I-95 OPERATIONS AND TRAFFIC MANAGEMENT ON-CALL

TECHNICAL MEMORANDUM

ENHANCED CONCEPTUAL PROGRAM FOR A NEW HAVEN TRAFFIC OPERATIONS CENTER

PREPARED FOR
SOUTH CENTRAL REGIONAL COUNCIL OF GOVERNMENTS

by

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in association with

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EXECUTIVE SUMMARY

A Traffic Operations Center (TOC) to be operated by the New Haven Department of Traffic and Parking is recommended to facilitate corridor operations in the New Haven area. While management of traffic in connection with the Harbor Crossing Corridor Improvement Program is an initial function, the TOC will serve to manage operations after construction is complete. The TOC will operate in close conjunction with the Connecticut Department of Transportation (ConnDOT) TOC in Bridgeport, and will exchange information with other key stakeholders. Existing and proposed field equipment will support this operation.

A significant reduction in delays to motorists resulting from incidents or construction is expected. Congestion monitoring, more rapid incident clearance, implementation of diversion plans and motorist information will provide this improvement. Signal timing on diversion routes will be adjusted to better service diverted traffic resulting from incidents. Provision of congestion information to emergency service responders will enable them to perform their missions with less delay.

Preliminary diversion routes to carry interstate traffic around the Pearl Harbor Memorial Bridge are identified in Section 2.2 of this Technical Memorandum, and must be reviewed by stakeholders. Congestion will be identified by traffic detectors, and diversions will be supported by variable message signs, highway advisory radio, dynamic trail-blazers, static trail-blazers and web site information. Congestion information developed by the TOC will also be provided in a concise and rapid format to emergency service providers.

ConnDOT currently operates much of the required equipment, however, additional field equipment will be required.

The project requires close cooperation among the major stakeholders including:

- New Haven Department of Traffic and Parking
- Connecticut Department of Transportation
- New Haven Fire Department
- New Haven Police Department
- North Central Connecticut EMS Council
- South Central Regional Council of Governments
- Town of East Haven
- Harbor Crossing Corridor Improvement Program

With stakeholder participation and approval, a Concept of Operations will be developed to define and coordinate project activities and information flows.

Estimated project costs in thousands of dollars are summarized below:

	New Haven TOC and Field Equipment	Connecticut DOT Field Equipment	Total
Construction	$2,400	$640	$3,040
Annual Operations and Maintenance During Bridge Reconstruction	$630	$60	$690
Annual Operations and Maintenance After Bridge Reconstruction	$490	$60	$550

The concept of using existing ConnDOT capabilities in conjunction with local corridor management represents a significant enhancement to current ITS capability, and may serve as a demonstration for metropolitan areas in Connecticut with similar requirements.

TABLE OF CONTENTS

EXHIBITS

EXHIBITS (CONTINUED)

APPENDICES

1. INTRODUCTION

This study evaluates opportunities to respond to the congestion impacts of the Pearl Harbor Memorial Bridge Project. The results of the following tasks are reported in this Technical Memorandum (TM).

- Development of an Enhanced Conceptual Program for a New Haven Traffic Operations Center (TOC)
- Evaluation of Variable Message Signs, Highway Advisory Radio and other Intelligent Transportation System Measures
- Evaluation of Emergency Vehicle Access and Delay

The interstate sections centering on the Pearl Harbor Memorial Bridge experience recurrent congestion during peak periods and at other times. Incidents commonly result in severe delays. These delays will become more frequent during bridge construction periods. The study concludes that traffic congestion will be improved by servicing the major demands as a traffic corridor managed by an Intelligent Transportation System (ITS). Thus, the focus of the New Haven TOC and ITS is to support the corridor management concept.

The Connecticut Department of Transportation (ConnDOT) traffic management system contains surveillance and motorist information technology for detecting traffic congestion, and communicating delays and diversion recommendations to motorists. Additions to existing equipment are required in some locations to perform the functions required by this project. ConnDOT traffic detector and CCTV information will be provided to the New Haven TOC. The New Haven TOC will use this information, along with incident information and additional detector information to implement corridor functions. It will provide information on alternate routes and will assist in providing support to emergency responders. Signal timing plans to support diversions will also be provided. Congestion information will be provided to emergency service responders to facilitate improved routing under congestion conditions.

Section 2 of the TM identifies the functions of the New Haven TOC, describes preliminary diversion routes and describes ITS processes to be implemented.

Section 3 provides the TOC equipment, space and staffing requirements.

Section 4 describes the existing and proposed field equipment and relates it to the diversion routes. It also describes the management requirements and controls associated with diversion and their expected effects.

Section 5 discusses possible ways to improve measures for improving emergency vehicle access. Section 6 provides the estimated project cost.

Section 7 identifies the stakeholders, describes the importance of agreement for coordination of operations among the stakeholders and proposes a Concept of Operations as a mechanism to define interagency relationships.

Section 8 provides conclusions, near-term recommendations and long-term recommendations.

2. ENHANCED CONCEPTUAL PROGRAM FOR A NEW HAVEN TRAFFIC OPERATIONS CENTER (TOC)

2.1 TOC REQUIREMENTS

2.1.1 OBJECTIVES

The TOC will serve to control traffic in the I-95 Corridor, and to assist in incident management operations both during and after the construction periods associated with the Harbor Crossing Corridor Improvement Program. Currently ConnDOT has surveillance and motorist information equipment on I-95, motorist information equipment on I-91, and plans for additional surveillance equipment. The New Haven TOC will implement diversion plans (related to specific alternate routes) utilizing this equipment, together with additional equipment to be provided, and signal timing plans that support the diversion plans. The TOC will also assist emergency service providers to more rapidly access and clear incidents. The system will provide motorists with a higher level of information on diversion routes during periods of construction related to the I-95 Harbor Crossing Corridor Improvement Program and after construction is complete. It is expected that these measures will result in the following benefits over and above those currently being provided by the ConnDOT ITS:

- Reduction of motorist delay by 20% resulting from incidents on I-95 or construction associated with the Pearl Harbor Memorial Bridge.
- Reduction of secondary accidents by 10% resulting from incidents on I-95 or construction associated with the Pearl Harbor Memorial Bridge.
- Reduction of delay to emergency responders by 20%.

2.1.2 FUNCTIONAL REQUIREMENTS

The key functions of the New Haven TOC include the following:

- Monitor traffic conditions and reports of incidents and congestion on I-95 and I-91.
- Verify and classify incidents.
- Select and implement response plans.
- Develop corridor based traffic management plans that are intended to respond to delays due to construction, incidents and special events. Coordinate the ITS implementation of management plans with plans developed by the Connecticut DOT, State Police and local police departments.
- Monitor New Haven traffic signals for appropriate signal timing plan selection and signal failure.[1]
- Update normal and diversion timing plans for the City of New Haven traffic signals.[1]

[1] Functions currently performed by the New Haven Department of Traffic and Parking.

- Coordinate maintenance activities for the City of New Haven traffic signals.[1]

2.2 ALTERNATE ROUTES AND MOTORIST INFORMATION CONCEPTS

2.2.1 GENERAL DIVERSION APPROACH

Diversion provides benefits to both those diverted (reduced travel time), and those remaining on the interstates (reduced demand resulting in considerably greater delay reduction). Thus, from the TOC's viewpoint, diversion is a tool to reduce total delay. High levels of diversion are not necessarily required to obtain significant delay reduction. To successfully accomplish this objective requires some level of control to assure that those diverted are not penalized in terms of longer travel time on the alternates. Diversion to the alternates will also affect local vehicles on those routes, and this effect must also be bounded.

De facto diversion is the current situation on the interstates. De facto diversion occurs when a motorist messaging technology such as an upstream variable message sign (VMS) indicates congestion, but does not suggest an alternate. Thus some local motorists will divert to alternates appropriate to their destination. Some through motorists familiar with the area will divert; however most through motorists are likely to be unfamiliar with the alternates and will remain on the interstate. Other VMS will advise diversion on the *planned diversion routes*. Research has shown that diversion levels are a function of the "strength" of the message.

To control the level of diversion on planned diversion routes, or at least to prevent over-diversion for the reasons cited above, travel time will be monitored on the interstates by using point detectors. Data from detectors on I-95 and I-91 will soon be available; however coverage gaps will exist and additional detectors will be required. Point detectors will also be required on the alternate routes at capacity critical locations. Point detectors will be used in conjunction with Synchro models or other simulations to estimate alternate route travel time and the volume to capacity ratio for diversion control purposes.

Motorists unfamiliar with the area will require additional guidance to navigate the planned diversion routes. Additional guidance will be provided in the form of *dynamic trail-blazers* and static (conventional) trail-blazers. Dynamic trail-blazers are signs, portions of which or all of which may be illuminated or blanked out by controls from the TOC. They will be provided at the exit ramps for planned diversion routes. They will also be provided at turning points near the start of the planned diversion route. Further along the planned diversion route, static trail-blazers will be provided. Static trail-blazers are provided where the diversion route is also the best path to the interstate under non-diversion conditions. In some cases it may be required to replace existing static trail-blazers with dynamic trail-blazers. Diversion signal timing plans will be used when a planned diversion is in effect and the signals are under closed loop control. Existing

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[1] Functions currently performed by the New Haven Department of Traffic and Parking.

highway advisory radio (HAR) facilities will serve as a supplement to the VMS. An additional HAR beacon may be required. In the New Haven area, HAR coverage extends to the areas off the interstates. Thus it may be possible to use the HAR to advise local motorists of congestion prior to entering the interstates.

It is envisioned that congestion on the planned diversion routes will be continuously monitored, and the diversion messages adjusted to maintain the level of service on these routes at an acceptable level. It should be noted that video processing detectors (a particular type of point detector) not only provide volume, lane occupancy and speed data, but also provide video images, thus enabling the TOC operator to override the controls if necessary.

2.2.2 DIVERSION ROUTES

The following is proposed as an initial approach for diversion routes to address the effects of construction impacts and traffic incidents in the area of the Pearl Harbor Memorial Bridge. This approach must be reviewed with the City of New Haven and the Town of East Haven. Exhibits 2-1 through 2-6 show these routes.

I-95 SB

For congestion starting at Exit 49 and extending to any exit up to and including Exit 55, congestion notification for de facto diversion will be provided by the existing VMS between Exits 57 and 56.

