions on a continuous spectrum

of possibilities. Scales are easier to construct than checklists since designers must simply fix the extremes and establish an increment on the scale.

### **General Tips**

Regardless of question format, in every effort to compose questions designers should consider some general tips. The main rule on composing questions is to keep the study objectives in mind. Every question should help satisfy those objectives. Effective questions should also:

1. be as short as possible;
2. use standard demographic questions and terms whenever possible;
3. avoid technical jargon and slang;
4. use words simple enough to be understood by the least sophisticated respondent;
5. define terms carefully. Respondents sometimes misinterpret very simple terms;
6. avoid controversial and other words that evoke strong responses;
7. avoid racial, ethnic, sexist, or otherwise biased language;
8. avoid leading questions;
9. avoid loaded questions;
10. avoid double negatives;
11. avoid "double-barreled" questions;
12. be very careful about prompting respondents' recall;
13. responses to threatening questions may be biased;
14. avoid hypothetical questions; and
15. ask respondents to recall events in the most immediate time frame feasible.

### **Protecting Respondents**

The United States and other countries have firmly established the right to privacy. Competent adults generally cannot be forced to answer any survey except a periodic census. Therefore, survey designers must take precautions to avoid violating respondent rights. In addition, survey personnel must treat respondents with respect and dignity. The relatively high response rates enjoyed by some surveys may result from goodwill established with respondents from previous surveys. The most common precaution undertaken to protect respondent rights is informing the respondent of the purpose and method of the survey before administration. In general, each respondent should receive the following:

1. a description of the survey procedures and an explanation of the purpose of each procedure;
2. a description of risks and benefits;
3. an offer to answer any inquiries; and
4. an offer to withdraw from the survey at any time without prejudice.

### **Training Interviewers**

Interviewer training is crucial to the success of interview surveys. Interviewers can waste a well-written question if they ask incorrectly or if they record the responses inaccurately. The goal for training interviewers is to produce results that are consistent between interviewers and consistent over time for individual interviewers. The survey designers should introduce interviewers to the survey method, questions, and answer form. Interviewers need to learn "how" to ask questions and "why" the questions are being asked. For each question, the survey designer needs to tell the interviewers the extent to which the "script" must be followed. The training schedule should allow plenty of time for interviewers to ask questions of the survey designer. After a general orientation to the survey, interviewers should practice asking questions and recording answers.

### **Pilot Test**

During a pilot test, survey conditions are simulated to scrutinize the survey method and questions. If the survey is found lacking during the pilot test, as most are, the survey can be revised before the actual data collection. The interviewers who will conduct the survey should also conduct the pilot test. The survey designer should intensely debrief the interviewers about each respondent during a pilot test. The pilot test sample size should include between 20 and 75 participants.

### **Survey Administration**

Once a survey instrument has been tested through the pilot test, a few final details must be attended to before data are collected. They include the following:

1. The issue of respondent compensation must be addressed before conducting the survey. Most transportation surveys do not compensate respondents. Compensation introduces an additional expense that may restrict sample size and may bias results.
2. Before the telephone interviewing begins, procedures should be developed for handling the possible outcomes from a call. A response should be decided on beforehand for each possible outcome. Interviewers should keep a log of telephone calls so that respondents not reached with the original call are retried and so that respondents are not called twice.
3. Sampling error is due to the selection of a sample from the subject population. Most samples from a population will provide results that differ from other samples. Analysts can control the amount of sampling error when they use accepted procedures for random sampling.
4. Analysts can detect and correct most coding and reduction before analysis. Thorough training of coders, close contact between analysts and coders, and frequent double-checks of coded and reduced data are needed.
5. Nonresponse is a problem in surveys when the portion of the desired sample that does not respond differs from the portion of the desired sample that does respond and a bias of unknown size is introduced. Correcting for nonresponse requires time and effort, so smaller surveys may suffer more from nonresponse errors. The best way to treat nonresponse is through prevention. The following classification for nonresponse should include:
  - a) Noncoverage: People in the sample are not given the opportunity to respond to the survey.
  - b) Unable to answer: People are reached but do not have sufficient information to answer the question.
  - c) Unwilling to answer: People are reached but refuse to respond.
  - d) Not-at-home: Survey workers try but cannot reach some people in the sample.

