Travel Time Monitoring System with Data Exchange with Houston TranStar

Concept of Operations – Version 1.X

Prepared for:

City of Anytown

Department of Engineering

Anytown, Texas

Prepared by:

Consultant

Othertown, Texas

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Anyplace County

CSJ XXX-XX-XXXX

MPO Project ID: XXXXX

Concept of Operations [Template]

## Travel Time Monitoring System (Re-ID) with Data Exchange with Houston TranStar

The Concept of Operations (ConOps) document defines the operational mission of the [project name] project and states the operational requirements necessary to achieve that mission. The ConOps defines: 1) the goals, objectives, and capabilities of each system included in the project; and 2) the roles and responsibilities of the [agency], other agencies, and associated project stakeholders.

# Concept of Operations Scope

This section provides an overview of the ConOps document and the proposed travel time monitoring system to which it applies.

* + 1. Identification of System

This project will deploy, operate and maintain a travel time monitoring system on/in [describe roadway segment or area]. This project is referenced as CSJ ###-##-#### on the H-GAC Transportation Improvement Plan (TIP) and referenced by [city/county] documents as ITS Project ###.

* + 1. Document Overview

This project is motivated by three main needs. First, the project will enable monitoring traffic conditions in real-time on the facility to provide traveler information and to identify abnormal travel conditions (e.g., those caused by weather or incidents). The second need is to provide the capability measure short-term travel times to identify when short-term added capacity or operational improvements (e.g., changing signal timing parameters) may be needed. The third need is to enable the calculation and reporting of longer-term performance measures to identify when major improvements may be necessary.

The purpose of this ConOps document is to:

* To ensure that [implementing agency] (and other stakeholder) needs and expectations have been documented early in the project development process;
* To ensure that the project deployment is linked to the agency mission, goals, and objectives;
* To identify and document existing operations, and where gaps may exist;
* To identify where the proposed system could supplement existing operations;
* To define the envisioned operational environment with the [project] in operation;
* To establish a list of operational requirements; and
* To begin the traceability of the systems engineering process.
	+ 1. System Overview

[Blind Note: Briefly state the purpose of the proposed system. Describe the general nature of the system, and identify the project sponsors, user agencies, support agencies, and the operating centers that will run the system. Mention other documents relevant to the present or proposed system. A graphical overview of the system is strongly recommended. This can be any type of diagram that depicts the system and its environment.]

A travel time monitoring system using re-identification techniques (e.g., through toll-tags, license plate recognition, or media access control technologies) can be used to collect travel time and speed samples along a roadway. The purpose of this type of system is to collect individual travel time samples, aggregate them over a defined time period, and calculate average travel time and speeds over roadway segments, or by combining travel times and/or speeds over multiple segments (or a route).

In the Houston region, Houston TranStar has been operating toll-tag and Bluetooth-based travel time monitoring systems for more than 20 years and has software available to process and view the data in real-time and for archived calculations. This project will [transmit raw data to TranStar for processing, viewing and archiving OR locally process raw data and send processed data to TranStar for viewing and archiving].

The project will be sponsored by [agency]. Other users of the data generated by the system will include [other users/agencies]. The travel time monitoring system will be run through the [local center OR Houston TranStar OR other].

[Blind Note: include high-level system operational graphic here – show representations of physical equipment and connections indicating high-level data elements to be transmitted AND calculations completed – DO NOT show technologies to be used in this graphic as the ConOps should be technology-neutral. Technologies are selected in the market studies/pre-design or design phases]

# Referenced Documents

[Blind Note: List the document number, title, revision, and date of all documents referenced in the ConOps document here. If references are not in the public domain, list the owning agency or source.]

1. U.S. Department of Transportation, California Division. Systems Engineering Guidebook for ITS. [Online] [Cited: Date] <http://www.fhwa.dot.gov/cadiv/segb/>
2. Travel Time Data Collection Handbook, Report No. FHWA-PL-98-035, Office of Highway Information Management, FHWA, March 1998, Page 3-6, Table 3-4.

Additional Local References:

* Houston-Galveston Area Regional ITS Architecture
* National ITS Architecture
* Houston TranStar IS Requirements
* Houston TranStar Policy and Procedures Manual

Houstontranstar.org:

* Route Builder: <http://traffic.houstontranstar.org/routebuilder/>
* Speed Charts: <http://traffic.houstontranstar.org/speedcharts/>
* Speed Map Archive: <http://traffic.houstontranstar.org/map_archive/>
* Annual Speed Averages: <http://traffic.houstontranstar.org/hist/histmain.html>
* Historical Travel Times: <http://traffic.houstontranstar.org/hist/hist_traveltimes_menu.html>

# Current System or Situation

[Blind Note: In this section, describe the system or situation as it currently exists. If there is no current system on which to base changes, describe the situation that motivates the proposed system.]