The planned diversion routes will start at Exit 52. Diversion will be recommended by the existing VMS between Exits 53 and 52. Motorists on US 1 will also be notified by the existing VMS at the Branford Connector.

Traffic destined for I-91 NB north of New Haven will utilize Route 100 to Route 80 to Route 17 to I-91 Exit 8.

Traffic destined for I-95 SB will utilize US 1 to Brewery Street to Sargent Drive to I-95 Exit 47.

I-95 NB

Information for planned diversion routes will be provided by the existing VMS south of Exit 43 and south of Exit 46.

For congestion starting at Exit 48 and extending to Exit 45 or 44, the planned diversion route starts at Exit 44 and includes Kimberly Avenue, Howard Avenue and US 1.

Traffic destined for I-91 NB will follow South Church Street to Church Street to Elm Street to State Street and enter I-91 at Exit 3.

Traffic destined for I-95 NB will continue on US 1 to I-95 Exit 51.

For congestion starting at Exit 48 and extending to Exit 46 the planned diversion route starts at Exit 46 and includes Long Wharf Road. and East Street.

Traffic destined for I-95 NB will take US 1 to I-95 Exit 51.

Traffic destined for I-95 N will continue on East Street. to Ives Place to I-91 Exit 2.

I-91 SB to I-95 NB

Congestion information for de facto diversion will be provided by the existing VMS north of Exit 12. The VMS south of Exit 9 will provide information for the planned diversion route.

For congestion starting at I–95 and extending to any interchange up to Exit 8 the planned diversion route starts at Exit 8 and includes Middletown Avenue, Route 80 and Route 100 to I-95 Exit 52.

I-91 SB to I-95 SB

Congestion information for de facto diversion will be provided by the existing VMS north of Exit 12. The VMS south of Exit 9 will provide information for the planned diversion route.

The congestion conditions and planned diversion routes are shown below.

NON-DIVERSION ROUTE	CONGESTION CONDITION		DIVERSION EXIT	DIVERSION ROUTE
	Queue starts	Queue ends		
I-91S to I-95S	I-95	Exit 3 or 4	4	Humphrey St., State St., W. Water St., S. Orange St., Route 34 to I-95S.
I-91S to I-95S	I-95	Exit 6	6	Willow St., State St., W. Water St., S. Orange St., Route 34 to I-95S.
I-91S to I-95S	I-95	Exit 7	7	Middletown Ave., Ferry St., State St., W. Water St., S. Orange St., Route 34 to I-95S.
I-91S to I-95S	I-95	Exit 8	8	Middletown Ave., Ferry St., State St., W. Water St., S. Orange St., Route 34 to I-95S.

The Connecticut Department of Transportation, in conjunction with the State Police and local police departments, has identified diversion route plans for other locations along I-95. These plans generally address closures at a point, and are intended to circumvent the closed location. The plans generally divert traffic at the exit ramp just upstream of the incident and return it to the entry ramp on I-95 downstream of the incident. These plans do not address the plans associated with the Pearl Harbor Memorial Bridge described above.

2.2.3 FUTURE CONSIDERATIONS FOR DIVERSION PLANNING

The diversion routes described in Section 2.2.2 are preliminary. The following must be accomplished to confirm the diversion route plan:

- Discussion of the control concept and the planned diversion routes with the City of New Haven and the Town of East Haven is required.

- The proposed approach, even after review, is preliminary in the sense that the impacts on the interstate and limitations on diverted volume must be determined under representative lane closure and incident conditions. The benefits for diversion must also be identified. These determinations are best accomplished by the use of simulations that model the interstate and planned diversion route impacts. The simulation can also help to identify the need and impact of such controls as ramp closures at Exits 51 and 49 to prevent queue jumping.

2.3 NEW HAVEN TRAFFIC OPERATIONS CENTER FUNCTIONS

Section 2.1.2 identifies key TOC functional requirements. The functions to be performed by the TOC to satisfy these requirements include:

1. <u>Coordinate the development and updating of traffic response plans</u>
   Draft plans in response to incidents, planned construction activity and special events will be developed and reviewed by stakeholders. The plans will be electronically documented and implemented by stakeholders. The plans will be stored in the TOC server for real time implementation. The use of simulation may assist in the development of traffic response plans. The roadway closure plans developed by ConnDOT together with the State Police and local police departments will be incorporated.

   Traffic response plans relate the location and nature of the event to the following controls and displays:

   - VMS and HAR messages
   - HAR beacons
   - Dynamic trail-blazers

- Entry ramp gate control systems including motorist warning devices[2]
- Traffic signal diversion timing plans. This includes City of New Haven and ConnDOT signals

2. Receive, process, display and communicate traffic related conditions
   Exhibit 2-7 shows a preliminary flow concept for information entering and leaving the New Haven TOC, and how this information relates to other field devices and stakeholders. These information flow relationships are further discussed in Section 7.

   CCTV and traffic detector information will be received from ConnDOT. Construction information will be obtained from the I-95 Harbor Crossing Improvement Program, from ConnDOT and from the City of New Haven. Incident information will be obtained from the New Haven 911 Communications Center in the form of 911 calls that have been entered into the management system and filtered for traffic incident information. Incident information will also be obtained from ConnDOT. Traffic detector speed data from ConnDOT on I-95 and I-91 will illuminate a traffic condition map. Additional detectors on these interstates as described in Section 4.1.1 will be required. City of New Haven detector data will also be displayed. The condition map will also identify the location of traffic incidents. The map will be provided to emergency vehicle responders by rapid, low cost communications. This display will be provided to the public on the City of New Haven website and will be available to ConnDOT and Harbor Crossing Project web sites.

   ConnDOT CCTV images and City of New Haven traffic cameras will be available for display in the New Haven TOC and will be rapidly accessible to emergency service providers and to the New Haven Harbor Crossing Improvement Program.

3. Implement traffic response plans
   Traffic response plans will be implemented based on the information described above. Implementation of response plans involves the following:
   - Scheduling of planned construction and special events.
   - Verification and classification of incidents and congestion.
   - Request for stakeholders to implement plans including notification to ConnDOT. It is expected that ConnDOT will implement messages on VMS and HAR, and will select appropriate signal timing diversion plans for its closed loop systems.
   - Control of equipment not controlled by ConnDOT including the New Haven traffic signals, dynamic trail-blazers and entry ramp gate control equipment (if appropriate).

[2] Use of gates annd associated equipment to be determined by later studies. If used, gates must be under CCTV surveillance and a motorist warning system must be provided for gate closure.

- Provide notification to stakeholders as to when the plan should be terminated.

4. Assist emergency responders
   TOC operators may assist emergency responders to access the incident site and to assist them in managing traffic at the site with the ability to monitor traffic conditions,