### **5.3.2.2 Focus Groups**

As mentioned earlier, another possible technique to discover more detailed information about service valuation and customer impressions, is to conduct focus group research. Similar to the telephone survey, where information is obtained through a telephone interview, focus groups will be used to expand this data and possible issues raised during the telephone surveys. Either slide or handout material, presentation module outlines, and visual material will be prepared for the focus group meetings, and summaries of findings will be prepared for each of the focus groups. An evaluation process, similar to the telephone surveys will be conducted, and the task will be completed with the preparation of a summary report.

For purposes of personpower estimating, it is anticipated that 5 such focus groups will be conducted, each with an average person survey size between 8 and 10 persons, and with 4 meetings for each group. The following tasks are anticipated for the alternative higher-cost, more complex approach pre-trip traveler information and route guidance evaluations:

1. Develop Focus Group Materials

2. Establish Evaluation Performance Measures
3. Conduct Focus Group and Summarize Findings
4. Collect and Review Corridor Traffic Characteristics
5. Conduct Evaluation
6. Prepare Summary Report

To provide guidance in focus group implementation, the following is a general description of what focus groups are and how they are used. The text is condensed from *Innovations in Public Involvement for Transportation Planning* developed jointly by the Federal Highway Administration and Federal Transit Administration.

### **Focus Group Definition**

A focus group is a tool to gauge public opinion. Borrowed from the marketing and advertising industry, it frankly regards transportation as a product that can be improved and the public as customers for that product. It is a way to identify customer concerns, needs, wants, and expectations. It can inform sponsors of the attitudes and values that customers hold and why. It can help drive development of policies, programs, and services and the allocation of resources. Focus groups were used as part of the ITMS Master Plan to determine customer impressions of New Jersey's transportation system and potential Intelligent Transportation System options.

A focus group is a small group discussion with professional leadership. It is a meeting of a carefully selected group of individuals convened to discuss and give opinions on a single topic. Focus group participants can be selected either randomly or non-randomly. Random selection is used to help achieve, to the extent possible, a group that is representative of the population as a whole. Non-random sampling, on the other hand, helps elicit a particular position or point of view. A combination of selection techniques could result in a focus group of people well-versed in transportation issues as well as those who are solely consumers of transportation services.

A focus group has these basic features:

1. a carefully crafted agenda, with five or six questions at most;
2. emphasis on gathering perspectives, insights, and opinions of participants through conversation or interaction;
3. identification of major points of agreement and divergence of opinion;
4. minimal presentation of material to set context and subject;
5. gleaning, not shaping, opinions or perspectives;
6. eight to twelve participants; and
7. understanding that the participants' role is to give personal insights and perspectives.

### **Focus Group Usefulness**

A focus group leader explores attitudes in-depth through follow-up questions. It offers an opportunity to get behind people's expressed attitudes and assess policy directions and program objectives. It is a chance to review allocation of resources. It can help confirm or deny established goals. It can help set new directions.

The informal setting of a focus group encourages full participation. The small size of the group lowers barriers to speaking out. A focus group is a place for people to speak out without criticism of their comments. Spontaneity in responding produces fresh information. Participants are not required to prepare for the discussion. Many focus groups have found that participants readily volunteer ideas and comments that have not been recorded elsewhere. For example, focus groups were used in Los Angeles to find out why commuters were not taking advantage of free transit passes.

## **Special Uses of Focus Groups**

A focus group provides citizen input from otherwise unrepresented individuals. Residents from specific areas within an urban region can be heard. Geographic-based opinions and issues can be more readily defined and discerned. Expert opinion about a specific issue can be investigated as well as comparisons made of particular opinions, both internal and external to an organization.

## **Focus Group Participation**

Focus group members are selected by the sponsor. Depending on the goals to be achieved, a focus group can be heterogeneous (with a variety of people from different backgrounds within a single geographic area) or homogeneous (with separate focus groups for residents, business and institutions). Members may be randomly selected or invited from previously identified, non-random groups.