This section describes the current operational situation and summarizes the rationale for deployment of a travel time monitoring system in the [corridor].

* + 1. Background, objectives and scope

The [city/county of X] currently operates and maintains ### traffic signals on a street system of nearly #,### center lane miles. Currently, most real-time operations are reactive in nature (responding to outages or responding to major arterial incidents with police, fire and EMS staff. There is some real-time signal control capability but little real-time modification of signal timing to current operational conditions. There is no arterial traveler information because the methods to collect real-time data and disseminate them in a meaningful manner do not exist. However, the [city] has identified enhanced arterial operations as a priority initiative in its mission. Proactive ITS elements are needed to extend the capability for enhanced signal operations, arterial traveler information, arterial monitoring and data collection on key [city] roadway corridors.

* + 1. Operational policies and constraints

City Council has determined that city streets should operate with higher level of service than currently experienced, but that determining the level of service through continuous monitoring is desired. The City Council stated that the system should be available to residents using a map and that a report should be provided at least once per year on the system operational status. The only constraints placed upon the system is to comply with all city ordinances, address public privacy concerns, and to operate the system in a secure manner per city IT and Engineering Department policies. The Engineering Department will be in charge of the travel time monitoring system

* + 1. Description of current system or situation

[Blind Note: The purpose of this section is to describe the current system and how it operates. This description should be simple enough and clear enough that all intended readers of the document can fully understand it using the users' terminology. Graphics should be used wherever possible. If parts of the descriptions are large or overly complicated, they can be included in an appendix or incorporated by reference. When the proposed system is new, discussion should focus on the current situation.]

The current operational situation in reference to travel time data is that travel time data is collected too infrequently to make a measurable difference in everyday agency operations and in the lives of our citizens. While travel times are available on nearby highways (operated by TxDOT and tolling authorities), they are not available on the major arterial network in the city/county. Having travel time information available on the city/county system will give the city/county visibility to problems on the network and the ability to adjust operations accordingly. Travel time monitoring will also allow for travelers to understand the travel time characteristics of the roadways included in the system (when and for how long there is congestion, for example) and when incidents may be impacting travel times.

The data sharing between Houston TranStar and the local system will also give travelers outside of the city/county knowledge of current conditions, and to be able to adjust routes accordingly. The Houston TranStar website is also used by broadcast media to alert travelers of adverse travel conditions, and the new system will give media the ability to give more local information.

* + 1. Modes of operation for the current system or situation

The city/county does not currently have a travel time monitoring system. To provide data on travel times within the city/county, manual travel time runs are conducted every three to five years. This data is adequate for periodic retiming of traffic signals but is inadequate for real-time operations and providing real-time public traveler information. This interval is also inadequate for developing meaningful key performance measures upon which timely action can be taken.

* + 1. User classes and other involved staff/personnel for the current system or situation

As the city/county does not currently have a travel time monitoring system, there is limited impact on user classes and staff. The manual travel time runs conducted every three to five years are conducted by contractors at a cost of $##,### per study. The Engineering Department is the primary user of this data for periodic retiming of traffic signals.

* + 1. Support environment for the current system or situation

The manual travel time runs conducted every three to five years are conducted by contractors with only a small amount of administrative and technical involvement. The Engineering Department administers these counts and no other city/county support resources are required.

# Justification for and Nature of Changes

In this section, shortcomings of the current situation that causes the need for development of a new system is described. This section provides justification for features of the new travel time monitoring system.

* + 1. Justification for changes

The city/county has realized that, in response to citizen concerns about traffic congestion in the area, that a feedback loop was needed to quantify the congestion problem, provide staff with the ability to quantify traffic operations daily and react through traffic signal timing changes. In addition, citizens had requested travel times and traveler information on roadways in the city/county. There was also an opportunity with this new system to provide local travel data to the region through a data sharing agreement with Houston TranStar, enabling non-local travelers to see what was happening in [city/county].

The Engineering Department realized that with a requirement from City Council to produce an arterial performance report, a new system would be needed to supply robust travel time and speed data – more than just sampling occasionally could provide.