5. Develop signal timing plans for the City of New Haven and coordinate maintenance of these signals.

Exhibit 2-1: Alternate Route - I-95 SB to I-91 NB

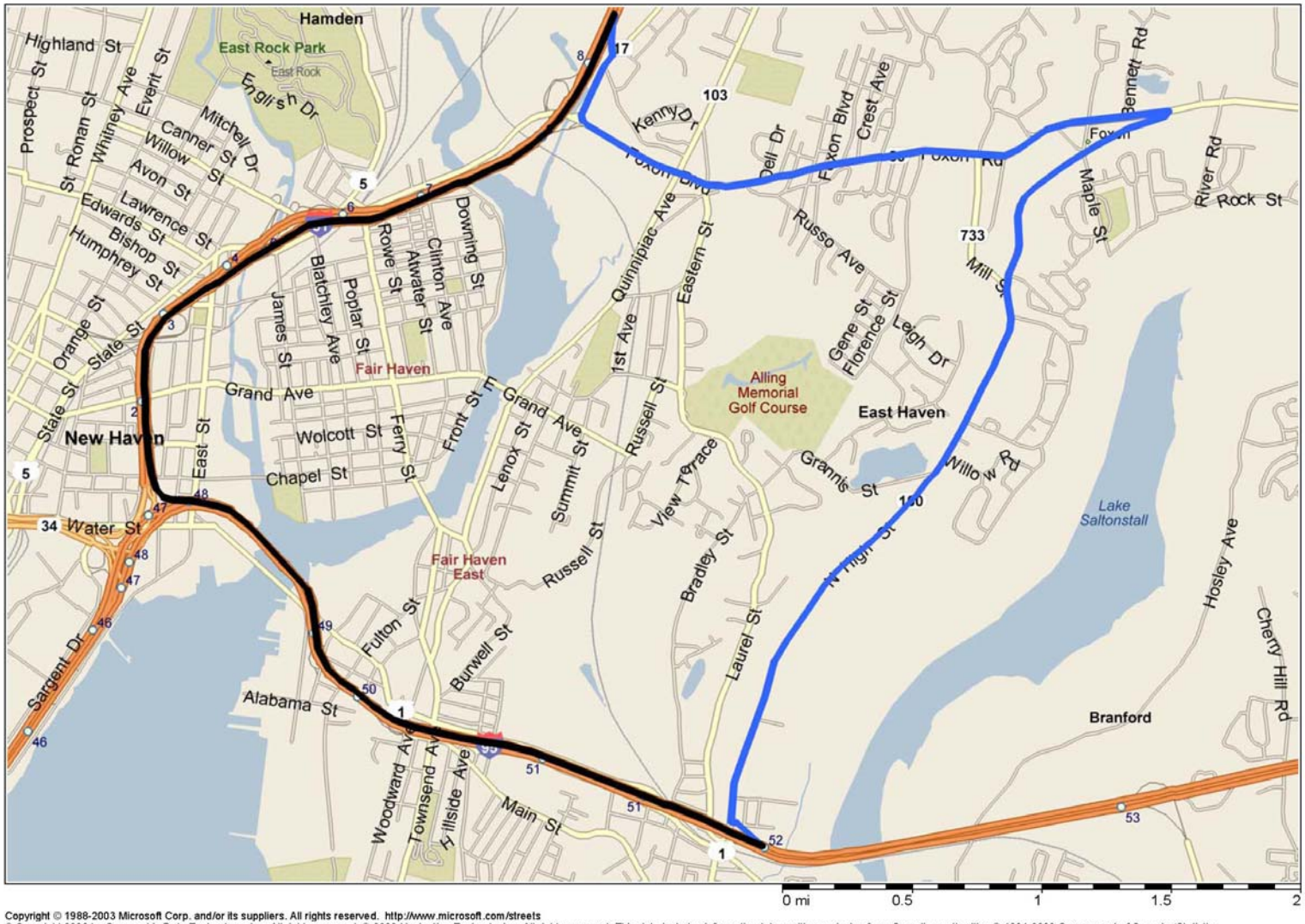


Exhibit 2-2: Alternate Route - I-95 SB to I-95 SB

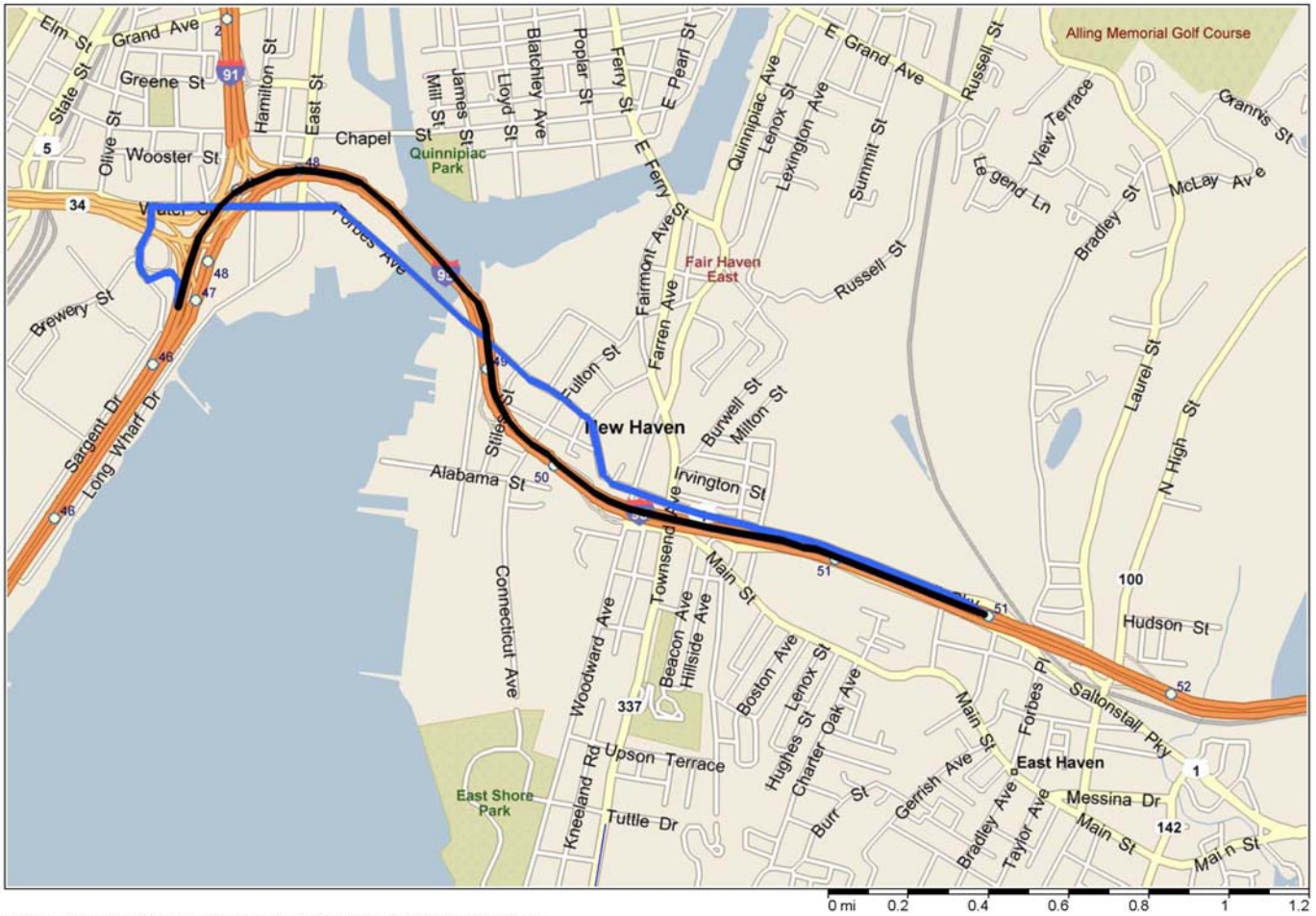


Exhibit 2-3: Alternate Route - I-95 NB to I-91 NB

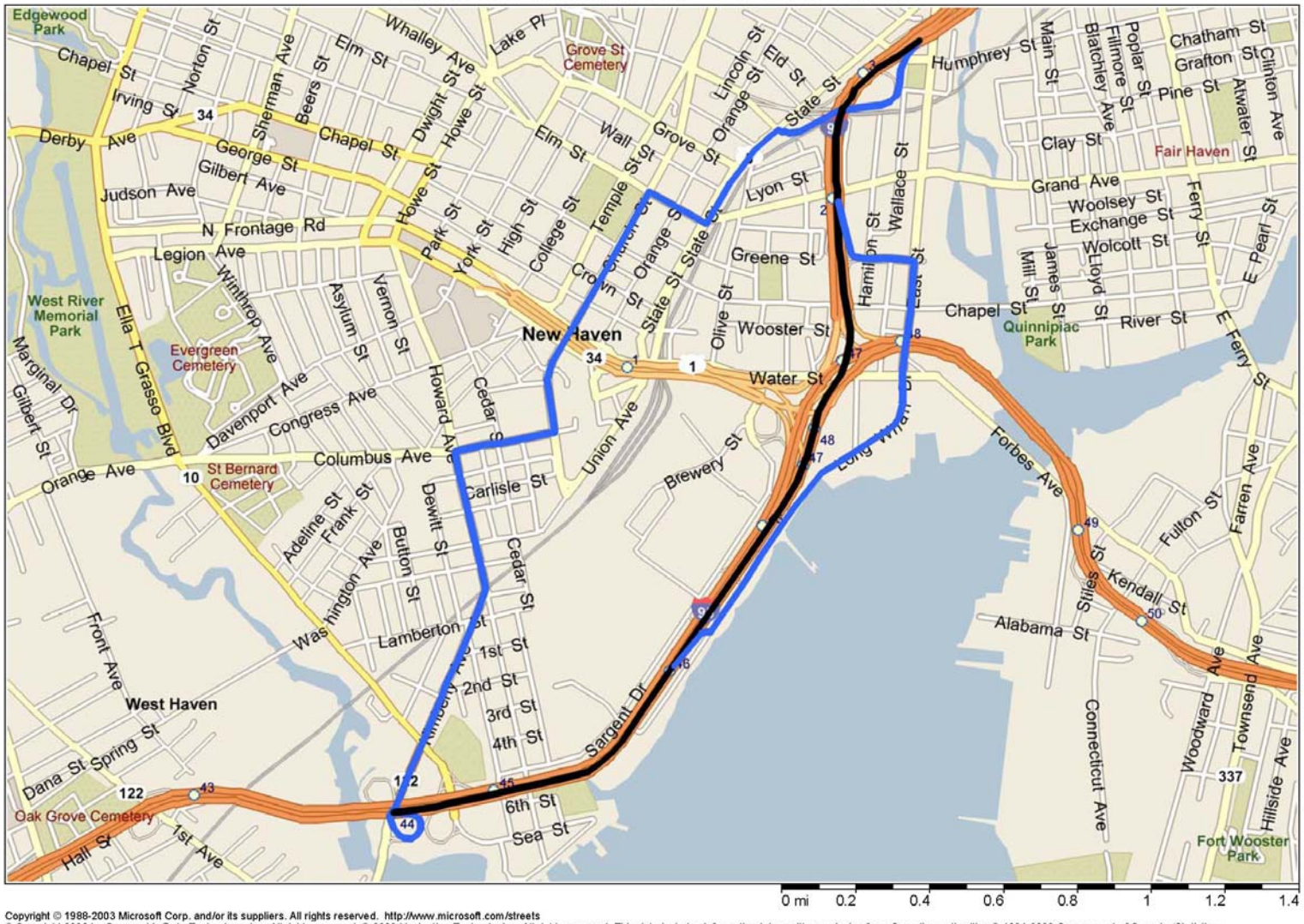


Exhibit 2-4: Alternate Route - I-95 NB to I-95 NB

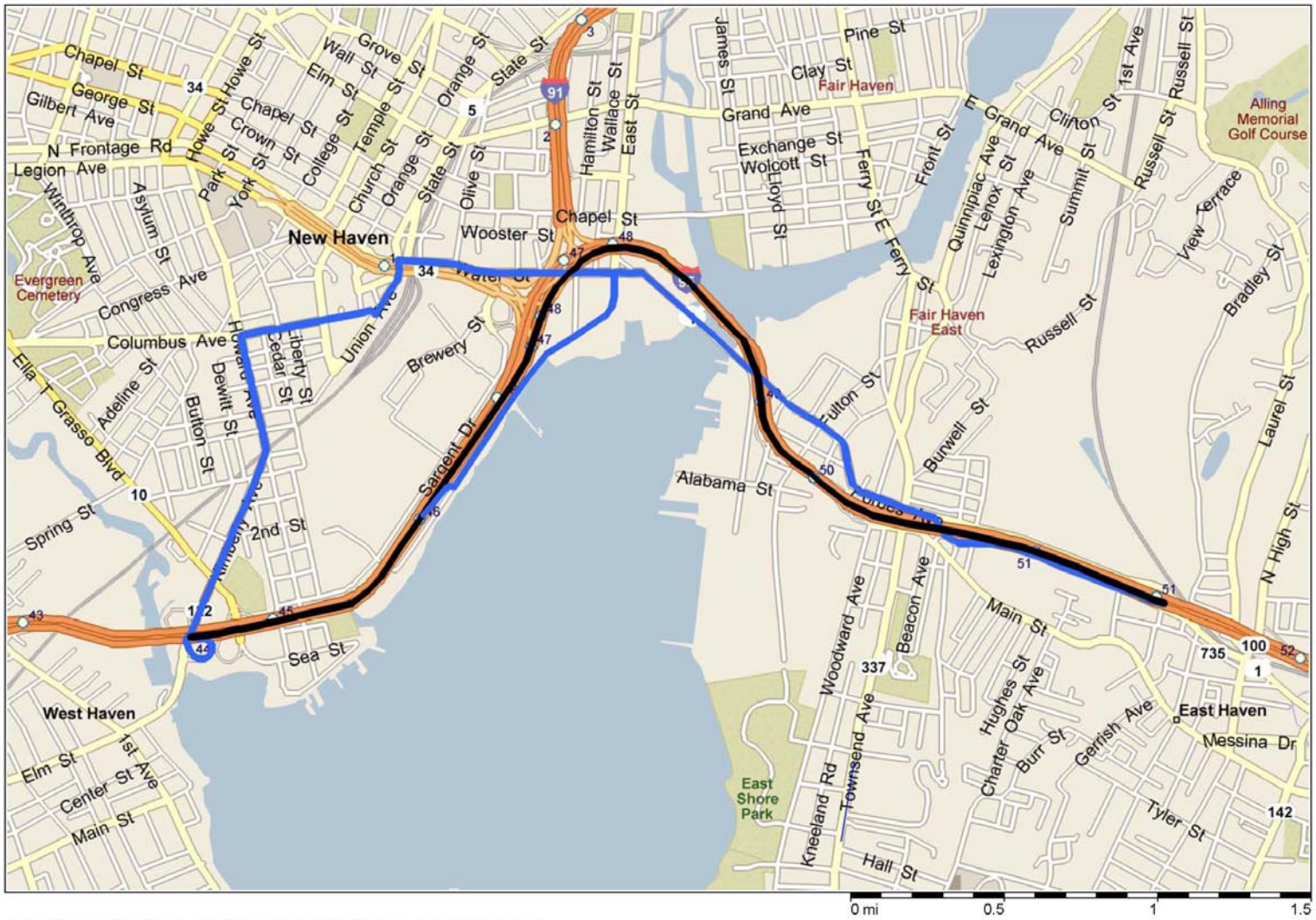


Exhibit 2-5: Alternate Route - I-91 SB to I-95 NB

Exhibit 2-6: Alternate Route - I-91 SB to I-95 SB

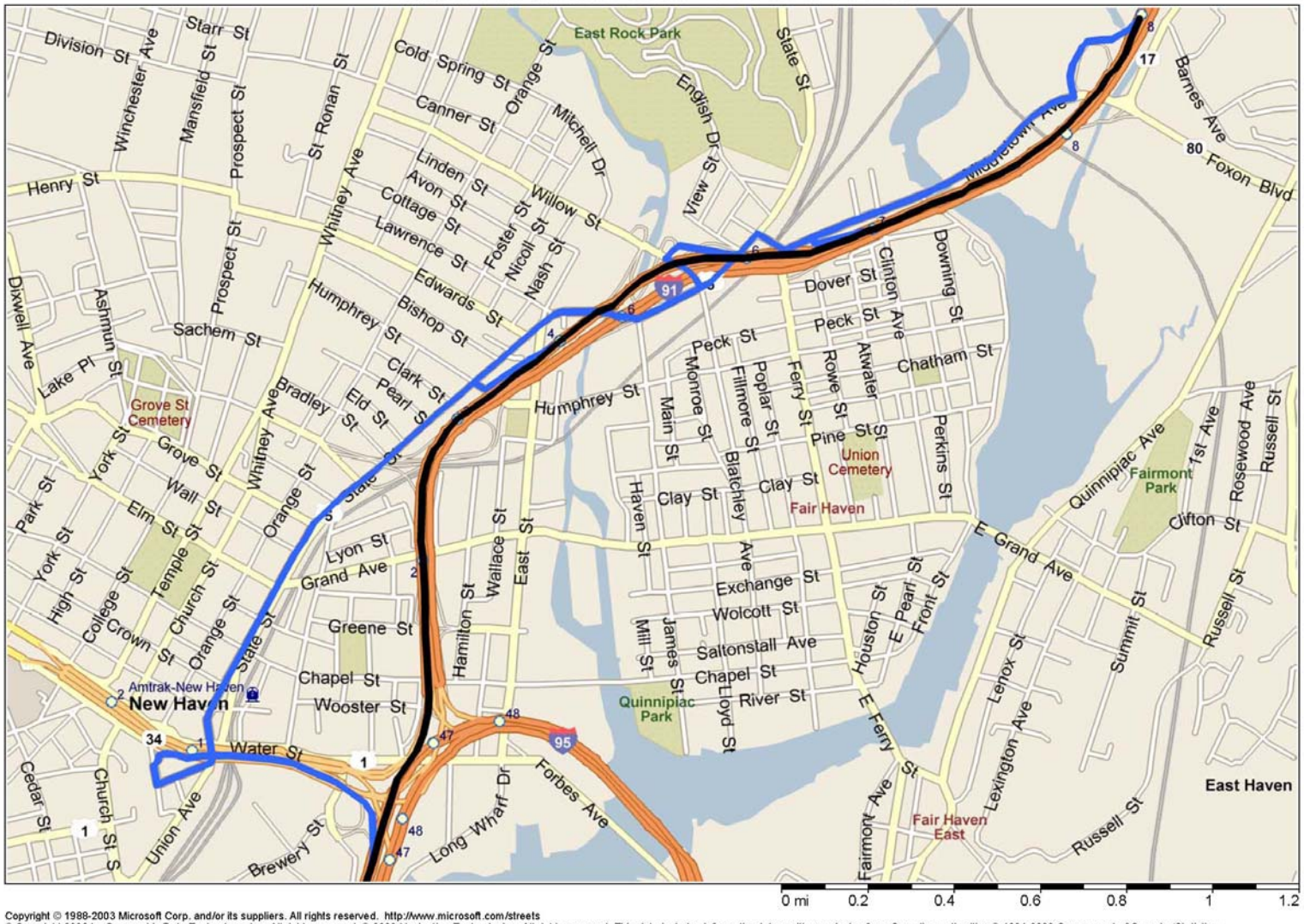
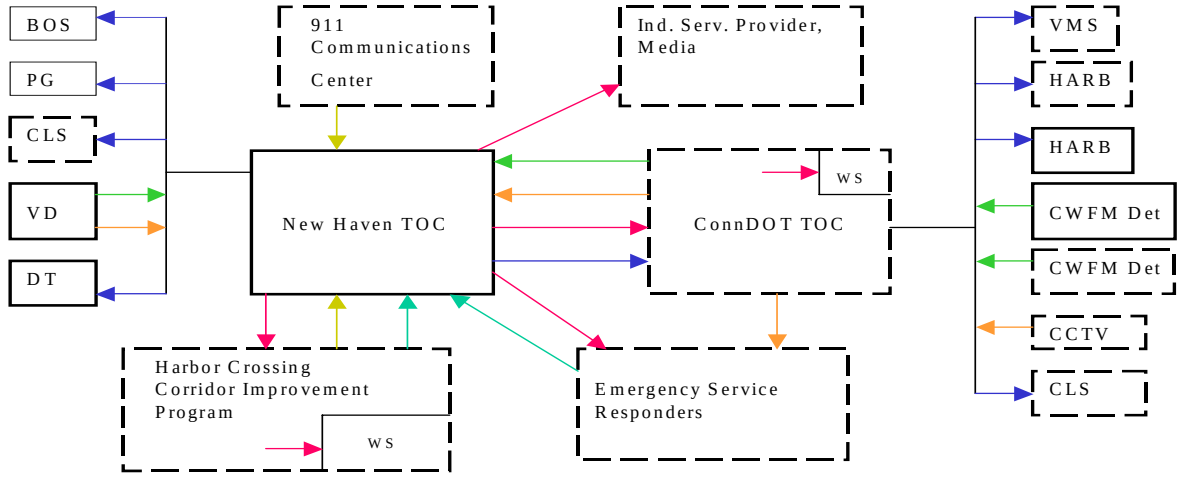


EXHIBIT 2-7

PRELIMINARY INFORMATION FLOW CONCEPT



Device Symbols

BOS – Blank out sign

CCTV – CCTV camera

CLS – Closed loop traffic controller

CWFM Det – Continuous wave frequency modulated traffic detector

DT – Dynamic Trailblazer

HARB – Highway advisory radio beacon

PG – Protected gate

VD – Video based traffic detector

VMS – Variable message sign

WS – Web site

Data Flow Functions

Detector Data

CCTV Signal

Response Plan Control

Traffic Information

Information Input for Response Plan Selection

Request for Control Assistance

Site or Device Outlines

Existing Site or Device

Proposed Site or Device

Requires Additional Consideration

3. TOC PHYSICAL REQUIREMENTS

3.1 EQUIPMENT REQUIREMENTS

The following is a preliminary estimate of the equipment required:

1. Existing Servers for the City of New Haven traffic signal control systems.

2. Server for the Event Management System.
   This server provides the intelligent management functions. These functions are expected to include:
   - Receiving traffic detector and incident information from ConnDOT.
   - Logging and displaying detector and incident information and traffic condition information, including detector information as available from the City of New Haven traffic signal control systems.