Citizens participate by stating opinions. Individuals within the group may react to others' opinions or bring up their own ideas. The facilitator of the group will guide discussion to cover all agenda items and to assure that all individuals get a chance to speak.

## **5.4 En-Route Driver Information Evaluation**

As envisioned in the ITMS Master Plan, this customer service would be provided by variable message signs (VMS) and highway advisory radio (HAR)

### **5.4.1 En-Route Driver Information Evaluation - Lower-Cost, Simpler Approach**

Since many freeway VMS are located adjacent to a ramp leading to an alternate route, it is recommended that during occasions of "planned incidents" such as a short-term lane closure for maintenance purposes, that a count be performed to compare the ramp split and the mainline volume to non-incident/construction conditions, which may be developed by a count performed close to the time after the condition is removed. From these counts, a percentage shift attributable to the VMS can be identified. Benefit determination in this situation can be difficult because of lack of information about the alternate route's performance characteristics. However, in some locations where information is known about the alternate route (local/express lanes, passenger car/truck lanes) and given average speeds on each route from loop detectors, then time lost and delay can be calculated. HAR, on the other hand, is more difficult to evaluate and perhaps the only viable technique in this approach is the use of mail survey cards distributed at toll facilities.

#### **5.4.1.1 Variable Message Signs**

"Planned incidents" as discussed above, will serve as the best situations to collect information necessary to evaluate the impacts of VMS on travel. By selectively developing an incident with a known viable alternative route and message "in hand", automatic traffic recorder machines (ATRs) can collect traffic information (speed, volume, class) for both the original and diverted travel routes in the vicinity of the "planned incident." Evaluation performance measures will also be developed as part of the evaluation process.

For purposes of personpower estimating, it is anticipated that five such evaluations will be conducted. Each evaluation will deploy four ATRs (two for the original travel route and two for the anticipated diversion route) for the week prior and week during the "planned incident." The following tasks are anticipated for the lower-cost, simpler approach en-route driver information VMS evaluations:

- 1. Establish Evaluation Performance Measures**

2. Collect and Review Traffic Characteristics
3. Conduct Evaluation  
Prepare Summary Report

#### **5.4.1.2 Highway Advisory Radio**

The handout/mail-back technique will be used to collect information on HAR performance. Surveys will be conducted during five "planned incidents", preferably for several different corridors. The survey will be developed to include questions pertaining to typical and diversion travel routes, perceived benefits of the travel diversion, and other information deemed necessary to evaluate the effectiveness and usefulness of HAR during events in which a diversion of travel is necessary. Evaluation performance measures will be developed, and toll plaza traffic characteristics (volume and queues) during "planned incidents" will be compared against typical toll plaza traffic characteristics to assist in verifying returned surveys and assessing travel changes due to diversions. A Summary Report will be prepared detailing the evaluation findings.

For purposes of personpower estimating, it is anticipated that five such handout/mail-back surveys and evaluations will be conducted. The following tasks are anticipated for the lower-cost, simpler approach en-route driver information HAR evaluations:

1. Develop Survey Instrument and Data Record Format
2. Establish Evaluation Performance Measures
3. Collect and Review Toll Plaza Traffic Characteristics
4. Conduct and Code Survey
5. Conduct Evaluation
6. Prepare Summary Report

#### **5.4.2 En-Route Driver Information Evaluation - Higher-Cost, More Complex Approach**

Similar to the other information-based customer services, the value of VMS and HAR is their ability to provide useful information upon which the customer can base decisions that result in a beneficial outcome. Accordingly, it is recommended that a mailback or roadside interview survey be conducted in the relevant corridor, supplemented by focus group research to draw out particular information as needed.

##### **5.4.2.1 Handout/Mail-back**

Surveys will be conducted during "planned incidents", preferably for several different corridors at the anticipated diversion point. The survey will be developed to include questions pertaining to typical and diversion travel routes, perceived benefits of the travel diversion, and other information deemed necessary to evaluate the effectiveness and usefulness of HAR during events in which a diversion of travel is necessary. By selectively developing an incident with a known viable alternative route and message for the HAR or VMS "in hand", automatic traffic recorder machines (ATRs) can collect traffic information (speed, volume, class) for both the original and diverted travel routes in the vicinity of the "planned incident" to assist in verifying returned surveys and assessing travel changes due to diversions. A Summary Report will be prepared detailing the evaluation findings. Evaluation performance measures will also be developed as part of the evaluation process.