* + 1. Description of desired changes

The new travel time monitoring system, at a high level, should provide the following capabilities, functions, processes, and interfaces:

* Result in adequate sample sizes to produce travel time and travel speed averages at 95% confidence, ±10% error (this is between 6 and 12 samples in the desired time period (typically 15-minutes), depending on traffic signal density (Reference 2)), between 6AM and 7PM on weekdays and from 10 AM to 6 PM on weekends
* The system should use field readers and a processing host application that provide at least 99% uptime
* Process reads and calculate matches between reader locations, and use filtering algorithms to remove outliers
* Provide an interface to view the data in charts, tables, and graphs; and compare the data to historical data in charts, tables and graphs.
* Provide system output to external systems in, at minimum, XML format with updates every 30 seconds.
* Provide an internet-based interface to view the travel time and travel speed data.
* Provide an internet-based interface to view system status
	+ 1. Priorities among desired changes and new features

Priorities among the new features are shown in Table 1 below. Each feature is classified as essential, desirable, or optional. Classifying the new features is important to guide the decision-making process during the life cycle of the proposed system. This information is also helpful in cases of budget or schedule cuts or overruns, since it permits determination of which features must be finished, and which ones can be delayed or omitted. Desirable priority does not mean that a requirement should not be met, but may be met at a level lower than stated if schedule or budget constraints preclude reaching stated performance thresholds.

Table . High-Level Requirements and Priority.

|  |  |
| --- | --- |
| High-Level Requirement | Priority (Essential, Desirable, Optional) |
| * Result in adequate sample sizes to produce travel time and travel speed averages at 95% confidence, ±10% error (this is between 6 and 12 samples in the desired time period (typically 15-minutes), depending on traffic signal density (Reference 2)), between 6AM and 7PM on weekdays and from 10 AM to 6 PM on weekends
 | Desirable |
| * The system should use field readers and a processing host application that provide at least 99% uptime
 | Desirable |
| * Process reads and calculate matches between reader locations, and use filtering algorithms to remove outliers
 | Essential |
| * Provide an interface to view the data in charts, tables, and graphs; and compare the data to historical data in charts, tables and graphs.
 | Essential |
| * Provide system output to external systems in, at minimum, XML format with updates every 30 seconds.
 | Essential |
| * Provide an internet-based interface to view the travel time and travel speed data.
 | Essential |
| * Provide an internet-based interface to view system status
 | Desirable |

There are no optional items listed in the high-level requirements.

* + 1. Changes considered but not included

The only system feature that was considered for this project was the addition of dynamic message sign deployment to enable roadside traveler information and travel times. This feature will be considered later as additional funding becomes available.

* + 1. Assumptions and constraints

The following assumptions were made to enable deployment of the system:

* To reduce project cost, most field readers will be co-located with traffic signal infrastructure;
* Communications between field readers and central processing host will be via existing fiber optic cable network and supplemented with wireless or cellular as needed;
* Adequate city/county resources will be dedicated to system operation and maintenance;
* Travel time/speed segments will be no less than ½ mile in length.

The following constraints will be placed on the system:

* The system must produce output that can be accepted by the Houston TranStar travel time monitoring system;
* The system must comply with city/county IT department and/or Engineering Department security protocols and TranStar IS protocols for shared data elements;
* The system should protect public privacy using encryption and/or truncation and encryption techniques.

# Concepts for the Proposed System

In this section, the proposed system is described in a high-level manner, indicating the operational features that are to be provided without specifying design details. This section explains how the proposed travel time monitoring system is envisioned to operate in fulfilling user needs. This discussion does not contain design specifications, but it does have examples of design strategies.

* + 1. Background, objectives, and scope of the new or modified system

The [city] has identified enhanced arterial operations as a priority initiative in its mission. Proactive ITS elements are needed to extend the capability for enhanced signal operations, arterial traveler information, arterial monitoring and data collection on key [city] roadway corridors.

The goals (high-level needs) of the proposed travel time monitoring system are:

* Provide real-time travel times and travel speeds on roadway segments and routes (Need 1)
* Provide input for engineers on signal timing operational effectiveness (Need 2)
* Provide a means to provide traveler information on the [arterial network] [including on DMS signs if present] (Need 3)
* Provide a system to report key performance indicators for the [arterial network] (Need 4).

The scope of the system is as follows:

* [Roadways (and extents) upon which the system will be installed]
* [Which portals will be required for traveler information (city/county website or app, houstontranstar.org, or by other means)]

The objectives of the system are:

* Provide quantitative input into the city/county transportation improvement program and regional planning processes (through the annual report to council and data transfer to H-GAC and other entities)
* Result in a 5% reduction in route travel times through the use of travel time data for traffic signal timing adjustments
* Provide traveler information through ##,### website and/or mobile app views of city/county traveler information.
	+ 1. Operational policies and constraints that apply to the proposed system

The Engineering Department has been tasked to deliver the travel time monitoring system and has set the goals listed in Section 1.5.1 as minimum for the system. The City Council stated that the system should be available to residents using a map and that a report should be provided at least once per year on the system operational status.