   - Storage of event management plans and provision for operator selection, monitoring and management of plans.
   - Communication of incident management plans to stakeholders.
   - Control of alternate routing devices not controlled by ConnDOT.
   - Provision of incident management information to media and independent service providers.
   - Display of dynamic message sign messages.
   - Gate controls and associated messages (if appropriate).

3. Workstations for the traffic signal systems and the event management system.

4. Workstation/monitor for information from New Haven 911 Communication Center.

5. Video wall for the display of CCTV cameras, traffic condition and equipment condition maps.

6. Video camera controls.

7. Local area network equipment.

8. Communication equipment. Communication with field devices not controlled by ConnDOT, communication with traffic signals (moved from existing location), communication with ConnDOT and other stakeholders.

9. Miscellaneous computer equipment (printers, scanner, etc.)

10. Uninterruptible power supply (UPS).

11. Miscellaneous office equipment.

3.2 PHYSICAL SPACE REQUIREMENTS

Exhibit 3-1 shows one possible layout for the operations area of the New Haven Traffic Operations Center. The footprint is 30 feet by 24 feet. In addition to the operations area, an office comprising approximately 200 square feet for the City Traffic Engineer/TOC Manager and 100 square feet for personnel support functions will be provided.

The control room space in the operations area is sufficient for operators or other personnel, a control desk containing workstations for the traffic signal systems and the event management system, some office equipment and a video display wall approximately six 19” to 24” inch monitors. These monitors are used to display CCTV camera images and maps showing traffic conditions and equipment status.

