

INTELLIGENT TRANSPORTATION SYSTEMS
CASE STUDY:
CENTRAL ARTERY (I-93)/TUNNEL (I-90) PROJECT
BOSTON, MASSACHUSETTS, USA

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1. INTRODUCTION

The Central Artery/Tunnel (CA/T) project provides an excellent opportunity to implement and test the application of Intelligent Transportation Systems (ITS) technology to improve traffic safety in a congested urban corridor. As currently designed, the CA/T project will have the most extensive ITS capabilities of any highway in U.S.A., and numerous opportunities exist to build upon these capabilities. Advances in the state-of-the-art of both ITS technology and applications can improve the safety and convenience of the travelling public in Eastern Massachusetts and provide significant regional economic benefits as well.

2. SUMMARY DESCRIPTION OF THE CA/T PROJECT

The CA/T project consists of approximately 12 km of new and reconstructed roadways, and includes the following major elements:

- A widened, mostly underground Interstate 93 (I-93) from north of the Central Artery/North Area interchange (I-93/Route 1) in Charlestown, to just south of the Massachusetts Avenue interchange. I-93 is referred to as the Central Artery north of Kneeland Street, and as the Southeast Expressway south of Kneeland Street.
- An extension of I-90 from its current terminus at I-93, via a Seaport Access Highway and Harbor tunnel, to Logan International Airport in East Boston, with a connection to Route 1A. An improved and expanded High-Occupancy Vehicle (HOV) system will be incorporated along I-93 and I-90, to link the downtown street network and the proposed South Station Transportation Center with Logan Airport and points south and west of Boston.
- An extended two-way frontage road system parallel to I-93 from Charles River to the southern project limits.
- The South Boston Bypass Road, most of which will be constructed in an existing railroad right-of-way. It will connect the Southeast Expressway to the Seaport Access Highway and the Commonwealth Flats area in South Boston, and will provide limited Commercial Vehicle (CV)/HOV access to the new tunnel for approximately four years, while the Seaport Access Highway is being completed.

The project has a number of important benefits for Boston and the New England region. It will relieve the major traffic bottleneck in the region while significantly improving the safety and convenience of travellers. Forecasts have indicated that the present system would be overwhelmed by future traffic levels, resulting in widespread congestion for up to 15 hours a day and stagnation of the economic life of the region. By doubling cross-harbor capacity to Logan Airport, projected increases in air passenger and freight travel can be accommodated without further impact on the downtown street system.

While the underground Central Artery and the Third Harbor Tunnel are the major elements of the project, other project facilities also have important transportation and economic benefits. The Seaport Access Highway will improve accessibility to the South Boston seaport and industrial areas; the HOV system will offer vehicles carrying multiple passengers head-of-queue privileges in tunnel access; the frontage road system will provide increased access to local streets along the Artery and the Expressway; and the South Boston Bypass Road will create a new route for trucks to avoid local neighborhood streets. The project will have major benefits for the City of Boston, with the development of new parkland in the heart of the City and a greatly improved pedestrian environment. With an estimated cost of \$8 Billion, the Central Artery/Tunnel project is scheduled to become fully operational in the year 2005.

2.1 Local Transportation Conditions

The Central Artery/Tunnel project area has unique transportation characteristics :