The engineering department has determined that the system (including field units, communications, and the processing system) should be operational 99.1% of the hours over a year, allowing time for system maintenance as needed. City Council has set aside additional operational funds for the system once installed at an annual amount of $XX,XXX, provided through the Engineering Department. City Council also specified that data from the system be shared with partner stakeholders (including TxDOT and other cities and counties), and with private-data providers who execute data sharing agreements through either the city attorney’s office or with Houston TranStar.

* + 1. Description of proposed system

This section contains a description of the proposed system.

* + - 1. The operational environment and its characteristics

The travel time monitoring system will operate in two environments: 1) field/roadside, and 2) server located in a city facility or at Houston TranStar with associated terminals.

In the field, readers would be card-rack or shelf-mounted systems likely co-located in traffic signal cabinet. An antenna is also required. The field units should have requirements regarding environmental specifications including temperature, humidity, and electrical power.

The server would need to comply with City IT requirements, including physical specifications and cooling functions.

* + - 1. Major system elements and the interconnections among these elements

Figure 1 shows the system elements and connections between elements (with high-level data types noted). The system components can be separated into four primary elements:

1. Field reader/antenna assembly
2. Communications
3. Host process
4. Human interface (internet-based browser)

The figure below shows the proposed system configuration with the city server as primary but a Houston TranStar server as a secondary/backup server. The field readers send data from the field to two separate systems for identical processing.



Figure . System Elements and Connections.

* + - 1. Interfaces to external systems or procedures

The primary system data interface to external systems is out via a required XML output from the system which includes aggregated data in 30-second update interval.

The system interface (internet browser-based) is manually used to create travel time summaries which can be compiled into the annual travel time report.

* + - 1. Capabilities or functions of the proposed system

The capabilities and functions of the proposed travel time monitoring system include:

* Reading unique identifiers at multiple locations;
* Matching unique identifiers among multiple locations;
* Filtering outliers of individual matches among multiple locations;
* Aggregating matches of unique identifiers among multiple locations;
* Averaging matches of unique identifiers among multiple locations;
* Reporting average speeds and travel times of aggregated matches between two locations; and
* Reporting percentile speeds and travel times of aggregated matches between two locations.
	+ - 1. Charts/descriptions depicting inputs, outputs, dataflow

Figure 2 shows the high-level system inputs, outputs and data flows between field elements, host processing elements (at the city and at Houston TranStar) and the interfaces. The unique ID’s are read by the field units and transmitted to the hosts for storage and matching. Once at the host, the matches are processed for valid/invalid status based on several programmable algorithms. Those processed matches are then provided in an interface to users via an internet browser.



Figure . High-Level System Inputs, Outputs and Dataflows

The system inputs include the following:

* Field devices:
	+ Configuration parameters (including logical name, IP address)
	+ Unique identifiers read via connections to an external (to housing) antenna
* Host processor:
	+ Configuration parameters (including segment names, lengths, speed limits and others)
	+ Filtering algorithm selection
* Human interface:
	+ Selection of travel speed charting and table generation parameters (date ranges, roadways, direction, segments, interval, and others)
	+ Selection of travel time charting and table generation parameters (date ranges, roadways, direction, segments, interval, and others)
	+ Selection of reader performance parameters (date ranges, roadway, reader(s) and interval)
	+ Selection of origin/destination charting and table generation parameters (date and time ranges, minimum/maximum travel times, days, readers, and performance measure (count of matches, trip %, travel times)
	+ Selection of parameters to generate intersection delay output (reader location, reference readers, start/end dates and times, days and others)
	+ Selection of parameters to generate travel time and speed statistics (averages, percentiles, and reliability measures)
	+ Selection of reader reads and match performance chart/table dates
	+ Selection of travel time report parameters
	+ Selection of segment/route comparison table parameters
	+ Selection of map parameters (current, current vs historical, historical)
	+ Selection of real-time data tables for roadways
	+ Selection of delay dashboard parameters

System outputs include:

* Field devices:
	+ Unique identifier (raw, encrypted, and/or truncated)
	+ Timestamp
	+ Heartbeat (I am here) message
* Host process:
	+ Travel speed charting and table generation
	+ Travel time charting and table generation
	+ Reader performance
	+ Origin/destination charting and table generation
	+ Intersection delay output
	+ Travel time and speed statistics (averages, percentiles, and reliability measures)
	+ Reader reads and match performance chart/tables
	+ Travel time report
	+ Segment/route comparison tables
	+ Travel time map
	+ Real-time data tables for roadways
	+ Delay dashboard
		- 1. Cost of systems operations, including manpower requirements

It is estimated that the cost of travel time monitoring systems operations and maintenance is incremental to existing operations and maintenance costs – meaning that the O&M of the system can be accommodated by existing staff given current workload. If current workload increases, or priorities changed, additional cost to operate and maintaining the travel time monitoring system may be required.