The computer/communications room would contain several servers and a number of 19” workstations for the traffic signal systems and the event management system racks for communications, a simple video system, local area network equipment and uninterruptible power supply. This equipment would fit into two or three 19" racks. The building facility must provide electrical circuits and HVAC. Access to communication services will also be required.

The office area shown in Exhibit 3-1 may be used for file storage, on-site consultant support, conferences and office work associated with the TOC. The office area will also have workstations for the traffic signal systems and the event management system.

3.3 STAFFING REQUIREMENTS

During the construction period related to the I-95 Harbor Crossing Corridor Improvement Program, it is expected that the New Haven TOC will be staffed around the clock. After the termination of impacts on I-95 resulting from construction on this project, the TOC will be staffed during the principal weekday periods as well as at other times. The New Haven City Traffic Engineer will serve as the manger of the TOC. The remainder of the staff may either be City employees or contract employees. In addition, contract assistance to support specialized functions such as software and communications support will be required.

In addition to the New Haven City Traffic Engineer/TOC Manager the following preliminary staffing plan is proposed:

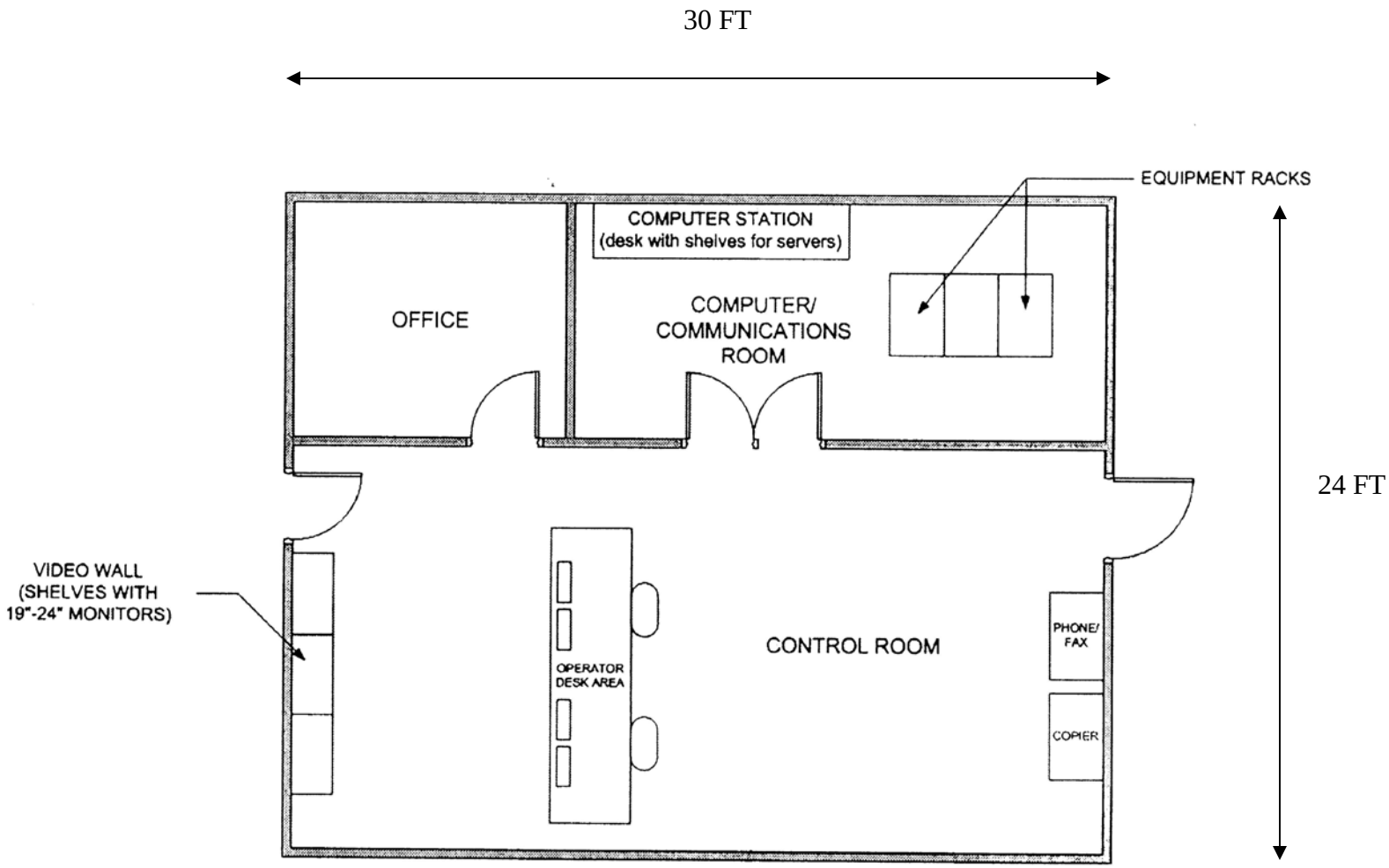
A. During Construction Period

   During this period, a senior operator and an operator will be required on a 24/7 basis. Thus, each position will require between four and five operators.

B. After Construction Period

During this period, a senior operator and an operator will be required during weekdays for fourteen hours per day. Each position will require two operators.

Section 6 provides estimated TOC costs.



OPERATIONS AREA

EXHIBIT 3-1

4. FIELD EQUIPMENT DEPLOYMENTS

4.1 DEPLOYMENT PLAN FOR FIELD EQUIPMENT

4.1.1 SURVEILLANCE EQUIPMENT

Existing and planned ConnDOT surveillance equipment to support congestion detection in the locations identified in Exhibit 2-1 (the I-95 and I-91 routes approaching the construction area) includes the following:

LOCATION	EQUIPMENT	AVAILABILITY
I-95N Exit 43-48	Radar detection	Not available for 4-5 years
	CCTV detection	Currently available
I-95S Exit 55-48	Radar detection Exits 64-51	End of 2007
	CCTV detection	Currently available
I-91S Exit 3-8	Radar detection	End of 2007

The current complement of CCTV together with the radar detectors to be available within one year provides most of the surveillance required. A detector surveillance gap on NB I-95 from Exit 43 to Exit 48 and a surveillance gap on I-91 from Exit 3 to I-95 exist. It is recommended that detectors of the type currently installed by ConnDOT (frequency modulated continuous wave radar detectors) be provided on a schedule consistent with New Haven TOC requirements.

4.1.2 MOTORIST INFORMATION AND CONTROL EQUIPMENT

Existing and new equipment on I-95 and I-91 will be used to support the diversion routes identified in Section 2. This equipment will be deployed in the following way:

- Existing VMS are sufficiently upstream of diversion points to enable motorists to conveniently and safely access the appropriate diversion exit ramp.
- Highway advisory radio (HAR) beacons will be provided at distances of two miles or greater from the exit ramp. This distance will enable the motorist to tune the radio and to receive the message from the beginning. Since HAR can be received in the New Haven area off of the interstates, publicity should be provided to encourage local motorists who might encounter congestion to access this media at the start of their journey. An additional beacon is recommended for I-91 SB just south of Exit 9.
- Dynamic trail-blazers will be provided at the interstate exit ramps and at other locations such as turns near the start of the diversion route to enable motorists not familiar with the area to navigate the diversion route. Static trail-blazers will be

provided at locations further along the route. Many static trailblazers currently exist in New Haven.

- When congestion spills back on I-95 SB past exits 49 or 51, gates[3] may be used to close these entry ramps to discourage motorists from using US 1 to jump the queue and reenter at these exits. Blank out signs are used to notify motorists when ramps are closed.
- Additional detectors (approximately 8) will be required for I-95 between Exits 43 and 48. Two detectors south of Exit 3 on I-91 are also recommended.

Appendix A provides a preliminary description of the relationship of display equipment to diversion plans.

Surface street detectors on alternate routes at critical capacity bottlenecks are also required. Approximately 20 such detectors may be required.

The estimated totals for new equipment are as follows:

New Equipment	Estimated Total Required
HAR Beacons	1
Dynamic Trail-Blazers	19
Ramp Gate Closure System including Blank-Out Signs	2
Detectors on Interstates	10
Surface Street Detectors	20

Section 6 identifies the estimated cost associated with the equipment.

Additional equipment may be required to accommodate the closure diversion routes recommended by ConnDOT, the State Police and local police departments.

4.1.3 TRAFFIC SIGNAL CONTROL

In some cases the signals comprising the alternate routes are controlled by the City of New Haven closed loop traffic signal systems. In other cases ConnDOT has a number of alternate route signals under closed loop control.

The City of New Haven closed loop signals on alternate routes include the following:

- Long Wharf Drive from Exit 46 to Canal Dock Road.
- US 1 from East Street to State Street.
- State Street from US 1 to Audubon Street.

ConnDOT closed loop signals on the alternate routes include the following:

[3] Use of gates to be determined by later studies. If used, gates must be under CCTV surveillance and a motorist warning system must be provided for gate closure.

- US 1 from Stiles Street/Wheeler Street to Woodward Avenue.
- Route 80 from I-91 to Old Foxon Road.
- Route 80 from Mill Street to Route 100

When a diversion plan is in effect, timing plans to support the diversion will be selected by the New Haven TOC and the ConnDOT TOC.

4.2 SYSTEM EFFECTIVENESSS

A key improvement provided by the New Haven TOC is its ability to manage the diversion of traffic resulting from events. Construction on I-95 will cause considerable partial blockages resulting in queues. Diversion of traffic not only results in travel time improvement to the diverted traffic, but more importantly, the diversion of even relatively small traffic volumes, if properly managed, can result in significantly shorter queues on I-95 and I-91. Examples of the upper limit of potential improvement available are shown in Exhibits 4-1 and 4-2. The example shown provides a potential improvement in delay to the non-diverted traffic of 58% based on a diversion of 10% that is properly managed. Additional improvement will result to diverted traffic. Key issues in the management of diverted traffic include the following:

- Diversion routes should have sufficient capacity for the level of diversion planned.
- The travel time on the diversion routes should not exceed the travel time under delay conditions on the interstate routes; otherwise diversion information will lose credibility with the public. This may require the initiation of diversion at some time later than the actual blockage (until sufficient delay is built up on the interstate to provide relative travel time benefits to the diverted traffic.)