For purposes of personpower estimating, it is anticipated that five such handout/mail-back surveys and evaluations will be conducted, and each evaluation will deploy four ATRs (two for the original travel route and two for the anticipated diversion route) for the week prior and week during the "planned incident." The following tasks are anticipated for the higher-cost, more complex approach en-route driver information evaluations:

1. Develop Survey Instrument and Data Record Format
2. Establish Evaluation Performance Measures
3. Collect and Review Corridor Traffic Characteristics
4. Conduct and Code Survey
5. Conduct Evaluation
6. Prepare Summary Report

#### **5.4.2.2 Focus Groups**

As mentioned earlier, another possible technique to discover more detailed information about service valuation and customer impressions, is to conduct focus group research. Focus groups will be used to expand this data and possible issues raised during the handout/mail-back surveys. Focus group participants will be selected from returned surveys. Either slide or handout material, presentation module outlines, and visual material will be prepared for the focus group meetings, and summaries of findings will be prepared for each of the focus groups. An evaluation process will be conducted, and the task will be completed with the preparation of a summary report.

For purposes of personpower estimating, it is anticipated that 5 such focus groups will be conducted, each with an average person survey size between 8 and 10 persons, and with 4 meetings for each group. The following tasks are anticipated for the supplemental higher-cost, more complex approach en-route driver information evaluations:

1. Develop Focus Group Materials
2. Establish Evaluation Performance Measures
3. Conduct Focus Group and Summarize Findings
4. Collect and Review Corridor Traffic Characteristics
5. Conduct Evaluation
6. Prepare Summary Report

**Appendix of Labor Hours and Expense Estimates**

**ITMS Master Plan Incident Management Evaluation  
Evaluation Methodologies Personhour Estimates**

	<b>Sr. Engin. Manager</b>	<b>Lead Engineer</b>	<b>Senior Engineer</b>	<b>Engineer I</b>	<b>Clerical</b>	<b>Grand Total</b>
<i>Assume modeling of 3 freeway sections</i>						
<b>5.1.1 Incident Management "IMPACT" Model</b>						
<b>Lower Cost, Simpler Approach</b>						
1. Software Acquisition and Installation	0	0	4	8	1	13
2. Software Training	2	0	24	24	0	48
3. Data Review and Modification	0	8	8	24	0	40
4. Input Data and Run Model	0	0	4	24	0	28
5. Develop and Interpret Results	4	8	32	16	0	56
6. Prepare Summary Report	8	16	24	0	24	64
<b>Total Hours</b>	<b>14</b>	<b>32</b>	<b>96</b>	<b>96</b>	<b>25</b>	<b>263</b>
<b>Direct Expenses = \$500</b>						
<i>Assume 2-week evaluation of one 10-mile, 4-lane freeway section</i>						
<b>5.1.2 Incident Management Field Audit</b>						
<b>Higher Cost, More Complex Approach</b>						
1. Collect Volume Data at Three Locations	0	0	6	120	0	126
2. Perform Classification and Occupancy Count at One Location	0	0	4	70	0	74
3. Monitor On-site Incident Activity	0	0	8	180	0	188
4. Monitor Queue Behavior	0	0	8	180	0	188
5. Data Compilation, Reduction and Analysis	4	8	40	16	32	100
6. Prepare Summary Report	8	8	32	32	24	104
<b>Total Hours</b>	<b>12</b>	<b>16</b>	<b>98</b>	<b>598</b>	<b>56</b>	<b>780</b>
<b>Direct Expenses = \$3000</b>						