The monetary value of travel time monitoring system operations and maintenance cost is estimated to be approximately $11,250 per year ($30/hour x 1.5 man-hours/day x 250 days/year) for labor and $12,000 per year for communications cost and supplemental equipment.

* + - 1. Operational risk factors

The primary operational risk factor of the travel time monitoring system is with protection of public privacy. To mitigate this risk, the travel time monitoring system shall have the capability to encrypt and/or truncate and encrypt unique identifiers in the field before sending data over a communication link back to the host for processing.

Other operational risk factors include failure of the city server which processed reads and matches, and through which the user interface is generated, a similar failure of the Houston TranStar server. Operational factors could also include inadequately trained maintenance staff, operating staff, and inadequate funding for system operation and maintenance.

* + - 1. Performance characteristics, such as speed, throughput, volume, frequency

The travel time monitoring system shall read unique identifiers and send immediately (no batch transfer) uniquely timestamped. The host process shall be able to receive up to 100,000 reads per second into the system and produce matches when received. The host process shall aggregate matches and produce system updates every 30 seconds. The host process should accommodate up to 100 concurrent users through the browser interface (but not serve the map directly).

* + - 1. Quality attributes, including: reliability and availability, others as needed

The travel time monitoring system shall be available 99.1% of the time of the year.

* + - 1. Provisions for safety, security, privacy, integrity, and continuity of operations in emergencies

There are no additional provisions for safety, security, or privacy in emergency operations versus normal operations. The integrity and continuity of system operations is provided by the data sharing agreement between the city and Houston TranStar which ensures backup of the system is in-place continuously.

* + - 1. Logistics requirements to support system

Other than providing communications to field units, standard inventory control of replacement parts (including confirming lead times with suppliers) and regular software updates of server operating system, there are no other significant logistics requirements to support the system.

* + 1. Modes of operation

The travel time monitoring system will have two modes of operation: normal (identifier reads processed by the city/county host) and backup (identifier reads processed by Houston TranStar host). These modes of operation are concurrent so that if one system is unavailable, the other system is still processing ID matches and calculating performance measures. The capabilities and functions of the system are the same with either mode, only the manner in reaching the data (either city site or via Houston TranStar) will change.

* + 1. User classes and other involved staff/personnel

This section discusses the user classes and how they interact with the system

* + - 1. Organizational structure

The organizational structure of user groups and classes that will be involved with the proposed system are shown in the figure below. This shows the relationship of city administration in relation to the various user classes listed in Section 1.5.5.2.



Figure . System/Organizational Structure of User Classes

* + - 1. Profiles of user classes

User classes for the system include:

* System Operator – individuals (likely Engineering Department staff) that manage system configuration and use the travel time monitoring system for real-time operations. These users require the highest levels of system authentication, are trained in the use of the system, and may make decisions on how to interpret system outputs. This class of user should be trained in the operation and configuration of the system and are responsible for its daily operation and function. The interface with the system will be primarily on the host configuration and data output interfaces.
* System Maintainer – individuals (likely Engineering Department staff) or contractors with primary responsibility to maintain the function of field equipment and communications links between field equipment and travel time host. A system maintainer could also function as one who maintains the host server with operating system and host software updates. These users should be skilled in electronics installation, troubleshooting and repair, and are likely the same staff that deal with traffic signal and telecommunications issues for the agency.
* City/County User – Administrator/Executive – this class of user desires travel time and travel speed information at aggregated/dashboard levels. This class might include city council members and city management staff (e.g., department/division heads).
* City/County User – Engineering/Planning – this class of user desires more detail on segments or routes for operations and planning activities internal to the city/county. This would include individuals interpreting travel time and travel speed data mostly in aggregate form but may observe data in real-time. These users would also export travel time and speed data from the system for more detailed analysis.
* Houston TranStar User – this class of user is internal to Houston TranStar, likely a Houston TranStar partner agency employee whose job is to either operate the roadway network and report incidents to the public or manage a traffic signal system with the need to cross jurisdictional boundaries.
* Public User – this class of user is a member of the traveling public with a desire to know more about roadway delays or slower than normal travel times. They interface with the system by viewing a color-coded map of arterial conditions, by viewing customized reports, charts and graphs of segments or routes, or by reading reports of data generated by the system and reported to the public on roadway conditions.
	+ - 1. Interactions with system among user classes

The various user classes interface with the proposed system as described below. Most of the interface will be through internet browser-based screens via PC and mobile devices, but some users will have access to field equipment interfaces and will need to connect via laptop computer or over mobile internet connections.