Exhibit 4-1
Delay Improvement (Veh hr) for Non-Diverting Vehicles

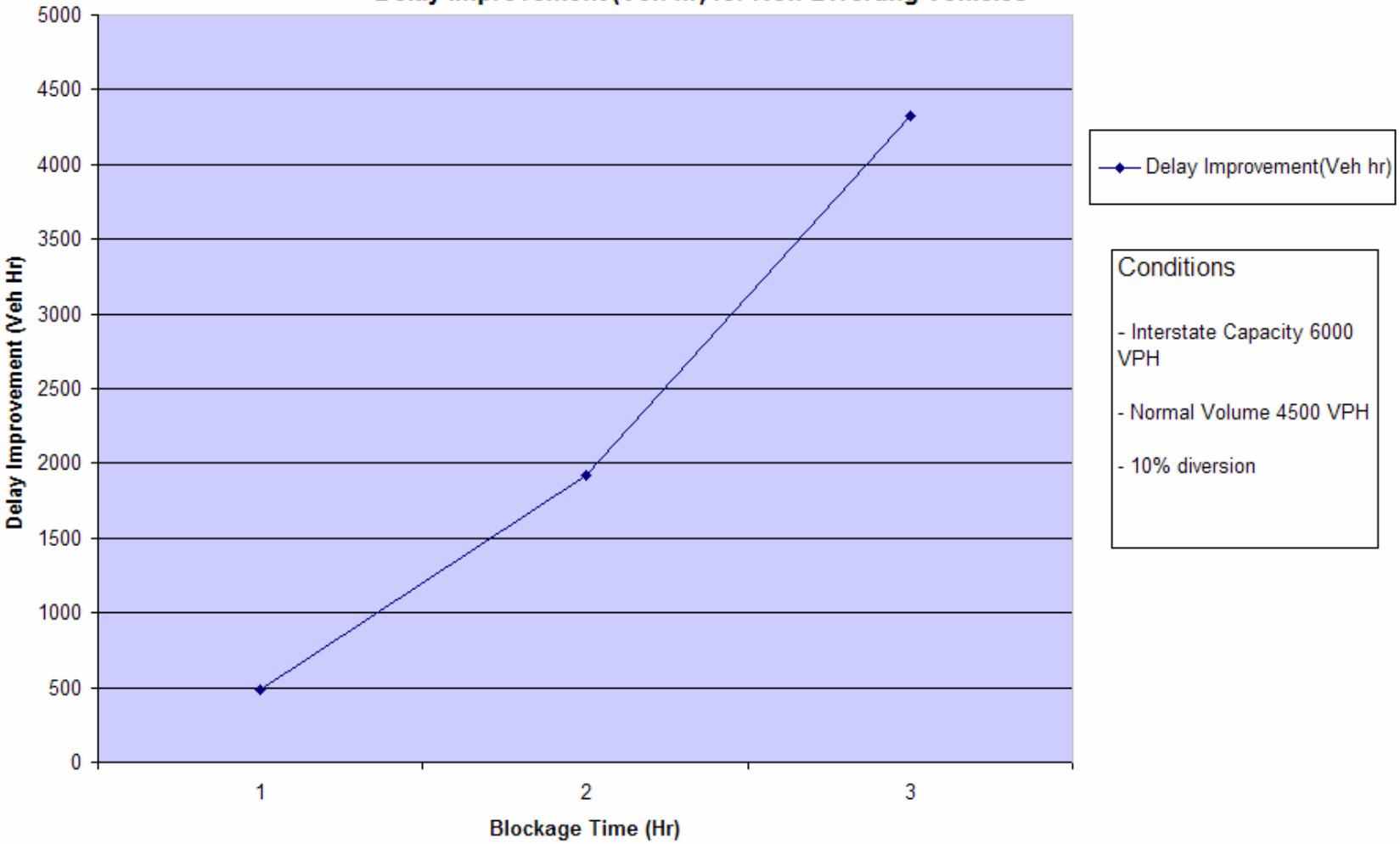
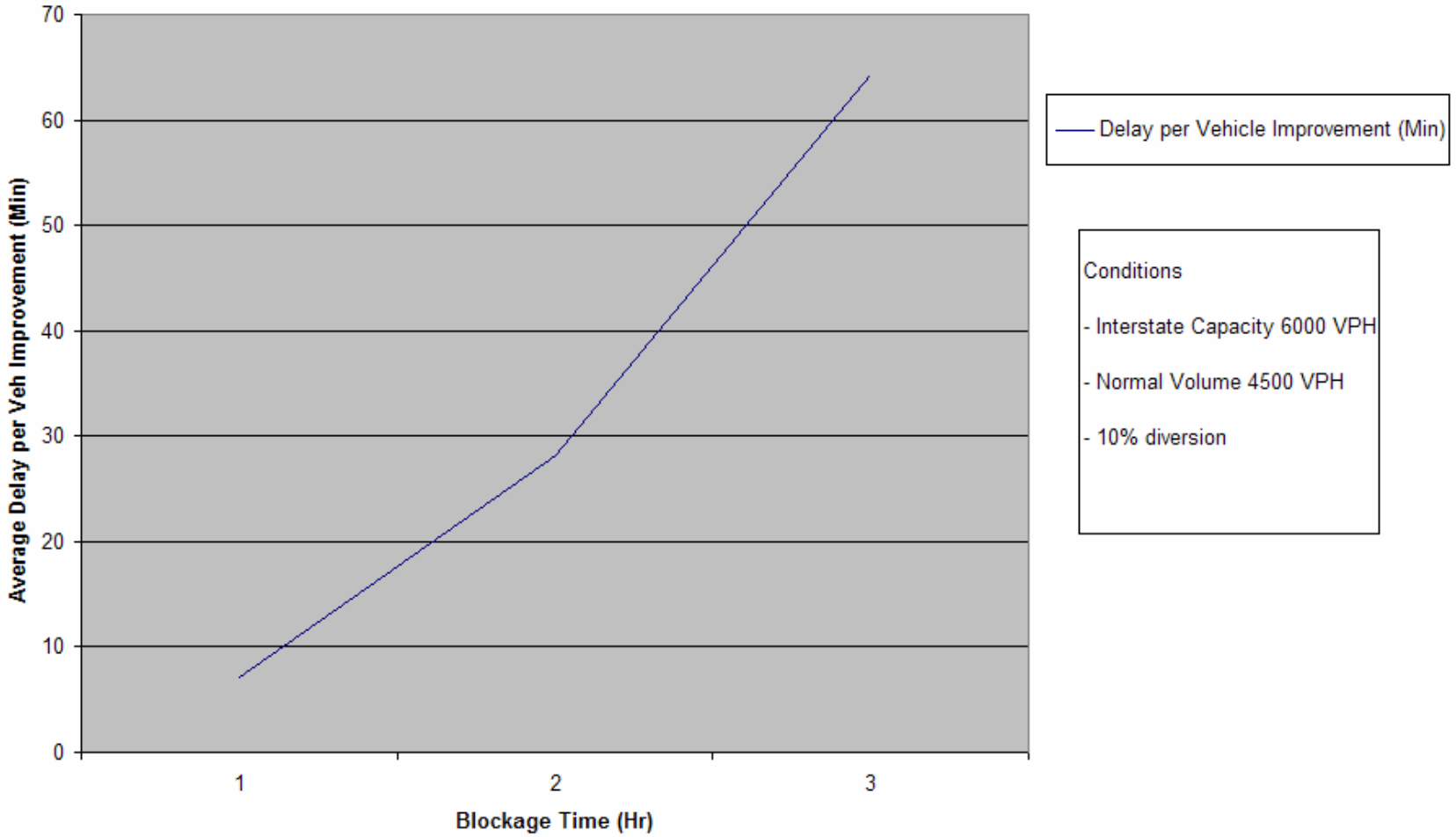


Exhibit 4-2
Delay per Vehicle Improvement (Min) for Non-Diverting Vehicles



5. EMERGENCY VEHICLE ACCESS

A study was conducted to identify the traffic related factors that result in impeding emergency vehicle access, and to identify measures that might mitigate the situation. Appendix C provides the minutes of a meeting held with emergency service providers to address these issues. The key conclusions from this meeting are:

- Traffic related delays are a serious issue.
- Emergency responders have considerable latitude in how they can access locations requiring emergency services. These include use of alternate routes, alternate dispatch locations or different hospitals. Lack of knowledge of traffic conditions is a major obstacle to optimal deployment and use of resources. Detailed concise real time information relative to the location of congestion and traffic speed, delivered inexpensively and promptly, would be a major asset in improving service.
- Traffic operation improvements to reduce congestion would significantly help access and should be considered further. Examples include:
  - Improved permit coordination to avoid simultaneous construction on alternate routes.
  - Rapid clearance of all incidents to reduce the extent and duration of congestion.
  - Prioritization of snow and ice removal for critical areas.
- Provision of strategically located gated access drives and turnaround locations on interstates for emergency response vehicles would reduce the delay in providing emergency response services.

6. COST

Exhibit 6-1 provides estimated costs for the major requirements to implement the New Haven ITS requirements described in this report. A more detailed breakdown for these costs is provided in Appendix B.

EXHIBIT 6-1

NEW HAVEN ITS ESTIMATED PROJECT COST

ITEM	CAPITAL COST ($ Thousand)	OPERATING AND MAINTENANCE COST ($ Thousand)
New Haven TOC Equipment	485	120
Field Equipment for New Haven ITS	1790	163
Connecticut DOT Equipment	640	60
New Haven TOC Staffing		
• During Bridge Construction		345
• After Bridge Construction		200
Preliminary Planning	125	
Capital Cost Summary		
New Haven ITS	2400	
Connecticut DOT	640	
Total Capital Cost	3040	
Annual Operations and Maintenance Cost Summary		
New Haven ITS During Bridge Construction	630	
New Haven ITS After Bridge Construction	480	
Connecticut DOT	60	

An alternative to the establishment of a TOC operated by the City of New Haven is to transfer the functions to the Connecticut DOT Bridgeport TOC. This approach would likely result in economies of scale. Implementation would require close operational coordination with the New Haven Traffic and Parking Department to implement diversion signal timing plans at the appropriate time.