- (1) Traffic density of 1.5 times the national average for this class of highway - The Central Artery currently carries over 190,000 vehicles daily in six lanes, or over 30,000 vehicles per lane. This exceeds estimated design capacity (75,000 vehicles daily) by a factor of nearly three. Estimates indicate that without the CA/T project, the existing facility would experience delays of up to 15 hours per day in year 2010.
- (2) As determined by the USEPA under the Clean Air Act, the Boston region is currently in the "serious category" of non-attainment for ozone, and there are some indications that the area may be raised to the severe category.
- (3) A variety of types of transportation facilities, such as highways, bridges, tunnels and toll and non-toll facilities - When complete, the project area will include three cross-harbor tunnels, over 55 km of underground expressway in the center of Boston, two major bridge crossings (I-93 and the Route 1 Tobin Bridge) and a number of arterial bridges. The three cross-harbor tunnels will all be toll facilities, as well as the Tobin Bridge and the Massachusetts Turnpike. The area is also characterized by a dense and complicated network of local streets.
- (4) Inability to expand capacity of existing surface transportation facilities - Limited ability to expand physical roadway capacity in the region is a function of public policy, practicality and history. With the exception of the CA/T project, additional roadway expansion in the project area is highly unlikely. To a large degree the economic success of downtown Boston as both a residential area and a tourist destination depends on a pedestrian and transit oriented environment; an environment which will be greatly enhanced by placing the Central Artery underground.
- (5) A significant mix of passenger, transit and commercial motor traffic - The CA/T project area is a major focus of commercial motor vehicle traffic in the region. While hazardous cargo will be banned from underground sections, the Central Artery will remain a major through route for commercial traffic, and substantial growth in air freight traffic in and out of Logan is projected. HOV facilities are built into the project, which will be tied into the multi-modal Transportation Terminal at South Station. The CA/T area is served by a wide range of public transit services, including heavy rail, light rail, commuter rail, AMTRAK inter-city service, express bus, local bus and ferry service. The MBTA is the major provider of service but there are numerous private bus services as well.
- (6) Complexity of traffic patterns - Constrained by water and designed over 200 years before the advent of the automobile, the downtown Boston roadway network is probably the most complicated and difficult to

negotiate in the U.S.A. The street network makes major bottlenecks unavoidable, and the existing Central Artery has an excessive number of on- and off-ramps, with consequent weaving and severe safety problems.

2.2 Goals of the CA/T ITS Program

The goals of the Massachusetts Highway Department in implementing an ITS program on the CA/T project are:

- (1) To enhance the mobility of people and goods in the Boston region, particularly in the highly-congested project area which includes downtown Boston, Logan Airport, Charlestown and East Cambridge.
- (2) To provide for the safety of the motoring public in the new underground tunnel and highway to be constructed as part of the CA/T project.
- (3) To use these extensive built-in ITS capabilities as the first building block of a regional, multi-modal ITS network in the Boston region.
- (4) To provide, through the partial Early Opening of the project in 1995 (South Boston Haul Road and Third Harbor Tunnel), an urban laboratory for testing ITS-related technologies and traffic management concepts.
- (5) To develop a partnership in the Boston region between public agencies, the private sector and academic institutions. The objectives of this partnership will be to increase the pool of financial and technical resources available to advance ITS-related technology and to maximize the economic and public safety benefits realized from ITS.
- (6) To help provide for the safety and mobility of the travelling public during project construction.

3. ITS ON THE CA/T PROJECT

Extensive ITS capabilities are already being designed and built into the project. When completed, the project will have more ITS technology within its infrastructure than any other highway in the U.S.A. The Integrated Project Control System (IPCS) will be the focus of CA/T project operations. It will provide the CA/T project with a substantial "head-start" in ITS application and testing.

The IPCS can also serve as the heart of an expanded regional system, stretching as far as Route I-495.

3.1 Integrated Project Control System (IPCS)

The Integrated Project Control System (IPCS) for the CA/T is composed of two major systems: Intelligent Transportation Systems (ITS) and Facilities Control. Together, the systems contain over 20,000 data points which are linked to an Operations Control Center (OCC) with redundant high-speed, fiber optic cable for voice, data, and video transmission.

3.1.1 Intelligent Transportation Systems (ITS)

For the CA/T, the ITS component integrates two major subsystems, the Traffic Surveillance and Control System (TSCS), and Toll Operations. The latter is controlled locally from the Toll Plaza in East Boston, while the TSCS connects directly to the OCC.