* System Operator – interaction with the system will be primarily on the host configuration and data output interfaces. Operators will monitor the travel time system map and produce tabular and graphical data via travel time and origin-destination analysis screens, including travel times by segment, matches by segment, travel times by routes, matches by routes, system reader status.
* System Maintainer – interaction with the system will be through the system status page, which shows communications status, last received read, IP/network address, and charts including communications status and reliability and device reads. Their interaction will also be in the field where they will interface with the reader hardware, antennas, and communication interfaces.
* City/County User – Administrator/Executive – this class of user will interface the system through the browser-based interface, primarily using the system performance dashboard, travel time and travel speed reports at aggregated levels, and travel time reliability reports.
* City/County User – Engineering/Planning – this class of user will interface the system through the browser-based interface, viewing charts (travel time/speed matches, sample rates and averages), device reads, and reader performance. These users would also use the browser interface to access origin/destination tools, intersection passage time (delay) calculator, travel time distributions, and read/match distribution and performance trends. They would also use the browser to view real time information (system map, data tables, delay dashboard, and alerts). These users would also access data export tools through the browser and readers status.
* Houston TranStar User – this class of user would primarily use the data generated by the system and superimposed on existing TranStar map interfaces to view traffic speeds on maps. Some users may use browser-based interfaces similar to the City/County User Engineering/Planning, but most use will be at a higher-level than detailed-level.
* Public User –The public will interface with the system largely by viewing a color-coded map of arterial conditions. They may also be allowed to view the engineering/planning interface to create customized reports, charts and graphs of segments or routes.
	+ - 1. Other involved personnel

Other agency executives and staff members may not directly interact with the travel time monitoring system but will influence it use and operational status. The city/county manager may not directly use the system but will use reports from the system to prioritize initiatives to improve mobility. City Council members may also not directly use the system but will use reports and input from staff derived from the system to make decisions on budgeting and priorities for investment in transportation systems in the community. Outside of the implementing agency, staff at the Houston-Galveston Area Council may use data generated by the system for reports and analysis purposes. Consultants may also be asked to use data generated by the system for analyses and reports on behalf of the city, but they may do so using exported data provided through city staff, and not by directly using the system.

* + 1. Support Environment

The travel time monitoring system is envisioned as one that does not require significant resources to maintain and operate. Aside from ensuring power (solar or AC systems) and communications remain in operation, the continuous operation of the travel time monitoring system is relatively free of maintenance requirements.

Preventative maintenance is recommended but is mainly limited to checks of the field equipment and associated antennas and cables and ensuring communications with the field units is continuous. The materials used in these systems are relatively small and spares can typically be stored on shelves in climate or non climate-controlled facilities.

Support for the system can be under the direction of the Engineering or Public Works Department, with additional support by contractors as needed. Typical levels of spare parts should be kept on hand (5-15% replacement in inventory). In some cases, bucket trucks or other heavy equipment may be needed to properly attach antennas or connect communications – those activities may be completed with in-house equipment or as contracted services.

The software interface should be used to identify readers which malfunction, either to the units themselves or from communications interruptions. This interface should identify readers that experience communications uptime below acceptable levels, or which have reads below acceptable levels.

# Operational Scenarios

Below are step-by-step descriptions of how the proposed travel time monitoring system should operate and interact with its users and external interfaces under certain circumstances.

## Normal Operations

Under normal operations, the travel time system is receiving unique ID’s from passing vehicles from roadside readers. Those readers are communicating with two servers: 1) at the city – the primary host server, and 2) at Houston TranStar – the secondary host server. Each field reader should have the ability to send data to multiple server IP addresses. It is communicating over existing city-owned fiber optic cables, over city-owned wireless communications links, and over leased cellular connections.

The software on the host server at the city is taking unique ID’s read in the field at one location and matching them to the same unique ID read at another location. The host then filters the matches for outliers as specified in the configuration file and then aggregates them to calculate average travel times and speeds. The secondary server at Houston TranStar is processing data identically.