**ITMS Master Plan Traffic Control Evaluation  
Evaluation Methodologies Personhour Estimates**

	<b>Sr. Engr. Manager</b>	<b>Lead Engineer</b>	<b>Senior Engineer</b>	<b>Engineer I</b>	<b>Clerical</b>	<b>Grand Total</b>
<b>Assume a candidate corridor 5 miles long with 6 critical intersections</b>						
<b>5.2.1.1 Delay Measurement</b>						
<b>Lower Cost, Simpler Approach</b>						
1. Field Data Collection (Before and After)	0	2	4	288	0	294
2. Reduce Field Data	2	0	24	120	0	146
3. Produce Histograms	0	4	24	144	0	172
4. Summarize Data	0	0	16	80	0	96
5. Conduct Evaluation	4	8	40	0	0	52
6. Prepare Summary Report	16	16	24	0	24	80
<b>Total Hours</b>	<b>22</b>	<b>30</b>	<b>132</b>	<b>632</b>	<b>24</b>	<b>840</b>
<b>Direct Expenses = \$1000</b>						
<b>5.2.1.2 Delay Measurement</b>						
<b>Higher Cost, More Complex Approach</b>						
1. Field Data Collection (Before and After covered in direct expenses)	0	0	0	0	0	0
2. Reduce Field Data	2	0	24	120	0	146
3. Produce Histograms	0	4	24	144	0	172
4. Summarize Data	0	0	16	80	0	96
5. Conduct Evaluation	4	8	40	8	0	60
6. Prepare Summary Report	16	16	24	8	24	88
<b>Total Hours</b>	<b>22</b>	<b>28</b>	<b>128</b>	<b>360</b>	<b>24</b>	<b>562</b>
<b>Direct Expenses = \$15000</b>						
<b>5.2.2 Average Speed Measurement</b>						
1. Field Data Collection (Before and After)	0	4	8	84	0	96
2. Reduce Field Data	2	0	8	48	0	58
3. Calculate Average speed on routes	0	4	8	32	0	44
4. Summarize Data	0	0	16	60	0	76
5. Conduct Evaluation	4	8	40	8	0	60
6. Prepare Summary Report	16	16	24	8	24	88
<b>Total Hours</b>	<b>22</b>	<b>32</b>	<b>104</b>	<b>240</b>	<b>24</b>	<b>422</b>
<b>Direct Expenses = \$2000</b>						

**ITMS Master Plan Traffic Control Evaluation  
Evaluation Methodologies Personhour Estimates**

	<b>Sr. Engin. Manager</b>	<b>Lead Engineer</b>	<b>Senior Engineer</b>	<b>Engineer I</b>	<b>Clerical</b>	<b>Grand Total</b>
<b>5.2.3.1 Number of Stops Measurement</b>						
<b>Lower Cost, Simpler Approach</b>						
1. Field Data Collection (Before and After)	0	4	8	84	0	96
2. Summarize Data	0	0	16	80	0	96
3. Conduct Evaluation	4	16	40	16	0	76
4. Prepare Summary Report	16	16	24	8	24	88
	20	36	88	188	24	356
<b>Direct Expenses = \$2000</b>						
<b>5.2.3.2 Number of Stops Measurement</b>						
<b>Higher Cost, More Complex Approach</b>						
1. Field Data Collection (Before and After covered in direct expenses)	0	0	0	0	0	0
2. Summarize Data	0	0	16	80	0	96
3. Conduct Evaluation	4	16	40	16	0	76
4. Prepare Summary Report	16	16	24	8	24	88
	20	32	80	104	24	260
<b>Direct Expenses = \$15000</b>						