Traffic information will be collected from thousands of data points and transmitted to the OCC, which will process the data and relay information to the operator on a real-time basis. The communications system has been designed primarily for rapid incident response, since breakdowns and accidents can quickly result in unacceptable carbon monoxide (CO) exposure levels in tunnel sections. Rapid incident detection will be supported with nine staffed emergency stations at peak hour, as well as instant communication with local police, fire, and emergency medical services.

Operations Control Center. The ITS component of the CA/T has a number of elements, with the critical one being the most advanced highway OCC in the U.S.A. The main OCC will be located in South Boston, with a backup OCC containing some of its essential components in Ventilation Building 6. The attributes of the OCC can be characterized as: input, processing, output, and control.

Data inputs will consist of over 20,000 points along the CA/T network. By comparison, the new Channel Tunnel connecting Great Britain and France will also have 20,000 data points, but in a tunnel that is over 50 km in length. On the CA/T, the ITS data points include:

- 1,400 loop detectors at 70 m intervals which will be used to measure traffic density and predict traffic patterns. During the Early Opening operations, video recognition systems (VID) will be field-tested to eventually replace loop detectors, and integrate traffic surveillance and monitoring activities. Slowdowns and other changes in traffic patterns will indicate the general location of a problem or incident, and trigger an alarm in the OCC.
- Closed circuit video equipment (CCVE): 500 color cameras will pinpoint the site, type, and severity of an incident. They will be pan-tilt-zoom cameras, at intervals of 150 m in covered sections and 400 m in open areas. Failure of any single camera will not result in a blind area. The application of VID technology to this extensive CCVE system could provide for highly integrated, efficient, and cost-effective traffic monitoring.
- Height detectors: 25 electronic height detectors will screen and help divert trucks and other vehicles that exceed the clearance limits inside the tunnels.

Processing capabilities are essential for this type of system. An OCC console will consist of two banks of computer screens. Three screens at the lower level will show route structure, traffic patterns, facilities data, and other data. On the top of the console will be eight more screens that will allow the operator viewing capacity for incidents or emergencies. The operator interface includes commands, alarms, device status, traffic status, and map displays which are integrated and consistent throughout the system. Status screens will be map based, color coded, and have a zoom capability.

A large-scale map, 4 m by 14 m, of the CA/T alignment will be displayed on a wall-sized back projection screen, identifying overall system status and traffic flows. It will display incident locations, traffic conditions, and device status, using a color coding scheme. A separate set of computers in the OCC will control the Facilities subsystem.

When an incident occurs, a system interface will automatically select the proper camera to display on the operator's monitor. The operator will also have manual control over selection of cameras to view the incident site, and will be able to program simultaneous scanning by a group of cameras. Once an incident is confirmed, pre-programmed response plans will be provided to the operator, with manual modification capabilities available. A checklist of manual operations will help ensure that all required activities are successfully performed.

The operator will have the capability to provide information to drivers on a real-time basis through a variety of output devices:

- Variable message signs (VMS): 130 VMSs will give both advisory and regulatory messages, providing specific traffic information rather than merely flashing "Delays Ahead".
- Highway Advisory Radio (HAR): Media tie-ins can give traffic advisories with improved time response over present commuter traffic reports. AM and FM receivers will be placed in the radio equipment rooms of ventilation buildings, with antennae on the roofs, so that drivers in the tunnels will have normal radio reception. HAR will broadcast on its own frequencies, but during an emergency, the HAR message will override all underground AM/FM frequencies.
- Electronic Toll and Traffic Management (ETTM): The East Boston Toll Plaza being constructed as part of the project will make significant use of ETTM technology. Read-write devices will be made available to vehicle operators willing to establish toll accounts, allowing travel-speed electronic transactions at the toll facility. The December 1995 Early Opening will see the first US all-electronic application of ETTM.

Slowdowns, breakdowns, and incidents will activate signals to control, check, or divert the flow of traffic with:

- 600 lane use signals
- 100 variable speed limit signs
- Lane and ramp metering at 15 locations, including HOV priority in tunnel access
- Rerouting of overheight vehicles.