The host servers are storing device ID reads and matches to query the data to produce graphs, tables and charts via an internet browser-based interface. This interface should be able to be viewed on a desktop computer, laptop, tablet or mobile devices. The interface also includes a map of the system, showing color-coded speeds currently on the network. If a user hovers their mouse over the colored links they receive details of the current speed, travel time and segment data (name and length). An alternate map shows whether current travel time and speed conditions are normal or abnormal (and the extent of abnormal).

City Engineering Department staff, primarily system operators, monitor the system via the map for real-time operations. They are monitoring the normal speed map (e.g., the red/yellow/green map) and the “abnormal vs normal” map. If segments are showing abnormal they can use the existing CCTV system to examine for incidents. If an incident is found, they system operator can place a phone call to emergency services for a response. If the abnormal travel time is found on a segment without CCTV coverage, emergency services can be sent to investigate.

City Engineering Department staff assist City Planning staff to access the interface and download data used for planning studies. This data is generated for segments and routes and is used as calibration data for transportation modeling projects by city staff and consultants, and is sent to H-GAC for regional modeling efforts.

On a monthly basis, Engineering Department staff create a summary report of average speeds and travel times, by segment and by several key routes, for a performance report. This monthly performance report is created for Engineering Department use but is used to create an annual report for city council.

For public users, interaction with the system will primarily be trough viewing the traffic map interface on the city’s website or through viewing the Houston TranStar website map for the city’s area. Broadcast media could be considered public users for this purpose and will view the city’s or Houston TranStar’s website to report traffic information on radio, internet and TV. An XML feed available from the host software would be published every 30-seconds for third-party consumption and use per city guidelines.

## Backup Operations (Houston TranStar switches to primary)

This scenario is called backup operations, but in reality, the city system and Houston TranStar system are running concurrently and either can be used for the same functions. The scenario assumes the city’s server has failed, but the backup operation would work if Houston TranStar’s server has failed.

If the city’s travel time monitoring server were to fail or required maintenance downtime, data would still be sent to Houston TranStar for processing from the field, assuming all communication links were working properly. In this case, the XML feed from TranStar’s service could be used as fail-over to populate the city’s travel time monitoring map so that the public experience would be seamless. For the time that the host server at the city was not working, the read and match data files could be imported into the city system after the outage was over so that future performance reporting would be all-inclusive of all data generated by the system.

# Summary of Impacts

This section describes the operational impacts of the proposed system on the users and the operations and maintenance organizations involved and describes how those users can prepare for the changes that will be brought about by the new system.

* + 1. Operational impacts

The anticipated operational impacts of the system on users, support, and operations and maintenance staff during the operations of the travel time monitoring system include:

* Users
	+ System Operator – operators will spend time interacting with the system, particularly in peak periods as they monitor traffic. They may also spend some time on the host configuration. Operators will monitor the travel time system map and produce tabular and graphical data via travel time and origin-destination analysis screens. Operators will be the most well versed users at the agency, and may be required to assist others with interpreting data outputs or supplying reports, charts and graphs from system output. The anticipated man-hours per week spent by one operator on this system could be 20-30 hours per week. New procedures may need to be developed to guide operators on their responsibilities with the system and their priorities related to it versus other duties. The operators may also need to have a policy about data sharing and permissions and procedures to provide data to third parties.
	+ System Maintainer – system maintenance may require interpretation of field reader status reports on the host interface and interaction in the field where they will interface with the reader hardware, antennas, and communication interfaces. System maintenance may require less than 4 hours per week per 10 readers. The maintenance staff will need to understand where in the repair priority the travel time monitoring system is in relation to other equipment and maintenance responsibilities. Departmental budgets will need adjustment to include the additional manhours and materials needed to maintenance the system.
	+ City User (internal) – Administrator/Executive – this class of user will interface the system through the browser-based interface, primarily using the system performance dashboard, travel time and travel speed reports at aggregated levels, and travel time reliability reports. These users need to be made aware of privacy policies and any limitations on the publication or use of the data.
	+ City User (internal) – Engineering/Planning – this class of user will interface the system through the browser-based interface, viewing charts (travel time/speed matches, sample rates and averages), device reads, and reader performance. Similar to administrator/executive users, these users need to be made aware of privacy policies and any limitations on the publication or use of the data. Administrators within the engineering and/or planning departments may spend additional hours overseeing operations and maintenance of the system, but much of that responsibility is seen being delegated to operators and maintenance staff.
	+ Houston TranStar User – this class of user (this is an agency staff member at Houston TranStar) would primarily use the data generated by the system and superimposed on existing TranStar map interfaces to view traffic speeds on maps. Agency staff at TranStar may be required to monitor system status and to respond to maintenance issues at TranStar, but otherwise as part of normal operations of other similar systems in the center. The backup host may need occasional configuration files copied into the system, for which TranStar IS would be responsible. It is envisioned that the backup host instance could run on an existing server in the center.
	+ Public User –The public will interface with the system largely by viewing a color-coded map of arterial conditions and view the engineering/planning interface to create customized reports, charts and graphs of segments or routes. There would be no direct cost for the public user for this service. However, users would be made aware that all content is copyright of the owning agency (a disclaimer should be put on every page viewed claiming copyright and no responsibility for use or misuse of the data).
* Support Staff – there will likely be a need for city IT staff to assist with obtaining network addresses for travel time field monitoring equipment initially, and to assist Engineering Department with ongoing maintenance issues. The level of support could be expected to be about 4 hours per 10 readers deployed initially, and less than 2 man-hours per week thereafter for normal operations and maintenance. City IT may also need to supply computerized archive space on the city server where the host instance will be housed, and work with Houston TranStar IS staff on data exchange policy and protocol. City IT and Houston TranStar IS will have to mitigate any security risks associated with the new system and ensure that security updates are applied to applicable servers.
	+ 1. Organizational impacts