**ITMS Master Plan Customer Services  
Evaluation Methodologies Personhour Estimates**

	<b>Sr. Engin. Manager</b>	<b>Lead Engineer</b>	<b>Senior Engineer</b>	<b>Engineer I</b>	<b>Clerical</b>	<b>Grand Total</b>
<b>5.3.1 Pre-Trip Traveler Information and Route Guidance Evaluation</b>						
<b>Lower Cost, Simpler Approach</b>						
1. Establish Uniform reporting Guidelines for Services	2	8	8	0	0	18
2. Establish Evaluation Performance Measures	2	8	0	0	0	10
3. Collect and Review Service Reports	0	0	8	40	0	48
4. Collect and Review Corridor Traffic Characteristics	0	4	8	40	0	52
5. Conduct Evaluation	4	20	40	40	0	104
6. Prepare Summary Report	2	20	20	40	24	106
<b>Total Hours</b>	<b>10</b>	<b>60</b>	<b>84</b>	<b>160</b>	<b>24</b>	<b>338</b>
<b>Direct Expenses = \$500</b>						
<b>5.3.2 Pre-Trip Traveler Information and Route Guidance Evaluation</b>						
<b>Higher Cost, More Complex Approach</b>						
<b>Telephone Surveys</b>						
1. Develop Survey Instrument	2	16	16	0	0	34
2. Develop Standards to Determine Sample Size and Data Format Record	2	8	0	0	0	10
3. Establish Evaluation Performance Measures	2	8	0	0	0	10
4. Collect and Review Corridor Traffic Characteristics	0	4	8	40	0	52
5. Conduct and Code Survey	0	8	24	160	0	192
6. Conduct Evaluation	4	20	40	40	0	104
7. Prepare Summary Report	2	20	20	40	24	106
<b>Total Hours</b>	<b>12</b>	<b>84</b>	<b>108</b>	<b>280</b>	<b>24</b>	<b>508</b>
<b>Direct Expenses = \$2000</b>						
<b>Focus Groups</b>						
1. Develop Focus Group Materials	4	24	0	24	8	60
2. Establish Evaluation Performance Measures	2	8	0	0	0	10
3. Conduct Focus Groups and Summarize Findings	120	120	16	40	0	296
4. Collect and Review Corridor Traffic Characteristics	0	4	8	40	0	52
5. Conduct Evaluation	4	20	40	40	0	104
6. Prepare Summary Report	2	20	20	40	24	106
<b>Total Hours</b>	<b>132</b>	<b>196</b>	<b>84</b>	<b>184</b>	<b>32</b>	<b>628</b>
<b>Direct Expenses = \$12000</b>						

**ITMS Master Plan Customer Services  
Evaluation Methodologies Personhour Estimates**

	Sr. Engin. Manager	Lead Engineer	Senior Engineer	Engineer I	Clerical	Grand Total
<b>5.4.1 En-Route Driver Information Evaluation</b>						
Lower Cost, Simpler Approach						
Variable Message Signs						
1. Establish Evaluation Performance Measures	2	8	8	0	0	18
2. Collect and Review Corridor Traffic Characteristics	0	4	8	40	0	52
3. Conduct Evaluation	4	20	40	40	0	104
4. Prepare Summary Report	2	20	20	40	24	106
Total Hours	8	52	76	120	24	280
Direct Expenses = \$20000						
Highway Advisory Radio						
1. Develop Survey Instrument and Data Record Format	2	20	20	0	0	42
2. Establish Evaluation Performance Measures	2	8	0	0	0	10
3. Collect and Review Corridor Traffic Characteristics	0	4	0	40	0	44
4. Conduct and Code Survey	0	24	80	400	0	504
5. Conduct Evaluation	4	20	40	40	0	104
6. Prepare Summary report	2	20	20	40	24	106
Total Hours	10	96	160	520	24	810
Direct Expenses = \$1000						
<b>5.4.2 En-Route Driver Information Evaluation</b>						
Higher Cost, More Complex Approach						
Handout/Mail-Back						
1. Develop Survey Instrument and Data Record Format	2	24	24	0	0	50
2. Establish Evaluation Performance Measures	2	8	0	0	0	10
3. Collect and Review Corridor Traffic Characteristics	0	4	8	40	0	52
4. Conduct and Code Survey	0	24	80	400	0	504
5. Conduct Evaluation	4	20	40	40	0	104
6. Prepare Summary report	2	20	20	40	24	106
Total Hours	10	100	172	520	24	826
Direct Expenses = \$21000						
Focus Groups						
1. Develop Focus Group Materials	4	24	0	24	8	60
2. Establish Evaluation Performance Measures	2	8	0	0	0	10
3. Conduct Focus Groups and Summarize Findings	120	120	16	40	0	296
4. Collect and Review Corridor Traffic Characteristics	0	4	8	40	0	52
5. Conduct Evaluation	4	20	40	40	0	104
6. Prepare Summary Report	2	20	20	40	24	106
Total Hours	132	196	84	184	32	628
Direct Expenses = \$12000						