7. INTERAGENCY DATA FLOW AND INSTITUTIONAL RELATIONSHIPS

Management of traffic in the event of construction delays or incidents requires concerted activity by the major stakeholders. The major stakeholders include:

- New Haven Traffic and Parking Department
- Connecticut Department of Transportation
- New Haven Fire Department (911 Communications Center, Emergency Medical Services, Fire Suppression, Hazardous Materials Response)
- New Haven Police Department
- North Central Connecticut EMS Council
- South Central Regional Council of Governments
- Town of East Haven
- Harbor Crossing Corridor Improvement Program

The relationship among these agencies to enable the New Haven TOC to perform its traffic management and incident response function may be viewed as real-time information flows among these agencies. A preliminary set of information flow relationships is shown in Exhibit 2-7. That figure also shows information flows between the New Haven TOC and the field devices it controls as well as the Connecticut DOT TOC in Bridgeport and the devices it controls that are related to the project objectives. Exhibit 7-1 further describes the information flow relationships among the major stakeholders.

The set of relationships described in Exhibit 7-1 requires a high level of agreement and coordination among stakeholders. This may be accomplished by a *steering committee of stakeholders* that will be responsible for establishing the functional relationships. A mechanism recommended by FHWA for the systematic identification of the TOC requirements in a multi-stakeholder environment is the development of a *Concept of Operations (COO)*[4,5]. The purpose of this document is best expressed by the FHWA Freeway Management and Operations Handbook as follows:

The Concept of Operations is a formal document that provides a user-oriented view of the traffic management and operations program. It is developed to help communicate this view to the other stakeholders and to solicit their feedback. In essence, the Concept of Operations lays out the program concept, explains how things are expected to work once it's in operation, and identifies the responsibilities of the various stakeholders for making this happen. The vision, needs, and services are also documented. The process to develop a Concept of Operations should involve

[4] *Transportation Management Center Concepts of Operation – Implementation Guide*, FHWA, FTA, December, 1999.
[5] *Developing and Using Concept of Operations in Transportation Management Systems*, FHWA, 2005.

all stakeholders and serve to build consensus in defining the mission, goals, and objectives; provide an initial definitive expression of how functions are performed, thereby supporting resource planning; and identify the interactions between organizations (within and between "tiers")[6].

Key elements in the development of the COO and in the planning of the project of the project include:

- Development of Response Plans – Response plans include the simultaneous implementation of motorist information and control devices including signal timing. Response plans should include plans for the alternate routes described in Section 2.2 as well as those identified in the ConnDOT I-95 Diversion Route Plans. Mutual stakeholder agreement is required.
- Stakeholder Responsibilities in Executing Response Plans – For example, where plans are called by the New Haven TOC and implemented, in part, by ConnDOT devices, what are the interagency control and approval levels required?
- Regional ITS Architecture – The Regional ITS Architecture must be updated to reflect the New Haven TOC requirements.
- Identification and Implementation of Needed Memoranda of Understanding
- Modification of the TIP as Necessary
- Form of Information Transmission Among Stakeholders – How will information be exchanged among stakeholders.
- Staffing and Hours of Operation of the New Haven TOC

[6] Neudorff, L.G, Randall, J.E., Reiss, R., Gordon, R., *Freeway Management and Operations Handbook*, FHWA Report No. FHWA-OP-04-003, September 2003.

EXHIBIT 7-1

INFORMATION FLOW BETWEEN NEW HAVEN TOC AND OTHER STAKEHOLDERS (PRELIMINARY)

Information Flow from NHTOC to Other Stakeholder	**Information Flow Descriptor**	**Function of Information Flow**
Connecticut DOT TOC	Traffic Information	Incident and construction delay information, congestion map.
Connecticut DOT TOC	Response Plan Control	Request for DMS and HAR messages according to response plans. Provides information for agency web sites.
Harbor Crossing Corridor Improvement Program	Traffic Information	Incident and construction delay information, congestion map. Provides information for agency web sites.
Emergency Service Responders	Traffic Information	Incident and construction delay information, congestion map.
Information Flow from Other Stakeholder to NHTOC	**Information Flow Descriptor**	**Function of Information Flow**
Connecticut DOT TOC	Detector data	Establish congestion location, support response plan selection and management, determine traffic speed, volume.
Connecticut DOT TOC	CCTV	Assist NHTOC to provide incident clearance support, retransmit video to other stakeholders.
911 Communication Center	Information input for response plan selection	911 reports filtered for traffic incidents are a major source of incident detection and confirmation.
Harbor Crossing Corridor Improvement Program	Information input for response plan selection	Scheduled construction and construction status are a major source for response plan selection. Agency may request NHTOC to provide motorist information or implement other controls.
Emergency Service Responders	Information input for response plan selection	Agency may request NHTOC to provide motorist information or implement other controls.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

- An ITS centered on the New Haven area with an architecture concept similar to that shown in Exhibit 2-7 has the capability to improve traffic operations in the I-95 corridor.
- A New Haven Traffic Operations Center working in close cooperation with the Connecticut DOT Bridgeport Traffic Operations Center and with new and existing field equipment can exercise local levels of traffic management that may be impractical for the ConnDOT TOC in Bridgeport to implement. Implementation of traffic management plans to respond to incidents and construction using ITS devices are key functions for the New Haven TOC. Initially the New Haven TOC will focus on traffic operations and incidents with respect to construction associated with the I-95 Harbor Crossing Corridor Improvement Program. After completion of this construction, operation should broaden to additional locations in the region.
- The New Haven TOC should fuse speed information from ConnDOT traffic detectors, City of New Haven traffic detectors, and sources of incident information and develop a map showing this information in real time. This map will facilitate selection of response plans. In addition, map information should be directly communicated to emergency service providers, and should be made available to the public via City, State, and I-95 Harbor Crossing Improvement Program websites.
- The traffic operations improvements described in Section 5 should be considered further.
- The combination of ConnDOT equipment and local corridor management represents a significant enhancement to current ITS capability. The project might serve as a demonstration for metropolitan areas in Connecticut with comparable requirements.

8.2 NEAR TERM RECOMMENDATIONS

- Establish a Stakeholder Steering Committee (Section 7).
- Develop a Concept of Operations (Section 7) with the participation of key stakeholders.
- ConnDOT should fill in the traffic detector gaps identified in Section 4.1.1.
- Develop a traffic model for the I-95 and I-91 corridors and the planned diversion routes. Identify the limits of acceptable diversion. Obtain stakeholder agreement with the routes and diversion limitations.
- Develop a project scope and detailed ITS system concept design based on the general concepts identified in Sections 2, 3 and 4. General equipment deployment locations are identified in Section 4.1.1 and in Appendix A. New Haven TOC requirements are identified in Sections 2.3 and 3. This effort will reflect the result of design requirements implied by the Concept of Operations.

- Develop a detailed design for the New Haven TOC and associated field equipment. Construct the New Haven TOC and install the associated field equipment.
- Develop a set of incident response plans for the finalized diversion routes that generally encompass those described in Appendix A. Enhance these response plans with the diversion routes and response plans identified by the Connecticut Department of Transportation, State Police and local police departments between I-95 Exits 44 and 56.
- Provide equipment for displaying concise map based information on traffic speeds and congestion and communications from the New Haven TOC to emergency responder dispatch facilities. Make this information available to the public via web sites.
- Consider measures to implement traffic operation improvements as described in Section 5.
- Develop a plan for providing strategically located gated emergency response vehicle access drives and turnaround locations on interstates.

8.3 LONG TERM RECOMMENDATIONS

The intent of this phase is to broaden the coverage area of the New Haven ITS to provide regional service. Certain additional measures to improve emergency vehicle response are also included. Specific recommendations include the following:

- Broaden the detector surveillance, motorist information services and alternate routing to include I-95 Exits 38 through 58. Extend alternate routing on I-91 to Exit 16. These extensions will provide additional coverage on I-95 and I-91 and will enable the Wilbur Cross Parkway to serve as a corridor bypass to New Haven for passenger cars not destined for New Haven. Extend the diversion strategies and incident response plans developed for the near term to the extended coverage areas.
- Interconnect those signals on the near-term and long-term alternate routes that are not currently interconnected.
- Consider the following measures to improve emergency vehicle response using the real-time traffic speed and congestion information provided by the TOC:
    - Provision of speed and congestion information in emergency response vehicles.
    - Software to provide minimum travel time routing information.

APPENDIX A
PRELIMINARY DISPLAY EQUIPMENT DEPLOYMENTS

The symbols used in the equipment plan table include the following:

BOS – Proposed blankout sign used in conjunction with optional gate
EB – Existing HAR beacon
EVMS – Existing VMS
GC – Proposed optional ramp entry restrictive gate
NB – Proposed HAR beacon
TB – Proposed dynamic trail-blazer

PLAN	NON-DIVERSION ROUTE	CONGESTION CONDITION		DIVERSION EXIT	DIVERSION ROUTE	ITS FIELD EQUIPMENT PLAN FOR MOTORIST INFORMATION DEVICES
		Queue starts	Queue ends			
1	I-95N to I-95N	Exit 48	Exit 47 or 46	46	Long Wharf Rd., East St., US 1 to I-95 Exit 51	EVMS #60 south of Exit 46 NB #1 south of Exit 43 TB #1 at Exit 46 exit ramp TB #2 on Long Wharf Rd. at Hamilton St. TB #3 on East St. at US 1[7]
2	I-95N to I-95N	Exit 48	Exit 45 or 44	44	Kimberly Ave., Howard Ave., US 1 to I-95 Exit 51	EVMS # 59 south of Exit 43 TB #4 on Exit 44 exit ramp TB #5 on Howard Ave. at US 1 TB #6 on US 1 at south Church St.[1]

[7] Diversion routing for two alternate routes

PLAN	NON-DIVERSION ROUTE	CONGESTION CONDITION		DIVERSION EXIT	DIVERSION ROUTE	ITS FIELD EQUIPMENT PLAN FOR MOTORIST INFORMATION DEVICES
		Queue starts	Queue ends			
3	I-95N to I-91N	Exit 48	Exit 46	46	Long Wharf Rd., East St., Ives Place to I-91 Exit 2	Same as Plan #1
4	I-95N to I-91N	Exit 48	Exit 45 or 44	44	Kimberly Ave., Howard Ave., US 1, South Church St., Church St., Elm St., State St. to I-91 Exit 3	Same as Plan #2
5	I-95S to I-95S	Exit 49	Exit 50 through Exit 56	51	US 1 to Brewery St., Sargent Drive to I-95 Exit 47	EVMS #72 north of Exit 56 EVMS # 73 south of Exit 53 EB at Exit 57 GC #1 at Exit 51 entry ramp[8] GC # 2 at Exit 49 entry ramp[2] BOS #1 at Exit 51 entry ramp[2] BOS #2 on US 1 at Stiles St.[2] TB #7 at exit ramp TB #19 at Stiles St. TB # 18 on US 1 at Brewery St.