At this point, it is not envisioned that this system would require additional staff to monitor and maintain the system. Existing operations staff will add monitoring to their normal duties and advise administration if additional resources are ultimately needed. Regarding maintenance, existing staff and/or contracted services can accommodate needs. Aside from the time to train on the system (both host/configuration and field device install/configuration) additional staff resources are not necessary.

The City Council will have to provide funding to deploy and maintain the system, and incrementally fund expansion as desired.

Where existing communications links are not available at deployment sites, cellular or wireless communications links will need to be provided and paid for using allocated operations funds. City Council and Engineering Department administrators will need to determine if those funds come from existing operations allocations or will need supplemental funds added.

* + 1. Impacts during development

During development of the system, staff members at various level of the agency, and at partner agencies, may be needed to provide input or be involved in meetings to discuss requirements, high-level design, and detailed design. In addition, key staff may be needed to be involved in verification and validation efforts to document compliance with system requirements once deployment begins. Designated staff members may need to take time from normal duties for training activities and support staff may be required to escort contractors during field installation and work in the right-of-way. Since this system is new, no parallel operations and no retirement of existing systems will be required. Coordination with Houston TranStar IS and TranStar agency partners will be required to setup protocols and procedures for data sharing.

# Analysis of proposed system

*Provide an analysis of the benefits, limitations, disadvantages, and alternatives considered for the proposed system. These benefits can be quantitative (preferred) or qualitative.*

* + 1. Benefits

The benefits of the proposed travel time monitoring system are that it produces travel time data with thousands more samples than currently produced using occasional floating car travel time runs and enables current travel conditions to be used for network monitoring and publishing traveler information to the public and broadcast media. The system does so at a reasonable initial capital cost and reasonable ongoing operations and maintenance costs. It provides the Engineering Department a way to meet the councils request for an annual congestion report to the city and provides other partner agencies with travel time and speed data in the city.

* + 1. Disadvantages and limitations

The type of travel time monitoring system envisioned is probe-based. While this system is very accurate, probe-based methods need to have travel already occur between two points to measure travel time, and subsequent measures. Probe-based methods are not truly “real-time” travel times but represent recent travel times which are representative of current travel times on the network. This delay in calculation of travel times is most evident during incident conditions where an incident between reader A and reader B can make matches take longer, and the system needs more time to reflect the incident. To minimize this impact, readers can be spaced closer together, or supplemented with other

* + 1. Alternatives considered

Other alternatives to construct a travel time monitoring system were considered, namely using radar sensors placed at ¼ mile spacing, magnetometer loops and inductive loop-based systems. These systems were deemed too expensive to install or are too intrusive (staff did not want to cut pavement for loops or magnetometers). These systems can produce travel times indirectly, which was also not desired.

# Appendices

[Blind note: Some information may be placed in appendices to the document. Each appendix should be referenced in the main body of the document where that information would normally have been provided. This can include proposed system coverage maps, locations of readers, communications links (existing and proposed) and graphics regarding the system.]

# Glossary

[Blind note: A glossary should be maintained and updated during the processes of concept analysis and development of the ConOps document. Include an alphabetical listing of all acronyms and abbreviations, along with their meanings as used in this document, and a list of any terms and definitions needed to understand the document. ]