At present there are no true real-time traffic management systems in the United States. While initial plans call for ITS capabilities to be used primarily for incident management, the ITS capability in the project could be used as the basis for a more extensive Advanced Traffic Management System (ATMS), and the implementation of more far-reaching Advanced Traveller Information Systems (ATIS). These systems would not only respond to incidents or slowdowns but would be designed to optimize usage of the entire transportation system, resulting in increased highway throughput capacity and greater use of alternate modes of travel. These systems could be used as the first building blocks of a regional ITS network.

3.1.2 Facilities Control System (FCS)

The CA/T IPCS also integrates the numerous components required to operate all project facilities. The elements of the Facilities Control System include:

- tunnel ventilation
- tunnel lighting
- drainage
- power distribution
- fire detection
- intrusion detection
- access control
- remote terminal units.

The tunnel ventilation subsystem controls over 130 air supply and exhaust fans located in seven ventilation buildings throughout the project. This subsystem will have operating algorithms to respond automatically to

traffic conditions, carbon monoxide (CO) levels, incidents, and fires inside the tunnels. Fan bearing and motor temperatures, and other equipment operating conditions will be monitored.

Additional capabilities of the FCS include monitoring of project lighting levels, drainage systems, the power distribution subsystem (including seven ventilation buildings and 10 medium-voltage substations), 14 fire alarm control panels located at the ventilation buildings, toll operations facilities, and the Service and Administration Complex. These panels will connect directly with the local fire departments and the OCC.

4. YEAR 2010

Sometime in the next decade a businesswoman from the southern suburbs of Boston will attend a meeting in the Financial District of Boston at 9:30 A.M. After finishing breakfast around 7:30 A.M., she will log into a home computer or interactive cable TV system, and enter her destination and desired arrival time. Estimates of travel times, based on both historical and real-time data for both highway and transit modes will be displayed on the screen. The time of departure for each mode will be suggested. This will help her make a final decision on when and how to travel. The service, provided by a private company for a monthly service charge, will also give her information on the availability and cost of parking at both nearby MBTA stations and parking garages at her final destination in the Financial District.

Once in her car, she will update travel information again using the on-board computer with heads-up display and cellular communications, or by listening to Highway Advisory Radio. She decides to drive into Boston, and along the Southeast Expressway, Variable Message Signs alert her to incidents ahead so that she can change routes or obtain information on transit services closer to the city. As she drives toward the new northbound Central Artery tunnel, she notices a flashing warning sign which has detected the presence of an overheight truck. She glances to the right to see the truck exiting the highway.

As she enters Boston, another check on the availability of the closest parking garage shows that spaces are still available. She will continue to receive routing advice while exiting the expressway and driving toward her destination on the city streets. As she travels into the Financial District via Dewey Square, queues begin to build along Summer Street in the South Station area. A traffic operations specialist in the OCC receives a message and some computer-generated suggestions for changing signal cycles along Summer Street. The operator approves these changes for the next 15 minutes and the motorists travels smoothly through the area.

When the meeting is concluded in the Financial District, she calls the office and finds that an important express package has arrived at Logan Airport. She gets into her car and receives updated route information between the Financial District and Logan Airport. The on-board computer shows that the new Harbor Tunnel is moving smoothly and is the fastest route. As she travels through the Tunnel, Highway Advisory Radio comes on to give notice that one lane of the eastbound Tunnel will be closed from 11 P.M. to 7 A.M. for cleaning for the next two days. She takes note since she may have to take an early flight to Washington tomorrow. Leaving the airport through the Third Harbor Tunnel, she sees ahead a message displayed on the VMS board: "MassPass Toll Collected", while an electronic reader deducts the toll from her smart card account. The transaction is effected in a transportation bank account set up on her credit card, which she also used to pay for downtown parking fees, and for her most recent MBTA trip to see the Celtics in the new Boston Garden.