[8] Optional use to prevent queue jumping

PLAN	NON-DIVERSION ROUTE	CONGESTION CONDITION		DIVERSION EXIT	DIVERSION ROUTE	ITS FIELD EQUIPMENT PLAN FOR MOTORIST INFORMATION DEVICES
		Queue starts	Queue ends			
6	I-95S to I-91N	Exit 49	Exit 50 through Exit 56	52	Route 100, Rt. 80, Middletown Ave. to I-91 Exit 8	EVMS #72 north of Exit 56 EMVS # 73 south of Exit 53 EB at Exit 57 TB #7 at Exit 52 exit ramp TB # 9 on Rt. 100 at Willow Rd.
7	I-91S to I-95S	I-95	Exit 4	4	Humphrey St., State St, W. Water St., S. Orange St., Route 34 to I-95S	EVMS #47 south of Exit 9 EVMS #46 North of Exit 12 EB at Exit 12 TB # 10 (diagrammatic) on exit ramp
8	I-91S to I-95S	I-95	Exit 6	6	Willow St., State St, W. Water St., S. Orange St., Route 34 to I-95S.	EVMS #47 south of Exit 9 EVMS #46 North of Exit 12 EB at Exit 12 TB #11 on exit ramp TB #12 on Willow St. at State St.
9	I-91S to I-95S	I-95	Exit 7	7	Middletown Ave., Ferry St., State St, W. Water St., S. Orange St., Route 34 to I-95S.	EVMS #47 south of Exit 9 EVMS #46 North of Exit 12 EB at Exit 12 TB #13 on exit ramp TB #14 on Middletown Ave. at Ferry St. TB #10 on May St. at State St.
10	I-91S to I-95S	I-95	Exit 8	8	Middletown Ave., Ferry St., State St, W. Water St., S. Orange St., Route 34 to I-95S.	EVMS #47 south of Exit 9 EVMS #46 North of Exit 12 EB at Exit 12 TB #15 at exit ramp TB #14 on Middletown Ave. at Ferry St. TB #16 on May St. at State St.

PLAN	NON-DIVERSION ROUTE	CONGESTION CONDITION		DIVERSION EXIT	DIVERSION ROUTE	ITS FIELD EQUIPMENT PLAN FOR MOTORIST INFORMATION DEVICES
		Queue starts	Queue ends			
11	I-91S to I-95N	I-95	Exit 8	8	Middletown Ave., Foxon Blvd., Rt. 100 to Exit 52	EVMS #47 south of Exit 9 EVMS #46 North of Exit 12 EB at Exit 12 TB #15 at Exit 8 exit ramp TB #17 on Foxon Blvd. at Rt. 100

APPENDIX B
PROJECT COST

The following page provides a preliminary estimate of the capital and operating costs for the project. The New Haven TOC will include a number of functions and personnel that are currently provided by the Department of Traffic and Parking. The costs presented in the table do not include these current costs.

	PRELIMINARY COST ESTIMATE FOR NEW HAVEN ITS PROJECT						
	Cost element		**Unit**	**Capital**	**Annual Operating**	**Annual Maintenance**	
A	**NEW HAVEN TOC EQUIPMENT**						
1	Basic equipment - computers, workstations, printers, scanners, UPS, misc office equipment, furniture			150,000		15,000	
2	Basic ITS software			150,000		30,000	
3	Specialized ITS software			100,000		15,000	
4	Office Rental (1000 sq ft @ $20)				20,000		
5	Utilities				5,000		
6	Telecommunications (ConnDOT, field devices, others)				25,000		
7	Design			40,000			
8	Contingency (10%)			44,000	5,000	6,000	
	TOTAL TOC			484,000	55,000	66,000	
B	**ConnDOT FIELD EQUIPMENT**						
		Quantity					
1	RTMS - Solar, SSR	10	45000	450,000		45,000	
2	HAR Beacon	1	10000	10,000		1,000	
3	Software & Equipment Modificatio	1	70000	70,000		7,000	
4	Design			53,000			
4	Contingency (10%)			58,300		5,300	
	TOTAL ConnDOT			641,300		58,300	
C	**NEW HAVEN FIELD EQUIPMENT**						
1	VIDS with CDMA2000	20	50000	1,000,000		100,000	
2	Dynamic Trail Blazer with CDMA2000	19	20000	380,000		38,000	
	ADDITIONAL NEW HAVEN						
1	Gate	2	30000	60,000		6,000	
2	Blankout sign	2	20000	40,000		4,000	
	Design			148,000			
	Contingency (10%)			162,800		14,800	
	TOTAL NEW HAVEN FIELD			1,790,800		162,800	
D	**NEW HAVEN TOC STAFFING**						
		Rate		**During Bridge Construction**		**After Bridge Construction**	
				Hrs/yr	**Total**	**Hrs/yr**	**Total**
1	Senior Operator	21		8760	183,960	5,110	107,310
2	Operator	15		8760	131,400	5,110	76,650
3	Contingency (10%)				31,536		18,396
	Total				346,896		202,356
E	**PRELIMINARY PLANNING**						
	(Scoping, simulation, conc. of ops., stakeholders, alt. routes)				125,000		
PROJECT TOTAL							
Total New Haven Construction Cost					2,399,800		
Total ConnDOT Construction Cost					641,300		
Total Construction Cost					3,041,100		
Operations and Maintenance Cost				During Construction		After Construction	
New Haven				630,696		486,156	
ConnDOT				58,300		58,300	
Total				688,996		544,456	

APPENDIX C
EMERGENCY VEHICLE ACCESS AND DELAYS
MINUTES OF MEETING
March 29, 2007

Subject: A meeting was held at 200 Orange St., New Haven to discuss traffic related problems with emergency vehicle access and possible remediation approaches.

Attendees:

NAME	ORGANIZATION	PHONE	email
Bijan Notghi	NH Traffic & Parking	203-946-8069	bnotghi@newhavenct.net
Gary Bruce	CMED NH	203-499-5684	cmed-newhaven@yahoo.com
John Gustafson	CMED NH	203-946-7038	Cmed.nh@snet.net
Ralph Black	NHFD	203-946-6218	rblack@newhavenct.net
Leo Bombalicki	NHPD	203-787-7002 203-687-0556	
Tim Craven	AMR	203-781-1306	tim.craven@amr.net
Jeffrey Boyd	AMR	203-781-1063	jeffrey.boyd@amr.net
Bill McKiernan	AMR	203-781-1046	bmckiernan@amr.net
Jeff Parker	Clough Harbour & Assoc.	860-257-4557	jparker@cha-llp.com
Greg Haas	Urbitran Assoc.	202-763-4524	ghaas@urbitran.com
Bob Gordon	Dunn Engineering Associates	516-938-2498	rob.gordon3@verizon.net

Topics discussed included the following:

1 Emergency Vehicle Operations Requirements:
- Delays in response time are critical to the provision of emergency services.
- Hospital patients arrive on an emergency basis, some from beyond the immediate New Haven area. The return journey of the vehicle to the location from which they are dispatched is also important, as it affects the vehicles' availability for future missions.
- Real time traffic condition information is critical not only to provide emergency vehicles with the best route choice but also to enable dispatchers to send equipment from different locations (depending on access capability) or to use different patient transportation modes (e.g. air evacuation.)
- Responders have alternate routes and alternate destinations (e.g. Yale-New Haven Hospital, Shoreline Medical Center located in Guilford) that can be used if travel delays are provided in real time.

2 General Traffic Operations
Emergency vehicle services are conducted on a continuous basis. While it is understood that traffic congestion is an everyday situation, it was pointed out that

given this situation, it is important to maintain the infrastructure and operations at a level consistent with what it is possible to do. Examples include the following:

- Permit coordination – Simultaneous construction on major alternate routes unnecessarily impedes emergency vehicle access. Improved permit coordination would be helpful.
- Pavement problems or the appearance of problems unnecessarily slows traffic and causes congestion. Quick clearance of even minor traffic problems is a key issue in reducing congestion. Rapid deployment of incident clearance equipment is essential. The elimination of police services to address property damage liability issues would speed the clearance of vehicles from the scene of minor accidents (this approach is successfully used in New York City). Surface street bottlenecks consistently result from incidents on I-95, thus rapid clearance of even minor incidents is essential.
- Winter maintenance/snow and ice removal operations should be prioritized for critical areas such as the Q-Bridge.

3 Traffic Information

Real-time information on congestion and the location of traffic incidents is a key requirement. CCTV information is of limited use because the vehicle dispatch centers do not have personnel to monitor cameras continuously. When this information is used, delays of 5-10 minutes are commonly experienced due to the time to access the information. This often requires person to person phone contact. The information must be compact and available in a directly usable form such as a map showing congestion and speed. The information must be distributed to the emergency service providers in a real time and economical way. Provision of active incident locations on the map would be helpful. Attendees expressed the need for statewide and regional coordination of information and dissemination of real time traffic information to dispatchers. Information is not useful if various sources must be accessed to obtain it. Information should be available from a single source such as a New Haven TOC. Current ConnDOT information has limited utility.

4 Emergency Vehicle Routing

- Routing software for emergency vehicles taking traffic conditions into account might be helpful. Commercial software packages such as Vertrax may be adaptable to the infusion of real time information.
- Alternate access points for emergency vehicles such as strategically located gated access drives and turnaround locations on interstates (e.g. I-91 between exits 8 and 9) would be helpful. Appropriate locations might be statistically identifiable.

5 Traffic Signal Preemption

Current policy is to limit state funding to fire vehicles. Extension to other vehicle classes is a possibility that should be considered. This might require technology changes. In addition, it was pointed out that the extension of preemption to too

many vehicles may result in additional traffic congestion that will impact other emergency vehicles on other missions.